WHITE PAPER

# Overview of SDR Market

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**This white paper contains the findings of independent research and analysis carried out by Informa Telecoms & Media during September and October 2008. The research was sponsored by ZTE.**

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## Abstract

Software Defined Radio (SDR) is the evolution of base station technology. Although too expensive to be considered in the past, underlying technology advances are starting to turn the new concept from expensive to efficient and even able to reduce costs. Several infrastructure vendors have now implemented SDR in their product portfolio and mobile operators are now realising that the new technology can provide significant cost savings, lower the Total Cost of Ownership (TCO) for a newly deployed network and provide compatibility with future standards.

LTE is widely accepted as the air interface of choice for 4G networks worldwide. The majority of Tier-1 mobile operators, including Vodafone, T-Mobile, Verizon Wireless and Orange have identified that LTE will be necessary to fulfil the growing demands of data-hungry end users in the years to come. However, LTE will require additional hardware expenditures both on the radio and core networks, meaning that mobile operators may be reluctant to experience another capital intensive upgrade cycle. Moreover, several mobile operators are currently experiencing capacity problems on their HSDPA networks, meaning that they will have to upgrade current hardware to satisfy current demands. By using SDR today to satisfy short term capacity demands, mobile operators will be able to reuse this hardware to later rollout LTE, thus minimising costs and removing the need for forklift upgrades when LTE enters the mass market.


# Introduction

With the growing number of access technologies and air interfaces, mobile operators are faced with the daunting task of carefully deploying current networks but also maintaining compatibility with future standards that have not yet entered the market. In developed markets in particular, mobile operators may be faced with radio infrastructure lifecycles of a few years, making it extremely hard to secure Return on Investment (ROI) for newly deployed equipment since marketing and user adoption always lags technology upgrades. Nevertheless, mobile operators follow predetermined technology evolution paths – including GSM to WCDMA to HSPA to LTE – but as technologies evolve, existing hardware that has not been designed for future upgrades has to be replaced or additional overlays need to be added. Especially with LTE which aims to change the air interface from CDMA to OFDM, existing equipment may have to be completely replaced. However, infrastructure vendors and operators are now looking at Software Defined Radio (SDR) as a way to minimise risk and costs regarding future infrastructure upgrades.

SDR is an umbrella term that covers a plethora of technologies and solutions, ranging from reconfigurable base stations to systems that can adapt to new technologies or new frequencies on the fly – without the system suffering any downtime or users experiencing service interruptions. Although SDR promises several benefits to mobile operators, a cost effective implementation is not without challenges. Indeed, true forms of SDR are only economically viable for military or government applications, but telecoms applications are starting to take advantage of the new concept to give mobile operators a guaranteed evolution path to future technologies.

## What is SDR?

Although SDR is now receiving increasing interest in telecoms, it is hardly a new concept. It has been used for military and government applications for several years but the technology is very expensive for commercial application.

SDR defines a telecommunications system where typical hardware components are implemented in software. Although the ideal concept of a SDR system is defined as a DSP connected to antenna, there are several hardware limitations that do not allow the implementation of specific components in software. Nevertheless, the SDR Forum defines the concept under several terms:

*Table 1: SDR Forum definitions*

| Term | Definition |
|---|---|
| Software Controlled Radio | Radio in which some or all of the *physical layer* functions are controlled by *software* |
| Software Defined Radio | Radio in which some or all of the *physical layer* functions are *Software Defined* |
| Adaptive Radio | Systems that *monitor* their own performance and *adapt* to improve their performance |
| Cognitive Radio | Radio that is *aware* of its environment and *internal state* and can make informed *decisions* |
| Intelligent Radio | Cognitive radio capable of *machine learning* |

*Source: SDR Forum*

The ultimate radio system is intelligent radio, which can fully adapt itself for new frequencies, modulation schemes and access technologies but is not feasible with current chipset technology. On the other hand, Software Controlled Radio (SCR) and SDR are now currently entering the market through major infrastructure vendors and being deployed by mobile operators in developed markets, especially where mobile broadband is proving popular. This white paper will examine SDR and SCR in the context of reconfigurable base stations, i.e. base stations that can be software upgraded to future technologies and standards.

SDR is defined as a system where several functions – typically implemented in hardware – are instead implemented in modifiable software components that run on flexible and powerful processing, usually Flexible Programmable Gateway Arrays (FPGA), Digital Signal Processing (DSP) chips and microprocessors. This flexibility allows new functions to be implemented without changing any hardware or even the air interface to be changed without additional requirements.

