A review of 5GAA's "V2X Functional and Performance Test Report" P-180106

1 Introduction and Summary

A report was recently published by 5GAA where it is claimed that C-V2X "is a superior technology" and that it offers "significant performance advantages … when measured against DSRC".

U-blox has done a thorough analysis of the 5GAA test procedure and results. Not only we find these claims largely exaggerated, but also indicating considerable degradation of on-the-field performance when compared to the lab test results, thus raising serious concerns about the level of maturity of C-V2X overall.

1. The comparison is based on a DSRC device which has significantly worse sensitivity compared to any commercial solution currently being deployed in the market. The level of performance is so low that it is not even compliant with the SAE J2945 standard as claimed in the report.

2. Even though, the comparison quotes a nominal bandwidth of 10 MHz for both C-V2X and DSRC, the C-V2X device was actually utilizing less than 5 MHz of bandwidth. This resulted in the C-V2X device experiencing a significantly lower noise floor. In terms of sensitivity, this translates to an unfair advantage of more than 3 dB in favor of C-V2X.

3. For C-V2X, redundant packets were transmitted using a so-called HARQ mechanism to increase the probability of reception. This however results in inefficient use of the air medium, especially in high-mobility condensed-traffic use cases. Using HARQ, C-V2X was again favored by another 3-4 dB. By combination of the reduced bandwidth and HARQ usage, C-V2X effectively was using up to 8 times higher channel occupancy to transmit the same amount of information as DSRC.

As highlighted above, there are no grounds that support the 5GAA claims of "superior performance of C-V2X". The 5GAA comparison clearly gives an overall advantage of approximately 14 dB for C-V2X, thus making this comparison entirely biased and unfair. In the following, u-blox will share measurements based on its own DSRC commercial chip that will demonstrate that under fair conditions, a competitive DSRC device provides similar performance with C-V2X under lab conditions and far better performance in field trials.

2 Conducted tests

Section 7.2.2 of the 5GAA report outlines the test procedure and results of a conducted measurement under a constant transmit power (20 dBm) and varying levels of attenuation (65 dB to 130 dB). With this configuration, the receiver sensitivity of both devices was evaluated. We see two major issues with the tests setup as described in the following sections.

2.1 The tests setup were favoring the C-V2X equipment in an unfair manner

Even though the nominal bandwidth was quoted as 10 MHz for both technologies, for the case of C-V2X less than half of that was actually utilized, as indicated by the use of 5 sub-channels configuration. Therefore, this measurement gave an unfair advantage to the C-V2X device since the latter would experience a noise level which is more than 3 dB lower than that of the DSRC device. Obviously, using a smaller bandwidth results in the C-V2X message requiring double the air-time, which is not mentioned in the report.

In our view, a fair comparison would involve tests which result in the same occupancy of the wireless medium. The same issue was also experienced with the utilization of the HARQ mechanism which transmits redundant information to improve the reception performance. Again, any fair comparison should ensure that the air time is approximately equal for both technologies, or that the different amounts of air-time is taken into account. For example, a fair metric would be the required energy to transmit a single bit of information under a given noise level (E_b / N_0).

2.2 The performance of the DSRC equipment used in the report is not representative of competitive DSRC products available today

Having a constant transmit power of 20 dBm and an attenuation of 110dB, implies that a PER of 10% is obtained for a received power of -90dBm at the DSRC unit, which is considered to be the receiver's sensitivity. This value is however more than 8 dB worse than most commercial DSRC systems[1].

On top of this, even though the report is claiming that the DSRC device is compliant with SAE J2945, this level of performance would clearly violate the specifications in this standard which requires a sensitivity of -92dBm with a packet size that is twice the size (400b) than the one used (193b).

Our own conducted tests verify that the performance of a competitive DSRC device is 11-12 dB better than the Savari equipment shown in this report, with the difference from the C-V2X device being only around 3-4 dB (Figure 1). When taking into account the unfair gain provided by the use of the HARQ mechanism, then the performance of the two technologies are almost equivalent. This comes as no surprise since they both use the similar underlying OFDM technologies.

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[1] CohdaMobility MK5 Module Datasheet (https://fccid.io/2AEGPMK5RSU/User-Manual/User-Manual-2618067.pdf)

