

# Remote Monitoring of Ice Formation over a Runway Surface

**ID: 50**

A. Troiano, F. Rugiano, and E. Pasero

Department of Electronics  
Politecnico di Torino  
Torino, Italy



23<sup>th</sup> May 2012

# Presentation outline

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- The innovative ice sensor
- The monitoring system
- Presentation of the data
- Conclusions

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# Applications



Airports



Roads



Aircrafts

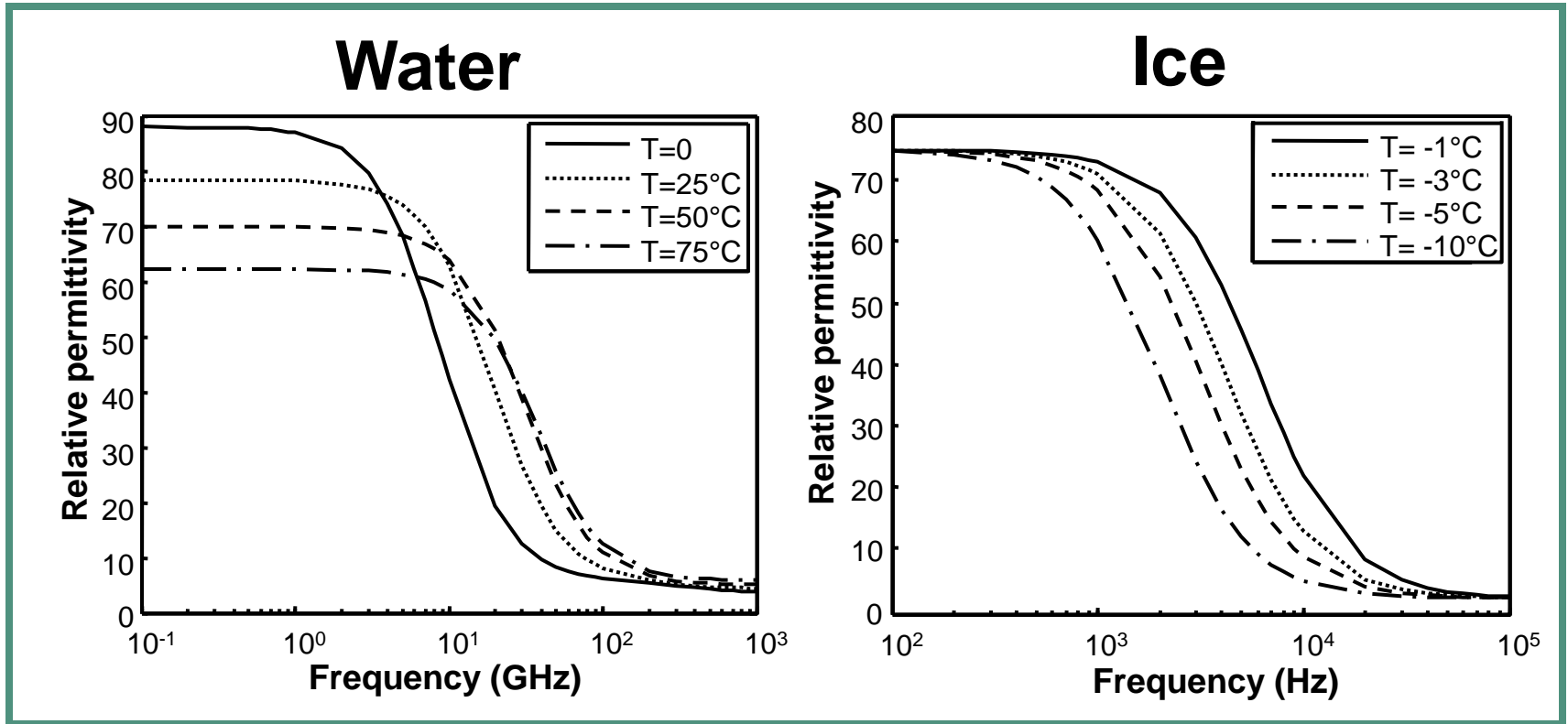


Walkways



Seas

# Relative permittivity of water and ice



Relative permittivity of air is about 1 for the whole range of frequencies and temperatures of interest