## Benefits

Ideally, an SDR chip will enable radios to be reconfigured, upgraded over the air, and turned on and off. It will also enable the signal power to be managed and handled at the software level while keeping the end-user from having to worry about the technology being used and offering an "always best connected" experience regardless of location, network or device.

### *Hardware benefits*

Compared to other hardware platforms, SDR presents significant benefits. The following table illustrates a feature comparison between ASIC, FPGA and SDR running on DSP. SDR has benefits

over both hardware platforms, with the exception of complexity; indeed, the software that is running on the DSP can be complex and the upgrade procedures intricate. Nevertheless, mobile operators do not have to get involved in these maintenance procedures as infrastructure vendors usually manage software upgrades.

*Table 2: Hardware comparison*

| | ASIC | FPGA | DSP (SDR) |
|---|---|---|---|
| Flexilibity | ○ | ◑ | ● |
| Cost | ● | ● | ● |
| Evolution path | ○ | ◑ | ● |
| Complexity | ● | ● | ○ |
| Size | ● | ◕ | ● |
| Power | ◕ | ◑ | ● |
| Time to market | ◑ | ◑ | ◕ |

*Source: Informa Telecoms & Media*

Although cost has previously been the most significant barrier for SDR adoption in the mobile market, Moore's law has allowed DSP processing power to double every year. This now allows SDR to run efficiently in modern DSP hardware, offering an alternative to technology-specific hardware.

## Challenges

Although SDR certainly presents several advantages for mobile operators, there are some challenges to be assessed before SDR can be widely accepted into the market. These are summarised in the following list, prioritised according to importance given by mobile operators as of 2H 2008.

*Cost*

The cost of true SDR systems is still far higher than operators would expect to invest for a base station. Such a system would be frequency and waveform agnostic, meaning that the majority of future systems would be supported. Nevertheless, the cost of implementing these features makes these systems inapplicable to telecoms, mainly because of the unavailability of cost effective RF processing. Baseband processing capabilities are currently advanced enough to be relatively future proof but RF equipment - especially power amplifiers – have still not reached a commercial stage.

Effectively, these cost issues may make SDR ineffective for several operators, especially those that have not yet formulated their LTE strategies and are not sure what spectrum they will run LTE on. Infrastructure vendors report that this is a major issue as of 2Q 2008, especially with operators who are experiencing demand for mobile broadband but also want to ensure that current equipment installations are future proof and upgradable to LTE. However, operators – even in the developed markets of USA, UK, Germany and Japan – may not be certain which frequencies LTE will run on, meaning that current WCDMA/HSPA equipment running on the 2.1GHz frequency band may have to be switched if LTE is to run in higher – or lower – frequencies. Indicatively, if the frequency of operation is not maintained from WCDMA to LTE,

the upgrade cost may be up to 90% of the original base station cost since the baseband processing, RF unit and antennas will have to be changed.

*Technology*

Current RF and baseband technology means that additional air interfaces can only be implemented by adding a new hardware module to the base station. Although the baseband hardware platform is in most cases upgradable, RF technology necessitates that new modules have to be included to support new frequencies. There is ongoing research to produce more wideband amplifiers so that RF is installed once, but current technology is not able to provide a cost-efficient solution that can be applicable in future systems.

True SDR systems include software reconfigurability up to the power amplifier; this means that RF filters and mixers are also reconfigurable, something not available today. Nevertheless, there is ongoing research to achieve this, but mobile operators are apprehensive that current SDR base stations will require new hardware upgrades to support new air interfaces that are implemented in different frequencies.

