FUTURE DEVELOPMENTS IN ATM – JAPAN

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Abstract

This paper first describes the present status of air traffic management (ATM) systems in Japan. Then ATM related research and development programs ongoing at the Electronic Navigation Research Institute (ENRI) are briefly introduced. Finally, the future research and development plans associated with ATM are described.

1. Introduction

Air Traffic Management (ATM) is the aggregation of the airborne functions and ground-based functions required to ensure the safe and efficient movement of aircraft during all phases of operation. This consists of air traffic services (ATS), air traffic flow management (ATFM) and airspace management (ASM). ATS is a generic term including flight information service, alerting service, air traffic advisory service, and air traffic control (ATC) service. ATC provides the tactical separation assurance for preventing the collisions between aircraft and between aircraft and terrain or obstructions. ATFM is the process that ensures that ATC capacity is utilized to the maximum extent possible, and that the traffic volume is compatible with the ATC capacity available provided by the ATC service.

The elements of the ATM system are airspace, aircraft including its crew, navigation, communication, surveillance and ATC systems, airports, aeronautical information, weather information, rules, regulations, procedures, and personnel such as controllers, technicians, and operators of ground systems. The system is a very complex and large-scale one.

In Japan, the Civil Aviation Bureau (JCAB), Ministry of Land, Infrastructure and Transport (MLIT) is responsible for the services mentioned above. Fig.1 shows the flight information region (FIR) under the Japanese authority. There are four area control centers at Sapporo, Tokyo, Fukuoka and Naha. In October 2005, the air traffic management center (ATMC) was established at Fukuoka. It has been in operation since February 16, 2006.

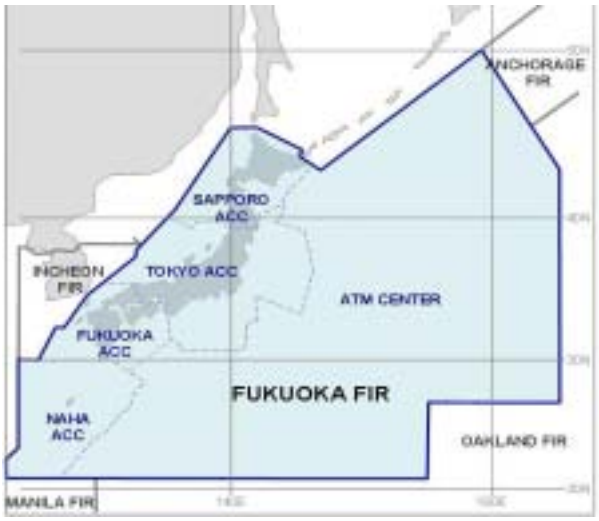

Fig.1 The FIR of Japan (JCAB).

In this paper, the present status of the ATM system and related works are briefly described firstly. Then, the research and development (R & D) programs of the Electronic Navigation Research Institute (ENRI) are explained. Finally, some views on the future development are briefly presented.

2. Current Status of Japanese ATM [1],[2]

To cope with the increasing air traffic demand the ATM service provider is planning to enhance the performance of ATM. The main events are:

(1) Opening the Chubu Centrair International Airport

This new airport was opened on February 17, 2005 to meet the demand for air transport from industrial activities within the Chubu (Central Japan) region. This is a major industrial region with a population of about 20 millions. This region accounts for approximately 25% of the GDP in Japan.

Fig.2 Bird's-eye View of Chubu Centrair Int'l Airport (JCAB) [1]

(2) Expansion of the Tokyo International (Haneda) Airport

This airport has a network with 400 round-trip flights a day linked with 48 airports mostly within the country. The number of domestic passengers is 60 millions per year.

To meet the demand to ensure its function as the key station for the domestic air traffic in the metropolitan area, an offshore development work on the airport is progressing. On December 1, 2004, Passenger Terminal 2 was opened but the airport has nearly reached the limit of its capacity. So, its expansion project was started. Construction of a new runway is a part of the expansion project. It will increase the airport capacity (the number of take-off and landing aircraft) from the current 285,000 to 407,000 per year [1].

