Weather radar technology and related frequency issues

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Weather radars and frequency allocations

What the radars do and where they sit in the spectrum

01

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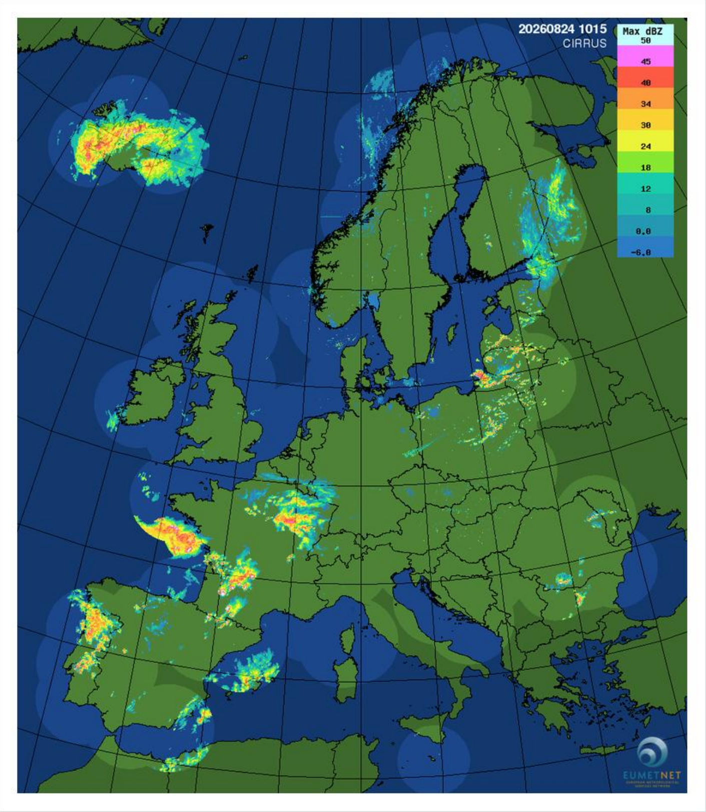
Short introduction to weather radars

- Weather radar networks are used for accurate and timely detection and forecasting of precipitation (and wind) over large geographical areas.
- Especially important for safety critical operations, e.g.:
  - Aviation safety
  - Urban flooding
  - Road and rail maintenance
  - Tornado detection and tracking
- Three allocations in ITU-R Radio Regulations:
  - S-band (2700-2900 MHz)
  - C-band (5250-5850 MHz, primarily 5600-5650 MHz)
  - X-band (9300-9500 MHz)



(Image courtesy of EUMETNET/OPERA)

