CARATS
Collaborative Actions for Renovation of Air Traffic Systems

2010

Long-term Vision for the Future Air Traffic Systems

~ Changes to Intelligent Air Traffic Systems ~

Study Group for the Future Air Traffic Systems

Introduction

Japan is now facing the harsh realities of population decrease, declining birthrate, and aging population. The environment surrounding the country's international economic and social activities is changing dramatically and becoming more complex: neighboring Asian states are enjoying rapid economic growth, and globalization is progressing. On the other hand, measures to counter global warming are attracting worldwide attention, and Japan is determined to positively address this issue.

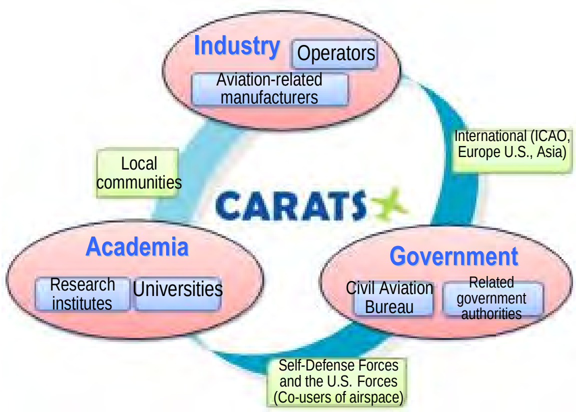
With this background, Japan needs to draw up and carry out a growth strategy, capitalizing on its strengths in order to sustain its economic growth and enhance its international position.

Aviation service is a fundamental economic and social infrastructure that allows more people and goods to move more freely and efficiently than ever, and supports Japan's growth strategy for economic and social progress and for enhancing the national living standard. It is becoming increasingly important to increase the quantity of domestic and international air service while improving its convenience and environmental friendliness.

To achieve this, in addition to improving the infrastructure, it is necessary to increase the air traffic capacity of congested airports and airspace over the Greater Tokyo Metropolitan Area and other areas, and to ensure efficient flight operations for all possible needs. However, there are various problems with the current air traffic systems[1] such as the concentration of traffic flows in certain airspace and routes arising from partially flexible use of airspace and routes. It is therefore necessary to reform Japan's air traffic systems decisively and strategically for the future.

In view of these issues, it was considered necessary to draw up a long-term vision in coordination with parties concerned, taking into account the uniqueness of air traffic in Japan and accurately grasping the needs of users and communities, intentions of operators, and technical trends in the ground systems as well as in the airborne. Therefore, a study group consisting of representatives from industry, academia and government, including academic experts, operators, research institutes and the Civil Aviation Bureau was set up and has been carrying out necessary studies.

The study group held a number of discussions and considered from various angles how the air traffic systems should be in future, taking global trends into account, and has finally compiled this "Long-term Vision for the Future Air Traffic Systems," which was named "CARATS: Collaborative Actions for Renovation of Air Traffic Systems" since it requires the following collaborative works with various aviation stakeholders:



(a) Collaboration among industry, academia and government
(b) Collaboration between operators and Air Navigation Service Provider (ANSP)
(c) International collaboration to realize seamless air traffic operations
(d) Collaboration among co-users of airspace (Civil, Japan Self-Defense Forces, US Forces)
(e) Collaboration with local communities

[1] The air traffic systems covered by this study group refer to air traffic management conducted to ensure safe, efficient and smooth air traffic, as well as the aircraft equipment, and ground- and satellite-based facilities required for this purpose. Among these, ground- and satellite-based facilities are called "aeronautical navigation facilities."

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Chapter 1　Basic Approach to Establishing the Future Air Traffic Systems

1. History of Improvements to the Air Traffic Systems in Japan

In the late 50's, the air traffic control that had been under the US Forces was gradually transferred to Japan and by 1959, Japan had regained control of most of its air traffic services. The arrival of the subsequent period of high economic growth ushered an age of mass rapid transit, and the modernization of aeronautical navigation facilities including introduction of air route surveillance radar and airport surveillance radar started in order to cope with the increasing volume of air traffic, introduction of jet aircraft, and enhanced performance of aircraft.

In the late 60's and the early 70's, a number of aircraft accidents such as the Shizukuishi accident occurred in succession. To ensure aviation safety, modernization of air traffic control procedure and aeronautical navigation facilities were accelerated, and data processing system was introduced to assist air traffic control. As aeronautical demand increased in line with the expanding global economy and globalization, aeronautical navigation facilities and air traffic control data processing systems were deployed on a national scale.

In the 90's, since air traffic control capacity of Japanese airspace including oceanic airspace was expected to reach its limit due to the technical limitations of traditional ground-based aeronautical navigation facilities, the development of future air traffic systems centered on an aeronautical satellite system was proposed in Advisory Report No 23 in 1994 by the Council for Civil Aviation in line with "Future Air Navigation System (FANS) Concept," drawn up by the International Civil Aviation Organization (ICAO).

Since then, the aeronautical satellite system, Air Traffic Management (ATM), Area Navigation (RNAV), etc. have been introduced.

2. Need to Renovate the Air Traffic Systems

Amid an anticipated global increase in air traffic demand, especially in the Asia-Pacific region, Japan expects air traffic volume to increase in the long term with the improvement of hub airports in metropolitan areas, economic progress of neighboring states and promotion of tourism-based country. By 2027, the demand is expected to rise to 1.5 times[2] of that in 2005. It is also necessary to address the diversifying needs of aircraft operators and users as well as global environment issues.

With the acceleration of economic and social activities as well as globalization, air services are indispensable as part of the growth strategy for the Japanese economy which includes promotion of tourism-based country, reinforcement of international competitiveness, regional revitalization, and improvement of national living standards. The air traffic systems are becoming increasingly important as the foundation of aviation services.

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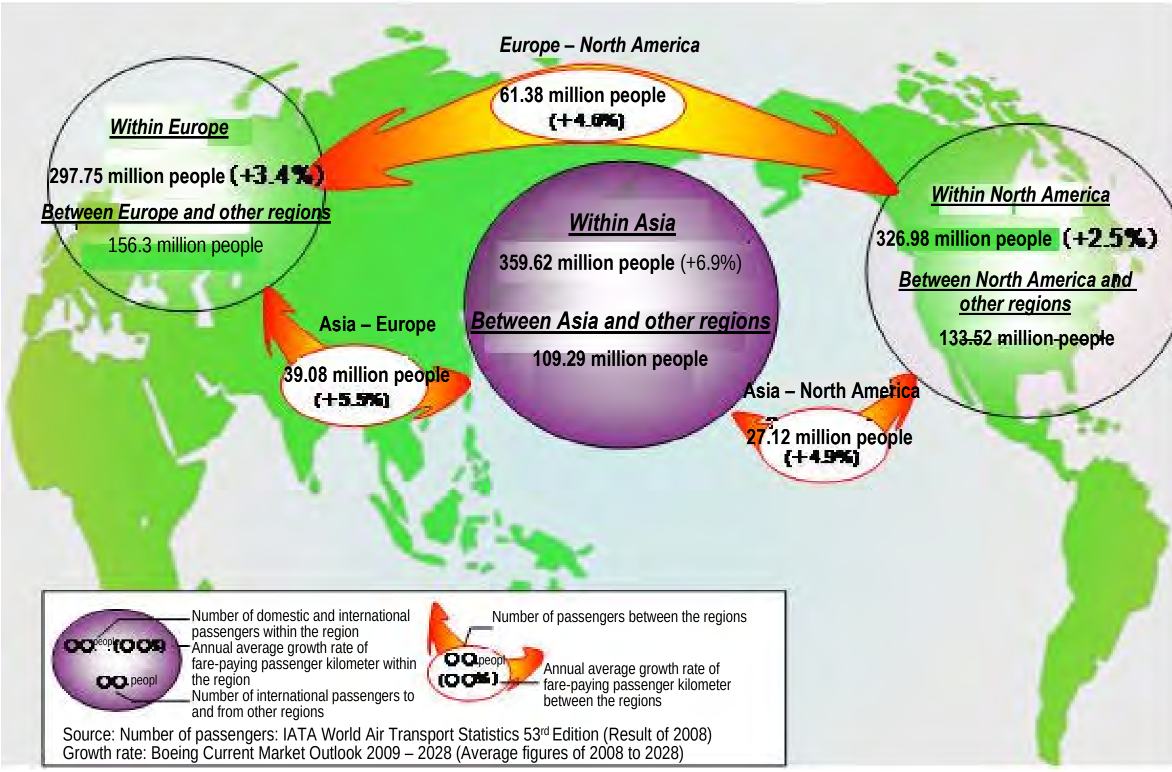
[2] Source: Materials of Aviation Subcommittee of Council for Transport Policy in 2007



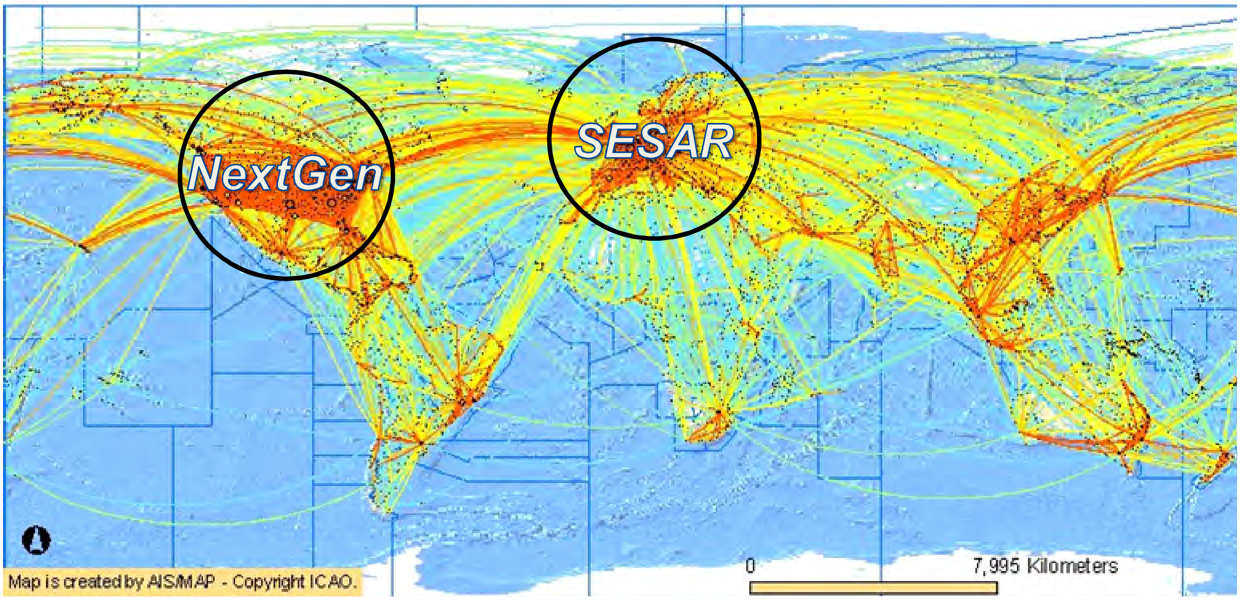
Predicted Demand of International Air Traffic Volume

(The growth rate within Asia is higher than that within North America and within Europe, and the growth rate between Asia and North America and between Asia and Europe is higher than that between North America and Europe.)

However, under the current air traffic systems, various issues have been emerging. These include insufficient air traffic control capacity against requests for increasing air traffic volume at airports and airspace, delays, constraints on efficient operation of aircraft due to limited flexible use of airspaces and routes, increased burden on controllers and pilots, and troubles arising from human errors.

It is therefore necessary to renovate the air traffic systems to contribute to the growth strategy by coping with the increase in air traffic volume and diversifying needs, and providing efficient aviation services.

Looking at international trends, Global ATM Operational Concept, the fundamental direction of globally harmonized air traffic management (ATM) targeting 2025 and beyond, has been developed by ICAO, in order to ensure the safe and efficient operation of aircraft in the future. In the U.S. and Europe, long-term visions to meet regional needs have been formulated based upon the ICAO Global ATM Operational Concept (NextGen in the U.S., SESAR in Europe). To realize seamless air traffic in the Asia-Pacific region where demand is expected to increase rapidly, it is necessary to establish future air traffic systems in collaboration with the U.S., Europe and other states, while securing international interoperability.



International trends of long-term plans for air traffic systems
(A long-term plan has not been formulated in the Asia-Pacific region.)

◎ Global ATM Operation Concept (ICAO)

A vision that defines how ATM is to be operated in the future to attain objectives such as the safety and efficiency of air traffic and compatibility with environmental issues. It indicates the direction for managing flight trajectory, etc. throughout all phases of flight to meet the requests of an operator for a flight trajectory wherever possible.

○ NextGen (Next Generation Air Transportation System)

A comprehensive vision for the next generation of air traffic systems targeting the year 2025. It embraces not only purposes such as dealing with air traffic demand and environmental issues, but also objectives specific to the U.S., such as national security against terrorist threats and retaining leadership such as promoting global standardization and so on. The vision is being jointly promoted as a national project by national organizations.

○ SESAR (Single European Sky ATM Research)

A modernization program for a new generation of ATM system for the year 2020.
It aims to provide consistent air traffic control services in order to create a Single European Sky across Europe, where a number of states and air navigation service providers exist.

In renovating the air traffic systems of Japan, it is important to take into account the following characteristics in terms of the actual operational situation, operational environment and needs of air traffic in Japan, compared with those in other states such as the U.S. and European states.

[Characteristics of air traffic of Japan]

(a) Air traffic is concentrated in the airports and airspace of the Greater Tokyo Metropolitan Area, which has a number of restrictions on operations and where air traffic control capacity needs to be expanded urgently.

(b) To remain competitive with other forms of mass transportation, a high level of convenience in aviation is required in terms of punctuality, speed of transport, etc. as the Shinkansen (Bullet Train) and other means of high-speed transportation are well developed.

(c) Since many airports are located near mountainous terrain or urban areas, there are restrictions on setting departure and approach routes. Furthermore, because there are large areas of oceanic airspace, remote islands, and mountainous areas, the coverage of radio waves for ground-based communication, navigation and surveillance is limited.

(d) Since there are many training airspaces of the Self-Defense Forces of Japan and the Armed Forces of the U.S., more flexible use of airspace is desired.

(e) The Japanese FIR (Flight Information Regions) borders a number of FIRs having various operating environments. Seamless operation is not fully implemented across such borders, with some routes not set up with consistent conditions.

(f) There are many overflights between North America and Asia and the number is expected to increase rapidly.