Fig.3 shows the runway configuration of the Haneda airport. The new 2,500 m runway will be installed on the southern seaboard of the present airport. If the construction progresses as planned, it will be opened in 2009.

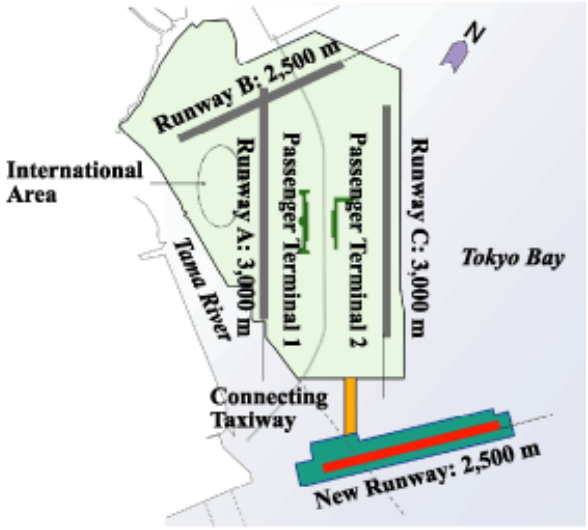

Fig.3 Haneda Airport Runway Layout (JCAB)[1]

(3) Restructuring of Domestic Airspace

To cope with the increasing traffic demand due to the expansion project of Haneda Airport, the restructuring of airspace will be promoted by

(a) introduction of reduced vertical separation minima (RVSM) (implemented in September 30, 2005)
(b) introduction and development of area navigation (RNAV) (RNAV Road Map was made in 2005)
(c) capacity enhancement by the above.
(d) more efficient utilization of airspace by the ATM Center functions which was opened in Feb. 2006.

(4) Expansion of RNAV Routes

Majority of the present aircraft has RNAV capability. RNAV is also known as random route navigation. The on-board navigation system determines the position of the aircraft. A navigation computer (often embedded in the flight management system) carries out the course computation to the next waypoint. RNAV aircraft are not constrained to travel directly toward or away from ground-based VOR/DMEs. Therefore, the more effective

utilization of airspace is expected due to the expansion of the RNAV routes.

In Japan, in June 2006, 53 RNAV routes exist in its airspace. The route will be expanded, and at the beginning of 2008, restructuring of airways, designating airspace over a certain altitude (FL285, for example) for the exclusive use of RNAV, will be implemented to avoid traffic congestion and ensure the smooth flow of traffic. This is called as the SKY Highway Plan [2]. RNAV routes will be implemented in three operational phases: en-route, terminal and approach.

(5) Use of MTSAT

MTSAT (Multi-functional Transport Satellite) is a satellite of which missions are air traffic control and meteorological observation. There are two satellites, i.e., MTSAT-1R (launched on February 26, 2005) and MTSAT-2 (launched on February 18, 2006). These satellites cover the Asia Pacific region for the provision of new communication service with a wide area augmentation system for GPS (MSAS). Fig.4 shows the coverage of MTSAT.

MTSAT enhances communication, navigation and surveillance functions shown in Table 1. ADS is a method of surveillance that is dependent on downlink reports from an aircraft's avionics. The reports occur automatically whenever specific time intervals are reached, or specific events occur. MTSAT-based Augmentation System (MSAS) provides the augmentation information to improve the reliability and accuracy of GPS via MTSAT for the aircraft using the GPS position information for their navigation.

Table 1 Enhancement by MTSAT

	Enhanced function
Communication	Direct communication between the controller and pilot using data link
Navigation	Augmentation of GPS (MSAS)
Surveillance	Automatic dependent surveillance (ADS)

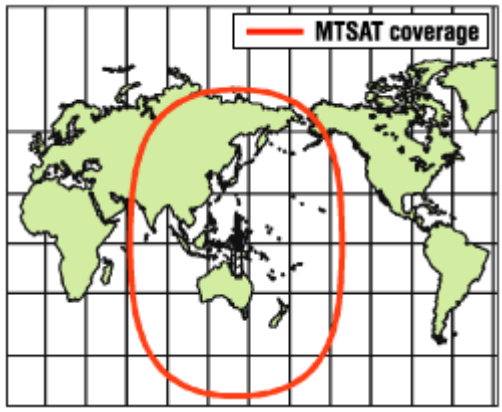

Fig.4 Coverage of MTSAT (JCAB)[2]

Using ADS and direct communication functions, the reduction of separation minima in oceanic airspace will be made. Ultimate separation minima under the full operation of two MTSATs are 30 NM lateral and 30 NM longitudinal.

