# Quality Improvement Trends in Companies Using the TL 9000 Quality Management System

Monetizing Cost Avoidance - A Retrospective Study Using the Return Rate Measurement for Wireless Infrastructure Products

## TL 9000 Return Rates Are Improving - Resulting in $1B Annual Cost Avoidance

This paper continues a series of industry white papers published by the QuEST Forum based on TL 9000 Performance Data Reports (PDRs). These reports summarize audited data that is submitted monthly to a secure and anonymous data repository by TL 9000 certified companies for over 140 different product categories and measurements spanning delivery, problem reports, fix responsiveness, outages, return rates, software and service quality.

This study is a retrospective of a study that originally analyzed 2008-2010 return rates for wireless infrastructure products which demonstrated significant improvement at that time. Simply put, return rates measure the number of items returned after purchase for any reason whether it is for a defect or the customer's expectations were not met. These returns are further categorized into early life (returns within six months of original shipment), one year (next 12 months) and then long term (greater than 18 months after shipment). In TL 9000 terminology, these are referred to respectively as the Early Return Rate Index (ERI), One Year Return Rate (YRR), and Long Term Return Rate (LTR).

Given QuEST Forum enhancements in the data reported since the last study, including the addition of annualized average units deployed, this retrospective study also calculates cost avoidance as a result of the performance improvements.

The data presented in this study demonstrates that return rates have broadly decreased and improved for wireless infrastructure products from 2008 to 2016, and this has resulted in tremendous cost avoidance. We will show how the Information, Communication and Technologies (ICT) industry (suppliers and service providers) are saving close to **$1 billion (B) USD annually** when comparing current performance to that at the start of the study.

For the three measurements (ERI, YRR and LTR) reviewed across five wireless infrastructure product categories, **EVERY one of the fifteen measurement trends studied has shown improvement:**

- The percentage improvement shown on a relative basis has been dramatic, ranging from 32% in the worst case (3G YRR) to as high as 92% (WLAN Base Station Equipment YRR and LTR)
- On an absolute basis, the improvements ranged from 0.34% to 2.04% per year and resulted in
- **Close to $1B dollars in cost avoidance annually**, given the large deployed base and a conservative cost estimate of $1000 per repair.

## Background

Rapid expansion coupled with emerging technologies and globalization challenges the ICT industry as it serves as the backbone of a connected world. With some of the world's largest and most innovative companies in direct competition to provide high-speed connections through telephone lines, cable, wireless, satellite, and the cloud, the quality and reliability of these networks and the supply lines to build and support them is a strategic differentiator. End customers look to their service providers to fulfill the promises of new technologies, which in turn, challenges the supply chain to continually improve the performance of both the products supplied and the services rendered. QuEST Forum, a collaborative industry association comprised of service providers and suppliers, is addressing this challenge with their development, deployment, and continual improvement of the TL 9000 Quality Management System (QMS).

The TL 9000 QMS, by dramatically expanding on ISO 9001, establishes a model that supports improved performance, better overall product quality, reduced cycle time, and improved customer satisfaction. The advantages of TL 9000 originate from the industry related supplemental requirements derived from practical experience and the standardized measurement reporting requirements for hardware, software, and service quality. Certified organizations anonymously submit performance results monthly into a secure repository and summary reports are compiled by product category. The reporting organizations then use the resulting data as a benchmarking tool to track their performance and drive improvement.

With the TL 9000 QMS well into its second decade, the overriding question is*: Are TL 9000 certified companies demonstrating improved quality and performance?* In order to objectively assess the performance of companies certified to the TL 9000 QMS, the QuEST Forum Performance Data Reports (PDR) Team has been producing a series of industry papers analyzing TL 9000 third party audited data. The third paper in the series, focused on return rates for the Wireless Product Family during 2008 - 2010.

This paper is a retrospective on this important measure for a very important product family. In addition, this paper goes two steps further. First, the time interval of the study is expanded from 2008 to the beginning of 2016. Second, and the most significant addition, are estimates of aggregate monetized cost avoidance of the TL 9000 certified organizations in this study due to return rate improvements.

## Products Studied

The study drills down into five product categories (number identifier/name) representing the wireless infrastructure:

- **3.3.1 Base Station Controller Equipment -** Equipment that provides the interface between wireless systems and the Public Switched Telephone Network (PSTN).
- **3.3.2.1 Basic (2G and Earlier) Base Transceiver System -** Second generation and earlier equipment that provides the radio link to mobile subscribers.
- **3.3.2.2 Advanced Base Transceiver System -** Post second generation (2.5G) or third generation (3G) equipment that provides the radio link to mobile subscribers.
- **3.3.2.3 4G Base Transceiver System -** Fourth generation (4G) equipment that provides the radio link to mobile and nomadic subscribers.
- **3.3.4 WLAN Base Station Equipment -** Wireless, land, and WiMax data interface to wireless data network mobile subscribers

## Return Rates Defined

Return rates are measured in three distinct phases.

- **The Early Return Index (ERI)** is a measure of the returns of units during the first six months after initial shipment. ERI represents the rate of return for the product during installation, initialization, and testing.
- **The One-Year Return Rate (YRR)** is a measure of the return rate of units during the first year following the Early Return Index period. YRR is the number of returns from the population of units shipped during the seven to eighteen months prior to the monthly calculation period. This period represents the rate of return for the product during the early life interval.
- **The Long-Term Return Rate (LTR)** is a measure of the return rate of units following the One-Year Return Rate period. LTR represents the rate of return for the mature period of the product.

Return rates are one measure of product reliability. Product returns are expensive to both the supplier and the customer replacing the repaired units. Reducing the return rate has a major impact on lowering operational costs and expenses for all of the impacted parties. Such data is useful in helping understand and focus on not only product reliability, but also training needs and other improvements. For example, a high return rate coupled with a high NFF (No-Fault-Found) rate may point to the need for improved troubleshooting, training, or diagnostic capabilities.

## Analysis Approach and Estimating Improvement Cost Avoidance

Since the initial study was completed for the 2008 - 2010 wireless return rate data, QuEST Forum has continually implemented initiatives to enhance the value of the benchmarking data. One improvement not available for the initial study is the inclusion of an average number of normalization units for each TL 9000 measurement. These are shown in the Annual PDR report for each product category and are available to QuEST Forum members and TL 9000 certified companies. The initial intent of providing this information was to allow TL 9000 certified companies to assess the extent that the market was covered by TL 9000 certifications including their competitors.

For the purposes of this study, knowing the average number of deployed Field Replaceable Units (FRUs) for the certified companies in these wireless infrastructure categories allows an estimate of the actual number of returns avoided on an annual basis. Using the percent improvement as estimated by the TL 9000 PDR Industry Average linear trend lines, and a conservative repair estimate of $1000 per repair, it is possible to estimate the annual cost avoidance for the ERI, YRR, and LTR measures across all of the studied product categories.

The industry average can be plotted over time to the extent available for the three measures, for each of the five product categories, and then a linear trend line can be established for each. Rather than showing the 15 possible charts including the trend lines, a single chart is shown for each return measure and includes only a trend line for each of the five product categories.

Before each of the measures is discussed, the two figures below illustrate extremes of the associated "fit" of a linear trend line. For the first case (Fig. 1), while the fit is not as strong as the second case (Fig. 2), an improvement trend can still be seen. Estimates for improvement can be made by using the end points. (All 15 charts can be found in the Appendix).