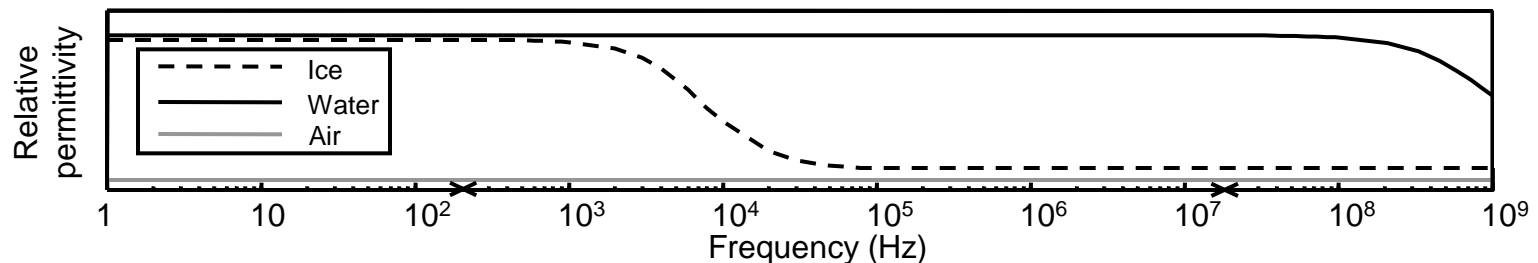
# Multi-frequency measurement

Low frequencies (<1kHz).  
Distinction between water and ice is not possible, only air can be identified

High frequencies (>100kHz).  
Distinction between air and ice is not possible, only water can be identified

Multi-frequency measurement

It is possible to distinguish between water, ice, and air by two measurements, at low (200Hz) and high (20MHz) frequencies.

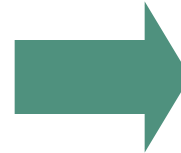


# Geometrical configuration and dimension of the electrodes

- Independent of the orientation of electrodes
- Independent of the position of raindrops or pieces of ice with respect to electrodes



