ENRI's R&D Long-term Vision

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Abstract: In Japan, the Electronic Navigation Research Institute (ENRI) developed its long term research and development (R & D) roadmap in July 2008. It was developed taking into account the visions on the future ATM of ICAO, SESAR and NextGen, and conditions surrounding Japan. Reviewing those visions, ENRI assumed that the key component of the future ATM will be 4-dimentional trajectory based operation. This paper is an English version of ENRI's long term vision and its R & D roadmap.
Keywords: Air Traffic Management, Long-term vision, Trajectory

1. INTRODUCTION

Since its establishment in 1967, the Electronic Navigation Research Institute (ENRI) has been playing a pioneering role in research and development (R & D) for electronic navigation (navigation using electronic technology) in Japan. ENRI became a government affiliated independent administrative (research) institution in 2001. In its second 5-year plan starting in 2006, ENRI has identified its position as the Japanese core research institute for air traffic management (ATM) supporting the aviation administration from a technical point of view. At present, ATM related studies have become the mainstream of its work.

R & D to satisfy the needs of the aviation administration and society is essential. However, it is also necessary for ENRI, which is expected to publicize its research results globally to the aviation world, not only to play a supplementary role of the administration but also to establish the long-term R & D directions shared by its researchers. Taking into account the world wide research trends and the current state of aviation industries and administration, it is recognized that we need further development of safe, efficient and economic ATM systems.

A main stream in the future research is "Trajectory Management". In Japan, where railroad transportation is highly networked and other modes of transportation are equally competing, it is essential for our air transportation that future ATM should provide "smooth and efficient services without delays" from passenger's convenience point of view. Our long-term vision is composed of indispensable research subjects to the realization of theses basic requirements of ATM.

2. HISTORY

A drafting committee, chaired by Director of Research Planning and Management, was established in July 2007 for the purpose of developing an ENRI's long-term vision that is appropriate for international trends and social needs. Recently, the committee has developed a roadmap for ENRI's future R & D.

Prior to drafting ENRI's long-term vision, the committee scrutinized the trends in R& D of ATM systems in the United States and Europe[1,2,3]. Moreover, the committee continued discussion with reference to the global operational concept of ATM of the International Civil Aviation Organization (ICAO) [5], the visions of future ATM of SESAR (Single European Sky ATM Research) [6], of U.S. NextGen (Next Generation Air Transportation System)[7], and JCAB's CARATS (Comprehensive Assessment on and Restructure of the Air Traffic Services) [4] and [8].

3. CONCEPT OF DEVELOPMENT

According to the definition of the ICAO Global ATM Operational Concept document [5], ATM is

"the dynamic, integrated management of air traffic and airspace - safely, economically and efficiently - through the provision of facilities and seamless services in collaboration with all parties".

The ultimate goal of ATM is to manage flights, such that their real trajectories come close to the intended ones. Intended trajectories are trajectories that are expected by the concerned parties. However, because expectations about trajectories change with time, for example due to weather conditions, a dynamic management of flights is required. That is to say, there are the following problems in the operation of ATM:

(a) Is the proposed trajectory suitable to the expectation of all users? (Collaborative decision making and dynamic management)

(b) How to bring it close to a suitable trajectory? (Problem of estimation and control)

As to the long-term vision, the committee decided to develop a roadmap from the current R & D projects to those which would realize the trajectory management (trajectory based air traffic management). For its realization of trajectory management, it is well known that the communications infrastructure and prediction techniques of air traffic and weather forecast techniques are prerequisite.

4. FUTURE IMAGES

SESAR is designed for the year 2020 and NextGen for the year 2025. We have developed the R& D roadmap towards the year 2020 taking into account the following assumptions:

(1) The future vision described in the ICAO Global ATM Operational Concept will be realized in 2025.

(2) Around the target years, the vision should be realized in our country. To realize this, the associated R&D must be completed 5 years before the target year.

