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International Civil Aviation Organization

THIRD MEETING OF (ADS-B) STUDY AND IMPLEMENTATION TASK FORCE (ADS-B TF/3)

Bangkok, 23-25 March 2005

Agenda Item 7: Any other business

COST/BENEFIT STUDIES - CITY PAIR 2: HONG KONG, CHINA - TOKYO, JAPAN

(Presented by Japan)

SUMMARY

This paper is an updated version of ADS-B-SITF/WP/14 submitted in October 2004, in which the Cost/Benefit studies for City Pair 2: Hong Kong, China - Tokyo, Japan are described.

1. Introduction

1.1 This cost benefit study will be conducted for the flights between Hong Kong and Tokyo on the assumption that ADS-B is implemented. This WP introduces additional assumption that some radar stations could be replaced with ADS-B ground stations from 2018. Based on the assumptions and the methodology written in this WP, CBR (Cost Benefit Ratio) will be calculated in the future work.

1.2 In this study it is assumed that the evaluation period for this CBA is 20 years from 2011 to 2030 in consideration for the lifetime of ADS-B ground infrastructure and the gradual increase of airborne equipage.

2. Assumptions for this CBA

2.1 Environment

2.1.1 Route

The typical route from Tokyo (Narita International Airport) to Hong Kong International Airport is shown in figure 1. As shown in this figure, the route is completely in radar coverage.

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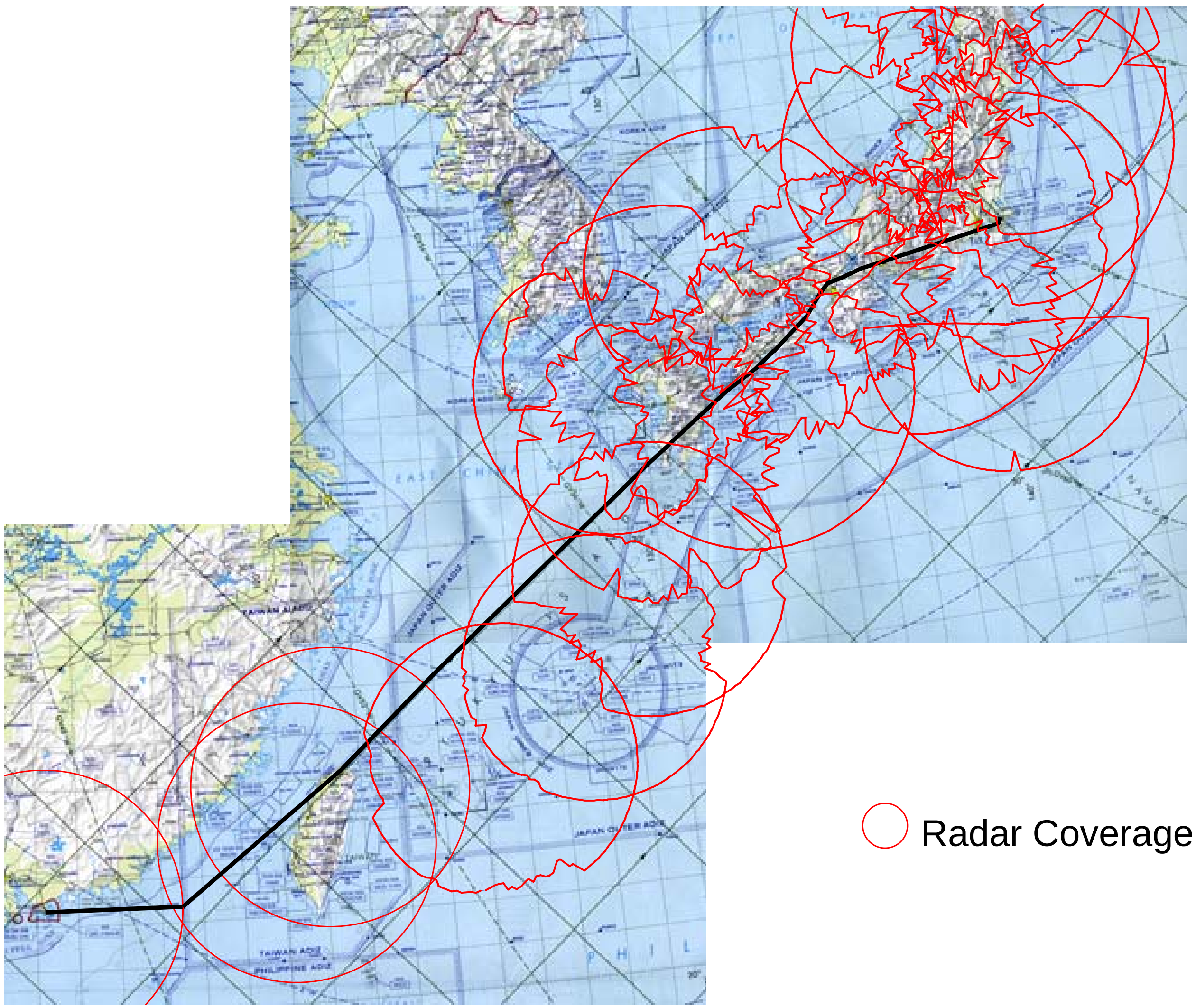

