International Civil Aviation Organization

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Agenda Item X: State Presentation

RNAV Roadmap and current status of RNAV implementation in Japan

(Presented by Japan)

SUMMARY

This paper presents the Japanese RNAV Roadmap version 2, which was established in April 2007 and was partly amended in November 2009, and the current status of RNAV implementation in Japan.

1. RNAV ROADMAP IN JAPAN

1.1 Japan started the trial of RNAV in 1992 and established the first RNAV Roadmap in 2005. Japan established the RNAV Roadmap version 2 in 2007 based on ICAO PBN manual and started the RNAV operations that meet global standards first in Asia in 2007. In November 2009, Japan partly amended the RNAV Roadmap version 2 and moved forward the original implementation schedule by one year in order to facilitate the RNAV implementation in Japan.

1.2 According to the RNAV Roadmap version 2 partly amended in 2009, Japan will complete the RNAV implementation for almost all domestic city pairs by 2011 and is planning to reduce the total flight distance by 2%.

1.3 The RNAV Roadmap version 2 (partly amended) is shown in appendix.

2. CURRENT STATUS OF RNAV IMPLEMENTATION IN JAPAN

2.1 Japan has implemented 88 RNAV 5 routes for en route, RNAV 1 SID/STAR in 21 airports and RNAV(GNSS) approach and RNP APCH in 15 airports.

2.2 Japan is planning to introduce RNP AR APCH from 2010 and Basic RNP 1 at non-radar airports in a near future. Furthermore, Japan is updating the MSAS, which is Japanese SBAS system, and is planning to introduce the APV-I in FY2013 and the LPV 200 in FY2014.

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Appendix

RNAV Roadmap in Japan
Version 2
(Partly Amended)

April 2007

(partly amended in November 2009)

1. Background

Future demands on aviation

It is expected that future demands on aviation in Japan (both international and domestic) will continue to increase, despite temporary stagnation due to events such as the Severe Acute Respiratory Syndrome epidemic. In particular, the demand on aviation operations between Japan and Asia is expected to vastly increase due to the economic expansion occurring in China and Southeast Asian countries. To cope with this situation in Japan, airport capacities are being expanded. For example, the New Chubu International Airport (Nagoya) opened in February 2005; and the number of runways will increase at Kansai International Airport with the completion of Phase 2 of the Kansai International Airport Project in August 2007. Finally, the Further Expansion Project for Tokyo International Airport will be completed in October 2010. The challenge is to establish a new air traffic system that enhances airspace capacity to cope efficiently with the projected increase in aviation demand, while also ensuring safe and efficient operations into the future.

Operational efficiency

Given the recent surge in fuel prices, economics require improvements in the efficiency of aircraft operations in all phases of flight (en route, arrival, approach and departure). The challenge is to meet the need for more efficient operations, while also accommodating increased demand and ensuring safety.

Environmental issues

Recently, environmental issues are becoming of greater importance. To help prevent global warming, aircraft operations need to produce fewer emissions of greenhouse gases (CO_2, etc.). Operating at reduced noise levels has also become an important requirement. To allow operations to meet both of these goals, it is necessary to establish more efficient flight paths (e.g., shorter distances with better climb and descent profiles) that do not pass over populated or other environmentally sensitive areas, especially during departure and arrival.

2. Area Navigation (RNAV)

RNAV

With RNAV, route creation becomes more flexible, as it is no longer constrained by the geometry or availability of ground-based radio navigation aids such as VOR/DME. This opens the possibility of shortening routes, or with the use of advanced Required Navigation Performance (RNP) standards placing routes closer together laterally than has previously been possible. Recently, many aircraft have acquired advanced navigation capabilities, having been equipped with a GPS receiver and high performance Flight Management Systems (FMS) that include an airborne computer for navigation. The number of such aircraft is expected to continue to increase into the future. The introduction of RNAV-based navigation procedures (presupposing such advanced aircraft navigation capabilities) is ongoing in Europe and the United States. The International Civil Aviation Organization (ICAO) is also working on the formulation of international criteria and guidance.

