GAMIC Primary ASR – Radar Weather Extractor – GAMIC Weather Signal Processor GWSP

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ABSTRACT

The goal of the GWSP is the improvement of safety of aircraft operations by means of timely detection and reporting of hazardous weather phenomena in the airport approach area, typically up to 60nm. This information can be extracted from Airport Surveillance Radars (ASR) data in parallel to the standard tracking function. In particular severe precipitation, wind shear near the terminal approach and departure zones of an airport are processed and identified. Specific sources of the hazardous weather are detected. Thunderstorms, micro bursts and gust fronts are among those critical events. Also the GWSP improves the management of air traffic in the terminal area through the forecast of any significant weather at the airport and the detection and tracking of precipitation.
The GWSP provides fast and precise weather data extraction and display of all weather parameters (Rain Reflectivity, Doppler Velocity and Turbulence) up to 60nm (100km) as available from the existing primary ASR receiver It can be either implemented as modernization, retrofit or improvement of the existing or new ASR systems supporting aviation commerce world wide. ASR radars serviced are Magnetron, Klystron and Solid State.
Weather and warning data are sent to the ATC controller workplaces in ASTERIX CAT 8 format. Other high resolution colour coded image formats are available.
GWSP systems are operational at the German Air Forces and Schiphol Airport, The Netherlands.

1. Introduction

This paper describes the GWSP weather Extractor concept implemented in conjunction with primary air traffic control (ATC) radars. These radars are typically operated at airports for a 60nm / 100km approach range, called also airport surveillance radars (ASR). This is also the range where severe and dangerous weather is affecting heavily the flight operations like final approach, takeoff and landing.
In many cases, such airports do not have dedicated weather radars available for detection of these phenomena in real time and with sufficient resolution of measurement.
Original manufactures of ATC – ASR radars had weather extractors built into their systems but those are mostly giving very coarse and limited data (6 - dBZ levels and no Doppler winds measurements).
The GWSP technical concept is based on well proven signal and data processing technology originating form conventional weather radar systems. This technology has been adapted to the ATC radar sensor interfaces and measurement concept.
Such systems now have been successfully tested and operated in different airport scenarios. In the following the concept, its performance and case studies are presented.

2. The GWSP concept

The goal of the GWSP is the improvement of safety of aircraft operations by means of timely detection and reporting of hazardous weather phenomena in the airport approach area, typically up to 60nm. This information can be extracted from Airport Surveillance Radars (ASR) data in parallel to the standard tracking function. In particular severe precipitation, wind shear near the terminal approach and departure zones of an airport are processed and identified. Specific sources of the hazardous weather are to be detected. Thunderstorms, micro bursts and gust fronts are among those critical events. The GWSP improves the management of air traffic in the terminal area through the forecast of any significant weather at the airport and the detection and tracking of precipitation.

The GWSP is designed to provide fast and precise weather data extraction and display of all weather parameters (Rain, Reflectivity, Doppler Velocity and Turbulence) up to 60nm. (100km) as available from the Primary ASR receiver.
It can be either implemented as modernization, retrofit or improvement of the existing or new ASR systems supporting aviation commerce world wide. ASR radars serviced are Magnetron, Klystron and Solid State.

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The main objectives of the FROG_ATC weather extractor are:
- Use the primary weather radar video from the ATC radar to extract the predefined precipitation levels.
- Output a digital weather data stream in the ASTERIX Cat008 contour format
- Provide real time “weather radar like” data displays
- Generate advance products for severe weather detection like Shear, severe rainfall etc.
- Use the primary radar control signals for timing.
- Include remote control and monitoring via a suitable local and remote HMI for the local and remote operator.
- Include a remote control agent, based on SNMP, to control and monitor the FROG_ATC weather extractor system operator.

The GWSP weather signal and data processing consist of the following standard GAMIC products:

- Adaptation box - ADAP ENIGMA III
- Weather signal processor – WSP, ENIGMA III
- Weather data processor – WDP FROG RT – ATC version

Such GWSP systems are in operation at the German Air Forces and Schipol Airport, The Netherlands. All installations have been tested over extended periods before being certified for use in flight guidance and control.

