

**AERONAUTICAL SURVEILLANCE PANEL (ASP)  
( SURVEILLANCE AND CONFLICT RESOLUTION SYSTEMS PANEL (SCRSP) )**

**FIRST MEETING OF THE  
WORKING GROUP**

**Kobe, Japan, 6 to 15 November 2006**

**Agenda item 5.9.1 ICAO documents related to ACAS**

**ACAS II Operational Monitoring Report on the Effect of RVSM in Japan,  
Second report of 2006**

Presented by Yasuto Sumiya (ENRI)  
Prepared by Yasuto Sumiya (ENRI), Shigeru Ozeki (ENRI),  
Kenji Miyabe (JCAB) and Masayuki Shirakawa (ENRI)

**SUMMARY**

Most of commercial aircraft are equipped with TCAS II in Japan. All TCAS II aircraft have equipped with version 7 by January 2003. The RVSM (Reduced Vertical Separation Minima) started at 4 a.m. on 30 September 2005 (JST) in Japanese air space.

This paper presents the results of operational monitoring based on the TCAS questionnaire submitted by pilots. Especially, it reports the RA monitoring results from 1 January 2004 to 30 June 2006, focusing on the effect of introduction of RVSM.

**Reference:**

[1] Y.Sumiya, et al. " ACAS II Operational monitoring report on the effect of RVSM in Japan", SCRSP/WG-A IP/A/10-19, 5/06, presented in Montreal, May 2006

[2] M.Sumiya, et al. "Analysis of Altitude after the Implementation of RVSM", IEICE Technical Report SANE2006-84, July 2006

## 1. Introduction

In Japan, an operational evaluation of ACAS started from 1990. Since the ICAO SARPs of ACAS II were implemented from 9 November 1995, the evaluation was finalized on 3 January 1996 and the official operation of ACAS II started from 4 January 1996.

In addition to the start of the official operation, all civil turbine-engined aircraft registered in Japan having the maximum approved passenger seat capacity of more than 30 or the maximum take-off mass exceeding 15000 kg is required to be equipped with TCAS II from 4 January 2001. From 1 January 2005, all civil turbine-engined aircraft registered in Japan having the maximum approved passenger seat capacity of more than 19 or the maximum take-off mass exceeding 5700 kg is required to be equipped with TCAS II.

The logic version of the TCAS II is 6.04A or 7. The upgrade from version 6.04A to version 7 has begun since 2000. All TCAS II aircraft have equipped with version 7 by January 2003. The RVSM (Reduced Vertical Separation Minima) has been introduced at 4 a.m. on 30 September 2005 (JST) in Japanese air space.

Since it is important to observe the operational situation of TCAS II and to investigate the consistency between ACAS algorithms and the operation in the airspace introduced RVSM, flight crews are encouraged to report RAs as ever. The results based on the reports are summarized as follows.

## 2. Monitoring results

### 2.1. RA reports and RA events

The results of "RA report", which is written by flight crews, are shown as follows. Figure 1 shows the number of RA events and RA reports from January 1995 to June 2006. The number of the total RA reports is 3973 for this periods. The RA reports are categorized by each logic version in this figure. The number of "Ver.6.04A" is 2881 for 8 years, and that of "Ver.7" is 1092 for 6 years and a half year. Multiple RA reports may be submitted for one RA event. The number of RA reports decreases from 2001. However, it is possible that it turns to increase in 2005.

The number of RA reports after the implementation of RVSM is 218 for a year and 3 months. The average of RA number of each month after the implementation of RVSM increases compared with before that of RVSM in 2005. Thus, the trends must be watched in the future.

### 2.2. Classification of each item

Especially, the RA report from 1 January 2004 to 30 June 2006 is classified to investigate the effect of RVSM. The number of the reports is 635 for the periods. The statistical value of items after the implementation of RVSM in 2005 and 2006 is shown as "'05-'06R". The value of items before the implementation of RVSM is shown as the year.