RF interference and mitigation

Observed cases, filtering and frequency shift

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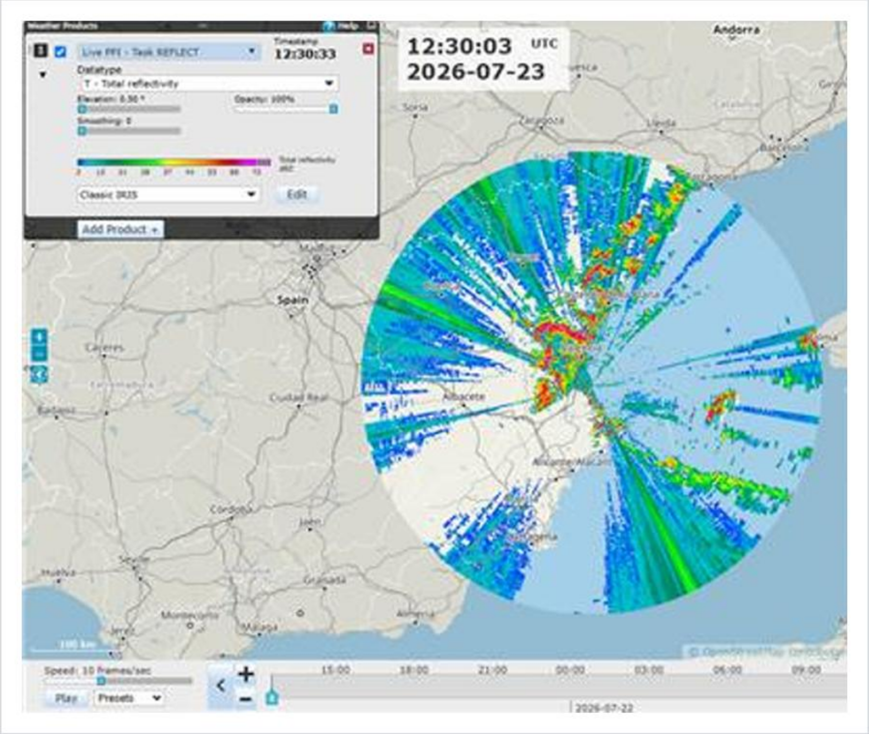
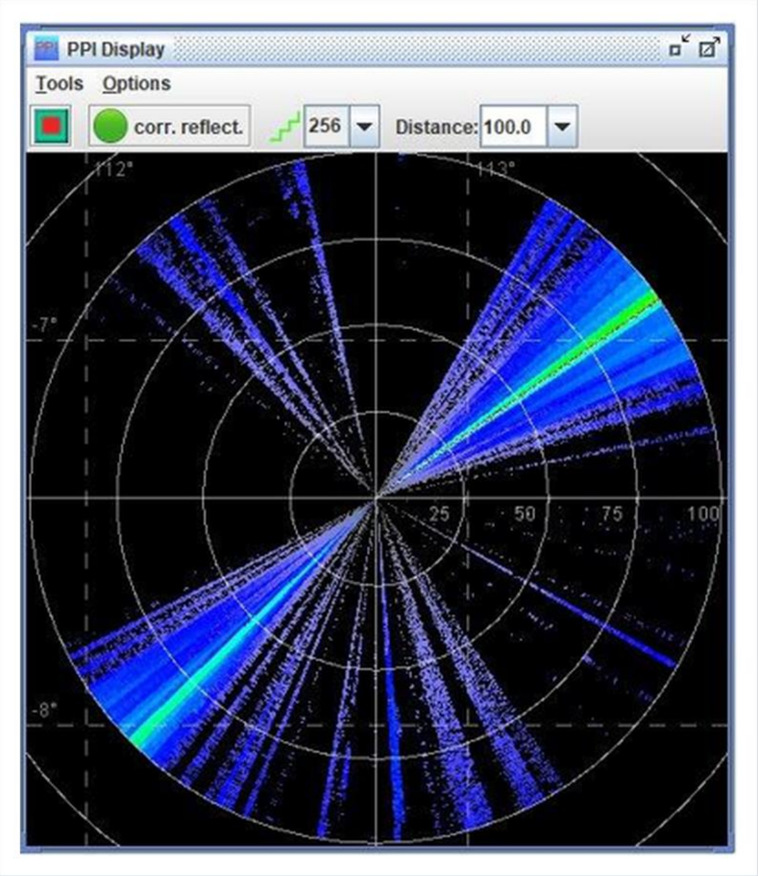
Frequency issues

- C-band weather radars share the spectrum with wireless LAN equipment since WRC-03.
  - Inside 5600-5650 MHz RLAN must comply with Dynamic Frequency Selection (DFS) requirement and change channel when a weather radar is detected.
  - Despite the DFS requirement, interference to C-band weather radars is a significant problem. Mostly caused by illegal RLAN devices where the DFS is not functioning or turned off.
- S-band radars have also been reported to suffer from RF interference at some sites.
  - In most cases this interference is coming from adjacent band emissions and can be handled by suitable filtering.
- X-band weather radars do not have as many reported RF interference cases.
  - Spectrum mostly shared with other radar systems.
  - Interference can typically be avoided by careful selection of operating frequency and coordination.



WLAN interference to C-band WR

- A continuous or high duty cycle transmission fills complete radials in radar data and is visible at all distances in given directions. (The polar plot on the right shows interference only for clarity.)
- Especially in or close to urban environment interference is typically seen in several directions.
- The frequency overlaps with the radar received frequency and cannot be filtered out by conventional HW filters (bandpass or band rejection).