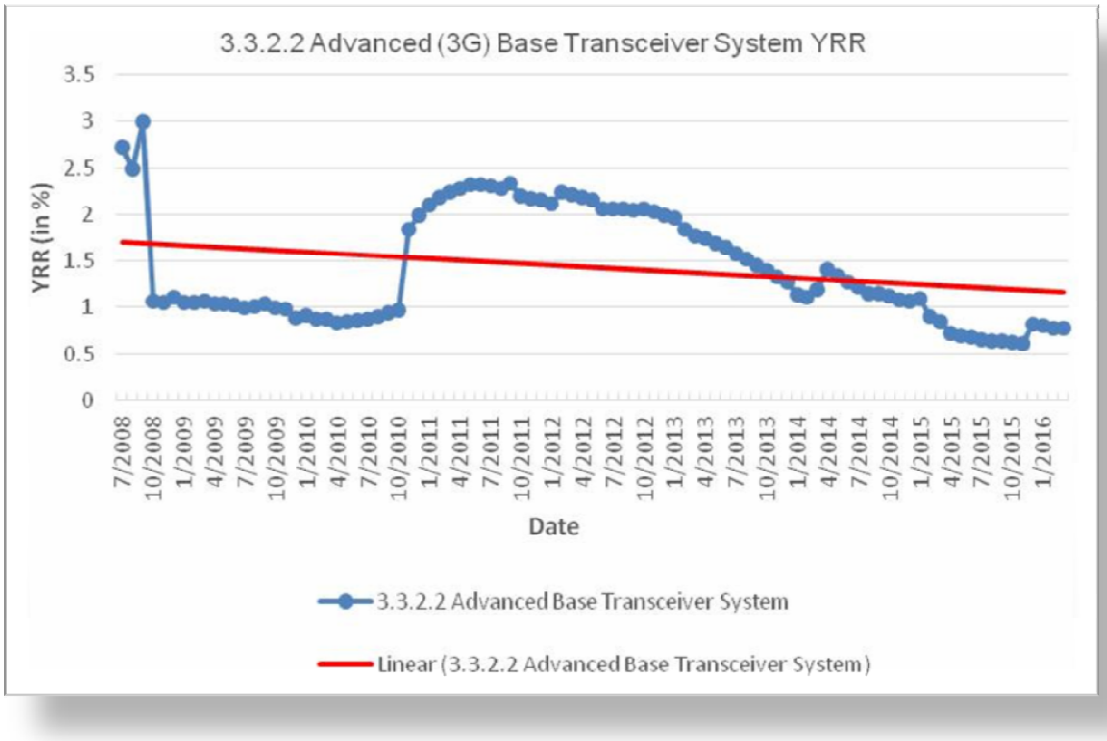



**Fig. 1** Example of one "Fit" extreme. Though the fit is poor, the data and linear trend line show improvement

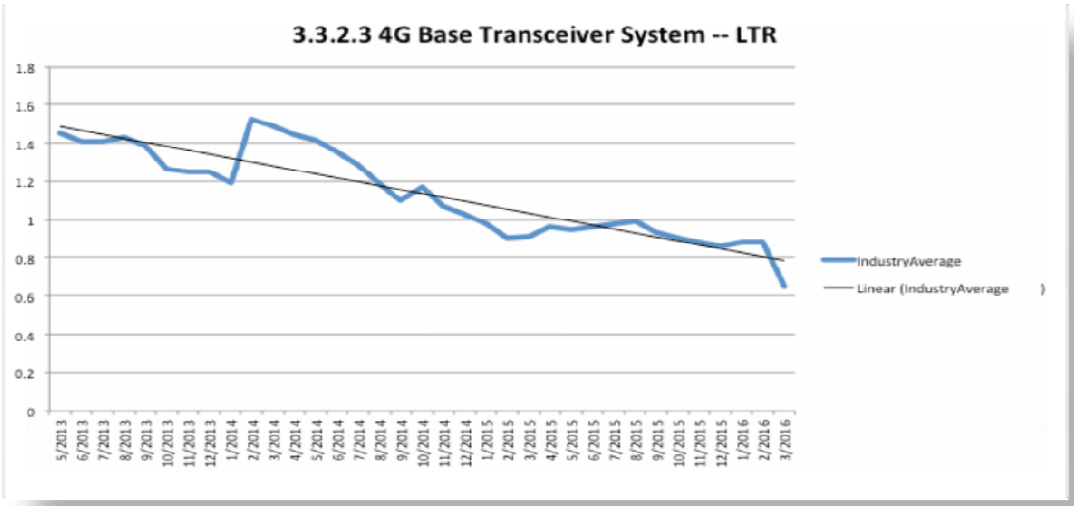



**Fig. 2:** Example of better fit, also showing an improvement trend

## A Few Words Regarding Repair Costs Estimates

The $1000/return cost estimate is believed to be conservative and likely much higher in practice from a complete end-to-end view. Items typically covered in repair cost estimates include supplier warranty, return and replacement shipping, new unit costs if needed, repair costs, processing costs and service costs. As this study also includes YRR and LTR which cover out of warranty periods, there are still costs incurred such as supplier technical support, trouble shooting, and administrative costs for returning material. The impact on operator reputation due to service interruptions which may occur due to returned units, is not considered in the estimate, but can have significant revenue and cost impact. The estimate also does not include costs of operators taking end-customer complaints, troubleshooting them, site visits etc., which may be required before a return is sent to a supplier.

## Early Return Index (ERI) Improvement and Cost Savings

As Fig. 3 shows, the trend lines for the ERI measurement for all five product categories are improving downward. Some are improving more rapidly than others. Many show improvements of more than 1% during the multi-year time period. Not surprisingly, the least mature product, 3.3.2.3 (4G Base Transceiver System), has the steepest slope, suggesting the most rapid improvement as it is on the steepest portion of its learning curve, and its design was more revolutionary, compared to the move from 2G to 3G.

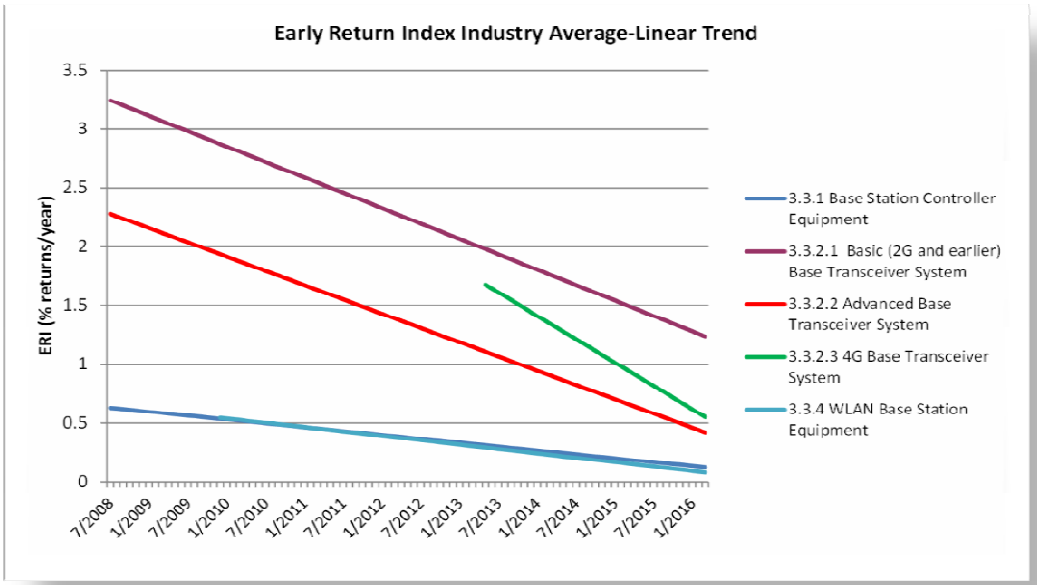



**Fig. 3:** ERI Return Trends

The only surprising result is that product category 3.3.2.1 (2G and earlier) has a consistently higher return rate than does product category 3.3.2.2 (3G). With 4G return rates being higher than 3G return rates, as might be expected, the comparatively high 2G return were unexpected. One speculation as to why the 2G products have higher return rates is that its production volumes are now relatively small compared to its less mature counterparts. Lower production volume likely leads to shorter manufacturing runs, which in turn requires more setups, which in turn leads to more defects and more field failures. This theory cannot be fully substantiated, but it does fit all of the available data for the Early Return Index.

The cost avoidance from lower return rates is substantial, particularly in the transceiver product categories, where the volume is large. In the first six months alone for the ERI measurement, such savings are on the order of $86 million (M) USD per year across all five product categories as shown in Table 1.

| **ERI Product Category - Data using linear trendline** | Start Date | End Date | Initial Data | Final data | Net Reduction | Avg # of NU's 2015 | # of FRU Returns Avoided | costs avoided |
|---|---|---|---|---|---|---|---|---|
| 3.3.1 Base Station Controller Equipment | Jul-08 | Mar-16 | 0.63 | 0.12 | 0.51 | 134128 | 679 | $678,688 |
| 3.3.2.1 Basic (2G and earlier) Base Transceiver System | Jul-08 | Mar-16 | 3.24 | 1.24 | 2.01 | 256858 | 5152 | $5,151,544 |
| 3.3.2.2 Advanced Base Transceiver System | Jul-08 | Mar-16 | 2.28 | 0.42 | 1.86 | 2671730 | 49651 | $49,651,430 |
| 3.3.2.3 4G Base Transceiver System | May-13 | Mar-16 | 1.68 | 0.55 | 1.13 | 2483391 | 27948 | $27,948,082 |
| 3.3.4 WLAN Base Station Equipment | Dec-09 | Mar-16 | 0.55 | 0.08 | 0.47 | 510482 | 2374 | $2,373,741 |
| | | | | Cost per return | $1,000 | Total | 85803 | 85803486 |

**Table 1:** ERI Cost Avoidance

## One-Year Return Rate (YRR) Improvement and Cost Savings

While ERI (returns during the first 6 months after shipment) highlights infant mortality failures, installation and manufacturing issues, YRR provides much better insight to early steady state failure rates and is more impacted by the design of the product. As with all return measures, due to the volume of deployments, small improvements to YRR performance translates to huge direct cost savings for service providers and/or network operators. More importantly, these improvements have a direct relationship to increasing network reliability. As was done for ERI, we will examine the economic impacts of YRR performance for the five wireless infrastructure product categories.