#### 2.2.1. Flight Phases of ACAS II Aircraft

Figure 2 shows the number of RA reports classified by flight phases. After the implementation of RVSM, the percentage of "CRZ" and "APP/LDG" decreases compared with before the implementation of RVSM. The trends of the other phases after RVSM are almost same as before RVSM.

#### 2.2.2. ACAS II Aircraft Altitude

Figure 3 shows the number of RA reports classified by aircraft altitude. The altitude classification is mainly based on sensitivity level of version 7. The percentage of the RA reports of the high altitude after the implementation of RVSM, which is especially above 30000ft, increases compared with before the implementation of RVSM. The percentage of the RA reports below 10000ft decreases. The altitude trend may be concerned with the trend of the flight phase, which is the decrease of the percentage of "APP/LDG".

It is possible to change how to use the airspace after the implementation of RVSM [2]. Since the number of RA reports after the implementation of RVSM is less than before the implementation of RVSM, the trends must be watched in the future.

### 2.2.3. RA Types

Figure 4 shows the classification with RA types. "Preventive", "Monitor Vertical Speed" and "Maintain Vertical Speed" are classified as the preventive RA. In the classification, "Reduce Climb", "Reduce Descent" and "Adjust Vertical Speed", which have been classified as the corrective RA in past monitoring[1], are classified as the adjust RA. When the pilot checked "climb (CLB)" or "descend (DES)" in addition to "Preventive" and "Monitor Vertical Speed", the RA is classified as "Both". The corrective RA except the adjust RA is classified as the corrective RA in this monitoring.

The percentage of the adjust RA after the implementation of RVSM increases compared with before that of RVSM. The percentage of the preventive RA is hardly changeable before and after the implementation of RVSM.

Figure 5 shows the classification with the additional RA. Each percentage of "No comment" and "none" is about each 40 %. after the implementation of RVSM. Figure 5(b) shows the classification with the additional RA except "none" and "no comment". The percentage of the additional RA except them is almost the same as for the periods of investigation. The percentage of "Decrease" and "Reverse" after the implementation of RVSM decrease compared with before that of RVSM.

The trends must be watched in the future, because the percentage of additional RA except "none" and "no comment" is a little.

### 2.2.4. RA Necessity, Follow to RA and RA Consistency

Figure 6 shows the number of RA reports that pilots followed or didn't follow the RAs. The percentage in which pilots followed the RAs is increasing. It is about 98%.

Figure 7 shows the flight phases when pilot didn't follow the RA on version 7. The percentage of "APP/LDG" is above 50 % and it is the largest among 6 phases. In 2005, all flight phase is "APP/LDG" in 6 RA reports that pilots didn't follow the RAs.

In 2006, there are 2 cases that the flight phase is "APP/LDG" and 1 case that it is "CLB". In 2 case of "APP/LDG", one altitude are 1500ft , and another is 2000ft. One case is that there is no time of the operation for resolving intruder, another is that own aircraft go around after that.

The altitude in the case of "CLB" is 27500ft on the way of climbing to 28000ft. Since intruder is cruising at 29000ft, own aircraft was monitoring the intruder.

Figure 8 shows the number of RA reports in which pilots thought that RAs were necessary. The necessary RAs include the useful RAs or the RAs that are effective in the increase of situation awareness for pilot. The percentage of the unnecessary RAs after the implementation of RVSM decreases compared with before RVSM. Other trends are unchangeable before and after the implementation of RVSM.

Figure 9 shows the number of RA reports in which pilots thought whether RAs were consistent with ATC advice. The trend is unchangeable before and after the implementation of RVSM.

### 2.2.5. Altitude Deviation after Vertical Maneuver

There are 196 reports in which pilots have written the amount of altitude deviation for 2 years and a half year. Figure 10 shows the classified results about the altitude deviation. The percentage of the altitude deviation below 700ft is increasing. The percentage of the deviation is about 90% after the implementation of RVSM. There is 1 report that the altitude deviation is exceeding 1000ft after RVSM.