(6) Opening of ATM Center (ATMC)

The air traffic flow management had been carried out at the Air Traffic Flow Management Center (ATFMC) at Fukuoka. The new ATM Center replaced the function of the ATFMC. The ATMC covers the air traffic control of oceanic airspace, air traffic flow management, and airspace management.

At each service of the ATM center, CDM (Collaborative Decision Making) is introduced. The center promotes information sharing and CDM with the organization such as area control centers, airport offices, the Meteorological Agency, Defense Agency, the U.S. Forces, airlines and foreign air traffic control agencies.


Fig.5 ATM Center Operation Room

3. Research and Development in Japan

3.1 Research Organization

ATM related research and developments have been done in national research institutes such as the Electronic Navigation Research Institute (ENRI) and National Aerospace Laboratory (currently a part of JAXA), some universities and other private sectors.

Among these institutions, the ENRI is a government-funded research organization. It conducts research and developments in response to the requests of the JCAB. Majority of the R & D projects at the ENRI is reflecting the needs from the JCAB.

3.2 Research & Development at ENRI

Since the infrastructure of air traffic has been enriched in Japan, the major issues of today are how to maximize the capacity and efficiency with limited resources such as airspace, infrastructures and human resources. The ENRI is trying to be a core research institute of the ATM system in Japan and started three areas of studies for:

(1) more efficient use of airspace and its capacity enhancement (including safety assessment),

(2) airport capacity enhancement, and

(3) improvement of safety and efficiency using risk prevention and advanced technology.

Details are shown in the following sections.

3.2.1 Studies for more efficient airspace utilization and its capacity enhancement (including safety assessment)

These studies are closely related to the present status of ATM in Japan. In considering the ATM system, the safety is a key issue as well as efficiency and capacity.

Especially, the safety assessment for introducing new air traffic control procedures and operational procedures such as RNAV and those associated with the SKY Highway Plan.

Study on separation minima has been carried out for the contribution to a specialist group (called Panel) of the ICAO (International Civil Aviation Organization). The current important subject is the feasibility study of the implementation of 30NM (lateral) and 30NM (longitudinal) separation minima in the North Pacific oceanic airspace under the ADS environments using MTSATs. See Fig.6.

Study on domestic air traffic flow management is ongoing. In the Japanese ATFM system for en-route sectors, the capacity is measured by an index representing controllers' workload. The current algorithm for calculating the workload is very complicated and the determination process of parameters for each sector is a not easy job. The method for improving the algorithm for estimating the workload has been studied.

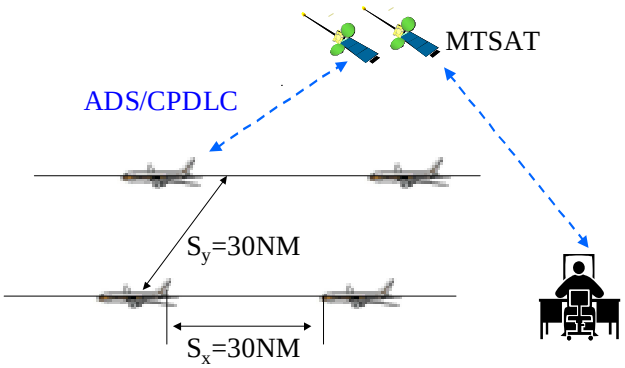

Fig.6 Reduced separation minima with MTSAT.

In addition to these, the following projects are ongoing:

- Improvement of SSR Mode S
- Satellite-Based Augmentation System
- High-accuracy satellite positioning technology using the quasi-zenith satellite system (QZSS)
- Real time kinematic GPS Improvement
- Near real time troposphere delay estimation.

These studies are for supporting the ATM system by the improvement of navigation and/or surveillance capability.

