International Civil Aviation Organization

Sixth Meeting of the Surveillance Implementation Coordination Group (SURICG/6)

Video Teleconference, 24 – 27 August 2021

Agenda Item 7: Report on surveillance ground system and avionics performance monitoring and improvement in compliance

PRACTICAL APPROACH TO ASSESS THE PERFORMANCE OF THE SURVEILLANCE SYSTEMS

(Presented by Incheon International Airport Corporation/Republic of Korea)

SUMMARY

This information paper presents the common misunderstanding about the radar specification and suggest the practical approach to access the performance of surveillance systems.

1. INTRODUCTION

1.1 The basic performance criteria of good surveillance sensor are the maximum detection probability of the airplane with minimum false target count. But the complexity of accessing the radar performance make it more difficult to compare the sensor performance between various types of surveillance radars. ANSPs could have very limited information about performance/cost ratio because of the calculation complexity. So it is ending up to make it difficult to select the best surveillance system for an ANSP in procurement process.

1.2 This information paper presents some performance assessment example and suggest ANSPs would try the evaluate their surveillance system and share the performance test result through ICAO workgroup to compare the surveillance system and to find the best optimum surveillance system for their country and airport.

1.3 Especially, Range & azimuth detection accuracy and PSR RCS (Radar cross section) are widely miss interpreted. Many experienced radar engineers still miss-understand it and possibly guide the surveillance contracting process to a wrong direction.

2. DISCUSSION

2.1 Surveillance performance standards for PSR & MSSR (Eurocontrol standards)

2.1.1. Eurocontrol document “SUR.ET1.ST01.1000-STD-01-01” contains the requirement of PSR and SSR for application in the provision of Air Traffic Services. But this standard written in 1997 is quietly old and it could not include the recent innovation of surveillance technology. For example, PSR false target count specification at Table #1 is “20 per scan” but the number of “20 per scan” is too huge. In the situation of “false target 20 per scan”, the most of ATC controller would complain about

the surveillance situation because too many false targets might generate many safety-net alarms at the CWP screen. Another point that must be made up for being is that there are no surveillance performance specifications for new surveillance technologies (WAM, MLAT, MSPSR).

2.1.2. About the surveillance performance specification, the current standards are old and making new international standards will take long time, probably always to fail to catch up the speed of the technology innovation of the surveillance. And there are difficulties in practically assessing surveillance performance. As the result, many surveillance installation projects work on a price-based competition and the surveillance system price are used as a main benchmark to select winning-competitor because there are little normative performance standards.

PSR target position detection (Overall probability of target position detection)	>90%
PSR false target reports (Average number of false target reports per antenna scan)	<20
SSR target position detection	>97%
SSR False target reports (Overall false target report ratio)	<0.1%
SSR multiple SSR target reports	<0.3%
SSR Code detection (Mode A)	> 98%
SSR Code detection (Mode C)	> 96%

<Table #1 : Eurocontrol, SUR.ET1.ST01.1000-STD-01-01[1]>

2.1.3. So this IP suggests that:-

i. Some important measurable performance specification for a surveillance must be selected for very basic performance analysis.

ii. Performance analysis must be done by an opened software tool for a standardized measurement.

iii. The ANSP could share their benchmark result that would be considered as decision criteria for future surveillance installation project.

iv. The performance specification for the new surveillance system would be researched and reviewed in this WG.

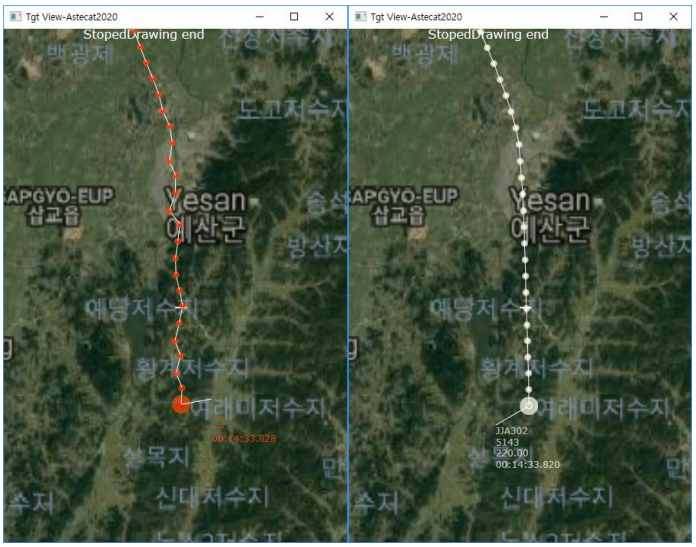
2.2 Common misunderstanding about PSR & MSSR performance specification