The committee worked to develop an R & D roadmap which indicates the way ENRI should follow for realizing the ATM system as shown in Figure 1.

Figure 1 Concept of the ICAO Global ATM Operations

5. ENRI'S R & D LONG-TERM VISION

As an expression of the above long-term vision, a roadmap has been made. In developing the roadmap, major domains of R & D were identified. The R & D subjects corresponding to the domains were allocated in appropriate places in the roadmap.

The following important domains are developed:

(1) ATM performance analysis for the bottleneck identification and efficiency improvement

(2) Functional airspace configuration and trajectory management

(3) Information and communications infrastructure for collaborative decision making

(4) Advanced operations of Airport/Airport surface

(5) Highly accurate, reliable, and flexible navigation technology.

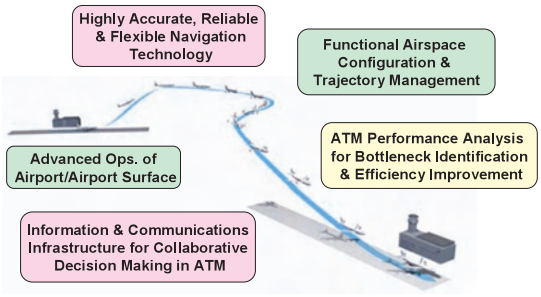

Figure 2 Identified Major Domains

The explicit research subjects are classified in Table 1, described separately for a short term, mid term, and a long term horizon. Subjects are described by purpose oriented expressions. In actual R & D processes, we need to deal with concrete methodologies. More detailed explanations of each R & D subject are shown in the Appendix.

In addition to those mentioned above, there are some research subjects to be continued though those do not belong to the major domain. These subjects are, for instance:

(a) measurement techniques of mental and body conditions such as fatigue of operators, e.g., pilots and air traffic controllers, which are important for ensuring safety.

(b) antenna characteristics

(c) performance maintenance and management of legacy system such as ILS

(d) development of various support systems for safety and efficiency enhancement such as obstacle detection and warning such as debris on the airport surface

(e) operational compatibility of the existing systems such as ACAS with trajectory based operation.

6. SUMMARY

A long-term vision from the present to the year around 2020 was developed through discussions in the committee. As a result, the main directions of future research subjects to be dealt with were identified. From now on, ENRI is planning to carry out its R & D programs from the long-term viewpoint.

However, the subjects to be dealt with depend strongly on the social circumstance surrounding ENRI. Therefore, continuous review and redirection processes are necessary. In defining concrete R&D subjects, it should take into account not only what we can do but also what is necessary and for what purposes based on the results of review process at that time.

There are some subjects not included in the long-term vision but are considered essential in producing fruitful results. For example, accurate wind (weather) prediction is essential for the trajectory management, however this

has not been pursued by ENRI in the past because it was beyond its terms of reference. To materialize the long-term vision, cooperation and partnerships with other organizations which have capabilities on such subjects may be needed. It is important for us to pursue the sharing of the ENRI's long-term R& D vision and its background, i.e., the image of the future air traffic and/or ATM with all parties concerned.

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Table 1 Roadmap of the Long Term Research and Development

