BODY OF KNOWLEDGE IN RESEARCH OF AIR TRAFFIC MANAGEMENT: CASE STUDY IN INDONESIA

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Abstract

Air Traffic Management (ATM) is a discipline that manages the movement of flights in the air and on the ground. Its functions are to maintain the safety level required by the authority and to provide the capacity required by the airlines. The challenges in ATM come from the in-balance between the market growth and the available infrastructure and also the gap between the regulations and the technology. The research in ATM provides the solutions by introducing new methods or technologies to cope with those challenges.

The effort in organizing and cataloging the Body of Knowledge (BOK) in research of ATM is presented in this report. This BOK is a complete set of research concepts and activities in term of managing the air traffic to improve the air transportation safety and its capacity. Considering the latest publications in the last 5 years, the BOK consists of five areas of operation which are enroute, arrival, terminal, departure and connectivity. Each area of operations consists of several knowledge units that contain several research topics. In this report, a special attention is given to the development of ATM research in Indonesian. It characterizes with the challenges that commonly faced in Indonesia such as high density air traffic, in-sufficient infrastructure/technology, in-balance demand and supply during peak hours and major disruption by natural disasters (volcanoes and earth quakes).

The report summarizes that the trend of ATM research in Indonesia is in the knowledge unit of capacity optimization. Additionally, it recommends to explore research activities by implementing new air traffic concepts such as the trajectory based operation and the integrated of departure and arrival management to improve capacity, efficiency and safety.

Key words: Body of Knowledge, Air Traffic Management, Indonesian air transportation, Enroute, Arrival, Terminal, Departure, Connectivity

1. Introduction

Air Traffic Management (ATM) is one of the components in aviation industry that mainly related with the movement of flights that includes departing from an airport, cruising in airspace and arriving on a destination airport. Current ATM emphasize on harmonization and interoperability systems that allow smooth transition of flight operations from one stage of operation to the next stage of operation and also from an airspace to the next airspace.

The challenges in ATM come from the in-balance between the market growth and the available infrastructure and also the gap between the regulations and the technology. The research in ATM will provide the solutions by introducing new methods or technologies to cope with those challenges. Currently, there are two major research projects that aim to prepare the ATM to cope with the future challenges. They are Next Generation (NextGen)

project in United States and Single European Sky ATM Research (SESAR) project in Europe [1]–[5].

Indonesia is one of the countries that enjoying the steady growth of its air transportation industry in this decade. Its geographic location, its population and its economic development are the main factors supporting this phenomenon. However, the limited infrastructure, the decades old air traffic control system and its man power capability limits the further growth. Increasing flight delay, longer flight route and long aircraft queue during takeoff and landing are several parameters that indicate the overall ATM system needs to be upgraded [6].

Upgrading ATM system will require contributions from all stakeholders. Indonesian government started the ATM upgrading with the Indonesian Modernization Air Navigation Services (IMANS) project. This project updates communication, ground navaid, PBN procedure and surveillance systems [7]. Research and academic community as one of the ATM stakeholders in Indonesia also needs to be involved by introducing an innovation in ATM technology to solve the issues facing by the operator.

The Body of Knowledge (BOK) in ATM research could guide the research community in Indonesia to define research topics that related with the future challenges. It also could assist the Air Navigation Service Provider (ANSP) in Indonesia which is AirNav Indonesia in selecting the ATM technologies that suitable to be implemented in Indonesia.

This report aims to classify the research topics in global ATM and identify the key topics that could significantly contribute to the development of ATM in Indonesian. It will start with the collection and classification of research topics in ATM based on the five areas of operation which are enroute, arrival, terminal, departure and connectivity. A special attention will be given to the development of ATM research in Indonesian. It will consider the special characteristics that relates to the challenges commonly faced in Indonesia. The summary will recommend the research area and topics that could provide significant benefits for ATM development in Indonesia.