Note: Radar coverage of Hong Kong FIR and Taipei FIR shown in this figure is not accurate.

Figure 1. Typical route from Tokyo to Hong Kong

2.1.1 Infrastructure

(1) Airport surface

ASDE is the only surveillance sensor for ATC at Narita International Airport today. Since multilateration system and ADS-B ground stations might be installed at Narita International Airport in the future, it is assumed that the fusion function of the data from these 3 sources (ASDE, multilateration, and ADS-B) is implemented to the airport surface surveillance system within this study. At Hong Kong International Airport it is assumed that ASDE is the only surface surveillance sensor in this study because there is no plan to implement new surveillance sensor at the airport.

(2) Terminal and en-route

2 sets of PSR/SSR are installed at Narita International Airport to acquire the surveillance data in the terminal airspace. One of them is for operational use, and the other is for backup purpose. As Japan Civil Aviation Bureau (JCAB) has no plan to implement ADS-B for the terminal airspace, it is assumed that the radars (PSR/SSR) are the only way to provide the surveillance data of the terminal area. The same assumption is applied for the terminal area of Hong Kong International Airport.

The en-route airspace which the flights between Tokyo and Hong Kong pass through is completely covered by radars. Although <u>Air Navigation Service Providers (ANSPs) of this area</u> have no plan to implement ADS-B, it is assumed in this study that some radar stations in Japan could be replaced with ADS-B ground stations after the lifetime, which is about 15 years, of the new SSR mode S deployed from 2003. It means that replacement of radars with ADS-B ground stations are assumed to start from 2018 gradually. It is also assumed in this study that downlinking FMS parameters using SSR mode S data link, which is similar to the European Enhanced Surveillance using SSR mode S data link will have been already introduced in 2018 in Japan.

It should be noted that these are just assumptions to conduct the cost/benefit analysis. Government of Japan has no plan to replace radars with ADS-B at present. Except for Tokyo and Naha FIRs, it is assumed that the radars are the only way to provide the surveillance data of the en-route airspace.

