

2Rx vs. 4Rx for XR

**T-Mobile USA, Deutsche Telekom, Telecom Italia,
Anterix, TELUS, Telstra, CHTTL, SK Telecom, Orange**

Overview

- Background
- 2 Rx for automobiles
- XR form factor
- Performance of 2Rx vs. 4Rx
- Would 2 Rx really provide the best user experience?
- Could the smartphone go the way of the pager?
- Conclusions



Background

- Higher frequency bands have 4Rx mandatory to improve performance and user experience
- There is a proposal to relax the requirement from 4Rx to 2Rx for bands that mandate 4Rx for XR devices that is not based on any technical need
- Many operators from around the globe have vehemently opposed relaxing the requirement from 4Rx to 2Rx for the 6 GHz licensed band on the grounds that it would lower spectral efficiency and capacity, and the value of their spectrum
- The XR WID includes “Specify the enhancements related to capacity” so changes that would reduce capacity would seem to run counter to the goals of the WID



What about the 2Rx relaxation for automobiles?

- Most operators were not in favor of the 2Rx relaxation
- The claim from the auto manufacturers was that there are already too many wires and cables in a car, so it is not practical to run so many cables to the roof mounted antenna.
- In reality, 2Rx antennas on the roof may outperforms 4Rx for a phone in the center console mainly due to less attenuation, better antenna performance, and gain from the antenna height. There are not any similarities to a VR device.



XR form factors

- VR headsets today have the form factor roughly equivalent of a smartphone mounted in front of the user's eyes. There is really no technical justification of 2 Rx for this form factor
- At least one possible vendor of these devices has indicated that “the goal of this proposal is to allow device company some design flexibility to come up with the best industrial design (the most capable device) that consumers are willing to purchase.”
- AR glasses may be more constrained by the form factor, but it seems like it would still be practical to mount 4 antennas
- Alternatively, could Redcap be sufficient for AR?
- Might tethering to a phone be a better option for AR glasses than a lower performance built-in radio for the impacted bands?



2Rx vs. 4Rx drive test performance Comparison

Data from Signals Research Group reports

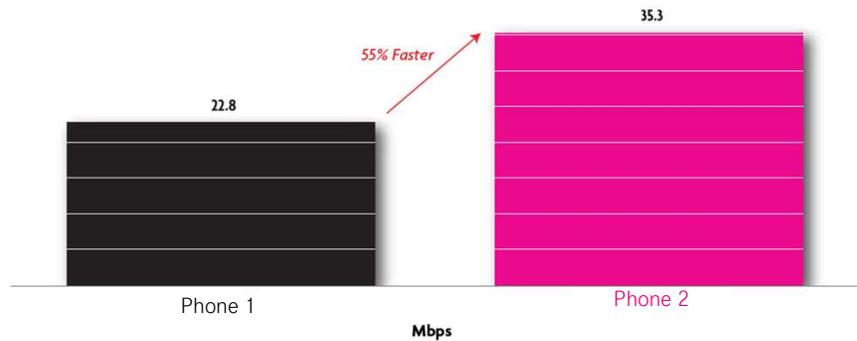
Signals Research Group drive test data

- The data on the following 3 pages is from drive tests with commercial devices performed by Signals Research Group
- The LTE Band 4 data is from a Signals Ahead report, “Finding MIMO” [1]
- The n77 and n41 data is from a private study done by SRG [2]
- The data is used with permission from SRG



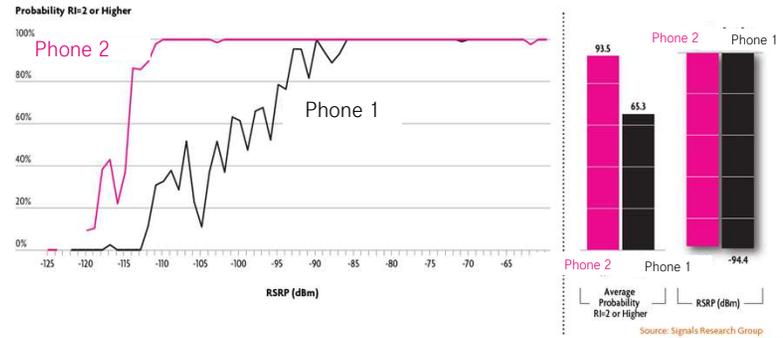
SRG 2Rx vs. 4Rx testing on LTE Band 4 [1]