2. Process for Classification of ATM Research

The author is planning to conduct a PhD research in area of Air Traffic Management and trying to formulate the most suitable research topic that could benefited for Indonesia air transportation development. However, I am not found any publications that highlight the classification of research area in ATM. Thus, the author got an idea from the BOK of other are such as Software Engineer [8], [9] and Project Management [10]. The BOK will consist of hierarchy description and decomposition of research area in ATM.

The development process of BOK is explained in 4 steps as shown in figure 1. It starts with the collecting the published research in the last 5 years to get the most up to date research activities. The source of research publication ranged from an open source publication search engine such as Google Scholar, Journal website, Conference website and also social media type research sharing platform such as Research Gate and Academia.

Figure 1. The development process of ATM research BOK.

It continues with cataloging the collected research publications. There are very wide research topics and it is very challenging to classify it based on the purpose or the result. On this stage, we collected the topic of research, the purpose, the method, the result and also the

summary. From this catalogue, it is more clearer the similarity and dissimilarity between them. Beside research publications there are also documents that aggregate the research activities such as documentation from SESAR and NextGen projects [1]–[5]. These documents give more general idea on the research area currently explored.

The next step is to classify the research activities in ATM. This BOK is classified as a hierarchy in 4 levels as shown in figure 2. The BOK is divided into several area of operation. Each area of operation consists of several knowledge units. The knowledge unit is expanded into several research topics.

The last step is the composing of BOK which gives the full hierarchy on each of the categories. It is supplied with the description of each category and it will be explained in the next chapter.

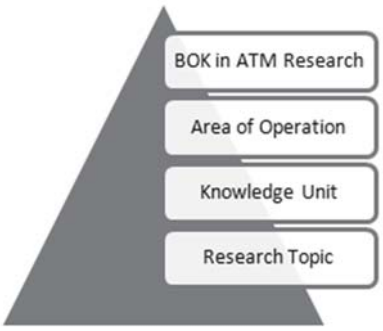

Figure 2. The hierarchy of ATM Research BOK.

3. BOK of ATM Research

Air Traffic Management (ATM) is a discipline that manages the movement of flights in the air and on the ground starting from the origin airport to the destination airport. Its functions are to maintain the safety level required by the authority and to provide the capacity required by the airlines. Basically, the ATM can be classified into several areas of operation based on the flight segments such as enroute, arrival, terminal and departure. Since a research in ATM tries to solve a traffic issue or to implement an innovation to improve a traffic condition at specific flight segment, the ATM research also can be classified based on the flight segments.

First, enroute or cruising flight segment is the biggest portion of a flight in term of time and distance. For long haul flight, it could cross several airspaces belong to different countries. The smooth handover between airspace controllers is a key factor in harmonizing global ATM.

The second area of operation is the arrival. It requires a separation between flights that fulfills the safety margin and at the same time provides a sufficient runway capacity. A new method in arrival which is the continuous descent operation has a potential to reduce the fuel consumption and noise produced. However, its implementation during peak hours is still in question.

The third area of operation is the terminal segment which is the ground part of a flight. In-balance of traffic during peak hours and non-peak hours is one of major issues. Furthermore, the uncertainty in visibility requires a new surveillance technology to improve the safety level.

The last area of operation is the departure segment which is considered as less complicated than the arrival. However, the integrated of departure and arrival management could improve the coordination in handling incoming and outgoing flight to improve the capacity and minimize delay time.

In addition to the flight segments, the communication between airside and ground side and also between each of them is also an important mode in ATM which needs to be addressed. With the advance in information technology, the communication is not limited to a voice, but also with a direct data link. The data link allows the usage of automation on aircraft monitoring and surveillance. Thus we can add a new classification of ATM research as connectivity.

The complete area of operation and its knowledge unit are shown in figure 3. It will be explained more detail in the coming chapters. Since this BOK in ATM Research is the first of such document, comments and suggestions are welcome for future revision.