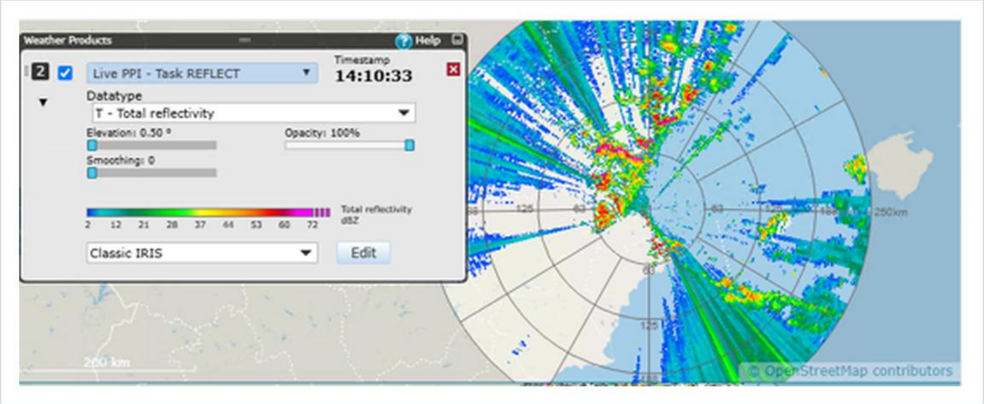
Examples of mitigation techniques and filtering

- Some mitigation techniques have been proposed and implemented to cope with the RLAN interference to C-band weather radars:
  - Ensuring that the radar transmission is recognizable by the DFS algorithms.
  - Filtering of interference in the radar signal processing. Although some filtering methods are more promising than others, there is always the risk of losing significant amount of weather data.
  - Moving some of the more severely affected radars to a different frequency range without allocation to RLAN equipment.

> From weather radar perspective the primary issue is lack of enforcement of the existing rules and regulations. If the DFS requirement was monitored and enforced as intended when the decisions were made, the problem would not exist.

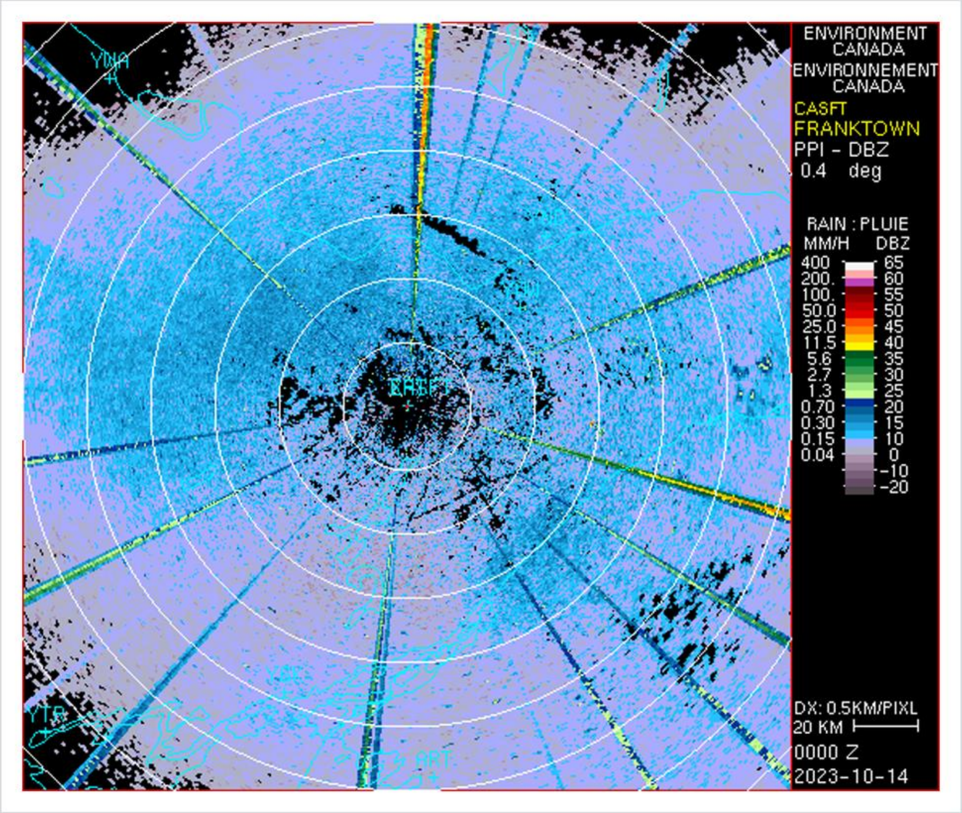
5.4 GHz example

- One of the proposed mitigation techniques to avoid RLAN interference to C-band weather radars is moving some of the radars to a lower frequency range 5350-5470 MHz.
  - No allocation to wireless LAN in ITU-R Radio Regulations, but also no specific reference to weather radars, like footnote 5.452 at 5600-5650 MHz.
  - In Switzerland weather radars have been successfully operated at this frequency range.
  - In some other countries reports of illegal use of RLAN equipment even at this lower frequency range. The example on the slide is from Spain, from a radar operating at 5418 MHz. (Confirmed mostly RLAN emissions by the Spanish NRA.)
  - There is also pressure for new allocations for communication systems at this frequency range.



