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# THE ESSENTIALS OF INTELLECTUAL PROPERTY, PART TWO

**Quantifying technology leadership in  
the development of the LTE standard  
through June 2014**

November 2014

*Prepared by  
Signals Research Group*

The logo for Signals Research Group features the word "SiGNALS" in a bold, black, sans-serif font. Above the "i" in "SiGNALS" are three curved lines representing a signal or Wi-Fi symbol. Below "SiGNALS" is the text "Research Group" in a smaller, orange, sans-serif font.

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*Study supported by Ericsson*

On behalf of Ericsson, Signals Research Group conducted an analysis of LTE related submissions that companies have made to the 3GPP standards body. Through this effort we were able to identify the companies who were primarily responsible for developing the LTE standard, based on the number of technical submissions that they made which were approved by their peers. It is our assumption that there is a relationship between a company's success in this endeavor and its essential patent portfolio. This study provides updated results to a similar study that we conducted in 2010. We have updated it to reflect all of the work that has taken place within 3GPP through June 2014.

As the sole authors of this paper, we stand fully behind the analyses and opinions that are presented in this paper. In addition to providing consulting services on wireless-related topics, including performance benchmark studies and network economic modeling, Signals Research Group is the publisher of the *Signals Ahead* research newsletter ([www.signalsresearch.com](http://www.signalsresearch.com)).

## 1.0 Executive Summary

In this whitepaper, we provide updated results to a study that we first published in 2010.<sup>1</sup> In that whitepaper we presented results from a study of 3GPP submissions to determine the companies that were primarily responsible for developing the initial release of LTE. The underlying assumption for that study and for this most recent study is that the companies demonstrating technology leadership, as determined by being actively involved in the standardization process and getting their submissions approved by their peers, are also the companies with more essential intellectual property (IP) that applies to the LTE standard.

Future LTE releases fully encompass all aspects of the original LTE standard in order to maintain backwards compatibility.

Since we published the first whitepaper, LTE has evolved to include new functionality and enhancements. 3GPP introduces new functionality and features through *Releases*. For example, *Release 8* introduced the original LTE standard and *Release 10* includes support for Carrier Aggregation, which allows operators to logically combine two different LTE radio channels to create a wider [logical] channel which supports much higher data rates. Each subsequent release fully encompasses all aspects of the original LTE standard in order to maintain backwards compatibility. Within the 3GPP standards body, work on *Release 11* is completed and *Release 12* should be completed in March 2015.

LTE adopts basic cellular network concepts that first originated with 2G and 3G technologies.

Similarly, LTE adopts many basic cellular network concepts that first originated with 2G and 3G technologies, suggesting that companies that played a key role in standardizing GSM and UMTS/HSPA+ indirectly supported the creation of the LTE standard.

Based on a review of 261,302 submissions to the 3GPP standards body, including 118,497 submissions that pertain specifically to LTE access network, we can make the following observations.

### **Ericsson was the single largest contributor of approved LTE submissions through June 2014.**

We analyzed the contributions to the five Working Groups within 3GPP that are responsible for defining a large portion of the LTE standard, not to mention the 3GPP Working Groups that are most likely to incorporate essential patents that companies in the wireless industry, such as mobile device manufacturers, will need to license. Using an objective methodology, which we describe later in this whitepaper, we identified those submissions that pertained to LTE and which were ultimately approved during the standardization process. Including unapproved submissions would reward companies for making submissions that have no bearing on the final LTE standard as it exists today.

Based on this methodology, Ericsson had the most approved submissions between 2007 and June 2014 corresponding to the period during which LTE Release 8 was published through much of the standardization work on Release 12. This result is consistent with our earlier study which focused exclusively on the 2007-2008 time period when the majority of work on LTE Release 8 was conducted.

The technology leadership associated with defining the LTE standards has largely been determined.

**Since Release 8 is the cornerstone of LTE – all future releases fully encompass it – there were far fewer approved submissions in the subsequent releases, to date.** Separate from the contributions of each individual company, we analyzed the total number of approved submissions in each release and compared it with the number of approved submissions in Release 8. LTE Release 8 introduced a fundamentally new air interface and network architecture compared with UMTS/HSPA+ so there were a substantial number of approved submissions, or 5,957 approved submissions. Conversely, subsequent releases only introduced incremental changes to Release 8.

<sup>1</sup> A copy of the 2010 study is available on the Ericsson website or it can be obtained by contacting Signals Research Group.

