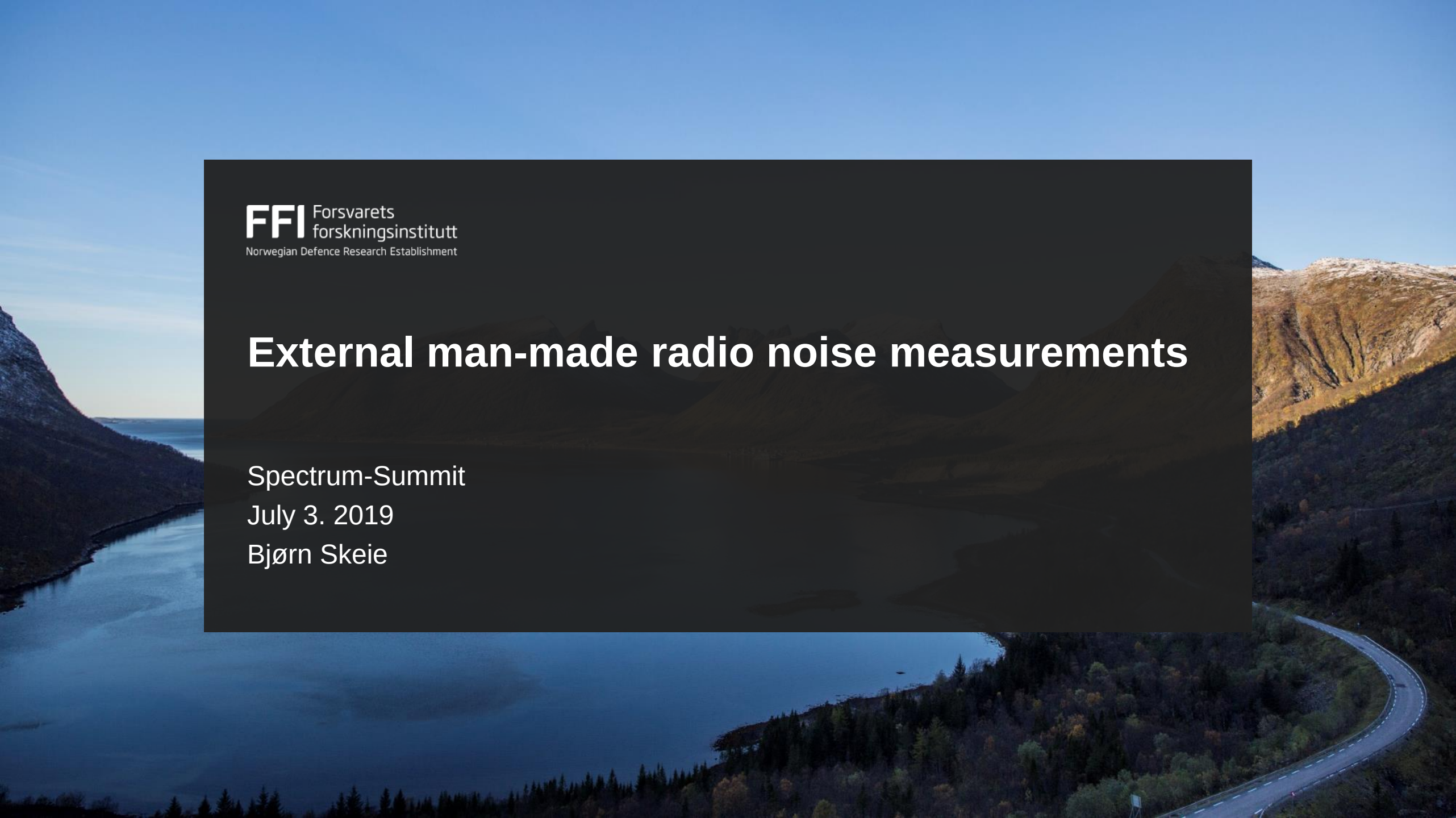


FFI Forsvarets forskningsinstitutt
Norwegian Defence Research Establishment

External man-made radio noise measurements

Spectrum-Summit
July 3. 2019
Bjørn Skeie

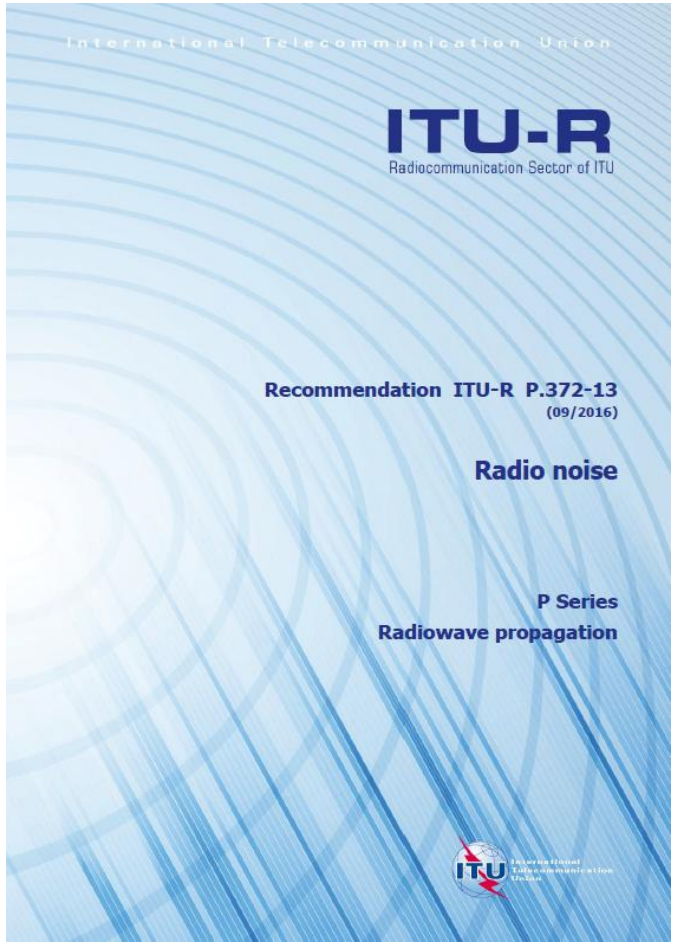
FFI (Norwegian Defence Research Establishment)

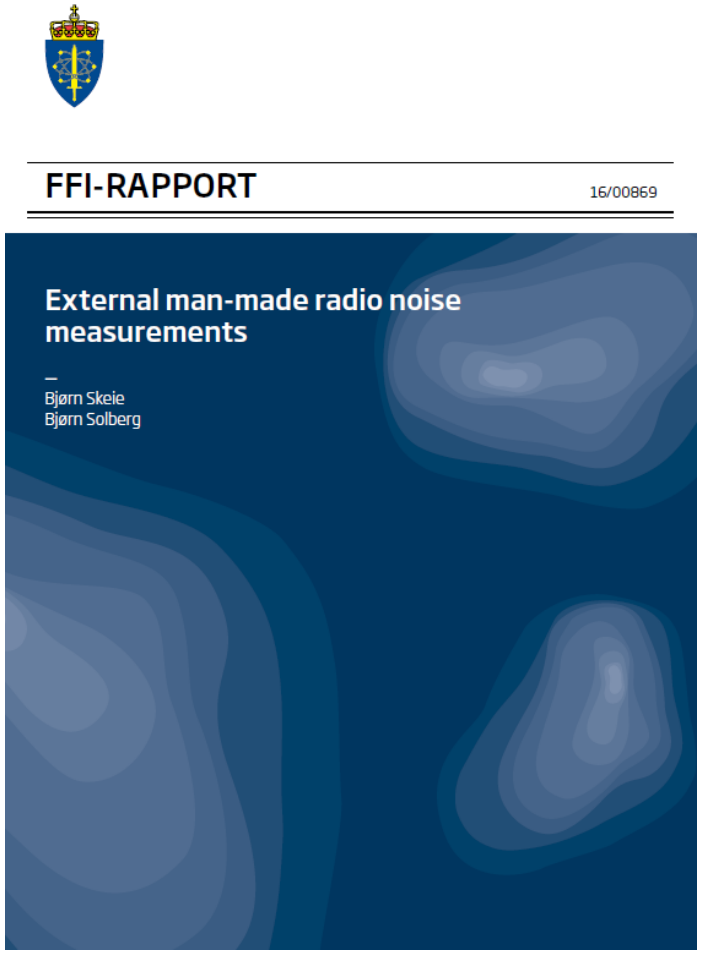
- Major defence R&D organisation in Norway
- Established by the Parliament 1946
- Staff 711
- Annual turnover 94 Mill € (2018)
- Research and development (R&D)
  1. Security policy
  2. Defence policy, structure and organisation
  3. Military operations
  4. Comprehensive defence, societal security and preparedness
  5. Personnel and competence
  6. Network, command, control and communication
  7. Intelligence, surveillance and reconnaissance
  8. Combat systems
  9. Sensor systems, signature adaption and electronic warfare
  10. Weapons systems, effects and protection

