SDR Market Size Study

July 2011

Presented by:

Mobile Experts and Wireless Innovation Forum

MOBILE EXPERTS

TABLE OF CONTENTS

CHARTS

MOBILE EXPERTS

EXHIBITS

Presented by Mobile Experts LLC

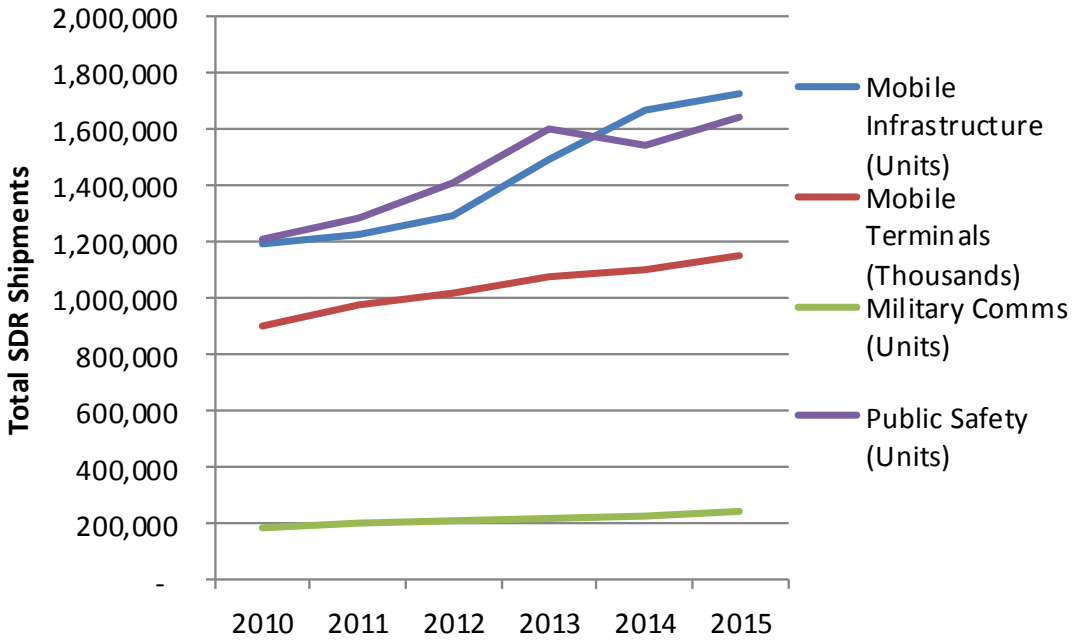
Principal Analyst: Joe Madden
joe@mobile-experts.net
+1 408 540-7284

1: EXECUTIVE SUMMARY

Software-Defined Radios have been widely adopted in many different communications applications, despite the popular belief that SDR technology is a "futuristic" technology that always somehow remains in the future. In fact, the typical radio has gradually been digitized gradually over the years, with various components of the radio incrementally absorbed into DSP cores and FPGAs as digital RF capabilities have improved over the years.

The SDR definition agreed upon by members of the Wireless Innovation Forum states that the use of software to implement operating functions of a radio should be considered a "Software Defined Radio". In practice, this definition means that the use of DSP cores or FPGAs in the implementation of a radio places the product in the SDR category.

Chart 1: Software-Defined Radio Shipments, by market segment, 2010-2015



Source: Mobile Experts (based on multiple sources)

Today, most of the cellular base stations, mobile handsets, military radios, and public safety radios on the market use DSP cores and FPGAs, in order to maintain the flexibility required to be able to make product improvements and to keep up with changing industry standards. Moore's law has improved performance and power

consumption to the degree that any performance drawbacks of programmable logic have become less important than the flexibility gained.

Overall, more than 1.1 billion SDRs will be shipped in 2011. Mobile handsets and other mobile terminals represent the largest segment by far, followed by mobile infrastructure, military communications, and public safety radios. Each of these market segments is growing, resulting in a healthy growing market for SDR technology.

2: SOFTWARE DEFINED RADIO DEFINITIONS

The argument over the term "Software Defined Radio" can get pretty heated. Individuals and vendors feel ownership of the term SDR and it seems that almost everyone has their own interpretation.

For the purposes of this study, Mobile Experts used the following definitions:

Software Defined Radio

Radio in which some or all of the physical layer functions are software defined. Software defined refers to the use of software processing within the radio system or device to implement operating (but not control) functions.

Software Controlled Radio

Radio in which some or all of the physical layer functions are software controlled. Software controlled refers to the use of software processing within the radio system or device to select the parameters of operation.

Cognitive Radio

Radio in which communications systems are aware of their environment and internal state and can make decisions about their radio operating behavior based on that information and predefined objectives. The environmental information may or may not include location information for the communication systems.