3.1. Enroute

Enroute is one of the ATM operation areas that relate with the usage of middle and upper part of airspace. It is mainly for the cruising segment of a flight that normally above altitude of FL100. Actually, it is the majority portion of a flight in term of flight time and fuel consumption. From airline view, all flights need to be flown at their optimum altitude and shortest route. However, with the growth of air traffic, accommodating the optimum flight profile become very challenging. The airspace needs to be optimized to improve the capacity and safety. In this area of operation, the published research can be categorized into three different research areas as explained in table 1.

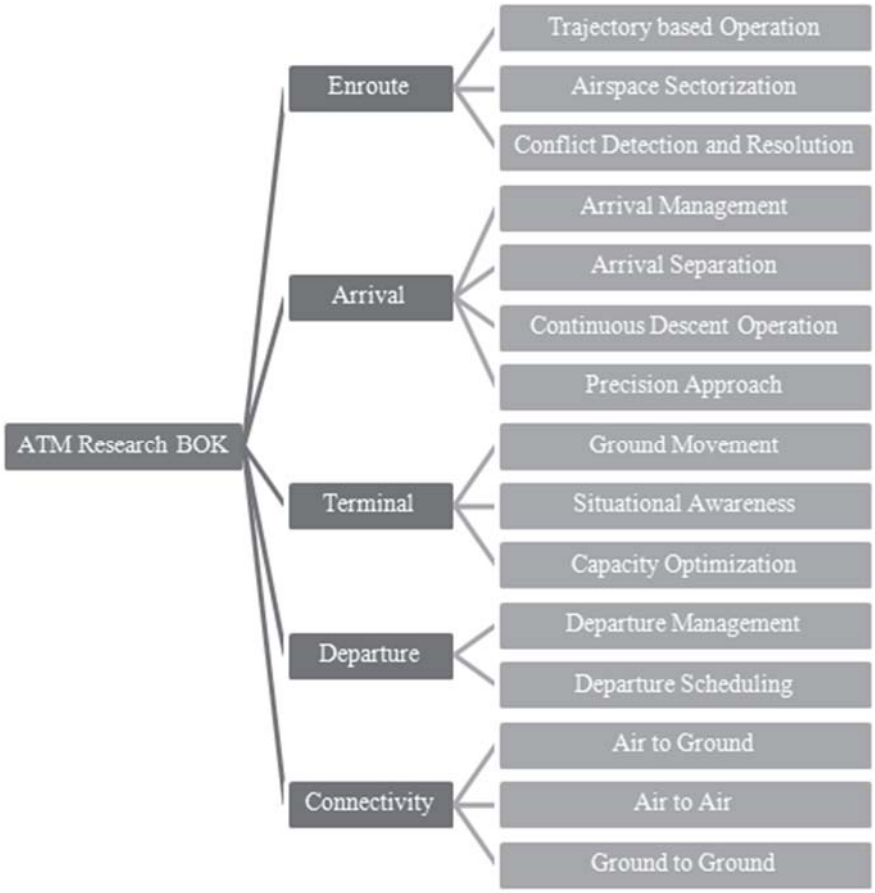

Figure 3. The area of operations and knowledge units in ATM research.

Table 1. Research Classification in Enroute operation area.

Knowledge Unit	1. Trajectory based operation
Description	It is the concept of improving throughput, flight efficiency, flight times and schedule predictability through better prediction and coordination of aircraft trajectories. It could employ trajectory-based automation, air/ground data link, and higher levels of automation for separation assurance to increase airspace capacity.
Example of Research Topics	An Oceanic Trajectory Based Operations Concept Shaped by Operational Influences. [11] Flight Trajectory Optimization Through Genetic Algorithms for Lateral and Vertical Integrated Navigation. [12]
Knowledge Unit	2. Airspace sectorisation
Description	Airspace sectorisation provides a partition of a given airspace into sectors, subject to geometric constraints and working constraints, so that some cost metric is minimised. Opening/closing of sectors should closely monitor the demand to achieve efficient use of all available resources.
Example of Research Topics	CDAS: A Cognitive Decision-Making Architecture for Dynamic Airspace Sectorization for Efficient Operations. [13] A multi-objective approach for 3D airspace sectorization: A study on Singapore regional airspace. [14]
Knowledge Unit	3. Conflict detection and resolution
Description	The conflict situation between aircrafts is detected on the basis of forecast of their motion, and parameters of the conflict. When a potential conflict is detected, then a resolution must be realized by manoeuvre of only one aircraft or both of them in the conflicting pair.
Example of Research Topics	Review: Analysis and Improvement of Traffic Alert and Collision Avoidance System. [15] A flexible framework for solving the air conflict detection and resolution problem using maximum cliques in a graph. [16]

