

## DEVELOPMENT AND APPLICATION OF A POLARIMETRIC X-BAND RADAR FOR MOBILE OR STATIONARY APPLICATIONS

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### 1. INTRODUCTION

Modern polarimetric radars offer enhanced capabilities for rain attenuation correction, rain rate estimation and precipitation classification (e.g. Bringi et al, 2001). In the past a few research radars were developed to investigate polarimetric radar performance (e.g. Brooks et al, 2001). Based on these results and simulations new algorithms were developed to verify more accurately the rain rate from the measured polarimetric variables (e.g. Testud et al, 2000, e.g. Le Bouar et al, 2002). These systems capabilities applied to X-Band radars lead to systems, which are of interest for hydrology and radar networks. Smaller size and reduced cost for these systems are ideal for mobile and gap filler applications in radar networks.

Selex SI GmbH developed a polarimetric X-band radar system, which has the same general parameters and software interfaces as large scale C- or S-band radars. This radar is mounted on a trailer for mobile application (Figure 1) or can be operated in a fixed installation e.g. on a roof. The system can be operated with and without radome, which makes it ideal for high quality polarimetric measurements. The technical details and first results of the mobile radar version are presented.

### 2. TECHNICAL DETAILS

The radar was designed to cover several different applications. Only X-band radars are suitable for mobile applications since they offer the best compromise between antenna size and angular resolution. For radar networks the data quality should be comparable to the other radars

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in the network. Hydrologic applications need



**Figure 1:** Mobile trailer radar attached to the towing vehicle. The weight of the trailer is 2.8 tons including radome.

reliable rain rate estimates. Due to that the radar was designed for comparable performance like antenna positioning time, velocity and different beam width. Table 1 shows the general available reflector characteristics. The values are comparable to C- and S-band radars.

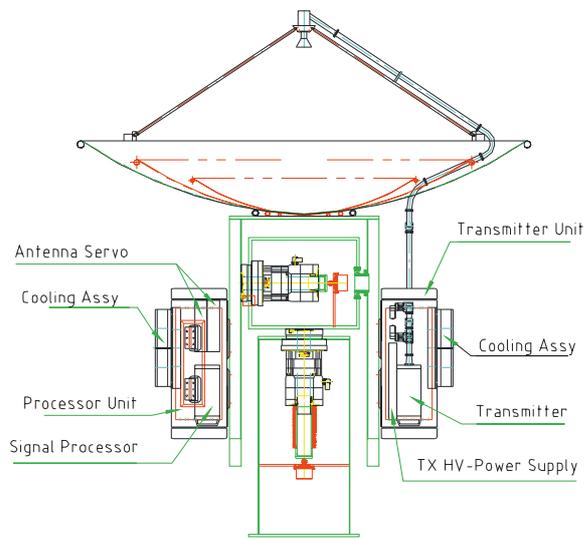
**Table 1:** Reflector characteristics for the 3 different reflector sizes

Antenna	XDP20	XDP15	XDP10
Operating freq. range	9.3 - 9.6 GHz		
Freq. - factory default	9.375 GHz		
Calibration freq. range	9.3 - 9.6 GHz		
Reflector diameter	1.2 m	1.8 m	2.4 m
Beamwidth at -3 dB	< 2°	< 1.35°	< 1.05°
Polarization	linear horizontal and vertical		
Power gain	> 38.5dB	> 42dB	>44.5dB
Min. first sidelobe level	< -23dB	< -25dB	< -27dB

The control components RCP (Radar control processor) and the signal processor (GDRX) are already used in the Meteor 1600/600 C+S band radars. Due to that the radar control is software compatible. The meteorological post processing is done with the dual polarisation version of the Rainbow 5 software. This software configuration allows the simple integration in existing radar networks. Existing volume scans sets for networks can be applied. For maintenance and

calibration the standard Ravis software can be used. The signal processing hardware allows all modern signal processing algorithms like DFT clutter filtering, 2<sup>nd</sup> trip recovery and dual PRF algorithms (e.g. GDRX manual 2005).