Therefore, the number of Release 10 (a.k.a. LTE Advanced) approved submissions was approximately forty percent (42.2%) of the number of Release 8 approved submissions. This finding indicates that the technology leadership associated with defining the LTE standard has largely been determined.

All essential patents from LTE Release 8 are just as relevant today as they were when the Release 8 standard was first published.

**The importance and need for LTE Release 8 technical specifications continues with future releases.** As a corollary to the previous observation, the technical specifications defined in LTE Release 8 are still valid and they have material relevancy for any foreseeable releases that will follow it. All subsequent releases build upon the LTE Release 8 standard; they do not replace it. This observation indicates that the earlier approved submissions and all essential patents from LTE Release 8 are just as relevant today or with the eventual standardization of Release 12 functionality as they were when the Release 8 standard was first published. Multi-mode devices (i.e., LTE + 3G) will also require 3G, indicating that those companies who exhibited technology leadership during the development of 3G are still well positioned to benefit. These companies are also well positioned to benefit with single-mode LTE devices since LTE leverages several basic cellular network concepts that existed prior to LTE standardization work.

## 2.0 Quantifying LTE Technology Leadership

It is extremely difficult to determine the essentiality of a patent and to quantify the value of a company's essential patent portfolio. The task is daunting because it requires an in-depth knowledge of every company's patent portfolio, including those unpublished patent submissions that may not be in the public domain, not to mention the need for expert knowledge of the LTE standard and the legal process. In fact, we doubt that even the licensing experts within the pertinent 3GPP member companies have a complete understanding of the relative strength of their patent portfolio until after they have completed several rounds of negotiations with companies that are interested in licensing and cross-licensing some or all of their patents.

Thousands of great ideas pertaining to cellular technologies get patented, but very few of them end up being truly essential to the implementation of LTE.

Over the last decade there have been numerous attempts to quantify the ownership of essential patents, but as we discussed in the first whitepaper, these studies have several inherent flaws. Put simply, the methodologies used in these studies do result in quantifiable results; it is just that the results do not provide any real information. In summary, the methodologies leverage self-reporting from participating companies or they include patents that have no real relevance to the LTE standard. A sports team that claims to be "Number 1" doesn't make it Number 1, just as a patent that incorporates words or descriptions of features that are associated with LTE, doesn't mean that the patent is applicable to the published LTE standard, let alone an essential patent. Given that companies "know the system," it is relatively easy for them to drop a few keywords into their patent filings or otherwise make claims that they have X number of essential patents in order to advance their cause. Thousands of great ideas pertaining to cellular technologies get patented, but very few of them end up being truly essential to the implementation of LTE.

Our approach conveniently sidesteps the difficulties associated with the analysis of essentiality.

Our approach conveniently sidesteps the difficulties associated with the analysis of essentiality. Although we consider ourselves to be fairly knowledgeable about the technical aspects of LTE, we are by no means anywhere close to knowing all that needs to be known. For every technical feature associated with LTE there are likely dozens of published patents and perhaps numerous patent filings that have yet to reach the public domain. Without a thorough analysis of all patents/patent filings it would be impossible to determine the patents that are essential.

We can, however, track the development of the LTE standard and readily identify the companies that were responsible along the way for successfully contributing concepts and ideas that were eventually incorporated into the standard. After all, this information is publicly available on the 3GPP website and it isn't contentious. Each submission that we reviewed clearly identifies the company or companies who made the submission. Further, the status of the submission and whether or not it was approved is contained in meeting notes that the 3GPP member companies have already accepted.

Companies who make technical submissions in these standards meetings do so with the belief that the acceptance of their submission is in their best interest.

Our assumption in taking this approach is that companies who make technical submissions in these standards meetings do so with the belief that the acceptance of their submission is in their best interest; for example, if they have already filed a patent application for the idea. There is a tremendous amount of work associated with making a submission and backing up the claims of the submission with simulation studies and other approaches. It seems most logical that if a company goes to this amount of effort that it does so on the belief that it has already protected its interest in the idea and that it will benefit by making the new solution available to others via a licensing agreement using fair and reasonable terms. Additionally, by analyzing the technical leadership of companies involved in the 3GPP standardization process it is possible to identify discrepancies in which a company claims to own a large number of essential patents yet it did very little, if anything, to get its [potentially patented] ideas adopted into the standard.

LTE leverages basic concepts that have their origin in the 2G and 3G technologies that preceded it.