3. Case Studies

3.1 ASR-E, Germany

The GAMIC ATC weather channel has been realized within in the ASR-E project for the German Air force together with EADS (1996-today).
The ASR-E is a fully solid state S-Band radar using pulse compression technique.

Currently ASR-E is in operation at the first air force airfields and being qualified for flight operation certification. The series deployment of >20 units is planned for Germany military airfields from 2008 to 20014.

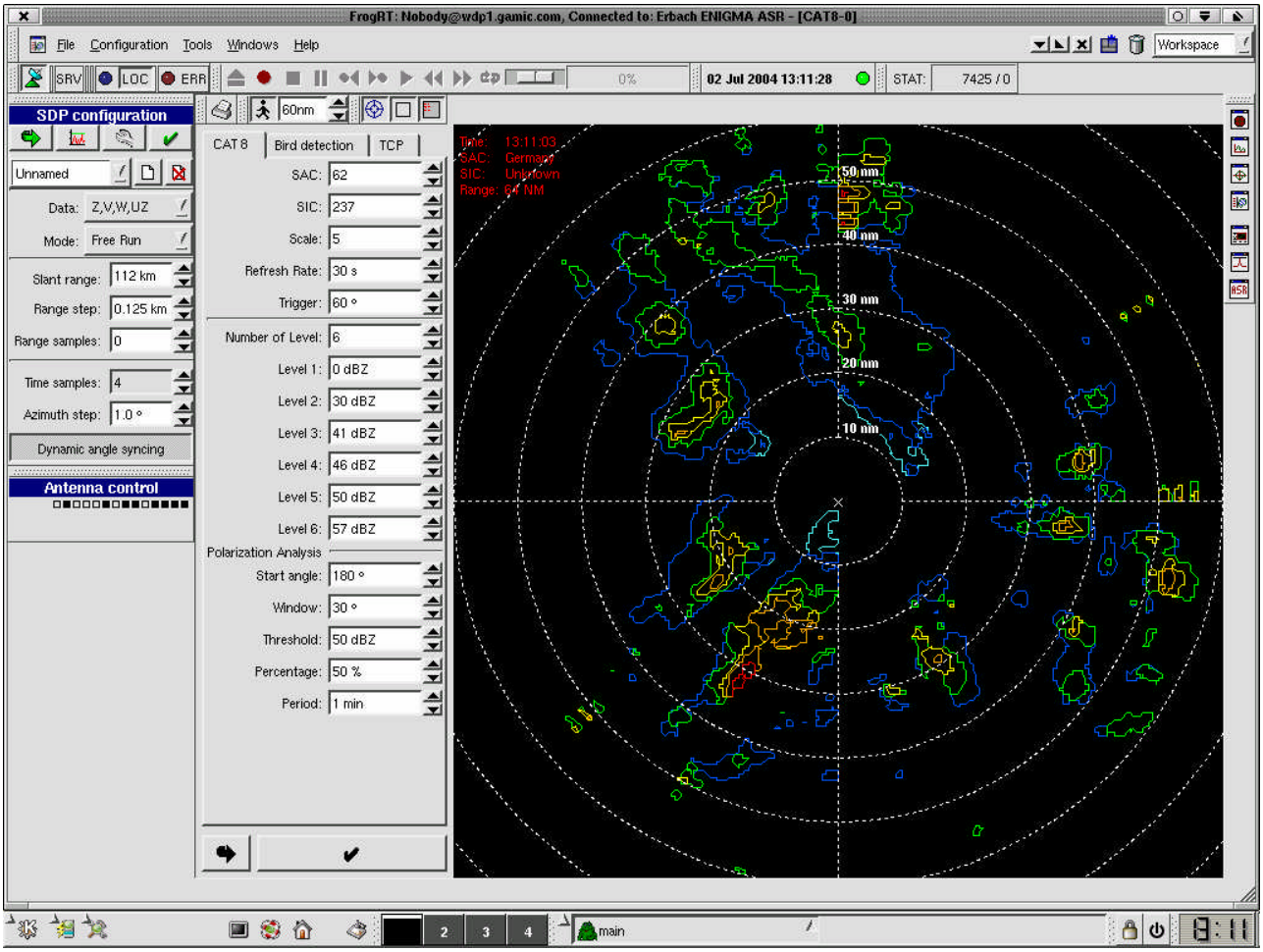
3.2 LVNL – Schiphol Airport, The Netherlands

