RESULTS OF EXPERIMENTAL TESTS FOR THE EVALUATION OF THE SIGNAL-TO-NOISE RATIO, SHORT-TERM STABILITY, LINEARITY IN THE TIME AXIS, AND LONG-TERM STABILITY OF THE GPR SIGNAL - ACCORDING TO COST ACTION TU1208 GUIDELINES

Milan Vrtunski[1], Lara Pajewski[2], Aleksandar Ristić[1], Željko Bugarinović[1] and Miro Govedarica[1]

[1]University of Novi Sad, Faculty of technical sciences, Novi Sad, Serbia
[2]Department of Information Engineering, Electronics and Telecommunications, Sapienza University, Rome, Italy

EGU General Assembly 2020

Introduction

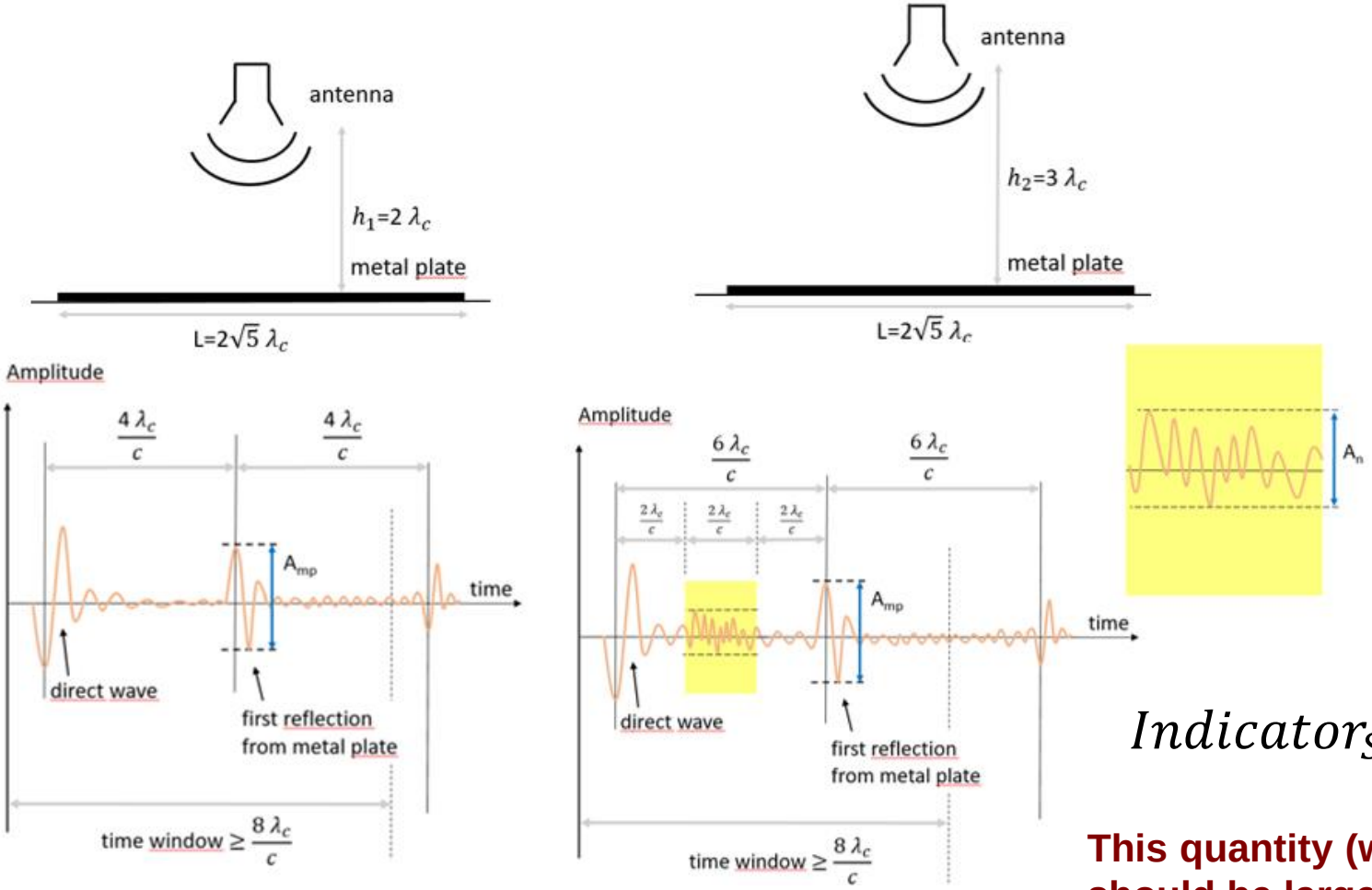
- Most GPR owners in Europe employ their radar units and antennas for years without ever having them verified by manufacturers, unless major flaws or issues become evident.