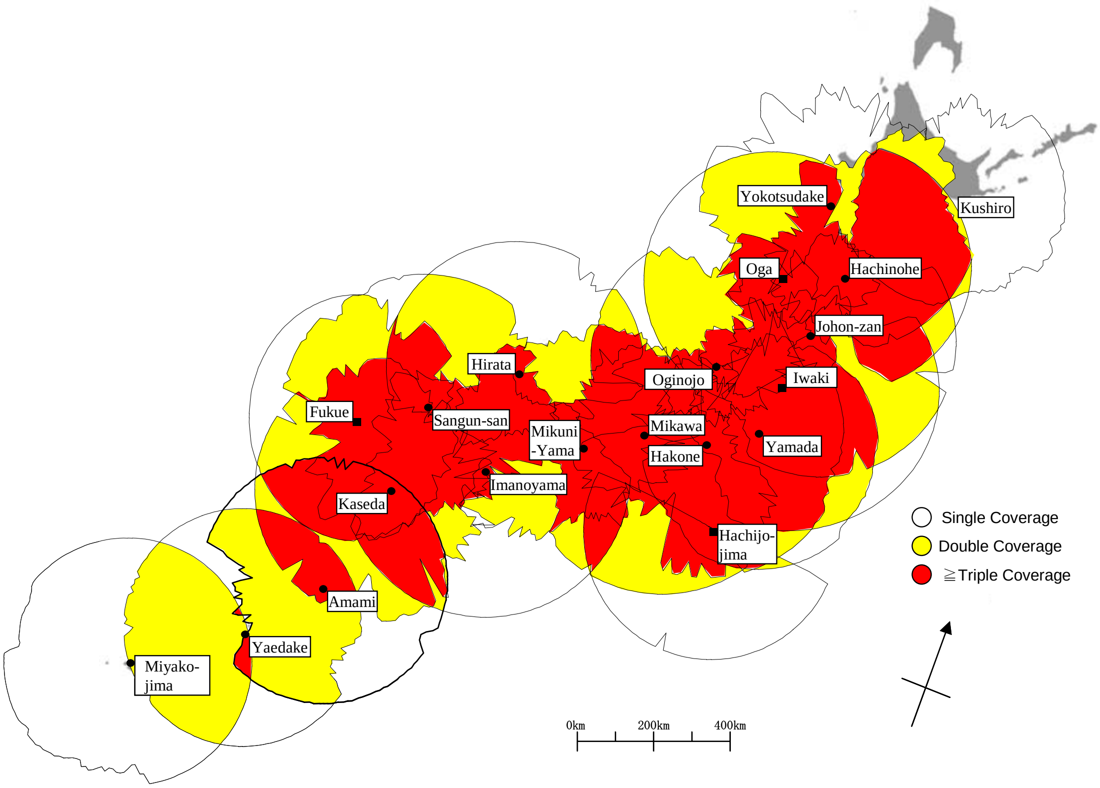

Figure 2. Current surveillance (radar) coverage (– 2018)

At present, 20 en-route radars are implemented to assure at least double coverage of radars for en-route airspace in Tokyo and Naha FIRs (See figure 2). It is assumed in this study that this double surveillance coverage could be realized by both radar and ADS-B, and also assumed that at least single radar coverage is required to assure the reliability using non-dependent surveillance technique. Under these assumptions, 8 existing en-route radars[1] could be replaced with ADS-B ground stations from 2018. In this case, although total surveillance coverage will be same as current radar coverage (See figure 3), the radar coverage becomes smaller as shown in figure 4.

[1] 2 radar sites (Oga and Hachinohe) are not related to the route between Tokyo and Hong Kong.

