GTI-GSMA CONSUMER ELECTRONICS WHITEPAPER

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Abstract

The purpose of this Whitepaper is to demonstrate the opportunity that the rollout of LTE networks provides the Consumer Electronics industry. The increased bandwidth that LTE offers the marketplace – and at improved networks economics – intersects with the growing consumer appetite for mobile access to data rich services, like multimedia streaming, video conferencing, and gaming. Consumers prefer the simplicity of embedded devices with built-in cellular modules. However, this paper will demonstrate several key requirements and considerations, in order to enable OEM and consumer mass-market adoption of embedded devices, including areas related to service pricing/bundles, module costs, network experience, and coverage footprint.

Given the experience of embedded laptops and tablets, this Whitepaper will primarily focus on these two device categories with some discussion on M2M. The Case Study on automotives, at the end of the Whitepaper, will highlight the opportunity for embedded LTE in emerging categories like the Connected Car.

Contents

1 Introduction

The Consumer Electronics marketplace is sizeable with over $1 trillion in global sales and encompassing 3.5-4 billion unit sales in 2012.[i] The convergence between consumer electronic devices and wireless connectivity has propelled innovation. Almost every major product category is finding an opportunity for an Internet-based offering, including cameras, alarm systems, automobiles, home appliances, glasses, watches, and televisions. We only have to look at the success of connected tablets to witness this dizzying pace of technological advancement. For example, tablets now serve as a broad platform for consumers to watch TV programs on Hulu; stream content on YouTube; video chat over Skype; access books with their Kindle application; game with others around the world; post real-time pictures via Twitter; and stay in touch with their social network over Facebook.

Consumers are increasingly looking for higher bandwidth access and a satisfactory network experience outside of typical “hot spot” areas. The development of 3G cellular USBs, and later MiFi devices, was an early step to provide ubiquitous wireless broadband access to consumers while they were on their laptops, tablets, and computing devices. Based on learnings from the WiFi connectivity experience –where embedded WiFi replaced attachment-based solutions – there was a growing trend to embed 3G modules into laptops and other consumer electronic devices. The idea was that customers wanted simplicity and to minimize the number of devices that they carried.

As we look at the opportunity that 4G LTE provides consumer electronics, with greater bandwidth and improved network economics, it is also important to learn from the experience of the embedded 3G model. While providing an “ease of use” solution for the mobile professional and high-end consumer, embedded 3G has not been able to effectively expand beyond these niche segments and penetrate the consumer mass-market. Consequently, if we use laptops as an indicator for success, 3G attachment rates could not move beyond 4%-5%. Several key factors that constrained the embedded 3G model include:

1) High module costs and service pricing
2) End-user experience
3) Differing 3G technologies

The rollout of 4G LTE networks provides the marketplace, in time, with the possibility to address these key limitations and to be an enabler of tremendous innovation. It should be stated that achieving the cost reduction in 4G modules, scale will need to be significantly increased relative to 3G. This can partly be achieved through innovative business models and consumer-friendly service plans/bundles.

LTE has become the standard migration path for most all 3G technologies -- UMTS/HSPA, CDMA 2000, and TD-SCDMA – and will bring to market download speeds 10x faster than 3G and at a 30%, or greater, cost advantage for service providers. The two branches of LTE – FDD and TDD – provide carriers the opportunity to deploy efficient and optimized solutions, based on spectrum designation and availability of contiguous spectrum.

In particular, TDD-LTE is a breakthrough for providing greater bandwidth to the global marketplace. For example, now countries like China, Japan, India, and the United States, where service providers have large amounts of contiguous spectrum in the 2.3GHz-2.6GHz frequency range, can deploy the more efficient TDD variation of LTE. The key benefits are that high population markets will have greater network throughput and at more advantageous network economics. The plans by Qualcomm, Intel, and other chipset providers to support both TDD and FDD LTE network technologies on a single chipset provide the consumer electronics ecosystem with one embedded solution, enabling OEMs to control inventory risk and minimize the number of SKUs.

In summary, increased bandwidth, improved network economics, a standard 4G technology path, and support by the leading chipset providers for FDD and TDD LTE provide the ecosystem with the opportunity to offer a better network experience, consumer friendly pricing, and lower-cost devices.

Recognizing the transformational impact that LTE offers the ecosystem, the Global TDD-LTE Initiative (GTI) and the Groupe Speciale Mobile Association (GSMA) have partnered together to support the progress of embedded consumer electronic devices. Through this Whitepaper, we hope to educate suppliers, OEMs, application developers, and service providers on the tremendous opportunity that LTE will have on driving innovation in a wide-array of device segments. We hope that this document will educate stakeholders on the opportunity and requirements for success.

In order to manage the scope of this Whitepaper and to lead a thoughtful discussion on the opportunity for embedded LTE, our primary focus will be on laptops and tablets. These two types of devices highlight consumer demand for mobility and high-bandwidth services. Additionally, the experience of embedded 3G in laptops and tablets provide meaningful learnings. Finally, in order to demonstrate emerging frontiers for embedded, we will conclude with a case study on M2M and the automotive industry.

(2) Consumer Electronics Device Market

The Consumer Electronics market achieved more than $1 trillion in sales, last year, representing 3.5-4 billion in unit sales. It is expected to grow by a further 10% in 2013 and hit $1.1 trillion. As a broad segment, Consumer Electronics include entertainment and communication devices. While the definition does vary, for the purposes of this paper, Consumer Electronic devices include navigation, DVD players, computers, tablets, MP3 players, smartphones, televisions, game consoles, stereos, and digital cameras to name a few.

Laptops & Tablets

Within the Consumer Electronics segment, PC sales comprise the largest category with an estimated 353 million global shipments in 2012. Laptops make up approximately 57% of PC shipments and its proportion is growing, partly driven by lower prices, more powerful processors, improved memory storage, and customer demand for mobility. While a very strong segment, PC sales have witnessed a 3.5% decline from 2011 and are expected to continue to be under pressure with the growth of tablets.

Since Apple released the iPad in April 2010, tablets have witnessed remarkable growth from 19.4 million shipments to an estimated 222.1 million units by 2016. The product category has been able to find an attractive product space, in between the smartphone and laptop device categories. Tablets run between 5” and 14”screen size, with the most popular form factors being 7” and 10”. Additionally, the light-weight OS, touchscreen capabilities, and plethora of optimized applications have distinguished tablets from smartphones and laptops.

Last year, tablet shipments hit approximately 107.4 million units, equating to approximately half of global laptop sales. While adversely impacting laptop sales, this trend does not mean the demise of laptops. Consumers are continuing to leverage laptops for productivity and content development. However, instead of multiple PCs in the home, tablets have started to cannibalize laptops as secondary devices.

In order to stem “commoditization” and declining sales, the laptop ecosystem has responded with a focus on “mobility”, improved innovations, and increased marketing support. Examples of this include Intel’s rollout of the Ultrabook platform and Microsoft’s release of Windows 8 in October 2012. Both initiatives demonstrate the importance of mobility and the push to move the laptop form factor and user experience to be closer to a tablet, while retaining the benefits of a larger screen and keyboard for productivity and content creation applications. With Windows 8, Microsoft shifted the OS user experience to be more like Android and the Apple iOS. A new touch interface, tile applications, Start screen, application platform, and support for ARM architecture are key features of its push towards driving a mobile and tablet experience.

In addition to improved form-factors and developing a tablet-like user experience, access to high-speed broadband networks will be critical to drive innovation and to further address laptop commoditization. Google’s Chromebook initiative – with its partners Samsung, Acer, and HP – places Chrome and cloud-based services at the center of Google’s strategy. As part of its value proposition, anywhere access to key Google services, like search, Gmail, Maps, Google Docs, and Picasa, is critical for broad adoption. Microsoft 365 is another example of the evolution of cloud computing.