Kjeller

Horten

External man-made radio noise





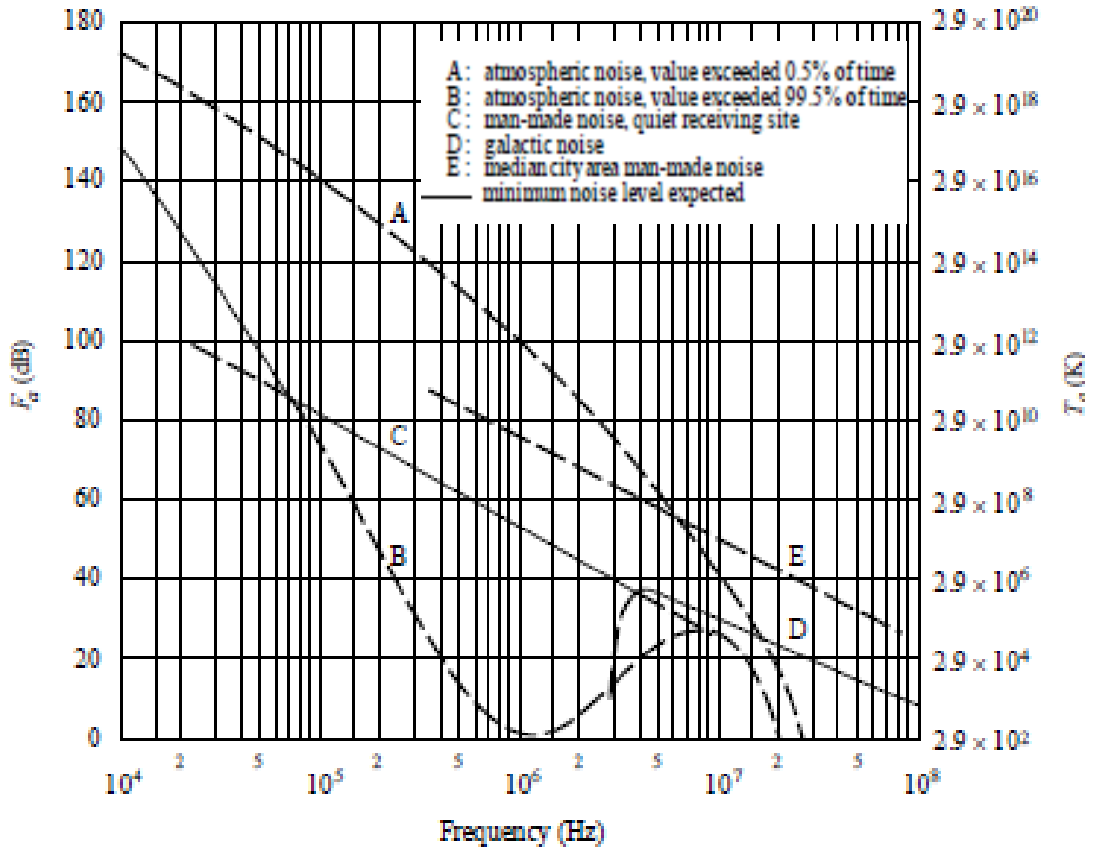
https://www.ffi.no/en/Sider/default.aspx

Sources of external noise

- Radiation from lightning discharges (atmospheric noise due to lightening)
- *Aggregated unintended radiation from electrical machinery, electrical and electronic equipment, power lines, or from internal combustion engine ignition (man-made noise)*
- Emissions from atmospheric gases and hydrometeors
- The ground or other obstructions within the antenna beam
- Galactic noise (or cosmic noise) originating from the sun or other celestial radio sources

FIGURE 2

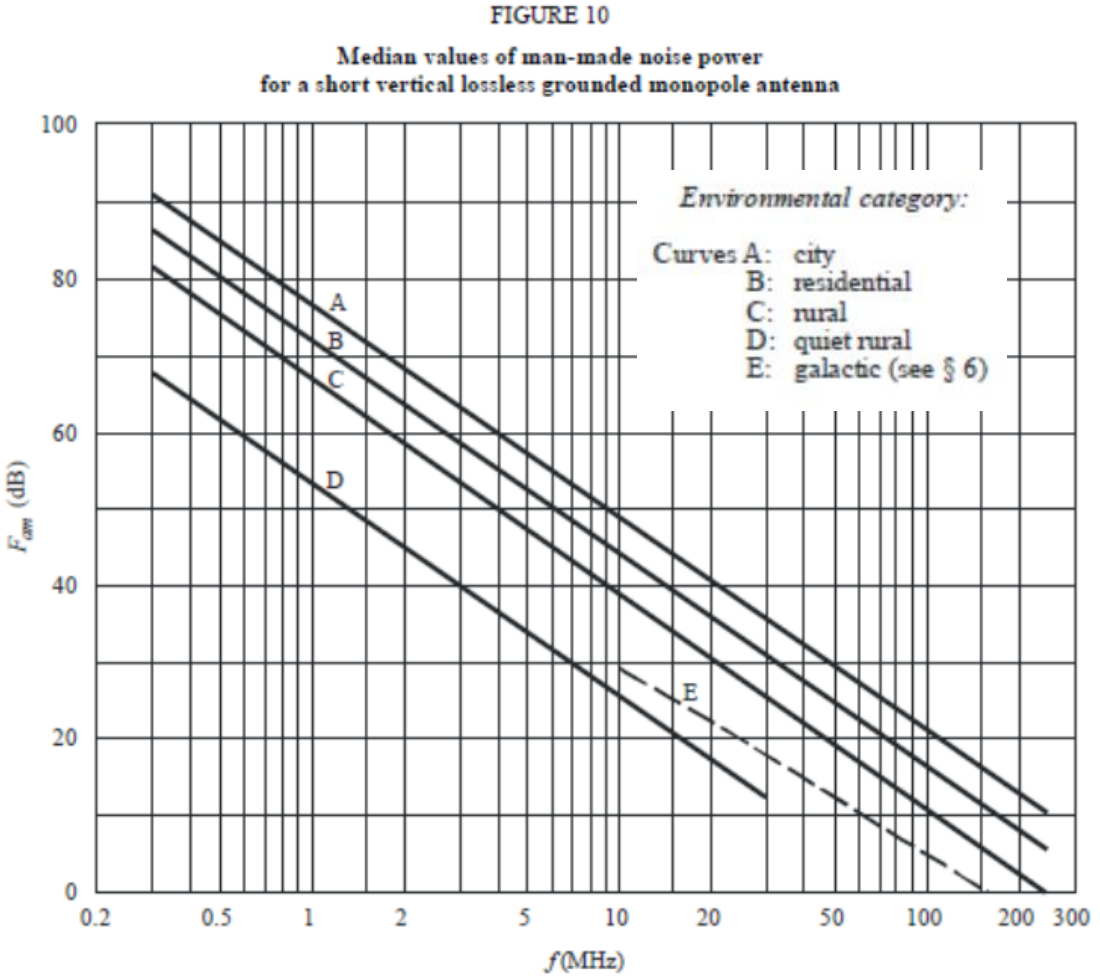
F_a versus frequency (10^4 to 10^8 Hz)