- Members of COST Action TU1208 have recently carried out a critical analysis of the few existing procedures for the calibration and performance verification of GPR systems; and, they have proposed four improved experimental tests to evaluate the signal-to-noise ratio, short-term stability, linearity in the time axis, and long-term stability of the GPR signal.

- In this work, we present the results of the tests executed in Novi Sad, Serbia, on a GSSI SIR 3000 control unit equipped with GSSI ground-coupled antennas having central frequencies of 400 MHz and 900 MHz. We have experienced that the execution of the tests helps to attain stronger awareness about the behaviour and limits of owned GPR equipment.

- Main aim of this abstract is to spread the voice and encourage GPR owners and manufacturers to execute the tests. If a wide variety of control units and antennas are tested, of older and more recent conception, with different numbers of working hours, reliable thresholds for the tests can be established and the proposed procedures can be further refined and upgraded.

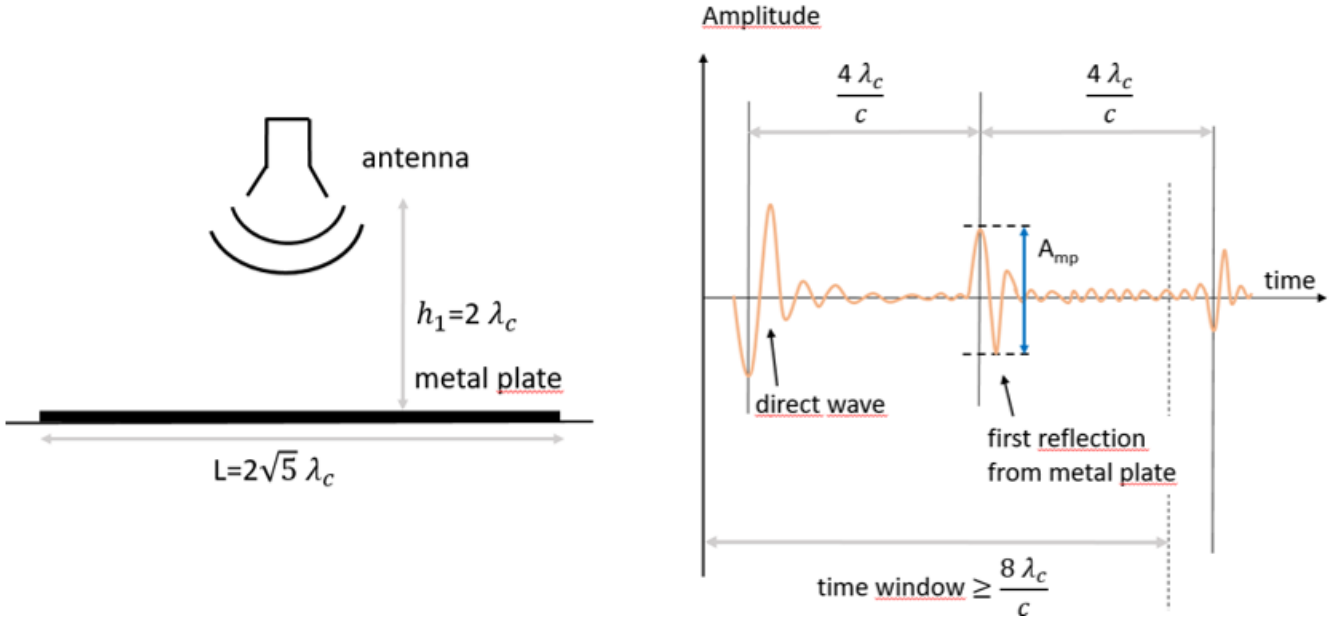
Test 1: Signal-to-Noise ratio



$$Indicator_{SNR} = \frac{< A_{\mathrm{mp}} >}{< A_{\mathrm{n}} >}$$

This quantity (which is not the SNR), should be larger than 20 (+26.0 dB).