S-band example from Canada

- S-band weather radars (2700-2900 MHz) have also been reported to suffer from RFI at some sites.
- The sources of interference in this case are base stations at the adjacent band below the radar frequency.
- Fixed by adding hardware bandpass filters to the radar received signal path.
  - Not 100 % effective with the strongest RFI sources.
  - Small loss of sensitivity.
  - Small additional cost.



(Image courtesy of Environment and Climate Change Canada)

Emerging SSPA technology

Solid-state transmitters and the DFS gap

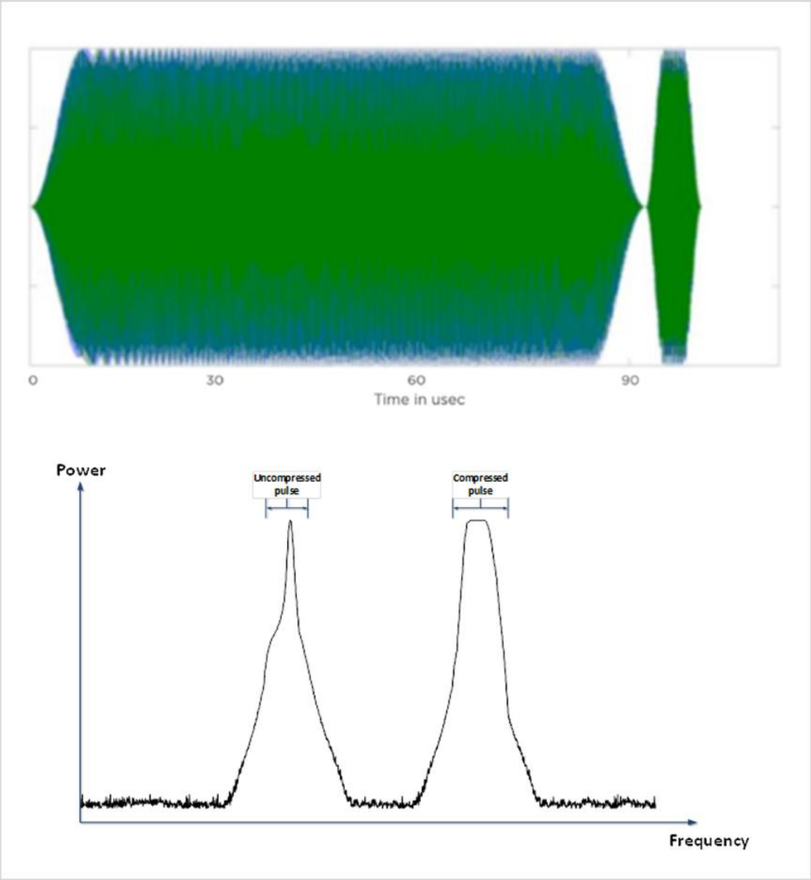
03

Emerging SSPA technology

- Until now, weather radars have mostly used vacuum tube transmitters (magnetrons and klystrons) as sources of microwave energy.
- Now, solid-state (GaN transistor) power amplifier (SSPA) based transmitters are becoming more and more common.
  - Lower peak power (a few kilowatts vs. hundreds of kilowatts)
  - Longer transmitted pulses (hundreds of microseconds vs. a few microseconds)
  - Higher duty cycle (10 % vs. 1 ‰)
  - Similar transmitted energy, leading to similar measurement sensitivity.

Challenges related to new SSPA radars

- C-band RLAN DFS function requirements only cover short radar pulses up to 20 μs.
- Long compressed (modulated) pulses transmitted by solid-state radar transmitters are not recognized by the RLAN devices, even if the DFS is functioning properly.
- Actions ongoing to:
  - Update the RLAN DFS requirements in EN 301 893. Working on TR 104 893 in ETSI TC BRAN.
  - Update ITU-R recommendations:
    - M.1849, Technical and operational aspects of ground-based meteorological radars.
    - M.1652, Dynamic frequency selection in wireless access systems including radio local area networks for the purpose of protecting the radiodetermination service in the 5 GHz band.



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