Figure 1. Aggregate Comparison of Results – Band 4 Only



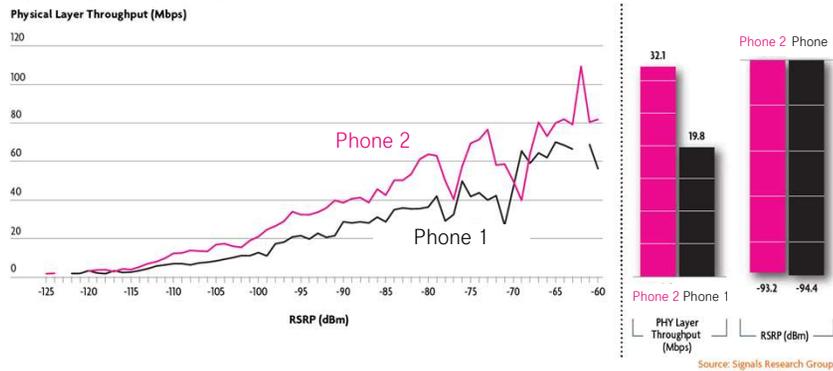
Source: Signals Research Group

Figure 7. Rank Indicator Reports Versus RSRP



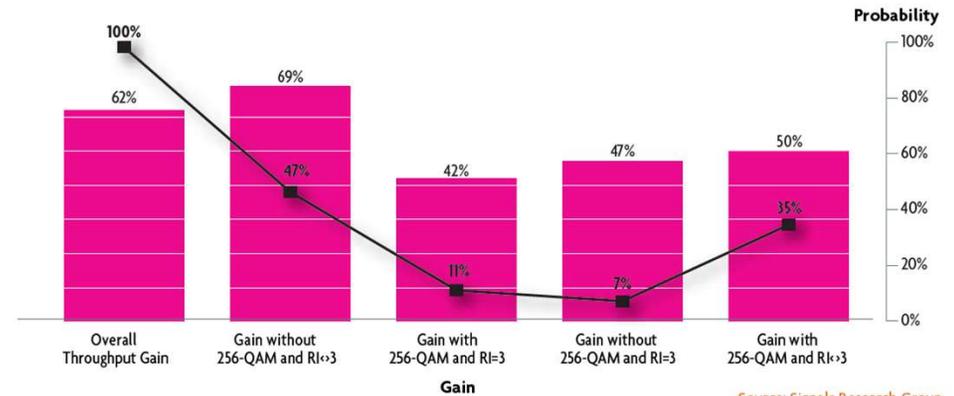
Source: Signals Research Group

Figure 6. Physical Layer Throughput Versus RSRP



Source: Signals Research Group

Figure 8. Performance Gain and Probability Analysis - 256-QAM and Rank Indicator = 3