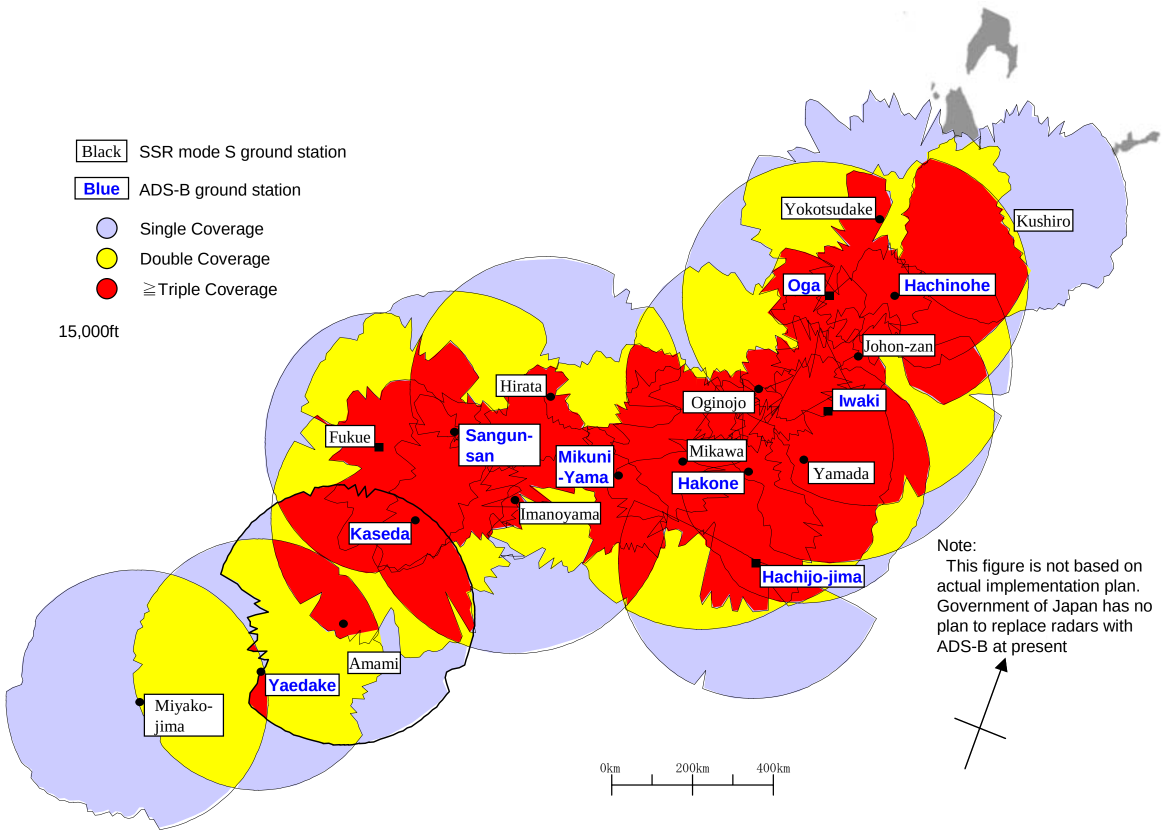

Figure 3 Total surveillance coverage (2030)

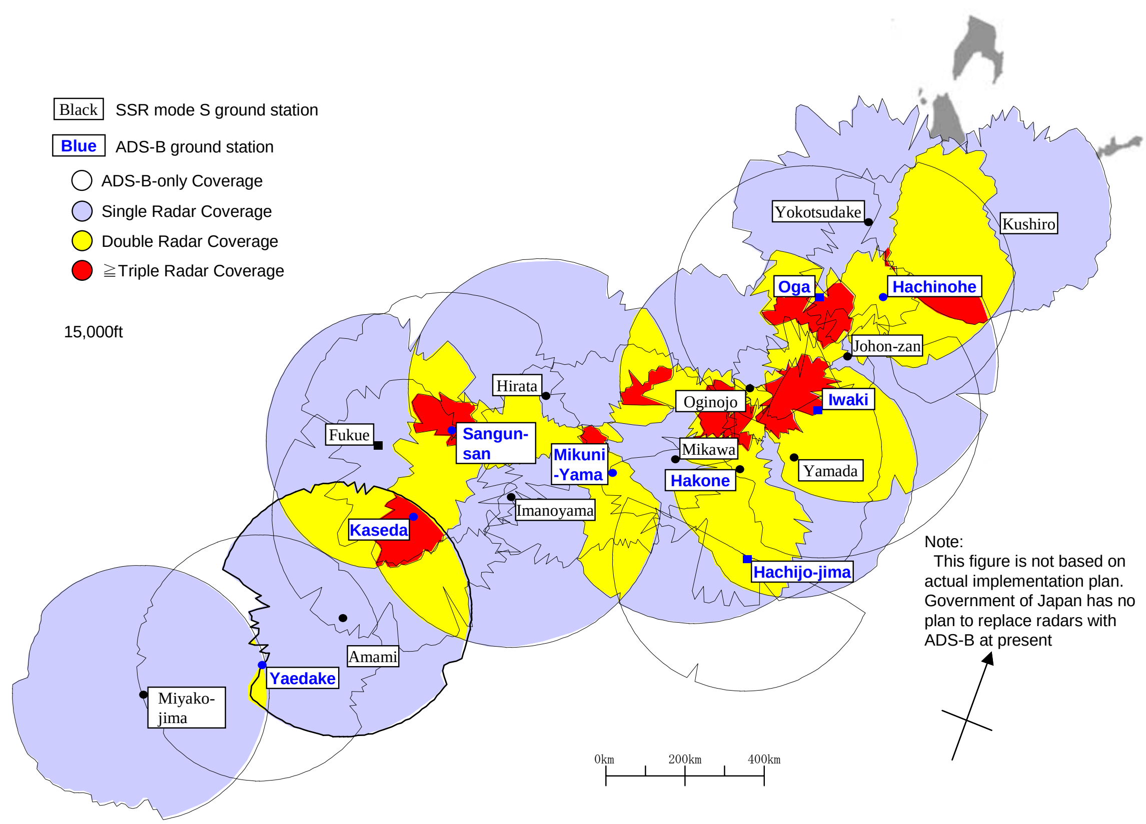

Figure 4. Radar-only coverage (2030)