As shown in Fig. 4, the trend lines for all five Wireless Infrastructure product lines show significant to dramatic quality improvement in YRR over the tracked period. Not surprisingly, the performance of 2G BTS, being the most mature, started with the best overall performance. 3G tracked its performance (and improvement), starting and finishing approximately 0.20% higher. 4G, while only starting its trend line in May 2013, showed the highest rate of improvement, with current performance substantially better than 2G or 3G. It is suspected the reason for this improvement is that 4G products were more of a revolutionary design compared to the move from 2G to 3G. This new design is more efficient and, together with the rapid deployment of technology starting in 2014, has allowed it to mature faster than earlier BTS designs.


**Fig. 4:** YRR Return Trends

Similarly, WLAN Base station equipment has also shown dramatic improvement, ending the period with the best overall YRR performance of the five product categories. While some might suggest that the performance improvement magnitude over the 7 ½ year period for any product category is less than 2% on an absolute basis, the relative percent improvement in each one is dramatic. The lowest relative percent decrease was for 3G BTS (at just over 32%) and the highest was for WLAN Base station equipment at 92%.

Again, as with ERI and shown in Table 2, using current values of FRUs outstanding to calculate the number of units that did not fail as a result of the performance improvement, the industry has avoided almost 130,000 annual YRR returns over the five product categories. Further, if you use the conservative estimate of $1000 per return as costs to suppliers, service providers, and their associated contractors, the industry is avoiding over $129M annually, due to the YRR performance improvement alone.

| **YRR Product Category - Data using linear trendline** | Start Date | End Date | Initial Data | Final data | Net Reduction | Avg # of NU's 2015 | # of FRU Returns Avoided | Cost Avoidance |
|---|---|---|---|---|---|---|---|---|
| 3.3.1 Base Station Controller Equipment | Jul-08 | Mar-16 | 0.7542 | 0.4138 | 0.3404 | 279224 | 950.478 | 950,478 |
| 3.3.2.1 Basic (2G and earlier) Base Transceiver System | Jul-08 | Mar-16 | 1.5576 | 0.9504 | 0.6072 | 600885 | 3648.57 | 3,648,574 |
| 3.3.2.2 Advanced Base Transceiver System | Jul-08 | Mar-16 | 1.7059 | 1.1539 | 0.552 | 5116984 | 28245.8 | 28,245,752 |
| 3.3.2.3 4G Base Transceiver System | May-13 | Mar-16 | 2.1248 | 0.6356 | 1.4892 | 5356894 | 79774.9 | 79,774,865 |
| 3.3.4 WLAN Base Station Equipment ** | Dec-09 | Mar-16 | 1.88950 | 0.1507 | 1.7388 | 945528 | 16440.8 | 16,440,848 |
| ** Used Actual IA for Final Data as Linear Trend was Negative | | | | | | | | |
| | | Cost per Return | | $1,000 | | Totals | 129061 | 129,060,517 |

**Table 2:** YRR Cost Avoidance

## Long Term Return Rate (LTR) Improvement and Cost Savings

While ERI looks at the early failures of the product and YRR gives insight into early steady state failure rates, LTR provides a look into the return rates of the product as it enters maturity and full steady state and then nears end of life. While all FRUs will eventually fail if left in service, reducing their failures during the full steady state and useful life will decrease the LTR and mean huge savings over time given the larger number of deployments.

As shown in Fig.5, where we see the linear trend line for LTR performance, significant improvements can be seen for all five product categories. As may be expected, the most mature product, the 2G Base Transceiver System, has the most significant improvement with just over a 2% decrease and an overall cost avoidance of $335M (see Table 3). The second most improved product category was the 3.3.4 WLAN Base Station Equipment with a 1.73% reduction in LTR performance. However, the overall cost avoidance for that product category was less at $101M. Conversely, the least improving product, the 3.3.2.2 Advanced Base Transceiver System with a significantly higher number of deployed units, showed an improvement of only 0.47% in LTR performance, but boasted $173M in cost avoidance. The remaining product categories, the Base Station Controller Equipment and Base Transceiver System tied for improvements of 0.72% and managed cost avoidances of $75M and $38M, respectively.

Overall, the cost avoidance for all five products was an astounding $723M with approximately 723,000 FRU returns avoided.

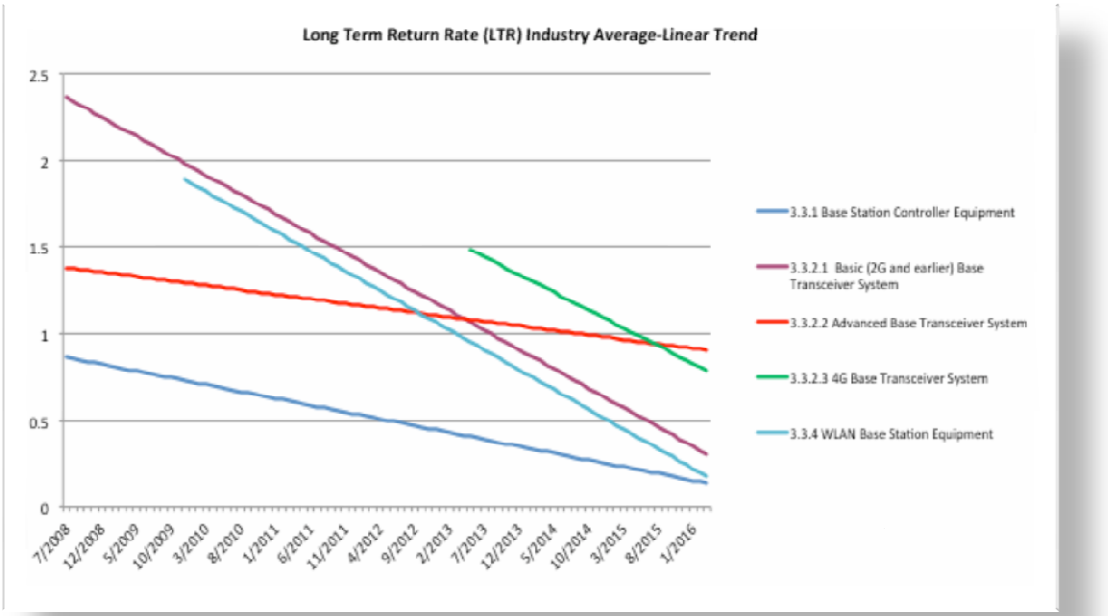



**Fig. 4:** YRR Return Trends

| LTR Product Category - Data using linear trendline | Start Date | End Date | Initial Data | Final data | Net Reduction | Avg # of NU's 2015 | # of FRU Returns Avoided | Cost Avoidance |
|---|---|---|---|---|---|---|---|---|
| 3.3.1 Base Station Controller Equipment | Jul-08 | Mar-16 | 0.8629 | 0.1361 | 0.7268 | 1E+07 | 74709 | $74,709,051 |
| 3.3.2.1 Basic (2G and earlier) Base Transceiver System | Sep-08 | Mar-16 | 2.3642 | 0.3258 | 2.0384 | 2E+07 | 335539 | $335,538,537 |
| 3.3.2.2 Advanced Base Transceiver System | Sep-08 | Mar-16 | 1.3823 | 0.9091 | 0.4732 | 4E+07 | 173100 | $173,100,218 |
| 3.3.2.3 4G Base Transceiver System | May-13 | Mar-16 | 1.4859 | 0.7649 | 0.7210 | 5E+06 | 38124 | $38,124,093 |
| 3.3.4 WLAN Base Station Equipment** | Dec-09 | Mar-16 | 1.8899 | 0.1507 | 1.7392 | 6E+06 | 101334 | $101,333,729 |
| ** Used Actual IA for Final Data as Linear Trend was Negative | | | | | | | | |
| | | | | Cost per Return | 1000 | Total | 722806 | $722,805,629 |

**Table 2:** YRR Cost Avoidance

## Summary

The data presented in this study demonstrates that return rates have broadly decreased and improved for wireless infrastructure products from 2008 to 2016, and this has resulted in tremendous cost avoidance for the ICT industry at a rate of nearly **$1B annually.**

For the three measurements (ERI, YRR and LTR), across five wireless infrastructure product categories, **EVERY one of the fifteen measurement trends studied has shown improvement:**

- The percentage improvement shown on a relative basis has been dramatic, ranging from 32% in the worst case (3G YRR) to as high as 92% (WLAN Base Station Equipment YRR and LTR)
- On an absolute basis, the improvements ranged from 0.34% to 2.04% per year and resulted in
- **Close to $1B dollars in cost avoidance annually**, given the large deployed base and a conservative cost estimate of $1,000 per repair.