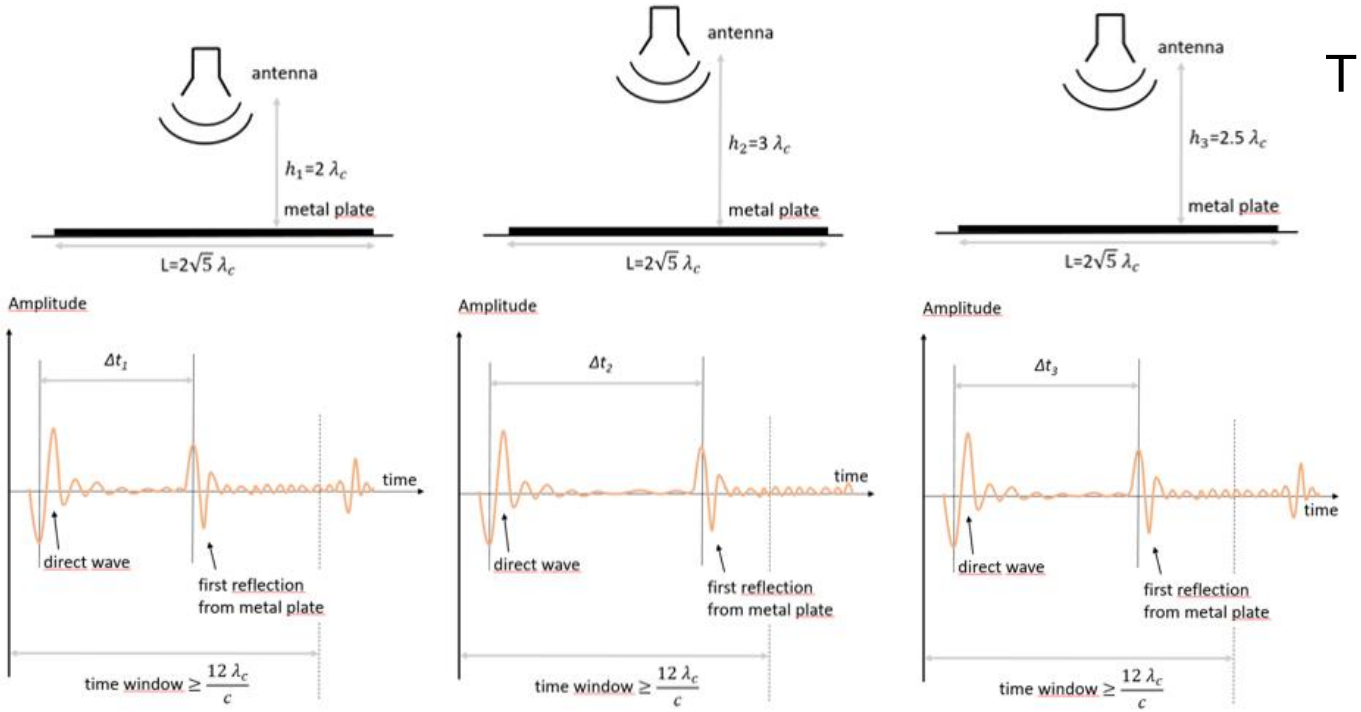
Test 2: Signal stability



$$Stability = \frac{A_{\max} - A_{\min}}{A_{\text{avg}}}$$

The signal stability has to be less than 1 %.

Test 3: Linearity in the time axis



The absolute differences:

$$T_{21}=|\Delta t_2 - \Delta t_1|$$

$$T_{31}=|\Delta t_3 - \Delta t_1|$$

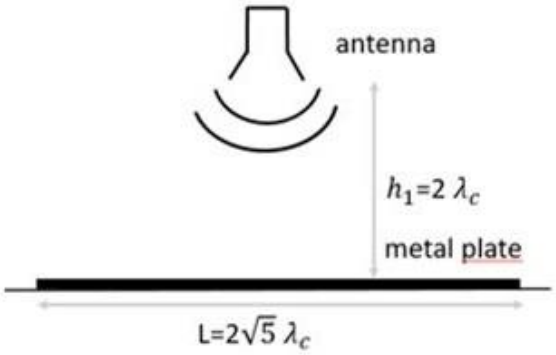
$$C_{21} = \frac{h_2 - h_1}{T_{21}}$$

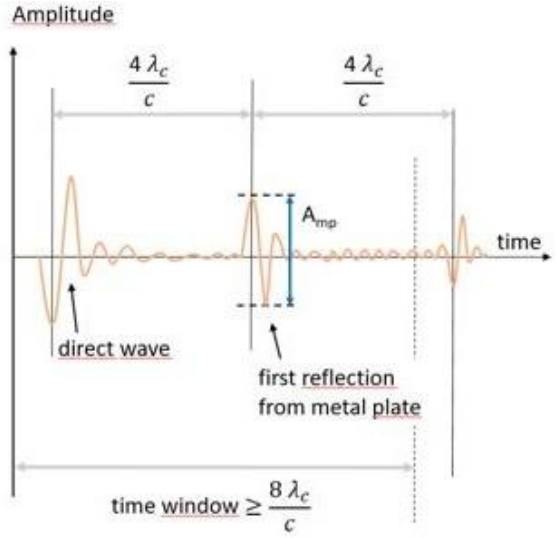
$$C_{31} = \frac{h_3 - h_1}{T_{31}}$$

$$Speed\ factor = \frac{2|C_{21} - C_{31}|}{C_{21} + C_{31}}$$

The speed factor should be less than 0.02 (2%).

Test 4: Long-term stability





$$M_q = \frac{1}{N}\sum_{h=0}^{N-1} A_{q+h}$$

$$Q_1 = \frac{M_{\max} - A_1}{A_1}$$

$$Q_2 = \frac{|M_{\min} - A_1|}{A_1}$$

$$\textbf{\textit{Long Term Stability}} = \max\{Q_1, Q_2\}$$

For N = 10, the long-term stability factor should be less than 3 %.

Experimental setup: 400MHz antenna

400 MHz GSSI ground coupled antenna

Metal reflector dimensions	3.5 x 3.5 m
Heights	
h_1	1.5 m
h_2	2.25 m
h_3	1.875 m
Time window	
T1	20 ns
T2	20ns
T3	30ns
T4	20 ns
Samples per trace	512

