International Civil Aviation Organization

Twenty Fifth Meeting of the Communications/ Navigation and Surveillance Sub-group (CNS SG/25) of APANPIRG

Video Tele-Conference, 18 – 22 October 2021

Agenda Item 7: Automation

7.2 Other automation related issues

THE IMPLEMENTATION OF THE WEATHER DATA CONVERTER FOR A LEGACY AUTOMATION SYSTEM AS AN INTERFACING TO TDWR

(Presented by Republic of Korea)

SUMMARY

This paper presents the implementation of weather data converter for a legacy automation system as an interfacing to TDWR (Terminal doppler weather radar) and benefit of it.

1. INTRODUCTION

1.1 To improve airport operation, timely and accurate weather information should be provided to air traffic controllers. This IP reports the implementation example of the weather data converter which transform the TDWR data format (UF, Universal Format) to Eurocontrol Asterix cat 8 format.

1.2 After implementing the weather data converter to the legacy automation system, ATCO[1] could check the air traffic situation overlapped with TDWR weather image on CWP screen.

1.3 The implementation of simple data conversion software could deliver cost-effective-benefit to a legacy automation system that does not have the SWIM capability and does not support RESTful API.

2. DISCUSSION

2.1 A comparison of weather detection performance in PSR and TDWR

2.1.1 In most countries, ANSP [2] s do not operate Weather radar systems because Meteorological agency is designed to operate TDWR system and provide weather information to the

[1] Air traffic control officer
[2] Air navigation service provider

public. This IP reports the difference of weather detection functionality between PSR and TDWR to improve understanding of the system.

	TDWR	**PSR weather**
RF frequency	C-Band(5.5~5.65)Ghz (But also possible S-Band, X-Band)	S-Band 2.7~2.9Ghz
RF power	250KW(C-band), Unmodulated pulse is used	21KW(S-Band) Short pulse and modulated Long pulse is used
Antenna	Rotation speed : 5 RPM Gain: 50dBi Dual polorization (Vertical & horizontal) Automatic vertical tilt adjustment	Rotation speed: 12RPM Gain : 34dBi Single polorization (Linear or Circular) Vertical tilt is not supported.
Detection result	3D Cloud (rainfall) , Windshear, Microbusrt , Gust Front Receiver sensitivity is regularly calibrated (ex Sun calibration)	2D Cloud (NWS 6 level) relatively inaccurate (Weak calibration).
Data format	UF(universal format) NetCDF4 File based result (every2~5 minutes)	Asterix CAT8, 9 UDP packet based result (every 30 seconds)
Detection range	130km (Doppler mode) 480km (Intensity mode)	148km

<Table : TDWR and PSR Weather >

2.1.2 PSR weather has a functional advantage in detection update interval, but the other performances are unrivaled with the TDWR detection result. Especially, cloud image detected by PSR radar could be varied depends on the radar optimization parameter. Radar engineering skill to maintain the quality of weather detection is important at PSR. TDWR radar has an internal mechanism to calibrate the receiver sensitivity.

2.1.3 The cloud image of TDWR shows the more accurate geographical distribution of rainfall rate than PSR weather. A matrix file format (ex. UF, NetCDF4) is used to represent 3D shape of a cloud. Bitmap (bmp or png) file format is used to draw more simplified 2D cloud shape. Dual-polarization radar transmit and receives both a horizontal and vertical orientation pulse. As a result, accuracy of precipitation estimation is improved and non-meteorological echoes are more easily rejected.

2.2 Weather data interface on the ATM automation system

2.2.1 The many ATC automation system does not understand weather radar file format directly (ex. NetCDF4 and UF). ATC system and weather radar (TDWR) are developed in the their own field. These two systems are advanced separately. There was few needs to make interactive connections between them.

2.2.2 The legacy automation system with no ability to process SWIM API(Application programming interface) normally does not support TDWR interface. Even if adding bitmap image at CWP screen is not big deal in the software programming, it should accompanied by monetary expenses to initiate the project as ANSPs are software user not software developer.

2.2.3 The alternative way to make interface between TDWR and ATC automation system is to implement the weather data converter.

2.3 The implementation of weather data converter

2.3.1 The weather data converter consists of the following modules.

i) Weather radar data analysis module (UF, NetCDF4)
ii) Bitmap to Vector conversion module (cloud intensity leveling by NWS 6 Level standards)
iii) Eurocontrol Asterix cat 8 encoding module (with Asterix cat 34 generation)

2.3.2 UF format[3] and NetCDF4[4] format have an open source reference library. Anyone who wants to use this file format can refer to the reference software. Weather radar data have 3D-arrayed detection result for each radar cell as the form of CZ (Corrected radar reflectivity), SW (Spectral width) and VR (radial velocity) of echo signals.