(g) Heavy aircraft account for a higher proportion of total aircraft handled in Japan than in other states. (Composition of aircraft types may change due to the operator’s responses to the increase of capacity in metropolitan airports and diversifying needs in the future.)

3. Need to Formulate a Long-term Vision

In establishing the future air traffic systems, we must draw up a long-term vision that parties concerned can systematically work on in close cooperation for the following reasons:

(a) The future air traffic systems must be established systematically, as it takes a large scale of project and a long time.

(b) Not only implementation of ground facilities but also equipping of aircraft is required, and integrated operations among parties are getting more important in the future. Therefore, ANSP as well as operators, manufacturers and research institutes must share a common recognition of the future direction and collaborate with each other.

(c) The air and the ground system as well as the satellite system must be considered and introduced systematically, taking into account the future technical trend of these systems.

(d) Coordination and collaboration with other states and organizations are necessary, taking into account the trends in the U.S., Europe and other states.

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Chapter 2　Objectives of the Future Air Traffic Systems

1. Objectives of the Future Air Traffic Systems

In establishing the future air traffic systems, it is necessary to clarify the objectives, considering the needs of operators and aviation users, social and economic trends, etc. The year 2025 is the target year of this vision.

In setting objectives, we define specific numerical targets for the following items, taking into account the characteristics of air traffic, social situation, etc., in order to promote policies effectively, while verifying the attainment of objectives of the air traffic systems.

Item	Numerical target
Enhancing safety	Increase safety level by 5 times
Responding to the increase in air traffic volume	Double the air traffic control capacity in congested airspace
Improving user convenience	Improve service level (punctuality and reduction of flight time) by 10%
Increasing operational efficiency	Reduce fuel consumption per flight by 10%
Improving productivity of air traffic services	Improve productivity of air traffic services by 50% or more
Responding to environmental issues	Reduce CO_2 emissions per flight by 10%
Enhancing the international presence of Japan in the aviation field	(Qualitative target. The number of international conferences in Japan, international cooperation projects, etc may be the index.)

(1) Increasing Safety

Increasing safety is also a major prerequisite in establishing the future air traffic systems. Measures to prevent accidents are essential, because it may cause great social and economic losses including the loss of human life if an aviation disaster occurs. Particularly, serious incidents related to air traffic services[3] are attributable to human error and therefore effective measures to prevent human errors are required. It is also necessary to help prevent accidents arising from meteorological factor such as air turbulence by capitalizing on and sharing meteorological information. As small airplanes still account for a large proportion of aircraft accidents and there are increasing needs for small airplanes for disaster recovery services and transporting emergency patients, safety measures are needed, taking their operational characteristics into full consideration.

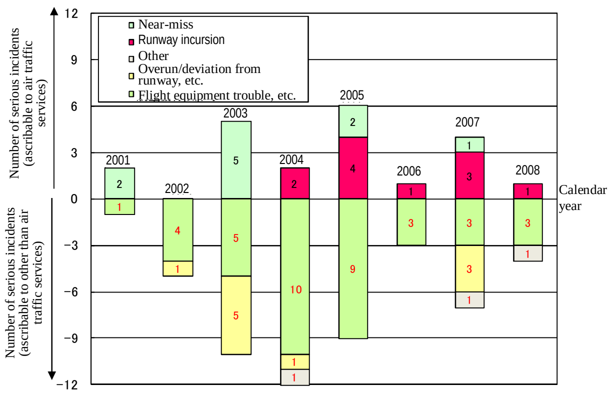
On the other hand, the air traffic systems are a key social infrastructure for aviation service, and a suspension of service would have a significant economic and social impact. Therefore, it is necessary to enhance our crisis management capability and ensure continuity of air traffic services in the event of a major disaster. Additionally, as there is increasing trend of interdependence among air traffic systems, the reliability of systems and maintenance of security are becoming increasingly more important.

[3] "Air traffic services" include services such as instructions on maintaining a safe separation between aircraft, collecting and providing information necessary for safe operation of an aircraft, improving and operating air navigation facilities, etc., which are provided to secure safe, orderly and efficient operation of aircraft.

Numerical Target
Increase safety by 5 times.

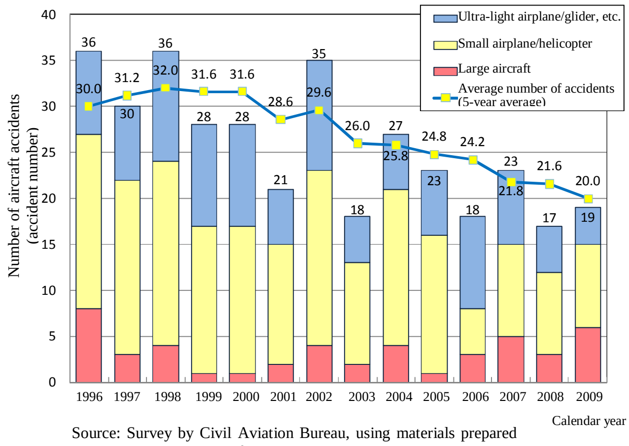
<Concept>

While air traffic volume is expected to increase by 1.5 times, the target is to reduce the number of aircraft accidents resulting from air traffic services such as collisions, near misses, and serious incidents almost to zero. As the probability of the occurrence of accidents increases in proportion to the square of air traffic volume, it is necessary to increase safety by 2.25 times (= 1.5 × 1.5 times) to maintain the number of accidents at the present level. We therefore aim to reduce the number of accidents at least by half, setting a numerical target of five-fold reduction (approximately 2.25 × 2) for enhanced safety in the air traffic systems.



Source: Survey by Civil Aviation Bureau, using materials, etc. prepared by Japan Transport Safety Board concerning the situation mentioned in Paragraph 4, Article 166 of the Enforcement Regulations of the Civil Aeronautics Act (materials published since 2001).

Transition of Number of Serious Incidents
(Serious incidents ascribable to air traffic services include near misses and runway incursion. There has been a succession of runways incursions in recent years.)



Source: Survey by Civil Aviation Bureau, using materials prepared by the Japan Transport Safety Board.

Transition of the number of aircraft accidents
(The number of accidents of small airplanes is still high.)

(2) Responding to the Increase in Air Traffic Volume

As a result of improvements to hub airports in the greater metropolitan areas, economic development of Asian countries, and promotion of tourism-based country, air traffic volume is expected to grow in the long run and so Japan's air traffic capacity as a whole needs to be increased. In particular, bottlenecks at congested airports and airspace in the Greater Tokyo Metropolitan area and other areas must be resolved, and air traffic control capacity should be expanded by using new technology. It is also necessary to deal with the significant increase in international air traffic volume including overflights.

Numerical Target
Double the air traffic control capacity in congested airspace.

<Concept>

Since total air traffic volume is expected to increase by 1.5 times, it is important to eliminate bottlenecks in congested airspace. This will require air traffic control capacity sufficient to handle approximately double the existing air traffic volume in congested airspace. It is necessary to improve airport facilities and other necessary infrastructure and to take environmental countermeasures as well.

Aircraft waiting in line for take-off and aircraft concentrated in the Metropolitan airspace(radar display image)

(3) Improving User Convenience

Air transport in Japan must compete with other means of transportation such as the Bullet Train, and also be highly convenient due to the national character of Japanese people. Although punctuality in air transport is already excellent, it is necessary to continuously address such needs and to enhance the convenience of air transport.

Whereas other means of transportation are becoming progressively faster, the flight time from departure to arrival is becoming longer due to the increase in air traffic volume, so it is necessary to enhance speed, which is the main characteristic of air transportation, in addition to enhancing traditional punctuality and serviceability.

Numerical Target
Improve service level (punctuality, serviceability and reduction of flight time) by 10%.

<Concept>

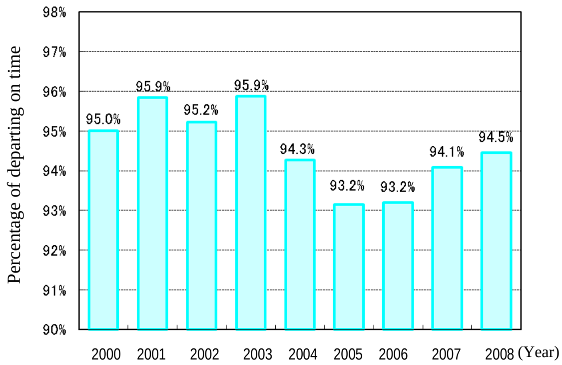
Improve the service level of the air traffic systems such as punctuality and rapidness by 10% as a whole, while coping with the increase in air traffic volume.

Unit: hours and minutes

	April 1, 2003	April 1, 2005	April 1, 2009
Haneda – Shin Chitose	1:30	1:30	1:33
Haneda – Osaka	1:00	1:01	1:05
Haneda – Fukuoka	1:42	1:42	1:45

From time-table

Trend in flight time on major trunk routes
(Flight time has trended to increase on trunk routes to and from Haneda Airport in recent years)



Source: Materials prepared by Civil Aviation Bureau

Trend of percentage of flights that departed on time among all departing flights (percentage of punctual departure)
(Percentage of punctual departure is roughly 93%, higher than in the U.S. (77%) and Europe (78%), yet greater punctuality is required, since the Bullet Train and other fast transportation means are well developed in Japan.)

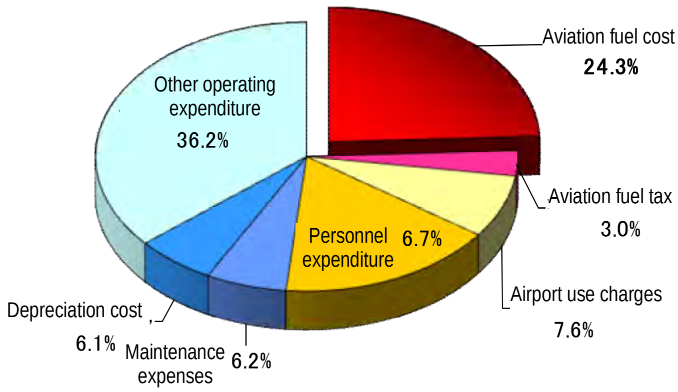
(4) Increasing Operational Efficiency

As the price of fuel oil remains high and the environment around aviation industry is becoming increasingly competitive, operators must strive to enhance operational efficiency. Therefore, measures are needed to reduce operational costs in the fields of the air traffic systems. As fuel costs account for a substantial percentage of the cost of operators, they must take measures for reducing fuel consumption. Enhanced operational efficiency leads to the maintenance and the expansion of air route networks by reducing costs.

Numerical Target
Reduce fuel consumption per flight by 10%.

<Concept>

Reduce fuel consumption per flight[4] by 10% through an advanced air traffic systems such as the introduction of Continuous Descent Operations (CDO) procedure, which makes it possible to descend without leveling in the descent phase of flight, resulting in a more fuel efficient operation.



Source: Average of major airlines in Japan in 2007
(summarized from financial statement of the companies concerned)

Cost composition of Japanese airline companies

(5) Improving Productivity of Air Traffic Services

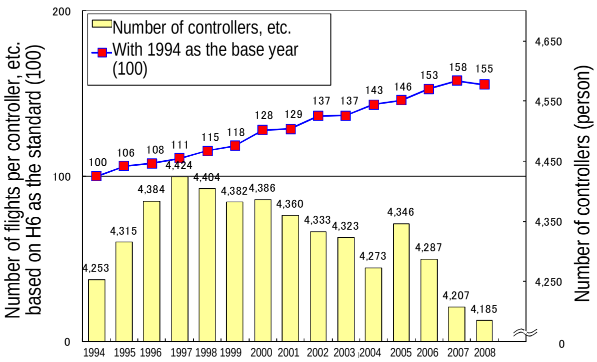
The productivity of air traffic services has been improved by enhancing the performance of aeronautical navigation facilities, and by systemization and integration of services and other means. Nevertheless, service productivity must be increased further to cope with the expected increase in air traffic volume amid limited resources. Facilities and air traffic services must be improved to meet demand and need.

Numerical Target
Improve productivity of air traffic services by 50% or more.

<Concept>

Despite limited resources, we will improve the productivity of air traffic services by 50% or more to cope with the 1.5-fold increase in air traffic volume, while enhancing safety and service levels at the same time.

[4] "Per flight" means "per great circle distance" (the shortest distance from departing airport to destination airport along the ground surface).



Controllers, etc. mean air traffic controllers, air traffic services flight information officers and air traffic services engineering officers.
Source: 2008 Policy Revue Evaluation Data

Transition of the number of controllers and operational workforce and number of flights per operational personnel
(Number of flights per controller = Total number of international and domestic flights and overflights ÷ Total

(6) Responding to environmental issues

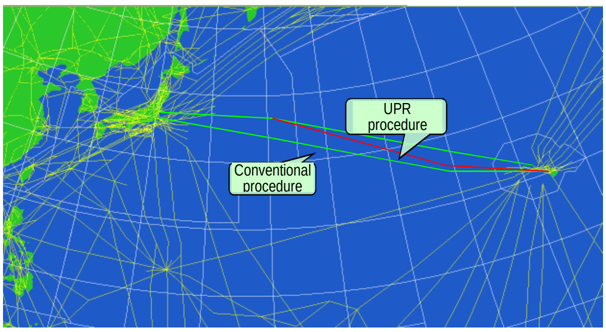
Combating global warming is a worldwide issue. Although CO_2 emissions from the aviation sector are insignificant compared with the total emissions of Japan, air traffic volume is expected to increase, so CO_2 emissions need to be reduced by upgrading the air traffic systems.

Measures against aircraft noise remain an important issue and a positive attitude to this issue is required with understanding and collaboration from local communities.

Numerical Target
Reduce CO_2 emissions per flight by 10%.

<Concept>

Reduce CO_2 emissions per flight by 10% by an advanced air traffic systems including the introduction of User Preferred Route (UPR) procedure. In addition to reducing CO_2 emissions through efficient air traffic operations, the goal is to reduce CO_2 emissions by reducing electricity consumption in aeronautical navigation facilities.



Introduction of UPR
(In some oceanic airspaces, operators are trying the procedure of flying optional routes taking into consideration operating airframe, operating time, weather forecast, etc. These are expected to reduce fuel consumption and CO_2 emissions)

(7) Enhancing the International Presence of Japan in the Aviation Field

In order to realize safe and smooth air traffic in the Asia-Pacific region where the air traffic volume is expected to significantly increase and to cope with global environmental issues, it is increasingly important to strengthen cooperation with other countries. One example of such cooperation is to achieve “seamless sky” by securing continuity of air traffic service and consistency of services with neighboring FIRs. To that end, international collaboration is needed to enhance the air traffic systems of the whole region, by dispatching experts, holding seminars, etc.