*Operator circumspection*

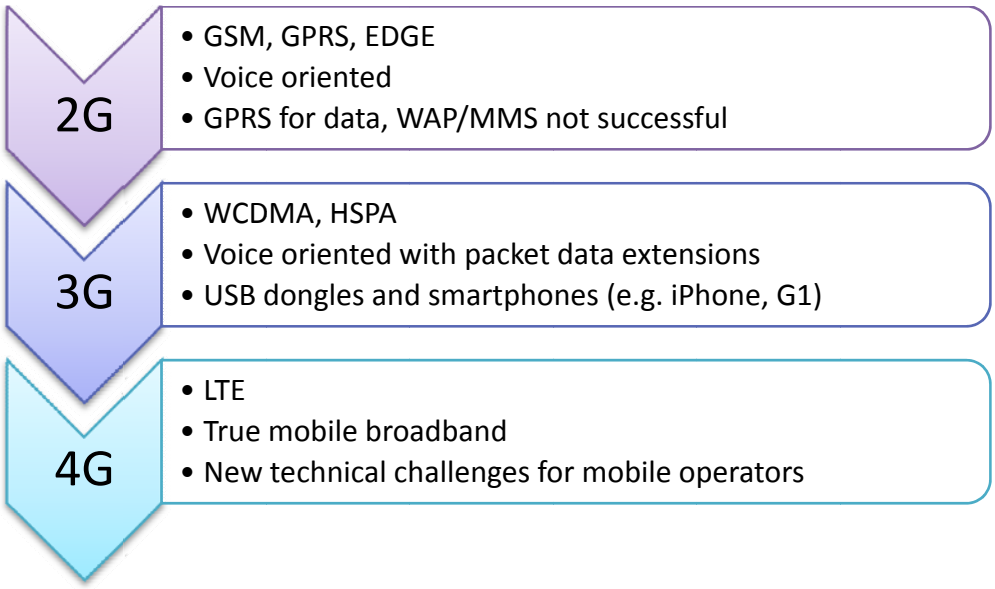
Operators have traditionally relied on hardware upgrades for new systems, usually with a single vendor in charge of all hardware installations, while maintenance and service are usually performed by the mobile operator. However, SDR will require a new relationship between the mobile operator and vendor, meaning that reconfiguration will be performed by the vendor – or that the operator will have to dedicate a team of software engineers to maintain their SDR base stations. Although the operator may have a simpler network to manage (through using a single hardware platform for all technologies), software reconfigurability is likely to be more complicated to maintain. In any case, SDR presents a new paradigm for mobile operators who are accustomed to hardware upgrades and single-vendor relationships.

# Market developments

The mobile industry is in the midst of a major transition from narrowband to broadband, voice to data and from its circuit-switched legacy to a future based on IP. But the scale of the transition means that both mobile operators and vendors have embarked on a grand experiment in transforming themselves to boost revenues and margins in markets that are often maturing, while keeping network and other costs under control.

One of the most successful aspects of this transition has been the introduction of mobile broadband services based on new technologies, including EV-DO and HSPA. EV-DO services were first introduced in 2002 and gradually matured into true mobile broadband services, with 141 live networks by January 2008. But the mobile broadband market really started to take off in 2006 and 2007 with the widespread deployment of HSDPA services.

*Figure 1: Mobile network evolution*




*Source: Informa Telecoms & Media*

After the first launch of HSDPA services by AT&T (then Cingular) in the US in late 2005, the system spread like wildfire to the vast majority of WCDMA operators worldwide. By January 2007, a little more than a year after the first HSDPA service was launched, there were 72 live HSDPA networks worldwide, and that more than doubled to 166 live networks by January 2008. To put that into context, in January 2008 there were 189 live WCDMA networks worldwide, meaning that 88% of them had been upgraded to offer HSDPA services.

Widespread availability of mobile broadband networks combined with competitive tariffs has led to a boom in mobile broadband subscribers. At the end of 2007, there were an estimated 60 million EV-DO subscribers worldwide and another 22 million HSDPA subscribers – and HSDPA in particular is ramping strongly. Informa Telecoms & Media predicts 51 million HSDPA subscribers worldwide at the end of 2008, and there will also be close to 5 million HSUPA subscribers.

However, the catch for operators ramping up mobile broadband services is that data traffic is growing much faster than data revenues. In its annual results statement, Vodafone notes that data volumes increased more than tenfold in the year ended 31 March 2008 compared with 2007, versus a 55% increase in data revenues.

Although it does not detail the costs associated with the tenfold increase in data volumes, it is clear that data traffic has a direct impact on network costs. It also means that mobile operators are now grappling with the challenges faced by ISPs in the early years of the fixed broadband Internet – how to scale their networks and cost structures to cope with data volumes that are growing dramatically faster than data revenues. And mobile operators have the additional challenge of scaling up networks that are based on extremely scarce and thus expensive radio spectrum.

All mobile operators are facing the same dilemma, and it is only going to get worse, according to Informa Telecoms & Media forecasts. While the mobile industry will see total global data

revenues grow at a CAGR of 12% from US$135 billion in 2007 to US$240 billion in 2012, total global data traffic will grow at a CAGR of 64% over the same period. In other words, in 2012 mobile data revenues will be 77% higher than in 2007, while mobile data traffic will be 1088% higher than in 2007.

*Less investment for base stations*

Many mobile operators – particularly HSDPA operators – can cope with the mobile broadband traffic boom in the short to medium term because there is a huge amount of spare capacity in their networks.