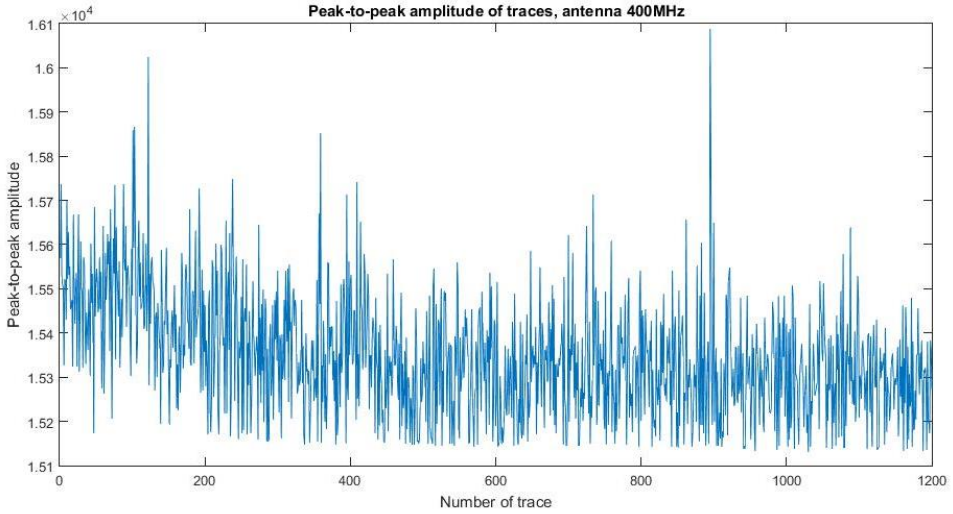
Experimental setup: 900MHz antenna

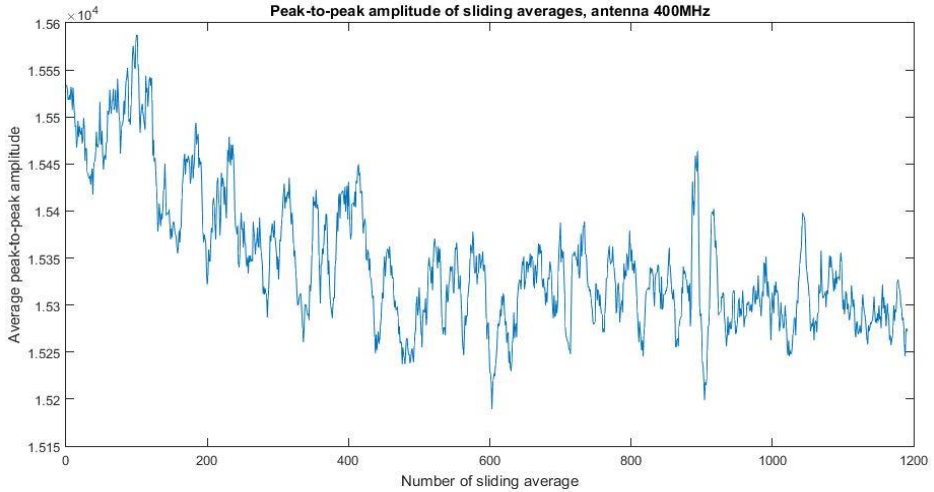
900 MHz GSSI ground coupled antenna

Metal reflector dimensions	1.7 x 1.7 m
Heights	
h_1	0.66 m
h_2	0.99 m
h_3	0.825 m
Time window	
T1	10 ns
T2	10ns
T3	15ns
T4	10 ns
Samples per trace	512

Results: 400MHz antenna

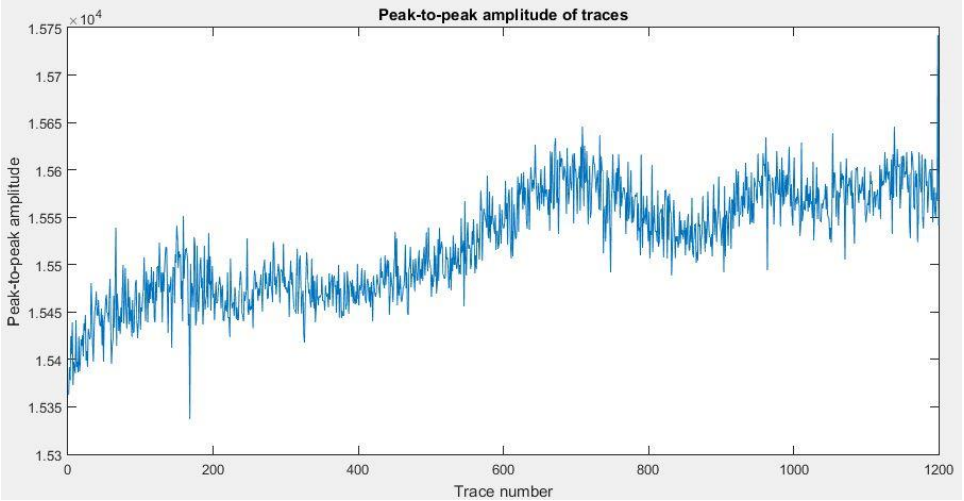
		400 MHz
Test 1	Signal to Noise Ratio	**10.576**
Test 2	Signal Stability	**7.914** %
Test 3	Linearity in the time axis	**5.18** %
Test 4	Long -term Signal Stability	**2.44** %