Excerpt from ITU-R P.372

External man-made radio noise

- Environmental categories:
  - City, Residential, Rural, Quiet rural
- Expressed as “external noise figure”
- The noise figure ($F_{a,m}$) or the noise factor ($f_{a,m}$) is commonly expressed by the *median* value of the statistical distribution that applies to the relevant category
- Components:
  - *Gaussian – ITU-R P.372 - measured*
  - Impulsive



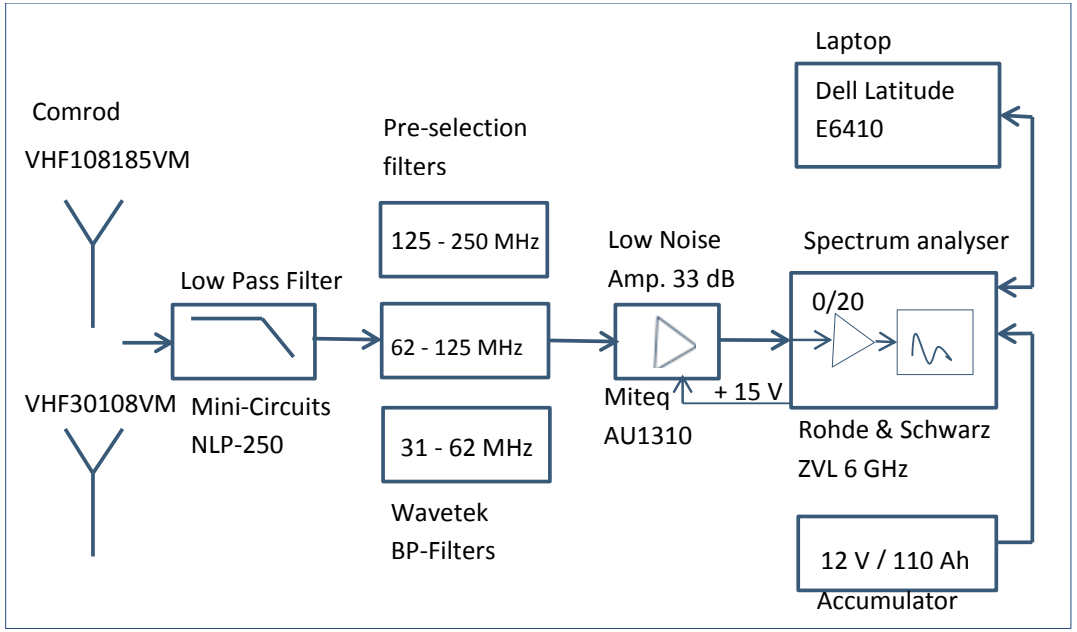
Excerpt from ITU-R P.372

External man-made radio noise measurements in Norway

- Why measure?
  - The underlying data for the ITU recommendation are from early 1970s
  - No previous external man-made radio noise measurements in Norway
  - More electric/electronic gadgets and equipment are in use today
  - Improved standards to control unwanted emissions
  - Ignition noise from engines and emanations from open-air power lines probably have been reduced
  - Uncertainty regarding how representative the ITU man-made noise model is for today's society
  - Results from other measurements programs indicate no increase in the man-made noise level
- Scope
  - The main objective of the program was to perform external noise measurements at different outdoor locations in the frequency range from about 30 MHz to about 200 MHz.
  - The measurement setup and procedures were chosen to be compatible with the requirements of the ITU man-made noise model, and the results were to be easily related to the ITU predictions.

