Man-made Noise measurement in Sweden

Results, lessons learned and concept for future measurement

Björn Johansson, Tore Lindgren
Dept. of Robust Telecommunications
Swedish Defence Research Agency

bjorn.Johansson@foi.se

FOI

Are ITU-R P.372 still applicable?

- Significant increase in noise levels compared to ITU-R?
  - Increase in electronic equipment ←→Stringent EMC standards
- Direction Dependence of the Background Noise?
  - ITU-R omnidirectional antenna←→directional antennas
- Gaussian Statistics of the Background Noise?
  - Performance calculations assume Gaussian Statistics but many sources of man Made Noise are impulsive
- Time-of-day variation of noise levels?
- Noise levels close to office buildings?

Measurement system

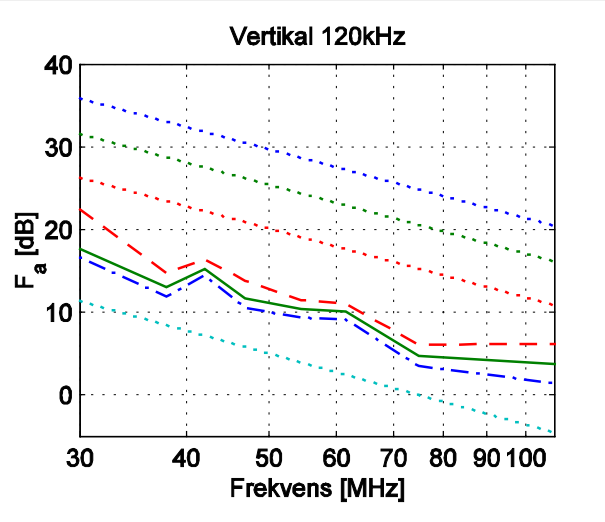
- Cross polarized antenna 30 -1000 MHz
- Antenna rotator
- Measurement receiver R&S ESVB12
- Noise statistic analyse
- Noise reference
- Control computer
- Shielded enclosure
- Remote control
- 20 silent frequency
- 10 kHz and 120 kHz bandwidth

Measurement sites

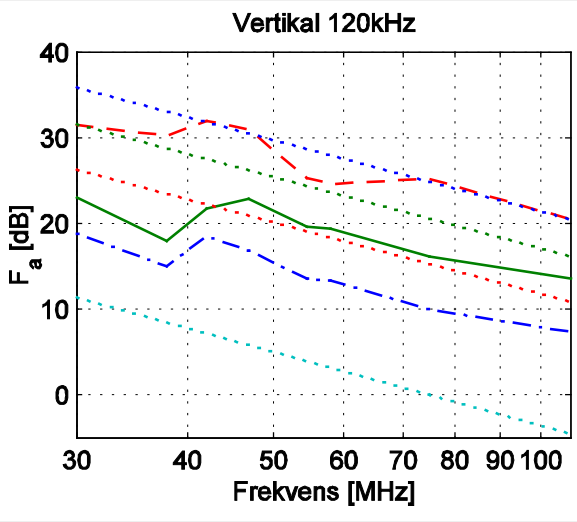
1. Normstorp, a rural site, fairly isolated 10 km south of Linköping (Spring 1999)
2. Ursvik, in a unbuilt area situated between four suburbia's of Stockholm (Summer and Autumn 1999)
3. Östermalm, a district of Stockholm. Apartment, Office buildings and roads are located nearby (Spring 2000)
4. Linköping, at FOI close to office building (2001)
5. Linköping, at a company in the outskirts (2003)
6. Linköping, at selected Office buildings in the Mjärdevi area (2006)