3.2. Arrival

It is the descending traffic toward the destination airports. It could start from cruise altitude until the aircraft lands on the runway. Arrival segment, especially the approach and landing part is considered as the most critical part of flight in term of safety because many major accidents happens in this segment. The other concern in landing is about the traffic capacity that defines by the separation applied between flights. In addition, the noise produced during landing becomes one of the issues in developed countries. In this area of operation, the published research can be categorized into four different research areas as explained in table 2.

Table 2. Research Classification in Arrival operation area.

Knowledge Unit	1. Arrival Management
Description	Arrival Management (AMAN) is designed to provide automated sequencing support for handling traffic arriving at an airport. It will continuously calculating arrival sequences and times for flights, taking into account the locally defined landing rate, the required spacing for flights arriving to the runway and other criteria. AMAN makes use of the available capacity at an airport combined with a more efficient and predictable traffic. It can assist in reducing low altitude holding and tactical intervention from ATC that can lead to lower fuel consumption, less noise and emission.
Example of Research Topics	Integrating Arrival Management with Airspace Design and Analysis. [17] Analysis on the Impact of Pop-Up Flight Occurrence when Extending the Arrival Management Horizon. [18]
Knowledge Unit	2. Arrival Separation
Description	Arrival separation is the concept of keeping an aircraft outside a minimum distance from another aircraft in an arrival traffic to reduce the risk of those aircraft colliding, as well as prevent accidents due to secondary factors such as wake turbulence. For an aircraft following the same tracks, longitudinal separation may be achieve by requiring aircraft to make position reports and comparing the time of their reports or by speed control, ensuring that the speed of the following aircraft does not exceed the speed of the leading aircraft.
Example of Research Topics	ECAC Use Case of Optimised Pre-tactical Time of Arrival Adjustments to Reduce Probability of Separation Infringements. [19] Optimal Arrival Time Assignment and Control Analysis using Air Traffic Data for Tokyo International Airport. [20]
Knowledge Unit	3. Continuous Descent Operation
Description	Continuous Descent Operation (CDO) is an aircraft operating technique in which an arriving aircraft descends from an optimal position with minimum thrust and avoids level flight to the extent permitted by the safe operation of the aircraft and compliance with published procedure and ATC instructions. The objective of a CDO is to reduce aircraft noise, fuel burn and emissions. The ideal CDO starts at the top of descent and ends when the aircraft starts the final approach and follows the glide slope of the runway.
Example of Research Topics	Study of Point Merge technique for efficient Continuous Descent Operations in TMA. [21] Research on Trajectory Generation and Optimization in Continuous Descent Operations. [22]
Knowledge Unit	4. Precision Approach
Description	Precision approach is an instrument approach and landing using precision lateral and vertical guidance with minima as determined by the category of operation. The guidance is provided by a ground based

	navigation aids, computer generated navigation data or a controller interpreting the display. The categories of precision approach and landing are defined according to the applicable decision height or visibility. On reaching the decision height, the pilot may continue the approach to land provided the required visual reference or commence a missed approach procedure.
Example of Research Topics	Geometric approach for RNP transition to xLS procedure design. [23] Automatic speed profiling and automatic landings during advanced RNP to xLS flight tests. [24]

3.3. Terminal

It is the ground movement of aircraft out of the runway toward the terminal gate/parking area and from the terminal gate/parking area toward the runway. In a large airport, the taxiway configuration allows for optimization in ground flow movement considering the shortest route or the less fuel consumption. However, the optimized route could complicate the ground traffic due to the difference of each aircraft taxi route. The safety could deteriorate when the poor visibility happens. Some new technique and technology such as ADS-B or Radar could be used to improve the situational awareness of traffic during taxi in low visibility. In this area of operation, the published research can be categorized into three different research areas as explained in table 3.