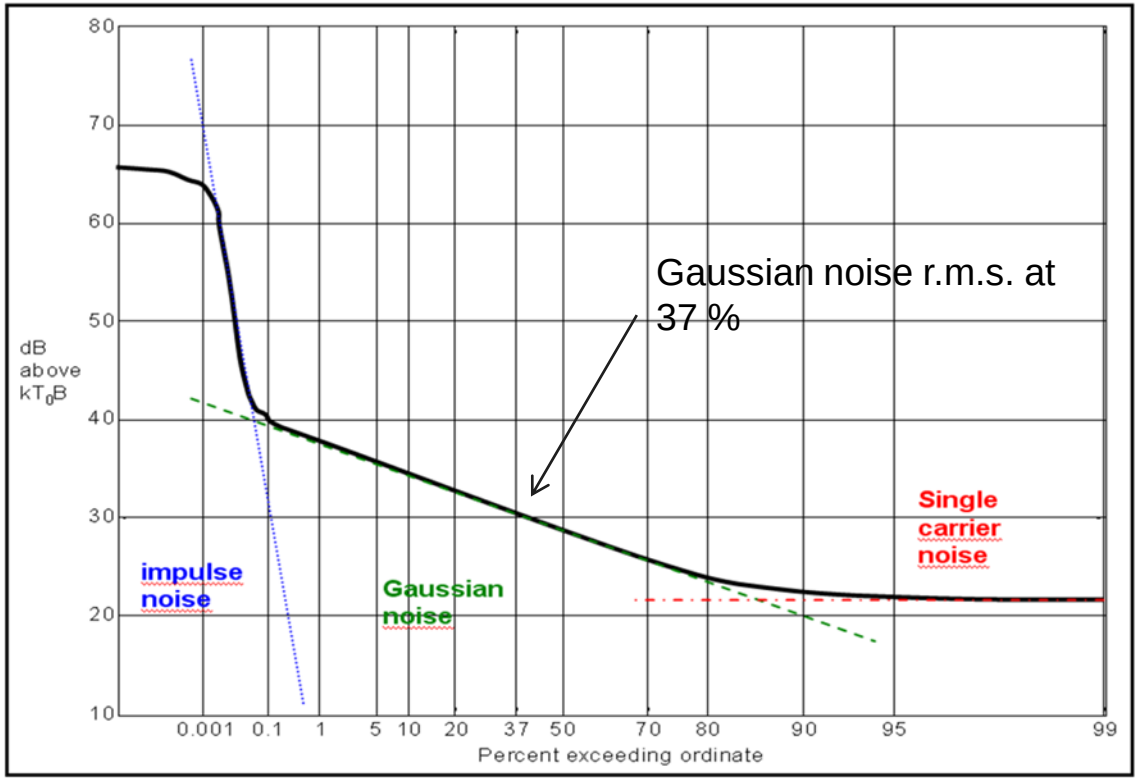
Measurement setup

- Omnidirectional antennas
  - 30 – 108 MHz
  - 108 – 200 MHz
- Low pass filter at 250 MHz
- Manually changeable and tunable bandpass filters
- Low noise amplifier 33 dB gain
- Spectrum analyzer for frequency scan and noise sampling
- Laptop with noise sampling program
- Accumulator 12V/110 Ah



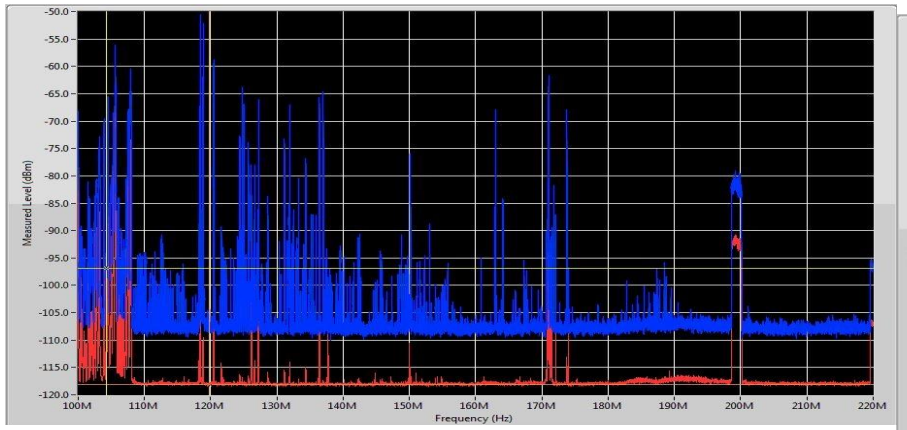
Measurement procedures

- Noise measurements on four “interference free” frequencies
  - 30,45 MHz, 84,5 MHz, 114 MHz, 203 MHz
- Measurement
  - Scanning:
    - Looking for interference free frequencies
  - Noise capture:
    - Sampling every (of four) frequencies for 10 minutes, generating 6 Mega samples of data
- Post processing
  - Generating Amplitude Probability Distribution (APD) plot
  - Aplying the 37% quantile of the APD as an estimate of total Gaussian noise
  - Calibrating the measurement chain, taking gain and losses into account
  - Plotting the noise figure of the Gaussian part of the external man-made noise

