



Signals Ahead

Redefining Research

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Michael W. Thelander
(510) 338 1284
mike@signalsresearch.com
www.signalsresearch.com

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2x20MHz of LTE and the Heisenberg Uncertainty Principle

Report Preview

This document contains an overview, including a complete Table of Contents, List of Figures and List of Tables for a separately published 62 page report that provides an exhaustive analysis of the performance of the LTE networks in Stockholm (ERICY RAN and CN) and Gothenburg (NSN RAN and ERICY CN). This report is included as part of a normal subscription to our research services or it can be purchased separately for \$1,495. If purchased separately, it will also include a companion report that compares TeliaSonera's HSPA+ and LTE networks as well as greater insight on the real user experience in an LTE network.

Later this year we will be publishing a third report that stems from this research trip which looks at the network scheduler efficiencies of the two networks. This effort, done in conjunction with Sanjole and its WaveJudge LTE System, which provides an air monitor for LTE networks, including multi-layer and multi-device density analysis, sheds even more insight into the capabilities of the two networks.

Following this short introduction we include a few sample figures from the report (the report contains 64 figures and 3 tables), an overview of recently published research reports, and our tentative research publishing schedule for the next 6-9 months.

Once again, we had the opportunity to use the Accuver XCAL LTE drive test tool to capture the data on the LTE and HSPA+ networks as well as the Accuver XCAP LTE

post-processing tool to analyze the data and to create many of the figures that appear in this report. We have become quite fond of using the tool as it provides a very powerful, yet relatively simplistic, means of collecting and analyzing the data. We are also convinced that it has allowed us [and presumably operators and vendors who use the tool] to identify network performance – both good and bad – that would

have otherwise gone unnoticed. While not shown in this report, the tools can actually capture and analyze a wealth of other valuable information, including

signaling messages, which can take the analysis to the next level, not to mention tax our knowledge of LTE and HSPA.

While we looked at some of the more basic performance KPIs, such as downlink and uplink data rates, the use of the Accuver solution allowed us to capture and analyze numer-



This report provides invaluable insight to any organization that is interested in how LTE currently performs.

ous underlying performance KPIs, including CINR, RSSI, resource block allocation, modulation scheme (Antenna 1 and Antenna 2), MIMO type, and BLER. Further, during the post-processing phase we analyzed these KPIs by several different means, including throughput versus CINR, CINR versus RSSI, handover success rate, throughput during a handover, uplink transmit power versus throughput, and CINR versus modulation scheme and MIMO type, to name a few. Many of the results are also shown as geo-coded plots using Google Earth.

Given the highly differentiated information that we provide, this report is critical reading for:

- Spectrum holders who have yet to deploy a broadband wireless network
- Mobile operators who are evaluating the merits of deploying LTE
- Organizations that want to understand how the critical building blocks of LTE (e.g., OFDMA and MIMO) actually behave in a real-world, commercial network
- LTE infrastructure, device and chipset suppliers who are looking for competitive intelligence
- Financial institutions who are making short-term or strategic investment decisions
- Government regulators who are responsible for spectrum or broadband service policies
- Anyone with a passion for wireless

The full report is divided into seven sections, including an introductory section. Section 2 of the report includes the key highlights and findings from drive testing the two networks. In this section we identify and discuss in detail twelve of the most significant conclusions and we offer our assessment on the current performance differences between the Ericsson and Nokia Siemens Networks LTE solutions. Without going into too much detail, we did observe meaningful differences in how the two networks performed and why this was the case. Further, we found that the choice of operating system can have a material impact on the achievable performance of the network – important ramifications given the move to a new operating system that may have certain shortcomings.