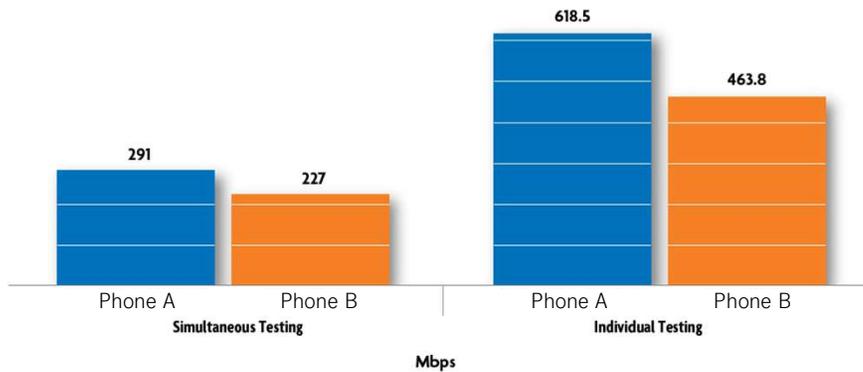


Source: Signals Research Group



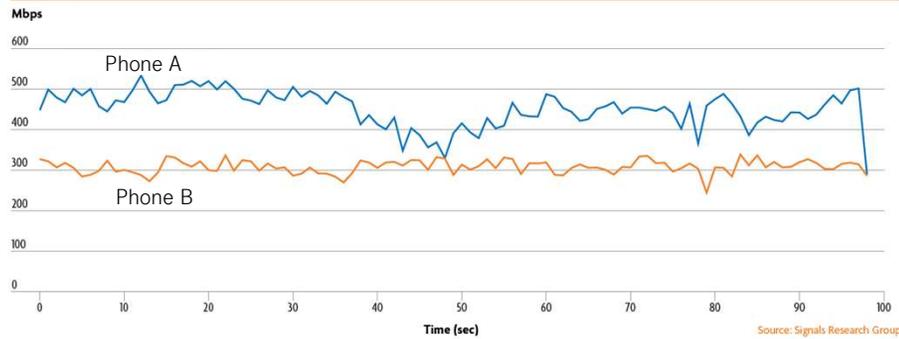
SRG 2Rx vs. 4Rx testing on n77 [2]

Figure 1. Summary of Results – Band n77



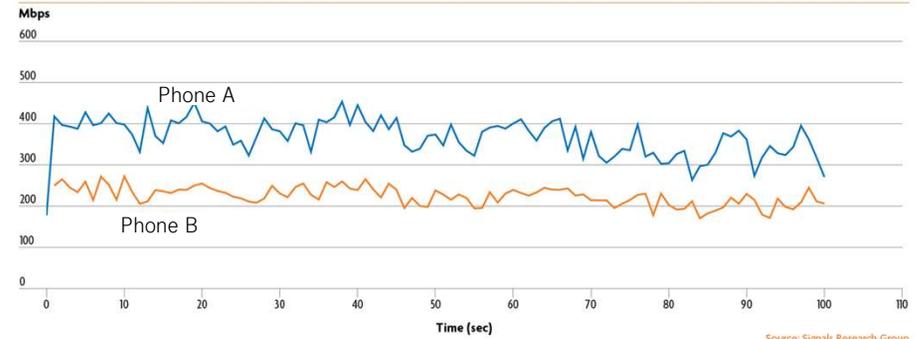
Source: Signals Research Group

Figure 6. Application Layer Throughput – time series



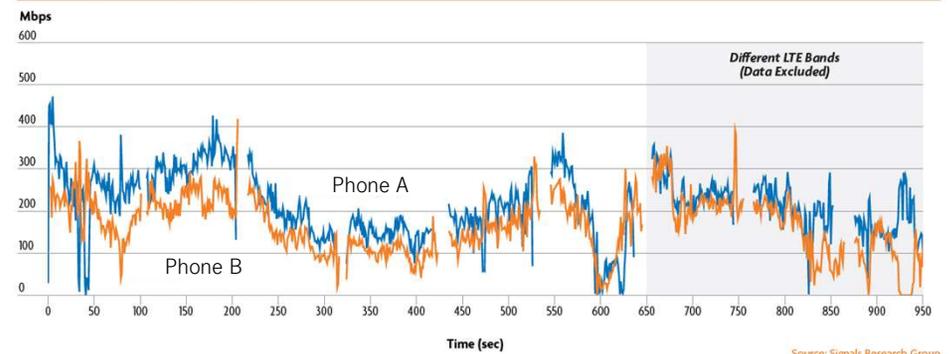
Source: Signals Research Group

Figure 17. Application Layer Throughput – time series



Source: Signals Research Group

Figure 22. Application Layer Throughput – time series



Source: Signals Research Group



SRG 2Rx vs. 4Rx testing on n41 [2]