2: MOBILE INFRASTRUCTURE MARKET

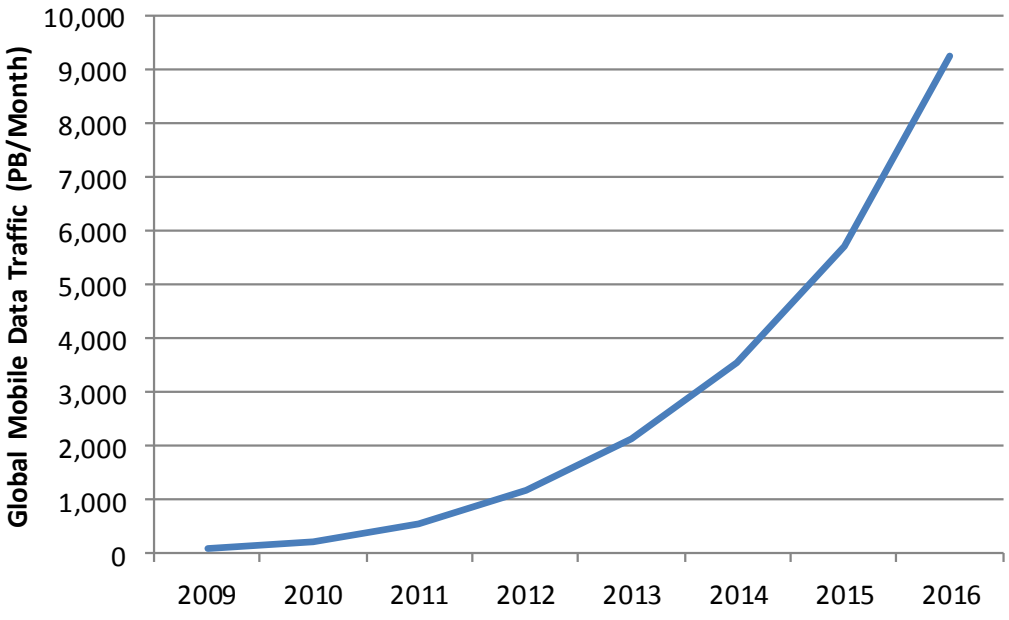
The mobile infrastructure market transitioned from single-purpose, cost-optimized radio equipment in the 1980's to more flexible platforms in the 1995-2000 timeframe. This transition roughly followed the changes in standards development, where single-purpose 1G mobile communications gave way to multi-purpose 2G mobile services (SMS and MMS were added). More importantly, new technologies were introduced over time which required changes in modulation, to take advantage of robust link budgets by advancing to higher order modulation when possible. As the standards become more complex, OEMs found that CDMA and EDGE base stations (followed by UMTS/WCDMA later) needed programmable logic to maintain flexibility.

As a result, the market has already made its major shift to programmable logic devices in the radio chain, and today, substantially all of the base stations on the market can be categorized as SDR equipment.

Market Drivers

Mobile infrastructure demand is driven simply by the growth in demand for mobile services. Mobile voice services continue to grow steadily, and during the 2008-2011 time period, demand for mobile data has grown at an incredible rate. Looking forward, by 2016 the demand for mobile data will grow by at least 5000%.

Chart 2: Forecasted mobile data demand, 2009 to 2016



Source: Mobile Experts

Along with dramatic growth in data has come a pressing need to boost signal quality for in-building environments. More than 70% of 2016 mobile data will be consumed indoors, and due to the physical propagation of radio signals, a traditional mobile network environment offers lower signal quality for indoor users. Therefore a strong trend is emerging toward "small cells" for indoor deployment, as well as lower-powered outdoor cell sites which are mounted at street level to penetrate nearby buildings without

Market Inhibitors

Consumer and enterprise demand for mobile data is strong, but the capital constraints of mobile operators balance the need for additional infrastructure. Operators have invested billions of dollars to acquire spectrum, and billions more to deploy typical 3G networks. Currently, the primary force preventing faster growth in mobile communications comes from the ability to raise new capital.

Many mobile operators offer "unlimited" data plans currently, in which a smartphone user can transfer up to 5 GB of data per month for a flat fee. This industry pricing structure has allowed for rapid growth in data usage, but it's now creating issues with profitability as mobile data traffic now exceeds voice traffic in terms of GB of data per month. As mobile operators such as Verizon Wireless, AT&T Wireless, and Vodafone change from "unlimited" plans to "pay per MB" plans, we can expect the capital markets to support ongoing growth in the network.

SDR Adoption

Recently, all major Network Equipment Manufacturers have chosen to offer some form of software-defined radio platform as a "common platform" in which the baseband processing elements utilize DSP cores and the radio chain is implemented with programmable logic (often FPGAs) to realize digital upconverters and downconverters. In particular, with the advent of LTE, the radio channel bandwidth has become a variable element, making digital filtering in the upconverter and downconverter impossible without programmable logic. Today's base station can switch easily from HSPA to LTE, and can fluently handle all of the optional states possible in 3G and higher-level standards.

Major reasons for this approach include:

- Manufacturing strategy. Top-tier OEMs choose SDR platforms as a flexible way to address a wide variety of air interfaces, frequency bands, and modulation formats. In the end, their goal is to reduce manufacturing cost by producing a hardware platform which can be easily adapted.

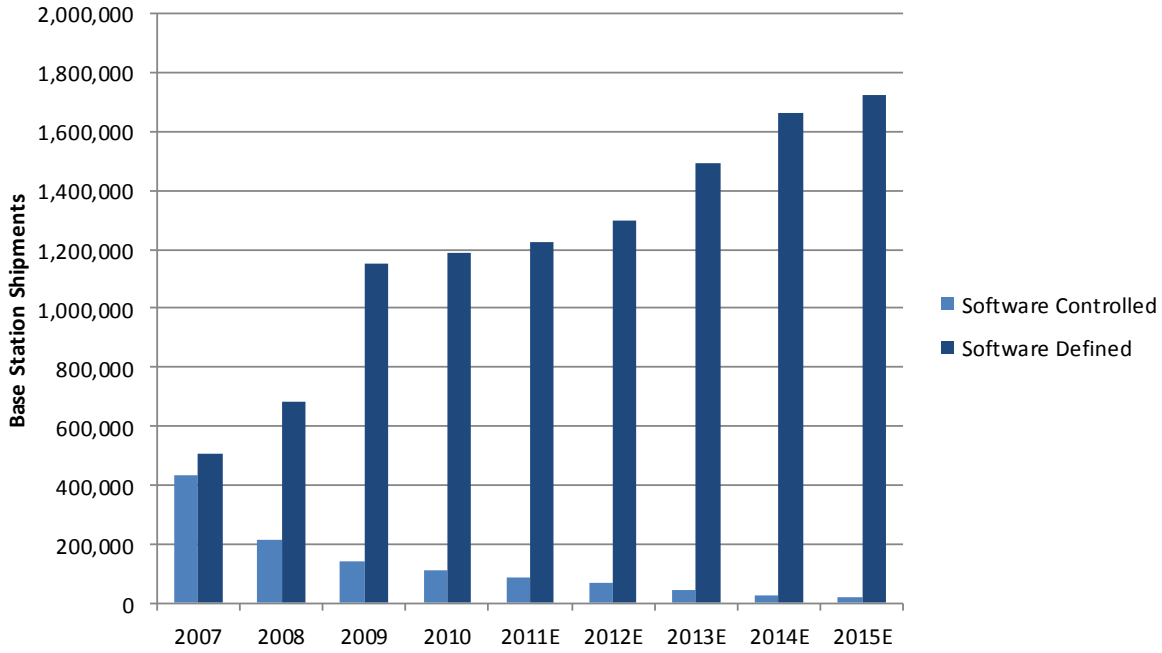
- Spectrum refarming. Mobile operators demand the ability to re-purpose their spectrum, upgrading from 2G to 3G and LTE. Operators were forced to rip out 2G base stations to implement 3G, and many operators have insisted on a more "future-proof" nodeB in their current 3G deployments.
- Changing standards. The 3GPP standards change every year. OEMs that placed bets on ASIC processors in the 1990s found that the standards changed too quickly for them to fully realize a return on their investment. Nowadays, DSP cores and FPGAs are utilized in order to avoid painful hardware changes to accommodate a variation in the standard.