Section 3 contains our test methodology. In order to ensure statistically valid results, virtually all of our testing took place while in vehicular or pedestrian modes. Although this approach reduced the potential throughput that we would otherwise have experienced, it ensured that our results are statistically valid since it is virtually impossible to achieve meaningful results from a stationary position – even if a large number of locations are selected at random. It also didn't hurt that we transferred nearly 600GB of data during our five and a half days of testing on the two networks, or the equivalent of ten years of data

traffic, based on a typical mobile operator's monthly maximum allotted usage. Further, we had access to high bandwidth servers, although in some cases server bandwidth limitations could have still impacted some of the test results. Finally, we publish all results that we collected to demonstrate that our conclusions are based on all available data points that we observed and analyzed.

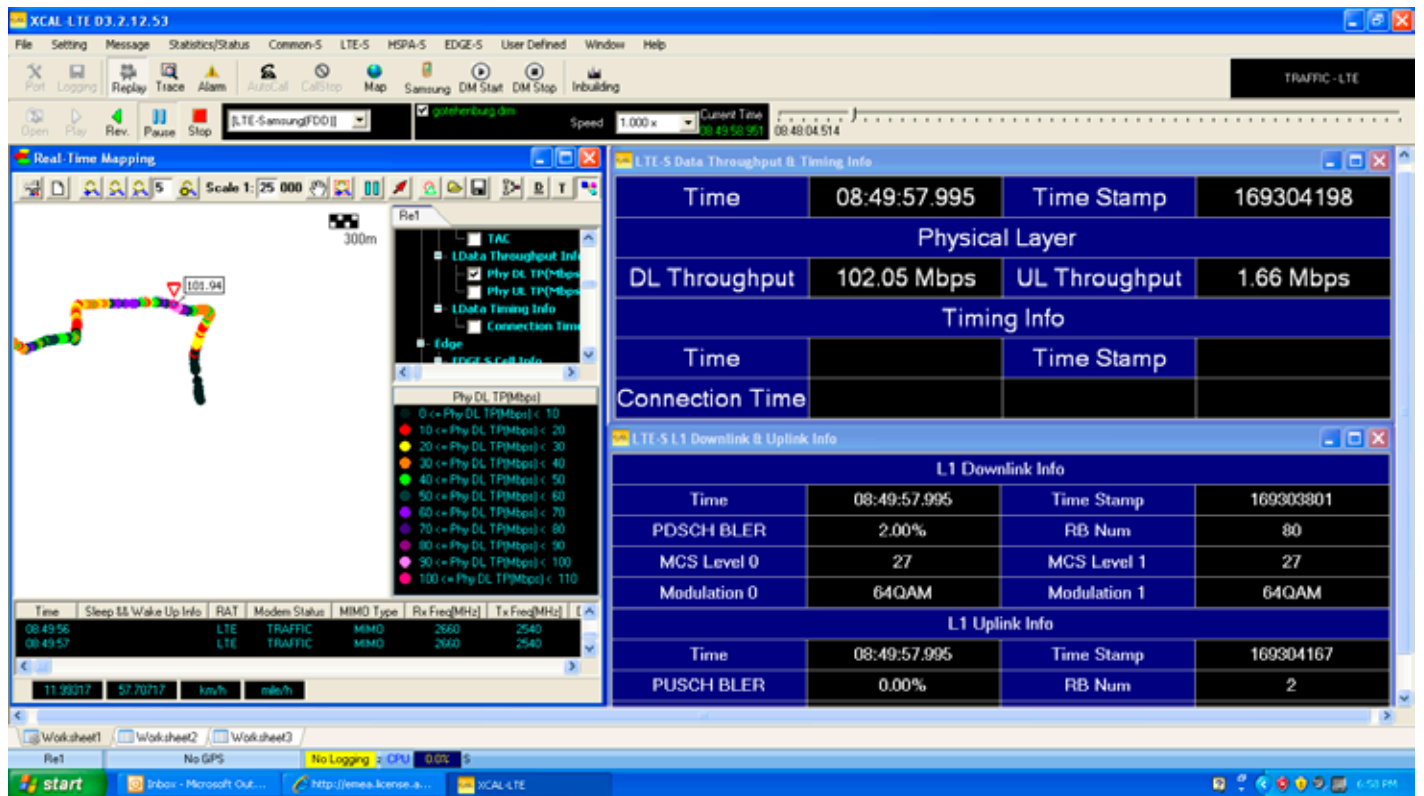
The next two sections of the full report contain detailed results for specific test scenarios – Section 4 is dedicated to the Stockholm network and Section 5 is dedicated to the network in Gothenburg. These sections contain a wealth of information presented in numerous figures as well as our analysis of the underlying data. This report preview includes a few sample figures based on real or fictitious data points. Section 6 provides some quick concluding remarks. Section 7 is an expanded appendix which includes additional results that didn't make their way into the main report.