Table 3. Research Classification in Terminal operation area.

Knowledge Unit	1. Ground Movement
Description	It involves all aspect of aircraft handling at airports as well as aircraft movement around the aerodrome. It needs to consider the smooth operation and safety aspect.
Example of Research Topics	Real-time airport surface movement planning: Minimizing aircraft emissions. [25] An integrated optimisation approach to airport ground operations to foster sustainability in the aviation sector. [26]
Knowledge Unit	2. Situational Awareness
Description	Situational awareness can be improved with the better sharing of information that accessible for all stakeholders in a user friendly, understandable and consistent format. It helps planning the resources on a daily basis and supports decision making in bad weather conditions.
Example of Research Topics	Conducting Safe and Efficient Airport Surface Operations in a NextGen Environment. [27] A Runway Incursion Detection Approach Based on Multiple Protected Area and Flight Status Machine for A-SMGCS. [28]
Knowledge Unit	3. Capacity Optimization
Description	A major goal of air traffic management is to strategically control the flow of traffic so that the demand at an airport meets but does not exceed the operational capacity. It needs to consider both the arrival and departure operations as an interdependent process.

Example of Research Topics	Optimizing key parameters of ground delay program with uncertain airport capacity. [29] Airline delay management problem with airport capacity constraints and priority decisions. [30]

3.4. Departure

It is the departed traffic from the runway to join the cruising segment. It includes takeoff and climb segment which aircraft gain altitude to join the enroute segment. Since the departure traffic is diverge at the end, this segment is less challenging compare to other flight segments. However, an optimization could be used to improve the runway capacity. Furthermore, integration with arrival management at the destination airport could benefit in reducing holding by departure delay and avoiding diversion or return to base flight. In this area of operation, the published research can be categorized into two different research areas as explained in table 4.

Table 4. Research Classification in Departure operation area.

Knowledge Unit	1. Departure Management
Description	Departure management (DMAN) is a planning tool developed to improve the departure flows at airports and increase the traffic predictability. DMAN calculate the target takeoff time taking multiple constraints and preference into account. It provided a planned departure flow with the goal to maintain an optimal throughput at the runway, reduce queuing at holding point and distribute the information to various stakeholders at the airport.
Example of Research Topics	Comparison of First-Come First-Served and Optimization Based Scheduling Algorithms for Integrated Departure and Arrival Management. [31] Management of Time Based Taxi Trajectories coupling Departure and Surface Management Systems. [32]
Knowledge Unit	2. Departure Scheduling
Description	Departure scheduling needs to consider wake-separation constraints for successive departures, miles-in-trail separation for aircraft bound for the same departure fixes, and time-window or prioritization constraints for individual flights. Besides these, emissions as well as increased fuel consumption due to inefficient scheduling need to be included. The aims are to improve efficiency and throughput of overall surface operations at busy airports
Example of Research Topics	A bi-objective integer programming model for partly-restricted flight departure scheduling. [33] A two-stage no-wait hybrid flow-shop model for the flight departure scheduling in a multi-airport system. [34]

3.5. Connectivity

Connectivity is a new communication mean that connects different actors in air traffic management. In the latest development, it includes direct communication between aircraft and ground systems using data link. This allows for implementation of more automation and

automatic monitoring that could improve the capacity and safety level. In this area of operation, the published research can be categorized into three different research areas as explained in table 5.

Table 5. Research Classification in Connectivity operation area.