To keep the design compact all radar components are placed at the elevation level and no rotary joints are used for the waveguide. This has the advantage that there are no long term effects due to the rotary joints aging and no leakage for operation without radome. Figure 2 shows the general setup of the radar. The system components are mounted over elevation at the side arms below the reflector. The boxes are hermetically closed and cooled.



**Figure 2:** Schematic drawing of the radar antenna setup. The different reflector sizes are indicated.

Due to the design the waveguide to the reflector has only 1m length, keeping losses to an absolute minimum. The general technical data of the radar hardware components are listed in Table 2. The system is magnetron based. The full coherent receiver design allows a klystron, TWT or solid state transmitter as well.

## 2.1 STATIONARY INSTALLATION

For the fixed installed radar the antenna pedestal is placed on a roof or a small tower. Figure 3 shows a proposal for a tower installation. The weight of the pedestal assembly is about 850 Kg. The antenna can be supplied with a single phase power and has a typical consumption of about a 1KW of electrical power. The pedestal is interfaced with a network plug to establish the

computer connection and control of the radar. The radar can be used with and without a radome.



**Figure 3:** Sketch of a typical fixed installation. The radar can be installed on top of a roof as well, with and without radome protection.

**Table 2:** Radar characteristics for the actual system design

Characteristics	Value	
Antenna beam width	1° to 2.0° max.	
Antenna gain	38.5 – 44.5 dB	
Operating freq. range	9.36 – 9.38 GHz	
Transmitter type	Coaxial magnetron	
Transmitter peak power	>55 KW, single channel	
Pulse Width	0.3 µsec	3.3 µsec
MDS	-107 dBm	-112 dBm
TX PRF, selectable within range	250– 3000 Hz	250 – 550 Hz
Range resolution	< 30 m	450 m
Unambiguous range	Vel.> 200 km	Refl.> 400 km
Range gates per pulse	2500	
Receiver Dynamic/Linearity	90 dB +/- 0.5 dB	
Noise figure RX	2.5 dB	
Max. unambiguous velocity	+/- 96 m/sec	
Position accuracy	< 0.1°	
Positioning time (2°)	1.5 s	
Operational wind speed without radome (XDP15)	120km/h	
Operational wind speed with radome (XDP15)	200 km/h	

## 2.2 MOBILE VERSION

The mobile version of the radar is based on a trailer solution as shown in Figure 1 and 4. The trailer is used to store additional equipment nec-

cessary for mobile operation like generator, additional computer equipment and air condition.