This report preview contains six figures from the report, albeit sometimes with hypothetical data versus real data. The first figure shows a screen shot of the XCAL LTE drive test tool in action during the data collection process. If nothing else, this figure demonstrates to the naysayers that LTE can deliver triple digit data rates that reach the theoretical limits of the Category 3 device we were using. The next two figures show where we were conducting the tests and the speed we were driving or walking while conducting the tests. In the report we used a similar approach to plot many of the more interesting KPIs pertaining to network performance for a number of the test scenarios. For these figures, and in order to provide greater clarity, we focus on specific regions of the network that pertain to the test scenario being analyzed.

The next two figures, based on hypothetical data, plot important and closely related KPIs as a function of time. The final figure is a scatter plot, again based on hypothetical data, that shows the relationship between two KPIs. These figures are followed by some additional information about our *Signals Ahead* research product and then we provide the full report's Table of Contents, List of Figures, and List of Tables.

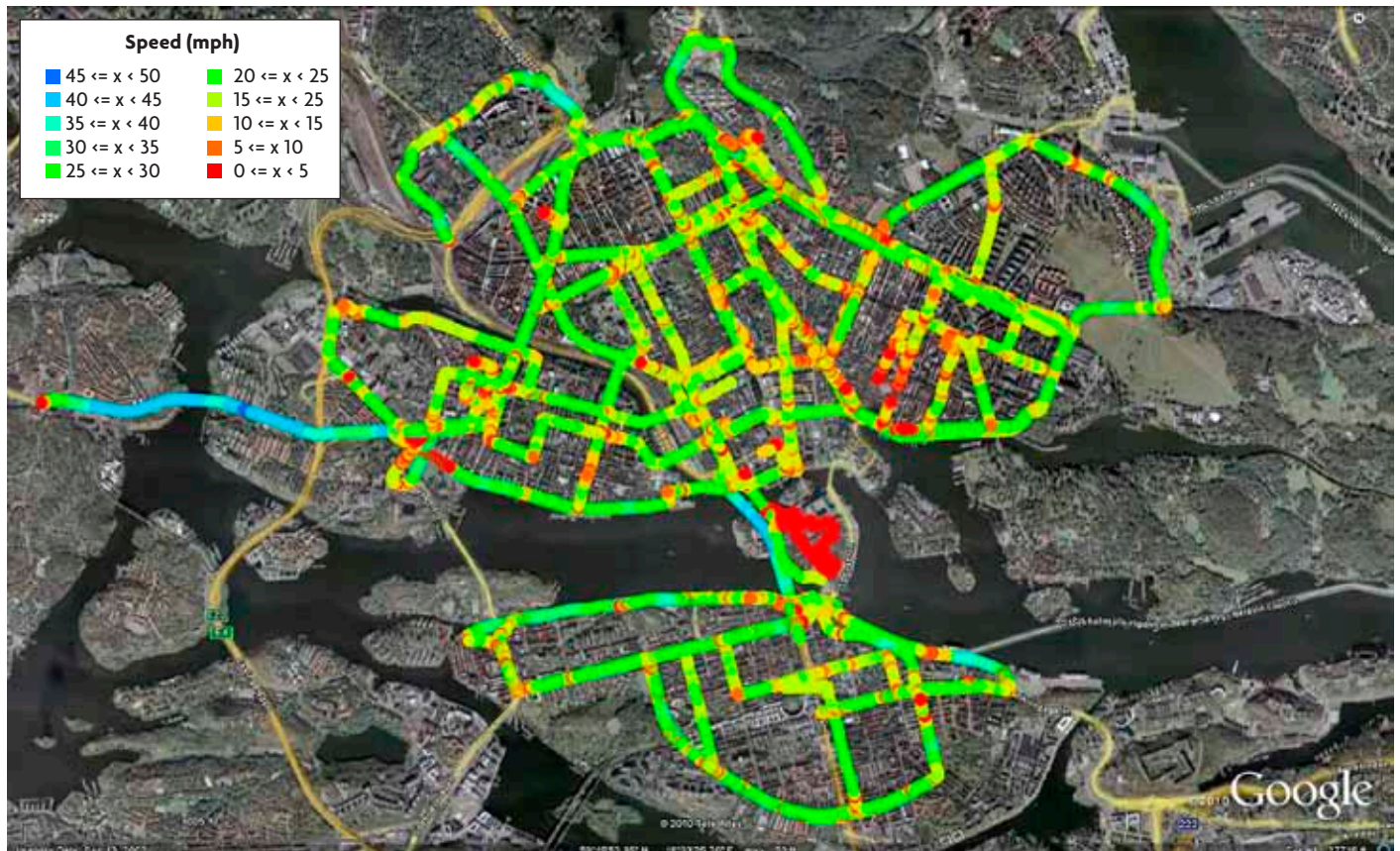
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Figure A. XCAL LTE Drive Test Tool in Action – DL performance