Figure 2. Summary of Results – Band n41

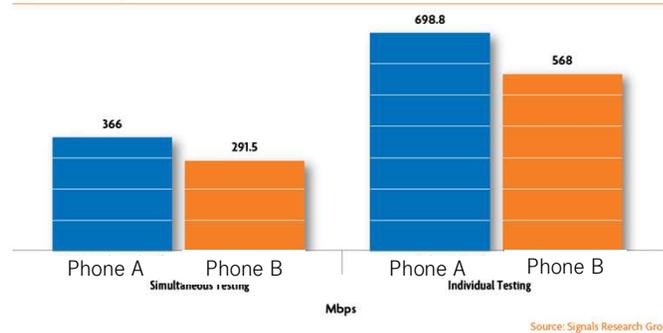


Figure 29. Application Layer Throughput

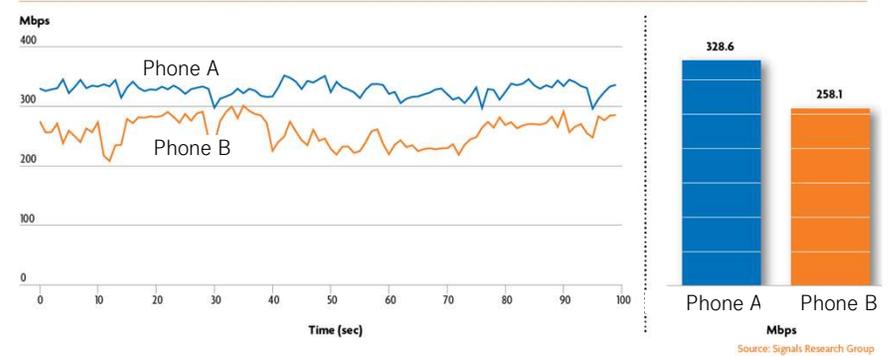


Figure 27. Summary Results – Simultaneous Testing

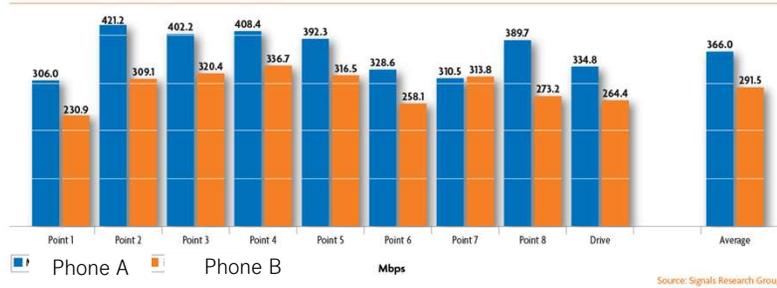


Figure 28. Summary Results – Individual Testing

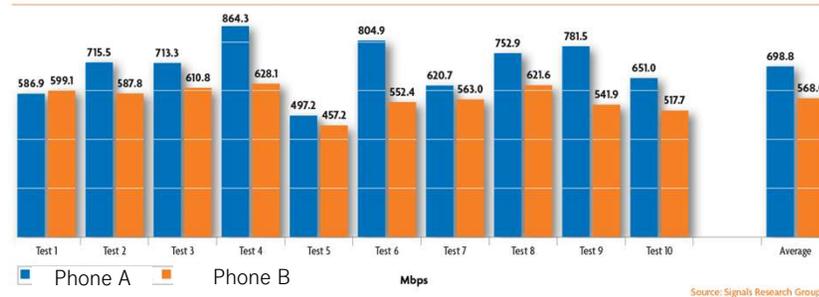
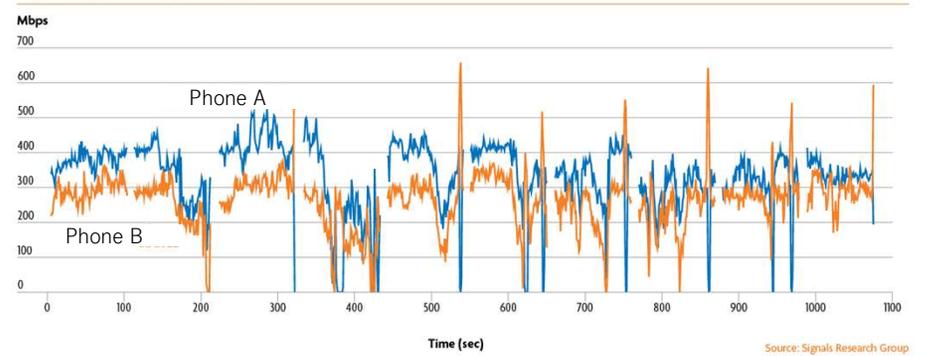