Noise levels

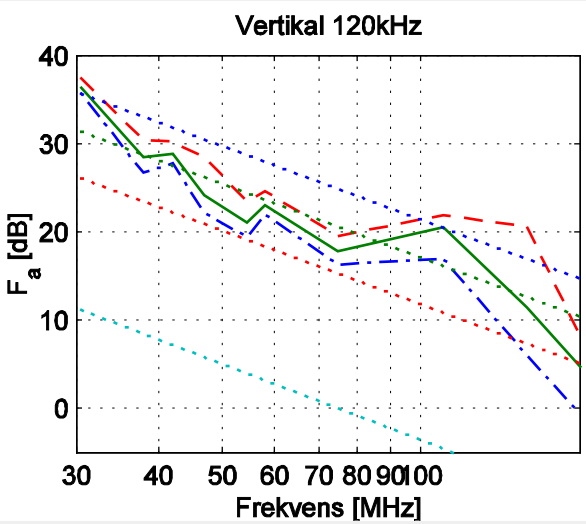
Median levels



Site 1



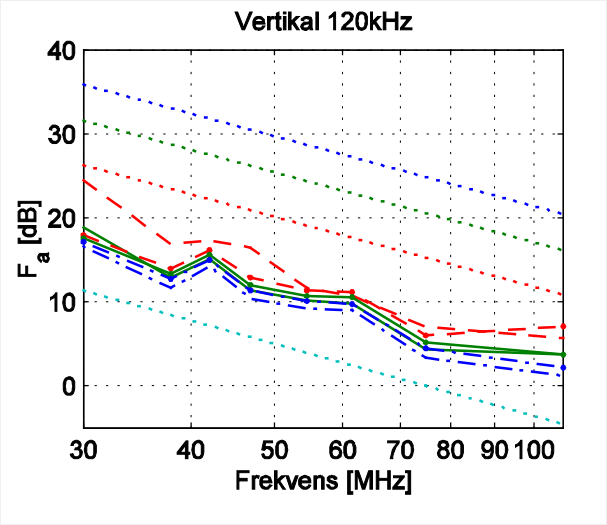
Site 2



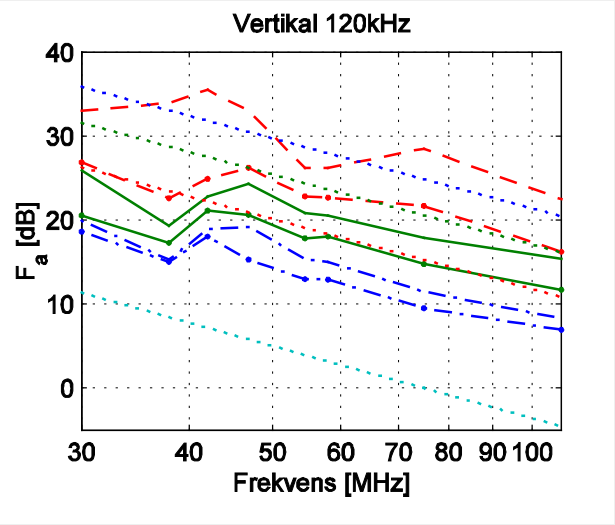
Site 3

- Lower levels than expected
- Fits well with the ITU classes

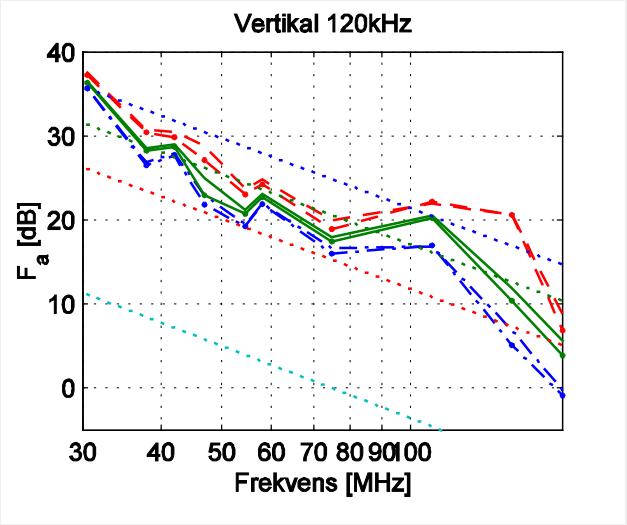
Diurnal variation



Site 1



Site 2