Source: Accuver XCAL LTE and SRG

Figure B. “Oh the places we did go!” – Geo plot of some Test Routes with Speed (mph) Stockholm



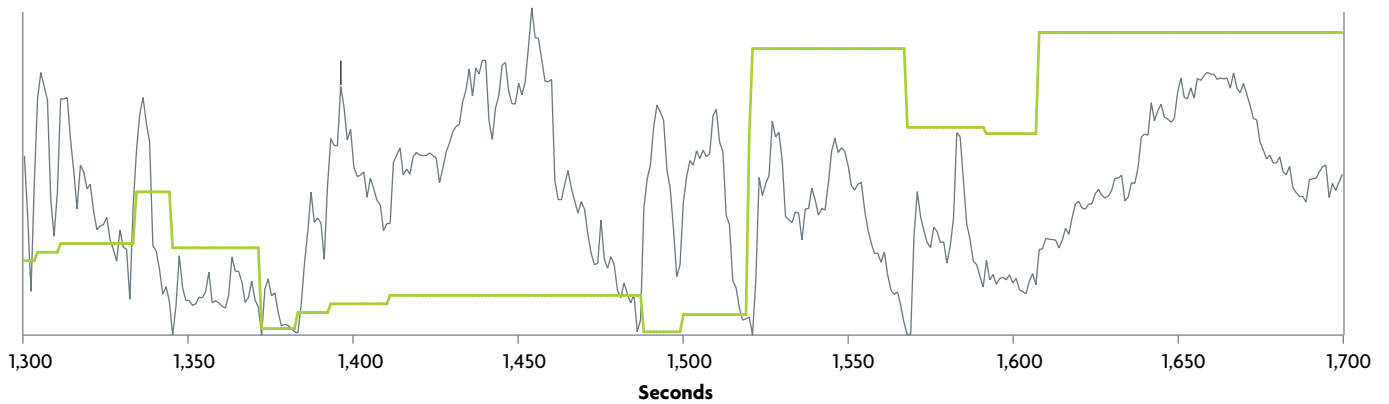
Source: Signals Research Group, LLC

Figure C. “Oh the places we did go!” – Geo plot of some Test Routes with Speed (mph) Gothenburg