	Short Term				Middle Term				Long Term			
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ATM Performance Analysis for Bottleneck Identification and Efficiency Improvement	ATM Performance Evaluation & Analysis								Performance Analysis of Trajectory Management (TM)			
	Air Traffic Controller Workload Analysis				Techniques for Reducing Human Errors				Safety Assurance taking into account HF			
Functional Airspace Configuration & Trajectory Management	Evaluation Method for Terminal Airspace				Functional Terminal Airspace Design				Strategic & Integrated Airspace Design & Operations			
	Oceanic Airspace Operational Procedures				Promoting Dynamical Routes Operation							
	RNAV Route Safety Assessment				Development of Safety Analysis Tools				Assessment & Improvement of Safety for Total Flight Phase			
	Development of Trajectory Model				Use of Trajectory Prediction Model				Operational Efficiency Improvement by TM in High Density Airspace			
Information and communications infrastructure for collaborative decision making	Traffic Information (Info.) Exchange by Airborne Surveillance				Spacing Applications of Airborne Surveillance				Supplement of Trajectory Management (TM) by Airborne Surveillance			
	Dev. of Surveillance Data Link for ATCo				Flight Info. Exchange for TM							
	Aeronautical Tele-communications Network				Information (Info.) Management among Systems: SWIM							
	Evaluation of Air-ground High-speed Data Link Medium				Development (Dev.) of Aeronautical High-speed Communications Techniques							
			Methods of Surveillance Information Processing (Sensor fusion, Integration of associated Info. and TM)									
	Radio Environments & Interferences Issues (subjects common to each domain)											
Advanced operations of Airport/ Airport surface	Impl. of Multilateration for ATC Applications				Advanced Airport Operation by TM							
	Impl. of ASMGC				Dev. of Airport Surface Navigation				Use of CAT-IIIc GBAS			
Highly accurate, reliable, and flexible navigation technology	Actual Use of CAT-I GBAS				Use of CAT-II/III GBAS							
	Requirement Review for GNSS Curved Approach				GBAS Dynamic Approach Paths Provision for TM							
	Performance Improvement of MSAS & Its Use for Precision Approach				Advanced ABAS				Use of CAT-I ABAS			

ATCo: Air Traffic Controller
GBAS: Ground Based Augmentation System
TM: Trajectory Management
RNAV: Area Navigation
Impl.: Implementation
ASMGC: Advanced Surface Movement Guidance and Control system
ABAS: Aircraft Based Augmentation System
MSAS: MTSAT based Augmentation System
ATN: Aeronautical Tele-communications Network
SWIM: System Wide Information Network

Appendix Brief Explanation of Each Research Subject

Table 2-1 Outlines of Each Research Subjects (Short-term: S, Middle-term: M)

Term	Subject	Outline
S-M	ATM Performance Evaluation & Analysis	Develop methods for analyzing and measuring the ATM performance using operational data and a system for evaluation.
S	Air Traffic Controller Workload Analysis	Develop methods for visualization and measurement of air traffic controller's task to use in educational training.
S	Evaluation Methods for Terminal Airspace	Develop methods and an evaluation system for evaluating terminal airspace design and operations in terms of multiple indexes
S	Oceanic Airspace Operational Procedures	Develop methods and an evaluation system for designing more flexible routes (such as UPR (User Preferred Route)) to improve operational efficiency of oceanic airspace
S	RNAV Route Safety Assessment	Develop safety assessment methods for implementation and continuous operation of RNAV routes.
S-M	Development of Trajectory Model	Develop a model for predicting aircraft trajectories and evaluate it using actual flight data
S	Traffic Information Exchange by Airborne Surveillance	Study and evaluate the methods for improving the air traffic situational awareness of flight crews with airborne surveillance.
S	Development of Surveillance Data Link for Air Traffic Controllers	Develop a surveillance data link for the future ground surveillance applications including the trajectory management.
S	Aeronautical Tele-communications Network: ATN	Carry out an evaluation experiment to validate the inter-operability between ATN and IP networks.
S	Evaluation of Air-Ground High -speed Data Link Medium	Develop a basic evaluation tool of L-band air-ground data link system (LDACS), which is a candidate of international standards, and evaluate the issues such as interference problems.
S	Implementation of Multilateration for ATC Applications	Implement a surveillance system for air traffic control which provides high update rate of surveillance data, keeping compatibility with current surveillance systems and without contaminating signal environments.
S	Implementation of ASMGCS	Implement the functions for airport surface control system to reduce the taxiing time.
S	Actual Use of CAT-I GBAS	Develop a prototype GBAS and carry out safety analyses which are necessary for the realization of CAT-I approach.
S-M	Requirements Review for GNSS Curved Approach	Develop guidance procedures of curved approach paths and aim at an early implementation of curved precision approach procedure which is impossible with ILS.
S	Performance Improvement of MSAS and Its Use for Precision Approach	Improve the performance of MSAS and enable precision approach procedures based on it.

