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# CASTOR2, A NEW COMPUTER FOR THE FRENCH RADAR NETWORK

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## 1. INTRODUCTION

The CASTOR2 project began in 1997 by defining the needs with the users. The main technical choices were done in 1998 and the softwares written during the 98-2000 period. After these developments, a first operational system was built. It is now under operationnal testing at the Trappes radar site. Il will thereafter be deployed during 2002 over the entire French network (18 radars). This paper briefly describes the CASTOR2 system, its main functions, and future evolutions.

## 2. PHYSICAL DESCRIPTION

The system is installed near the radar, in a dedicated cabinet well protected against electromagnetic perturbations. Its core is a VME VXworks real time computer connected :

- to a PC LINUX computer for graphic user interface and local data storage through the local ethernet link. A similar PC computer with the same software can be connected to the VME computer from one or several distant sites for maintenance or survey purposes.

- to a microwave signal generator, and to a powermeter, for calibration purposes;

- to the radar for video signal digitization

- to the Météo-France communication network through a telephone link.

## 3. MAIN FUNCTIONS

Apart from the classical functions (signal processing, transmission of the images to the users, various alarm generation and transmission of these alarms to distant maintenance staff, some original characteristics are :

3.1 *Radar Commands*

CASTOR2 can interface with various radars:

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**(i)** ON/OFF relay commands are sent to the old RODIN motors, **(ii)** numerical character chains are sent to modern Gematronik or Thomson radars, **(iii)** continuous voltages, variable with the desired rotating speed, are sent to old DLM10 and Gematronik radars. Sofisticated softwares have been developped to calibrate the antenna motors in position and speed, in order to optimize the motors servo-controls.

3.2 *Calibration*

Various techniques are used to insure a correct calibration : **(i)** a microwave signal, issued from a generator, is periodically injected in the wave guide to compute a calibration factor; **(ii)** the transmitted pulse amplitude is measured for each pulse and the time variation of the averaged values of this parameter can be visualized, as well as its standard deviation, **(iii)** as suggested by Delrieu et al., the time variation of the energy received from some specifically chosen ground echoes can also be visualized to survey the radar, **(iv)** an automatic software control using the Sun position is also available to control the antenna position, and **(v)** finally, before sending to hydrologic users, the data are multiplied by a correction factor monthly computed by comparison with rain gage measurements (Chèze, 1994).

## 4. THE DIRECT CARTESIAN-COORDINATES PROJECTION METHOD

The radar row data flow is around 2 Mo/second after the digitizer. Averaging these data is necessary to decrease their statistical fluctuations, and also to decrease the amount of data to be stored. This is generally done by summation over range and azimuth to produce row-polar images with 0.5° and 1 km spatial resolution, and CASTOR2 produces such an image. However, most users need cartesian coordinates and those row-polar images must then be converted, for instance to 1x1 km cartesian coordinates. This leads to a loss in spatial resolution damageable for clutter suppression or small scale precipitation identification.

*the direct projection method*

To avoid this, the CASTOR2 averaging is directly performed in the user cartesian grid: after each transmitted pulse, and for each range gate, the corresponding position of the cartesian cell is computed and the detected signal added to the cell. The corresponding cell in a "counter grid" is also incremented and, after completing the image, the data grid is simply divided by the counter grid.

With the rotating speed and the pulse rate we use (5°/sec and 300 pps), no cells stays empty up to 256 km in range and we therefore do'nt need any algorithm to feed empty cartesian cells.

In addition to the classical row-polar image mentioned above, two cartesian images are producted by CASTOR2 with different space resolutions and maximum ranges : one 1x1 km image up to 256 km in range, and one 250x250m up to 128 km in range.

*taking in account advection vectors to correct for cells motion during the acquisition time*

The acquisition time is 5 minutes for a complete image, which uses up to 3 antenna revolutions in azimuths at different site angles. During this time, the rain cells can move, up to several kilometers, leading to significant distortions of the image. To correct for this, the cell position computing takes in account the cell velocity (through an advection computing method) multiply by the time delay between the time of the measurement and the reference in time $t_o$. In the resulting image, all the cells are representative of a measurement at the same time $t_o$.

## 5. GROUND CLUTTER CANCELLATION

The French radars are at present non-Doppler radars. The only one method for ground clutter filtering is thus the "statistical method" based on the fact that the standard deviation of the received signal amplitude is much higher for precipitation echos than for ground echos. The algorithm, originally coded by Résibois 1985, has been extensivelly tested (Jamet et al. 1996, Perier 2000, ...). It is coded in the software and 3 kind of images are produced : (i) reflectivity without fixed echos filtering, (ii) reflectivity with fixed echos filtering, and (iii) standard deviation of the received echos (for future studies). The method provides a 20 to 30 dB rejection which is not always enough and we also use data from higher site angles.

## 6. FUTURE DEVELOPMENTS

The introduction of an ultra fast AD conversion and frequency transposition card in the VME computer is expected this year. This will allow digital conversion, and numerical frequency transposition, for up to 4 signals at 30 MHz IF frequencies (two transmitted signals and two received one). If we succeed, the CASTOR2 will therefore have the capability of numerical reception, and processing, for Doppler and dual polarization.

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