### 2.2.6. Intruder Aircraft's Types

Figure 11 shows the classification with intruder types. The percentage of "commercial" increases and those of "Military" and "Small Aircraft or G/A" decreases after the implementation of RVSM.

### 2.2.7. Unaccountable RA

Figure 12 shows the number of unaccountable RA reports. They include the RA reports that the flight crews thought it the false alarm. The false alarm means that ACAS operation is normal but the alarm is false because of reflection, signal interference or other reasons. The classification is executed mainly based on our judgment. The RA still reports a few percents in recent years.

### 2.2.8. Complementary Maneuver

Judging from the reported time, altitude and the position, 48 RAs are reported from both aircraft simultaneously for 2 years and a half year. Followings are the results of analysis on such complementary maneuver cases.

Figure 13 shows the relation between advisories. The combination of RA reports in which both RAs are complementary each other are that one RA is "DES" and another is "CLB" for 2 years and a half year. The percentage of the combination is 20% in 2004, 50% in 2005 and 37.5% after the implementation of RVSM. After RVSM, the percentage that one RA is "Corrective RA" and another is "Adjust RA" increases. Figure 14 shows the relation between the flight phases of both aircraft at the time of RA occurrence. The combination that one flight phase is "DES" and another is "CLB" is about 40 % and the trend is unchangeable before and after the implementation of RVSM.

## 3. Conclusion

In Japan, all turbine-engined commercial airplanes of a maximum certified take-off mass in excess of 5700kg or authorized to carry more than 19 passengers shall be equipped with an TCAS II from 1 January 2005. The upgrade from version 6.04A to version 7 has begun since 2000. The ACAS II aircraft have already been equipped with version 7 by 15 January 2003. The RVSM (Reduced Vertical Separation Minima) has been introduced at 4 a.m. on 30 September 2005 (JST) in Japanese air space.

This report summarizes the operational evaluation based on RA reports from 1 January 1995 to 30 June 2006. The total number of RA reports that were submitted by pilots is 3821 for 11 years. This report is especially described the results of RA monitoring except RA number from January 2004 to June 2006. The number of RA reports for this periods is 635. The number of RA reports after the implementation of RVSM is 218 for a year and 3 months.

After the implementation of RVSM, the percentage of "CRZ" and "APP/LDG" decreases compared with before the implementation of RVSM. The percentage of the RA reports of the high altitude above 30000ft increases and those below 10000ft decreases compared with before that of RVSM. The percentage of the adjust RA after the implementation of RVSM increases compared with before that of RVSM. The percentage of the preventive RA is hardly changeable before and after the implementation of RVSM. After the implementation of RVSM, the percentage in which pilots followed the RAs is increasing. It is about 98%.

The percentage of the altitude deviation below 700ft is increasing. The percentage of the deviation is about 90% after the implementation of RVSM. There is 1 report that the altitude deviation is exceeding 1000ft after RVSM. The percentage of "commercial" increases and those of "Military" and "Small Aircraft or G/A" decreases after the implementation of RVSM. The unaccountable RA is decreasing, but still occurs a few percents.

In the case of complementary maneuver, After the implementation of RVSM, the percentage that one RA is "Corrective RA" and another is "Adjust RA" increases. The combination that one flight phase is "DES" and another is "CLB" is about 40 % and the trend is unchangeable before and after

the implementation of RVSM.

The periods monitored RA reports after the implementation of RVSM is about a year and 3 months. The number of RA reports after RVSM is a little compared with before the implementation of RVSM. We will analyze RA reports taking into account the effect of version 7 after the implementation of RVSM in the future.