As we will discuss in the following sections, the growth of cloud-based services, demand for multimedia applications, popularity of video conferencing, and adoption for online gaming are shaping innovations in laptops and tablets. The rollout of LTE networks offers OEMs the opportunity to deliver to consumers the required ubiquitous connectivity with higher bandwidth.

(3) Mobile Trends

The term “hypermobility” best characterizes the trends taking place in the consumer and enterprise markets. Customers are rapidly adopting mobile technologies and downloading applications that keep them connected anywhere, anytime. It is within this space that we are seeing the success of cloud-based services, enabling customers to store their data in the cloud. The cloud-based services witnessing the highest degree of demand include online email services, online gaming, video, streaming music, and data storage.

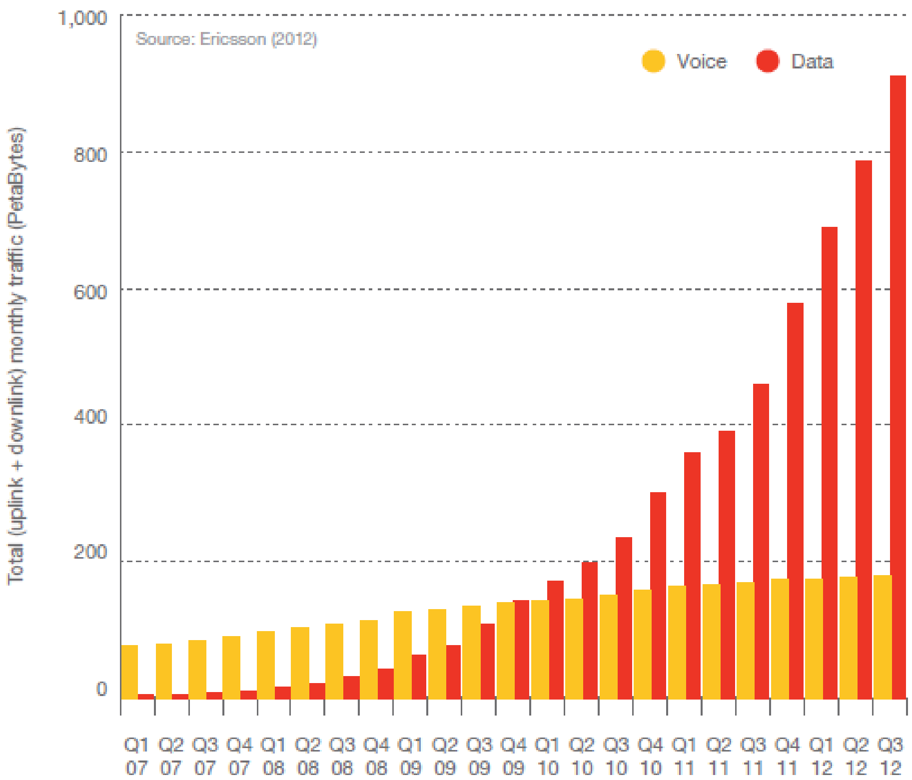


Figure 1: Global total traffic in mobile networks, 2007-2013
Source: Ericsson Mobility Report, November 2012

The impact that these services are having on global networks is staggering. Figure 1 demonstrates the stable trend of voice traffic and the exponential growth of data. Between Q3 2011 and Q3 2012 data traffic doubled to over 900 petabytes per month.

Based on an Ericsson survey, mobile video accounts for 20%-40% of the traffic going over embedded laptops, tablets, and smartphones. Figure 2 highlights other bandwidth intensive applications that are driving global data demand.

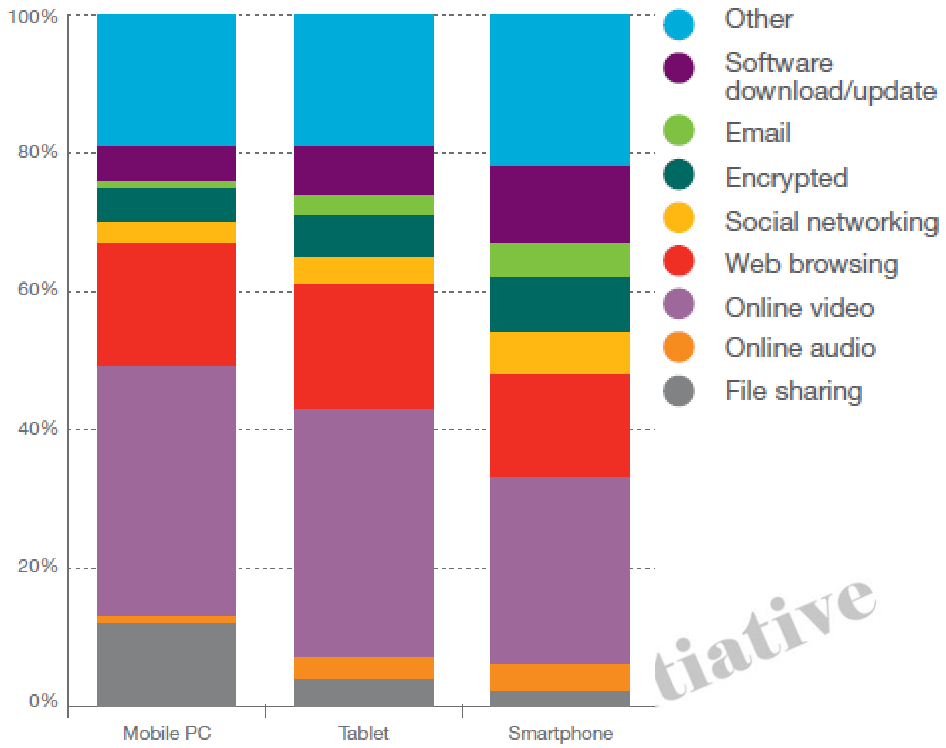


Figure 2: Application mobile data traffic by device type (HSPA & LTE networks in Asia, Europe, and Americas)

Source: Ericsson Mobility Report, November 2012

The Ericsson estimates are not surprising, and may appear conservative, when we reflect on Google's March 2013 announcement that YouTube achieved a billion unique visitors per month with a quarter of traffic coming from mobile devices.[ii]

(4) LTE Opportunity for Consumer Electronics

This convergence of powerful, mobile computing devices, consumer trends toward "hypermobility", and the rollout of 4G wireless networks offers OEMs and content providers a tremendous opportunity for innovation and differentiation.

Based on research, there is no doubt that there is appetite for Internet connectivity over consumer electronic devices. In particular tablets, laptops, and M2M are expected to see strong device and data traffic growth in the next five years. For example, between 2012 and 2017 the compounded average growth rates for data traffic on tablets, laptops, and M2M devices are expected to achieve 113%, 31%, and 89%, respectively.

	Growth in Devices 2012-2017 CAGR	Growth in Mobile Data Traffic 2012-2017 CAGR
Device Traffic		
Smartphone	20%	81%
Tablet	46%	113%
Laptop	11%	31%
M2M Module	36%	89%

Table 1 - Source: Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update (Feb. 2013)

To understand the importance of mobile connectivity, we only need to look at tablets and laptops which, in addition to smartphones, are the strongest indicators of convergence between devices, services, and network.