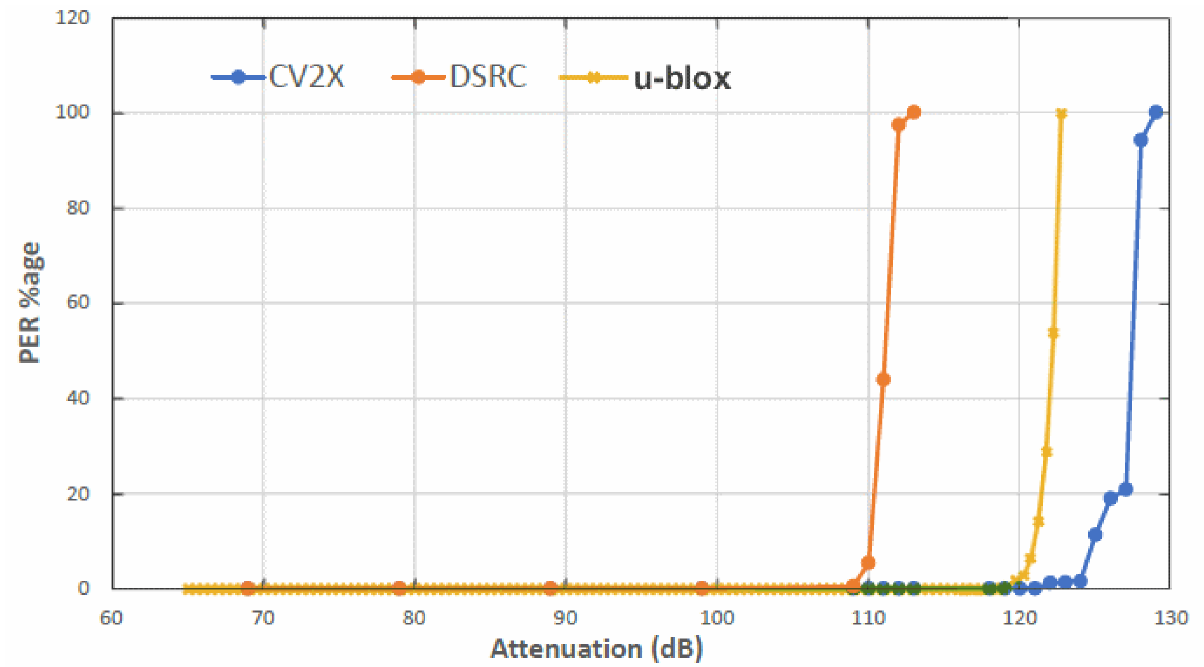

Figure 1: 5GAA (DSRC & C-V2X) vs u-blox (DSRC) conducted tests results

3 Test trials

3.1 Path loss

Section 8.5.1 of the 5GAA report shows the tests from a field trial under Line-of-Sight conditions. In Figure 46 of this report, the RSSI level is plotted. This is shown to follow the predictions from a two-ray propagation model quite closely, as expected in such a scenario. In order to test the claims in this section we have replicated the two-ray conditions as shown in Figure 2 below. This model is used in the next section to relate the distance with the received power.