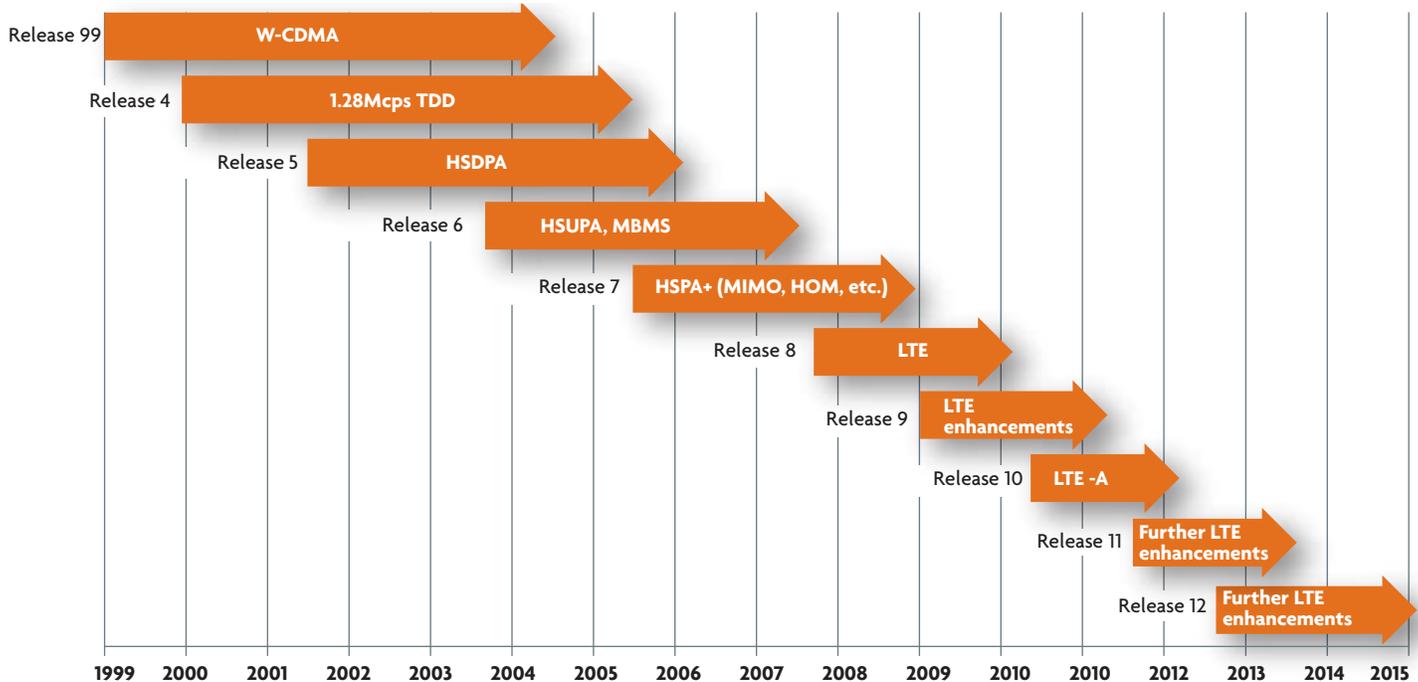
There are a few additional points worth mentioning. First, although LTE is a *new technology* it still leverages basic concepts that have their origin in the 2G and 3G technologies that preceded it. These basic concepts include, for example, the network *paging* the mobile device in order to find it and deliver a message/instruction, and the movement of a mobile device between adjacent cells (*cell handovers* or *cell selection*), based on the quality of the signal strength and other important parameters. In other words, some of the founding companies of the cellular age who were responsible for technology leadership during the 2G and 3G standardization process indirectly contributed to the LTE standardization process.

Somewhat related to the first observation, it is important to understand that LTE is based on a family of releases. Release 8, which was the focus of the initial study, first incorporated LTE into the 3GPP standard. However, LTE continues to evolve with new features and enhancements. These new features and enhancements are incorporated into the original LTE standard through a series of releases, as shown in Figure 1. LTE Release 10, for example, introduces Carrier Aggregation, which enables the logical combining of two radio channels in different frequency bands to create a wider [logical] radio channel that supports much higher data rates. As a side note, Release 10 also includes new features and enhancements to HSPA+ since the 3G standard continues to be of utmost importance to operators around the world.

The importance of Release 8 remains unchanged even as new features and enhancements are introduced in subsequent releases.