It should be noted that the mandate to equip ADS-B out for aircraft operating en-route airspace must be required when some radars are replaced with ADS-B ground stations.

(3) ATC automation systems

It is assumed that RDP (Radar Data Processing System) could have been already enhanced by 2018 to enable to process downlinked parameters from FMS via mode S data link and ADS-B out. It is also assumed that multi-sensor tracking capability, including ADS-B information, could have been already implemented for RDP within the periodical system update cycle. It means that the cost of RDP system modifications is not taken into consideration in this study.

ARTS (Automated Radar Terminal System) is processing the terminal radar data to provide air traffic situation pictures for the controllers at Narita International Airport today. It is assumed that ARTS is upgraded to process both terminal radar data and surface surveillance data which is acquired by ASDE, multilateration and ADS-B at Narita in this study.

It is also assumed that TIS-B is installed in Narita International Airport in this study. TIS-B will provide benefits to CDTI equipped aircraft in early stage.

2.1.2 Equipage

It is assumed that 10% of the aircraft on the surface of Narita Airport are equipped 1090MHz extended squitter ADS-B out in 2007 because of the mandatory of mode S Elementary Surveillance and Enhanced Surveillance in the European airspace. (This means that about 10 % of aircraft at Narita fly to Europe.) It is assumed that the equipage will increase gradually from 2007 at a certain growth rate.

It is assumed that no aircraft will equip ADS-B in and CDTI in 2007 and that the equipage will increase gradually from 2007 at a certain growth rate.

2.1.3 Operation

ADS-B will be applied to the following operation to the flight between Tokyo and Hong Kong.

- En-route ATC surveillance （supplement SSR mode S）
- CAP (Controller Access Parameters) and SAP (System Access Parameters) services for en-route controllers. (almost same as mode S DAPs)
- Airport surface surveillance at Narita International Airport (ATC and the airport authority)
- Airport surface operation at Narita International Airport (flight crew)
- Airborne traffic situational awareness (en-route and terminal)

2.1.4 Traffic volume

According to "ICAO DIGEST OF STATISTICS No.518 (2002)", the traffic volume between Tokyo and Hong Kong is shown in table 1. The prediction of future traffic increase is not considered in this study.

Table 1. Traffic volume between Tokyo and Hong Kong

		Tokyo – Hong Kong	Hong Kong – Tokyo
Total revenue passengers carried		753,038	725,126
Total revenue tonnes of freight and mail		67,863	106,961
Total number of flights		4,553	4,395
Breakdown	EA34	67	66
	EA33	632	632
	EA30	122	123
	DC10	47	47
	MD11	177	178
	B767	505	503
	B747	2,492	2,335
	B777	511	511

The annual number of flight movements at Narita Airport is 176,365 in FY2003. (This value includes both departure and arrival flights.)

3. Calculation of the cost

3.1 Cost factors

The following cost factors are assumed.

- Cost to equip ADS-B out x the number of equipped aircraft (except for aircraft which already equip ADS-B out by 2010), which include installation, modification, certification cost
- Cost to equip ADS-B in and CDTI x the number of equipped aircraft, which include installation, modification, certification cost
- Reduced initial cost to replace radars with ADS-B ground stations, which is about US $ 48M.
- Reduced running cost to replace radars with ADS-B ground stations, which is about US $ 5M/year.
- Installation cost of ADS-B ground receivers at Narita International Airport
- Installation cost of data fusion processor at Narita International Airport
- Modification cost of ARTS at Narita International Airport
- TIS-B system development cost
- Maintenance cost of ground infrastructure
- Development cost of airport surface map of Narita International Airport

3.2 Estimation of cost

Total cost in each year will be estimated based on 3.1 in the future work of this study. It should be noted that the cost implementing/maintaining ADS-B ground stations located far from the route between Tokyo and Hong Kong is excluded from the estimate in this study.