Status of RNAV operations in Japan

In 1992, RNAV test operations started with three RNAV routes. In 1995, provisional working standards for RNAV were established, and the operations progressed with an RNAV evaluation, identifying those aircraft that met the necessary standards. In June 2002, RNAV operations were formally initiated in Japan. Sixty RNAV routes have since been established (as of March 2007). In May 2006, Conditional ATS Routes (CDR) based on RNAV procedures were set up in training/testing areas. The Conditional ATS routes are only available for operators during a time period in which no training or testing flights were conducted.

RNAV procedures using FMS in terminal areas started in March 1999 at Tokyo International Airport, targeting midnight arrivals. In September 2004, additional RNAV arrival routes were set up at five other airports (Hakodate, Osaka, Takamatsu, Fukuoka, and Kagoshima). In January 2005, RNAV approach procedures requiring GPS were established at Shin-Chitose, Hakodate, and Naha Airports. In October 2006, a Baro-VNAV approach (which provides vertical guidance utilizing a barometric altimeter and FMS) was set up at Shin-Chitose, Hiroshima, and Naha Airports.

3. Benefits of RNAV and Global Harmonization

In order to cope with increases in air traffic, airspace capacity and the number of aircraft that can be handled by one controller must be increased. However, the development of a procedure or system that will ensure both safety and efficiency cannot be accomplished with a single operational change. It is necessary to take an approach that considers the overall system, taking into account the use of procedures such as Reduced Vertical Separation Minima (RVSM) and increasing the number of available routes to increase the airspace capacity; possible restructuring of airspace (e.g., reviewing Area Control Center [ACC] sectors and terminal areas, etc.); improving air traffic management; and introducing tools that will increase the number of aircraft that can be handled by each controller. Because RNAV allows a more flexible route system to be set up, route lengths may be shortened. In addition, it becomes easier to establish airspace and routes that provide a smoother and more efficient control service. Also, by specifying navigation performance, such as navigation accuracy, it will be possible to reduce the spacing between neighboring air routes, making operations more efficient and increasing the airspace capacity.

The current RNAV procedures that have been introduced for en route, terminal and approach procedures in Japan use only part of the full navigational and functional capabilities of many RNAV-equipped aircraft. Navigation accuracy is not specified for the current RNAV routes in Japan. Considering the advanced navigation performance of modern aircraft, the current RNAV procedures in Japan provide only part of the potential benefits. Operating procedures need to be drawn up for the introduction and development of RNAV, and routes need to be set up that make use of the advanced navigation performance of modern aircraft so that more benefits can be provided from the RNAV procedures. It is particularly important to ensure that navigation performance and functional requirements are established in order to comply with international guidance.

Aircraft that do not meet the requirements for the new RNAV procedures are expected to continue flying, so there will be a period during which aircraft that meet the new requirements must coexist with aircraft that do not. In establishing the new RNAV procedures with specific navigation performance and functional requirements for Japan in accordance with international guidance, accommodations for those aircraft that do not meet the requirements should be considered.

4. Challenges

Increasing demands

En route: Measures must be introduced to increase both airspace capacity and the number of aircraft that can be handled by individual controllers without increasing workload. Candidates for achieving this include: RVSM and/or double-or-quadruple-tracking of routes, re-structuring of airspace, improving air traffic management, and introducing tools to assist air traffic controllers that can increase the number of aircraft handled by a controller without increasing their workload.

The present route network in Japan is a mix of airways that are connected by ground-based navigation aids such as VOR (VOR routes) and RNAV routes. These mixed routes have created complexity for ATC and increased controller workload at specific points. In order to increase the number of aircraft that can be handled by each controller, the ATC complexity caused by the mixed operation must be removed, and measures to reduce controller workload should be introduced. This was the reason for planning and development of the Sky Highway Project, which will separate flights on the VOR routes and RNAV routes operationally at 29,000 feet.

About 100 flights operate between Tokyo and Shin-Chitose and between Tokyo and Fukuoka each day. These are among the busiest city-pairs in the world. For the main domestic airways such as Tokyo/Shin-Chitose and Tokyo/Fukuoka, capacity needs to be increased by double-tracking or, if possible, quadruple-tracking associated with introducing RNAV and RNP routes that would reduce the width of the corridors between neighboring airways. Even at altitudes below 29,000 feet, for routes connecting to departure and arrival procedures and medium distance routes, the airspace capacity will be increased by introducing RNAV and RNP routes that allow double-tracking or, if possible, quadruple-tracking.