## Other Highlights

**ERI:**

- Percent relative improvement across the five products categories is strong (62% – 85%).
- Absolute improvement ranges from approximately 0.3% to 1.7 % per year resulting in
- **$86M annual cost avoidance** across all five product categories combined.
- Good news for the industry in that the least mature product, 3.3.2.3 (4G Base Transceiver System), had the greatest rate of improvement during the period studied (May 2013 to Early 2016).
- Surprisingly, product category 3.3.2.1 (2G and earlier) has a consistently higher ERI than 3.3.2.2 (3G). It is speculated that this could be due to lower production volume/shorter manufacturing runs potentially leading to more defects.

**YRR:**

- Percent relative improvement across the five products categories has the widest range of the three measures (32% – 92%), and includes one of the greatest improvement trend lines (WLAN Base Station Equipment).
- Absolute improvement ranges from approximately 0.5% to 2% per year resulting in
- **$129M annual cost avoidance** across all five product categories combined.
- Not surprisingly, the performance of the most mature product, 2G BTS, started with the best overall performance.
- 3G tracked its performance (and improvement), starting and finishing approximately 0.20% higher.
- 4G, while only starting its trend line in May 2013, showed the highest rate of improvement, with current performance substantially better than 2G or 3G.

**LTR:**

- Percent relative improvement across the five products categories also has a wide range (32% – 92%), and similarly to YRR also includes one of the greatest improvement trend lines (WLAN Base Station Equipment).
- Absolute improvement ranges from approximately 0.5% to 2 % per year.
- **$723M annual cost avoidance** across all five product categories combined due to the extensive deployed base for LTR compared to the other measures.
- As may be expected, the most mature product, the 2G BTS, has the most significant improvement with an over 2% decrease and alone has an overall **$335M annual cost avoidance**.

## Imagine the Future with TL 9000 Certified Companies

One of the fundamental drivers for the formation of QuEST Forum and creation of TL 9000 was the ICT industry's need to objectively measure quality performance. When a competitive marketplace has reliable benchmark data for comparable products, the participants need to differentiate themselves, resulting in an accelerated improvement loop. The TL 9000 QMS has provided this environment and as shown by the data presented in this study, certified companies that are using the TL 9000 Measurements and Performance Data Reports have demonstrated significant improvements and cost avoidance. For a supplier, TL 9000 data provides the company with a report card on its improvement progress including gaps with the competition. It also provides them with objective industry performance results not easily obtained by their non-TL 9000 certified competition. For operators, the availability of objective TL 9000 performance data provides critical information to use in order to better manage their supply chain. For the entire industry, $1B annual cost avoidance is earned for just the products in this study.

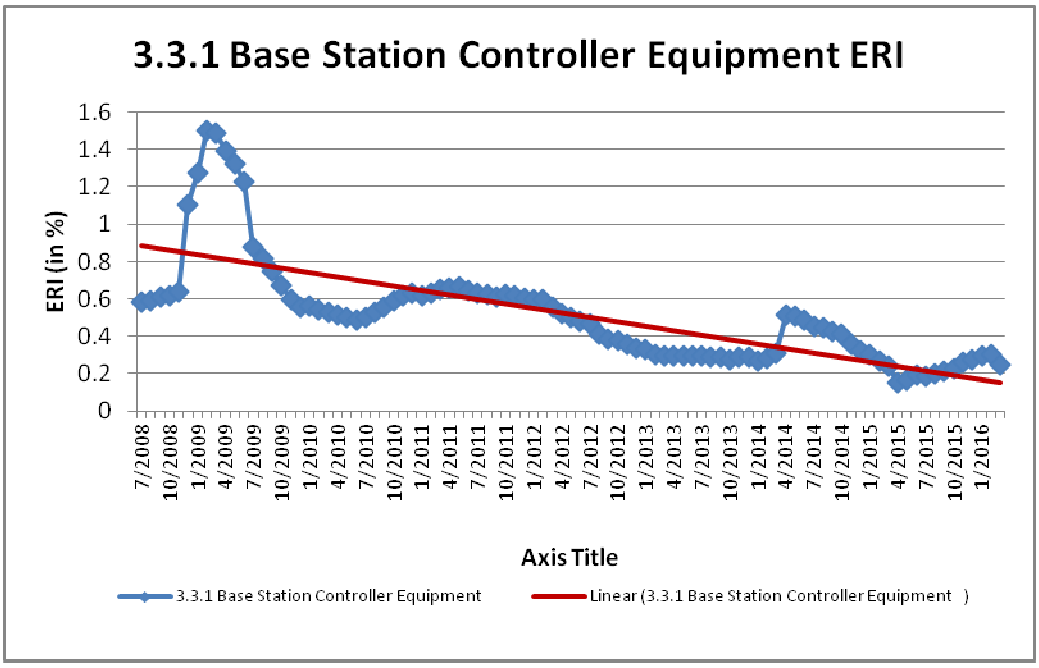
Now imagine if cost avoidance like this could be realized for the over 140 product categories across over 40 TL 9000 measures/sub measures. The savings for suppliers and operators would multiply and accumulate. While the team surmises that the overall industry has improved for the scope of this study, the data only substantiates that the companies using the TL 9000 QMS improved. The team cannot speak for those companies not certified, as the data does not exist, or would be prohibitively expensive to collect. As customers become more aware of the improvements driven by TL 9000, it is expected that they will seek to purchase products and services only from TL 9000 certified organizations.

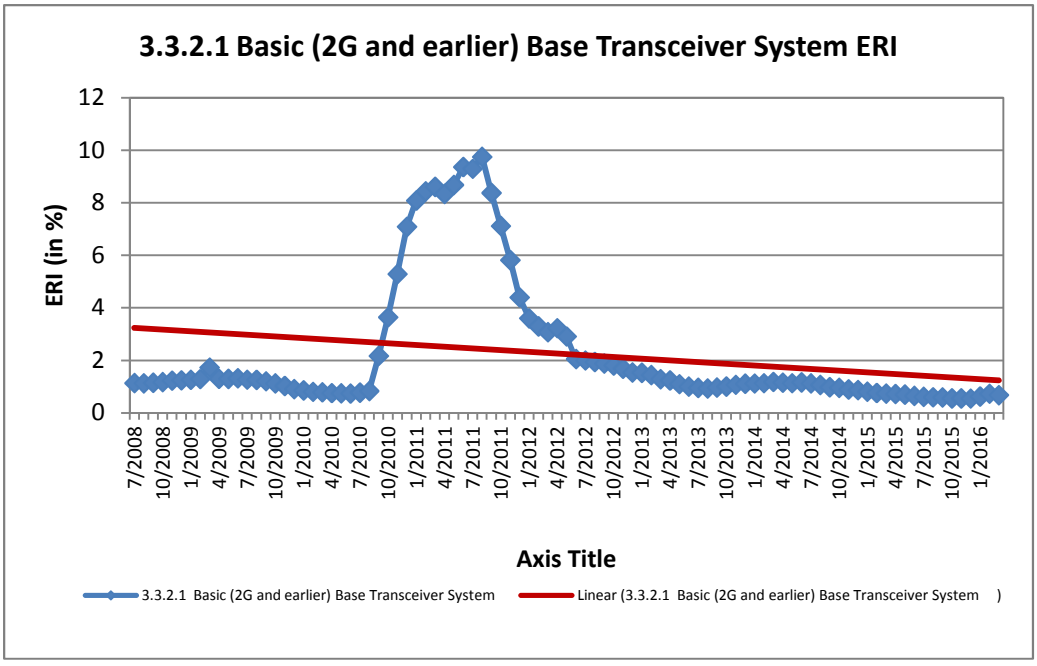
Finally, this study would not have been possible without TL 9000 certification including a common measurement system and the requirement for certified companies to submit their validated and audited data on a monthly basis. Thank-you to all of these TL 9000 certified companies, as the data in this white paper and the demonstrated improvements and cost avoidance would not exist without their faithful diligence to continually improving quality.