Example of performance specification	Common miss-understanding	Real meaning
PSR Radar cross section(RCS) ex) 2 square meter	A radar can detect any airplanes that are bigger than 2 square meter RCS.	RCS specification is designed for Low noise amplifier (LNA) at pulse-by-pulse detection process. Real PSR sensitivity is much lower than 2 square meter RCS to reduce false targets. Practically, it is very little relationship with real PSR detection sensitivity because modern digital PSR radar have several processing step after LNA. So RCS is not

[1] EUROCONTROL Standard Document for Radar Surveillance in En-route Airspace and Major Terminal Areas

		overall system parameter, but LNA parameter at digital radars.
PSR Detection probability : ex) 80%	A radar can detect 80% target in a scan. For example, 80 targets can be detected among 100 targets.	Detection probability is closely correlated with RCS specification. 80% are decision criteria to sense a pulse as an echo signal from a aircraft in noisy environment. It is nothing to do with a count of detecting aircraft at many cases. So PSR Pd[2] must be distinguished between video level Pd and report-level Pd.
PSR false alarm ratio : ex) 10^{-6} %	False target could be generated at the ratio of 10^{-6} percents	RCS, Detection probability and False alarm ratio are correlated each other. It is nothing to do with a count of false target. It is a statistical parameter to decide the theoretical noise level at RF pulse receiving process.
Range & azimuth detection accuracy (PSR, MSSR): ex)Range:100m, Az:0.1degree	The error of measured position is less than 100m with 0.1 degrees.	At many cases, the detection accuracy specification does not mean an overall system performance, but encoder specification. The real detection error is much bigger than this.

<Table #1 : Common miss understanding about Radar specification >



<Picture #1 : Position detection difference between PSR(Left) and MSSR(Right) for same aircraft >

2.2.1 The picture above shows azimuth accuracy difference between PSR radar and MSSR radar for 50NM target. The manufacturer says PSR azimuth accuracy is *0.15 degrees* RMS and MSSR azimuth accuracy is *0.022 degrees*. In the above case, maximum azimuth deviation of PSR target is about *0.6 degrees* at 50NM. Real azimuth accuracy is much worse than theoretical azimuth accuracy. But many radar manufacturers only suggest theoretical accuracy figures not real detection results for real target.

[2] Pd : probability of detection

2.3 Suggested PSR & MSSR performance specification (Practical approach)

No	Performance specification
1	PSR Pd (probability of detection for a passenger jet) * To define Pd, the size of airplane fuselage must be defined. PSR Pd must be calculated based on the target report basis. PSR Pd calculation method must be decided before the contract process of the surveillance system
2	PSR false target reports (Average number of false target reports per antenna scan) (Peak number of false target reports in a day per antenna scan) * The PSR false target generates many false safety-net alarms at CWP. The peak number of PSR false targets must be considered also.
3	PSR detected range & azimuth accuracy (RMS , Peak to Peak) * The accuracy value must be calculated at the target report level instead of the encoder specification.
4	PSR tracking parameter (track initiation delay, Maximum speed of target, Maximum acceleration) * Some PSR radar has internal tracker to reduce a false target even at the plot mode. * tracking parameters are very important for the performance of a radar.
5	SSR Probability of detection * SSR Pd calculation method must be decided before the contract process of the surveillance system
6	SSR detected range & azimuth accuracy (RMS , Peak to Peak) * The accuracy value must be calculated at the target report level instead of the encoder specification.
7	SSR false target reports (Reflected, Gabled) * The generation of ground reflected targets is a main SSR detection issue. Sometimes it is affected by meteorological situation.
8	Mode-S Daps interrogation strategy (Selected altitude, ACAS, Track & turn report, Heading Report)

<Table #2: Suggested PSR & MSSR Key performance specification>

2.3.1. This IP suggest the list of the performance specifications of PSR/MSSR radar. Table #2 only includes the measurable and practical specification item for the field engineer of the surveillance system. By reviewing the following key performance parameters, ANSPs can easily evaluate and compare their surveillance system performance with other radars. Table #2 is informative. ANSPs could have a different view and opinion about it.