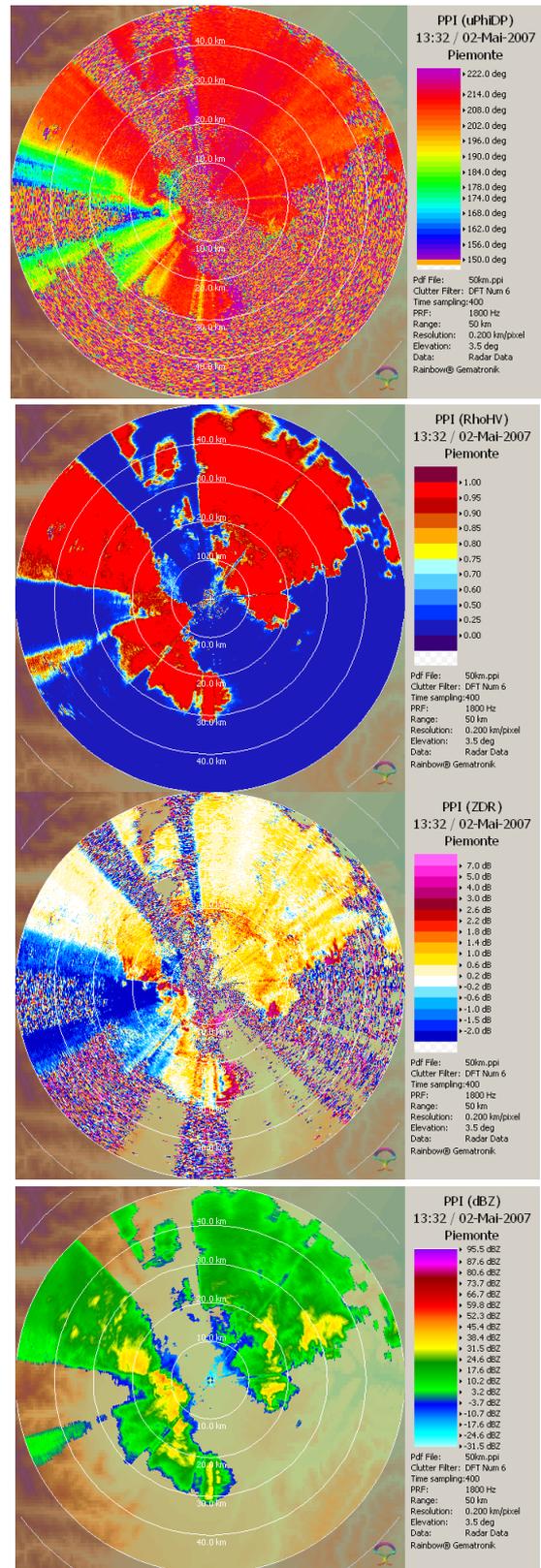


**Figure 4:** Trailer radar without radome installed. For standard setup the trailer is mounted on support feeds. The alignment for operation is done by mechanical leveling (0.05°), built in GPS and solar calibration.

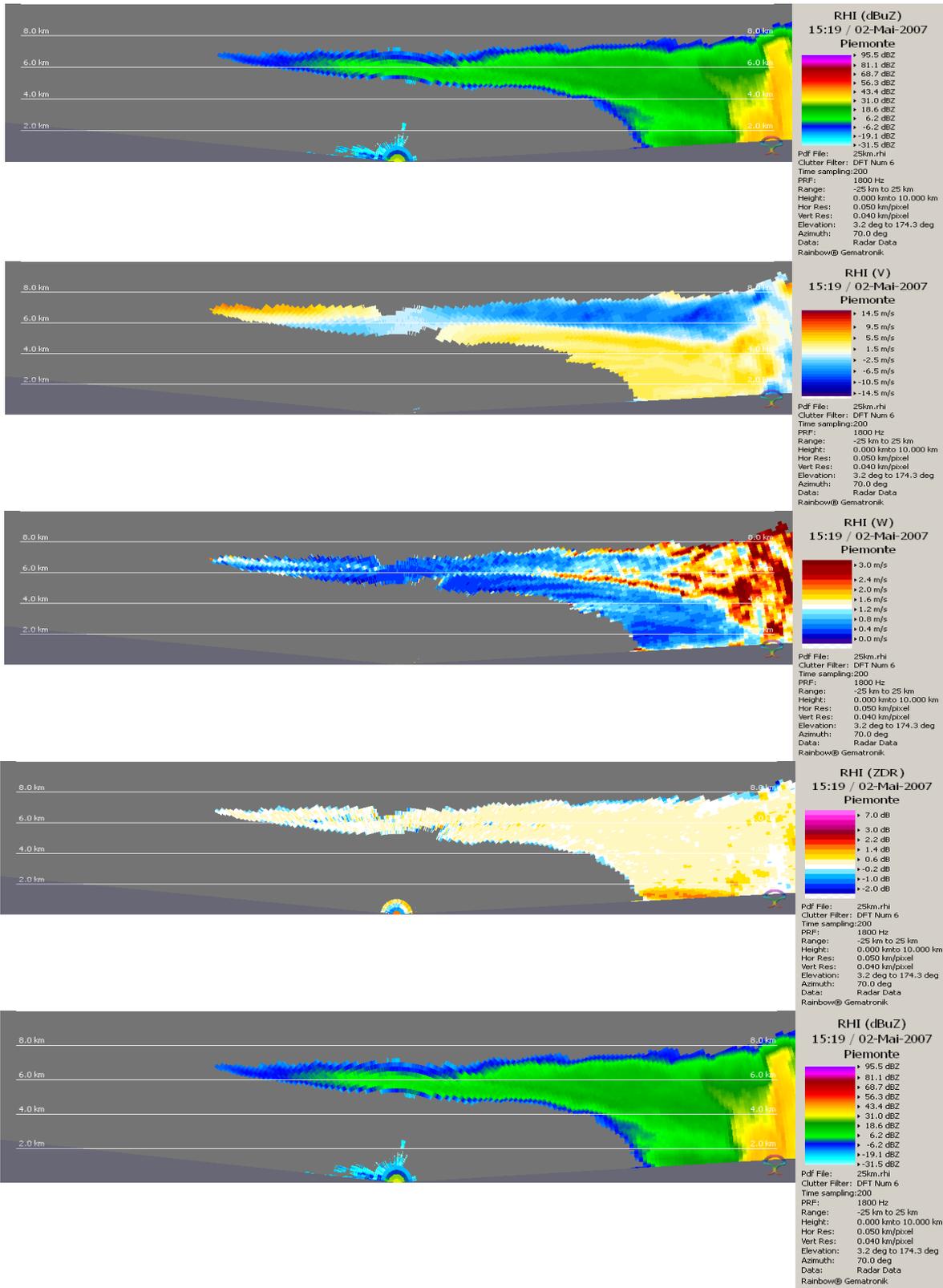
In the trailer there is an additional cabinet with computer equipment, a Rainbow computer, GDRX-Signal Processor and WLAN Router, which allows the storage of additional equipment. The air condition is used to cool/heat the radome and the additional equipment. The radome can be lifted mechanically for maintenance work or can be removed completely for operation without radome as shown in Figure 4.

