

International Civil Aviation Organization



ICAO

**THE FOURTH MEETING OF MODE S DOWNLINKED
AIRCRAFT PARAMETERS WORKING GROUP
(MODE S DAPs WG/4)**

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Agenda Item 3: Sharing of State's implementation on Mode S and related issues

MODE-S RADAR SI OPERATION TEST RESULT

(Presented by Incheon international airport corporation/Republic of Korea¹)

SUMMARY

The increase of Mode-S radar within the region, it is very difficult to avoid a radar coverage overlap with 0~15 II code. This information paper presents the test result about the Mode-S radar SI code operation. As the result, the target detection performance of SI was same with II code. SI mode operation is tested for 15 days. There was no detection degradation or target loss originated from SI mode operation.

1. Introduction

Acquiring the aircraft address (ICAO 24-bit address) by Mode-S radar is the first step to detect new targets. Mode-S radars(interrogators) required an assignment of the IC (Interrogator codes) that is not required by SSR radars. Such IC could be II (Interrogator identifier, 0~15) or SI (Surveillance identifier codes, 0~63).

Because SI code is newly adapted Mode-S IC addressing method, it was easily anticipated that all Mode-S transponder (aircraft) might not be SI code capable so there could be some detection miss by SI operation of Mode-S radar.

SI code capability of aircraft transponders is mandated by 1 January 2005 (ICAO Annex 10 Vol. IV §2.1.5.1.7.1)

To check the feasibility of SI operation of Mode-S radar, one of the Mode-S radars at Incheon airport is configured to use SI code for 15 days. The following is the SI operation test result from it.

2. The summary of SI operation test result

<Test condition>

Tested Mode-S Radar: ShinbulB at Incheon airport.

Manufacturer: Indra Systamas, IRS-20 (installed year 2016)

Test Period: UTC 2021.1.25 00:00~ 2.9 07:00 (15 days)

IC code: Before: II 2 , Tested : SI 34

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MIP (Mode interlaced pattern): UF11, Selective, Mode-A Inter-mode, Mode-C Inter-mode
 Interrogation Configuration: Lockout override with probability 1/2.

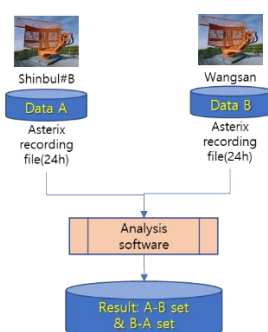
<SI Code operation result>

For 15 days, ShinbulB Mode-S radar is configured to use SI 34 code. Based on our analysis result, we can finally address that every Mode-S target are detected very normally at the SI operation mode also. There is no detection degradation at SI operation.

3. Analysis method about SI operation

<Targe analysis method>

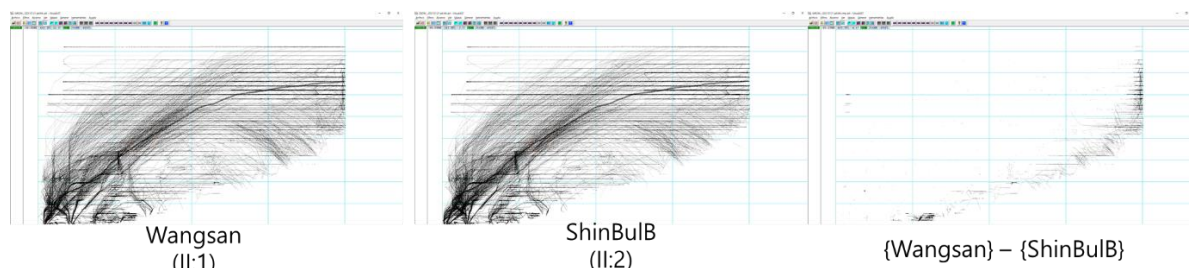
By reviewing one radar recording, finding silently undetected targets is very difficult. To find undetected targets by SI operation radar, we need to compare the detection results of multiple radar recordings that have coverage overlap between the radars. Manual observation over CWP display by personnel is not a perfect solution to find undetected target. So, the Incheon airport developed analysis software to find undetected Mode-S targets by SI operation. The analysis software named as “*Astecat frametest*” designed to compare the two of Asterix recordings of different radars to find undetected targets. The software works as the following.