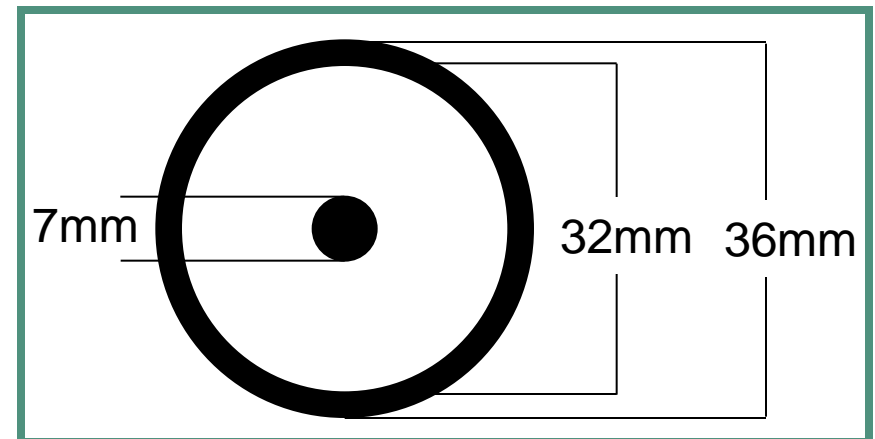
## Concentric electrodes



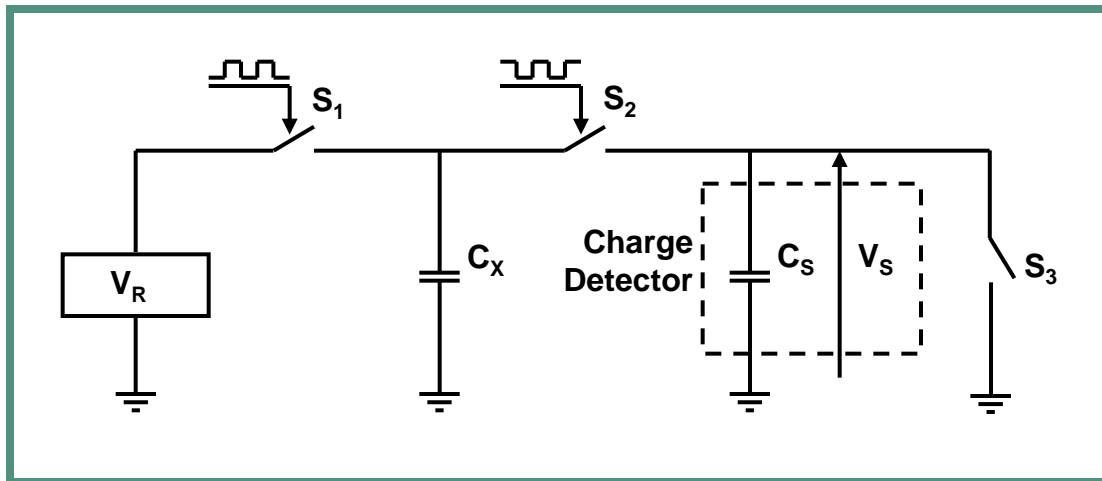
Top view



- External maximum ring dimension imposed by the box
- External minimum ring and internal circle dimensions in order to explore a largest area between the 2 electrodes, but still large enough to get a measurable value of capacitance



# The capacitance measurement circuit



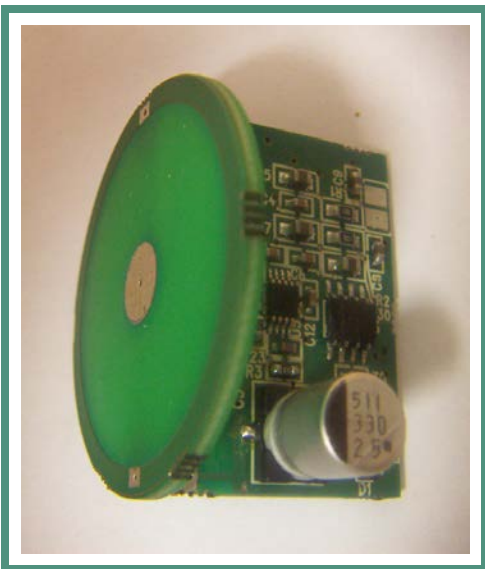
Repeating the transfer process for  $n$  times:

$$C_X = \frac{C_S}{n} \frac{V_S}{V_R}$$