In all cases, the future releases of LTE are fully backwards compatible with LTE Release 8. In other words, the yet-to-be published Release 12 specification includes all technical features (i.e., patentable ideas) that were first introduced in Release 8. Further, since Release 8 is the cornerstone of LTE, the importance of the release remains unchanged even as new features and enhancements, which may never achieve commercial status, are introduced. This statement is also supported by the findings from our study. Specifically, we found there were far more submissions associated with Release 8 than with the releases that have followed it. This finding also suggests that the technology leadership for LTE has already been established, indicating that it will be very difficult for a company to meaningfully increase its relative contribution to the overall LTE standard.

**Figure 1. 3GPP Releases and Associated Functionalities**



Source: 3GPP Website (recreated by SRG)

There is currently work taking place in organizations, such as METIS (Mobile and wireless communications Enablers for the Twenty-twenty Information Society), “to generate a European consensus on the future mobile and wireless communications system.” In principle, the research taking place within these organizations and their member companies will result in the technology that follows LTE. When this technology migration eventually takes place sometime in the next decade it will create an entry point where a new technology leader could emerge. Then again, LTE will continue to play a very important role, just as 3G will continue to play a very important role as LTE becomes more mainstream. In this scenario, the technology leaders for LTE will still be major stakeholders even after this technology transition takes place.

Most LTE enabled devices will continue to include 2G and/or 3G functionality.

Lastly, in addition to LTE incorporating several 2G/3G concepts, and presumably 2G/3G essential patents, most LTE enabled devices will continue to include full support for 2G and/or 3G. This so-called multi-mode support will be critical to enable a seamless fallback to 2G/3G when LTE network coverage is inadequate and for roaming in markets where LTE has not been deployed in a suitable band. Keep in mind that while the industry has consolidated on a single LTE standard there will remain a high degree of device fragmentation due to the numerous frequency bands where it is deployed, combined with practical and technical limitations associated with a smartphone supporting every single band where LTE is deployed. Since GSM/HSPA+ has been deployed in a limited number of frequency bands, virtually all existing mobile devices operate in at least one GSM/HSPA+ frequency band in any market throughout the world. Further, since LTE incorporates numerous 2G/3G concepts, several 2G/3G patents will still have relevance with single-mode LTE devices. Therefore, the importance of essential 2G/3G patents will remain for the foreseeable future, even though a new cellular technology is being deployed.

## 2.1 Our Methodology

We reviewed 261,302 submissions made to the five 3GPP Working Groups that are primarily responsible for defining those aspects of the LTE standard that have a high impact on the mobile device. Further, for the follow-on study we wanted to be consistent with the previous study in terms of the Working Groups that we analyzed while we also recognized that the actions of the selected Working Groups are patent intensive, in particular relative to the other 3GPP Working Groups. For example, a Working Group, such as RAN WG5 (Mobile Terminal Conformance Testing), plays an important role in the standardization process, but it is unlikely that the specifications made by this Working Group incorporate essential patents. Table 1 identifies the five working groups that we included in the study along with associated time periods for each group.

**Table 1. Scope of 3GPP Submission Study (2005 – June 2014)**

Working Group	Areas of Responsibility
CT1	Responsible for the specifications that define the user equipment – core network Layer 3 radio protocols and the core network side of the lu reference point
RN1	Responsible for the specification of the physical layer of the radio interface for UE, UTRAN, Evolved UTRAN, and beyond; covering both FDD and TDD modes of the radio interface
RN2	Responsible for the specifications that define the radio interface architecture and protocols, the radio resource control protocols, the strategies of radio resource management and the services provided by the physical layer to the upper layers
SA2	Defines the main functions and entities of the network, how these entities are linked to each other and the information they exchange
SA3	Responsible for security and privacy requirements, and specifying the security architectures and protocols

Source: Signals Research Group

We used an automated approach to objectively identify the LTE submissions and to appropriately attribute the submission to the correct company(s).

When we did the first study in 2010 our role was to independently audit and validate the original work done by Ericsson. Nonetheless, with more than 42,000 submissions requiring our attention it still took us a couple of man months to complete. Given that the scope of this recent study was nearly four times the size of the original study and that we would be doing all of the work from scratch, we needed a more automated methodology to make the task manageable. Further, we recognized that an automated approach is based on entirely objective criteria and that we could customize the algorithms in order to analyze the information in a different manner.

For purposes of this study we only counted the approved submissions.