To promote the global deployment of Japan's aviation industry, it is necessary to appeal its superiority and to actively participate in international standardization work through collaboration among industry, academia and government.

The 46th Conference of the Director General of Civil Aviation in the Asia-Pacific region (at Kansai)
(The Conference confirmed that it should start considering the future air traffic systems of the Asia-Pacific region to create seamless skies.)

Technical assistance provided by Japan in the Philippines
(Developing the next-generation air navigation system)

2. Examples of Setting Indexes

We will set indexes to evaluate the achievement of numerical targets, as shown by the examples below.

Objective	Set up indexes (Example)
Increasing safety [Increasing safety by 5 times]	(a) Number of accidents due to air traffic services and serious incidents per number of flights
	(b) Number of RA (Resolution Advisory) by TCAS (Traffic Alert and Collision Avoidance System) per number of flights
	[Qualitative evaluation]
	(a) Improvement of IFR environment suited to small airplanes
	(b) Implementation of measures against human errors
	(c) Comparison of safety of countries
Coping with the increase in air traffic volume [Double the air traffic control capacity]	(a) Number of flights handled per unit time in peak hours in congested airspace
	(b) Number of flights in Japan (international flights, domestic flights and overflight)
	(c) Average ATFM delay per aircraft
	(d) Sufficiency ratio (percentage of flights satisfying conditions of no ATFM delay among all flights)
Improving convenience [Improving service level by 10%] (punctuality, service rate and speed of transport)	[Punctuality]
	(a) Percentage of flights whose arrival or departure is delayed by 15 minutes or more among all flights
	(b) Average delay in arrival or departure
	(c) Percentage of cancelled flights due to meteorological conditions of the airports
	[Rapidness]
	(d) Operational time from departure to arrival on major routes (taxiing time + flight time)
Increasing efficiency of operation [Reduce fuel consumption by 10%]	(a) Ratio of longer flight path expansion (Ratio of actual flight distance to minimum distance and ratio of actual flight distance to flight plan distance)
	(b) Rate of obtaining desired cruising altitude
	(c) Rate of implementing efficient descent procedures
	(d) Average taxiing time
	[Reference value]
	(a) Fuel consumption by aircraft type
Improving productivity of air traffic services [Improving efficiency by 50% or more]	(a) Number of flights per controller, etc.
	(b) Number of flights per unit ATM cost
Responding to environmental issues [Reduce CO_2 emissions by 10%]	(a) to (d) Same as indexes for increased efficiency of operation
	(e) Electricity consumption in air navigation facility, etc.
	[Qualitative evaluation]
	(a) Implementation of measures for reducing noise pollution
Enhancing the international presence of Japan in the aviation field	[Reference value]
	(a) Number of countries with which cooperative relations have been established concerning the future air traffic systems
	(b) Number of Japanese personnel working actively in international organizations involved in the future air traffic systems
	(c) Number of international conferences held in Japan
	(d) Number of working papers submitted to international conferences, etc.
	(e) Number of foreign trainees accepted
	[Qualitative evaluation]
	(a) Contribution made by Japan to establish future air traffic systems in the Asia-Pacific region

* The method of obtaining detailed data on each index and calculation method, etc. will be studied in detail later.

Chapter 3 Constraints in the Current Air Traffic Systems

1. Constraints in the Current Air Traffic Systems

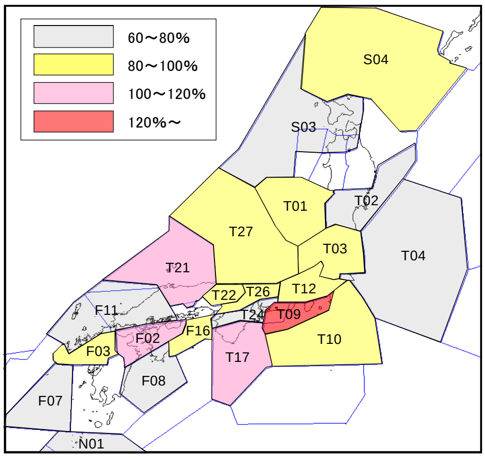
The Air Traffic Systems are composed of ATM (Air Traffic Management) and CNS (Communication, Navigation, and Surveillance) technologies which support ATM. There are the following issues and limitations in each field for attaining the objectives stated in Chapter 2.

(1) Operational Constraint in ATM

In the current air traffic systems, ATM is composed of three domains: Air Traffic Control (ATC), Air Traffic Flow Management (ATFM), and Air Space Management (ASM). ATM should comprehensively handle each domain in collaboration with the others. However, there are the following issues concerning ATM .

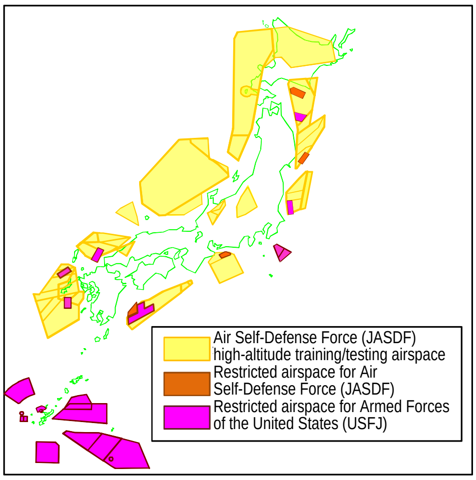
Constraint in Airspace-Based ATM Operation

In the current ATM system, which is based on Air Traffic Control of sectorized airspace and predetermined routes in principle, routes and sectors are operated flexibly corresponding to air traffic flow through airspace management, albeit with restrictions. Where the air traffic volume is likely to exceed the air traffic control capacity, ATM operation has coped by managing the flow of air traffic such as instructing ground delays or alternative routes. However, these procedures have limitations, and it is becoming increasingly difficult to maintain an efficient and orderly flow, due to the unavoidable concentration of traffic in specific airspaces and routes and continuous delays.



Workload per sector when traffic volume increased by 1.5 times
(result of simulation)
(ATC capacity is expected to be exceeded if air traffic volume increases.)

With Air Traffic Control conducted for each sectors by short-term route prediction based on information of present positions of aircraft, it is becoming difficult to fully optimize flight routes and flight times over the entire flight from departure to arrival. As the air traffic volume has increased, the number of flow control procedures and delays have risen year by year, making it difficult to ensure convenience for passengers and efficient operation of aircraft with the current method. Another issue is that meteorological information is not fully used for predicting air traffic volume and airspace capacity. Further, with flexible use of airspaces and flight routes being limited to specific sectors and/or airspaces, airspace cannot be fully used, which makes it hard to increase the air traffic control capacity.



High altitude training/testing airspace, restricted airspace
(More flexible use of airspace is required for efficient operation.)

Other constraints with ATM operation are that there is no system of international collaboration for ATM in international air routes, so it is impossible to create a seamless operation, and that there are few routes suitable for the operational capability of small airplanes.

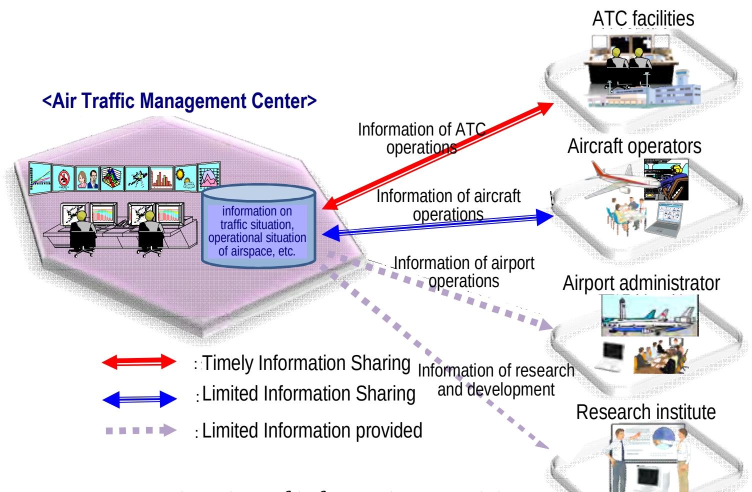
Constraint concerning Information management and usage which is based for ATM

In ATM operation, information-sharing among ATC facilities, aircraft operators, airport administrators, pilots, and other agents is most important. However, collaborative decision-making (CDM) is not fully implemented as required information is only partially shared in current circumstances.

Although both the controller and pilot possess effective information, such information is not fully utilized because the controller and pilot communicate mainly by voice and systematic coordination between ground and airborne is not sufficient. There is also a risk of human error such as a misunderstanding in ATC communication.

On the other hand, with regard to operation at airports, there are inadequate unified management of information on the accurate operational situation of spots, ground handling, airplane assignment, vehicle operation on the ground, and aircraft status before takeoff and after landing, resulting in congestion on the surface at congested airports.

Further, regarding evaluating the performance of ATM, because the accumulation of traffic data is limited, full analysis and evaluation of the data to improve ATM operations are not implemented.



Present situation of information provision
(At present, each of the parties uses only a limited part of the data they possess.)

(2) Technological Constraints of CNS

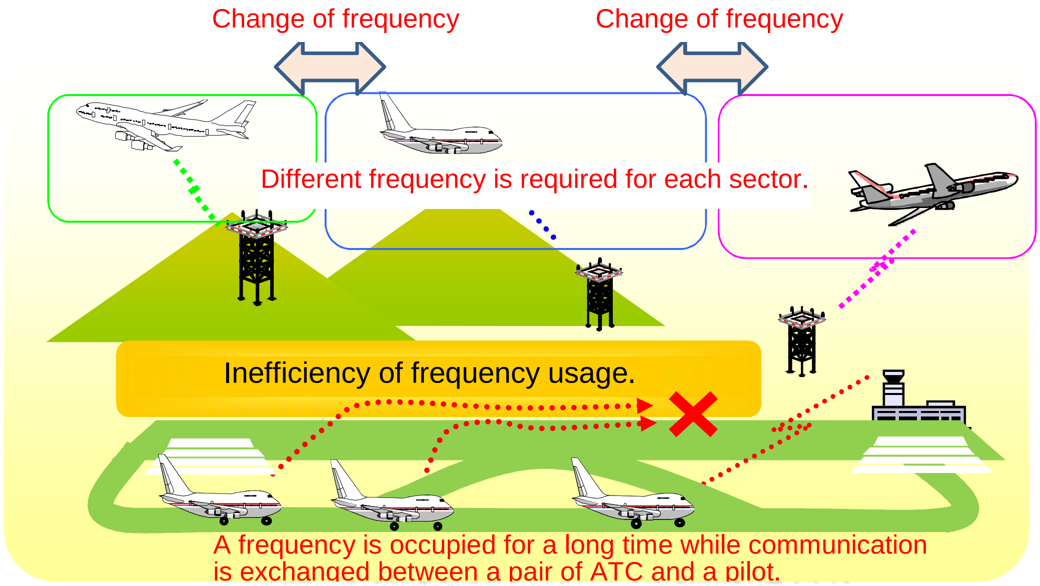
The fundamental technologies supporting ATM are: Communication, Navigation, Surveillance and data processing technologies.

Communication means technology by which mainly the controller and pilot exchange information and make themselves understood, and is conducted mainly by voice. Navigation means technology by which an aircraft detects its own position and operates. An aircraft flies, receiving radio waves from Navigation Aids (NAVAIDS) on the ground (VOR/DME, ILS, etc.). Surveillance means technology with which controllers detect the position of aircraft and conduct surveillance of an aircraft based on position information provided by airport surveillance radar or air route surveillance radar. Data processing means the technology with functions for assisting controllers, based on information of radar data, flight plan data, etc.

The issues with each of these technologies are shown below.

Constraints involved in communication technology

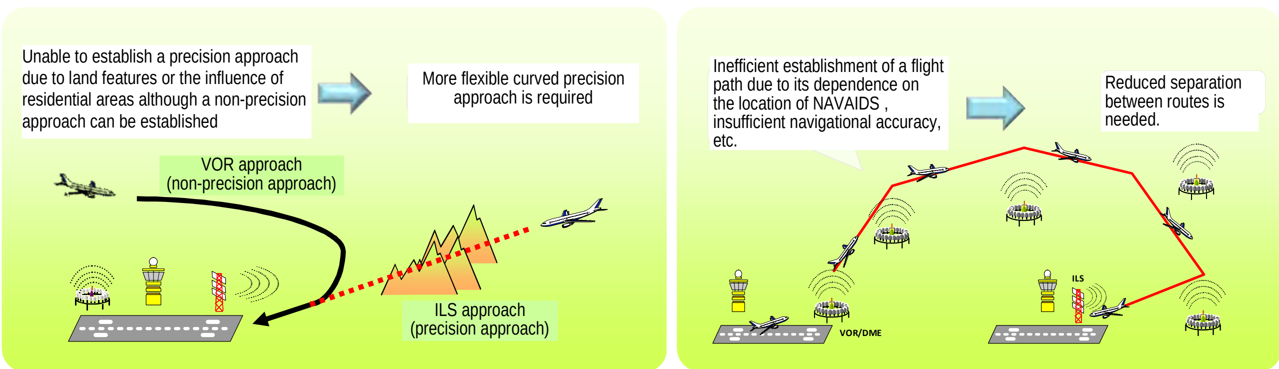
Communication between ground and air is mainly done verbally by radio. As traffic volume increases, communication becomes congested and exceeds communication capacity, increasing the risk of human errors such as misunderstanding in ATC communications. In voice communications, the inefficiency of frequency usage exist; a different frequency is required for each sector and while a controller communicates with a pilot, other pilots must wait. As there exists no media through which large quantities of information can be exchanged at high speed between an aircraft and a ground system, it is difficult to realize the high performance of air traffic control with current communication technology.



Constraints in voice communication between ground and air.

Constraints involved in navigation technology

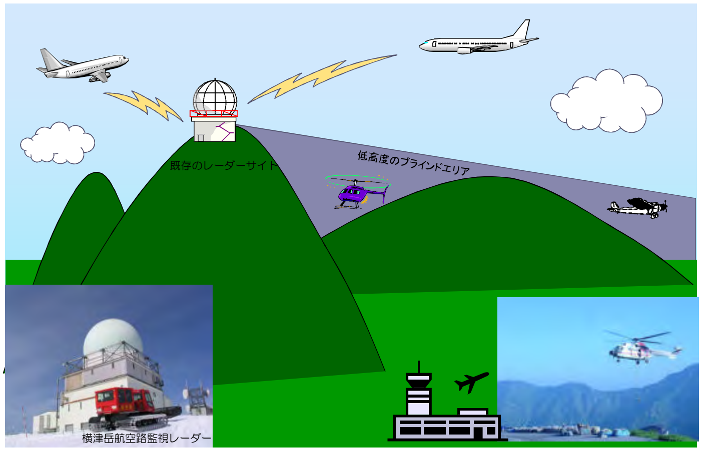
As existing en-route, arrival, and departure routes are established based on ground Navigation Aids (NAVAIDS) , the routes are not established flexibly and efficiently due to the locations of these ground NAVAIDS , their accuracy, and limited radio coverage. In particular, sometimes it is impossible to establish an efficient route or precision approach for a runway due to land features or the influence of residential areas near the airport.