3.2.2 Airport Capacity Enhancement

The capacity enhancement of congested airports such as Haneda Airport and the surrounding airspace is required. To cope with requests, we need to develop methodologies for improving the design of air traffic control sector and route structure around an airport.

Some experiments using a real time ATC simulator will play an important role to validate or estimate the capacity of adjacent airspace to the terminal area. Real time simulations are core tools in this field of R&D. In addition to the real time simulation, fast time simulation will be made depending on the nature of the problems to be solved.

Fig.7 ATC simulator consoles at ENRI.

We also need to develop supporting technologies for the precision approach to the airport using satellite navigation systems.

The examples of R& D programs are as follows:

- Air traffic controller assisting tools
- Advanced surface movement guidance and control system (A-SMGC)
- Ground-based augmentation system (GBAS)
- Wake turbulence detection

3.2.1 Improvement of safety and efficiency using risk prevention and advanced technology

In this area of study, to improve the safety, and efficiency of ATM system, the following study programs have been carried out at the ENRI.

- - Aeronautical telecommunication network (ATN)
- VHF digital link
- Radio signal environments for aeronautical radio navigation services
- Multi-path error reduction
- Effect of portable electronic devices upon aircraft system
- Advanced aeronautical satellite communication system using internet technologies
- Conflict detection method with down-linked aircraft parameters
- ATC workstation in the next generation
- Task analysis and workload study on en-route ATC
- Measurement of human factors

Some programs are of human factors and infrastructures of ATM such as communication systems.

4 Future Developments in ATM

4.1 Long-term Future Plan

Future ATM developments in Japan seem to be closely related to the direction of the global aviation society. In the U.S., the Joint Planning and Development Office is developing the NGATS (Next Generation Air Transportation System) [3] for 2025. In Europe, SESAR (Single European Sky ATM Research) program [4] is ongoing. The end of the deployment phase is set in 2020.

In Japan, a technical group within the JCAB started discussing about the next generation air traffic system. The group is preparing the draft plan, tentatively called, the Comprehensive Assessment on the Restructure of the Air Traffic Services (CARATS). The long-term future

ATM developments in Japan will depend on the outcome of the discussions.

4.2 Short-Term Future Developments

4.2.1 ATM Performance Indexes

Performance in ATM is very important for designing the ATM system since the purpose of ATM is safe and efficient movement of aircraft in the airspace. However, it is not clear what indicators should be used for evaluating the performance of ATM. In Europe, there is a body to look at the performance annually [6]. However, in Japan, the solid mechanism to comprehensively evaluate the performance of ATM is not established yet. The ENRI will start the study program on this subject from Fiscal 2007.

Fig. 7 ATM Performance Measures

4.2.2 ATM System's Dependence on Human Factors

Human operators are playing important roles in the current ATM system. In the long-term future, the role of human controllers might be changed by automation. And the part of the responsibility for separation assurance might be delegated to the cockpit aided by some assistance tools. Studies for the validation of the effectiveness and safety of the introduction of new technologies will be necessary.

The quantitative study on human reliability may be required for the safety analysis of airspace.

4.2.3 Application of data-link

Application of data-link such as automatic dependent surveillance-broadcast (ADS-B), airborne separation assistance system (ASAS) will enhance the surveillance performance significantly. ADS-B applications using SSR Mode S data-link is our concerns. The down-linked information may be available for enhancing ATC function such as short-term conflict alert. In addition, ADS-B down-linked information can be used for situation awareness of general aviation (GA). The ENRI is planning to start the study program on this subject from Fiscal 2007.

2.2.4 Other R & D Plans

Other R & D programs similar to those listed in Chapter 3 will be continued during the short-term future. Among those, the weight of the safety studies seems to be increasing in response to the request of the ICAO Annex 11 (para.2.26 (ATS safety management)) [5].

5. Summary

This paper introduced the present status of air traffic management in Japan. Then, the research and developments in ATM carried out at the ENRI, as a representative research institute of Japanese ATM, are summarized. Finally, some comments on future R& D in Japan are described briefly.

[Note] The contents of this paper reflect the views of the author and do not necessarily reflect the views of the ENRI or JCAB.

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