### 3. RESULTS

The radar was setup in Piemonte, Italy in March 2007 and tested at Selex-Gematronik before. Due to the use of the standard GDRX digital receiver and signal processing equipment it is possible to record high quality data and use the possibilities for dual polarisation evaluation. It was possible to record clear air data up to 30km and analyze some precipitation events close to the Alps. Figure 5 and 6 show the data of the same thunderstorm event at different time. The core of the storm can be clearly identified.



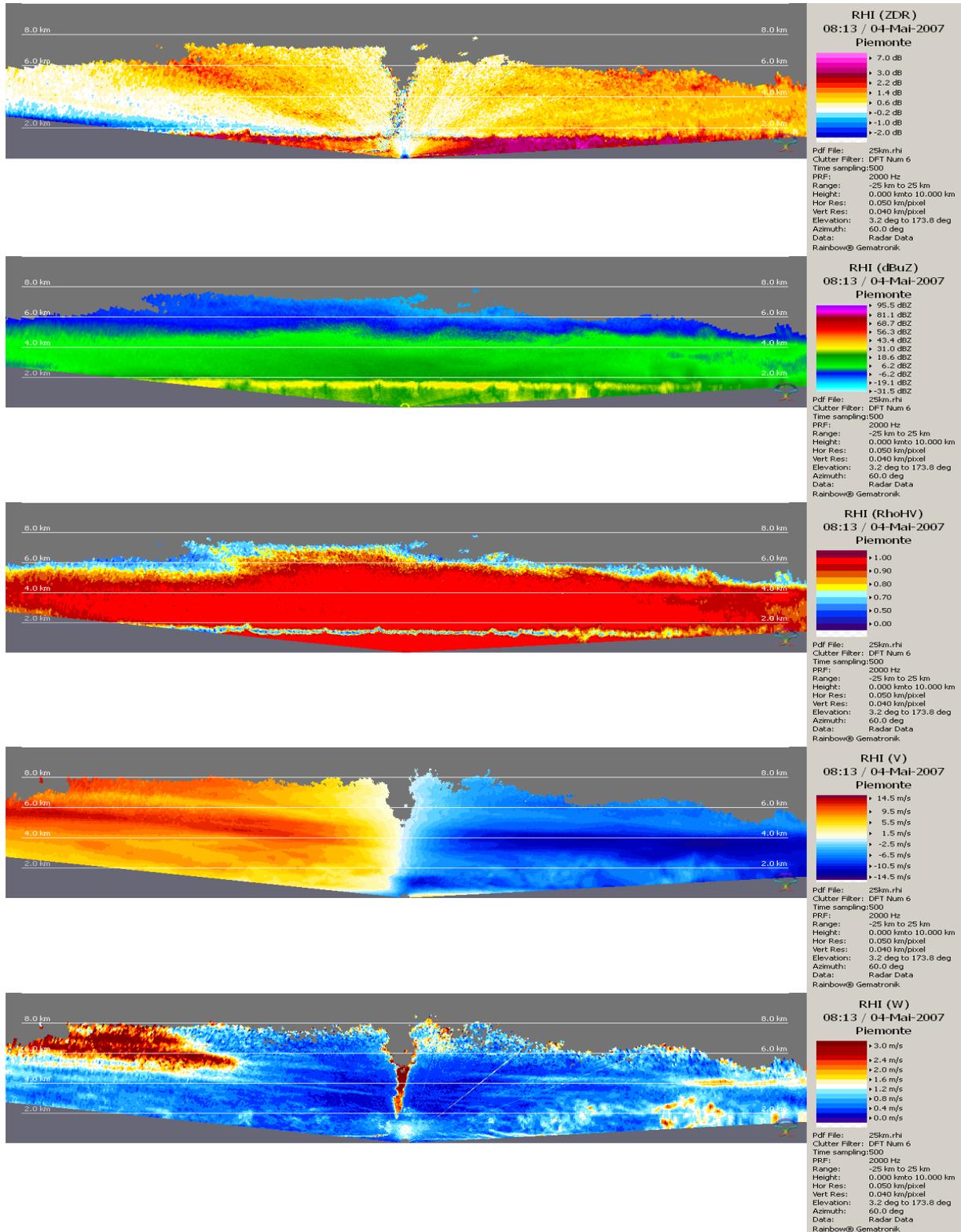
**Figure 5:** PPI-scan of a local thunderstorm at Carmagnola near Piemonte, Italy.