Terminal Areas: Although flights enter a terminal area from more than one direction, they must all finally converge onto courses that correspond to landing runways. This is the reason that simply developing RNAV routes alone cannot drastically increase the airspace capacity at busy airports such as Tokyo. However at airports that are not as busy, or during quieter times at busy airports, introducing RNAV and RNP with navigation performance and functional requirements can increase the airspace capacity as aircraft can more precisely fly along the published routes, especially in turns. For midnight flights at Tokyo International Airport in particular, RNAV can allow aircraft to fly ground tracks that better avoid noise sensitive areas, resulting in an increase in the number of aircraft that can be handled at night. For busy airports, the airspace capacity can be increased by restructuring the airspace, improving air traffic management, and introducing new controller tools, as well as developing RNAV routes.

In the future, most aircraft are expected to have the capability for advanced RNAV and RNP that includes a time of arrival control (TOAC) function. Aircraft can then pass over a specific point on the route precisely at the time directed by the controller. Hence, longitudinal separation can be maintained by the aircraft system, keeping separation to the minimum needed for efficiency while also ensuring safety. This allows the capacity of the air traffic system as a whole to increase without necessarily increasing controller workload.

Efficient operations

In order to improve operating efficiency, both en route and terminal operations must be systematically taken into account when developing routes. Because RNAV allows the establishment of routes that are not anchored to the location of ground-based navigation aids, routes for departures and arrivals in terminal areas could be more easily shortened than in en route areas, since departure and arrival routes may involve many turns depending on the location of these navigation aids. Therefore, the development of RNAV within terminal areas should be a priority.

En route: For Japanese domestic airspace above 29,000 feet, RNAV routes need to be established to increase operational efficiency. The Sky Highway Project will separate VOR routes and RNAV routes operationally at 29,000 feet. Even in airspace below 29,000 feet, for routes connecting departure and arrival procedures and medium distance routes, RNAV routes will be designed to increase operational efficiency as well. Conditional ATS route (CDR), which go through training/testing areas, are expected to shorten flight distances significantly and increase operational efficiency; therefore more CDRs will be published after discussions with the organizations involved.

Terminal Areas: RNAV departure and arrival routes can be made shorter than routes that use VOR and other ground-based navigation aids. Analysis and coordination for the establishment of RNAV departure and arrival routes should begin immediately so the benefits from RNAV operations can be provided to operators as soon as possible. Operations on the published RNAV routes can reduce the amount of communication required between the pilot and the controller significantly, and thus reduce their workload, resulting in an improvement in safety while also increasing the airspace capacity. To shorten the routes to the maximum possible extent, arrival routes will be connected directly to the approach phase. To minimize fuel consumption, the routes will be designed so that an optimized profile descent can be made using the aircraft's FMS. For airports without Airport Surveillance Radar (non-radar airports), RNAV could be very effective in shortening routes. In response to requests from operators, RNAV procedures will be developed at non-radar airports as soon as possible.

For the approach phase, most airports in Japan with runways over 2,000 meters are equipped with an ILS. However, due to limitations such as terrain and noise sensitive areas, only five airports (Shin-Chitose, Narita, Kansai, Chubu, and Fukuoka) allow a straight-in precision approach with ILS at both runway ends. At those runway ends where a straight-in precision approach with ILS is not possible, a study for RNP Authorization Required (AR) approaches, which allow the use of an RF turn (a constant radius turn passing through two waypoints) and the application of smaller RNP values in the final segment, should be conducted in order to improve the flight service rate (runway access) and safety.

In response to requests from operators and to make operations more effective in general, a planned expansion at Tokyo International Airport will help to accommodate the expected large increase in traffic. Plans include the development of RNAV routes that take into account the return of the Yokota airspace to Japan along with the restructuring of the Tokyo and Narita airspace.