Navigation dependent on ground NAVAIDS
(More flexible flight path desired)

Constraints involved in surveillance technology

Under the current surveillance system using radar, some areas such as low altitude areas, mountainous areas, and remote islands are not covered by radio waves and also the surveillance performance to monitor airport surfaces is generally not adequate. Also, it is not possible to obtain information needed for enhanced surveillance performance such as the setting status of avionics (selected altitude, etc.) and high-accuracy aircraft derived information (position, speed, turning rate, climb and descent rate, etc.).

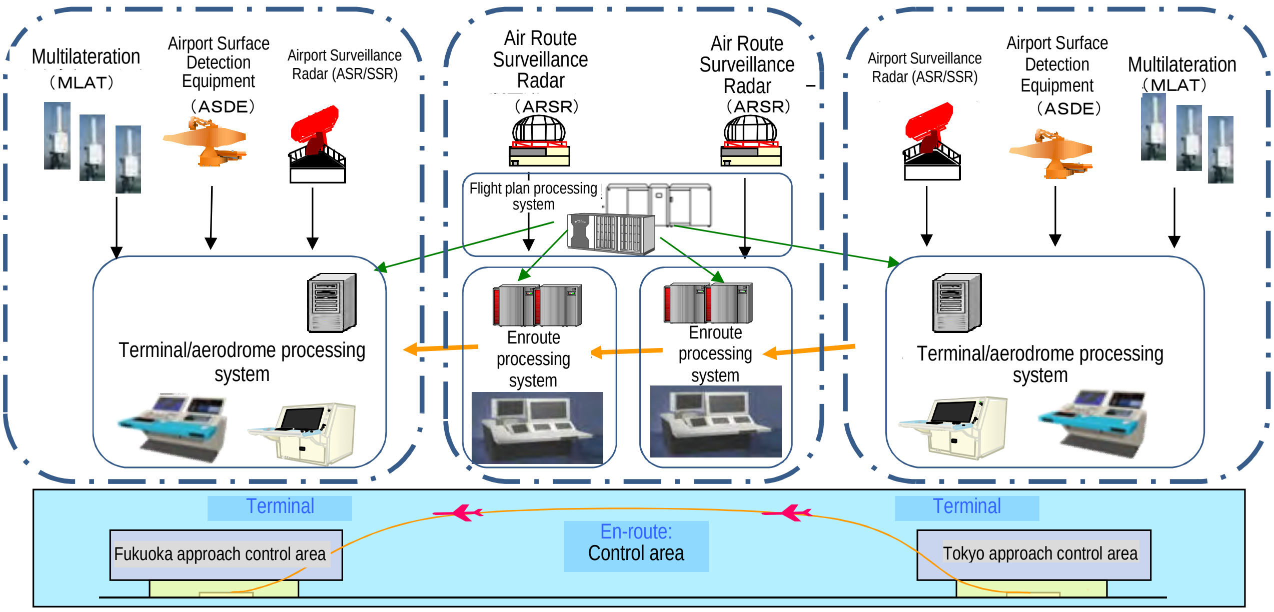


Area not covered by radio waves

Monitoring of the actual surrounding traffic situation by the pilot on the aircraft by visual means and by information from the controller may be inadequate.

Constraints involved in data processing technology

The current ATC data processing system, which is established individually for each flight phase such as departure, arrival, or en-route, is not managed on a fully integrated basis with associated systems. This makes it difficult to upgrade consistent ATC support functions from departure to arrival, standardize the human-machine interface, and recover the system quickly and consistently with associated systems when a system trouble occurs.



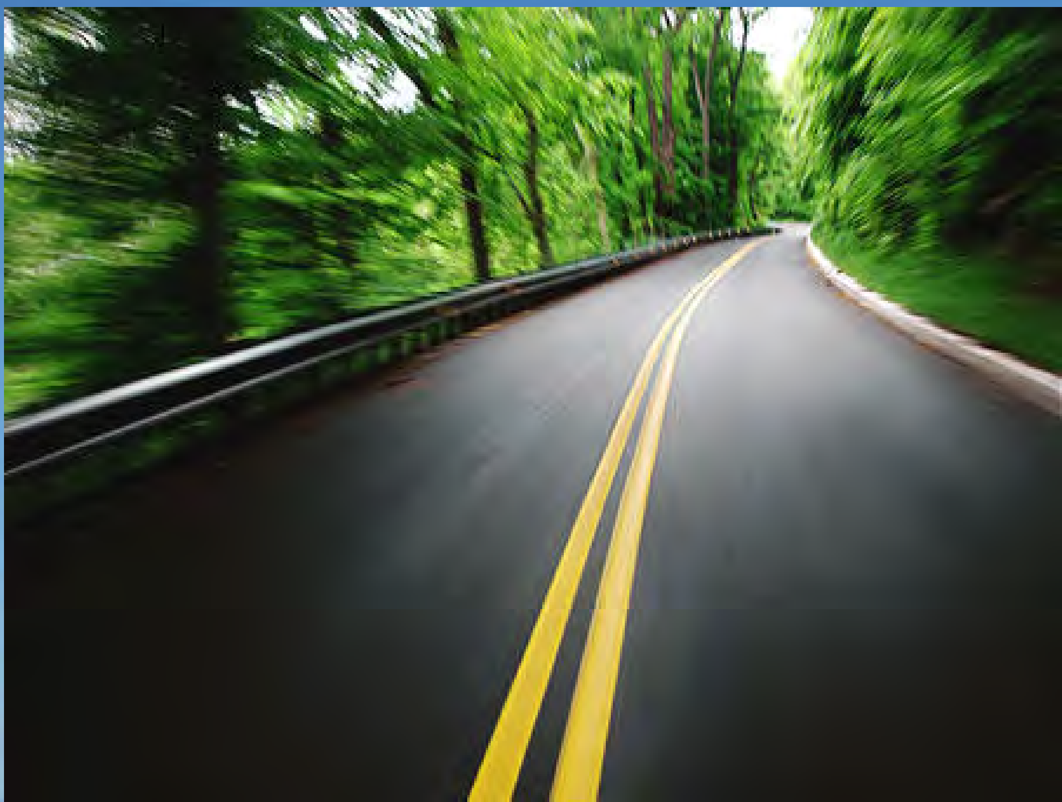
Concept of the current ATC data processing system
(The ATC data processing system has been established individually.)

2. Summary of Constraints

As described in this chapter, the constraints of the current air traffic systems are summarized as follows.

Classified items		Constraints
ATM	Airspace-based ATM operation	Concentration of air traffic flow into specific airspace and routes cannot be avoided and it is difficult to maintain an orderly and efficient flow.
		Due to air traffic control procedures for each airspace based on short-term expectation of demands, it is difficult to fully optimize entire flight paths from departure to arrival and reduce flying time.
		The number of flow controls and ground delays are increasing every year and it is becoming increasingly difficult to ensure convenience for passengers and efficiency of aircraft operation by the present procedures.
		Meteorological information is not fully used to predict air traffic volume and ATC capacities.
		Flexible use of airspaces and routes is limited to certain airspace, making it impossible to fully use airspace and preventing expansion of ATC capacities.
		Coordinated establishment of the ATM system is not implemented in international airways, hindering a seamless operation.
		Unable to establish routes that take into account the performance of General Aviation.
	Information as the basis for ATM	Only limited information is shared in a timely manner among the parties, so collaborative decision-making has been unsatisfactory.
		As information is exchanged between controller and pilot mainly by voice, there is a risk of human error such as a misunderstanding of communication in ATC service.
		Integrated management of information before take-off and after landing of aircraft such as accurate operation status at spots is not fully conducted.
		Due to limited accumulation of operation-related data, such data are not fully analyzed and evaluated in order to improve ATS systems.
CNS	Communication technology	In addition to inefficient utilization of frequencies, there is no media that allows high-speed exchange of large quantities of information between an aircraft and the ground-based system.
	Navigation technology	Routes cannot be efficiently established due to restricted location of Navigation Aids , accuracy of radio wave and radio coverage.
		At many runways, efficient routes and precision approach procedures cannot be established.
	Surveillance technology	Coverage of radar is limited.
		Surveillance performance on the airport surface is not sufficient.
		High-accuracy dynamic surveillance information of the aircraft cannot be obtained.
		Status of other aircraft cannot be fully detected in the cockpit .
	Data processing technology	The present ATC data processing system, which is established individually for each phase of flight, is not managed on a fully integrated basis with associated systems.

Chapter 4　Direction for Renovation of ATM Operational Concept and CNS Technology



1. Direction of Renovation

In the existing air traffic systems, there are various problems and limitations as described in Chapter 3 including airspace-based ATM operation with its increasing difficulty of maintaining an efficient and orderly air traffic flow, such as continuous delays caused by the concentration of traffic flow in specific airspaces and routes, and the inability to fully optimize entire flight routes from departure to arrival. It is difficult to solve such problems with basis on traditional solutions and approaches. Rather, it is necessary to dramatically change the traditional ATM operational concept and CNS technology in order to achieve the target of the future air traffic systems.

In renovating the ATM operational concept and CNS technology, we will focus on shifting to a strategic "trajectory-based ATM operation" from the traditional airspace-based ATM operation, minimizing operational restrictions and optimizing the performance of air traffic as a whole, while also realizing flexible and efficient flights.

(1) Realizing Trajectory-based Operation (TBO)

We will shift from the current ATM operation, which focuses on ATC based on airspace sectors and air traffic flow management by adjusting departure time, to ATM operation along 4-DT (4-Dimensional Trajectory), which considers the whole of our FIR as one airspace, manages the entire flight trajectory from departure to arrival of all aircraft concerned in an integrated manner, and introduces time-based management in all phases of flight. This operation allows the flexible flights desired by operators, while addressing policy issues such as increased air traffic capacity at congested airports, crowded airspace, and reduction of CO_2 emission by adjusting trajectories strategically and cooperatively prior to departure.

Specifically, coordinated adjustment based on the needs of an operator will start at an early stage such as when setting schedules, between the operator and ANSP along the route, altitude, speed and time of arrival on the trajectory of the flight plan. The trajectory will be updated continually as information on the status of use of airspace and meteorological forecasts becomes known, until immediately before the departure, thus attaining an optimum trajectory. Information will be updated periodically during the flight, and the trajectory calculated in advance will be adjusted as required to flexibly cope with meteorological changes and unexpected changes in circumstances.

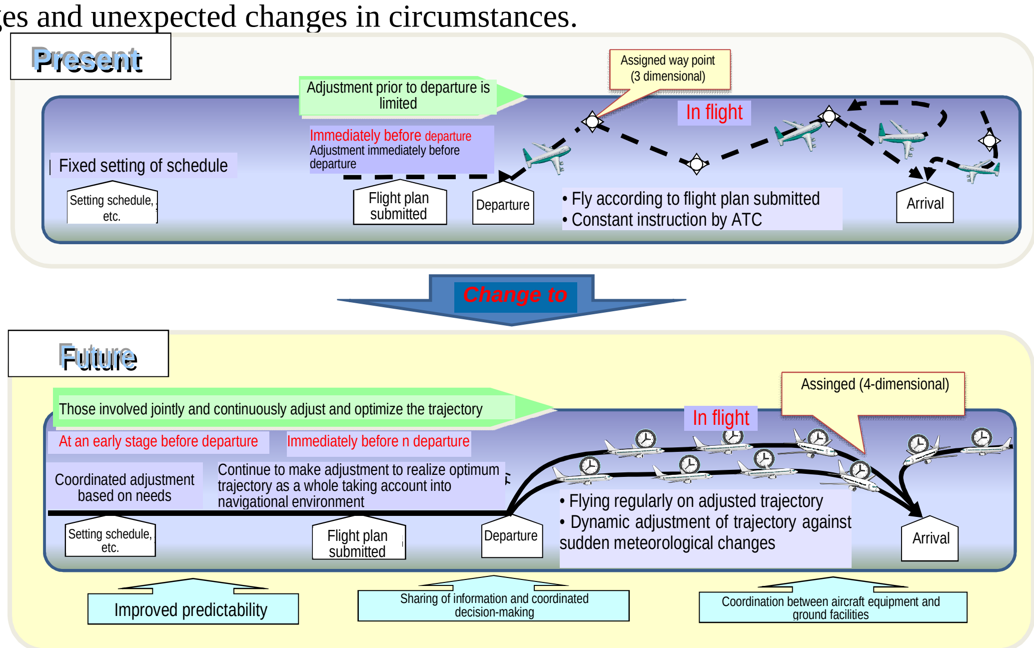
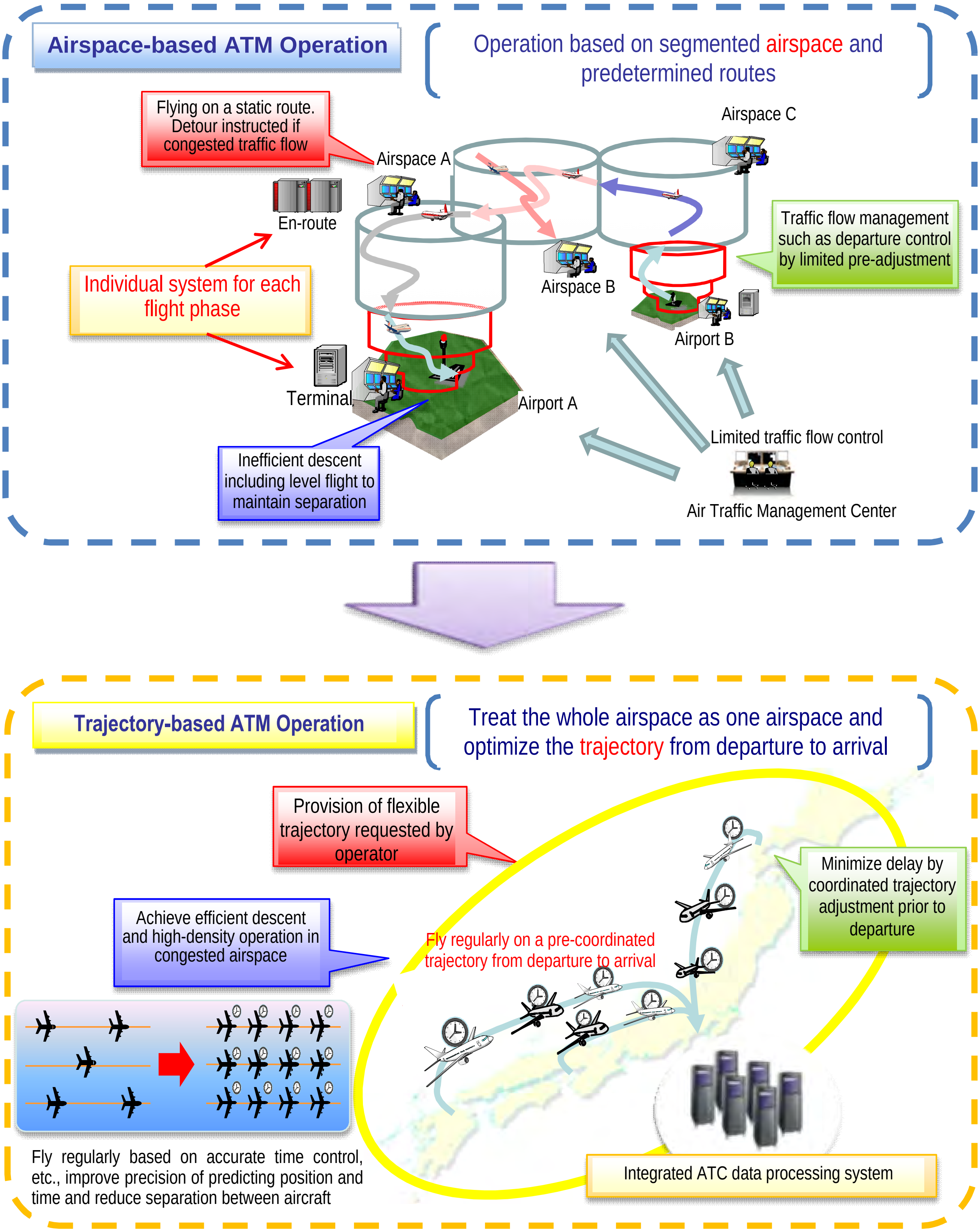