	2012	2017
Device Traffic (MBs per month)		
Non Smartphone	6.8	31
Smartphone	342	2,660
4G Smartphone	1,302	5,114
Tablet	820	5,387
Laptop	2,503	5,731
M2M	64	330

Table 2 - Source: Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update (Feb. 2013)

The average traffic for laptops and tablets is expected to grow from 2,503 MB/month and 820 MB/month, respectively, to 5,731 MB/month and 5,387 MB/month by 2017. Other estimates show an even more aggressive tonnage ramp-up for computing devices, like 10 GB/month for embedded laptops by the end of 2018.[iii]
As discussed earlier, tablets are expected to continue their spectacular growth trajectory and achieve 222.1 million shipments in 2016. This will have a significant impact on mobile tonnage, accounting for over 10% of mobile traffic in 2015. Cisco has concluded that “mobile-connected tablets will generate more traffic in 2017 than the entire global mobile network in 2012.” The amount of mobile data traffic generated by tablets in 2017 (1.3 exabytes per month) will be 1.5 times higher than the total amount of global mobile data traffic in 2012 (885 petabytes per month).

(4.1) 4G LTE Background

Long Term Evolution (LTE) is a standard for wireless communications of high-speed data for mobile devices. Widely known as “4G”, LTE has become the dominant upgrade path, globally, for different 3G radio technologies, including UMTS/HSPA, CDMA 2000, and TD-SCDMA, which makes it truly emerge as the first global mobile radio access standard.

Unlike the "evolution" from 2G to 3G, the emergence of LTE is more like a "revolution" compared to former generations of radio technologies, as it's an all-IP network. Since it is designed to significantly increase capacity and speed for wireless data services, LTE has several key performance achievements:

- Higher Throughput: Downlink peak rates exceed 100 Mbps and uplink peak rates exceed 50 Mbps with a scalable carrier bandwidth up to 20 MHz
- Lower Latency: Permitting a transfer latency at millisecond level, which can better support real-time services
- Improved Support for Mobility: Support for terminal moving at up to 350 km/hour or 500 km/hour, depending on frequency band
- Improved Network Economics: Due to improved spectrum efficiency and a simplified network architecture, Alcatel-Lucent has estimated LTE cost/GB to be 30% lower than 3G[iv]

There are two variations of LTE – Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD) – which are technically very similar and part of the same radio access specification. The key difference between TDD and FDD is that in TDD the sub-frames can be allocated for either the uplink or downlink. In FDD systems, the sub-frames are allocated in two different carrier frequency channels – one for the uplink and the other for the downlink.

Since much of the frequency operated by global carriers is paired and non-contiguous, FDD enables them to allocate the uplink and downlink to their existing spectrum channels. For example, in a 10 MHz by 10 MHz design, the carrier will allocate the downlink on one 10 MHz channel and the uplink on the other 10 MHz channel.
For carriers with large amounts of unpaired contiguous spectrum, TDD provides an optimal LTE implementation, since service providers can determine the amount of spectrum to allocate for the downlink versus the uplink. Since consumers view content (i.e. download) more than they create content (i.e. upload), the network can be biased to the downlink and bandwidth can be used more efficiently. Moreover, with larger contiguous spectrum assets, carriers can implement larger 20 MHz carriers. The end-result is that service providers will be able to provide customers with a better user experience. For non-FDD operators, using WiMAX, PHS, and TD-SCDMA, the TDD-LTE network technology provides an upgrade path to the LTE global standard.

The FDD and TDD implementations of LTE are often mischaracterized in the media. There is the misconception that FDD-LTE and TDD-LTE are competitive networks and likened to (1) VHS and Beta, and (2) Blu-Ray and HD-DVD. With the plans of service providers, like China Mobile, Softbank, Clearwire, and Bharti Airtel to rollout TDD-LTE, the hardware ecosystem has embraced support for both duplexing schemes. This is evident by Qualcomm and Intel's support for both FDD and TDD LTE on a single module. Consequently, OEMs are able to support the global LTE carriers, regardless of whether it is TDD or FDD, on their consumer electronics devices.

(4.2) LTE Network Experience

On average, 4G LTE networks, using a 10 MHz by 10 MHz configuration, are delivering speeds that are approximately 10 times faster than 3G networks. Customers of Verizon Wireless in the United States are experiencing, on average, 5-12 Mbps on the downlink, 2.5 Mbps on the uplink and latency of 50 milliseconds. This compares to their 3G EVDO Rev. A experience of 600-1,400 Kbps on the downlink, 500-800 Kbps on the uplink

and latency of 150-250 millisecond. Softbank's TDD-LTE commercial network in Japan is experiencing even greater average throughput at 20.4 Mbps with a latency of 17 milliseconds.
The network and latency achievements from the LTE networks are becoming more competitive with the in-home, fixed-line, broadband experience. Customers will now achieve the desired user experience for higher-bandwidth multimedia applications, like video streaming, online gaming, and video conferencing. Moreover, the ubiquity of wireless 4G networks will enable consumers to have the desired broadband experience in a mobile environment.

(4.3) LTE Global Rollouts

On December 14th 2009, TeliaSonera opened the world's first commercial 4G LTE networks in the city centers of Stockholm and Oslo as a data connection with USB modem. By the end of 2012 more than 60 countries had active LTE networks (FDD-LTE, TDD-LTE or both) and this figure is set to grow to over 80 countries by the end of 2013. Many of these countries have multiple networks operating and, as a result, there were 154 live networks in Q1 2013. By the end of this year, it is estimated that there will be 234 commercial LTE networks in 83 countries.[v]

As TDD-LTE network deployments have only recently started to receive industry attention, it will be useful to briefly highlight some recent advancements. By the end of January 2013, a total of 13 operators have launched 14 commercial TDD-LTE networks crossing different areas of the world including Asia, Europe, North America, South America, and Oceania.

In terms of network scale, the global number of installed TDD-LTE base stations exceeded 50,000 by the end of 2012. This year, China Mobile will significantly expand the scale of its TDD-LTE pre-commercial networks by covering more than 100 cities and deploying more than 200,000 base stations.

Given the rollout of TDD-LTE networks in high-population regions, it is estimated that by the end of 2014, addressable populations covered by TDD-LTE will be 2 billion.

(4.4) LTE Connections

At the end of 2011, with LTE networks in a state of relative infancy, connections were yet to hit the 10 million mark. However, by the end of 2012, this figure had reached almost 70 million and is expected to more than double by the end of 2013.

North America currently accounts for more than half the global LTE connections. Two years after the launch of the country's first LTE network, 7% of the North American connections base had been migrated to LTE. This represents a more rapid adoption than in most European or Asian markets (with the exception of Japan and South Korea), which are still lacking momentum due to spectrum allocation issues. The early allocation in 2008 of digital dividend spectrum for LTE use in the USA has helped fuel rapid development of attractive devices and allowed aggressive network deployments.

After the USA, South Korea and Japan represent the highest numbers of LTE connections (with 22% and 14% of the global total respectively).