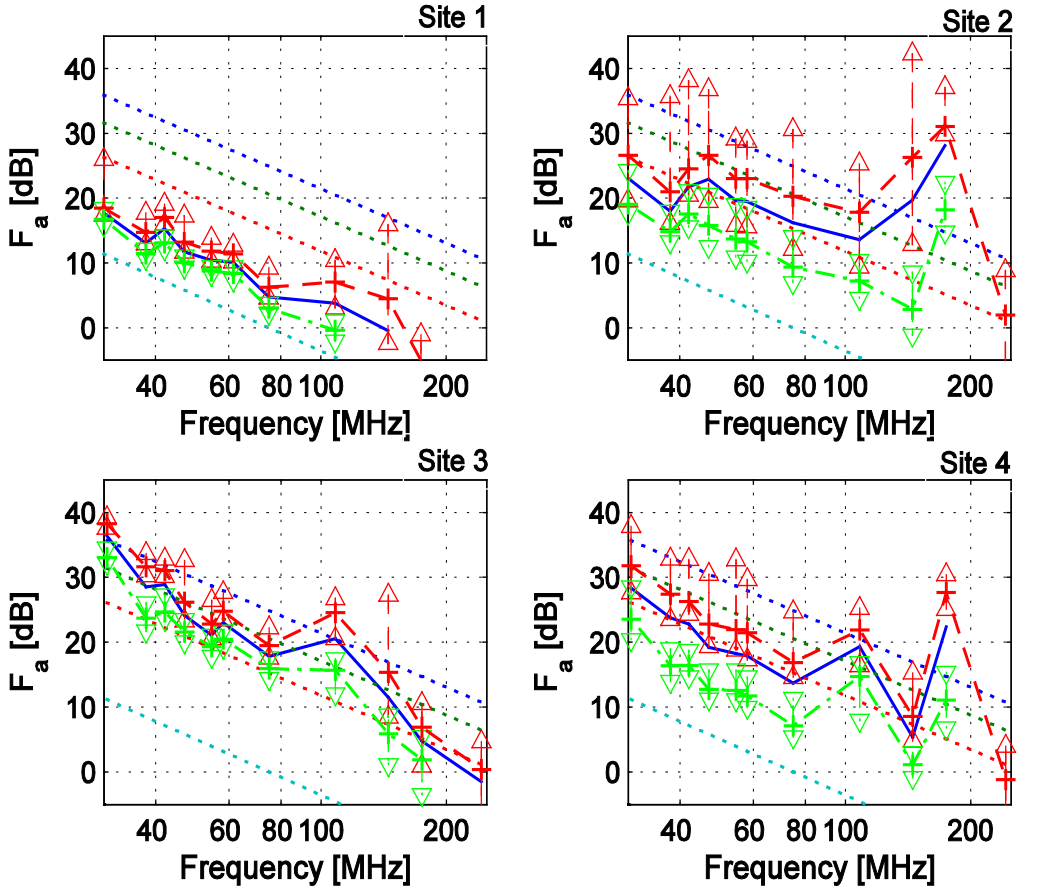
Site 3

- Small variations at site 1 and site 3
- Clear diurnal variation at site 2

FOI

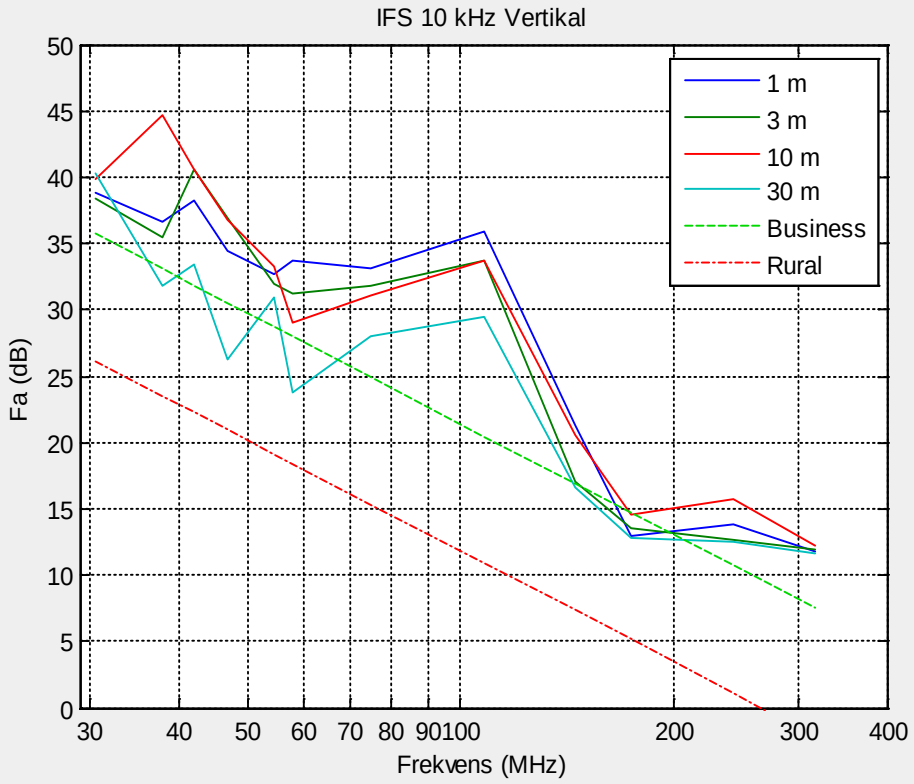
Direction dependency

- Small variations in the spatial distribution for site 1 and 3
- Distinct variations for site 2



Direction dependence vertical polarization 120 kHz.