SDR Outlook in Mobile Infrastructure

Over 93% of the mobile infrastructure market utilizes SDR technology, and future growth to support mobile data demand will simply drive more SDR base stations. The trend toward use of smaller indoor cell types (microcells, picocells, DAS systems) will also drive growth in the absolute numbers of SDR base stations shipped, since even the low-cost and low-power cell types will utilize highly integrated Systems on a Chip (SoCs) with DSP cores for baseband processing and up/downconverter functions.

Over time, the fully hardened ASIC solutions that are utilized in legacy GSM equipment will totally fade away.

Chart 3: Forecasted growth in mobile base stations, 2007 to 2015



Source: Mobile Experts

3: MOBILE TERMINALS MARKET

The overall mobile handset market continues to grow at a healthy rate, and the addition of tablets, PCs, and machine-to-machine modems has created a new growth surge in the industry. The number of terminals shipped per year is approaching 1.6 billion units per year.

Today's mobile terminals range from very simple, single-mode modems to highly functional smartphones supporting 10+ frequency bands and multiple air interface standards, including GSM, EDGE, CDMA, WCDMA, and HSPA. Tablet and PC modems tend to be more focused, with fewer bands and standards since they need not support the "phone" functionality… so, from a radio point of view the tablet is not necessarily more sophisticated than the smartphone.

Market Drivers

Consumer demand for mobile voice communications still drives the majority of revenue for worldwide operators, but mobile data applications are coming on strong. Revenue from mobile data applications has reached more than 30% of total revenue for Orange, Vodafone, and Verizon Wireless. (For the global market on average, however, mobile data is a bit lower at about 10-15% of total revenue).

Mobile subscriptions will also soon exceed the number of people on the planet. How can this be? In fact, many electronic devices are now connecting to the Internet in new ways:

- Vending machines send inventory data into a database;
- Medical products record and upload medical test data or other records;
- New cars will soon have 4G entertainment consoles in the back seats.

Market Inhibitors

The market could conceivably grow even faster, except for a few factors:

- The market for operating system software is fragmented for smartphones;
- Networks cannot keep up with data demands in a crowded environment;
- Mobile data business models currently do not meet the ROI standards of a voice network operator.

Overall, the mobile network must evolve so that data can find its way to/from the Internet less expensively, and the raw capacity of today's networks must be increased by at least a factor of 20 in order to support the public's desire for streaming media and social networking applications.

Overall, these inhibitors are fading, as mobile operators are investing in new network equipment and the fragmentary OS battlefield is slowly clearing.

SDR Adoption

Most mobile terminals use DSP cores for implementation, because of the flexibility inherent to the DSP baseband processor. Over the years, mobile handset manufacturers have learned that the mobile air interface standards change periodically. Even a small change in the standard can be death for a hardened ASIC solution.

In short, almost all simple phones already use a DSP core in the radio implementation. Flexibility is key, and the cores available from CEVA are a good example of a low-cost, flexible semiconductor block tailored for the simple GSM market.

Smartphones are less simple, but roughly half of smartphone chipsets also utilize DSP cores for the transceiver elements, especially in 3G implementations. One reason is that in 2G and 3G digital cellular communications, the standards allow for several optional settings in the communication links. The air interface can change frequency channel, power level, modulation format, forward error correction, and more in order to continuously optimize the mobile link. Infineon/Intel's product line of mobile baseband processors/transceivers are a good example of the typical DSP integration with DSP embedded processor cores, which allow low-power operation for mobile feature phones. Qualcomm and Mediatek, on the other hand, represent the other half of the market, using multiple hardened transceiver elements to realize the mobile transmitter and receiver functions, not DSP cores.

Exhibit 1: Adoption of SDR technology in mobile terminals

	2009	2010	2011	2012	2013	2014	2015
Feature Phones	54%	53%	52%	51%	50%	49%	49%
Smartphones	62%	56%	53%	50%	48%	46%	44%
Tablets	60%	60%	60%	60%	60%	60%	60%
PCs	76%	76%	76%	76%	76%	76%	76%
M2M	74%	74%	74%	74%	74%	74%	74%