The objective criteria that we used focused on a list of keywords and phrases that are normally associated with LTE. We also used keywords and the timing of when the meetings occurred to categorize the submissions by release number. We knew, for example, that most of the work pertaining to Release 10 occurred in late 2010 and 2011, so we took that information into consideration along with other criteria, such as the appearance of a keyword or phrase in the reviewed document that implied a Release 10 feature, to classify the document as a Release 10 submission. In many cases, the submission documents, such as Change Requests, are directly tied to a particular release since the pertinent release is clearly identified in the header of the document.

We used Excel VBA to develop a proprietary means of automatically reviewing each document. The program leveraged Microsoft APIs for Word, Excel and PowerPoint. Since many of the submissions were in Adobe PDF format, we had to convert those PDF documents to a text document to analyze their contents. In essence, the program searched each document for the keywords, kept track of which keywords appeared in the document and how many times the keywords appeared, documented the source of the submission, and the status of the submission. We also avoided double-counting a submission by tracking whether or not the document was revised, and ultimately only counting the final revision. For purposes of this study we only counted the approved submissions since including non-approved submissions could inadvertently reward a company for making numerous poor submissions that lacked technical merit and which were ultimately rejected by its peers.

Using our criteria, we categorized all 3GPP submissions according to their association with the LTE standard and their status.

Using our criteria, including a list of keywords, we categorized all 3GPP submissions according to their association with the LTE standard and their status. In many cases the appearance of a keyword in a document allowed us to determine that the document pertained to LTE. Certain keywords, the clear identification of the Release in the header field, and/or the submission date of the document allowed us to match the submission document with the appropriate Release. As shown in the next section, there was a very small number of LTE-related documents that we couldn't associate with a specific Release so we labeled them as *Other*.

Our category counting methodology was done in a particular order to ensure that each document was correctly categorized and that we did not include submissions which should not be included in the analysis. For example, if a document was categorized as being Administrative or Withdrawn then it would not appear in our final count, even if the document pertained to LTE.

We used the *Source* field to identify the company or companies responsible for making the submission.

Finally, we used the *Source* field to identify the company or companies responsible for making the submission. In the event that multiple companies submitted the document we gave each company partial credit. For example, if a single company was responsible for a submission then it received a credit of 1 submission in the count tally. If two companies were responsible for a submission then each company received a credit of 0.5 for the submission.

This approach is the most fair and unbiased method that we identified, however, it isn't perfect. For example, it tends to reward companies who merely provided their support for a submission without originating the idea or conducting all of the technical analysis and simulation studies

that are required with the submission. Conversely, companies frequently seek out co-sponsors for their submissions in order to garner enough initial support to get their submission approved. Since we did not attend any of the pertinent 3GPP meetings, it is impossible for us to distinguish between the originator of the submission and its co-sponsors. As a result, our methodology tends to give undue credit to followers at the expense of the 3GPP technology leaders.

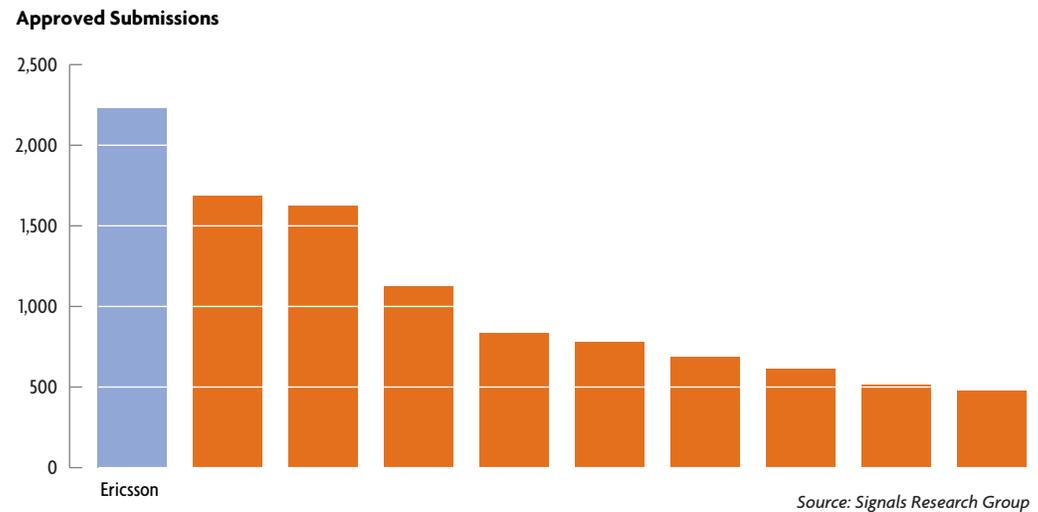
Before moving forward with the actual analysis we spent considerable time and effort to validate that our new approach was producing accurate results. We accomplished this task by running the automated process for the time period covered by the original study and then comparing the results between the automated method and the results that we published in 2010. As presented in the next section, our new automated methodology was able to nearly replicate the original results with a fairly high degree of accuracy.