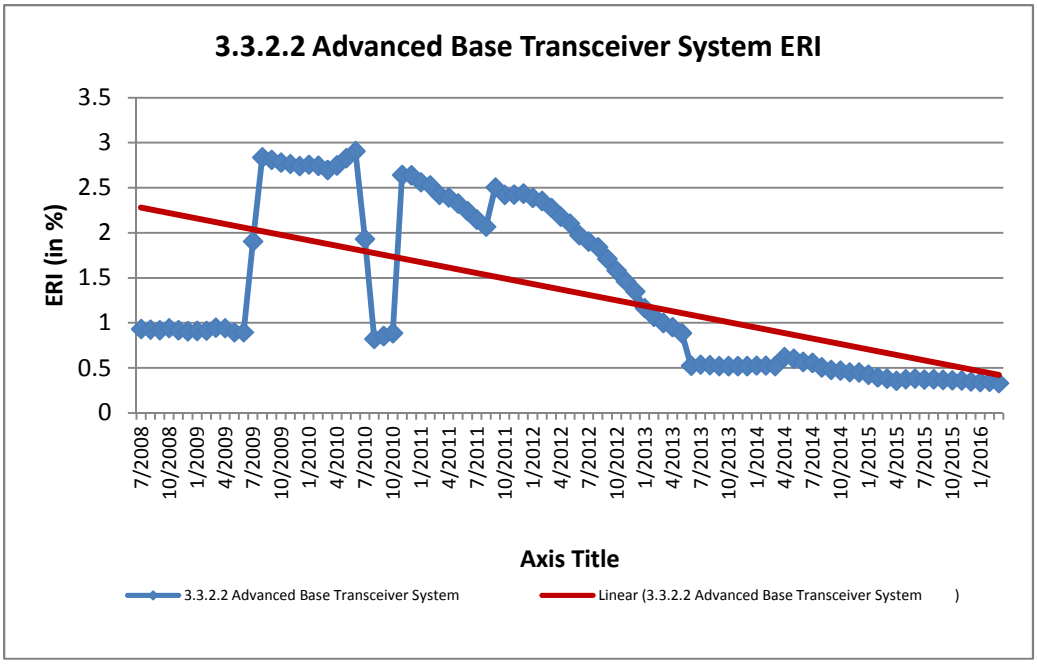
For additional information on QuEST Forum or TL 9000 please visit www.questforum.org or call +1-972-423-7360.

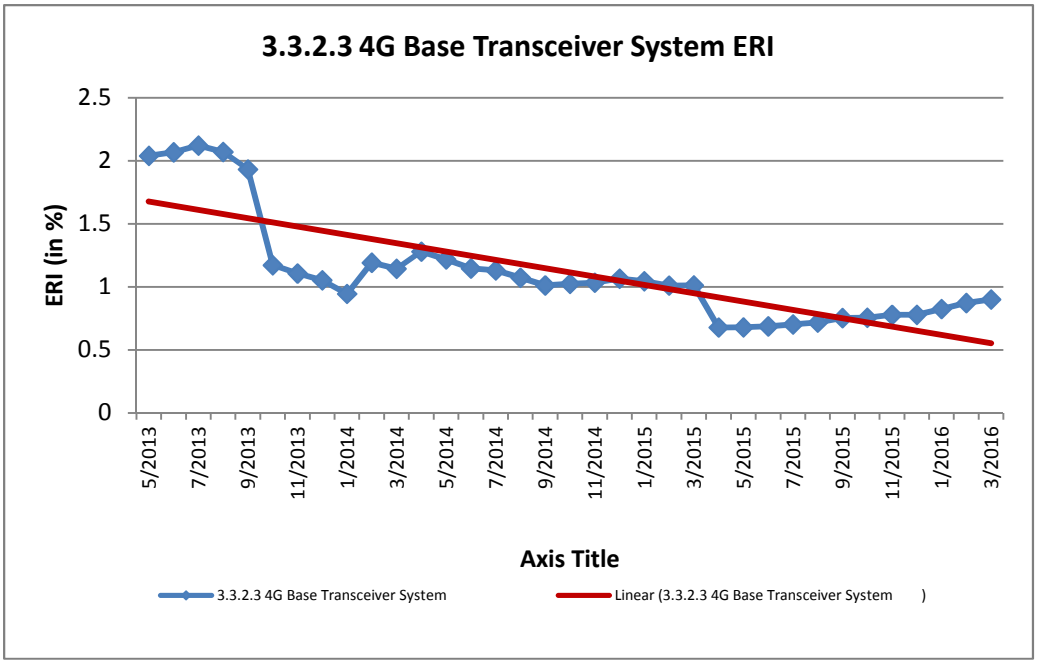
## Appendix - ERI, YRR, LTR Industry Averages and Trend Lines