Source: SDR Forum, Mobile Experts

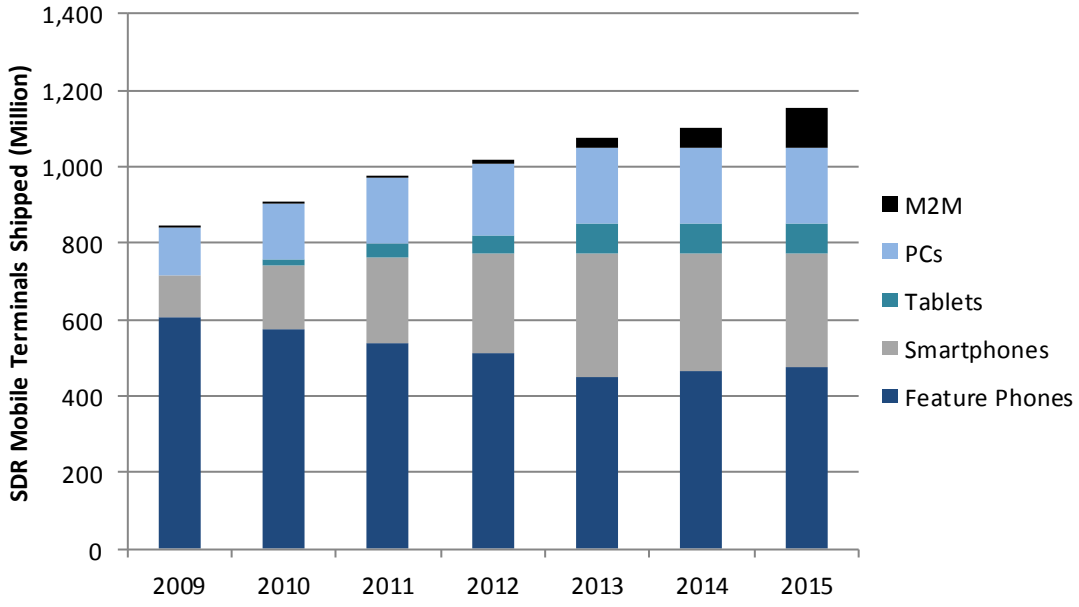
In tablets and netbook applications, the Qualcomm Gobi chipset similarly does not use DSP cores to run code for the mobile transceivers. Therefore, a segment of the tablet/netbook market remains outside of our definition of SDR. The Android-based tablets generally use the Gobi chipset, such that the roughly 20% market share of the Android tablet platforms do not count as software-defined radios.

PCs, at the high end of the spectrum, have relatively simple embedded modems or dongles since PCs are rarely used for voice communications. In addition, PCs do not need the processors of the Gobi or Snapdragon variety, with Intel dominating the CPU segment. Most PC modems revert to low-cost radios using DSP, so we estimate that three quarters of PCs enabled for mobile communications use SDRs.

SDR Outlook

Almost 1 billion software defined radios will be shipped in 2011 for mobile terminal applications….and growth for the next few years will come from the overall growth of the mobile market, not from increased adoption.

Chart 4: SDR Mobile Terminals Shipped, 2009 to 2015



Source: Mobile Experts

4: MILITARY COMMUNICATIONS MARKET

The military communications market is globally driven by political tensions… with budgets rising during conflict and generally light during peacetime. In a broad sense, the United States dominates the market, representing more than half of the global market.

Market Drivers

Military forces worldwide are modernizing their communications gear, replacing old worn-out equipment with modern equipment. In many cases, the replacement takes the force from simple (even analog) voice communications to modernized, digital communications formats which are more secure and more reliable.

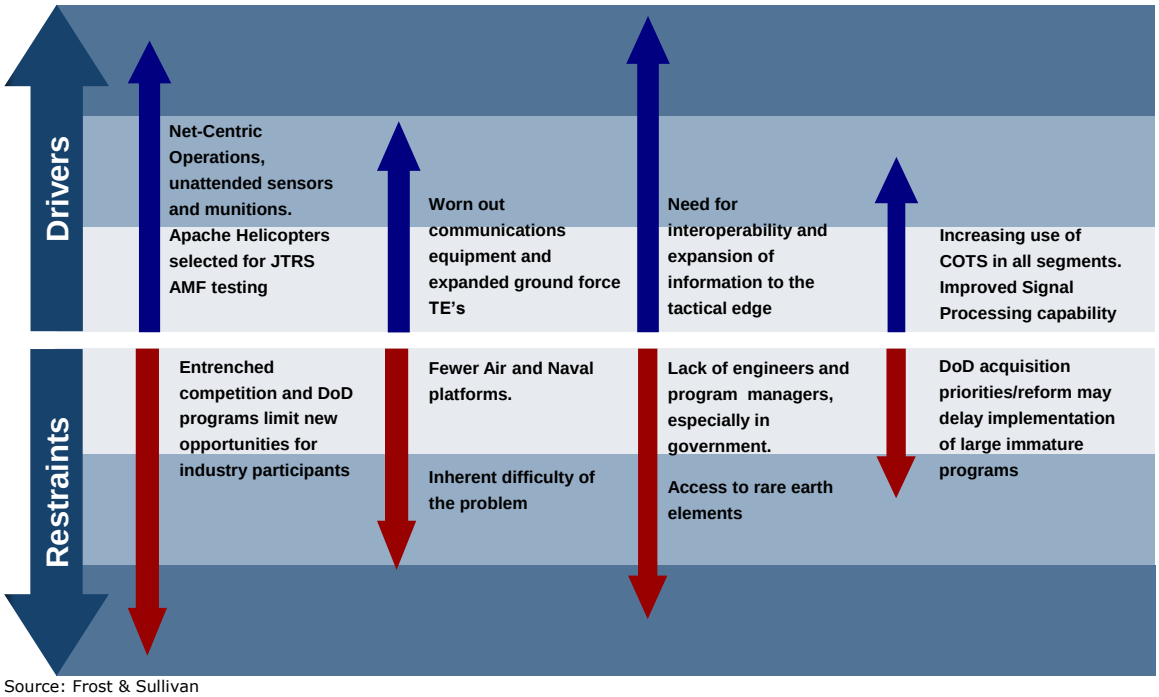
Military communications are also driven by the need for network-centric architectures, instead of one-on-one communication. Unattended sensors, UAVs, and weapons platforms can provide data to the network for multiple users to download.

Along with the increased scope of data to be communicated, there is a need for multiple platforms to interoperate. Tactical radios at the "edge" of the network (i.e. at the front lines) increasingly need access to the rich data available on the network.