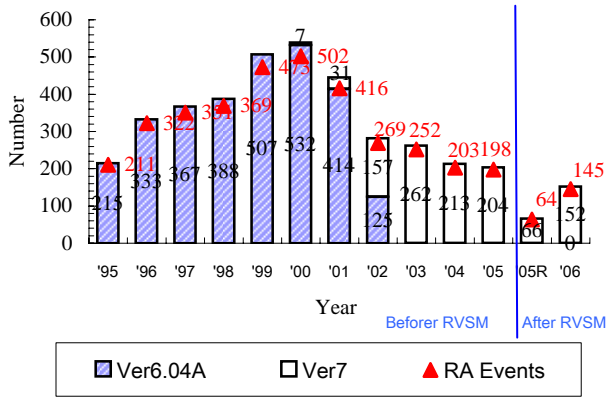


Fig.1 RA reports classified by the algorithms version, and RA events

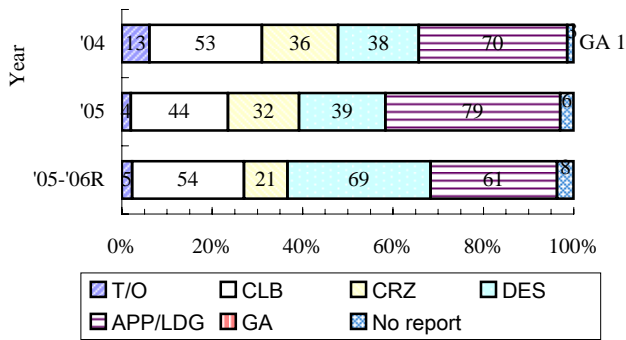


Fig.2 Flight phase classification

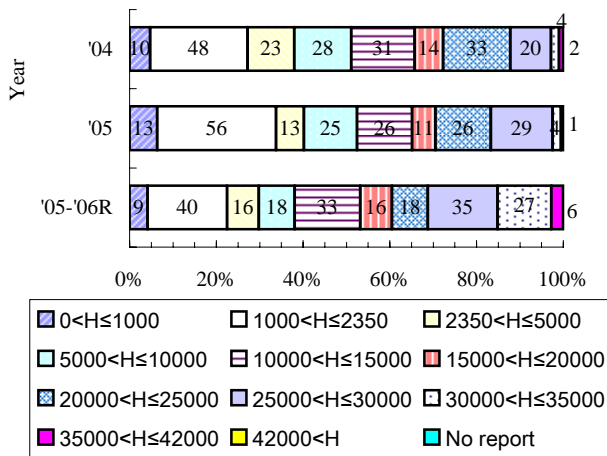


Fig.3 Altitude classification

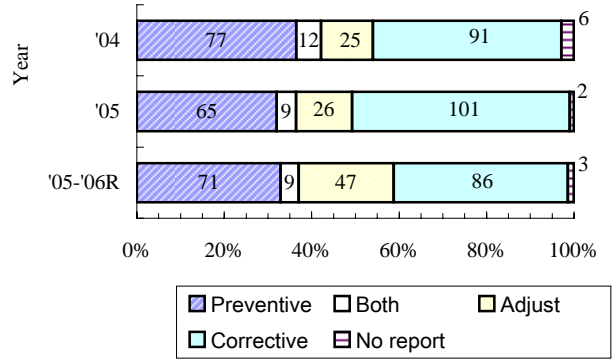


Fig.4 RA Type

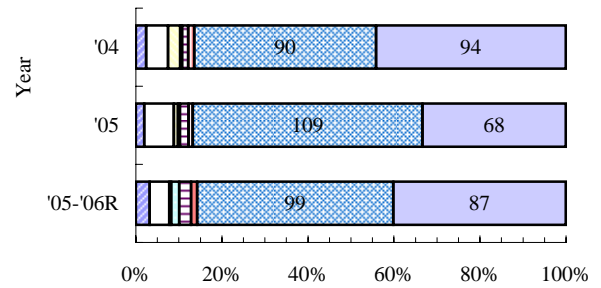


Fig.5(a) Additional RA

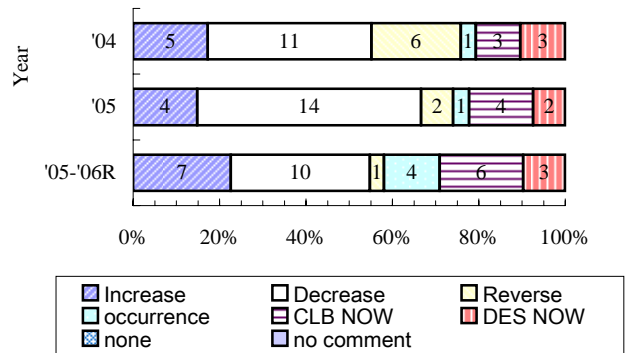


Fig.5(b) Additional RA (except "none" and "no comment")