Environmental impact

With the improvements in operational efficiency that result from shortening published routes, greenhouse gasses (CO_2, etc.) will also be reduced over all routes including en route, terminal, and approach procedures. Departures, arrivals, and approach procedures will be developed to reduce noise exposure by avoiding populated areas and other noise sensitive areas. Overall, noise levels may increase, especially at Tokyo International Airport with the increase in traffic expected after the scheduled expansion; however, implementation of RNAV and RNP operating procedures that take advantage of the more advanced features of FMS will prevent any increase in noise exposure.

5. Implementation

The implementation of RNAV will fall into three phases.

- *Short-term:*
  Early achievement of improvements in operational efficiency by introducing RNAV that meets globally harmonized standards.
- *Medium-term:*
  Improvements in operational efficiency by increasing the airspace capacity step by step in response to the Phase 2 Project at Kansai International Airport and the Further Expansion Project at Tokyo International Airport.
- *Long-term:*
  Direction for future RNAV and RNP operations for Japan.

The RNAV routes, Conditional ATS routes, and terminal RNAV routes using FMS currently published in the Japan Aeronautical Information Publication (AIP) are to be changed to routes based on the guidance shown in the ICAO Performance Based Navigation Manual (ICAO PBN Manual). Newly established RNAV routes will also be based on the guidance shown in the manual.

Because most IFR operations in Japan consist of scheduled airline services, it will be more effective to introduce RNAV on a route (city pair) basis rather than on an airport basis. In order to ensure that RNAV contributes to operational efficiency as soon as possible, the priority will be given to first introduce RNAV on busy city pairs and those routes serving the largest number of passengers.

Since it is important to construct a route network that will be able to handle the increase in traffic resulting from the expansion of Tokyo International Airport, priority will be given to the development of RNAV routes to airports that form the main domestic network and are equipped with Airport Surveillance Radar. RNAV routes will be implemented to and from all these airports by fiscal year 2010.

Short-term (by the end of FY 2007)

En route: Existing RNAV routes are to be changed in 2007 to routes based on the RNAV 5 standards set out in the ICAO PBN Manual. Routes should be restructured, where necessary. New RNAV routes are to be based on the RNAV 5 standard. Operational requirements for RNAV 5 are to be determined with reference to the ICAO PBN Manual. Route design criteria for RNAV 5 routes are to be determined by referring to ICAO PANS-OPS and the ICAO PBN Manual.

For the main routes, including Tokyo/Shin-Chitose and Tokyo/Fukuoka, double-tracking or, if possible, quadruple-tracking of RNAV routes with narrower corridors between neighboring routes are to be set up to increase the airspace capacity and improve the operational efficiency. On double-tracked or quadruple-tracked routes, the width is to be reduced from the existing 20 NM to 10 or 15 NM. Moreover, one-way traffic flow is to be widely introduced to improve the operational efficiency and increase the number of aircraft that can be handled without increasing the controller’s workload. Track-to-track spacing is to be reduced taking into account the traffic configuration and controller’s workload, based on the safety assessment set out in ICAO Annex 11.

Conditional ATS routes that were set up in May 2006 and pass through training/testing areas can significantly shorten the flight distance. In response to many requests from operators to increase the development of such routes, coordination is to be increased with the organizations involved. Conditional ATS routes are to be based on the RNAV 5 standards.

Because traffic between China and Japan and between the Republic of Korea (ROK) and Japan is expected to increase significantly, active coordination with both countries is necessary to develop RNAV routes that can increase the airspace capacity. RNAV routes between China, Taiwan, ROK and Japan are to be based on the RNAV 5 standards so that global harmonization is ensured.

Departures and Arrivals: Existing terminal RNAV routes are to be changed in 2007 to routes based on the RNAV1 standards set out in the ICAO PBN Manual. New RNAV departure and arrival routes are also to be based on the RNAV 1 standards. Operational requirements for RNAV 1 are to be determined with reference to the ICAO PBN Manual. Procedure design criteria for RNAV 1 routes are to be determined by referring to the ICAO PANS-OPS and ICAO PBN Manuals.