Distance to building



- No free space loss

Noise statistics

Frequency (MHz)	Horisontal 120 kHz			Vertical 120 KHz		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
30	82	38	2	86	27	1
37,9	77	29	22	84	25	3
42	78	34	42	90	37	17
46,9	80	19	49	87	25	26
54,5	68	17	54	95	15	15
58	-	17	63	-	13	56
61,5	89	-	-	95	-	-
74,85	95	45	71	98	24	36
108,1	96	67	93	99	34	86
145	-	-	85	-	-	91
174,5	-	-	95	-	-	95

Percent of data with impulsiveness ratio < 1.1.

Frequency (MHz)	Horizontal 120 kHz			Vertical 120 KHz		
	Site 1	Site 2	Site 3	Site1	Site 2	Site3
30	87	47	52	88	38	1
37,9	82	38	54	85	31	25
42	81	33	68	89	35	38
46,9	83	19	71	85	21	64
54,5	69	18	68	93	14	58
58	-	18	85	-	13	77
61,5	91	-	-	94	-	-
74,85	90	53	89	93	34	76
108,1	95	61	92	96	40	95
145	-	-	81	-	-	66
174,5	-	-	94	-	-	93

Percent of data with modified Chi-2 test 1 < 35 for both I and Q.

Noise statistics

Frequency (MHz)	Horisontal 120 kHz			Vertical 120 KHz		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
30	82	38	2	86	27	1
37,9	77	29	22	84	25	3
42	78	34	42	90	37	17
46,9	80	19	49	87	25	26
54,5	68	17	54	95	15	15
58	-	17	63	-	13	56
61,5	89	-	-	95	-	-
74,85	95	45	71	98	24	36
108,1	96	67	93	99	34	86
145	-	-	85	-	-	91
174,5	-	-	95	-	-	95

Percent of data with impulsiveness ratio < 1.1.

Frequency (MHz)	Horizontal 120 kHz			Vertical 120 KHz		
	Site 1	Site 2	Site 3	Site1	Site 2	Site3
30	87	47	52	88	38	1
37,9	82	38	54	85	31	25
42	81	33	68	89	35	38
46,9	83	19	71	85	21	64
54,5	69	18	68	93	14	58
58	-	18	85	-	13	77
61,5	91	-	-	94	-	-
74,85	90	53	89	93	34	76
108,1	95	61	92	96	40	95
145	-	-	81	-	-	66
174,5	-	-	94	-	-	93

Percent of data with modified Chi-2 test 1 < 35 for both I and Q.

- Clearly non-Gaussian noise at site 2

FOI

Summary

- Significant increase in noise levels compared to ITU-R?
  - No, roughly the same levels for the corresponding environmental type
- Direction Dependence of the Background Noise?
  - Yes, for suburban sites. No, for Rural and Business sites.
- Gaussian Statistics of the Background Noise?
  - No, for suburban sites and for frequency below 100 MHz at business sites. Yes, for Rural sites.
- Time-of-day variation of noise levels?
  - Yes, for suburban sites. No, for Rural and Business sites.
- Noise levels close to office buildings?
  - No free space decreasing

FOI

Lessons learned (1)

- Hard to find silent frequency declared as unoccupied
  - Easy to find frequencies listed occupied but silent most of the time
- Calibration schedule important
  - “You always measure noise”
  - Miss-match caused by hardware errors can produce high noise level
- Selected signal processing solution unflexible
  - ”Penny-wise, pound-foolish”.

Lessons learned (2)

- Mechanical and electromechanical component the largest source of interruptions
  - Minimize the number of antenna relay and connectors
- Remote control saved time
  - Remote-controlled mains switch compensated unstable software and errors was detected quickly in daily control of calibration data
- System not easy to deployed in urban environment
  - Safety requirements and guy lines made the system cumbersome

Ideas for future system (1)

- Small deployed systems
  - By sacrificing sensitivity small antennas can be used
  - Small systems can be used indoors and close buildings, environments where noise levels are expected to be high
- Cooperative systems
  - Multiple cooperative systems deployed in an area can identify the noise spatial distribution
- Flexible choice of frequency
  - Significant part of the radio spectrum is rarely used. Use sensing techniques from cognitive radio development.

FOI

Ideas for future system (2)

- Take advantage of the experience from the EMC
  - A number of measures for evaluating the impact of digital radio systems have been developed.
- Take advantage of the experience from SIS
- Modular design
  - Comparable and interchangeable measurement data despite measurements over several years, a number of measurement sites and several organizations with different interests
- Connected system

Example of system

A system for monitoring of illegal GPS jammer. Contains most of the elements that would be relevant for a Man Made Noise measurement system.

Despite the risk of saturation, we propose a wideband active dipole antenna. Small, wide frequency range and good impedance match.

FOI

Questions?