2.3.3 For the implementation of weather data converter, to generate Asterix CAT 8 data, only CZ information is used because CZ field represents the strength of the echo signal. Unit of it is a mm/hour or dbZ (precipitation). US NOAA, NWS[5] has the recommendation about precipitation level classification[6]. In this case, NWS 6 level is a little bit modified to make the better converting result to reflect subjective assessment by ATCO.

2.3.4 TDWR radar data uses the bitmap pixel to draw the shape of a cloud. The Asterix Cat 8 format only supports vector to depict cloud. Cloud is a set of many clouded areas. In Asterix Cat 8 format, cloud is depicted by many lines (vectors). Converting from areas to lines needs custom parameters to decide the number of vectors that could be generated.

2.3.5 If an excessive number of weather vector is generated, the core functionality of an ATC automation system could be adversely affected. So the number of vectors is limited and regulated. In the worst-case scenario, it is tested if the core ATC functionality is affected and reserved. The developed weather converter is tested more than for 6 months (stability) and fine-tuned to meet ATCO requirements(performance).

2.3.6 Incheon airport is operating Indra Systemas ARTS system of which the weather vector rendering method is slightly coarse. It is not designed to draw very accurate weather vector because PSR weather data is not elaborated generally. The converted weather image from TDWR is more accurate than PSR weather. The frustum with an azimuth of about 5 degrees is used to draw one weather vector to the CWP screen in the weather vector rendering process.

2.3.7 Even so, the benefit of the weather data converter is clear. It is cost effective. Stability of the ATC automation system is maintained as the before. ATCO could improve the situation awareness.

[3] UF format : https://trmm-fc.gsfc.nasa.gov/trmm_gv/software/software.php
[4] NetCDF4 format : https://www.unidata.ucar.edu/software/netcdf/
[5] NOAA NWS : National oceanic and atmospheric administrators Nation weather service
[6] NWS 6 level : https://w1.weather.gov/glossary/index.php?word=VIP

2.4 Summary

2.4.1 This paper presents the implementation of weather data converter for a legacy automation system for an interfacing to TDWR (Terminal Doppler weather radar). The implementation of simple data conversion software could deliver cost-effective-benefit to a legacy automation system that does not have the SWIM capability and does not support RESTful API. After implementing the weather data converter to the legacy automation system, ATCO could check the air traffic situation overlapped with TDWR weather image on CWP screen.