**2.2 Results and Analysis**

Ericsson was responsible for the most approved submissions during the LTE standardization process through June 2014.

In total, we reviewed 261,302 submissions of which 118,497 submissions pertained to LTE access network. For purposes of this study, we did not include submissions from the five aforementioned working groups that dealt with ancillary components and features associated with LTE – an example is policy control and charging. We also excluded many documents that dealt with IMS unless the document also included a sufficient amount of keywords to also classify it as an LTE radio access document. Worth noting, Ericsson would have still been the top contributor if we had included these documents in the analysis.

**Figure 2. 3GPP Approved Submissions for LTE Release 8 through Release 12 – by company (2007-June 2014)**



Ericsson was responsible for the most approved submissions during the LTE standardization process through June 2014.

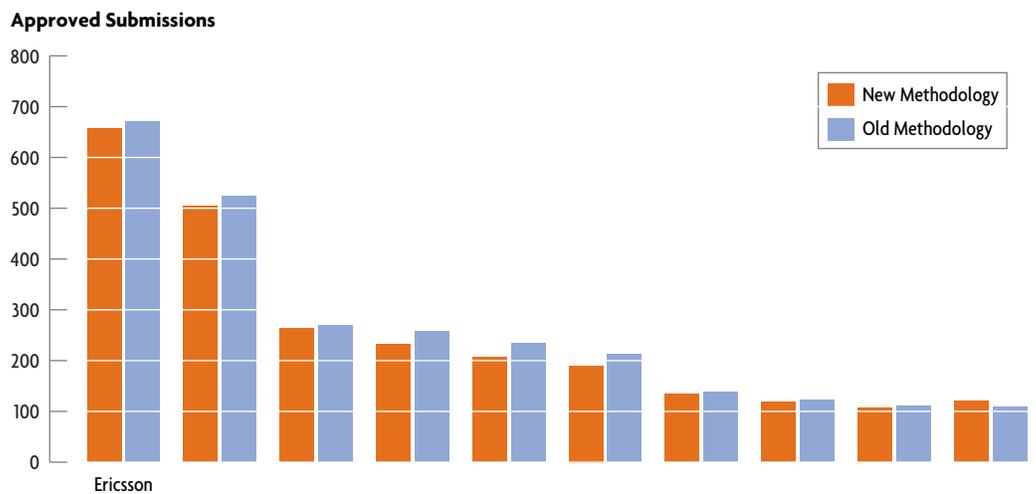
Of the LTE submissions, far fewer than 20% of the submissions were actually approved. As shown in Figure 2, Ericsson was responsible for the most approved submissions during the LTE standardization process from Release 8 through the work that has taken place on Release 12 through June 2014. 3GPP has not yet published the Release 12 specifications but it is our understanding that the standards body will complete the Release in March 2015. In our earlier study, Ericsson was also the leading contributor of approved submissions when LTE Release 8 was being standardized.

We were able to validate our new methodology by replicating the results from the previous study.

As previously indicated, we spent a considerable amount of time validating and fine-tuning our new methodology so that it produced accurate results. As a litmus test, we applied our new methodology to the same time period covered by the previous study and then compared the new results with the results published in the first study. This information is shown in Figure 3. It should be pointed out that the number of approved submissions shown in the figure only applies to LTE Release 8, and only to the time period covered by the first study. Since a number of approved LTE Release 8 submissions have occurred after 2008, the actual number of approved LTE Release 8 submissions is higher than the number we obtained in the original study. The updated results for LTE Release 8 submissions are provided later in this section.

In a few cases there are some slight discrepancies between the two sets of results. In some cases, we intentionally excluded some approved submissions during the last study since at the time the submission dealt with a feature that at the time wasn't being considered for Release 8. In a few other cases we believe that our most recent set of results is more accurate since we believe that a few unintentional mistakes were made in how a few submissions were categorized. In any event, the discrepancies that still exist are largely rounding errors in the big scheme of things and they do not detract from the main findings of this study.