In response to requests by operators, RNAV departure and arrival routes are to be set up to improve operational efficiency, so that they may be shorter than VOR departure and arrival routes at radar airports. It is important to increase the number of aircraft that can be handled and improve traffic flow control without increasing the controller’s workload. To achieve this objective, aircraft that do not meet the RNAV 1 standards (non-capable aircraft) will be requested to fly on VOR/DME routes, whereas aircraft that meet the RNAV 1 standards (capable aircraft) are to fly on RNAV routes in general. Radar vectoring and/or clearances for short-cut flights (flying directly to the next fix) for non-capable aircraft will be issued taking into account the traffic situation.

Flying on the published routes in the Japan AIP enables the aircraft to enter ACC sectors or the terminal area of the destination airport at a more precise time. This makes it possible to maintain ordinary traffic flows and the sector capacity calculated by the ATM center. Flying on published routes also allows a reduction in the amount and frequency of communications required between pilot and controller. This makes it possible to reduce the workload for both pilot and controller compared to flights controlled by radar vectoring, resulting in improvements in safety.

Approaches: RNAV (GNSS) approaches are to be widely developed at radar airports. Baro-VNAV approaches are to be developed at more airports. This will contribute significantly to improving safety because it reduces the pilot's workload, and prevents Controlled Flight Into Terrain (CFIT). In order to improve the flight service rate to airports where ILS is not installed due to geographical limitations, studies for the introduction of RNP AR approaches with RF turns and high navigation accuracy are to be conducted.

Medium term (FY 2008 – 2011)

En route: RNAV routes are to be developed during 2008 to 2010 mostly in coordination with the restructuring of the Kanto airspace (Tokyo and Narita Terminal areas). RNAV routes are to be established on a city pair basis, and RNAV operations from departure to arrival are to be available at major city pairs by 2010. RNAV operations are to be available by the end of fiscal year 2012 at local airports, including non-radar airports.

The Sky Highway Project, which will separate VOR routes and RNAV routes over a specified altitude, is to be fully implemented at a suitable time in fiscal year 2010 along with the Further Expansion of Tokyo International Airport. VOR routes themselves are to be set up without any upper limitation. The Sky Highway concept will be realized by not allowing use of VOR routes at an altitude over 29,000 feet. For routes connecting departure and arrival routes at Tokyo and Narita Airports and medium range airways, double-tracking or, if possible, quadruple-tracking is to be developed to increase airspace capacity and improve operational efficiency.

Studies for RNAV routes between China and Japan and between ROK and Japan for which an increase in capacity can be achieved are to be conducted. One-way traffic with double-tracking and separating flights in each direction by altitude is to be developed on these routes.

Development of new VOR routes is to be minimized. Existing VOR routes and routes for which demand is low because of the development of a direct route are to be abolished after coordination with operators.

Departures and Arrivals: Consistent RNAV operations from departure to arrival are to be developed. RNAV operations from departure to arrival are to be available at major city pairs, including routes to and from Tokyo International Airport, by fiscal year 2010. RNAV operations are to be available at local airports, including non-radar airports, by the end of fiscal year 2012. For routes on which RNAV becomes available, radar vectoring should be avoided as much as possible, and procedures should be adopted to allow flights on published routes in the Japan AIP. This operation will maintain the volume of traffic that the ATM Center has calculated.

For non-radar airports, arrival routes based on RNAV 1 standards are to be developed so as to connect with the existing approach procedure within the coverage of Air Route Surveillance Radar. Similarly, departure routes based on RNAV 1 standards are to be developed within the radar coverage that connect with the existing departure procedure using VOR/DME, etc. Studies for development of departure and arrival routes based on the RNP 1 standards that can be established in non-radar airspace are to be conducted. Routes that already exist for non-radar airports based on the RNAV 1 standards are to be changed to routes based on the RNP 1 standards. Those routes are to be restructured, where necessary.

Studies for development of RNAV routes that can help to reduce noise levels are to be conducted so that they can be introduced at airports where significant benefits can be expected, such as at Tokyo International Airport at midnight. Implementing RNAV arrival routes that allow a profile descent is expected to improve operational efficiency in the descent mode.