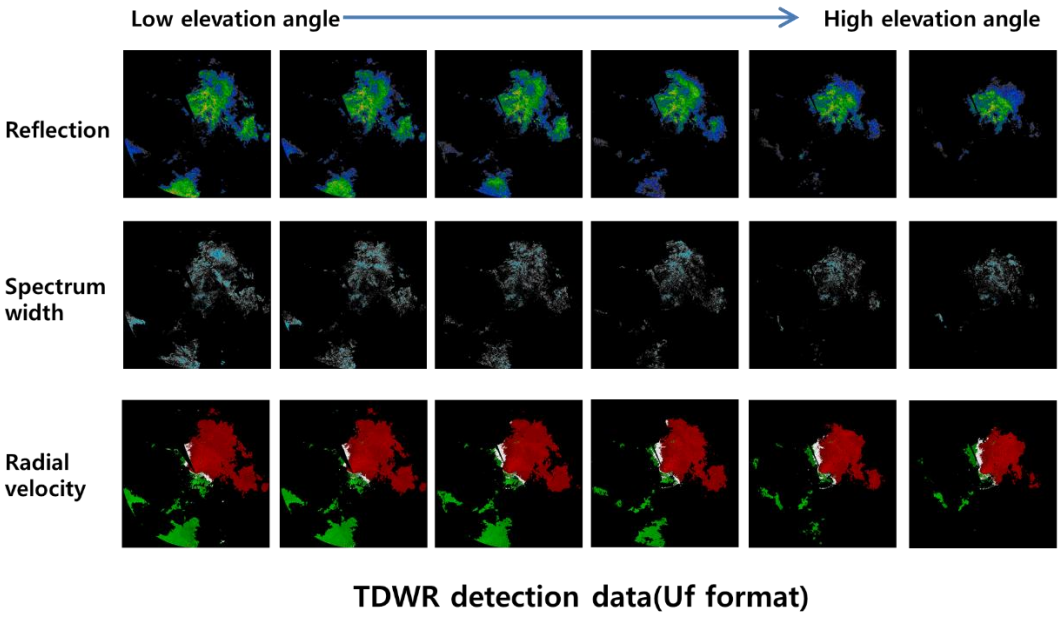
3. ACTION BY THE MEETING

3.1 The meeting is invited to:

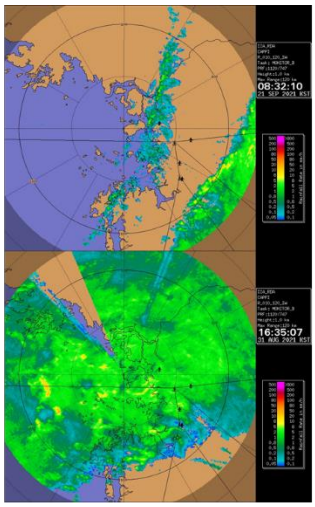
a) note the information contained in this paper and

b) Discuss any relevant matter as appropriate.

Appendix 1 -TDWR detection image

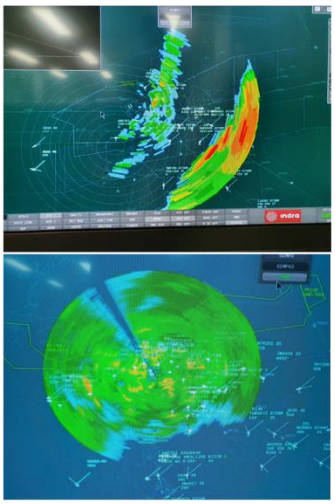


Appendix 2 -Weather data conversion example



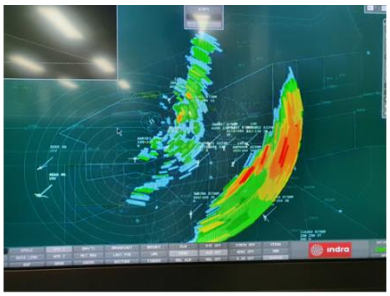
TDWR Detection image
(Avaiation meteorological office)

Weather data converter
(UF => Asterix Cat 8)

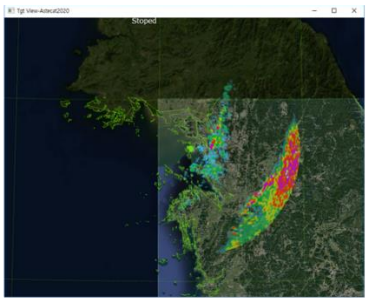


CWP weather image
(Seoul approach)
Indra systemas uses a frustum to
render one weather vector

Appendix 3 – The rendering method difference for same Asterix Cat 8 data

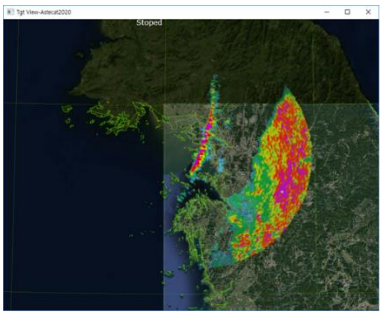


frustum(az 5 degree)
rendering method

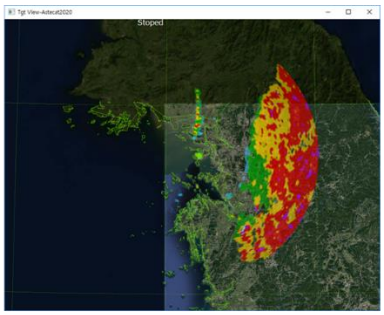


small rectangle rendering
method

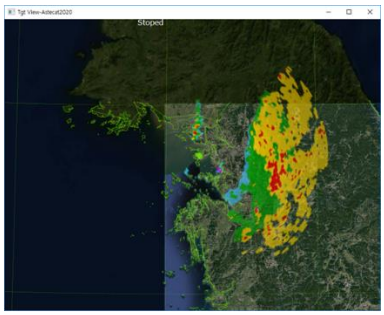
Appendix 4 – TDWR vs PSR weather detection example about the same time



Converted weather data from
Wangsan TDWR



PSR weather detection
Wangsan PSR



PSR weather detection
ShinBul#B PSR

Appendix 5 – Cloud rendering method