By the end of 2018, there will be an estimated 1.6 billion LTE subscribers, globally.[vi]

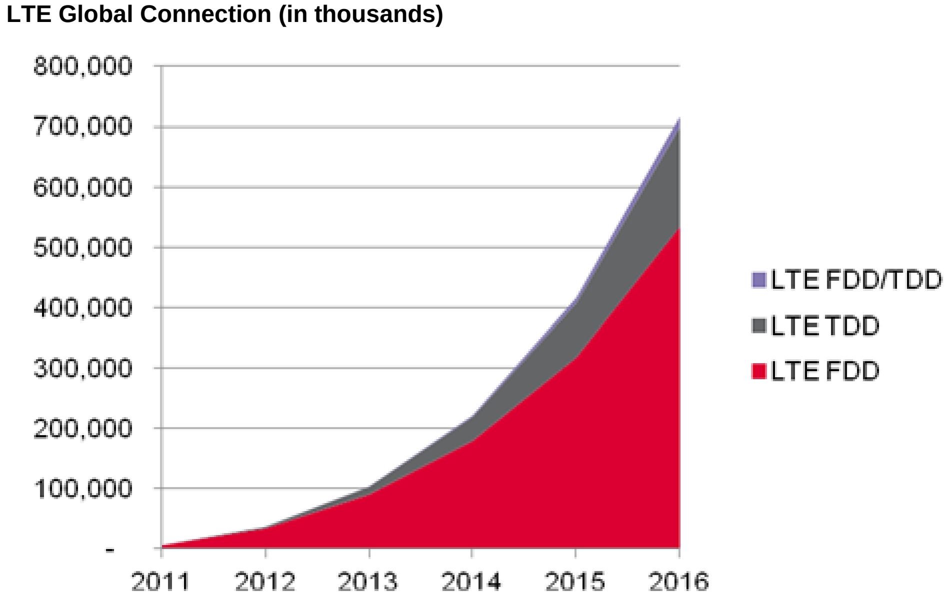


Figure 3 – LTE Global Connections

Source: "LTE TDD Goes Mainstream", Ovum (June 2012)

(4.5) Embedded Laptops & Tablets Opportunity

The global rollout of LTE networks and the improved network experience will have an impact on the number of cellular embedded laptops and tablets. Consumer trends toward "hypermobility" will intersect with the proliferation of low-cost laptops and tablets, enabling consumers to access the Internet on-the-go.

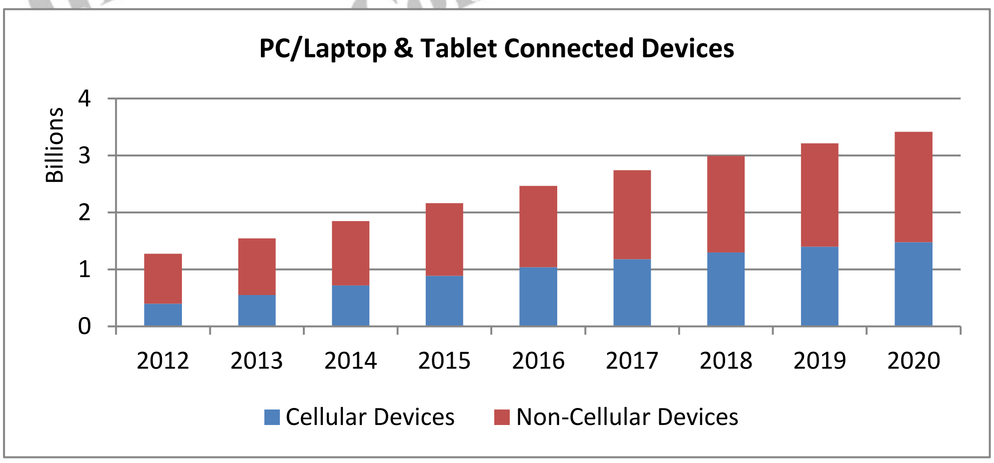


Figure 4 – Connected Laptops and Tablets (Source: Machina Research, 2013)

By 2020, it is forecasted that there will be almost 3.5 billion connected PC/laptop and tablet devices across all connection technologies – of which 1.5 billion are expected to be mobile broadband connections. This presents a tremendous opportunity for embedded Consumer Electronics. **Currently, approximately 15% to 20% of mobile broadband connections are through embedded modules, representing 225 million to 300 million embedded**

laptops and tablets. This forecast can significantly increase with the introduction of lower cost chipsets and consumer-friendly service plans (and data buckets).

From 305 million connections at the end of 2012, PC/laptop mobile broadband connections are set to reach just over 1.3 billion by the end of 2020. The fastest growing region is Emerging Asia-Pacific, including the giants of China and India. The region will grow from 95 million cellular connections at the end of 2012 to over 600 million in 2020.

The number of connected tablets (regardless of connection type) is expected to grow from 230 million in 2012 to over 1 billion by the end of 2020.

As would be expected, in terms of technology, 3G will gradually be supplanted by 4G (and beyond) technologies. In 2012 3G accounted for 92% of PC/laptop and tablet cellular connections, with 2G taking 3% and 4G around 5%. By 2020, 2G has all but disappeared, with 4G accounting for 52% of connections and 3G the remainder.

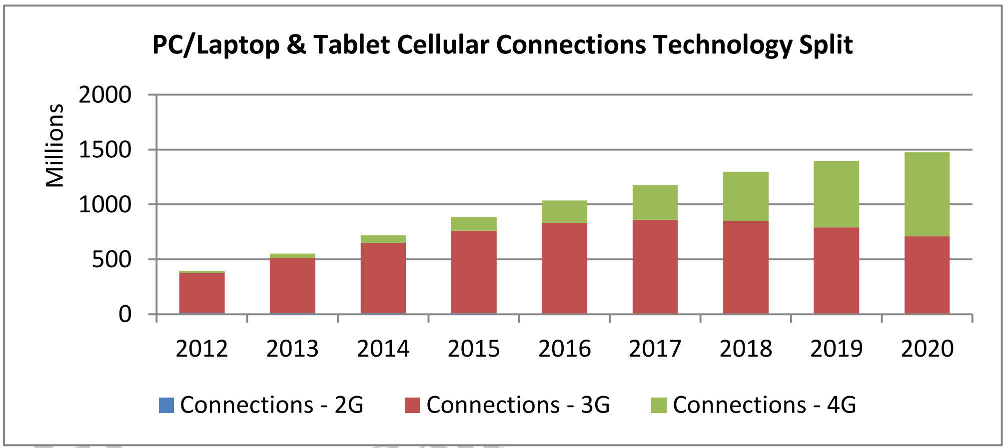


Figure 5 –Technology Split for Connected Laptops/Tablets (Source: Machina Research, 2013)

(4.6) Embedded M2M Forecast

While the main body of this document is primarily focused on embedded laptops and tablets, it is also important to understand the opportunity for embedded LTE in other device categories, including machine-to-machine (M2M). Furthermore, our Case Study at the end of the Whitepaper will focus on the opportunity of M2M and the automotive industry.

Leveraging either wired or wireless connectivity, M2M refers to a broad category where one device, typically, relays data to an end software program. Examples of M2M include telematics, remote monitoring, and smart meters.

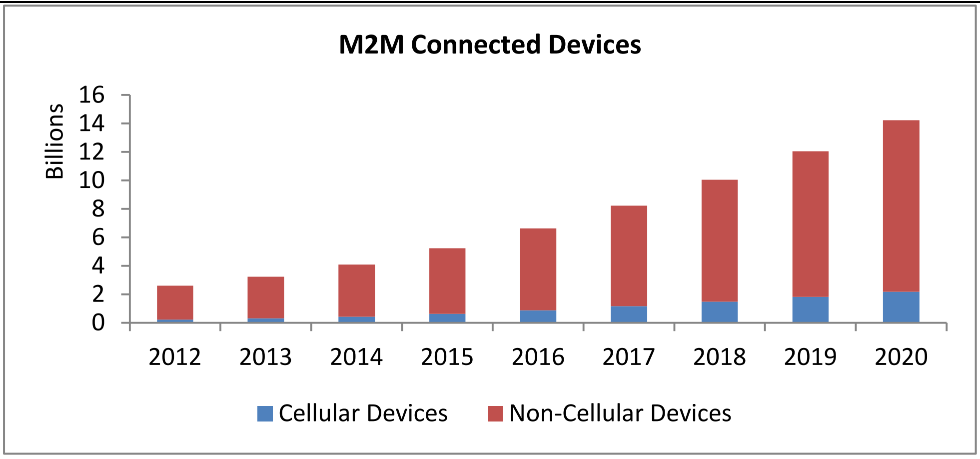


Figure 6 – M2M Connected Devices (Source: Machina Research, 2013)

The number of connected M2M devices is forecasted to grow from 2.6 billion in 2012 to over 14 billion in 2020. Whilst many of the devices will use short range or fixed connectivity, the opportunity for cellular devices remains significant.