Table 2-2 Outline of Each Subjects (Middle-term)

Term	Subjects	Outline
M	Techniques for Reducing Human Errors	Develop a method for analyzing tasks of air traffic controllers in order to reduce human errors.
M	Functional Terminal Airspace Design	Develop methods for designing functional terminal airspace by introducing dynamic procedures.
M	Promoting Dynamic Routes Operation	Develop procedures for operating domestic routes dynamically according to operators' needs in order to improve operational efficiency.
M	Development of Safety Analysis Tools	Promote standardization of safety assessment methods for airspace and develop tools for making the analyses efficient.
S-M	Use of Trajectory Prediction Model	Develop methods for applications of trajectory prediction models into ATC support function and air traffic flow management.
M	Spacing Applications of Airborne Surveillance	Study and evaluate the airborne spacing applications to accomplish ATC direction or clearance with displayed traffic information by airborne

		surveillance.
M	Flight Information Exchange for Trajectory Management	Develop an information exchange system and data links for air traffic controllers in order to exchange FMS information and coordination requests between aircraft and ground stations.
M	Information Management among Systems: SWIM	Develop a method for realizing a System Wide Information Network (SWIM) necessary for effective collaborative decision making (CDM).
M-L	Development of Aeronautical High-speed Communication Techniques	Develop communication technology which enables high-speed information transfer and exchange in ATM.
M~L	Advanced Airport Operation by Trajectory Management	Develop an airport surface surveillance and ATC communication system and a ground-based ATC support system for the control of taxiing aircraft.
M	Development of Airport Surface Navigation	Develop an air-ground cooperative system for air traffic control, guidance and navigation in airport surface.
M	Use of CAT-□/□ GBAS	Aim at realization of high categories precision approach procedures based on GBAS.
S～M～L	GBAS Dynamic Approach Paths Provision for Trajectory Management	Study on procedures for designating variable approach paths according to aircraft.
M	Advancement of ABAS	Study on an airborne augmentation system using GPS satellites of which performance and functionality are advanced.

Table 2-3 Outlines of Each Subject (Long-term: L)

Term	Subject	Outline
M～L	Performance Analysis of Trajectory Management	Carry out the performance analysis of trajectory management.
L	Safety Assurance taking into account Human Factors	Improve safety by identifying requirements for developing systems taken into account human factors of air traffic controllers.
L	Strategic and Integrated Airspace Design and Operations	Develop procedures for strategic and integrated airspace design and operations based on trajectories.
L	Assessment and Improvement of Safety for Total Flight Phase	Develop methods of safety assessment for flight phases as a whole.
M～L	Operational Efficiency Improvement by Trajectory Management in High Density Airspace	Aim at the implementation of trajectory management in a high density airspace.
L	Supplement of Trajectory Management by Airborne Surveillance	Evaluate and study the applications of airborne surveillance necessary for supplementing the trajectory management.
L	Use of CAT-IIIc GBAS	Aim at the implementation of CAT-IIIc GBAS including surface movement guidance in non-visual conditions.
L	Use of CAT-I ABAS	Study an airborne augmentation system which enables CAT-I approach using GPS satellites with advanced function and performance.

Table 2-4 Outline of Subjects（Permanently:P）

Term	Subject	Outline
P	Methods of Surveillance Information Processing (Sensor fusion, Integration of associated information, and trajectory management)	Develop a method for integrating various surveillance sensors such as SSR, WAM (Wide Area Multilateration) and ADS-B for the implementation of a surveillance system which meets the surveillance performance requirements for trajectory management applications.
P	Radio Environments and Interferences Issues (subjects common to each domain)	Develop the monitoring and controlling method for radio signal environment to establish the smooth cooperation among new and old systems with sharing their radio spectrum, and to resolve various interference issues.