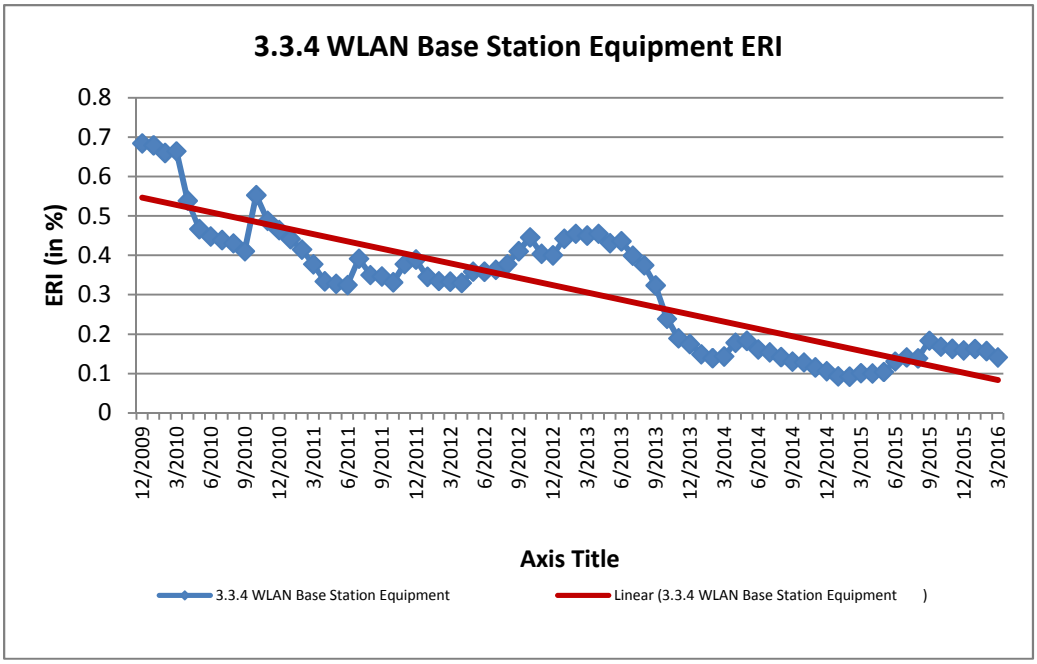
### ERI Improvement Trends



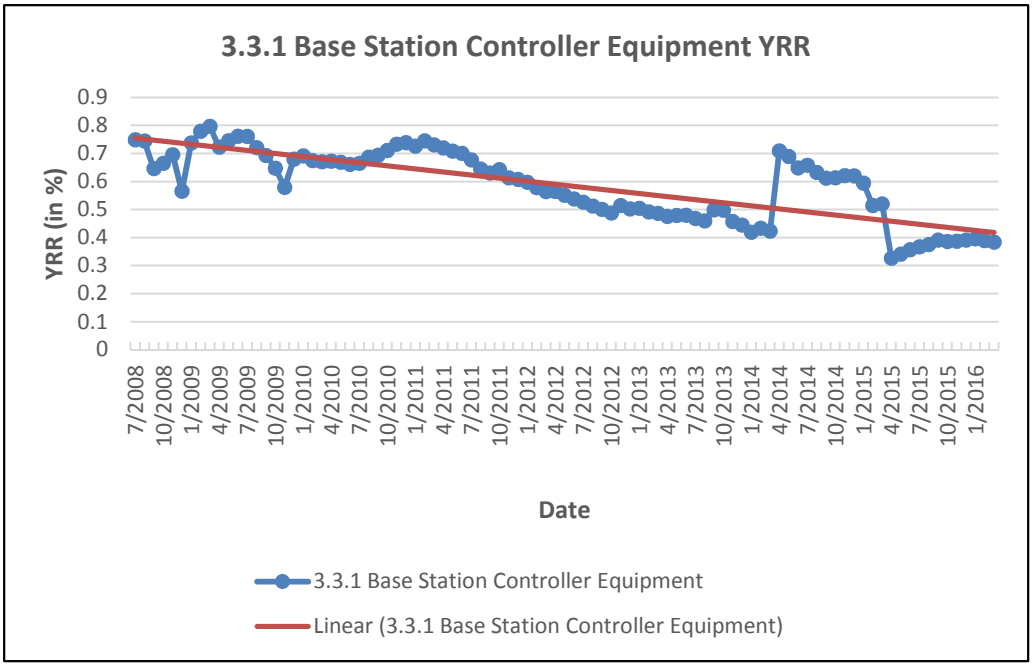



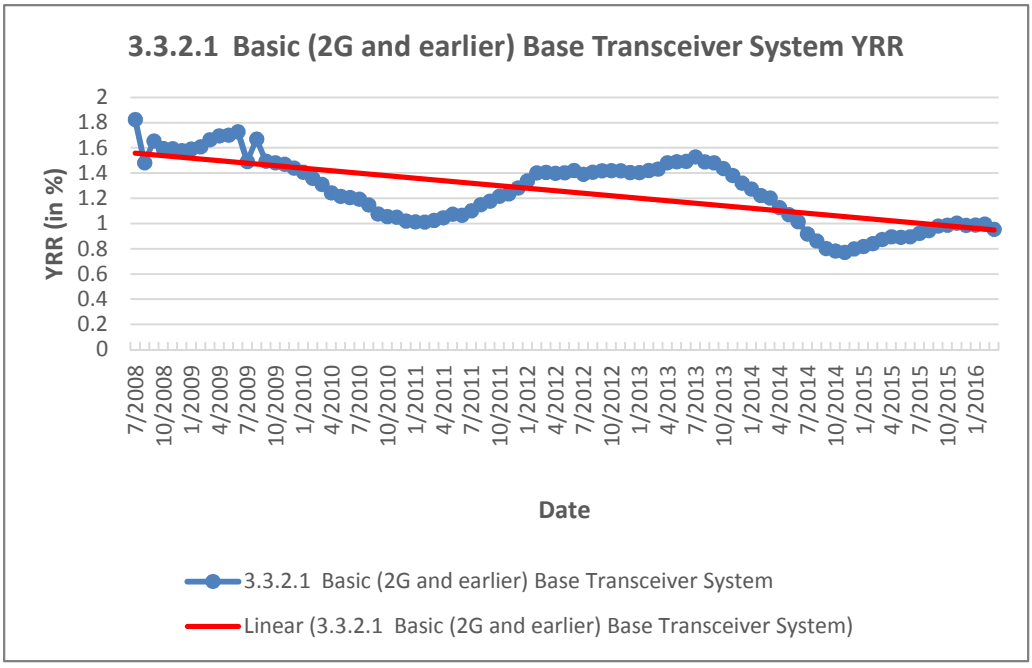

3.3.2.2 Advanced Base Transceiver System ERI
ERI (in %)
3.5
3
2.5
2
1.5
1
0.5
0
7/2008
10/2008
1/2009
4/2009
7/2009
10/2009
1/2010
4/2010
7/2010
10/2010
1/2011
4/2011
7/2011
10/2011
1/2012
4/2012
7/2012
10/2012
1/2013
4/2013
7/2013
10/2013
1/2014
4/2014
7/2014
10/2014
1/2015
4/2015
7/2015
10/2015
1/2016
Axis Title
3.3.2.2 Advanced Base Transceiver System
Linear (3.3.2.2 Advanced Base Transceiver System )


3.3.2.3 4G Base Transceiver System ERI
ERI (in %)
2.5
2
1.5
1
0.5
0
5/2013
7/2013
9/2013
11/2013
1/2014
3/2014
5/2014
7/2014
9/2014
11/2014
1/2015
3/2015
5/2015
7/2015
9/2015
11/2015
1/2016
3/2016
Axis Title
3.3.2.3 4G Base Transceiver System
Linear (3.3.2.3 4G Base Transceiver System )




**YRR Improvement Trends**




3.3.2.1 Basic (2G and earlier) Base Transceiver System YRR
YRR (in %)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
7/2008
10/2008
1/2009
4/2009
7/2009
10/2009
1/2010
4/2010
7/2010
10/2010
1/2011
4/2011
7/2011
10/2011
1/2012
4/2012
7/2012
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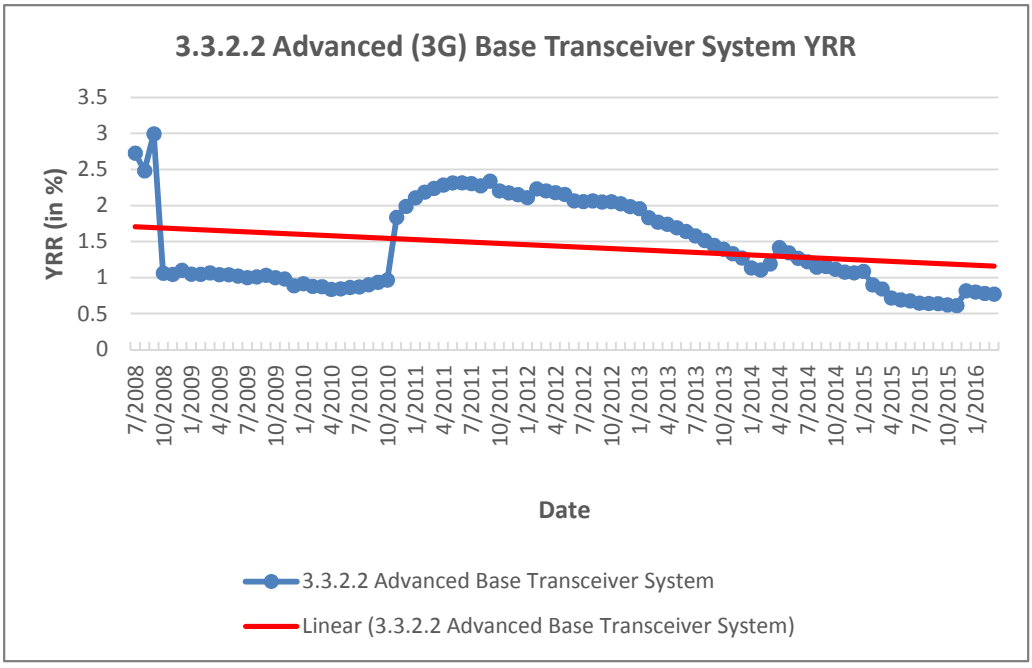
10/2013
1/2014
4/2014
7/2014
10/2014
1/2015
4/2015
7/2015
10/2015
1/2016
Date
3.3.2.1 Basic (2G and earlier) Base Transceiver System
Linear (3.3.2.1 Basic (2G and earlier) Base Transceiver System)