This is partly due to slow take-up of early 3G services and partly due to the technical characteristics of WCDMA, which has relatively large 5MHz channels. One result is that, in their initial rollouts, WCDMA operators had to deploy a huge amount of capacity relative to previous technologies such as GSM, which uses 200KHz channels. Of course, WCDMA is an evolution of GSM and was specifically designed with wide channels to support higher data speeds and more advanced services, but slow early take-up of these services has left many operators with a huge amount of spare capacity in their networks.

Informa Telecoms & Media expects increasing mobile traffic to be supported in large part by base stations that are already deployed, contributing to a decline in global base station unit sales through 2009 and in global base station revenues through 2010.

Of course, mobile broadband is not the only factor driving operators to deploy base stations. India, China and other emerging markets continue to add huge numbers of base stations to support mainly voice services, but there are indications that the pace of deployments in some major emerging markets are slowing. On a global level, the increases in unit sales in some key markets are more than offset by declines elsewhere.

Other factors impacting the base station market include fierce price competition among mobile network vendors, despite the wave of consolidation that reduced the number of major competitors in the market via the creation of Alcatel-Lucent and Nokia Siemens Networks. Price competition – mainly from Asian vendors ZTE and Huawei – is making the base station market one of the most competitive in telecoms.

## Network convergence and evolution

As mobile operators experience a traffic boom in their networks, there will be an increasing need for capacity improvements or even forklift upgrades in older systems. In seeking to upgrade their systems mobile operators will also be sensitive about evolving these to future systems and they will not have to invest in completely new hardware when choosing to upgrade to future systems, including Evolved HSPA and LTE.

Several mobile operators invested billions in 3G licences and RAN equipment after 2000 but as of 2007, have not yet experienced positive ROI from mobile data services. As 3Q 2008 is ending, mobile operators are seeing mobile broadband services take off, mostly based on the HSPA family of technologies. The ROI cycle has taken nearly 8 years, something that operators may not want to repeat with current upgrades and investments. As a result, operators are wary that current

hardware must be future proof and that some level of compatibility with future systems must be maintained.

Even in developing markets where GSM is currently growing, mobile operators need flexible platforms to make sure that they do not repeat the mistakes Western European operators made during the early phases of 3G. In these markets, a flexible hardware platform which can be upgraded to 3G through software can ensure that both GSM and 3G subscribers are catered for without causing network disruptions.

Several operators in developed markets have invested in equipment from multiple vendors as they have upgraded their networks. These operators are finding it increasingly difficult to maintain their networks as several support mechanisms are necessary for each system. In these cases, a single hardware platform that is software reconfigurable can provide significant cost savings in network management and can be a key mechanism in making the core of the operator business simpler.

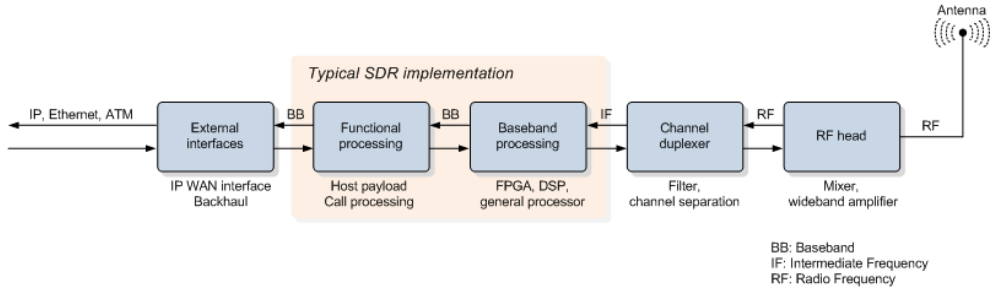
# The need for SDR

SDR presents a new concept for mobile operators and allows them to have a simpler, more efficient network and in many cases, a guaranteed evolution path to future technologies. In most cases, current base stations need to satisfy several prerequisites to be considered for deployment. Base stations need to:

- Be wideband enough to be able to run several air interfaces in the same frequency band. For example, running GSM and UMTS simultaneously at the same frequency in the same hardware platform will provide significant cost savings for operators in emerging markets.
- Not be constrained to a single waveform. Existing equipment must be upgradable to future air interfaces, either by software or by adding a new baseband processing card to the installed hardware platform. The majority of infrastructure vendors now claim to support LTE through a card addition to their baseband units.
- Have upgradable processing capabilities for future air interfaces. This is especially applicable to LTE, which is expected to require additional processing at the base station due to its low latency, higher bandwidth requirements. Existing base stations need to be hardware upgradable to more powerful processors.
- Be environmentally friendly. Power consumption is receiving increasing interest as operators aim to operate “green” networks. Moreover, savings power in the base station will result in far lower operational expenditures. Mobile operators have traditionally relied on running several independent equipment racks for different air interfaces. However, a single hardware platform that can run all of these simultaneously can limit power costs greatly.