- $C_X$  is the capacitance of the electrode assembly and the material placed over the sensor
- $V_R$  and  $C_S$  are the reference voltage and capacitance
- Since  $C_X \ll C_S$ , nearly all charge in  $C_X$  is transferred to  $C_S$  when  $S_2$  is closed
- $V_S$  is measured by an ADC
- $S_3$  is used to discharge  $C_S$



# Final prototype



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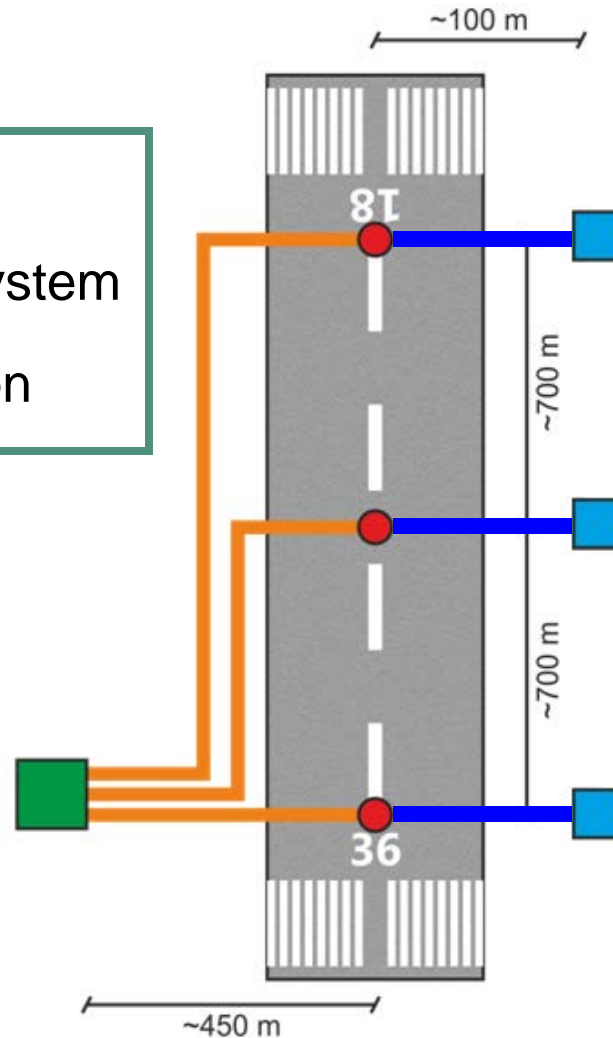
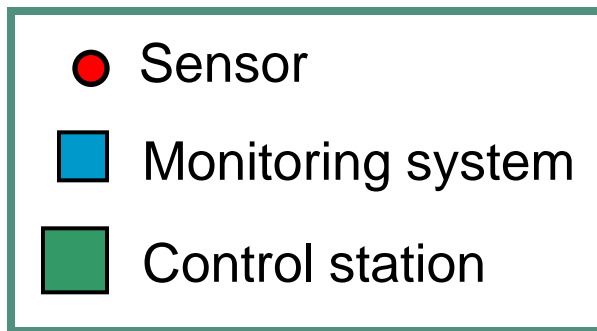
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# Sensors at the Turin-Caselle airport