Knowledge Unit	1. Air to Ground
Description	It is the means by which the ground systems or the ground personals communicate with the airborne systems or the flight crew
Example of Research Topics	How much is too much on monitoring tasks? Visual scan patterns of single air traffic controller performing multiple remote tower operations. [35] In-Flight Broadband Connectivity: Architectures and Business Models for High Capacity Air-to-Ground Communications. [36]
Knowledge Unit	2. Air to Air
Description	It is the means by which the airborne systems or the flight crew communicate with the other airborne systems or the flight crew in different aircraft
Example of Research Topics	A Formally Verified Hybrid System for the Next-Generation Airborne Collision Avoidance System. [37] Realities and challenges of NextGen air traffic management: The case of ADS-B. [38]
Knowledge Unit	3. Ground to Ground
Description	It is the means by which the ground systems or the ground personals communicate with the other ground systems or the other ground personals
Example of Research Topics	The approach of SWIM data sharing based on multi-dimensional data encryption. [39] A Method for SWIM-Compliant Human-in-the-Loop Simulation of Airport Air Traffic Management. [40]

4. ATM Research in Indonesia

Indonesia is the largest archipelago in the world with more than 17,000 islands requires air transportation to connect each of its cities and communities. With its current population is more than 250 millions, the size of air transportation is 97 million passengers in 2017 [41]. However, there are some special characteristic of air traffic in Indonesia that will be explained in the next section of this report. It will follow with the research development of air traffic management in Indonesia.

4.1. Air Traffic Characteristics in Indonesia

There are 4 major characteristics of air traffic in Indonesia which are:

4.1.1. High density air traffic.

In the last 5 years, Indonesia experienced double digits growth in air transportation [6]. It is supported by the introduction of low cost carriers and the growth of middle class income. According to a report from AirNav Indonesia, it increases the maximum runway

capacity in Soekarno Hatta airport up to 84 movements per hour [42]. Another evidence of high traffic density is the Jakarta-Surabaya route ranked the 4th busiest route in the world as 819 flights per week [43].

4.1.2. In-sufficient infrastructure/technology.

The rapid growth in air traffic improves the country economical sector. However at certain airports such as Soekarno Hatta airport, the growth is limited by the capacity available. When the capacity is increased further without the sufficient support from infrastructure or technology, the safety level will deteriorate. Currently, there are some new runways, new terminals and new airports project at certain locations to cope with the increasing demand.

4.1.3. In-balance demand and supply during peak hours and non peak hours.

The typical demand of air traffic is high at peak hours due to the nature of passenger preference. For example the traffic demand in Juanda airport is above the maximum capacity only during morning peak hours [44]. This trend can be found in other busy airports. One of possible solution is to spread out the demand into the wider period of time.

4.1.4. Frequent major disruptions due to natural disasters.

Volcanoes and earth quakes are two phenomenon commonly happen in Indonesia due to its location in "the ring of fire". Many active volcanoes erupted recently such as Mount Agung in Bali, Mount Sinabung in North Sumatera, Mount Gamalama in Ternate and Mount Raung in East Java [45]. Also, the latest earth quake in Lombok this year devastated the city and also disrupts the air traffic around that area.

4.2. Research development of ATM in Indonesia

In the last 5 years, I found 14 publications from Indonesian scientist that related with ATM research as shown in table 6. It can be categorized according to this BOK: one publication in enroute, two publications in arrival, seven publications in terminal, one publication in departure and three publications in connectivity.

Table 6. ATM research publications in Indonesia.