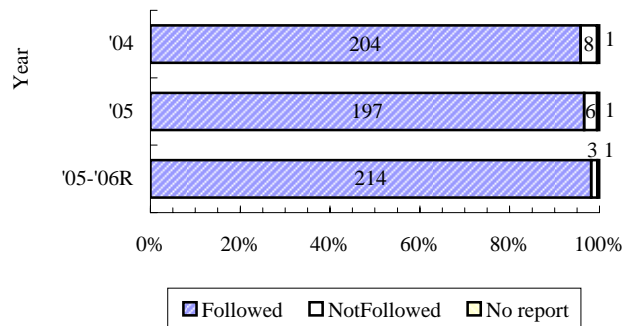


Fig.6 Followed RA

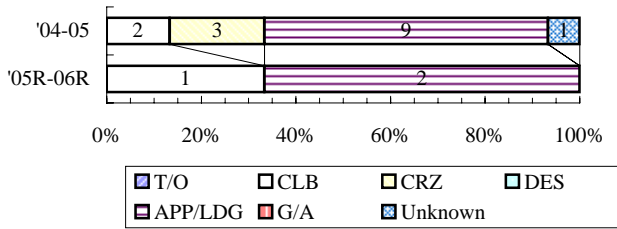


Fig.7 Phase when pilot did not follow the RA on version 7

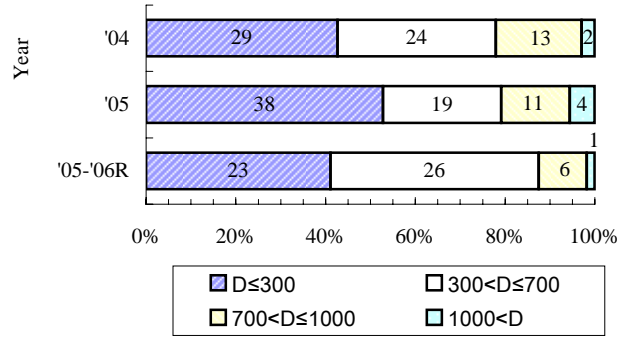


Fig.10 Altitude deviation

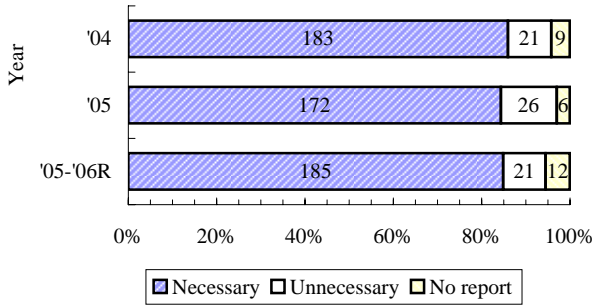


Fig.8 RA Necessity

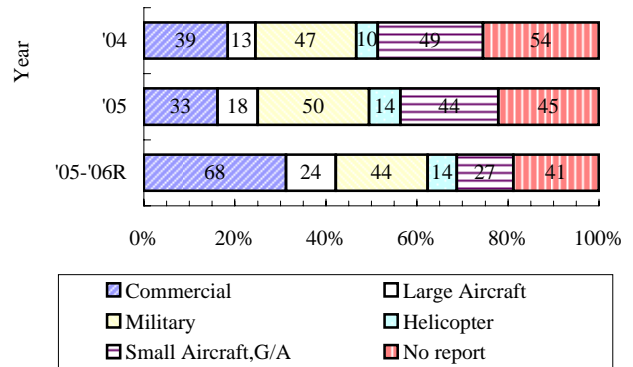


Fig.11 Intruder types