< Picture#1 The framework to find the undetected target through the analysis software >

<The example of comparing the radar recordings for Mode-S transponder>

The following pictures are vertical representation of 24-hours of the radar recordings. X-axis is Nautical Mile and Y-axis is altitude. Each black dot represents the vertical position of aircrafts in 24 hour accumulation method into one picture. The data type is Eurocontrol Asterix 34/48/8. To check the Mode-S detection performance of ShinbulB, we used the software “*Astecat frametest*” to get the difference of target sets from Wangsan radar recordings. The most of vertical space of the picture {W}-{S} is empty region where two radars have perfect detection coverage overlap. The remaining black dot in the picture {W}-{S} represents the detection coverage difference between two radars that is originated from a radar location and an antenna tilt differences.



< Picture#2 – an example of comparing the radar recordings (Vertical drawing) >

4. Analysis result about SI operation

For 20 days (including 15 days of SI operation), two radar recording data are compared each other to find undetected target. The following is the analysis result.

<Analyzed data sets>

2021.1.20~1.24 : Wangsan (II:1), ShinbulB(II:2)
2021.1.25~2.5 : Wangsan (II:1), ShinbulB(SI:34)

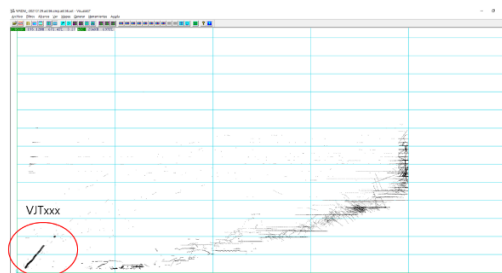
<Analysis result>

For 15 days of SI operation, 5 aircrafts are partially detection-missed by ShinbulB (SI:34) radar. The following is a list of the undetected aircrafts by ShinbulB (SI:34).

- Three passenger jet (VJTxxx, KALxxx, KALxxx)
- Military transport aircraft (ODxxx)
- Military jet (Mode-S address : 0x000001)

-About three passenger jet (VJTxxx, KALxxx, KALxxx)

Three passenger jets are equipped with EHS-level transponder that transmit various BDS data blocks. So, it is hard to think that EHS-level transponder does not have SI capability. They are partially missing only in an adjacent region (11NM) of the airport. Beyond 11NM, three passenger jets are detected very normally. Also, these aircrafts are partially missed not only by ShinbulB(SI:34) but also by ShinbulB(II:2). It is very obvious that the SI operation of ShinbulB radar does not affect the detectability of aircrafts by the radar. Now we are investigating about interoperability issue between an interrogator and a transponder.



< Picture#3 – Undetected target by ShinbulB(SI:34) >

-About military transport aircraft (ODxxx)

This transport aircraft is equipped with very old version of Mode-S transponder. The transporter had already a detection issue by ShinbulB(II:2). It is very obvious it is not related to the SI operation of the radar.

-About Military jet

Some military jets are detection missed by ShinbulB(SI:34) , ShinbulB(II:2) and Wangsan(II:1). It is reviewed by radar manufacturer. They say, “When there are several planes with the same identification code A, the reflection suppression functionality would start working so eliminating plots.”. It is nothing to do with SI operation.

<Final analysis result>

For 15 days of SI operation, based on our analysis, there was no detection degradation or target loss originated from SI mode operation.

5. SI capability flag at Asterix 48

At Asterix format, “Data Item I048/230, Communications/ACAS Capability and Flight Status, (SI)” is designed to show the capability of SI/II transponder. But based on our analysis, SI flag does not give

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us relevant information about SI/II capability. We think SI flag must not be used to decide the capability of SI/II at transponders. This result is coincided with Eurocontrol workshop material “Operation on II and SI codes, MICA Workshop for ICAO MID States, Agenda Item#4, Jérôme Bodart, 26-28 February 2019”

6. Discussion

As a result, the target detection performance of SI was same with II code. SI mode operation is tested for 15 days. There was no detection degradation or target loss originated from SI mode operation.

By using the analytical method to radar recordings, Incheon airport could identify several MSSR detection issues. We think it is very preferable that each ANSP (Air-navigation service provider) regularly review the performance of their surveillance system with a analysis software to maintain a detection capability and to find a new detection issue about a radar.