3.3.2.2 Advanced (3G) Base Transceiver System YRR
YRR (in %)
3.5
3
2.5
2
1.5
1
0.5
0
7/2008
10/2008
1/2009
4/2009
7/2009
10/2009
1/2010
4/2010
7/2010
10/2010
1/2011
4/2011
7/2011
10/2011
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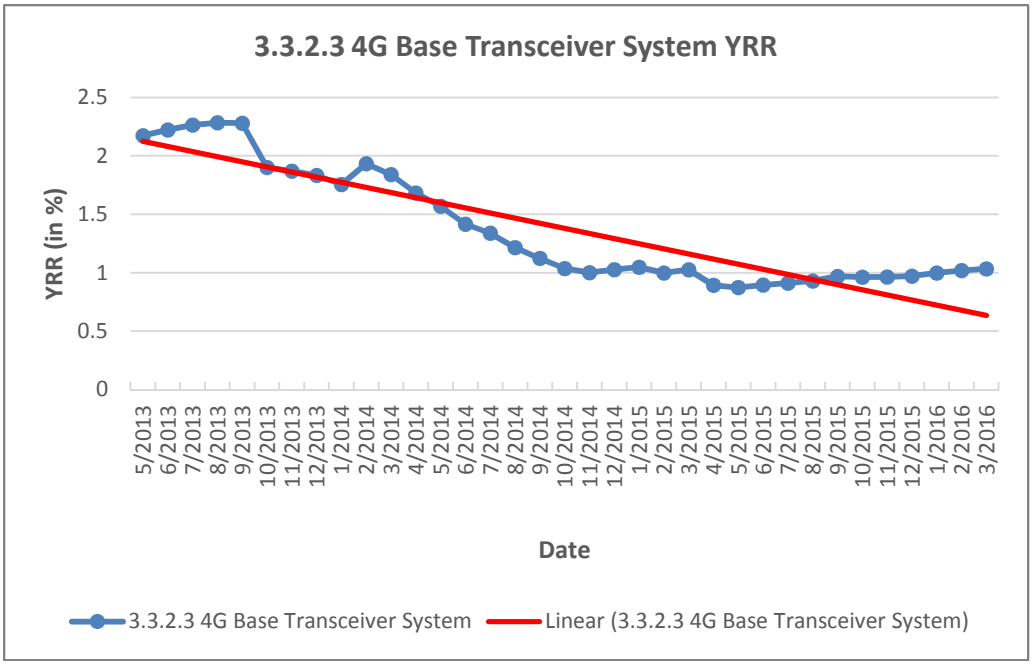
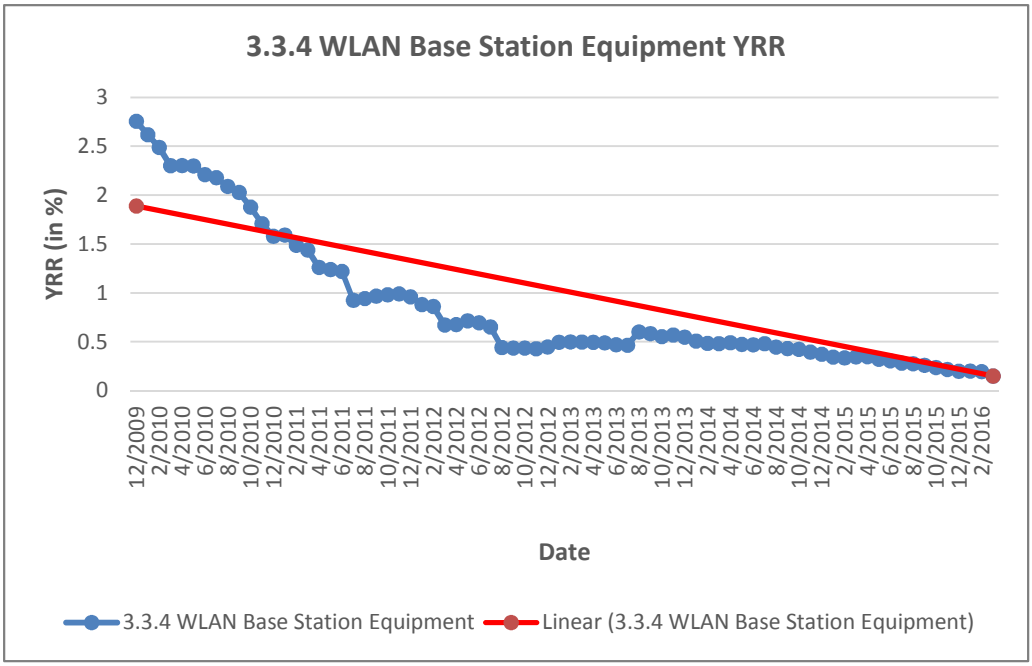
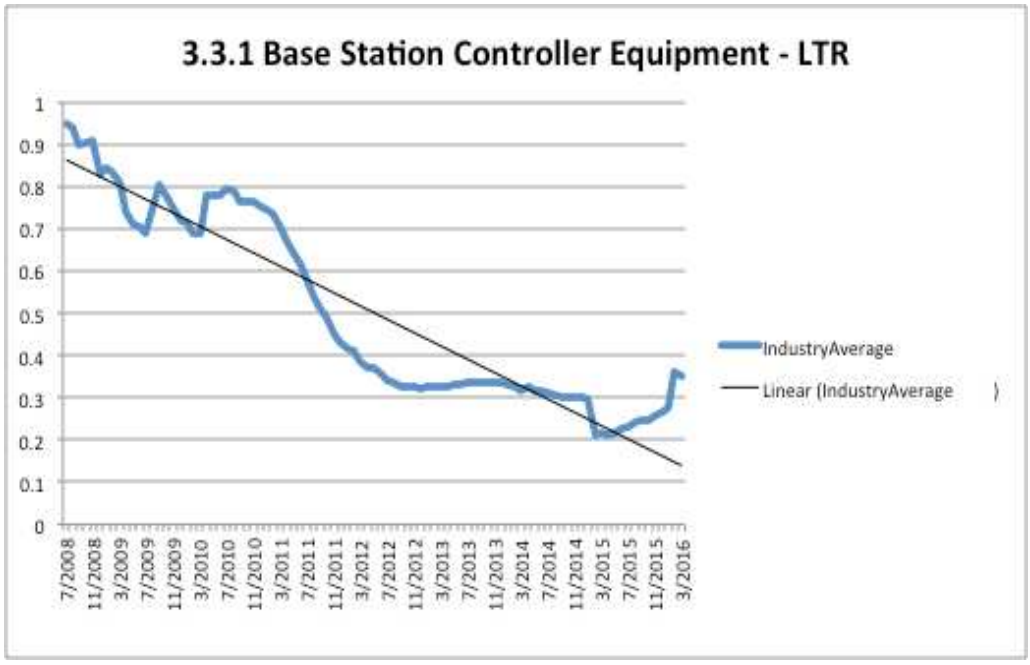
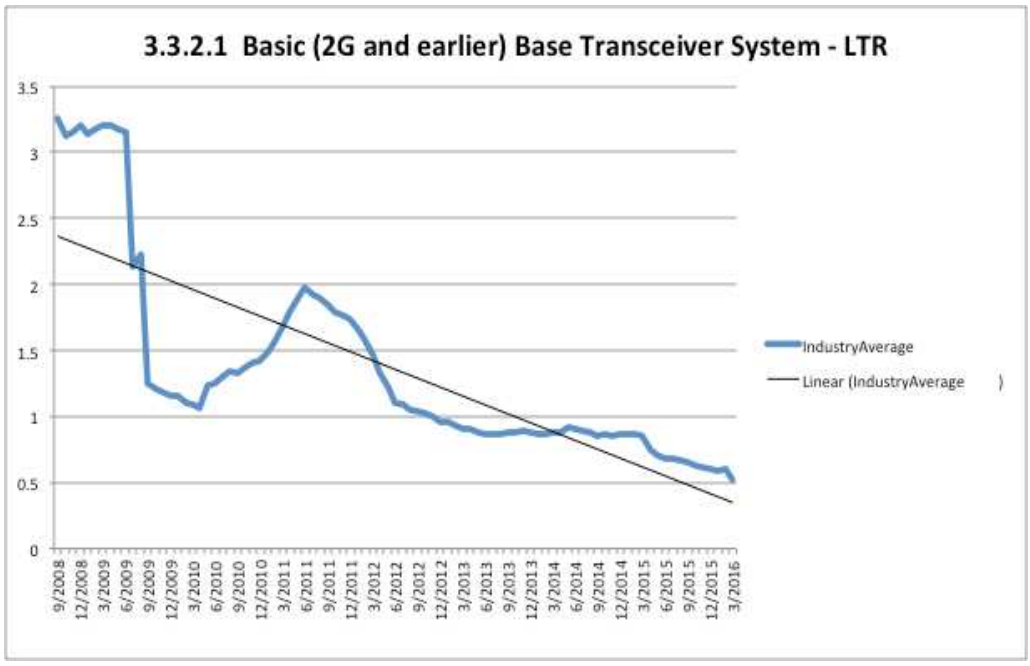
1/2016
Date
3.3.2.2 Advanced Base Transceiver System
Linear (3.3.2.2 Advanced Base Transceiver System)