Of course, a major driver for the military SDR market comes in the form of government funding for research and development. In particular, the United States Department of Defense provides more than $1.8 billion in funding to tactical radio suppliers for R&D, service contracts, and other non-production line items, making it possible for the vendors to provide advanced technology to a relatively low-volume production environment.

Finally, cost pressure has driven the use of Commercial Off-The-Shelf electronics since the end of the Cold War, allowing competitive pressure to bring down the cost of tactical radios.

Exhibit 2: Drivers and Inhibitors for the Tactical Military Radio Market



Source: Frost & Sullivan

Market Inhibitors

Of course, the major market constraint currently is the lack of any anticipated global conflict. Without World War III looming on the horizon, most countries have scaled back on military spending and therefore a steady, relatively stable number of tactical radios are produced each year.

Entrenched competition and a small number of development programs result in a very limited opportunity for new competitors to enter the market. The existing programs tend to carry on for years or even decades, especially as more flexible SDR platforms enable the radios to accommodate multiple applications. As a result, there is a small cadre of engineers that support military radio development and very few outsiders developing new equipment.

Lack of new spectrum for military applications also inhibits the market from growing faster. With additional spectrum, new applications utilizing video feeds and other rich datastreams could be more widely utilized, but in many countries the focus lies on making spectrum available for commercial applications.

SDR Adoption

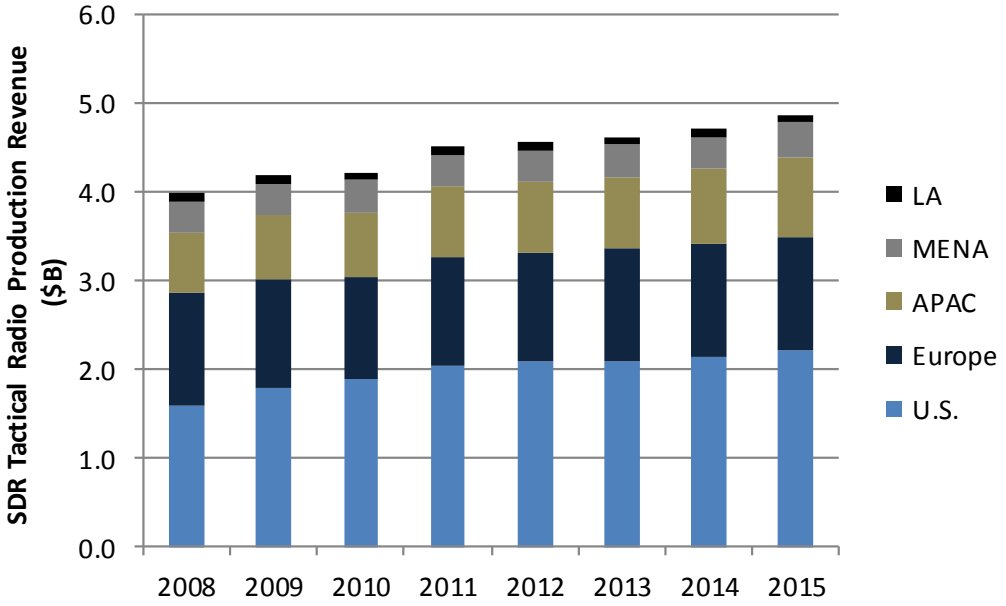
Virtually all of the tactical radios sold for military communications utilize SDR technology today. The development of the Joint Tactical Radio System (JTRS) took place in the 1990s, and over the years the production of JTRS and similar SDR platforms have brought the cost down somewhat. European countries including Finland, Sweden, Poland, France, Italy, and Spain are collaborating to develop a similar platform known as European Secure Software Radio, with over $100M in funding through 2010. On the other hand, continued development of COTS radios (which also utilize SDR technology) puts even more cost pressure on the high-end platforms such as JTRS. Between the high-end Programs of Record and the COTS hardware, SDR techniques are becoming standard in tactical radios.

Most radios for tactical communications, including radios embedded in sensors and UAVs, countermeasures for Improved Explosive Devices (IEDs), Homeland Security, and even some radar countermeasures utilize programmable logic in the radio chain. The flexibility of programmable devices such as FPGAs and DSPs in these platforms allows for adaptation such as frequency hopping, changes in modulation and/or encryption for tactical communications, and varying bandwidth to accommodate different modes of operation.

SDR Outlook

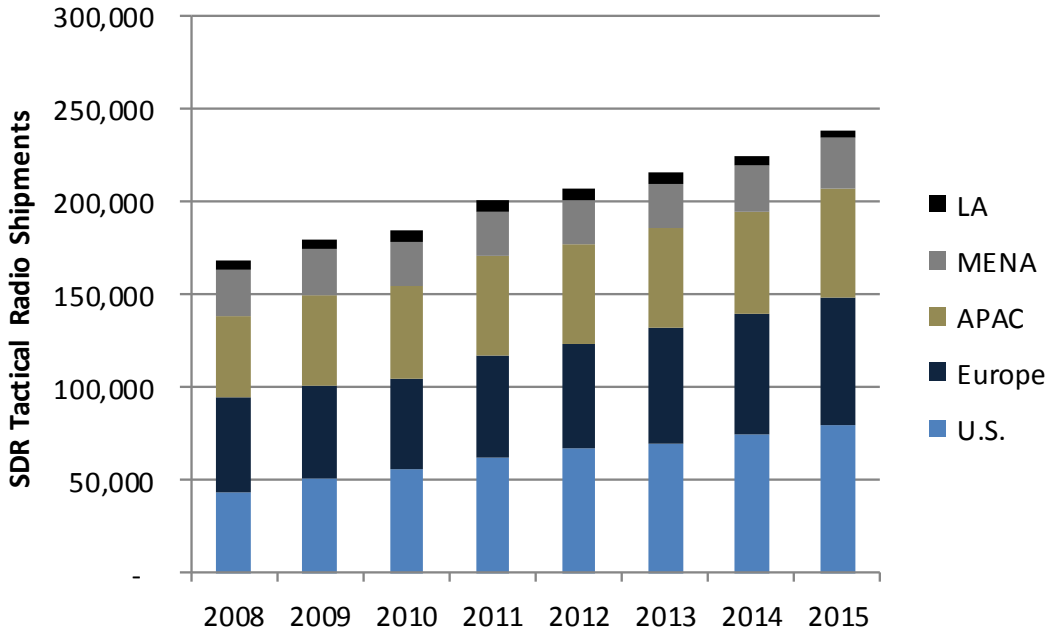
Worldwide spending on tactical communications radios should remain fairly stable over the next few years, with slow growth in the market. The United States represented 53% of the global market revenue during 2010, and should remain at 53-54% through 2015. Asia-Pacific and Europe will see slight growth in spending through 2015, while the Middle East, Africa, and Latin America will remain flat.