LVNL formerly had displays of analogue weather information (precipitation) on the air traffic controller displays. The source of this weather information is combined terminal approach radar, named TAR-4. It is located near Schiphol-East and equipped with a separate primary weather channel receiver.
Schiphol's primary radar is an Alenia ATC-33K, with a G-33 antenna. This is relatively modern radar even though it is klystron-based (not solid state) version of the ATC-33, which has less capability in eliminating clutter. The ATC-33 employs MTD processing and incorporates several clutter maps. These processes are effective at eliminating moving returns from road traffic around Schiphol. The next picture shows a typical installation of such an ATCR-33K without radome.

The „old“ ALENIA weather channel concept (Weather data receiver and processor) included a separate S-Band receiver which processed weather information, with 6 layers separation capability.

The NEW system from GAMIC “FROG_ATC” for the LVNL project replaced the old weather displays. The new TAR4 FROG_ATC weather extractor system was installed in 2006 and now supplies a modern digital weather picture at the output at TAR-4 and SPL sites.
The standard format for the output to the ATC controller consoles is “ASTERIX Cat008”.
The following picture shows the TAR4 radar.

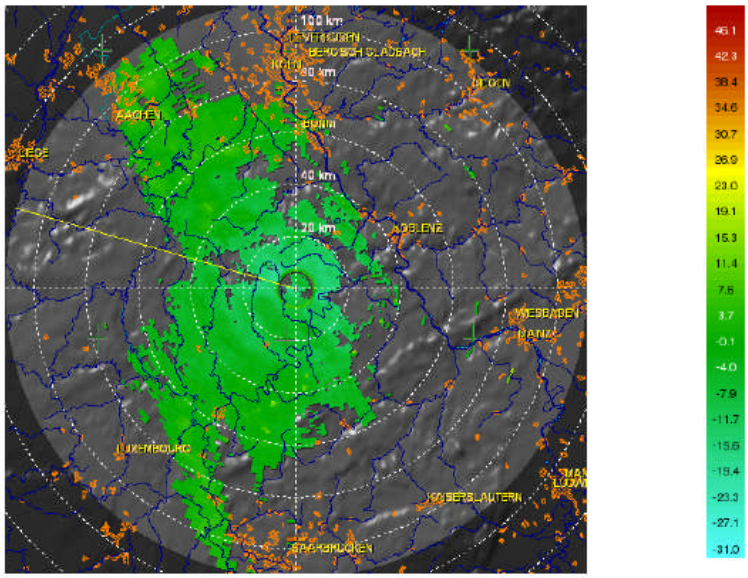
Additionally real time color coded “PPI” weather data displays (Z, V, W) are available for local and remote maintenance and meteorological users, similar to the images as generated by weather radars.



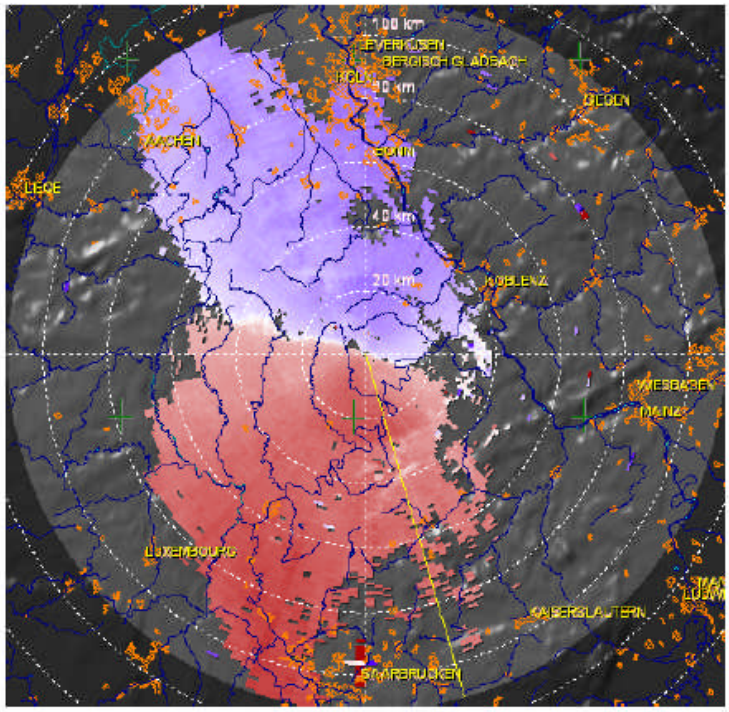
ASTERIX CAT 8 color coded dBZ contour display (6 FAA levels + 2 warning levels)