Figure 34. Application Layer Throughput – time series



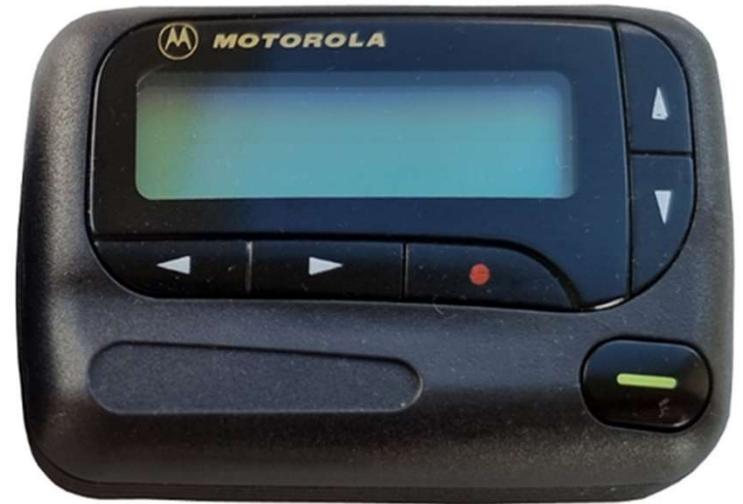
Would 2Rx provide a better user experience?

- 2Rx would have lower user throughput
- 2Rx would have lower network capacity, impacting all users
- 2Rx could lower the cost and weight of XR devices, but is that all that matters in user experience? Certainly, available throughput and connection reliability also impacts user experience.



Could the smartphone go the way of the pager?

- This may seem absurd today, but what if we could use AR glasses to access e-mails, texts and social media, browse the web, make calls, run apps, etc.
- Would we even need a smartphone?
- XR may be seen as a niche market today, but could the majority of devices on our networks be XR devices someday?
- This is why it is important to ensure the best possible performance of these types of devices



Conclusions

- Relaxing the requirement from 2Rx to 4Rx for XR would have a quantifiable negative impact on spectral efficiency and network capacity, as well as user throughput and thus user experience.
- Relaxation would be counter to the WID objective to “Specify the enhancements related to capacity”
- “You would have to be a Luddite to not appreciate the benefits of a 4-way receive antenna architecture.” [1] 😊
- Given the dramatic performance advantage of 4Rx over 2Rx seen for Band 4, instead of relaxing the requirement from 4Rx to 2Rx for higher frequency bands maybe we should be discussing increasing the requirement from to 2Rx to 4Rx for mid frequency (2 GHz) bands
- Operators who acquired licenses under the understanding that 4Rx is mandatory would face reduced spectrum capacity and value if the requirement is relaxed
- If XR devices become a significant part of the devices in the network, all users will suffer from the reduced network capacity if they are allowed to operate with less than the required 4RX antennas
- It might be useful to distinguish between VR and AR, where the VR form factor might easily handle 4 Rx, while Redcap might be sufficient for AR



References

- [1] “Finding MIMO,” Signals Ahead, January 9, 2017, Vol. 13 No. 1, Signals Research Group
- [2] Hello Moto, “A Third Party Benchmark Study,” June 2022, Signals Research group



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