4. Estimation of benefit

Following benefit will be estimated in the future work of this study.

4.1 Benefits of improving airport surface surveillance (ATC and airport authority)

Benefits of improving airport surface surveillance are,

- to improve controllers' traffic situational awareness, especially under low visibility conditions when ASDE can not be used.
  - Improving safety (prevention of runway incursion, conflict resolution at taxiway crossings, conflict avoidance between aircraft and ground vehicles)
  - Improving efficiency (controllers' efficient instructions based on the surface surveillance data, efficient operation referring the identification shown with each target, provision of more accurate traffic information to flight crews, confirmation of the vehicle's action for the corresponding controller's instruction, provision of more appropriate instructions to flight crews and vehicle drivers)

4.2 Benefits of improving airport surface operation (flight crew)

Benefits of improving airport surface operation are,

- to improve flight crews' traffic situational awareness
  - Improving safety (prevention of runway incursion, conflict resolution at taxiway crossings, avoidance of conflict with ground vehicles)
  - Improving efficiency (Reduction of taxing time)

4.3 Benefit of enhanced airborne traffic situational awareness

Benefits of enhanced airborne traffic situational awareness are,

- Improving safety (more efficient manoeuvre because of flight crews' better awareness of surrounding traffic).
- Improving efficiency (more efficient aircraft trajectory, workload reduction for both ATC and flight crews, decrease radio frequency load, Reduction of TCAS RA)

4.3 Benefit of replacing some existing SSR mode S radars with ADS-B ground stations

Benefits of replacing some existing SSR mode S radars with ADS-B ground stations are,

- Reducing implementation cost and maintenance cost (This benefit is already accounted in section 3 as a cost factor)
- As the different kind of sensors, radar and ADS-B, provide the surveillance data acquisition capability, improvement of the system reliability might be expected.

4.4 Example of estimating benefit

"Standard Inputs for EUROCONTROL Cost Benefit Analyses" is one of the useful documentation to conduct CBA. Table 2 is a part of standard inputs shown in this documentation. These values will be referred to conduct this study.

The cost benefit ratio (CBR) will be calculated using the following expression, where B_t and C_t stands for the benefit and cost of the t-th year respectively, n stands for the evaluation period, and i stands for the social discount rate. In this study, n is assumed 20 years from 2011 to 2030, and the social discount rate i is assumed 10-12% which is provided by The Asian Development Bank.

$$\frac{\sum_{t=1}^{n} B_t/(1+i)^{t-1}}{\sum_{t=1}^{n} C_t/(1+i)^{t-1}}$$

Table 2 Example of Standard Inputs data

Item	EUROCONTROL recommended value (2001 price levels)
Operational Values	
DELAY COSTS	€ 62 - € 89 per minute
PASSENGER VALUE OF TIME	€ 36 - € 46 per hour
CANCELLATION COST	€ 6000 per cancellation
DIVERSION COST	€ 4281 per diversion
RATE OF FUEL BURN	4.4 tonnes per flight
Accident-related	
VALUE OF AVOIDED FATALITY	Up to € 3.2 million
VALUE OF AVOIDED INJURIES	Minor injury: € 45,918 Major injury: € 622,338
Economic	
COST OF FUEL	Reference “Airline Business”
Environmental	
AMOUNT OF POLLUTANTS RELEASED BY FUEL BURN	CO_2: 3.149 kg per kg fuel H_2O: 1,230 kg per kg fuel $S0_2$: 0.84 g per kg fuel HC per 1000 tonne: 1.788 tonnes CO per 1000 tonne: 8.647 tonnes
COST OF POLLUTANTS	CO_2 (per tonne): € 31.6 H_2O (per tonne): € 8.8 NO_x (per kg): € 3.8

5. Conclusion

The cost benefit study for City Pair 2: Hong Kong, China - Tokyo, Japan will be conducted based on the methodology and assumptions described in this WP.

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