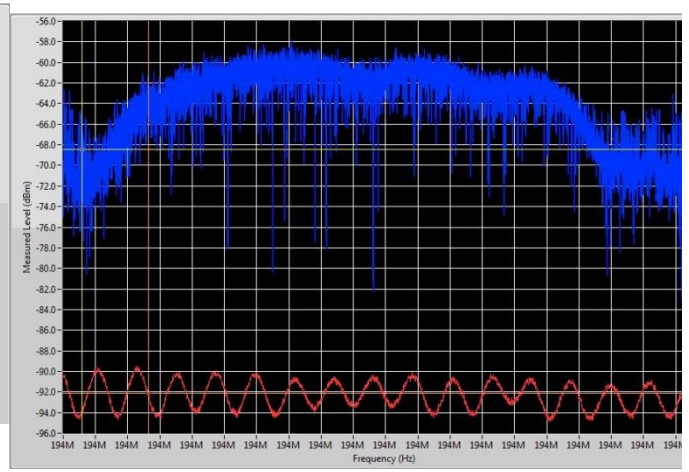


Amplitude Probability Distribution (APD) plot

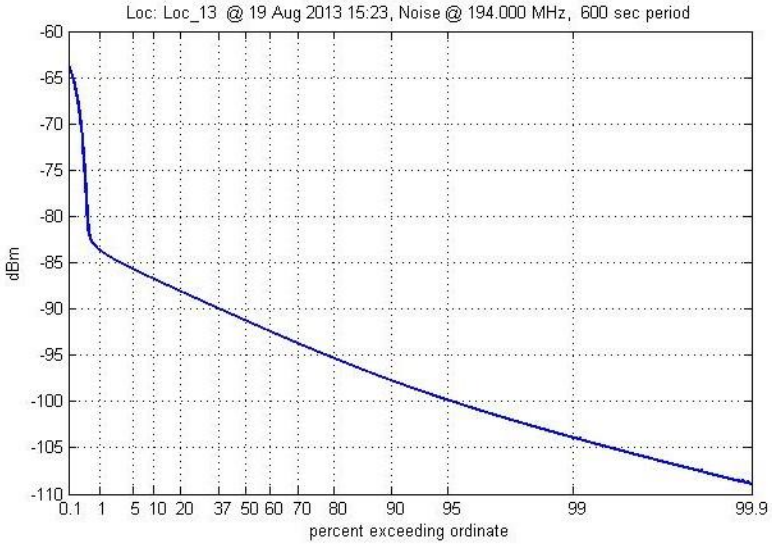
Interference



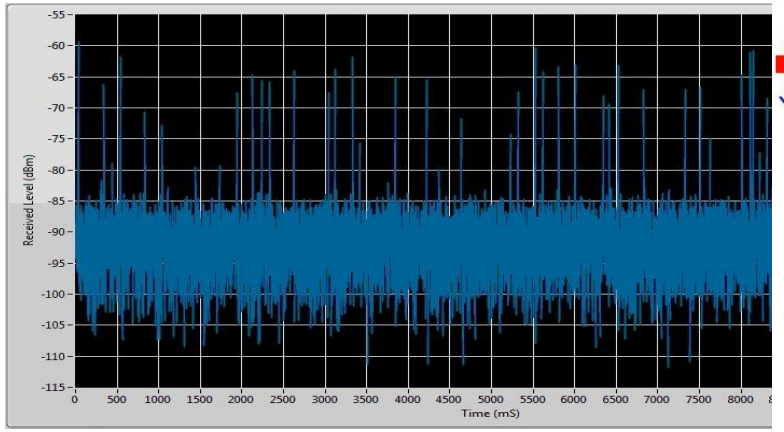
Wideband scan 100 MHz



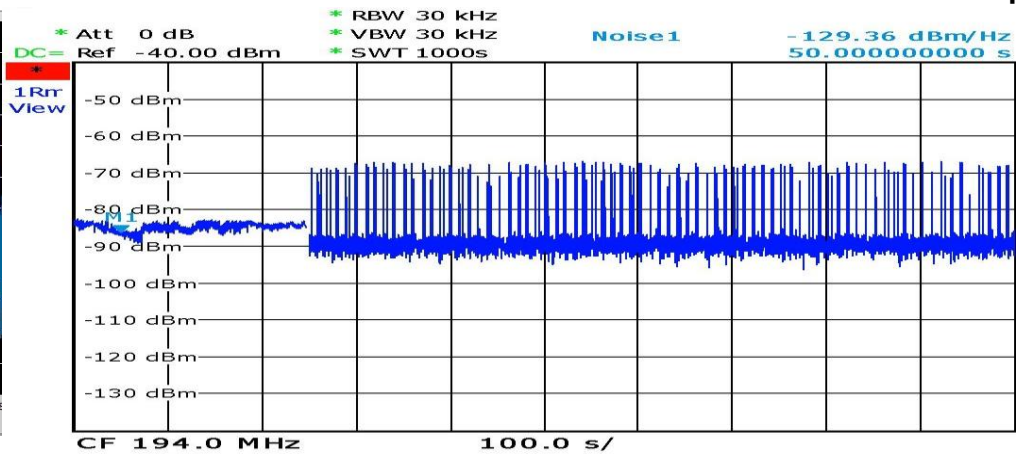
Narrowband scan 1 MHz



APD plot