Image of coordinated and staged adjustment of trajectory



From airspace-based ATM operation to trajectory-based ATM operation

(2) Improving Predictability

In order to realize trajectory-based operation, it is necessary to improve the ability to predict air traffic flow and air traffic control capacity. As it is necessary to predict compatibility of traffic conditions and air traffic control capacity from departure to arrival including taxiing for the trajectory requested by an operator and a pilot, we will improve the calculation of air traffic control capacity for each of airport and sector and estimation of traffic flow, and establish the trajectory-based calculation method.

Because meteorological phenomena are significant uncertainty when predicting air traffic flow and air traffic control capacity, we will strive to upgrade meteorological information by preparing meteorological forecasting information specialized for aviation use and by using meteorological data gathered by aircraft. By improving the predictability of meteorological phenomena, operational efficiency can be increased and flight safety regarding turbulence can be enhanced.

(3) Promoting Performance-based Operation (PBO)

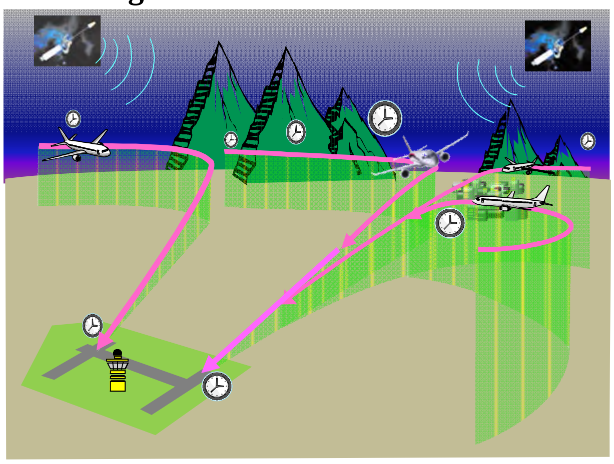
In order to appropriately and efficiently, meet various needs of an operator and to achieve flexible 4-dimensional trajectories, the provision of aircraft performance requirements and more advanced ATC operation in line with such requirements are necessary, rather than ATC operation that depends on the traditional specific airborne equipment and ground NAVAIDS. Although performance-based navigation (PBN) such as RNAV has been introduced, operation that gives greater importance to aircraft capability such as high-precision RNAV enabling curved approaches and more strict assignment of required time of arrival and satellite based navigation will become important.

High-tech aircraft equipment

(4) Realizing Satellite-based Navigation for All Flight Phases

Aircraft must determine position and time accurately in all FIR of Japan to ensure precise and flexible 4-dimensional trajectories from departure to arrival. We will introduce satellite-based navigation with more precision, reliability and flexibility in all phases of flight.

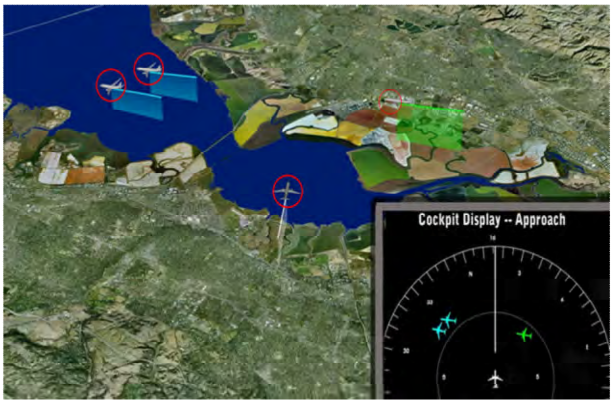
We will also enable curved precision approaches instead of the traditional straight precision approach with its limitations, by using more precise, flexible satellite based navigation, thereby enhancing flight safety and convenience, making efficient use of airspace and mitigating noise.



Flexible route-setting by satellite based navigation (Realizing flexible and high-precision approach not affected by land features and urban areas)

(5) Enhancing Situational Awareness on the Ground and in the Air

In order to accurately predict the trajectory of an aircraft in all flight phases, it is necessary to enhance situational awareness by integrated information-sharing between the ground facility and the aircraft to precisely calculate the aircraft position and traffic situation. Data communication enables air traffic controllers to grasp the intention of the pilot by using detailed aircraft-derived information, and the aircraft can use it to maintain awareness of surrounding aircraft.



Grasping the situation of other aircraft in the air

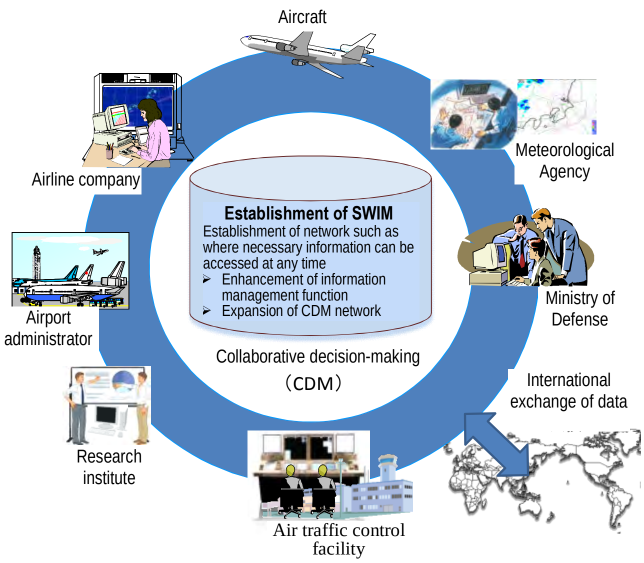
Furthermore, by introducing air-to-air surveillance by ADS-B (Automatic Dependent Surveillance-Broadcast), the aircraft can realize self-separation using airborne situational awareness capability.

(6) Making Maximum Use of the Capability of Human Beings and Machines

A highly automated and comprehensive ATC support system is indispensable for trajectory-based operation. For more advanced air traffic control, we will create an environment that makes full use of the capacity of human beings and machines, for example, by allowing, a pilot and a controller to focus on providing value-added service, by automating routine communication.

(7) Complete information-sharing and Collaborative Decision-Making

In order to achieve a safe and smooth air traffic flow and make effective use of airspace, all the control facilities, government agencies, airport administrators, pilots, operators, and others concerned should share information as needed and participate in Collaborative Decision-Making. We will therefore establish a network where all information related to operation is comprehensively managed and necessary information can be accessed by any party when necessary (SWIM: System Wide Information Management). At international level, information sharing and coordinated operation will be encouraged through data exchanges among control facilities.



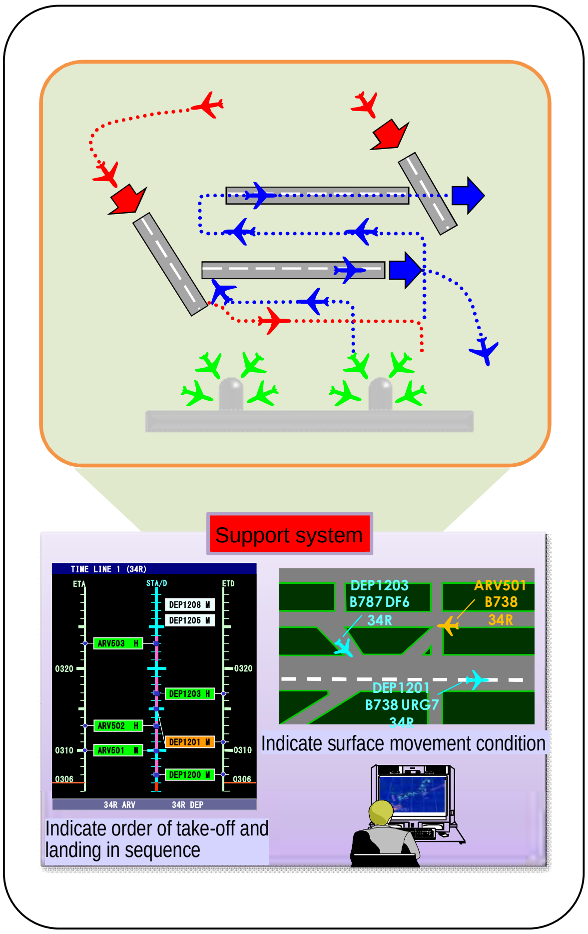
Concept of SWIM

In addition, we will create an environment that will enable the parties to share all information related to aviation safety, and safety will be enhanced by feeding back such safety information to operation sites.

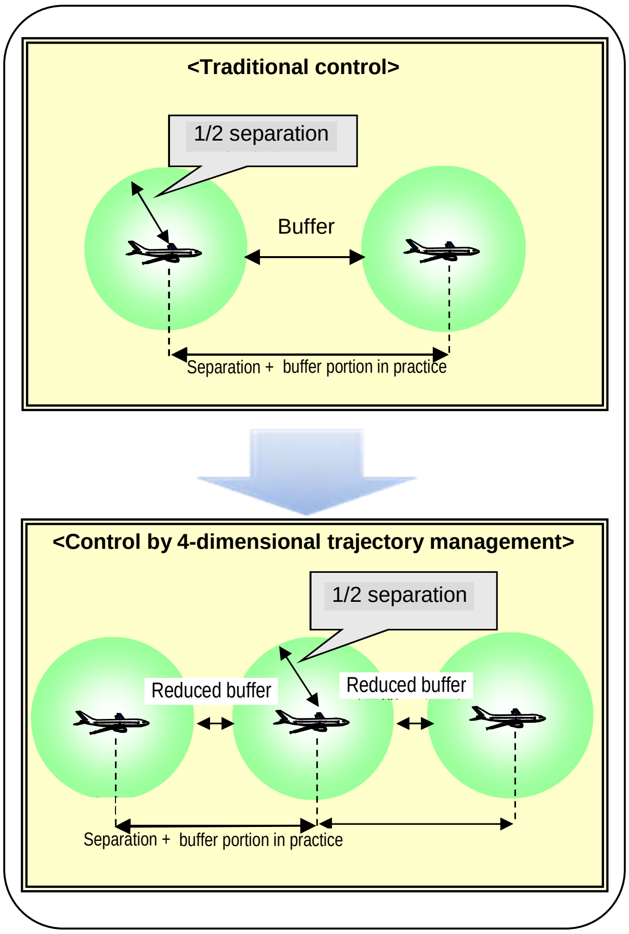
(8) Realizing High-density Operation in Congested Airports and Airspace

To realize more effective trajectory-based operation as air traffic volume increases in the long term, bottlenecks at congested airports and airspace in the Greater Tokyo Metropolitan area, etc. must be eliminated. While ensuring safety, we will enhance ATC capacity by effectively using airspace through performance-based operations, satellite-based navigation, dynamic airspace management and optimal use of various ATC support systems including take-off and landing order adjustment.

We will also seek to reduce the separation between aircraft by accurate time management, and realize a high-density operation by trajectory-based operations. This will enable us to meet further increases in capacity.



Use of ATC support system at congested airports
(In congested airports where the traffic flow of departing and arriving flights is complicated, we will use the ATC support system to optimize the order of take-off and landing and to make taxiing more efficient.)



Reduction of separation between aircraft
(Enhance the precision of predicting position and time by enhancing surveillance ability and navigational precision as well as accurate time management, and reduce the separation between aircraft)

2. Example of Specific Measures

In establishing the future air traffic systems, it is necessary to promote the following specific measures in line with the direction of renovation.