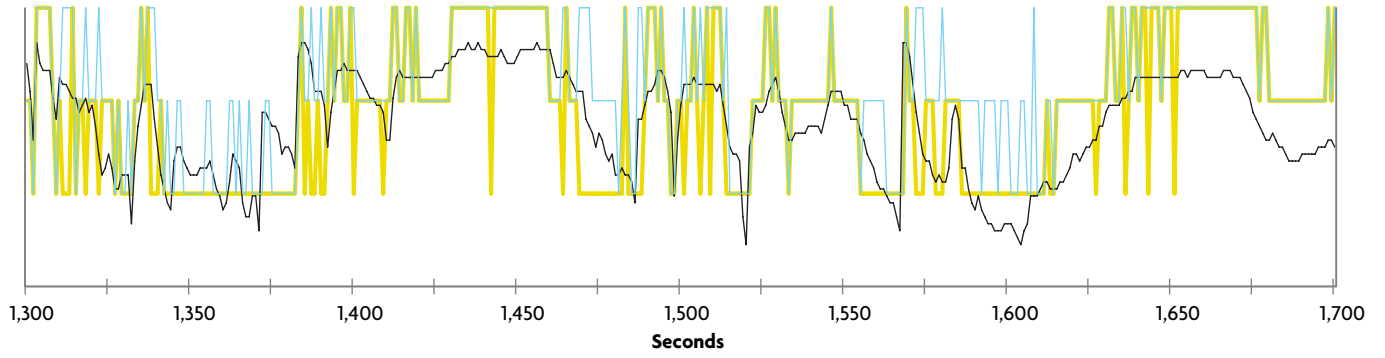
Source: Signals Research Group, LLC

Figure D. Sample Figure Showing KPIs as a Function of Time



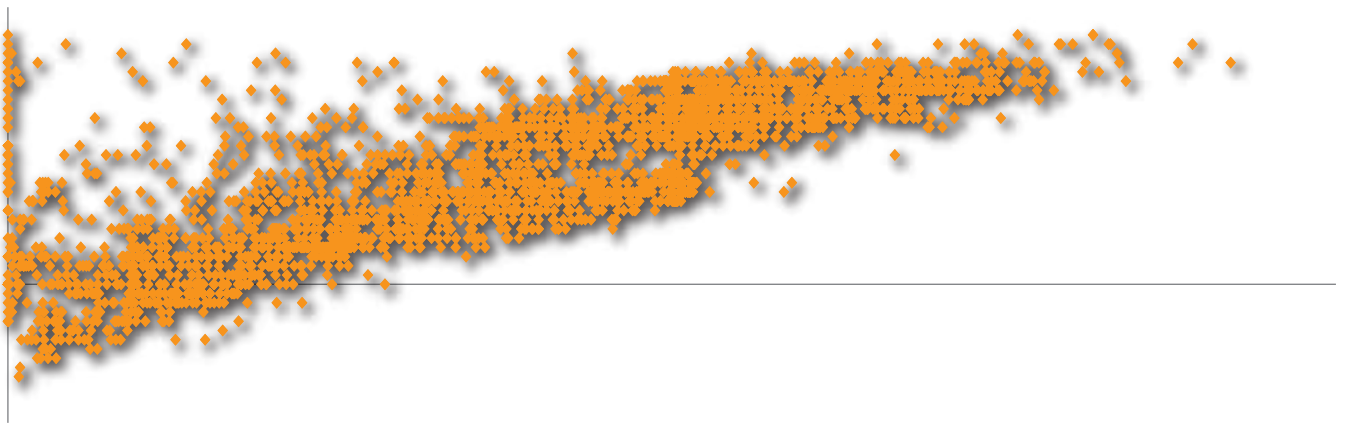
Source: Signals Research Group, LLC

Figure E. Sample Figure Showing KPIs as a Function of Time



Source: Signals Research Group, LLC

Figure F. Sample Figure Showing a Scatter Plot of Two KPIs



Source: Signals Research Group, LLC

IN CASE YOU MISSED IT

- **9/7/10 "I'LL TAKE WHAT'S BEHIND 3GPP"** Release 9, no make that Release 10 We look at many of the more interesting features of 3GPP Release 9 and Release 10, including LTE Advanced. Many of the LTE-Advanced features sound compelling on paper but we discuss why some of them will have no material benefit in a real world network. Additionally, there are pending improvements to good old GSM that will support new and compelling features, not to mention improve its voice capacity.
- **8/10/10 "BACKHAUL REDUX – ARE WE THERE YET?"** We explore many of the more challenging aspects associated with an operator's next-generation backhaul strategy. In addition to analyzing the various ways in which Carrier Ethernet can be implemented we also look at the debate surrounding whether or not to implement Carrier Ethernet at Layer 2/1 or at Layer 3.
- **6/16/10 "TURNING TD-LTE, I REALLY THINK SO"** Following a recent trip to Shanghai where we attended the NGMN event, we provide our views on the maturity and market opportunities for TD-LTE. We discuss the likely events over the next year and the long-term outlook for the technology around the world, with a particular focus on the implications for Mobile WiMAX, including 802.16m.
- **6/7/10 – "CHIPS AND SALSA XII – A CHIP OF A DIFFERENT COLOR"** We continue the long-standing tradition of providing results from independent performance benchmark tests of leading baseband chipsets. This time we collaborated with Agilent Technologies to test 5 leading Mobile WiMAX chipsets.
- **5/5/10 "VOICE OVER LTE – A MODERN DAY TOWER OF BABEL?"** We examine 5 different approaches for implementing VoLTE. We look at the technical merits of each solution, who is advocating the various solutions, as well as the probability that any given solution ever sees the light of day.
- **4/12/10 "CHIPS AND SALSA XI – I'LL TAKE CATEGORY 14 FOR 21MBPS PLEASE"** In this issue, which was done in collaboration with Spirent Communications, we provide results the industry's latest round of independent HSPA chipset testing. In this report we provide results for 10 different solutions, representing chipsets from five different leading suppliers. Tested chipsets supported Cat 8, Cat 9, Cat 10 or Cat 14 capabilities with 56 test scenarios for the Cat 8-10 platforms and 46 test scenarios for the Cat 14 (HSPA+) platforms.