Cellular connections in M2M devices are forecast to grow from 212 million in 2012 (or 8% of the total) to over 2 billion connections by 2020 (or 15% of the total). Despite the factors driving short range connectivity, ease of deployment, homogeneity of solutions and mobile capabilities will ensure a thriving cellular M2M market.

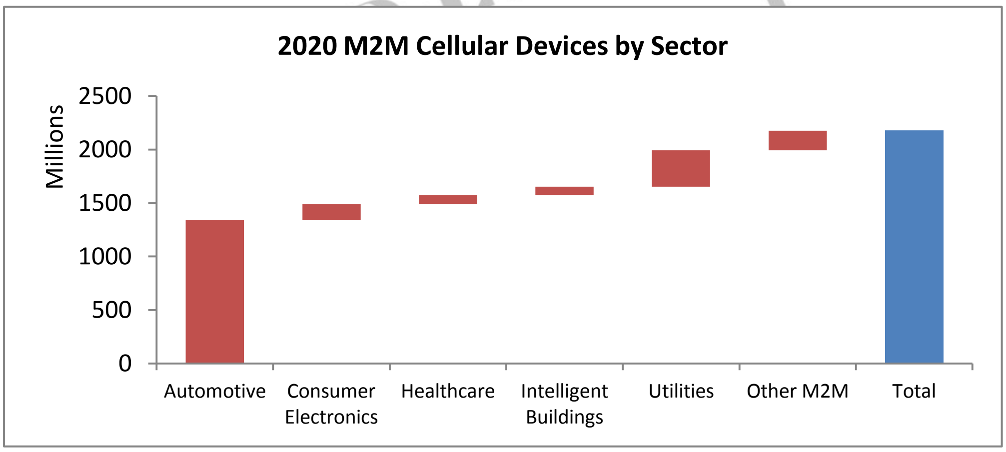


Figure 7 – M2M Cellular Devices by Sector (Source: Machina Research, 2013)

**PC/Laptop and Tablet connections are considered separately below.*

Automotive and Utilities will clearly represent the highest proportion of cellular M2M connections – within automotive; vehicle platform, insurance and emergency/eCall are the largest applications. As we will see in the Case Study, the automotive industry is experiencing a remarkable evolution from basic embedded telematics and safety services to advanced infotainment and integrated navigation, which provide a tremendous opportunity for LTE networks.

(5) Key Requirements to Achieve Embedded Consumer Electronic Volume Opportunity

As previously highlighted, there is strong opportunity that 4G LTE networks provide the consumer electronics ecosystem. The availability of high-speed wireless broadband will enable consumers to access bandwidth-intensive services and stay connected outside of their traditional "hotspot" areas. Compared to tethered connectivity, the simplicity of built-in mobile broadband and the opportunity for integrated services provide a strong value proposition for end-consumers.

There are 5 key requirements in order to achieve mass-market adoption of the embedded model:

1) Consumer-friendly service pricing and bundles
2) Lower cost chipsets
3) Improved network experience and bandwidth
4) Large-scale coverage footprint
5) Certification & testing support

(5.1) Service Pricing Models

Carrier service pricing plans need to be appropriate for mainstream consumers. One of the major barriers to adoption of embedded cellular solutions is the high cost for data subscriptions. During the initial rollouts of embedded 3G laptops, consumers needed to purchase additional service plans, often at a steep premium compared to their in-home wireless Internet service. For example, in the US, consumers typically paid $50-$80 per month (contract) for their embedded 3G laptop subscription, in addition to their existing smartphone or handset service plan. This type of offering was adopted by high-end consumers and mobile professionals, who placed mobility at a premium and were typically using embedded 3G as a replacement for costly WiFi service.

Recently, we have seen a growing number of service providers offering non-contract options and bundled service plans, where customers can share a bucket of data over multiple devices. For example, one US wireless operator offers bundled service plans, ranging from $30 for 4GB to $60 for 10GB for the data bucket and an additional $10 monthly access fee for each device connected to the service plan. While a positive development, the bundled service offering still falls short of addressing the consumer mass market, since high-end consumers primarily benefit from a higher pricing threshold with its cost per GB advantage (i.e. $10/GB for 4GB plan + monthly device access and $7/GB for 10GB plan + monthly device access).

We have also witnessed OEMs and their partners testing innovative plans to drive embedded connectivity. Amazon was a pioneer in bundling embedded wireless, when it launched its Kindle eReader in 2007. The device came with embedded CDMA for the Sprint network in the US. In its future Kindle releases, Amazon added GSM to its portfolio to support an international market. One major innovation with the embedded Kindle model was that consumers never saw a bill for their wireless download of eBooks. With the convergence of the eReader and tablets, a growing number of consumers were using their Kindles for video and Internet-based activities. On the release of the Kindle Fire 4G LTE in 2012, Amazon launched a one-year wireless subscription plan option. For $50 a year, consumers received 250MB/month for one year. This service plan equated to $17 per GB. Lower wholesale rates between service providers and OEM, like Amazon, will further drive market adoption for these innovative business models.

Another example of this type of innovation is Google's embedded 3G Chromebooks. With purchase of the device, customers get 100MB/month free for two years. Given the relatively small amount of data provided, especially for bandwidth intensive user, customers can purchase an unlimited day pass ($9.99), 1GB ($20), 3GB ($35), and 5GB ($50) prepaid carrier service plans.

No doubt, the industry will make further advances in pricing. New business models are emerging, such as sponsored access and micropayments. In the sponsored access model, third-parties would sponsor free access to specific sites, such as Facebook, Wal-Mart, Outlook, Twitter, and eBay. With micropayments, customers would be charged a nominal amount for a limited time on specific Internet services (e.g. 50 cents for 10 minutes on Facebook).

(5.2) Chipset Pricing

Cellular chipset pricing still remains a barrier for OEMs and consumers. Embedded cellular modules are typically 3-10x the price of WiFi modules. While volume is an important function of pricing, it is estimated that average 3G modules are ~$20-$40 and 4G multimode modules are ~$70-$75. If engineering costs are considered, the cost of an embedded module is an additional ~$25-$35 per device compared to WiFi. As with other technologies, it is expected that the price for 4G modules will fall in the coming years. However, in order for OEMs to propel innovation and adoption, current pricing as a percentage of bill-of-materials is still too high for the mass consumer market. For example, if we consider that the price of tablets is averaging $299 and falling to the $199 range, it becomes evident that a 4G module and associated engineering costs account for ~50% of total tablet costs. While there are consumers that will pay a premium for embedded 4G, the pricing will still be prohibitive for most consumers.