Direction of change	Examples of specific measures
1. Realization of trajectory-based operation	(a) Introduction of time management in flight phase
	(b) Introduction of trajectory-based operation in descent phase
	(c) Realization of 3.5-dimensional trajectory-based operation (trajectory-based operation designating time of arrival at a specific fix)
	(d) Gradual introduction of time management on the airport surface
	(e) Creation of premeditated traffic flow by gradual adjustment of schedule, etc.
	(f) Realization of 4-dimensional trajectory-based operation (4-dimensional trajectory throughout the trajectory, dynamic trajectory correction)
2. Improvement of predictability	(a) Promotion of utilization of weather forecast information
	(b) Enhance precision of meteorological forecasting using data monitored by aircraft
	(c) Utilization of meteorological forecast information on an aircraft
	(d) Prediction of compatibility of trajectory-based traffic volume with capacity
3. Promotion of performance-based operation	(a) Nationwide implementation of RNAV
	(b) Effective use of airspace by high-precision RNP (e.g. RNP2)
	(c) Performance-based navigation including time-based precision (4D-RNAV)
	(d) Realization of flexible and optimum flight trajectory (random route unhampered by airway and FIX)
4. Realization of satellite based navigation in all flight phases	(a) Provision of navigation service in low-altitude airspace (utilization of GNSS)
	(b) Realization of satellite based precision approach
	(c) Flexible route-setting by curved precision approach
5. Improving situational awareness performance on the ground and in the air	(a) Improving surveillance capacity on the airport surface and in blind areas (multilateration, wide-area multilateration)
	(b) Improving situational awareness performance through air-to-ground cooperation (utilization of aircraft derived information)
	(c) Improving situational awareness performance by air-to-air surveillance (self-retention of separation between aircraft)
6. Maximum use of the capability of humans and machines	(a) Upgrading of ATC support function (avoidance of medium-term conflict, support for sequencing)
	(b) Enhancement of ATC capacity by automated routine communication
	(c) Prevention of human errors by ATC support function (prevention of runway incursion such as RWSL)
	(d) Upgrading of ATC support function (including cooperation with pilot)
	(e) Revision of role allocation between humans and machines (promotion of automation of routine processing)
	(f) Improvement of ATC support function for 4DT
	(g) Revision of role allotment between humans and machines (humans may mainly engage in monitoring under the automated system)
7. Complete information-sharing and Collaborative decision-making	(a) Information-sharing among the parties concerned at an airport (airport CDM)
	(b) Route-setting under internationally-coordinated airspace management (international CDR)
	(c) Real-time information-sharing among common users of airspace, coordinated adjustment of training airspace
	(d) Establishment of network (SWIM) where necessary information can be accessed at any time
	(e) International information-sharing and Collaborative decision-making (international ATM, etc.)
8. Realization of high-density operation at congested airports and airspace	(a) Upgrading of airport operation (spot management, taxiing support, etc.)
	(b) Effective use of airspace by dynamic airspace management (dynamic management of variable sector and training airspace)
	(c) Reduction of separation and route setting by high-precision RNP
	(d) Compatibility of enlarged capacity with reduced noise by flexible route-setting (curved precision approach)
	(e) High-density operation under 4-dimensional trajectory-based operation

Since each direction is closely related with each other, when carrying out renovation, each field of ATM and CNS must work in collaboration with others, and R&D and implementation must be carried out according systematically. It is also necessary to proceed with each measure by stage, envisaging the anticipated operation and circumstances of R&D and introduction of operation and technology.

In the short term, we will implement initial renovation of the air traffic systems, mainly by using already established technologies and methods. In the medium term, we will upgrade the air traffic systems by using technologies and methods whose timing for implementation can be reasonably determined. In the long term, we will implement renovation by using technologies and methods to possibly be produced by R&D in the future, including those whose timing of realization is not yet clear. The phased implementation schedule for specific measures is outlined below.

Example of specific measures by implementation phase

1. Realization of trajectory-based operation	(a) Introduction of time management in flight phase (b) Introduction of trajectory-based operation in descent phase (d) Gradual introduction of time management on the airport ground phase (e) Creation of scheduled traffic flow by gradual adjustment of schedule, etc.	(c) Realization of 3.5-dimensional trajectory-based operation (Trajectory-based operation designating time of passing a specific point)	(f) Realization of 4-dimensional trajectory-based operation (Realization of 4DT on all the trajectories, Dynamic trajectory correction)
2. Improvement of predictability	(a) Promotion of utilization of weather forecast information (d) Prediction of compatibility of trajectory-based traffic volume with capacity	(b) Enhancement of precision of meteorological forecasting using data monitored by an aircraft	(c) Utilization of meteorological forecast information on an aircraft
3. Promotion of performance-based operation	(a) Nationwide development of R-NAV (Introduction of RNAV/RNP, RNP/AR)	(b) Effective use of airspace by high-precision RNP (RNP2, etc.) (c) Performance-based navigation including time-based precision (4D-RNAV)	(d) Realization of flexible and optimum flight path (random route unhampered by airway and FIX)
4. Realization of satellite navigation in all flight phases	(a) Provision of navigation service in low-altitude airspace (utilization of GNSS)	(b) Realization of precision approach using satellites (c) Flexible route-setting by curved precision approach	
5. Improving situational awareness performance on the ground and in the air	(a) Improving surveillance capacity on the airport surface and in blind areas (multilateration and wide-area multilateration)	(b) Improving situational awareness performance through air-to-ground cooperation (utilization of aircraft derived information)	(c) Improving situational awareness performance by air-to-air surveillance (self-retentionof separation between aircraft)
6. Maximum use of the capability of humans and machines	(a) Upgrading of control support function (avoidance of mid-term conflict, support for se qencing) (b) Enhancement of processing capacity by automated routine communication (introduction of data link) (c) Prevention of human errors by control support function, etc. (prevention of runway incursion such as RWSL)	(d) Upgrading of control support function (including cooperation with pilot) (e) Division of roles between humans and machines (promotion of automation of routine processing)	(f) Enlargement of control support function for 4DT (g) Division of roles between humans and machines (humans may mainly engage in surveillance under the automated system)
7. Full information-sharing and coordinated decision-making	(a) Information-sharing among the parties concerned at an airport (airport-type CDM) (b) Route-setting under internationally-coordinated airspace management (international CDR)	(c) Real-time information-sharing among common users of airspace, coordinated adjustment of training airspace (d) Establishment of network (SWIM) where necessary information can be accessed at any time (e) International information-sharing and coordinated decision-making (international ATM, etc.)	
8. Realization of high-density navigation at congested airports and airspace	(b) Effective use of airspace by dynamic airspace management (dynamic management of variable sector and training airspace) (a) Upgrading of airport operation (spot management, taxiing support, etc.)	(c) Reduction of separation by high-precision RNP (d) Compatibility of enlarged capacity with reduced noise by flexible route-setting (curved precision approach)	(e) High-density navigation under 4-dimensional trajectory-based operation

(*1) Before starting a project, its cost benefit analysis will be examined carefully and the project will be assessed accordingly.
(*2) The measures cited in the above table are just representative example, and not all the options.
(*3) Division of short term, medium term and long term is tentative and subject to change depending on technological progress, change of situation, etc.
Term of implementation shows the time each project will start. Projects will start during such term, but may not finished during the term.

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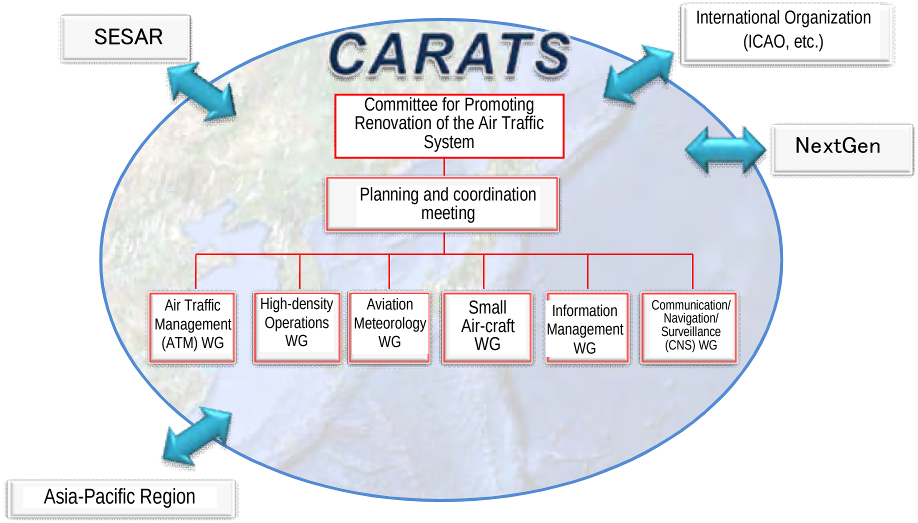
Chapter 5 Actions for Realizing the Vision

1. Establishing a Road Map

In order to systematically establish the future air traffic systems based on a long-term vision, we must first draw up a detailed road map with the cooperation of the parties concerned. The short-term measures should be initiated for its implementation step by step, while research and development should be systematically conducted for the long-term measures. The road map may be revised as necessary to flexibly cope with changes in circumstances. A scheme for materializing the long-term vision smoothly and effectively will be arrangedwith the cooperation of industry, academia, and government.

	FY 2009	FY 2010	Implementation phase (FY 2011-2025)
Long-term vision	Formulation	Formulation	
Road map		Preparation	Revised as necessary
Short-term measures			Implementation
Long-term measures			Research and development → Implementation

Image of proceeding for the establishment of the air traffic systems in the future



◆ Committee for Promoting Renovation of the Air Traffic Systems

This committee is to prepare and implement the road map of the long-term vision with the cooperation of industry, academia and government. The committee is composed of academic experts, operators, research institutes, aviation-related manufacturers, related ministries and agencies including Civil Aviation Bureau, etc.

◆ Planning and Coordination Meeting

This meeting analyzes indexes and the state of achievement of the goals of the long-term vision, and coordinates working groups. It also carries out pre-coordination for the Committee for Promoting Renovation of the Air Traffic Systems, organizes themes to be studied, and summarizes them in preparation for discussion by the Committee.

◆ Working Groups (WG)

Working groups are set up to conduct more specific studies on themes in individual fields and to prepare a road map.

2. Role-sharing and Collaboration among Parties

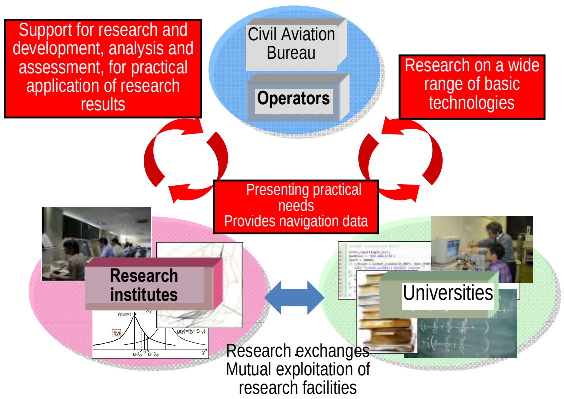
In establishing the future air traffic systems, not only the Civil Aviation Bureau but also all other parties including related ministries and agencies, operators, research institutes, and aviation-related manufacturers must play their roles in a coordinated manner. The roles of each entity in implementing individual measures must be clearly defined in the road map. The key roles of each party in realizing the long-term vision are expected as follows.

Civil Aviation Bureau and Related Ministries and Agencies (Government)

The Civil Aviation Bureau should set the future direction based on discussions with the parties concerned and play a leading role in steadily and effectively realizing the long-term vision with extensive cooperation of all parties. The Bureau should systematically improve the air navigation facilities required for this purpose and draw up standards for introducing new technology, while reviewing and revising related systems as necessary. As a world-leading organization, it should actively work with ICAO and other agencies in drawing up international standards related to new operating rules and technologies, with the cooperation of industry and academia. It should also make its own data available for research and development. The Bureau should provide technical assistance to the Asia-Pacific region and other foreign countries, thereby contributing to the establishment of the future air traffic systems in the region.

Research Institutes and Universities (Academia)

While research institutes are expected to take into account the needs of ANSP and operators as well as the trends in foreign countries of research and development, they must also effectively utilize their research facilities to analyze and evaluate new technologies in collaboration with the Civil Aviation Bureau. In addressing long-term research projects, they must conduct research systematically and effectively with this long-term vision as a guiding principle.



Roles of research institutes and universities

Universities are expected to study a wide spectrum of basic technologies.

Research institutes and universities should actively cooperate in ATM field with each other in their research and development, thereby expanding the scope of research.

Aircraft Operators, Aviation-related Manufacturers, etc. (Industry)

Operators should systematically install airborne equipment while verifying cost effectiveness and improving the compatibility with the ground aeronautical navigation facilities, in developing the future air traffic systems in collaboration with the Civil Aviation Bureau.

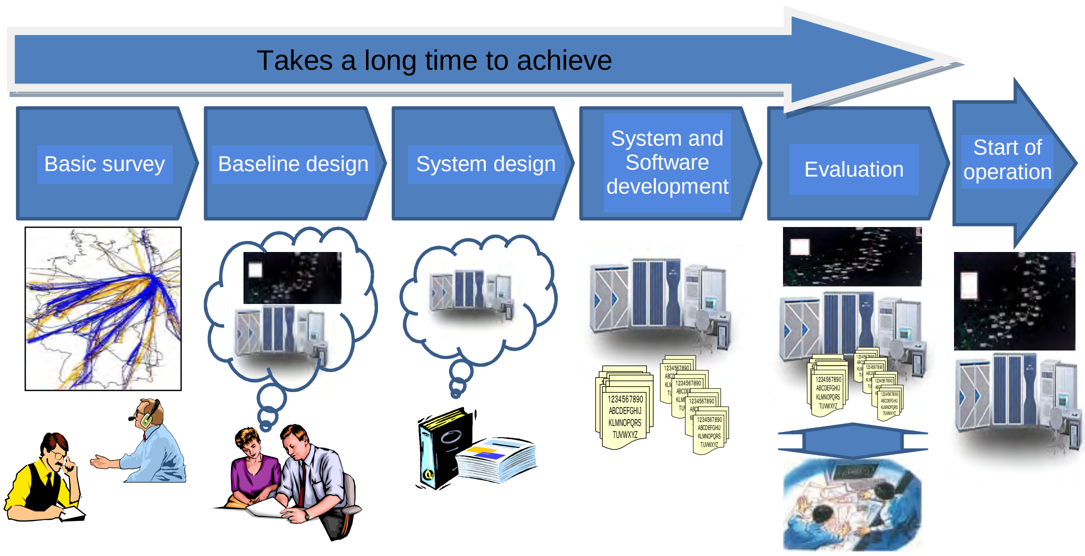
Aviation-related manufacturers are expected to develop and introduce new candidate technologies and practical technologies, taking the operational needs of ANSP and operators into account. They should also actively deploy aviation-related products internationally and contribute to building up and improving the international air traffic systems.

3. Promoting an Effective and Stable Project

In establishing the future air traffic systems, it is important to effectively carry out measures while verifying the achievement of objectives. We must therefore regularly assess indexes corresponding to the objectives set in Chapter 2. As each index is related to one another, a comprehensive analysis is required in setting indexes and evaluating achievements.

Research and development of the air traffic systems will take a long time and must be implemented systematically, and it is also necessary to consider how to secure stable funding. To improve system efficiently within limited resources, it is important to analyze cost-effectiveness before implementing measures, taking into consideration the effectiveness of the system to be introduced and the possible fade out of existing systems. It is also necessary to cope flexibly with changes in circumstances that may arise.

In order to steadily promote measures for a long-term vision, it is necessary to consider ways of smoothly transition to the future air traffic system, and creating a scheme for this transfer, by collaboration among ministries and among agencies, industry, academia and government. In this regard, examples in Europe and the U.S. and the concept of PPP (Public Private Partnership) may serve as a useful reference.