Area of Operation	Publication	Knowledge Unit
Enroute	Sekartadji, R., Ahyudanari, E., & Jaelani, L. M. (2017). Analysis of Air Traffic Density using GIS , Case Study : Jakarta-Surabaya Analysis of Air Traffic Density using GIS , Case Study : Jakarta-Surabaya.[43]	Airspace Sectorisation
Arrival	P. R. Aswia *et al.* (2015). Optimalisasi STAR RNAV 1 menggunakan konsep point of merge di wilayah terminal airspace bandar udara. [46]	Arrival Separation
Arrival	I. Setiowati, I. Hasbiyati, and M. D. H. Gamal (2017). Scheduling Aircraft Landing at Single Runway. [47]	Arrival Management

Terminal	M. L. Caroline, Y. Asnar, and A. I. Kistijantoro. (2016). Scheduling model for air traffic in Indonesia. [48]	Capacity Optimization
Terminal	S. Hamzah and S. A. Adisasmita. (2014). Aircraft parking stands: proposed model for Indonesian airports. [49]	Capacity Optimization
Terminal	C. W. M. Noor and R. Mamat. (2017). Application of Artificial Neural Network to Predict the use of Runway at Juanda International Airport Application of Artificial Neural Network to Predict the use of Runway at Juanda International Airport. [50]	Capacity Optimization
Terminal	F. A. Perdana and R. Moxon. (2014). Traffic distribution study on Multi-Airport systems in the Greater jakarta Metropolitan Area (GJMA) and associated implications. [51]	Capacity Optimization
Terminal	M. I. Rachmansyah and Nahdalina. (2017). Pengaruh Penyeimbangan Pergerakan Pesawat Terhadap Peningkatan Kinerja Bandara (Studi Kasus: Bandara Internasional Soekarno-Hatta). [52]	Capacity Optimization
Terminal	Safrilah and J. C. P. Putra. (2017). Review Study on Runway Capacity Parameters and Improvement. [44]	Capacity Optimization
Terminal	C. Setyarini and E. Ahyudanari. (2017). Analisis Pengaruh Pergeseran Runway Holding Position terhadap Runway Occupancy Time dan Runway Capacity (Studi Kasus: Bandar Udara Internasional Juanda). [53]	Capacity Optimization
Departure	K. Novianingsih and R. Hadianti. (2014). Modeling flight departure delay distributions. [54]	Departure Scheduling
Connectivity	A. Bharata. (2017). Perancangan Sistem Pintar Prediksi Trajektori Pesawat Menggunakan Data ADS-B dengan Metode Kalman Filter untuk Mencegah Collision. [55]	Air to Ground
Connectivity	S. Nugraha and A. T. Caesar. (2016). Analisis Kinerja Sistem Doppler VHF Omnidirectional Range dan Distance Measuring Equipment pada Navigasi Penerbangan. [56]	Air to Ground
Connectivity	Y. Nurhayati and Susanti. (2014). The Implementasion of Automatic Dependent Surveillance Broadcast (ADS-B in Indonesia). [57]	Air to Ground

In the enroute area of operation, the reseach analyzes the air traffic density for Jakarta-Surabaya route which is one of the busiest routes in the world [43]. The current traffic data is used to predict the future density of this route considering the development of new runways

and airports in that airspace sector. The knowledge unit of trajectory based operation is not yet explored and further conflict detection and resolution could improve the safety level.

The two publications in arrival area of operation consist of one publication in arrival separation and another one in arrival management. The first publication proposed an application of point merge technique for arrival separation in STAR RNAV 1 procedure in Soekarno Hatta airport. Based on the simulation, it could reduce the ATC workload and communication by 20%. Also it can save 3-5 minutes of flight time [46]. The second research developed a mathematical model for landing scheduling to minimize the overall flight time [47]. Both of the research emphasize on maximize the capacity available by managing the arrival flow more evenly. The knowledge unit of continuous descent operation and precision approach are not explored yet.

The seven publications in terminal area of operations emphasize on airport capacity optimization from different point of view. The first four publications optimized the runway utilization in order to improve the airport capacity [44], [48], [50], [53]. The fifth publication improved airport capacity by optimization of parking stand and apron model [49]. The sixth publication optimized airport capacity by the traffic distribution of multi airport system in greater Jakarta area [51]. The last publication proposed of using bigger aircrafts for domestic routes to increase the airport passenger capacity [52]. The knowledge unit of situational awareness is not explored yet.

The only publication in departure area of operation used genetic algorithm to predict departure delay and analyze its effect on the schedule sensitivity. Thus airline can develop a schedule that robust to the departure delay [54].