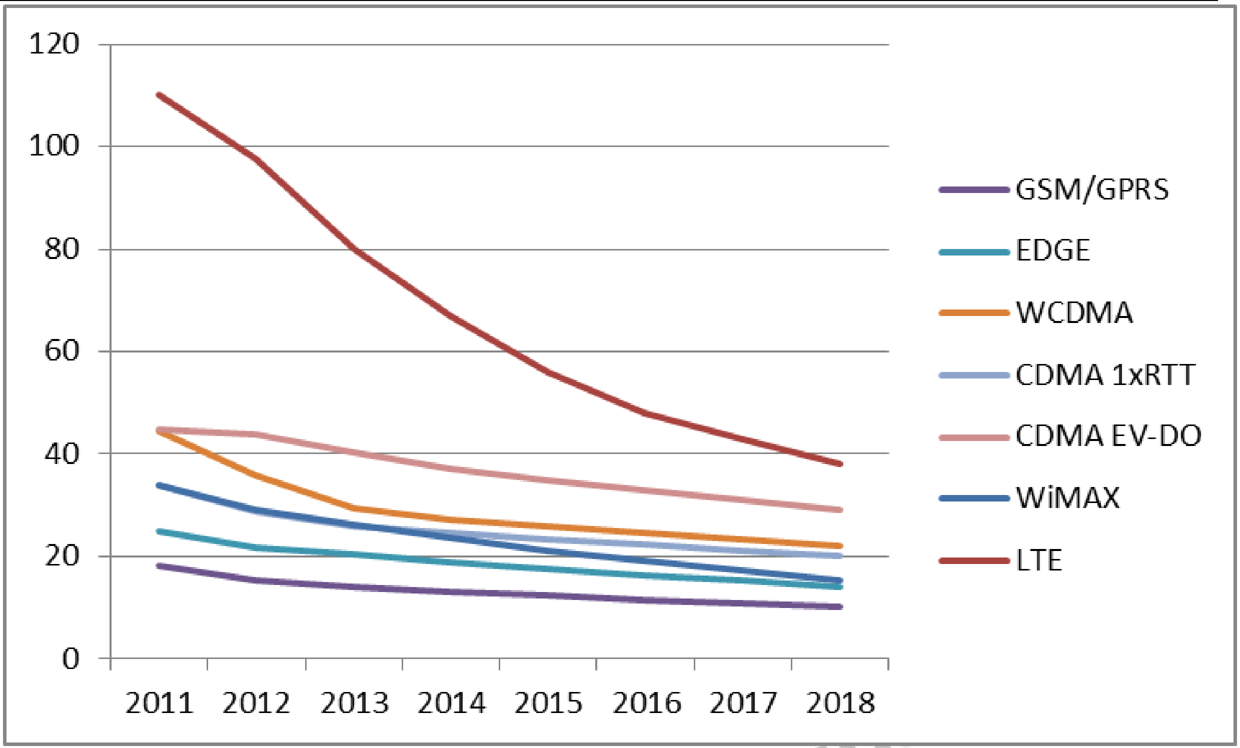


Figure 8: Forecasted Module Pricing -- ABI Research (May 2013)

If chipset providers do not address 4G module pricing, we may see new models emerge. One such model would be for OEMs to adopt WiFi and LTE-only at select global bands (i.e. 2.3 GHz – 2.7 GHz). While not offering a full global footprint, this model would provide access to major population centers like China, Japan, India, and the United States. These types of devices could bolster an emerging “Hotspot plus” category.

(5.3) Network Experience

Consumers demand network throughput experience to be similar to in-home broadband, which has impacted consumer adoption for embedded cellular connectivity. As discussed earlier, the rollout of 4G networks has increased network speed to 5-12 Mbps (average downlink) compared to the 600-1,400 Kbps (average downlink) experienced with 3G. The rollout of 4G networks continues to improve customer experience. The average network connection speed for tablets grew from 2,030 Kbps in 2011 to 3,683 Kbps in 2012. 4G connections generated 19x more traffic than non-4G connections, while representing only 0.9% mobile connections and 14% of mobile data traffic.[vii] These are all indications of consumer appetite for high-bandwidth applications – like video streaming, video conferencing, and music streaming –which require adequate network experience.

(5.4) Coverage Footprint

Another key prerequisite is the 4G global footprint and covered population. This enables OEMs to develop global SKUs and better manage device inventory. As mentioned in the previous section, by the end of this year, there will be nearly 150 countries that rollout LTE networks. While TDD-LTE will represent much fewer countries, from a population perspective, it will cover an estimated 2 billion -4.4 billion populations by the end of 2014.

(5.5) Certification & Testing

Certification and testing of embedded devices need continued attention from service providers. Given the relatively short product lifecycles of consumer electronic devices, OEMs are challenged by service provider processes and their own go-to-market requirements. For example, operator interoperability testing on embedded laptops and tablets takes approximately 2 months for devices sold through the OEMs channels. For embedded devices sold through the service providers channels, certification can take up to 6 months. Based on learnings from embedded 3G programs, there are opportunities to shorten the testing period for OEMs that purchase pre-certified modules. One area that has garnered recent attention from service providers is enabling OEM to self-test for areas related to the antenna and connection manager. This would be a positive development for the ecosystem as it would help reduce OEM timeline pressures.

(5.6) Support from the Ecosystem

From our standpoint, the ecosystem is already making important strides to support high-innovation consumer electronics that are able to access global wireless networks. The rollout of higher-throughput LTE networks, the global LTE coverage plans, and the convergence of TDD and FDD LTE on a single wireless chipset, will enable OEMs to deliver embedded global SKUs and applications. Progress is also being made with certification and testing to reduce time-to-market for devices. The key remaining areas, which need more attention, is for service pricing to be more accessible to the mass market and chipset pricing to be appropriate for low-cost consumer electronic devices.

(6) Case Study – Automotives

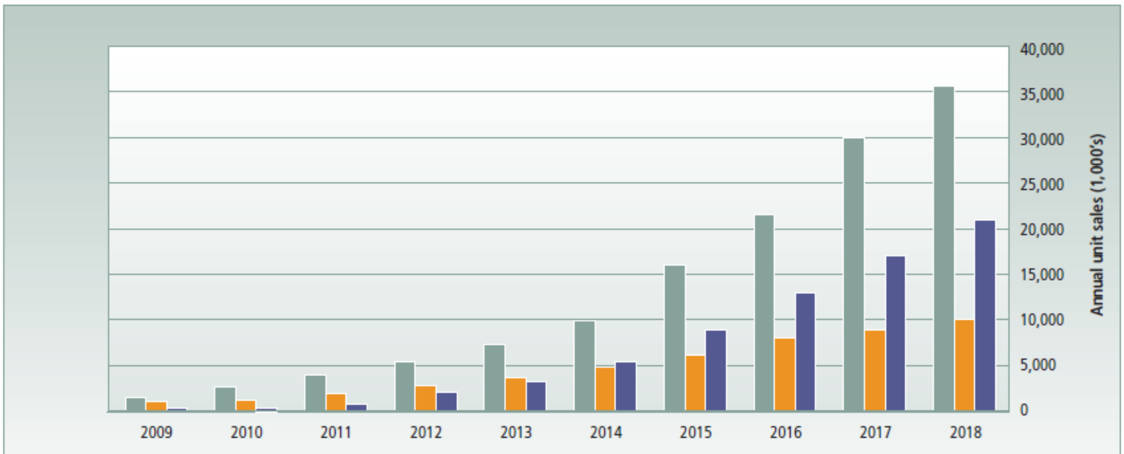
When the GTI and GSMA established its cooperation in 2012, one of the agreed areas of focus was supporting the consumer electronics ecosystem by highlighting the opportunity for embedded LTE. In addition to supporting laptop and tablet OEMs, the GTI and GSMA also decided to collaborate on the M2M opportunity in the automotive sector, given that the automobile industry is in the middle of a tremendous evolution from basic telematics and safety services to advanced infotainment and integrated navigation. In addition to highlighting the M2M and automotive opportunity in this case study, the entities are also exploring opportunities to support combined TDD and FDD LTE trials with leading automobile manufacturers.