**Figure 3. Validating our Methodology – old study versus new study (2007-2008)**



Source: Signals Research Group

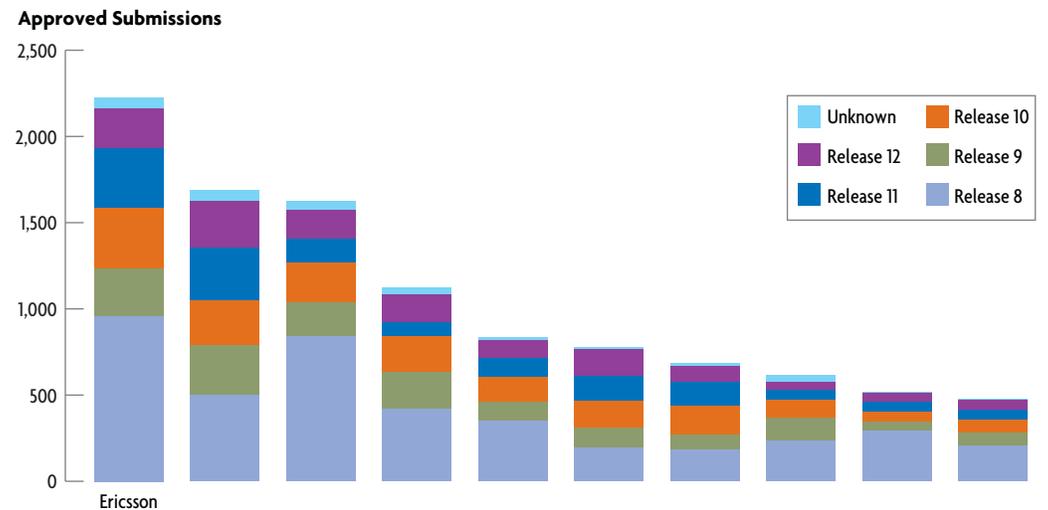
In the original study, we identified the top 10 3GPP contributors, other than Ericsson, in a numerical manner (e.g., Company 2, Company 3, etc.). However, since the ranking of some of the unidentified companies has changed with the inclusion of the later releases, we have decided to remove the labels in order to avoid any confusion. It is also worth pointing out that the start point in the original study was 2007, when the Release 8 activities started in earnest, but in this updated study we started the study in 2005.

Figure 4 provides the same results that we provided in Figure 2, but we have also categorized the submissions based on the appropriate Release number for each submission. Figure 5 slices the information in Figure 4 slightly differently. Instead of showing the results by company, the figure shows the number of approved submissions by Release number without any consideration for the company or companies that made the submission. We are showing these figures since they help illustrate some misconceptions in the industry regarding the relationship between LTE and the

releases that have followed it. Specifically, it is very evident in the two figures that LTE Release 8 represents the cornerstone of LTE, based on the relatively large number of approved submissions associated with the release. Although subsequent releases do introduce important features and enhancements, they are incremental to the original LTE release.

Although it isn't evident in the figures, some of these new features and enhancements introduced in subsequent releases are unlikely to achieve widespread commercial status. Some operators will embrace a new feature/enhancement while other operators will not be interested in deploying it. All operators with LTE in their technology roadmap are inherently obligated to deploy LTE Release 8 functionality.