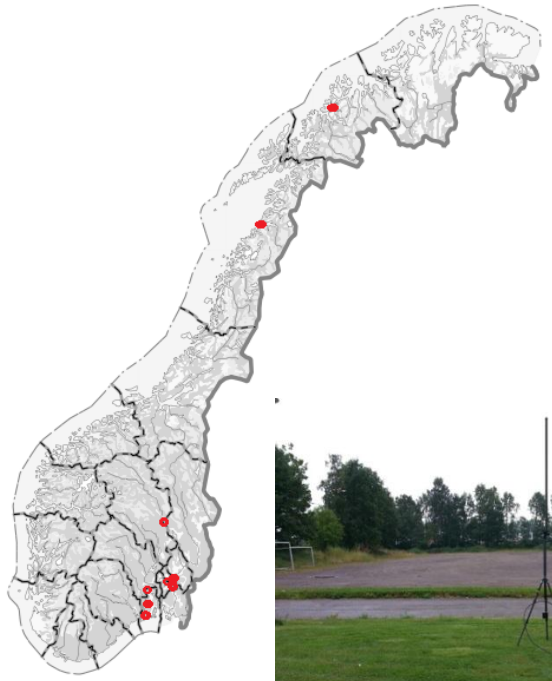


Noise samples



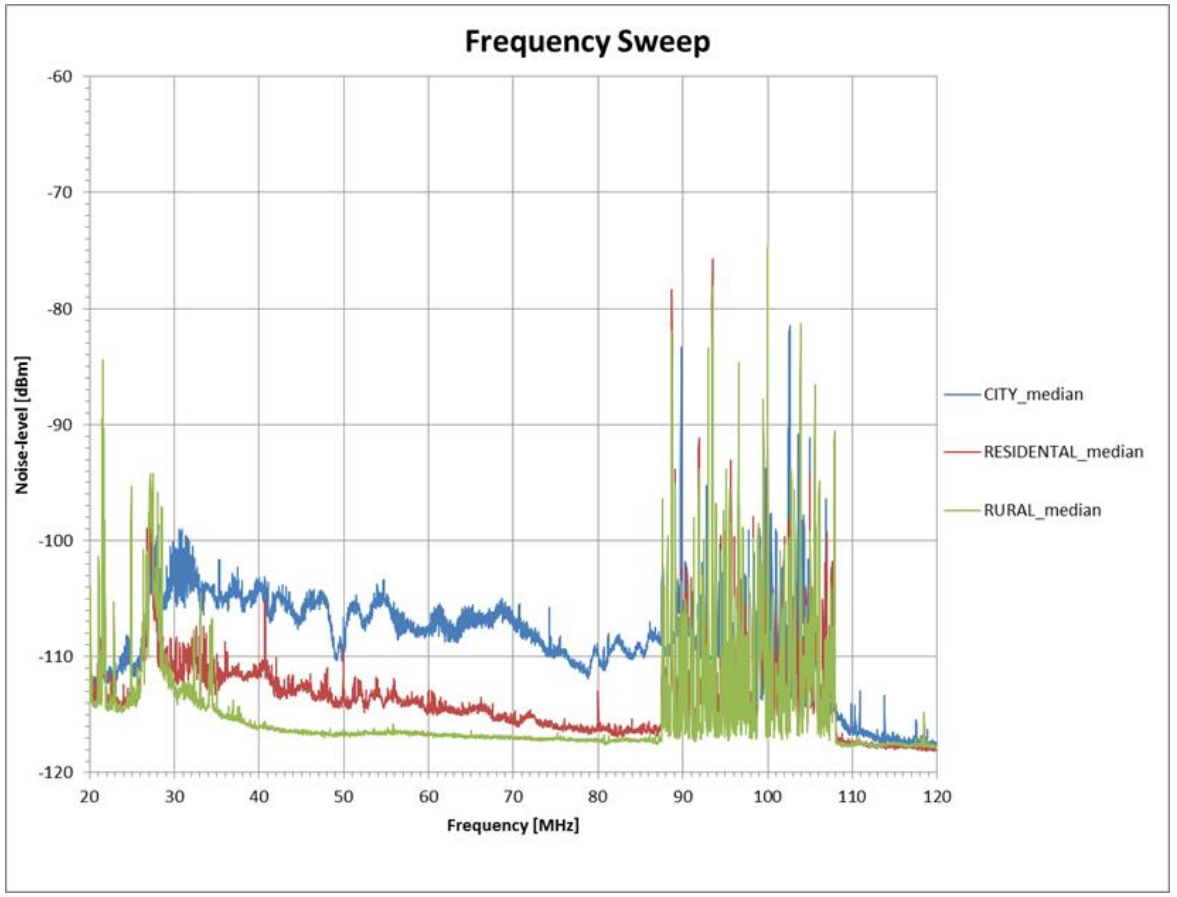
Impulsive noise, zero span

Measurement locations

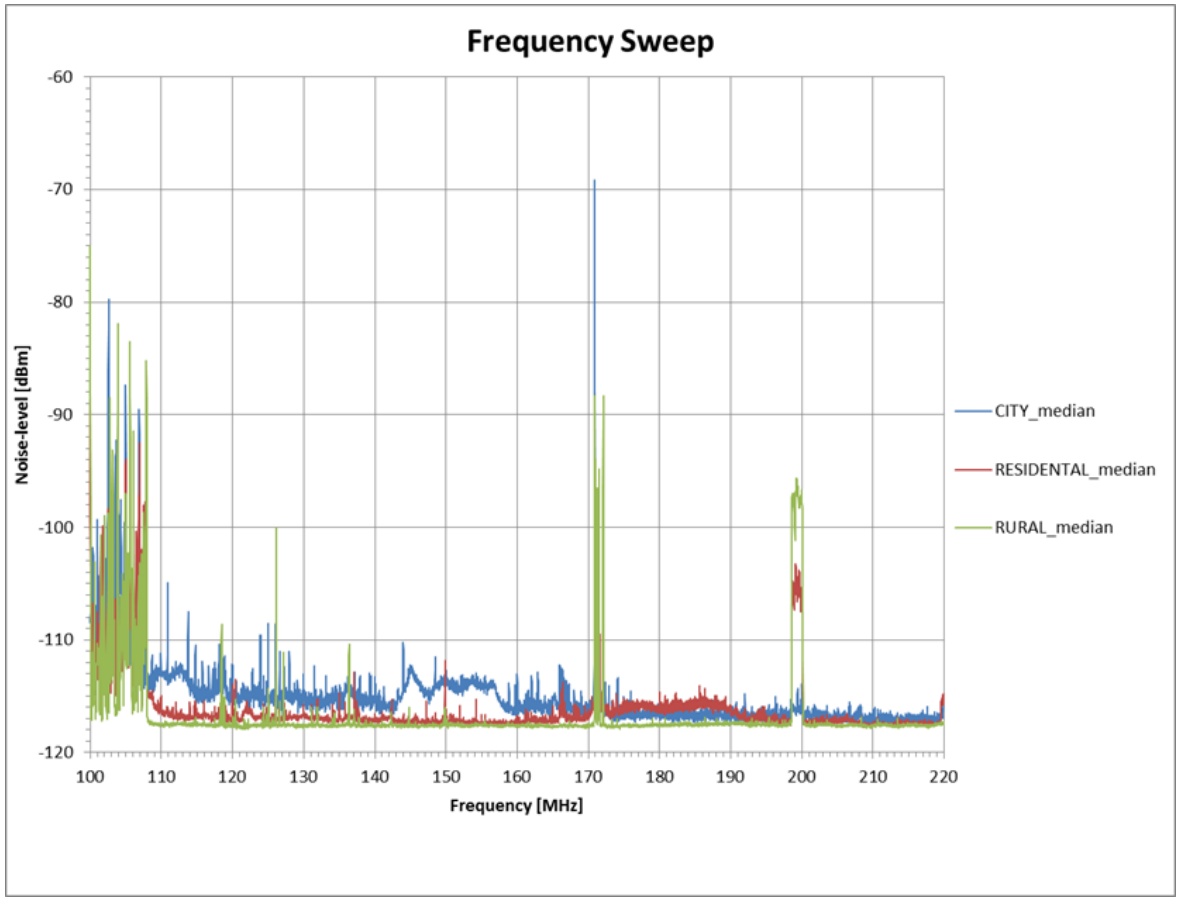


20 locations in total

Frequency sweeps



20 – 120 MHz



100 – 220 MHz

Results and conclusion

- In general, the measured median external noise figure in Norway showed up to be lower than predicted by the ITU man-made noise model.

Category	Average below ITU F_{am}
City (5)	4,7 dB
Residential (9)	7,9 dB
Rural (6)	6,8 dB

- It is important to know the noise levels because it affects the performance of radio systems