Chart 5: SDR Tactical Military Radio Revenue, 2008 to 2015



Source: Frost & Sullivan, Mobile Experts

Chart 6: SDR Tactical Military Radio Shipments, 2008 to 2015



Source: Frost & Sullivan, Mobile Experts

5: LAND MOBILE RADIO MARKET (PUBLIC SAFETY AND PRIVATE MOBILE RADIO NETWORKS)

In public safety and private land mobile radio, roughly 1-2 million radios are purchased per year, historically using inexpensive analog technology. Increasingly, low cost digital radios using SDR technology are taking over, especially as an increasing number add data communications (maps, video, etc).

Market Drivers

Interoperability is the major driver which is cited by municipalities, when they specify new public safety radio systems. The historical fragmentation of different land-mobile radio systems for police, fire, highway patrol, ambulance, and other emergency services makes for a nightmare scenario for inter-agency communication, and after September 11, 2001, massive government funding became available in the US to address interoperability. A few major government-sponsored programs such as Project 25 and TETRA have been initiated to drive improved interoperability into the the field radios.

In addition, in the United States the Federal Communications Commission ruled that public safety radios must migrate to a narrowband format (12.5 kHz) in order to clear congestion in the public safety bands. A surge of spending is anticipated to take place during the 2012-2013 timeframe for agencies to comply with the new ruling.

Congestion in communications is another major driver for SDR technology adoption in public safety radios. In highly impacted radio scenarios, the equipment needs to adapt to ease congestion.

In addition, public safety agencies are looking for reconfigurability to add new services. Most players recognize that the future will bring new data applications into the public safety arena, but nobody can predict exactly how the data will be used. As a result, the public safety agencies desire a radio platform which is reconfigurable and future-proofed.

In vertical markets such as construction, hospitality, and transportation systems, inexpensive digital mobile radios offer better battery life than analog alternatives, so simple DSP-based digital radios are becoming the most popular option.

Market Inhibitors

While the US Federal government has sponsored programs such as Project 25 through the Department of Homeland Defense and funded a variety of research and

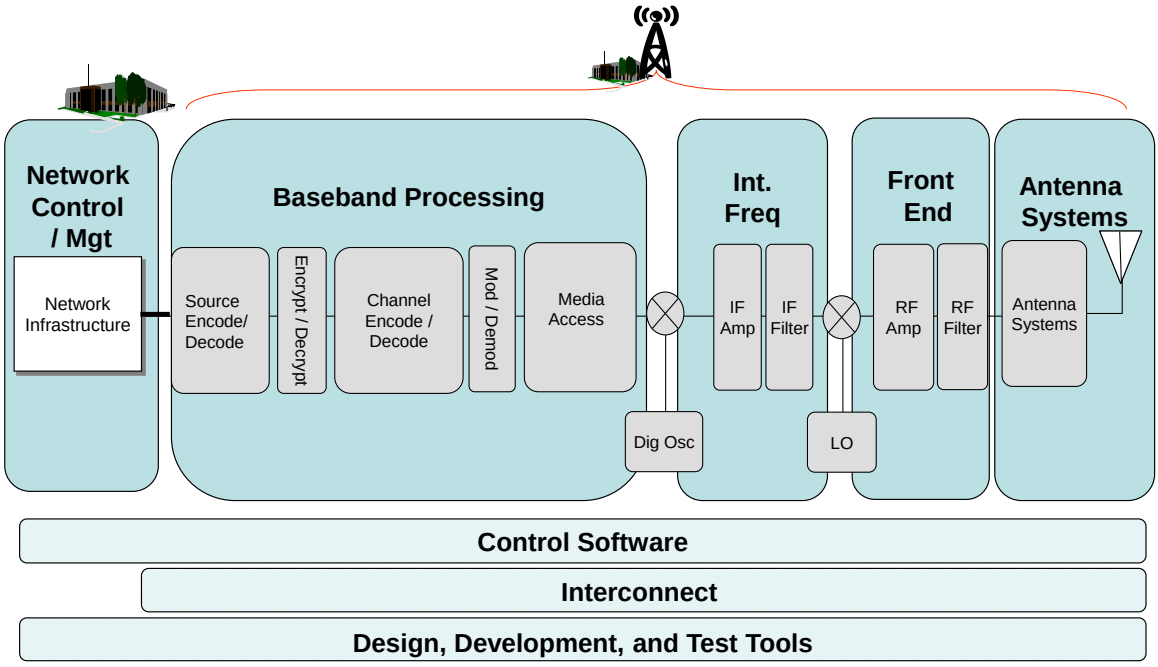
development to enable technology and study options, the overall plan depended on a commercial vendor purchasing 700 MHz spectrum to be devoted to interoperable public safety radio. In 2009, the 700 MHz auction failed to attract a bidder with sufficient financial commitment to license the spectrum and roll out a nationwide network. As a result, many cities have applied for waivers to the overall project in order to deploy their own systems. In short, the grand plan has broken into smaller pieces due to lack of commercial support.