**Figure 4. 3GPP Approved Submissions for LTE Release 8 through Release 12 (June 2014) – by company and by release**



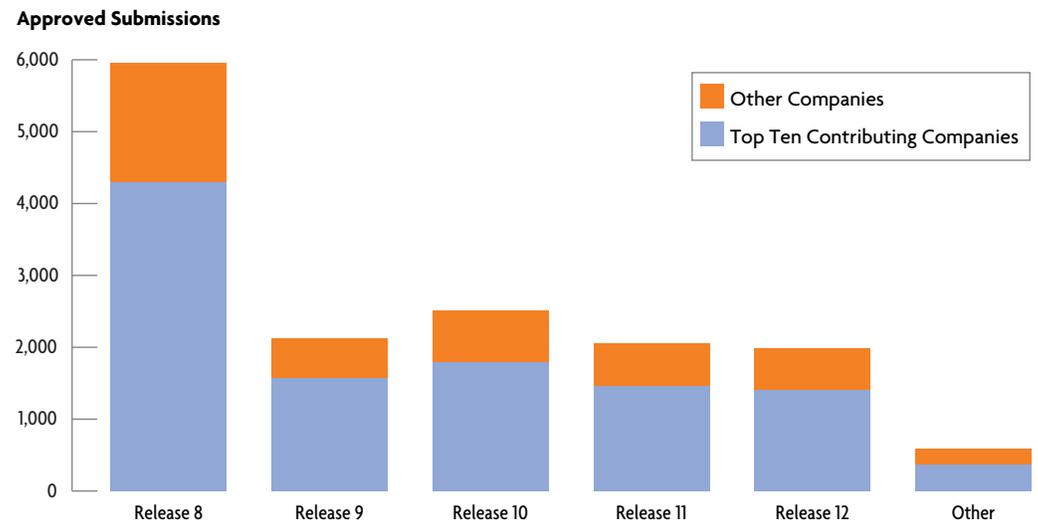
Source: Signals Research Group

LTE and LTE Advanced have a high degree of commonality with each other.

As implied by the information presented in Figure 5, LTE and LTE Advanced (Release 10) have a high degree of commonality, with Release 10 building on the foundation established by Release 8. This commonality is reflected in the relatively low number of approved submissions that were generated when the 3GPP standards body was developing Release 10. Conversely, when the 3GPP started its initial work on LTE in Release 8 there was a considerable number of approved submissions, largely because LTE is in many ways different than the pre-existing 3G standard. As previously discussed in this whitepaper, despite the differences between LTE and UMTS/HSPA+, there are still a large number of interdependencies between the two standards. Further, for the foreseeable future it is almost a certainty that mobile devices and multiple network infrastructure elements will support both standards. Therefore, the need for the underlying technologies defined by the essential 3G patents still exists. Quantifying the technology leadership that occurred when the UMTS/HSPA+ standard was developed falls outside the scope of this study.

Figure 5 includes a column that we have labeled *Other*. This column includes 589 submissions, which include some pre-Release 8 activities, some very preliminary work on Release 13, and some submissions that fell between the cracks, meaning that the objective criteria we used with our automated process could not readily identify the appropriate Release. Conceivably, we could have manually reviewed the submissions that fell between the cracks and applied subjective criteria to place them into one of the five releases. However, we felt it would be more credible and consistent with our objectives to leave them in the *Other* category. Further, this low number has no practical influence on the results while it also demonstrates that our automated process is capable of classifying and capturing almost all submissions of relevance.

**Figure 5. 3GPP Approved Submissions for LTE Release 8 through Release 12 – by release (2007 – June 2014)**



Source: Signals Research Group

All of the LTE Release 8 essential patents have as much relevancy with LTE Advanced as they do with LTE Release 8.

The focus of this whitepaper is not on the technical features of each release, but it is worth highlighting that LTE Release 8 and LTE Release 10 have a lot in common. For example, Carrier Aggregation, which is one of the features of Release 10, is fundamentally the logical combining of two discrete LTE Release 8 carriers. This situation indicates that all of the LTE Release 8 technical specifications (i.e., the Release 8 approved submissions and the implied essential patents) have as much relevancy with LTE Advanced as they do with LTE Release 8. There were definitely 3GPP submissions which proposed how to logically combine the two LTE Release 8 radio channels together and these submissions suggest the introduction of new essential patents. However, these patents will only apply to the subset of LTE devices that support the carrier aggregation feature. Conversely, all LTE Release 8 essential patents will apply to all LTE Advanced (Release 10) devices.

By most accounts, Carrier Aggregation is a key part of Release 10 and over an extended period of time there will likely be widespread adoption of the functionality across a large percentage of a handset manufacturer's LTE device portfolio. For other Release 10 features, such as relay nodes and more advanced implementations of MIMO (Multiple Input, Multiple Output) antenna schemes, the jury is still out. Although we are not suggesting that the approved submissions beyond Release 8 are of less importance or value, it is fair to state that in many cases the approved submissions post Release 8 may not apply to the universe of devices and deployed networks.

It will be difficult for the 3GPP member companies to have a material impact on their overall contribution to the LTE standard on a go-forward basis.

The other observation from these two figures is that it will be difficult for the 3GPP member companies to have a material impact on their overall contribution to the LTE standard on a go-forward basis. There were, for example, approximately forty percent (42.2%) the number of approved Release 10 submissions as there were approved Release 8 submissions. Even if a company was able to somehow dramatically increase its involvement in the standardization process by generating a vast number of technical submissions that its peers approved, it wouldn't have a meaningful impact on the company's overall contribution to the LTE standard. The train has left the station. One day in the next decade work may commence on the next G and at that point these companies will have their opportunity.