Automotive is another indicator of the intersection between consumer demand for “everywhere and anywhere connectivity” and technological advancements, which include the rollout of LTE networks. There have been LTE connected car announcements from BMW ConnectedDrive, Audi Connect, GM OnStar, Mercedes-Benz myCommand, Toyota NG Connect, and Proton Inspira – most of which include embedded solutions.

(6.1) Opportunity for Connected Cars

By 2025, nearly every automobile sold, globally, is likely to be connected to mobile broadband networks through a variety of connectivity solutions – embedded modules, tethered (IP sharing), or integrated smartphone applications.

The forecasts for connected vehicles, sold globally, show nearly 5x growth from 14.1 million automobiles, this year, to 67 million in 2018. Specifically, embedded will grow from approximately 7.4 million in 2013 to 35.9 million in 2018, representing 54% of vehicles sold.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Embedded	1,522	2,750	4,010	5,440	7,381	9,832	16,095	21,685	30,043	35,941
Tethered	917	1,245	1,790	2,603	3,525	4,673	5,997	8,144	8,975	10,032
Smartphone	39	98	711	1,938	3,205	5,394	8,915	13,093	17,206	20,975

Figure 10: Global Sales Forecast of Original Vehicle Manufacturer Connectivity Solutions in Passenger Cars (Source: GSMA, June 2013)[1]

[1] Tethering refers to IP sharing and Integrated refers to Smartphone Integration.

In contrast to tethered connectivity[2] or smartphone integration, consumers prefer embedded connectivity in the vehicle because it is fundamentally simpler – they just work "out-of-the-box". Integration of Internet-based services with front-console navigation and multimedia systems with back-seat entertainment screens provides consumers with an optimal experience.

Additionally, as we will review, infotainment and high bandwidth services provide a natural extension to the embedded services that auto manufacturers have already rolled-out in the past – such as safety, security, and telematics. However, high priced subscription services and costly automotive-grade modules could limit the possibilities of embedded, thereby, causing automakers to rely on other solutions to bring connectivity to the vehicle --such as tethering and smartphone integration.

(6.2) Services

Consumer demand for connected services, across all the major global geographies, is influencing the rapid growth in forecasted connective vehicles. Already, in research conducted by SBD, consumers indicated that connected car services were a must-have for over 20% of those surveyed globally (and specifically in the US, China, and Brazil).

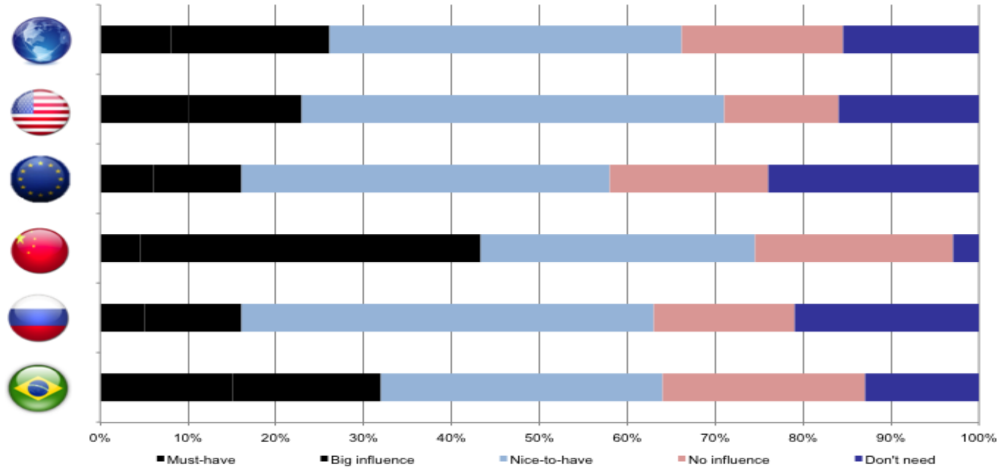


Figure 11: How Important is it to Offer Telematics: Regional Realities (SBD 2011)

Similar to the applications being consumed over laptops, tablets, and smartphones, consumers are demanding access to high-bandwidth multimedia and navigation services in the car. Specifically, consumers want increased access to Internet radio services, social media, email, video streaming, integrated navigation services (such as Google Maps with satellite and street imaging), point-of-interest information, and other location-based services.

As a result, automakers are now using infotainment, convenience and navigation services to attract consumers to connected car services, as opposed to the historic approach of emphasizing safety and security services.

[2] Tethering relates to using a wired (e.g. USB cable, USB key, OBD Dongle) or wireless connections (typically Bluetooth today, but also WiFi) to allow the phone's IP data connection to be shared with the car and should not be confused with other applications of Bluetooth in the car, such as hands-free voice calling.

(6.3) Embedded Connectivity

Overall "connected car" services have been limited by the availability of mobile broadband networks, device technology, and consumer behavior. The rollout of LTE networks, the capabilities of computing devices, and consumer trend towards "hypermobility" are propelling the industry to make connected services a selling point for vehicles.

While consumers prefer the simplicity of embedded broadband connectivity, these services have generally been limited to premium vehicles, with some notable exceptions:

- Volume brand manufacturers, such as General Motors, Peugeot, Renault and Roewe offer service for entry models and upwards using embedded connectivity
- Regional- specific regulations exist that require embedded solutions, such as eCall in Europe. Legislators in a number of regions are the world are also planning to mandate the fitment of such systems

To deliver on the embedded experience, there are several critical requirements that need attention. While there are many other factors that can be discussed, including antenna/band considerations, automaker supply constraints, and testing, given the nature of this case study, our focus will be on the key areas - footprint of LTE networks, module costs, and pricing models. These are similar items that were mentioned in our discussion of tablets and laptops.

(6.4) LTE Network Deployments

Automakers have a number of unique requirements for cellular network deployments to support their services, including:

- Keeping pace with network technology evolution. In general, the vehicle lifetime duration is 7-10 years. When 2+ years of product planning is considered, automobile manufacturers are ideally looking for cellular technologies to be relevant for a 9-12 year cycle.
- Moreover, the importance of cellular coverage of road geographies, as opposed to "solely" population centers, is needed for infotainment and Internet-based services.

For these reasons, the expected 234 "live" commercial LTE networks in 83 countries by the end of this year are positive signs for automobile manufacturers to invest in LTE for the vehicle. Moreover, the widespread TDD and FDD LTE network deployments and coverage rollout plans in Japan, China, South Korea, and North America address "major market" concerns relating to the expanse of the coverage experience within a given geography.

(6.5) Module Pricing

Similar to laptop and tablet OEMs, the highly competitive nature of the automobile industry has put pressure on profit margins. Since vehicles are high price-tag items, it is often believed that that they can absorb the cost of new technology features. However, when we consider that, on average, automobile manufacturers achieve profit margins in the sub 1%-2% range, it is clear that every cent added to cost of the vehicle is closely monitored.

Moreover, vehicles require higher priced automotive-grade modules, which have much higher requirements (e.g. temperature range, warrantee periods, etc). In order to support consumer coverage requirements, 4G modules must also be multimode and support 3G fallback. On average, automotive-grade modules (4G and 3G) are approximately 1.7 to 1.9 times the price of mainstream modules used in laptops and tablets.