**Figure 7:** RHI-scan generated from volume data of a thunderstorm at Carmagnola near Piemonte, Italy. In this plot the core of the storm cell can be clearly seen.

The strong precipitation area leads to some reflectivity reduction behind the cell. The second event was a stratiform precipitation at the same site in Carmagnola. In the data the bright band can be clearly identified in high spa-

tial resolution. The polarimetric data shows the layer more clearly. On same data clutter filter were applied. The data show the capabilities for high spatial resolution measurements.



**Figure 7:** RHI-scan of stratiform precipitation data measured at Carmagnola near Piemonte, Italy. The bright band is clearly visible in the polarimetric and reflectivity data. The data were measured with radome.

#### 4. SUMMARY AND OUTLOOK

A new x-band based polarimetric radar has been successfully demonstrated. The measured data are of high resolution and ideal for short range investigation and research. The mobile platform allows fully independent remote operation and enhanced interfaces for further algorithm development. First measurements with the performance were shown, which demonstrate the general performance.

The performance and long term operation stability and polarimetric calibration will be further analysed. Other topics for further analysis are:

- The systematic measurement of the polarimetric performance with and without radome under different environmental conditions.
- The bias of the polarimetric variables for X-band due to environment .
- Comparison of data measured with a C-band polarimetric radar at the same location.

#### 5. REFERENCES

Bringi, V. and V. Chandrasekar, 2001: Polarimetric Doppler Weather Radar: Principles and Applications. Cambridge University Press, 636 pp.

Brooks E. Martner, Kurt A. Clark, Sergey Y. Matrosov, W.Carroll Campbell, and Janet S. Gibson NOAA/ETL's POLARIZATION-UPGRADED X-BAND "HYDRO" RADAR 30th Intl. Conf. on Radar Meteor. Munich 2001

GDRX Receiver and Signal Processor Manual  
Selex SI GmbH, Neuss, Germany 2005

Le Bouar, E, J. Testud and S. Y. Matrosov, 2002: Rainfall rate estimate from the rain profiling algorithm "ZPHI" applied to X-band polarimetric radar data. Proc. European Conf. Radar Meteor., November 2002, Delft, Netherlands, 238-242.

Testud, J., E. Le Bouar, E. Obligis, and M. Ali-Mehenni, 2000: The rain profiling algorithm applied to polarimetric weather radar. J. Atmos. Oceanic Technol., 17, 332 – 356.