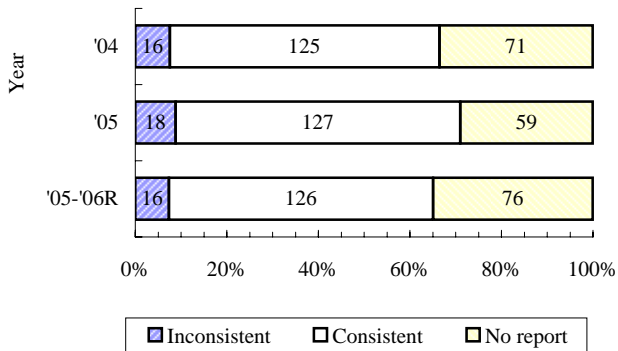


Fig.9 RA Consistency

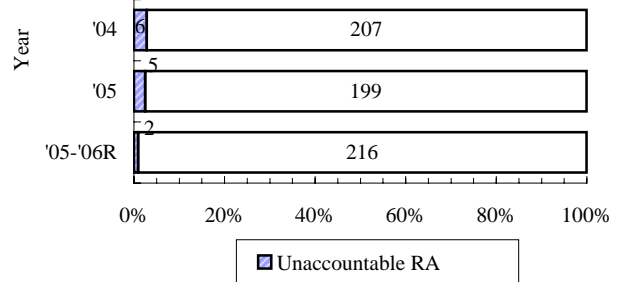


Fig.12 The RA reports of the uncertain cause

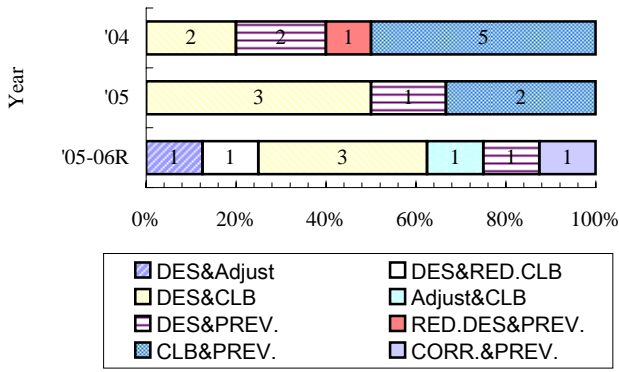


Fig.13 The relation of advisory (Complementary Maneuver)

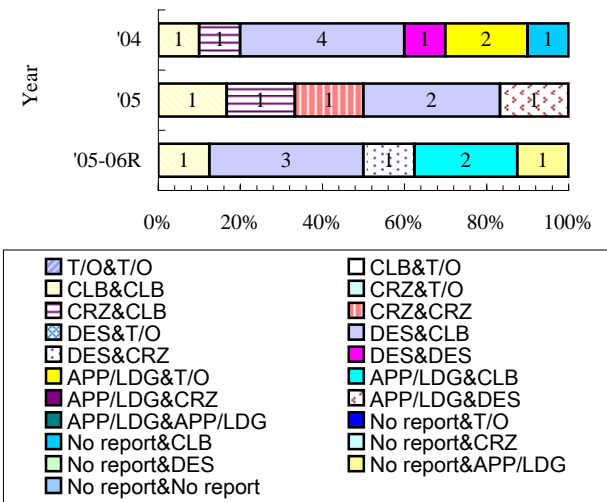


Fig.14 The relation of the flight phase at RA occurrence(Complementary Maneuver)