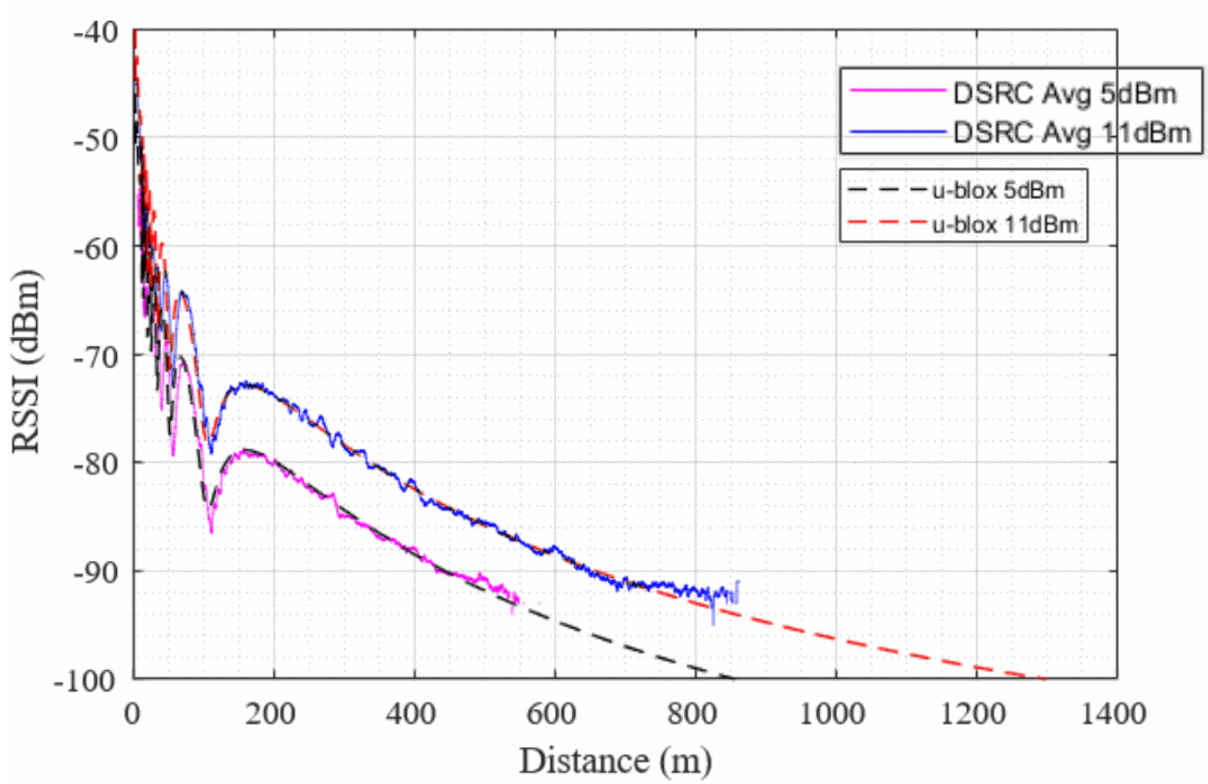

Figure 2: RSSI against distance from 5GAA measurements vs u-blox model

3.2 Distance measurement

Let's first consider the DSRC results. In the case of 5 dBm transmit power, the PRR is 90% (equivalent to PER of 10%) at a distance of ~460m. At this distance, according to Figure 2 above, the received power level is -90 dBm which is in accordance with the conducted tests previously mentioned. Very similar remarks can be made in the case of 11 dBm transmit power. From these observations, it appears that even though the absolute performance level of the DSRC device was very low, the relative performance between the cabled and trial tests are in agreement.

If we now attempt to apply the same logic to the C-V2X results, we end up in very significant inconsistencies. When a 5dBm transmit power is used, the C-V2X device shows a 10% PER (or 90% PRR) at around 790m. At this distance, the received power level according to the 5GAA measurements is -99 dBm. However, the conducted tests were implying a receiver sensitivity of -104 dBm which demonstrates a 5 dB difference between the lab and test trial results. Similar remarks can be made in the case of 11 dBm transmit power. This is a clear evidence that the C-V2X device, even under fully controlled and favorable conditions cannot provide the benefits claimed by the lab measurements when it comes to operation in the field.

To examine the same scenario with a competitive DSRC device, we plot the expected range of such a device in the following figure. Even if the unfair use of HARQ is not accounted for, the range of operation achieved by the DSRC device is significantly better than that of the C-V2X device.

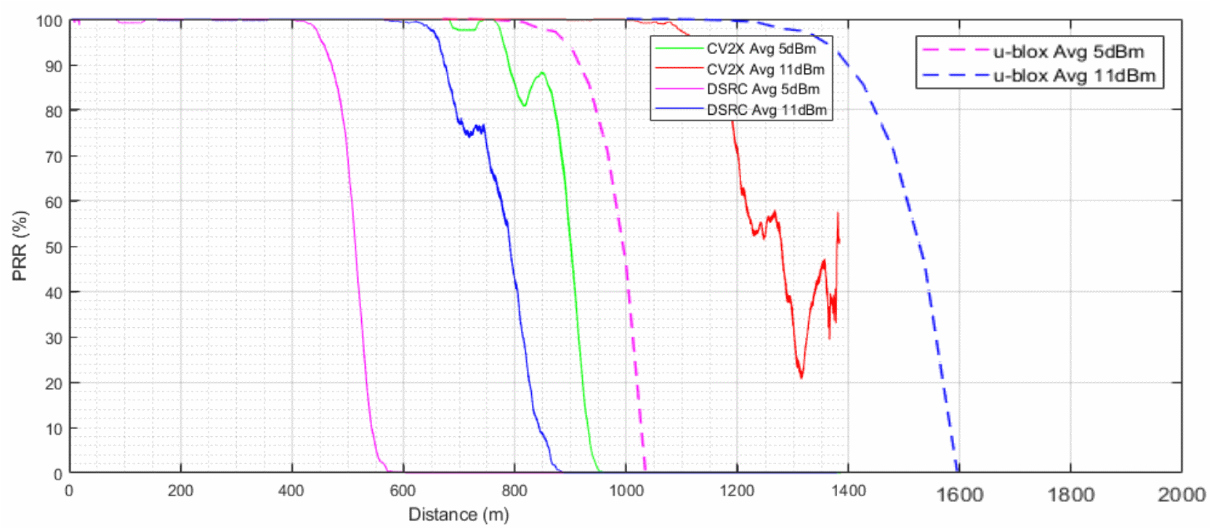

Figure 3: 5GAA LOS field trial results (DSRC & C-V2X) vs u-blox (DSRC)

4 Conclusion

u-blox has carried out an in-depth analysis of the test methodology and results presented on 5GAA's "V2X Functional and Performance Test Report". Our findings are that the validity of the claims made in this report are not only false, but reveal significant evidence that the C-V2X technology is unable to perform reliably even under fully controlled and favorable conditions.

When the tests and measurements are replicated in an unbiased manner, the performance of a competitive DSRC device provides similar performance to the C-V2X device in lab conditions and significantly better performance under field trial conditions.