Three sensors were embedded at the Turin-Caselle airport in order to detect formation of ice at the beginning, ending and in the middle of the runway, and increase safety during take off and landing of the aircrafts.



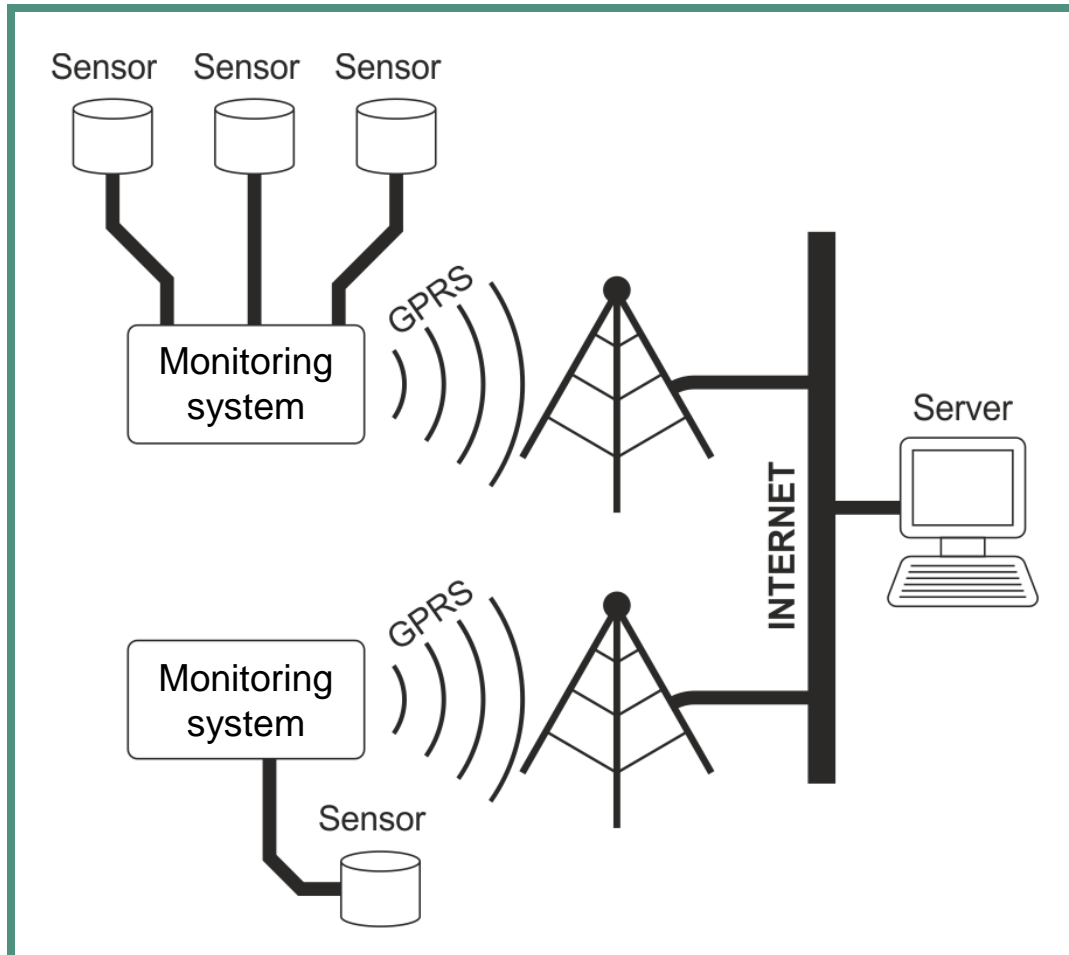
# Wireless sensor network



**Using cable:**  
3450m of cable

**Using a wireless monitoring system:**  
300m of cable

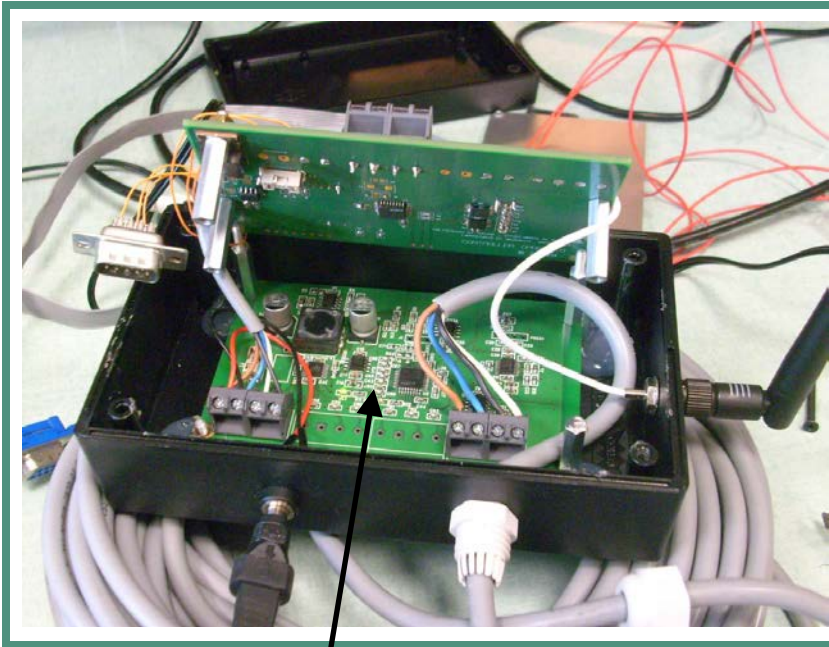
# Wireless sensor network



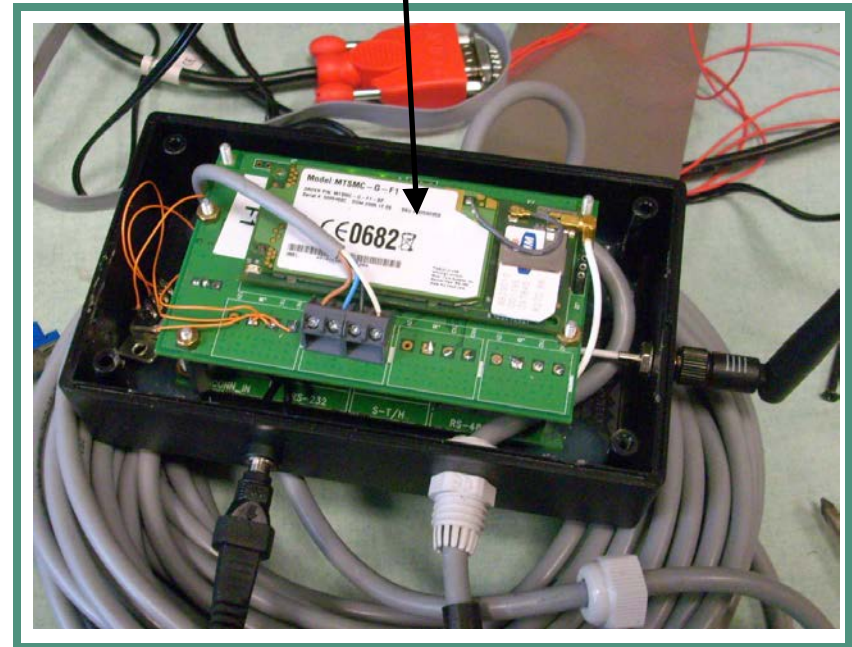
GPRS was chosen since:

- cover a large area without using repeaters
- secure (using encryption algorithms)
- be manageable via Internet

# The monitoring system



Data acquisition board



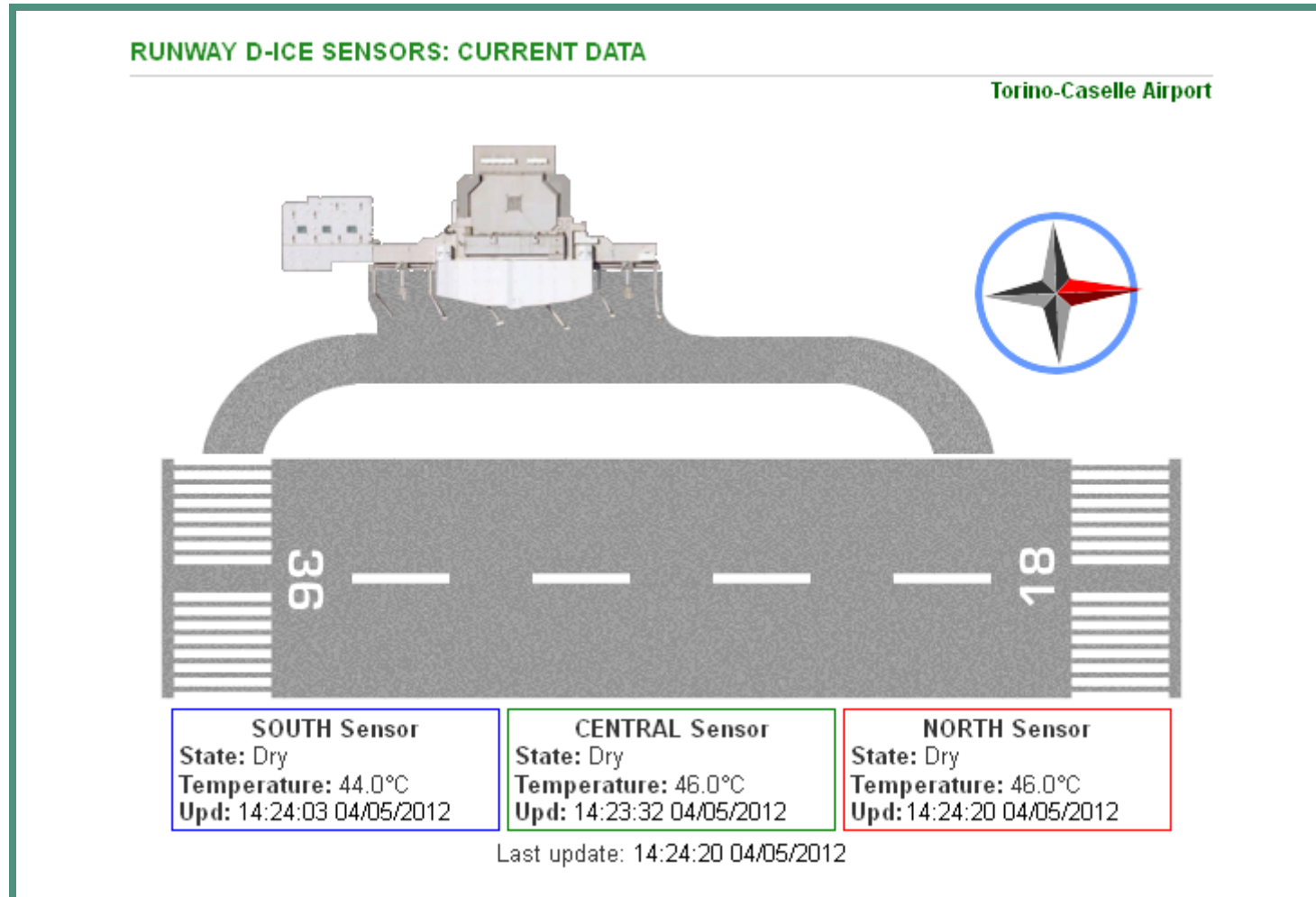
GPRS board

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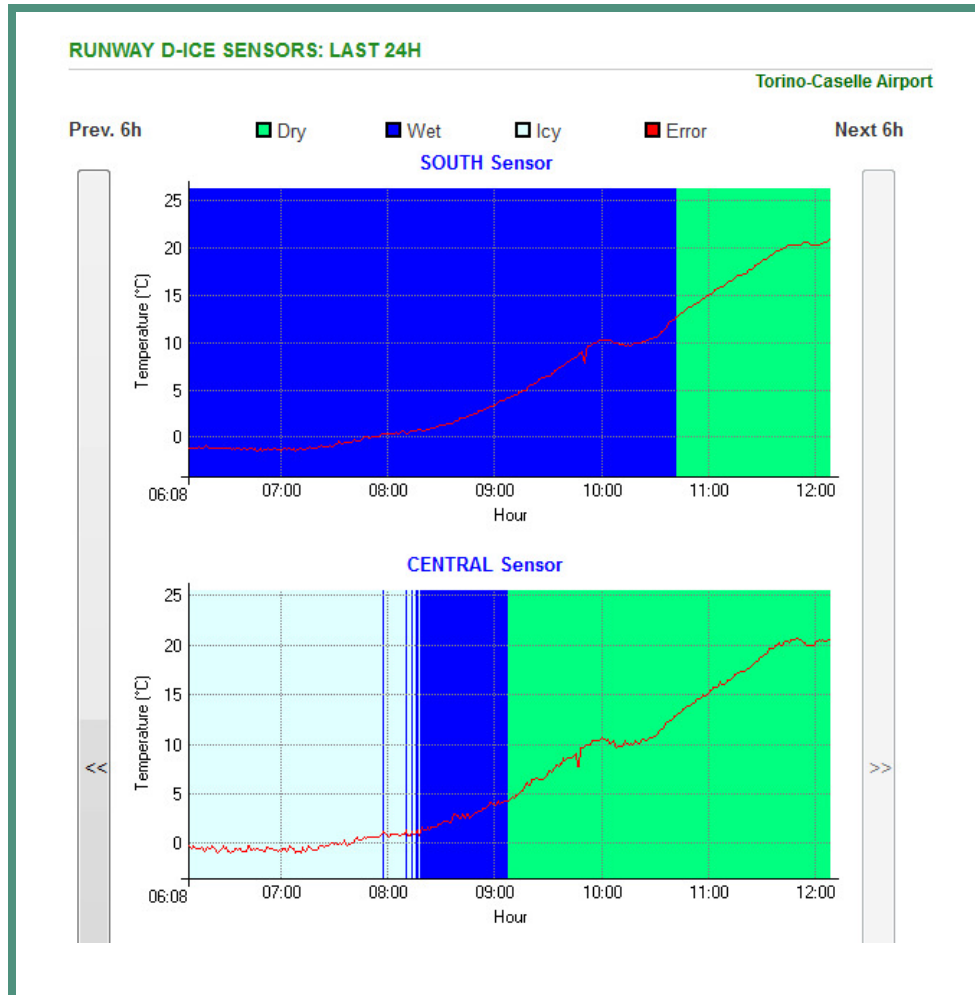
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# Presentation in a web site: current state





# Presentation in a web site: last 24h state



[www.neuronica.polito.it](http://www.neuronica.polito.it)

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# Conclusions

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- An innovative system to monitor the data collected by sensors at the Turin-Caselle airport was presented.
- The data are presented on web pages for simple access.
- The GPRS based monitoring system was installed more than one year ago showing correct working and automatic reactivation after malfunctions without any external help.

# The end

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Thank you for your attention!

[amedeo.troiano@polito.it](mailto:amedeo.troiano@polito.it)