- **3/11/2010 "186GB IN AN LTE NETWORK – BEEN THERE, DONE THAT (PART 2)"** In part two of a special two-part series we provide results from the industry's first independent drive test of a commercial LTE network. Part two is specific to the Oslo network, plus it puts the LTE throughput results into perspective, based on real usage scenarios.
- **3/11/2010 "186GB IN AN LTE NETWORK – BEEN THERE, DONE THAT (PART 1)"** In part one of a special two-part series we provide results from the industry's first independent drive test of a commercial LTE network. Part one provides the key conclusions and observations from testing two networks along with the detailed results for the Stockholm network. Detailed results include multiple KPIs which provide key insight into how the network performs (modulation scheme, MIMO type, throughput, # of resource blocks, CINR, RSSI, etc).

In order to provide greater insight into the type of research that we provide, we have included brief summaries of recent reports that we have done as well as identified a list of likely topics that we will pursue in the coming year. Note that the research topics we pursue could change based on industry events and market trends, not to mention ideas that we develop through the course of doing normal research.

Potential topics for the coming year include:

- LTE versus HSPA+ and the real user experience in an LTE network
- Embedded modules/netbooks
- LTE network scheduler efficiency test results
- The challenges of delivering video in a mobile network
- HSPA+/HSPA chipset performance benchmark test results
- Going Green – financial implications and challenges
- The impact of Type 3i receivers on UE performance (includes chipset benchmark tests of leading solutions)
- Whatever happened to IMS?
- LTE Americas
- 4G World and GSMA Asia
- DC-HSDPA network performance benchmark results
- HSPA+ (MIMO) network performance benchmark results
- The impact of latency
- TD-LTE network performance benchmark results
- Public Safety Options with 700MHz
- Technology and Market Outlook for 1X Advanced and EV-DO Advanced
- EV-DO Rev B network performance benchmark results
- LTE chipset landscape
- LTE chipset performance benchmark test results

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