General Flow of development of facilities Air Traffic System

Conclusion

The study group, which met seven times, sort out the current problems, conducted hearing from the parties concerned, reviewed international trends and held a number of discussions on the objectives and direction of renovation. As a result, this long-term vision was established.

From now, we must work on transition to the intelligent air traffic systems based on this long-term vision. This requires joint efforts by the parties concerned to steadily promote research and development and specific measures as represented in the name: “CARATS (Collaborative Actions for Renovation of Air Traffic Systems).” Further efforts by the government and aviation industry are expected.

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Reference materials

Comparison of Direction of Renovation among Japan, ICAO, the U.S. and Europe

Japan (CARATS)	ICAO (Global ATM Operational Concept)	U.S. (NextGen)	Europe (SESAR)
Direction of renovation (a) Realizing trajectory-based operation ・Manage trajectory from departure to arrival ・Time control in all flight phases (b) Improving predictability ・Improving predictability of air traffic flow and capacity ・Upgrading meteorological information (c) Promoting Performance Based operation ・Airbone quipment-focused operation (d) Realizing satellite navigation in all flight phases ・Grasping position and time accurately ・Flexible approach procedure (e) Enhancing situation awareness on the ground and in the air ・Application Aircraft derived information ・Air-to-air surveillance (f) Making full use of the capacity of humans and automation systems ・Advanced support system (g) Full information-sharing and Collaborative Decision Making(CDM) ・Establishing SWIM (h) Realizing high-density operation in congested airports and airspace ・Reducing separation between aircraft by accurate time management, etc.	Components and important changes ・Structure and Air Space Management(ASM) - Dynamic ASM ・Airport Operation - Infrastructure to maximize airport capacity - Maintaining capacity and ensuring safety operation under all meteorological conditions - Monitoring moving aircraft and vehicles ・Demand and capacity balancing - Ex-ante coordination of trajectories and airspace structure (CDM) ・Traffic Synchronization - Dynamic 4DT control - Elimination of bottlenecks ・Operation of airspace users - Sharing of operational information, etc. - Formulation of 4DT project - Participation in CDM ・Conflict management - Strategic conflict management, making separation, avoidance of collision ・Delivery management of ATM service - 4DT and information on flight intent ・Information service - Exchange and management of information (Source: Global Air Traffic Management Operational Concept (Doc 9854))	(Key Characteristics) ・User focus ・Distributed decision-making ・Integrated Safety management system ・International harmonization ・Taking advantage of human and automation capability Key Capabilities ・Network-enabled Information access ・Performance-based operation and service ・Weather assimilated Decision-making ・Layered adapted security ・Position, navigation, and time service ・Aircraft Trajectory-based operation ・Equivalent visual operation ・Super density arrival/departure operations (Source: Next Generation Air Transportation System, Integrated Plan)	Major characteristics of 2020 ATM operation concept ・Trajectory Management is introducing a new approach to airspace design and management ・Collaborative planning continuously reflected in the Network Operations Plan ・Integrated Airport operations contributing to capacity gains ・New separation modes to allow for increased capacity ・System Wide Information Management – integrating all ATM business related data ・Humans will be central in the future European ATM system as managers and decision-makers (Source: SESAR Definition Phase – Deliverable 3 The ATM Target Concept)

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Relationship between Objectives and Specific Measures (a)

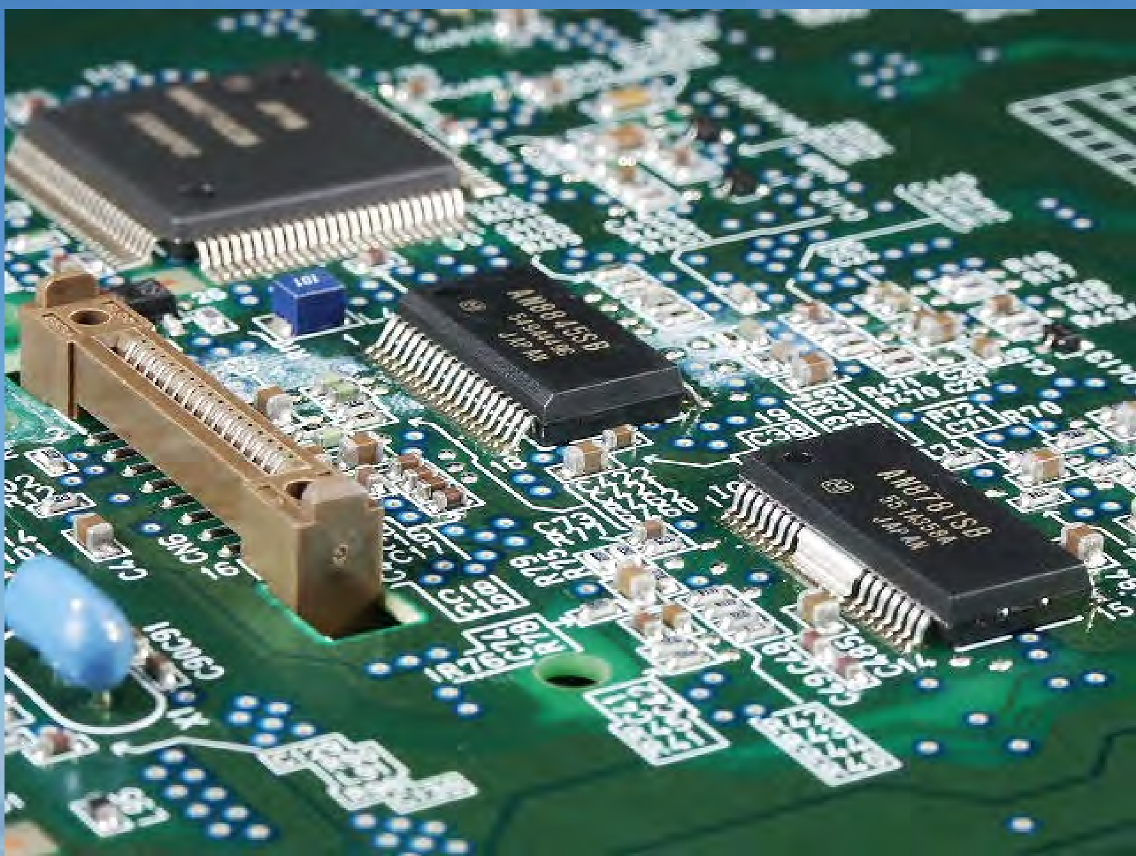
Direction of renovation	Time	Examples of specific measure	Objective: Increasing safety	Addressing the increase in air traffic volume	Improving availability	Increasing efficiency of operation	Improving efficiency of air traffic services	Environmental consideration	Improving the international presence of Japan
1 Realizing trajectory-based operation	Short term	(a) Introducing time management in flight phases		◎		○		○	
	Short term	(b) Introducing trajectory-based operation in descent phase				◎		○	
	Medium term	(c) Realizing 3.5-dimensional trajectory-based operation		○		○		○	
	Short term ～ Medium term	(d) Phased introduction of time management on airport surface		○	◎	○		○	
	Short term ～ Medium term	(e) Making of traffic flow by gradual coordination of schedule, etc.		○	◎		○		
	Long term	(f) Realizing 4-dimensional trajectory-based operation (realization of 4DT in all the trajectories, dynamic trajectory correction)		◎	○	○		○	○
2 Improving predictability	Short term	(a) Promoting utilization of weather forecast information	◎		○	○		○	
	Medium term	(b) Enhancing precision of meteorological forecasting using data observed by an aircraft	○		◎	○		○	
	Long term	(c) Utilizing meteorological forecast information on an aircraft	◎			○		○	
	Short term ～ Long term	(d) Predicting compatibility of trajectory-based traffic volume with capacity		◎	○				
3 Promoting performance-based operation	Short term	(a) Nationwide development of area navigation		◎		◎		○	
	Medium term	(b) Effective use of airspace by high-precision RNP (RNP2, etc.)		○	○	○		○	
	Medium term	(c) Performance-based navigation including time-line precision (4D-RNAV)		○	◎				
	Long term	(d) Realizing flexible and optimum flight path (random route unhampered by airway and FIX)		○	○	◎		○	
4 Realizing satellite-based navigation in all flight phases	Short term	(a) Providing navigation service in low-altitude airspace (utilization of GNSS)	◎		○				
	Medium term	(b) Realization of precision approach using satellites	○		◎	○		○	
	Medium term	(b) Establishing Flexible route realized by curved precision approach		○	○	◎		○	
5 Enhancing situational awareness on the ground and in the air	Short term	(a) Improving surveillance capacity on the airport surface and in blind areas (multilateration, wide-area multilateration)	◎	○			○		
	Medium term	(b) Improving situational awareness performance through air-to-ground cooperation (utilization of aircraft derived information)	◎	○		○			
	Long term	(c) Improving performance of monitoring traffic by air-to-air surveillance (self-retention of separation between aircraft)	○	○			◎		

Relationship between Objectives and Specific Measure (b)

Direction of renovation	Time	Examples of specific measure	Objective: Increasing safety	Addressing the increase in air traffic volume	Improving availability	Increasing efficiency of operation	Improving efficiency of air traffic services	Environmental consideration	Improving the international presence of Japan
6 Making Maximum use of the capacity of humans and automation system	Short term	(a) Upgrading of control support function (avoidance of medium-term conflict, support for sequencing, etc.)	◎	○			○		
	Medium term	(b) Upgrading of control support function (including cooperation with pilot)		◎	○		○		
	Long term	(c) Enlarging control support function for 4DT		○	○		◎		
	Short term	(d) Enhancing processing capacity by automated routine communication	○	◎			○		
	Short term	(e) Preventing human errors by control support function, etc. (prevention of runway incursion such as RWSL)	◎	○			○		
	Medium term	(f) Division of roles between humans and automation system (promoting automation of routine processing)	◎				○		
	Long term	(g) Division of roles between humans and automation system (Humans may mainly engage in surveillance under the automated system.)	○				◎		
7 Full information-sharing and coordinated decision-making	Short term	(a) Information-sharing among the parties concerned at an airport (Airport CDM)	○	◎		○		○	
	Medium term	(b) Real-time information-sharing among common users of airspace, collaborated adjustment of training area		◎		○		○	
	Medium term	(c) Establishment of network (SWIM) where necessary information can be accessed at any time				○	◎	○	
	Short term	(d) Route-setting under internationally-collaborated airspace management (international CDR)		◎		○		○	○
	Medium term to Long term	(e) International information-sharing and collaborated decision-making (international ATM, etc.)		○		◎	○	○	◎
8 Realizing high-density operation in congested airports and airspace	Short term	(a) Upgrading of airport operation (spot management, taxiing support, etc.)		◎		○		○	
	Short term to Medium term	(b) Effective use of airspace by dynamic airspace management (dynamic management of variable sector and training area)		◎	○				
	Medium term	(c) Reduction of separation by high-precision RNP		◎		○		○	
	Medium term	(d) Compatibility of capacity enlargement with noise abatement by flexible route-setting (curved precision approach)		◎	○	○		○	
	Long term	(e) High-density operation by 4-dimensional trajectory-based operation		◎	○				

* The marks in the list tentatively show the degree to which specific measures illustrated for the respective direction of renovation in “4. Concept of ATM Operation and Direction for Renovating CNS Fundamental Technology” contribute to achieving individual objectives mentioned in “2. Objectives of the Future Air Traffic Systems” (◎ and ○). Such objectives are not necessarily achieved by the measures marked. Note that ◎ and ○ do not show a specific difference in the degree of contribution, such as ◎ contributes N times more to achieving objectives compared with ○, and the same mark does not show the same degree of contribution.

Terminology and glossary



Acronyms and abbreviations

Terms	Definition	Explanation
4DT	4-Dimensional Trajectory	4-Dimensional Trajectory (introducing time control)
4D-RNAV	4-Dimensional Area Navigation	4-Dimensional Area Navigation
A		
ADS	Automatic Dependent Surveillance	Automatic Position information Transmission/Surveillance (Automatic Dependent Surveillance) Function
ADS-B	Automatic Dependent Surveillance-Broadcast	Automatic Position Information Transmission (in Broadcast Mode)/Surveillance Function
ARSR	Air Route Surveillance Radar	Air Route Surveillance Radar
ASDE	Airport Surface Detection Equipment	Airport Surface Detection Radar
ASR	Airport Surveillance Radar	Airport Surveillance Radar
ATFM	Air Traffic Flow Management	Air Traffic Flow Management
ATM	Air Traffic Management	Air Traffic Management
C		
CARATS	Collaborative Actions for Renovation of Air Traffic Systems	Long-term vision of the future air traffic systems in Japan
CDA	Continuous Descent Arrivals	Continuous Descent Arrivals
CDM	Collaborative Decision Making	Collaborative Decision-Making (between a navigator and air traffic control facility)
CDR	Conditional route	Conditional route
CNS	Communication･Navigation･Surveillance	Communication･Navigation･Surveillance
D		
DME	Distance Measuring Equipment	Distance Measuring Equipment
F		
FAA	Federal Aviation Administration	Federal Aviation Administration
FANS	Future Air Navigation System	Future Air Navigation System
FIR	Flight Information Region	Flight Information Region
FIX	FIX	Check-point set up on a flight path
G		
GNSS	Global Navigation Satellite System	Global Navigation Satellite System
GPS	Global Positioning System	U. S. Global Positioning System
I		
ICAO	International Civil Aviation Organization	International Civil Aviation Organization
IFR	Instrument Flight Rules	Instrument Flight Rules
ILS	Instrument Landing System	Instrument Landing System
M		
MLAT	Multilateration	Multilateration

N		
NextGen	Next Generation Air Transportation System	Comprehensive vision of the air traffic systems of the next generation with 2025 set as a year of goal.
P		
PBN	Performance-Based Navigation	Performance-based navigation (based on performance of an aircraft)
PBO	Performance-Based Operation	Performance-based operation (based on operation of an aircraft)
PPP	Public Private Partnership	Public Private Partnership
R		
RA	Resolution Advisory	Collision avoidance instruction under Traffic Alert and Collision Avoidance System (TCAS)
RNAV	Area Navigation	Area Navigation
RNP	Required Navigation Performance	Required Navigation Performance
RNP2	Required Navigation Public Private Partnership	Standard that meets the requirement of navigation precision of ±2 miles, etc.
RNP-AR	Required Navigation Performance Authorization Required	RNP navigation that only an aircraft and a pilot with a special authorization may operate during turning flight at the time of landing
RWSL	Runway Status Light	Runway light system showing its status
S		
SESAR	Single European Sky ATM Research	New generation ATM system modernization program in Europe with target year of 2020
SSR	Secondary Surveillance Radar	Secondary Surveillance Radar
SWIM	System Wide Information Management	Network where aviation-related information is collectively controlled and the parties concerned can access required information when necessary
T		
TBO	Trajectory Based Operation	Trajectory Based Operation
TCAS	Traffic alert and Collision Avoidance System	Computer-controlled avionics equipment developed to prevent danger of mid-air collision between aircraft
U		
UPR	User Preferred Routes	User Preferred Routes
V		
VFR	Visual Flight Rules	Visual Flight Rules
VOR	VHF Omni-directional Radio Range	VHF Omni-directional radio beacon facility
VOR/DME	VHF Omni-directional Radio Range / Distance Measuring Equipment	VHF Omni-directional radio beacon Facility / Distance Measuring Equipment

Glossary

ADS-B: Automatic Dependent Surveillance - Broadcast

Automatic position information transmission and surveillance function, of the broadcast type. Also called Automatic Dependent Surveillance of Broadcast-type, or Broadcast-type ADS.