In the operation area of connectivity, there are three publications that focused on air to ground connection. The first and second publication analyze the implementation of ADS-B which the former use it for collision avoidance and the later for surveillance [55], [57]. The last publication analyze the DVOR signal modulation used for flight navigation [56]. The knowledge units of connection between air to air and ground to ground are not yet explored.

Thus, the trend of ATM research in Indonesia is the capacity optimization for enroute, departure, arrival and terminal area of operation. This trend is very reasonable because the major issue in Indonesia's air traffic is the in-balance between capacity and demand. The air transportation industry growth very high but the infrastructure development is slow.

4.3. Potential ATM Research for Indonesia

There is a huge gap between ATM research in global especially US and Europe compare to Indonesia. There are many new ATM concepts that can be adopted to improve the Indonesian air traffic. Some of them are free route and Trajectory Based Operation (TBO) in enroute, Continuous Descent Operation (CDO) in arrival, integrated Departure and Arrival Management (D-AMAN) and System Wide Information Management (SWIM) concept for connectivity

The free route concept was started to be implemented in some European airspaces. This concept allows for more direct route that lead to shorter flight time and saving fuel consumption. However this implementation requires a validation system that avoids any conflicts during the planning and conflict, detection and resolution system to mitigate the possible conflicts [3]. This concept can be used to optimize the airspace capacity instead of using high density fix route such as the case for Jakarta-Surabaya route.

The Trajectory Based Operation (TBO) concept allows each flight to have its own optimum trajectory. It means that each flight has its own optimum 4D trajectory (location, altitude and time) that updated continuously. It requires a data link connection between all traffic with the ground controller systems. This concept could improve capacity, flight efficiency and schedule predictability [3]. Since flight delay is very common in Indonesia, the

implementation of this concept could improve the on-time performance through the better prediction and coordination of flight trajectories.

The concept of Continuous Descent Operation (CDO) allows for less fuel burn and less noise due to the idle engine setting used and no step descent segments. However, it requires a spacing monitoring system to make sure that the separation is not below the minimum safety margin. That is the reason that currently in Europe this concept only implemented during low density traffic. In Indonesia, CDO is not very interesting research because reducing emission and noise are not the top priority in the aviation regulation yet.

The integrated departure and arrival management allows for accurate runway sequencing but requires close controller coordination between departure and arrival flights. However it could lead to increase in runway capacity and flight efficiency [3]. This coordination concept is a better solution for a busy airport such as Soekarno-Hatta airport, Denpasar airport and Juanda airport.

The SWIM concept allows sharing information and seamless data access and interchange between all stakeholders. It encourages interoperability and standardization of data that enable user and provider to exchange data without different protocol [3]. This concept is not mature yet and requires new information technology infrastructure that support this functionality.

From those new ATM concepts, the trajectory based operation and integrated of departure and arrival management could be the top choices to be adopted in Indonesia. It could allow for improvement in capacity, efficiency and safety with less supporting requirements. Furthermore, the free route, CDO, and SWIM are less suitable for current ATM situation in Indonesia. It is because requires additional advance system to support its implementation and also not yet required by the regulations.

5. Summary

The development of a BOK requires a comprehensive process start from collecting the publications from several sources, cataloging the main information and classifying it according to the hierarchy. The hierarchy used in this BOK consists of operation area, knowledge unit and research topic. The resulted BOK in ATM research is an effective way to map the research activities and to look for the latest research trend. It can also be used to define the research area that are not explored yet and have the opportunity to be explored more.

In the case of ATM research in Indonesia, the research trend is in the knowledge unit of traffic capacity optimization for most of the operation area. It is due to the in-balance between capacity and demand of air traffic in Indonesia today. In addition, there are only a few research conducted in enroute and departure. The suggestion for future research is to implement the new air traffic concepts such as trajectory based operation and integrated of departure and arrival management to improve the capacity, efficiency and safety.

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