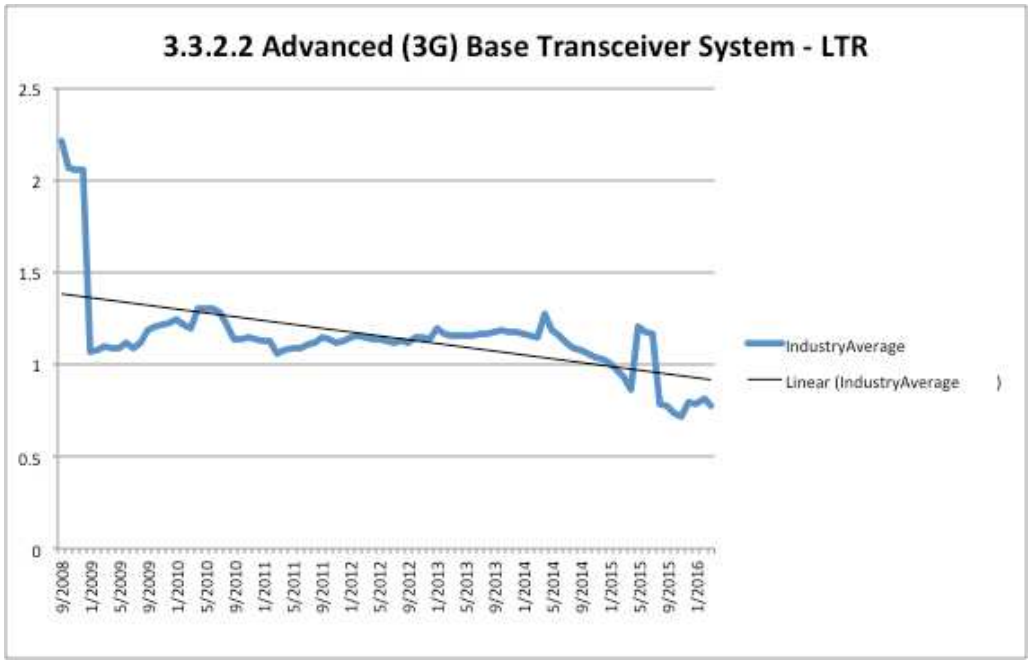

3.3.2.3 4G Base Transceiver System YRR
YRR (in %)
2.5
2
1.5
1
0.5
0
5/2013
6/2013
7/2013
8/2013
9/2013
10/2013
11/2013
12/2013
1/2014
2/2014
3/2014
4/2014
5/2014
6/2014
7/2014
8/2014
9/2014
10/2014
11/2014
12/2014
1/2015
2/2015
3/2015
4/2015
5/2015
6/2015
7/2015
8/2015
9/2015
10/2015
11/2015
12/2015
1/2016
2/2016
3/2016
Date
3.3.2.3 4G Base Transceiver System
Linear (3.3.2.3 4G Base Transceiver System)

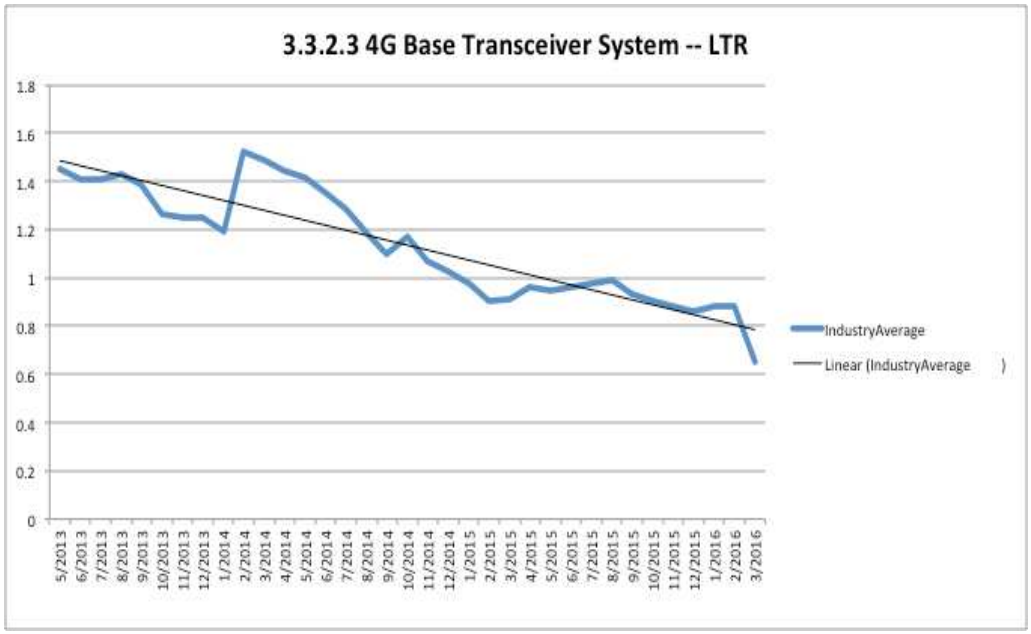

3.3.4 WLAN Base Station Equipment YRR
YRR (in %)
3
2.5
2
1.5
1
0.5
0
12/2009
2/2010
4/2010
6/2010
8/2010
10/2010
12/2010
2/2011
4/2011
6/2011
8/2011
10/2011
12/2011
2/2012
4/2012
6/2012
8/2012
10/2012
12/2012
2/2013
4/2013
6/2013
8/2013
10/2013
12/2013
2/2014
4/2014
6/2014
8/2014
10/2014
12/2014
2/2015
4/2015
6/2015
8/2015
10/2015
12/2015
2/2016
Date
3.3.4 WLAN Base Station Equipment
Linear (3.3.4 WLAN Base Station Equipment)

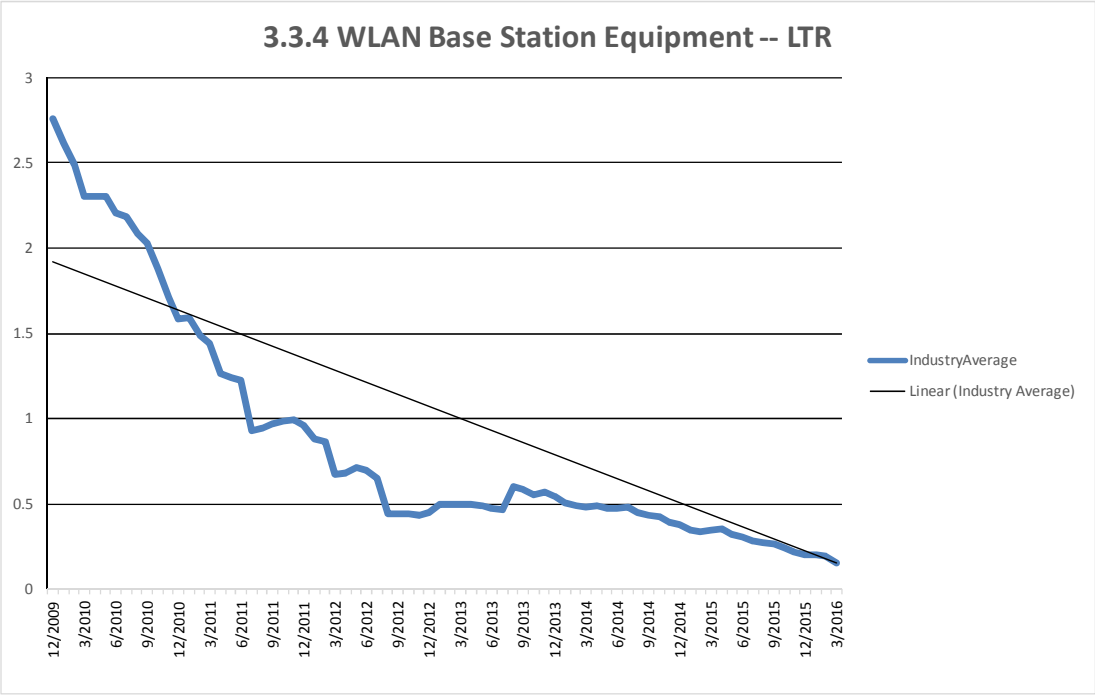
**LTR Improvement Trends**




3.3.2.2 Advanced (3G) Base Transceiver System - LTR
2.5
2
1.5
1
0.5
0
9/2008
1/2009
5/2009
9/2009
1/2010
5/2010
9/2010
1/2011
5/2011
9/2011
1/2012
5/2012
9/2012
1/2013
5/2013
9/2013
1/2014
5/2014
9/2014
1/2015
5/2015
9/2015
1/2016
IndustryAverage
Linear (IndustryAverage )


3.3.2.3 4G Base Transceiver System -- LTR
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
5/2013
6/2013
7/2013
8/2013
9/2013
10/2013
11/2013
12/2013
1/2014
2/2014
3/2014
4/2014
5/2014
6/2014
7/2014
8/2014
9/2014
10/2014
11/2014
12/2014
1/2015
2/2015
3/2015
4/2015
5/2015
6/2015
7/2015
8/2015
9/2015
10/2015
11/2015
12/2015
1/2016
2/2016
3/2016
IndustryAverage
Linear (IndustryAverage )


3.3.4 WLAN Base Station Equipment -- LTR
3
2.5
2
1.5
1
0.5
0
12/2009
3/2010
6/2010
9/2010
12/2010
3/2011
6/2011
9/2011
12/2011
3/2012
6/2012
9/2012
12/2012
3/2013
6/2013
9/2013
12/2013
3/2014
6/2014
9/2014
12/2014
3/2015
6/2015
9/2015
12/2015
3/2016
IndustryAverage
Linear (Industry Average)