In Europe and the rest of the world, the market is generally limited by a long replacement cycle for radio equipment. TETRA has provided a common platform which enables some economy of scale, improving cost and overall availability of radios and infrastructure. Overall, the key remaining limitation is the overall economy and the ability for local government to fund upgraded radio sets.

SDR Adoption

Virtually all of the new public safety radio equipment sold on the marketplace (both in terms of base station infrastructure and field radios) has adopted software-defined radio technology. A typical public safety radio utilizes programmable baseband processing, which includes channel encoding/decoding, modulation and demodulation, as well as encryption and other functions.

Exhibit 3: Block Diagram for a Public Safety Software Defined Radio



Source: Noblis

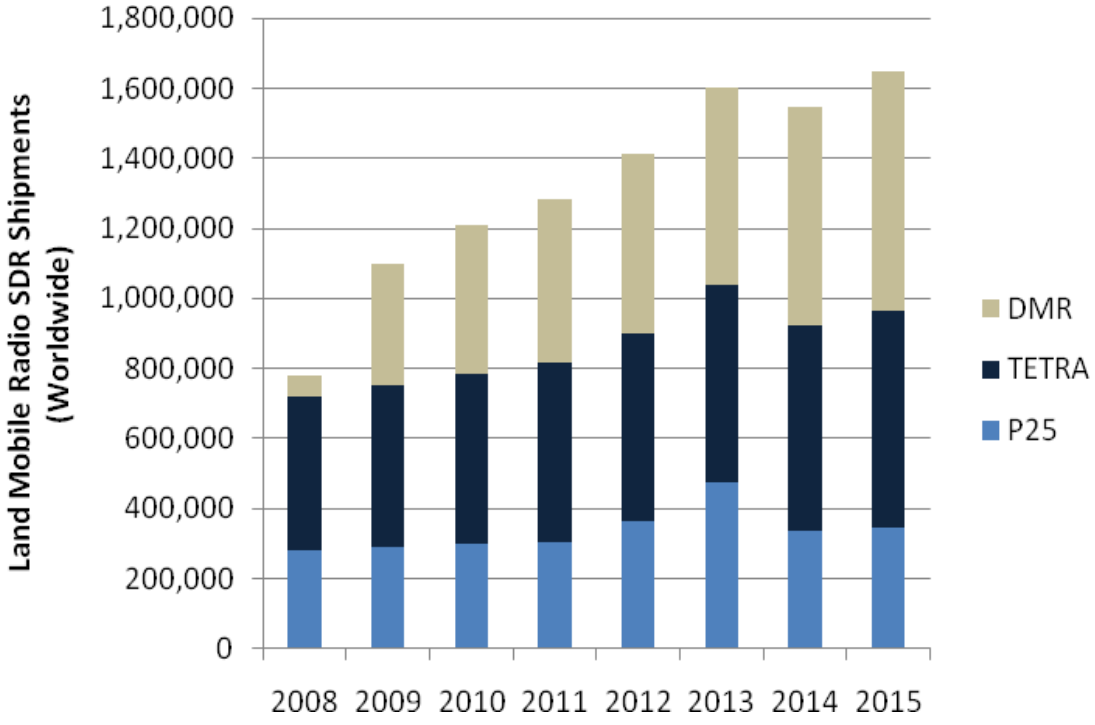
SDR Outlook

Global shipments of public safety radios will continue at a fairly steady rate over the next several years, because radio communications for public safety agencies will always be seen as essential. The replacement cycle for public safety radio was in the 20-25 year range during the 1980s and 1990s, but the replacement cycle has recently become shorter due to the availability of new technology, as well as changes in government regulations.

During 2012 and 2013, the US public safety market, represented roughly by the P25 standard, will experience an increase in shipments due to new rules that come into effect during 2013, requiring all US public safety agencies to comply with a narrowband waveform mandate, imposed by the Federal Communications Commission. Some radio replacements will be accelerated for purchase in 2012 and 2013 in order to comply with the new federal regulations. Accordingly, industry insiders expect a drop in US business during 2014.

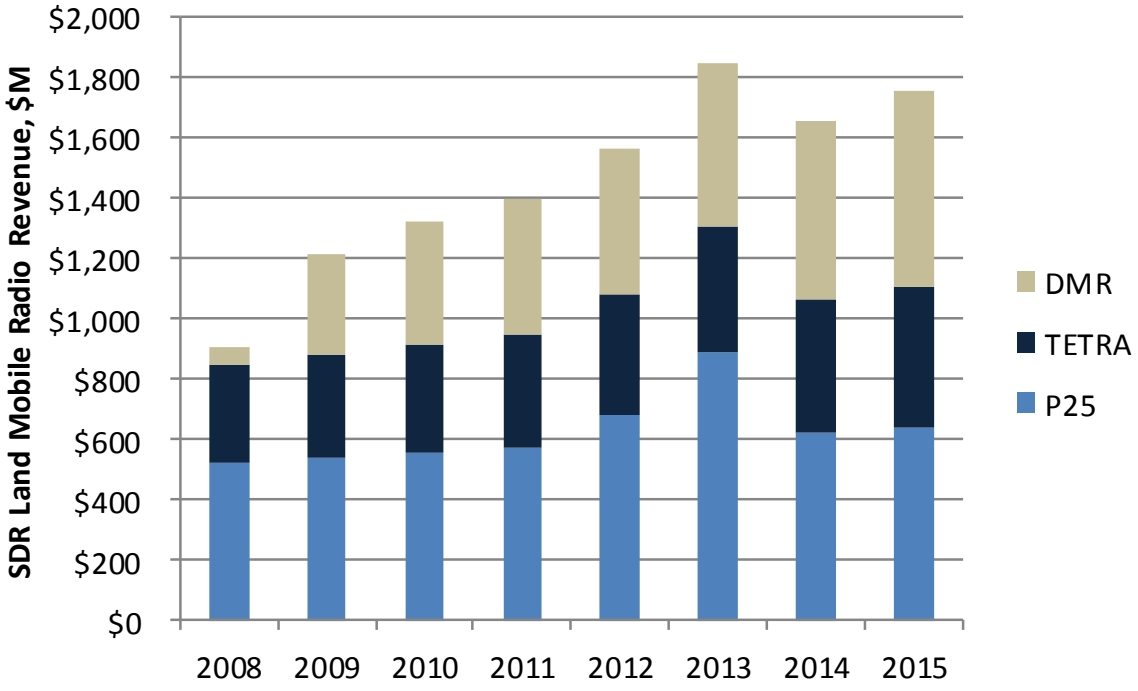
On the other hand, most of the world adopts the TETRA standard for public safety and the new DMR (Digital Mobile Radio) standard for private mobile radios used by taxi drivers, construction, hospitality, and other vertical markets. These two standards are quickly taking market share away from the roughly 1-2 million analog radio terminals which have dominated the annual shipments until now. With the introduction of DMR hardware in 2008, the DMR market has grown quickly due to low cost and improved battery life/functionality compared to analog alternatives.