(6.6) Pricing & Business Models

As was witnessed with laptops and tablets, carrier service pricing plans need to evolve, in order to support embedded connectivity in mainstream vehicles. Subscription pricing has been attractive to automobile manufacturers because it is relatively simple for the dealerships to sell, it minimises the number of transactions involved in the management of the services, and it provides a relatively easy way to predict revenues. However, it has become evident that the limits to the subscription-model include the following:

- Unable to address consumers' desire to:
    - Trial services before purchasing
    - Tailor service bundles throughout the lifetime of the vehicle
    - Maintain flexibility on service commitments
- Unable to strengthen the business case for connected car services by opening up new revenue streams and adapt to the differing connectivity usage levels for all services

For these reasons, business models for connected car services are expanding to incorporate additional models beyond just subscription (which is likely to remain for some service categories), including those which:

- Facilitate the entrance of new revenue streams (and actors)
- Allow for differential allocation of service costs to beneficiaries (split charging and billing)
- Foster flexibility in adding new services in the future
- Used in other consumer electronics sectors (such as apps stores and e-books)

Five potential revenue models underpin the deployment of telematics and infotainment services (see Figure 13). These different solutions could be employed in parallel to optimise the market appeal of the services and to keep the final service prices competitive. Historically, automakers relied on one or more of the first three options, while, today the focus is geared towards leveraging multiple revenue streams and third party players.

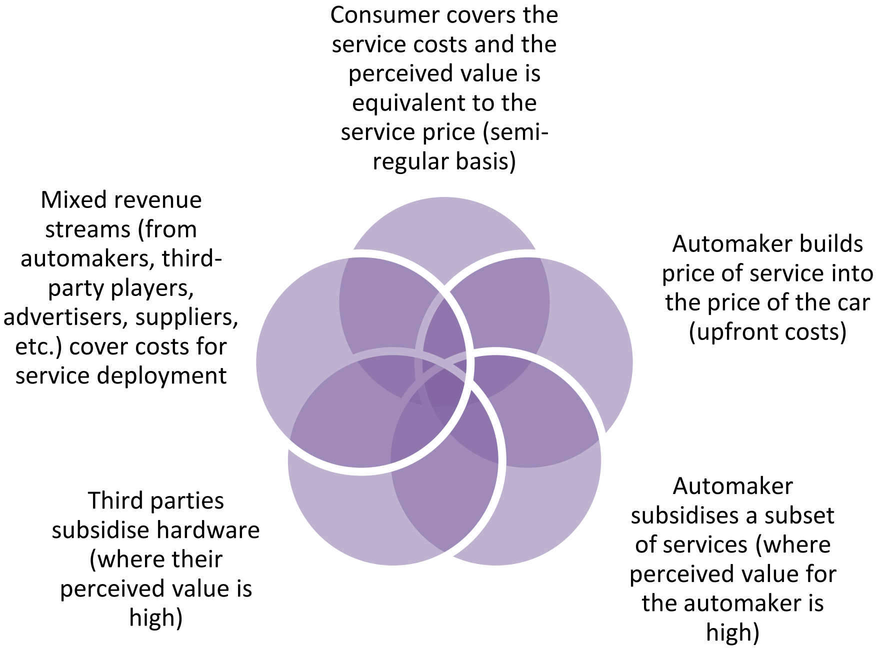


Figure 12: Potential revenue streams for connected car services (2012)

Given these various types of business and pricing models, the flexibility and cooperation of service providers become increasingly critical, in order to scale embedded services to the mass market.

(6.7) Real-Life Examples of LTE Deployments in the Car

The services that LTE enables and the competitive nature of the industry have prompted auto manufacturers to announce LTE-based "connected car" services in premium and volume vehicles across the globe. The following table highlights some expected releases for BMW, Audi, GM, Mercedes-Benz, Toyota, and Proton – most of which include embedded solutions.

Automaker	Services	LTE Announcement	Release (Planned/Actual)
BMW	BMW ConnectedDrive: 1st Release: Wi-Fi hotspot for broadband connection for up to 8 mobile devices 2nd Release: Connected Services Navigation, Infotainment (Assist, Online, etc)	IAA 2011	Q4 2012 2013-2014
AUDI	Audi Connect: Simultaneous voice and data services, advanced connected navigation with street level imagery streamed to the vehicle, Infotainment (i.e. multimedia streaming and downloads), plus a mobile Wi-Fi hot spot for up to eight devices.	MWC & CES 2011	2013 in US (released at CES in Audi A3)
GM	OnStar Wi-Fi hot spots, new infotainment options (e.g. streaming video entertainment in the back seat), real-time traffic and navigation updates and faster application downloads	CES 2011/12, MWC 2013	2014 in US market (on the 2015 fleet of most Chevrolet, Buick, GMC, and Cadillac)
Mercedes-Benz	Mercedes-Benz myCommand: Connected navigation (off-board navigation and trip assistance); infotainment (world radio, internet telephony, web browser while parked, software updates)	Various, 2008/2009	TBC
Toyota	Ng Connect: Vehicle centric services (incl. Wi-Fi hotspot), advanced navigation, infotainment (video on demand, gaming, audio library, social networks, internet radio); remote services (home control, eCommerce)	CES 2010	TBC
Proton	Proton Inspira: In-car Wi-Fi hotspot	'4G' car launch event 2012	2012 Launched

Figure 13: Launches for Connected Car Services based upon LTE (SBD 2013)

(6.8) Support from the Ecosystem

Consumer demand for Internet-based services in the vehicle is pushing automobile manufacturers to incorporate "connected car" services as key selling points. As discussed, by 2025, nearly all cars sold, globally, will have some type of broadband connectivity—whether it occurs through tethering, embedded, and smartphone integration. All of these conduits for connectivity will play a role in the rollout of in-vehicle broadband services.

However, given the simplicity of the embedded model and its ability to provide a tightly integrated experience, it is important for the ecosystem to address key factors that are limiting mass-market success. A key pilaster for viable LTE connected car services relies on the business models. Higher bandwidth services will only be feasible in the market if they are considered economically competitive with regards to user experiences in consumer electronics. This vision will require innovation in the cost structures and business models for the different value chain players.

(7) About GTI & GSMA

About GTI

The Global TD-LTE Initiative ("GTI") is a virtual open platform established in 2011 to advocate cooperation among global operators to promote the development of TDD LTE and the convergence of TDD-LTE and FDD-LTE. The Mission and Objectives are:

- Energizing the creation of a world-class and a growth-focused business environment
- Delivering great customer experience and bringing operational efficiencies
- Promoting convergence of TDD-LTE and FDD-LTE in order to maximize the economies of scale
- Facilitating multilateral cooperation between and/or among operators

About GSMA

The GSMA represents the interests of mobile operators worldwide. Spanning more than 220 countries, the GSMA unites nearly 800 of the world's mobile operators with more than 230 companies in the broader mobile ecosystem, including handset makers, software companies, equipment providers and Internet companies, as well as organizations in industry sectors such as financial services, healthcare, media, transport and utilities. The GSMA also produces industry-leading events such as the Mobile World Congress and Mobile Asia Expo.

With the GTI, GSMA has played an active role in promoting the usage of TDD-LTE as a key component of the overall LTE technology family, and has supported GTI in working on driving embedded LTE in consumer electronics and M2M; LTE roaming trials; and definitions in GTI for VoLTE.

[i] "CES: Global Consumer Electronics Market Expected to Grow This Year", CEA (January 2013)

[ii] "YouTube Reaches 1Bn User Milestone", Financial Times (March 22, 2013)

[iii] Ericsson Mobility Report (November 2012)

[iv] Alcatel Lucent Presentation at Mobile World Congress (2013)

[v] "Evolution to LTE Report", GSA (January 2013)

[vi] Ericsson Mobility Report (November 2012)

[vii] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update (February 2013)