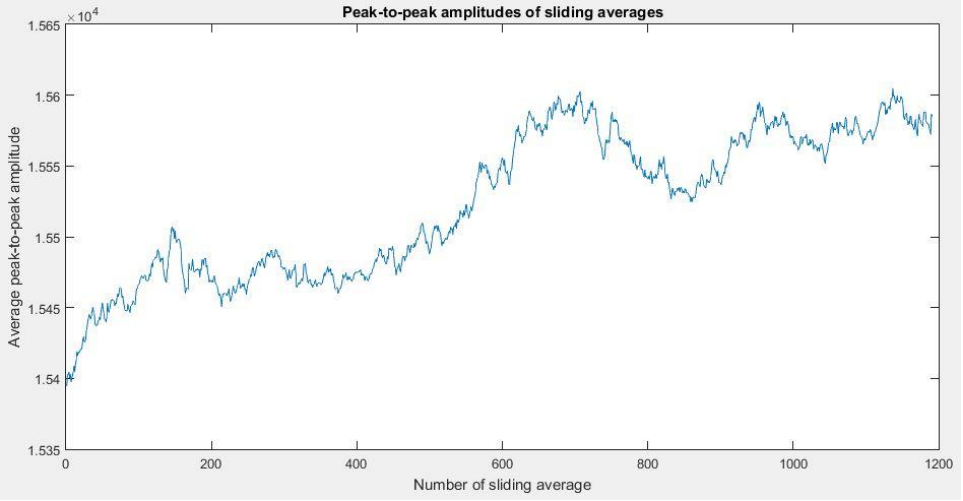




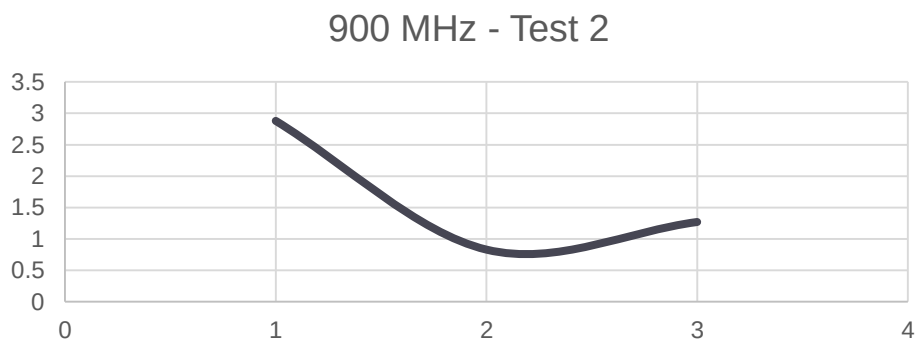
Results: 900MHz antenna

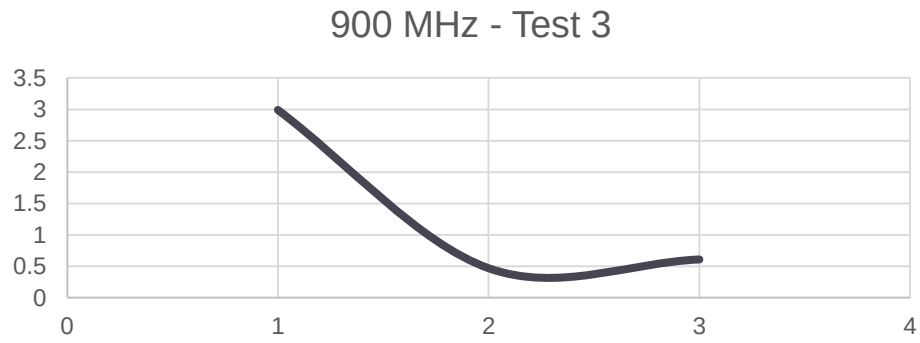
		2017	2018 (1)	2018 (2)
Test 1	Signal to Noise Ratio	**12.479**	**13.411**	**13.256**
Test 2	Signal Stability	**2.88 %**	**0.83 %**	**1.27 %**
Test 3	Linearity in the time axis	**2.99 %**	**0.47 %**	**0.61 %**
Test 4	Long-term Signal Stability	**1.57 %**	**0.22 %**	**0.46 %**

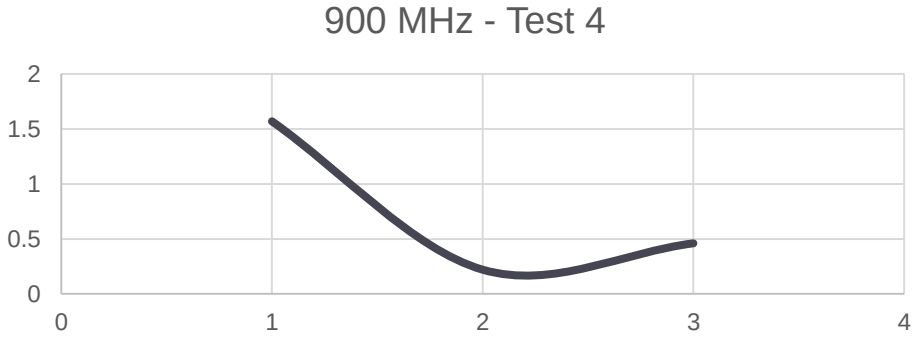




Results: 900MHz antenna







Conclusion

- 400MHz antenna failed to meet the criteria at 3 tests.
- Performance of 900MHz antenna mostly meets the criteria. Long-term signal stability is in decline.
- COST TU1208 Guidelines for GPR equipment compliance test provide a solid basis for GPR equipment testing and monitoring of its performance.
- The size of the metal reflector and the height may be issues when testing antennas of lower frequencies.

Thank you for your attention!