Chart 7: Public Safety and Private Mobile Radio Shipments, Worldwide, 2008 to 2015



Source: Mobile Experts, US Congress, Sepura PLC investor info

Chart 8: Public Safety and Private Mobile Radio Revenue, Worldwide, 2008 to 2015



Source: Mobile Experts, US Congress, Sepura PLC investor info

6: SATELLITE COMMUNICATIONS MARKET

Satellite communications systems are unique, in that one end of the communications link is totally inaccessible for hardware upgrades. Software upgrades to a satellite are possible, but the cost of a space shuttle flight or replacement satellite would be incredibly high.

Market Drivers

The overall increase in multimedia data traffic on communications networks spills over into all areas of data communications. Defense, enterprise, and mobile backhaul applications are examples of forces behind the growth in satellite data communications traffic, especially in emerging markets with rural areas not covered by fiberoptic lines or other backhaul resources.

One strong growth trend involves the use of machine-to-machine satellite communications applications (such as geofencing, scientific monitoring, logistical tracking, etc). A wide variety of M2M applications has emerged during the past two

years and the shrinking size of embedded modems is currently enabling adoption in multiple new applications.

Market Inhibitors

The satellite link competes with fiberoptic lines and microwave point-to-point communications to connect local data traffic to the global network. As the fiber assets in emerging countries multiply and proliferate, the option to tie into a fiber will increasingly be more economical than a satellite link.

SDR Adoption

The extreme difficulty in making hardware changes to a satellite makes the satellite communications area an obvious candidate for programmable/reconfigurable radio elements. DSP and FPGA radio implementations have been common for over 15 years, such that most earth stations contain these programmable elements in the radio chain for modulation and encoding.

SDR Outlook

No industry analyst studies are available, projecting unit sales for software defined radios in the satcom market.

7: OTHER MARKETS

Other markets for software-defined radios are emerging in wireless sensors, intelligent automotive and transportation areas, as well as any communications in the "Television White Spaces".

Market Drivers

Machine-to-machine communications represents a growth segment for a huge number of applications… the general trend is for anything with an electronic function to be connected so that data can be tracked, operation can be automated, or multimedia content can be shared among multiple devices.

Many of these machine-to-machine applications are "bursty", short-distance links which do not necessarily need to occupy expensive 2G/3G/4G spectrum, and do not carry enough potential revenue to fit into the mobile business model. As these applications grow, financial pressure will grow to use either "free" spectrum or new spectrum which is otherwise not useful for other wireless services.

Intelligent transportation systems have received some attention due to the prospect of government funding for radio systems. However, funding has been slow to materialize, so this market segment is not progressing quickly at this time.

Market Inhibitors

Currently, the wide availability of 2G and 3G make new applications for short-range communications, sensors, and intelligent highways doubtful in the short term. Because existing wireless networks can handle small, bursty packets of data, the return on investment for a completely new system is inadequate to attract funding from private investors. Most market participants are holding out for government-funded research grants to support system development, especially in the case of public improvements such as intelligent automotive/highway networks.

SDR Adoption

Lack of spectrum will drive short-range communications into new frequency bands. The Instrumentation, Scientific, and Medical (ISM) bands at 900 MHz, 2.4 GHz and even at 5 GHz are becoming crowded with interference due to the huge proliferation of WiFi, Bluetooth, toys, garage door openers, and millions of other devices. As a

result, new modes and frequency bands will open up to address new communications applications.

Implementation of machine-to-machine communications in frequency bands shared by other services (such as television or radio) will require cognitive features to be implemented along with software defined radio flexibility. Whenever a radio is ready to transmit data, the link must be checked for pre-existing traffic, and the radio parameters must adapt to avoid interference. Frequency settings, modulation settings, power levels, and filtering may all be adapted to utilize spectrum which is nominally occupied by another wireless service.

As a result, we can expect all new implementations of machine-to-machine communications in "shared" spectrum bands to be implemented with programmable logic in the radio chain.

SDR Outlook

No quantitative industry analyst studies are available in TV White Spaces, Intelligent Transportation, and other emerging markets.

8: METHODOLOGY

Mobile Experts compiled the information in this report based on presentations, forecasts, and reports provided by multiple industry analysts and experts. Sources included:

- ABI Research
- ARCChart
- IMS Research
- Noblis
- Regent Square Group
- Signals Research
- Sepura PLC Financial Results
- US Congress Subcommittee on Science & Technology

In compiling the forecasts of software-defined radio shipments, Mobile Experts evaluated the forecasts of each industry analyst and industry source, and modified the forecasts as needed to conform with the Wireless Innovation Forum's definition of a Software Defined Radio.

In addition, Mobile Experts interviewed key industry insiders and industry analysts, to gain additional information regarding typical industry pricing, industry replacement cycles, new applications, and market growth trends. These primary inputs were used to extrapolate market revenues and unit shipment forecasts from the raw forecasts provided by individual industry sources.