Approaches: RNP approaches utilizing GNSS are to be widely developed for both radar airports and non-radar airports. This will allow an almost straight-in approach that leads the aircraft without basic turns from the end of the RNAV arrival route to the closest point to the runway, to increase operational efficiency. RNP approaches that can be used jointly with Baro-VNAV are to be developed. RNP AR approaches are to be introduced to airports where benefits can be expected, taking into account the percentage of capable aircraft and the operational merits.

Long-term (FY 2012 – 2018, and beyond)

En route: Routes based on the RNAV 5 standards are to be changed gradually to routes based on RNP 2. This aims to construct a nationwide route network in Japan based on RNP that can achieve a higher level of operational efficiency. 4D-RNAV navigation and ATM are to be linked closely to achieve higher operational efficiency from departure to arrival. This is aimed at achieving a higher overall level of traffic control. The aim is to mandate RNP 2 for airspace over 29,000 feet and route segments that connect the airways to the departure and arrival routes at busy airports.

Departures and Arrivals: Departure and arrival routes that are designed based on the RNAV 1 standards at airports with traffic above medium level are to be changed gradually to routes based on RNP 1, which will require a higher level of navigational performance and FMS functionality enabling the achievement of a higher level of operational efficiency by closely linking 4D-RNAV and ATM. For busy airports, the aim is to mandate RNP 1 with a higher level of navigational performance and FMS functionality.

Approaches: APV is to be introduced along with improvements in GPS performance. RNP AR approaches are to be developed for the major airports to improve the flight service rate and safety. The aim is to mandate RNP AR approaches capability for airports where an increase in airspace capacity and a reduction in noise levels on approach can be expected.

6. Other Areas Relating to RNAV

Oceanic areas: Oceanic routes where 50 NM longitudinal separation minimum based on RNP 10 is applied are to be expanded, in addition to the North Pacific Routes, on which such minimum was introduced in July 2006. Oceanic routes outside the North Pacific and the Central Pacific, including those in the direction of Guam and Oceania, are to be restructured gradually to routes with 50 NM lateral separation minimum based on RNP 10, taking into account the percentage of capable aircraft.

30 NM longitudinal separation minimum based on RNP 4 will be introduced to increase the airspace capacity, taking into account the percentage of capable aircraft and controller experience. Following the introduction of the 30 NM longitudinal separation minimum, 30 NM lateral separation minimum based on RNP 4 will be introduced and oceanic routes will be gradually restructured. In the future, RNP 4 is to be mandatory for North Pacific Airspace and Central Pacific Airspace. The aim is to introduce 30 NM longitudinal and lateral separation minima based on RNP 4 for all oceanic ATS routes within the Fukuoka FIR.

Airports on remote islands: Regarding RNAV procedures for non-radar airports on remote islands that have low levels of traffic, RNAV 5 routes will be established for en route segments, and RNAV 1 departures and arrivals will be established within the coverage of Air Route Surveillance Radar starting from fiscal year 2007. The RNAV 1 routes are to be set up so as to connect them to RNAV approaches utilizing GNSS or existing approach procedures utilizing VOR within radar coverage. In the future, RNP 2 routes will be established for en route segments and RNP 1 departures and arrivals will be established. These RNP 2 and RNP 1 routes will enable continuous operation from departure to cruising and from cruising to arrival, even when out of coverage of air route surveillance radar.

Withdrawal of VOR stations: A general plan to gradually withdraw VOR stations is to be prepared, taking into account the progress of RNAV operations and the necessity for radio navigation aids (VOR). Withdrawal of VOR stations will commence beginning in fiscal year 2012 when RNAV has been well-established. The aim is to reduce the number of VORs by half by fiscal year 2023. This plan is to be reviewed as necessary. Withdrawal is to be done after coordination with operators.

Approach procedures using satellites: Approach procedures that use satellite-based navigation such as SBAS or GBAS are to be studied. The aim is to introduce the most suitable approach procedures that use satellite-based navigation for airports in Japan.

RNAV routes for GA aircraft: The possibility of establishing RNAV routes for general aviation (GA) aircraft that fly at low altitudes will be studied. In order to enable operations at low-altitudes, the study should include the availability of air navigation systems, such as communication, navigation, and surveillance, as well as ATC considerations.