3.3 Conventional weather displays

The GWSP is capable to generate color coded Z, V, W displays as know from conventional weather radars.



Reflectivity Z and V measurement (with clutter correction) R=100 km = 60 nm range

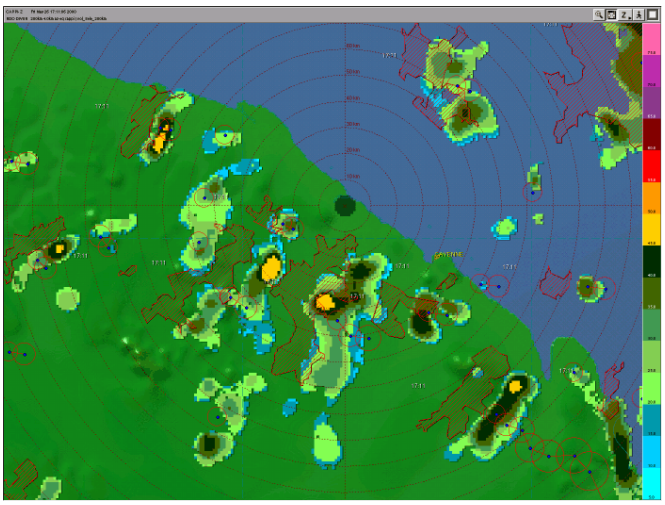


Doppler velocity V measurement (with clutter correction) R=100 km = 60 nm range

It can be seen that these data look very similar to the information gained by conventional weather radars.

The following “derived products” can be generated using the Z, V, W raw data:

- VAD – velocity azimuth display
- STP- storm tracking and forecasting
- RDS-radial shear
- AZS-azimuth shear
- RAS-combined radial and azimuth shear
- WARN-severe weather warnings based on (Z, V, W)
- PAC-Precipitation accumulation, estimate only



Weather tracking STP display

4. Conclusions

The following “Pro’s and Con’s” can be seen when comparing ATC radar weather extractors with conventional weather radars….

4.1 ASR limitations:

Using weather data extracted from an ASR radar has a number of system immanent disadvantages or limitations:

- Fan beam antenna: There is an “averaging” of reflectivity measurement over app. 10 deg in Elevation.
- No Elevation control: Limited indication of the weather height – just a high- and low-beam mode may be available
- Switching to circular polarization in bad weather conditions – stimulated by ATC needs to better detect aircraft.
- High antenna rotation rate limits sampling = S/N ratio is rather low

4.2 ASR + GWSP advantages:

Using weather data extraction concept GWSP with ASR radars has a number of **advantages** over conventional weather radars:

- High antenna rotation rate = very fast measurement update, up to 20 RPM
- High stability radars (Klystron or SST) will give optimum Clutter cancellation even at high RPM, typically >60dB
- Radar position at or near the airport is very good for detection of severe weather implication on flight operations: Shear, gusts, thunderstorm, side winds etc.

Important reasons to use ASR- GWSP:

- Cost saving: No additional airport weather radar (TDWR) is needed in most cases.
- The ATC radar + GWSP can do the job reasonably well if the requirements on quantitative rainfall estimate is less important compared to real time data update rate.

Additionally these data can be used:

- For weather radar network gap filling
- As complementary data source to existing radars or radar networks, where high speed data update rates are desired

Acknowledgment

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References

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(2) Malkomes et. al. Primary ATC – Radar Weather Extractor – Weather Signal Processor GWSP, ERAD 2008, Helsinki