A means of keeping under surveillance the position of a moving object such as a flying or taxiing aircraft. A procedure by which each aircraft transmits position information obtained by using a positioning system such as GNSS to ground facilities or other aircraft via a broadcast-type data link.

→ GNSS

Air Traffic Service

Relying on the pilot of an individual aircraft for safe, orderly and efficient operation of air traffic has limitations and some external assistance is required. This assistance is the air traffic service provided mainly by ATS officers of the Civil Aviation Bureau of the Ministry of Land, Infrastructure and Transport. These services include the following:

- Air traffic control service including giving air-traffic-related instructions to establish safe separation between aircraft.
- Air traffic control and navigation information service to collect and provide information necessary for search and rescue and safe navigation of an aircraft.
- Air traffic control and communication service to provide communication and information required for safe navigation to an aircraft engaging in international aviation over the ocean.
- Air traffic control and technological service to improve, manage and operate various air navigation radio facilities, etc.
- Aeronautical lights and electricity service to improve, maintain and manage various aeronautical lights and other electric facilities.
- Flight inspection service to make inspections to check the performance of air navigation facilities and to make inspections on the safety of navigation of an aircraft.
- Satellite operation service to operate the MTSAT system used for communication with an aircraft, navigation and surveillance of an aircraft, etc.

ARSR: Air Route Surveillance Radar

Radar used for controlling air route traffic using radar, which includes detecting the position of an aircraft flying in airspace within 250 nautical miles (about 460 km) of the radar site, guiding an aircraft and setting the separation between aircraft.

ASDE: Airport Surface Detection Equipment

High-resolution radar used for aerodrome control, which keeps under surveillance the movements of aircraft, vehicles, etc. on the airport surface and secures their traffic safety.

ASR: Airport Surveillance Radar

Radar used for terminal radar control service, which includes detecting the position of an aircraft flying in the airspace within 60 to 100 nautical miles (about 110 to 180 km) of the airport and guiding a departing or approaching aircraft and setting the separation between aircraft.

Conflict

The state in which aircraft in flight approach closer to each other than the prescribed separation.

DME: Distance Measuring Equipment

This equipment measures distance using the constant speed of propagation of radio waves. An aircraft transmits to a ground-based DME facility a radio wave to detect the distance. The distance to the ground station can be continuously measured by the time taken to receive a response to the wave transmitted by the DME facility.

DME is often installed together with VOR and is used as a short-distance aid procedure that provides an aircraft with position information (distance and azimuth direction). It is also installed together with a localizer or a glide path instead of an ILS marker and is used as a precision approach aid facility (Terminal DME: T-DME) that continuously provides information on the distance to the landing point.

→ VOR, VOR/DME, ILS

FAA: Federal Aviation Administration

The U.S. administration agency that governs air traffic control and navigation of civil aviation. It is equivalent to the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism of Japan.

GNSS: Global Navigation Satellite System

Outline

Positioning systems by which the position of a receiver on the globe is found by its positional relationship with groups of satellites for positioning. They include GPS (Global Positioning System) now operated by the U.S., GLONASS (Global Orbiting Navigation Satellite System) now operated by Russia, and Galileo, a system that is now being developed by the EU.

The position of a receiver is calculated on the basis of information on the distance from each of multiple positioning satellites (theoretically, four satellites are sufficient; if there are five or more, more than four satellites may be used to enhance precision) and the trajectory information of each satellite. The former information on distance is found by the time taken for the time signal of a clock on the satellite to reach the ground (this distance is called pseudo-distance, due to an offset arising from the discrepancy between the clock on the satellite and the clock on the receiver, and is converted into the actual distance by correction) and the latter trajectory information is transmitted along with the clock signal. At least 24 positioning satellites are required to cover the whole globe and about 30 such GPS satellites have been launched.

An atomic clock of extremely high precision is installed on each positioning satellite; it can also be used as a clock in addition to for positioning.

Reinforcing system

Sufficient precision for aviation is not possible by positioning using only positioning satellites and occasional information obtained from a satellite, due to changes in the positions of satellites with time and ionospheric activity. Navigation of an aircraft requires guaranteed high-precision positioning (precision of several meters, particularly for guided landing), seamless positioning and reliable positioning. Therefore, to enable aircraft to use satellite navigation, various reinforcing systems to correct positioning errors and keep monitoring satellite operations are needed in combination with a cluster of positioning satellites. GNSS is a navigational positioning system that combines the cluster of positioning satellites with a complementary reinforcing system.

There are the following three kinds of reinforcing system.

- SBAS

  Satellite navigation reinforcing system of the geostationary satellite type. In this system, the receivers (base stations) of satellite signals are installed extensively on the ground and information such as error correction information and integrity information obtained from data measured at each point of such receivers are provided to every aircraft via a geostationary satellite.
- GBAS

  Satellite navigation reinforcing system of the ground type. This system is used for takeoff and landing at an airport where particularly high precision and reliability are required. In this system, errors are measured at multiple base stations installed on the ground but, different from SBAS, base stations are installed only in the vicinity of an airport and correction information of positioning errors, integrity information, etc. are provided by a communication facility at the airport via air-to-ground data communication using the VHF band.
- ABAS

  This system enhances navigational reliability by a simple receiver installed on an aircraft; failure of a GPS satellite is verified by data obtained from multiple satellites (if insufficient, a barometric altimeter, etc. is added).

ICAO: International Civil Aviation Organization

Specialized agency of the UN established for making legal international arrangements, and drawing up and introducing technical standards for the operational procedures of civil aviation. It was established in 1947 and has 190 member countries at present.

It makes legal international arrangements and technical standards for controlling aircraft licenses, airport markings, performance specifications for safety, air traffic control procedures, forms for accident investigations, etc., which are compiled in statutory form as the “Convention on International Civil Aviation,” which is the basic international law on civil aviation.

The laws and ordinances of civil aviation of the member countries are governed by the Convention on International Civil Aviation which also governs the Civil Aeronautics Act of Japan.

IFR: Instrument Flight Rules

A flight is operated using the instruments of the aircraft and visual observation, and is always under instructions from an air traffic controller.

ILS: Instrument Landing System

Two kinds of guiding radio wave indicating the approach route and descending route are transmitted by ILS facilities established at an airport to a landing aircraft.

In bad weather, a pilot is able to land at the airport safely by flying on the prescribed course, by receiving radio waves from the ILS and navigating according to instrument indicators, which are airborne equipment.

The system consists of a localizer indicating horizontal divergence, a glideslope (glidepath) indicating vertical divergence, and a marker that shows the distance to the runway.

Multilateration

A surveillance system in which squitter and SSR response signals transmitted by air-borne transponders are received by three or more receiving stations and the position of an aircraft is measured by the difference in receiving time among the receiving stations.

In multilateration, the difference in receiving times among receiving stations is converted to the difference in distance between each receiving station and the aircraft, and the position of the aircraft is calculated by finding the point of intersection of curves of equal difference in distance.

Characteristics of multilateration include: performance does not deteriorate in bad weather, and the function of displaying identification information (call sign) of an aircraft can be added using information contained in the SSR answering signal used for positioning. The problem in the current ASDE (Airport Surface Detection Equipment) can be improved. Because areas that can not be monitored by ASDE due to blocking by buildings, etc. (blind area) can be monitored by locating receiving stations correspondingly, multilateration offers advantages for airport surface surveillance sensors.

RNAV: Area Navigation

Navigation by which an aircraft flies while confirming its own position and flight direction based on position information obtained from ground-based radio facilities (VOR/DME, etc.) and position information made available by GNSS and airborne inertial navigation systems, while utilizing airborne FMS at the same time.

Traditionally, airways above land used to be established on routes connecting ground-based air navigation radio facilities (VOR/DME, etc.). In RNAV, the introduction of FMS, which is high-performance airborne equipment, has made it possible for an aircraft to establish direct and variable routes unconstrained by the geographic locations of ground-based air navigation radio facilities and thus airspace can be effectively utilized. The use of GNSS for positioning has also enabled RNAV over the ocean.

→ GNSS

Sector

The smallest unit of airspace divided for a facility, etc. to take partial charge of air traffic control service.

SSR: Secondary Surveillance Radar

Secondary surveillance radar is used together with primary surveillance radar (PSR). When an aircraft receives a request signal transmitted by this SSR, the airborne ATC transponder (ATCRBS: Air Traffic Control Automatic Responding Equipment) answers and advises the DBS (aircraft identification code) assigned to each aircraft, flight altitude, etc. This answer signal is decoded and identified by a ground-based radar facility and is processed by the air traffic control processing system, making it possible to display the flight number, altitude information, etc.

In SSR mode S (Selective), the use of aircraft identification signals in transmitting the request signal makes it possible to exchange communication with individual aircraft alternatively. Further, a data link function using the S long answer signal, which is a mode having a large information capacity, makes it possible to obtain not only the altitude but also various other information including position, heading, speed, and waypoints. This is now gradually spreading worldwide in order to cope with the increasing number of aircraft to be handled. Different from primary surveillance radar, because SSR is a surveillance means in which airborne equipment plays a significant role, an aircraft must be equipped with highly reliable airborne equipment compatible with the operation mode of SSR.

VFR: Visual Flight Rules

Rules by which a pilot navigates an aircraft by relying on visual checking and own judgment.

VOR: VHF Omni-directional Range

VHF Omni-directional Range Radio Beacon

With this radio beacon, an ATC facility can continuously instruct to all flights within effective communication range the azimuth direction to magnetic north from the VOR facility using very high frequency (VHF) transmission. By installing VOR facilities at main points, an aircraft can accurately navigate an airway. By using VHF, an ATC facility can accurately instruct a flight course without being significantly affected by lightning, etc. DME is usually installed together with VOR and used as VOR/DNE (azimuth direction/distance information providing facility).

→ DME, VOR/DME

VOR/DME: VHF Omni-directional Radio range/Distance Measuring Equipment

Radio beacon combining VOR (VHF Omni-directional Range Radio Beacon) with DME (Distance Measuring Equipment). It is the basis of radio navigation positioning of aircraft.

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Summary of subjects studied by the Study Group

April 23, 2009	First Meeting ・ Objectives of the Study Group ・ The present situation and problems of the air traffic systems in Japan ・ Trends of international organizations, the U.S. and Europe
May 20, 2009	Second Meeting (industry survey) ・ Operators (The Scheduled Airlines Association of Japan, All Japan Air Transport and Service Association Co., Inc.) ・ Ground system manufacturers (NEC Corporation, Toshiba Corporation, Mitsubishi Electric Corporation, Japan Radio Co., Ltd., Oki Electric Industry Co.,-Ltd., NTT Data Corporation) ・ Research institutes (Electronic Navigation Research Institute, Japan Aerospace Exploration Agency)
June 22, 2009	Third Meeting (direction of future work) ・ Basic view on establishing the future air traffic systems ・ Objectives of the future air traffic systems ・ Constraints of the current air traffic systems and direction of improving operational concept and technologies
August 26, 2009	Fourth Meeting ・ Numerical targets ・ Examples of specific measures ・ Name of the vision
October 21, 2009	Fifth Meeting ・ Numerical targets and indexes ・ Actions for realizing the vision
December 8, 2009	Sixth Meeting ・ Discussion of Draft report
February 22, 2010	Seventh Meeting ・ Discussion of Final report

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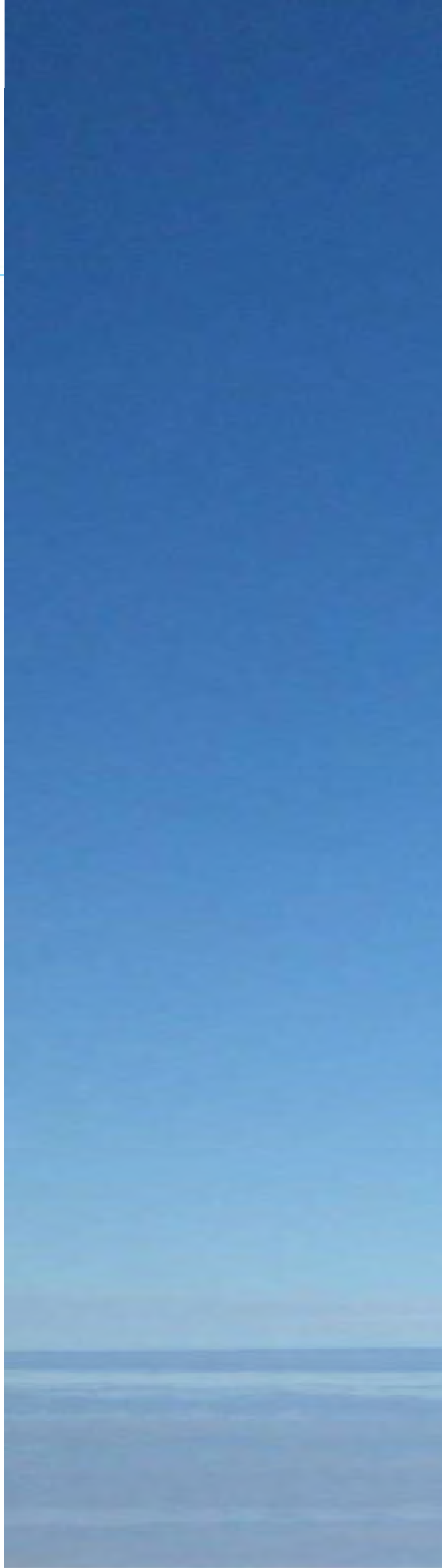
CARATS

Collaborative Actions for Renovation of Air Traffic Systems



Study Group for the Future Air Traffic Systems