2.3.2. There are various surveillance systems in the market. Because of the complexity of the CNS installation project and long installation period, ANSPs have some difficulty to find the most cost/benefit efficient solution for their ATS. After finishing the project, each ANSPs could easily evaluate their surveillance system performance with Table#2.

2.3.3. It is very hard to check and compare the surveillance system performance with the neighboring country. To improve the performance of a surveillance system, we need to share their benchmark result of their surveillance system. By doing so, price-based competition for CNS project could be turned into quality-based competition.

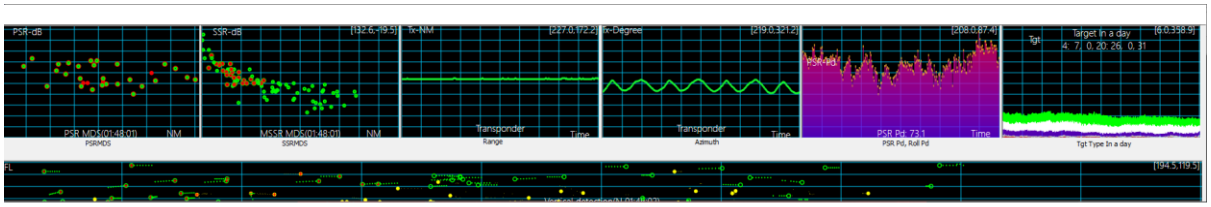
2.4 Real time PSR & MSSR performance monitoring (Practical example)

2.4.1. The radar system is very complex and sensitive measuring equipment. Even if there is an in-depth built-in test module, the radar performance can be silently degraded. At MSSR radar system, mono-pulse table management is the one of the most frequent causes of a position detection degradation. By only doing an in-depth monitoring the target motion, the mono-pulse table fault can be easily detected. Actually, many performance degradation is hard to find in the manual inspection.

2.4.2. To detect a degradation of the radar performance in real-time, a relevant software tool is necessary. FAA RBAT(Radar Beacon Analysis Tool) is one of the free radar analysis software. RBAT is a PC Windows-based software that can give a calculation result of PSR Pd (probability of detection), MSSR Pd and etc. RBAT is a good software tool that can be used to measure the overall radar system performance. The SASS-C[i] is most frequently used analysis tool for a European radar manufacturer.

2.4.3. Incheon airport also has internally developed radar analysis software named as “Astecat” that is more simple, easy to use and optimized for the Eurocontrol Asterix Cat032/048 interface.

2.4.4. The following is the example of real-time performance monitoring example by using “Astecat”(Internal software solution). This IP represents the real-time radar performance monitoring example to address the benefit of it.



<Picture #2 : Real-time radar performance monitoring screen “Astecat” >

2.4.5. Current version of “Astecat” can measure the following parameters

i. PSR target strength graph (x:NM, y:PSR target strength)
ii. MSSR target strength graph (x:NM, y:SSR target strength)
iii. MSSR test transponder (Far-field monitor) range accuracy : (x:Scan, y:range(NM))
iv. MSSR test transponder (Far-field monitor) azimuth accuracy : (x:Scan, y:azimuth(degree))
v. PSR Probability of detection (x:Scan, y:PSR Pd)
vi. The number of detected targets (x:Scan, y:Cat48 target type)
vii. Vertical target detection situation graph (x:NM, y:FL)

3. ACTION BY THE MEETING

3.1 This information paper presented some performance assessment example and suggest ANSPs would try the evaluate their surveillance system and share the performance test rest through ICAO workgroup to compare the surveillance system and to find the best optimum surveillance system for their country and airport.

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[i] SASS-C https://www.eurocontrol.int/online-tool/surveillance-analysis-support-system-atc-centres