In order to satisfy all of the above, base stations need to be reconfigurable and have flexible hardware platforms. A form of SDR is the only solution in the long term and operators are now coming to realise that they can benefit now and in the future by deploying a flexible base station.

*Figure 2: Typical SDR base station implementation*




*Source: Informa Telecoms & Media*

### *Network evolution*

Mobile operators that have invested in UMTS and other 3G technologies may now be reluctant to engage in a new round of investments to upgrade their networks to 3G+ or even plan a large investment campaign to rollout LTE on their networks. However, several mobile operators are now finding that their 3G networks are saturating due to increased mobile data usage and that they have to embark on a new upgrade campaign to satisfy existing – and short term – demand. Effectively, this means that additional hardware equipment will be necessary in base stations and operators must remain aware of new technologies and air interfaces.

Several operators that are now performing capacity upgrades are switching to software reconfigurable base stations in order to either maintain compatibility with future standards or they have simply found out that an SDR base station will yield performance and financial benefits even in the current market status.

### *Applications in GSM/UMTS*

Infrastructure vendors have illustrated SDR base stations that can operate two systems simultaneously. These are primarily GSM and UMTS, following market demand for emerging markets where both a GSM and UMTS subscriber base has to experience growth without sacrificing either one in favour of cost issues. In this case, the GSM subscriber base has to be increased and additional hardware is required in the RAN but also UMTS must be introduced without heavy additional capital expenditures. Especially in the case where operators obtain the licence to run both 2G and 3G in adjacent frequencies, SDR base stations can yield significant cost benefits, as a single hardware platform can effectively replace two. However, in most cases two RF units will be necessary and the baseband processing is likely to be shared as GSM and UMTS run on the 900MHz and 2GHz frequency bands respectively.

Interest in SDR for existing air interface technologies and reducing costs for operators illustrates that SDR must not only be considered in developed markets to ensure compatibility with future standards; mobile operators in developing markets may benefit substantially from SDR base stations and can be equipped with a competitive advantage that can give them a significant edge compared with other mobile operators.

## Benefits to mobile operators

Despite having a guaranteed evolution path and not being tied in to a single technology, operators are presented with several advantages when choosing to deploy SDR. The following list summarises key benefits for mobile operators.

- Clearer and simpler network: Instead of running separate hardware platforms for each technology, operators can have different air interfaces implemented in software on a single hardware platform. Fewer engineers are required since there is a single platform to manage, maintenance and service is also simpler and operational expenditures are kept to a minimum compared to running several hardware platforms.
- Lower Total Cost of Ownership (TCO), even for existing technologies: Although SDR base stations are typically more expensive than a single-technology equivalent (Informa Telecoms & Media estimates an SDR base station to cost 1.2-1.3 more than a single technology one), the TCO for a mobile network is many times lower than performing forklift upgrades or hardware upgrades for new air interfaces.
- Lower investment risk: Since hardware platforms can be reused, there is significantly less investment risk for deploying hardware. Moreover, as the SDR market develops, it is expected that some form of standardisation will occur, potentially allowing hardware to be reused between different vendors.
- Competitive network evolution: Mobile operators that have invested in SDR can have a significant advantage over their competitors that require hardware upgrades to implement a new air interface. Time to market for implementing a new technology is also minimised (assuming that the new technology runs on the same frequency as the hardware platform) since only a software upgrade is necessary to include the new air interface.

## SDR usage scenarios

SDR can be used in a variety of scenarios, but current market trends indicate that it can provide significant benefits if it is deployed as a common hardware platform, on top of which two – or more – technologies operate. Especially in developing markets that are price sensitive and cost driven, mobile operators will be able to save significant capital and operational expenditures and also gain a competitive edge against rivals if they deploy a single platform for both voice and data solutions.

Mobile operators have expressed interest, mainly in running GSM and 3G in the same platform. However, there are few operators currently able to do this since spectrum is usually licensed for single technology use and advanced air interfaces require more spectrum than originally licensed for the voice-centric 2G networks. It is anticipated that there will be opportunities for spectrum reuse – especially in the developing markets of Africa, Asia and Latin America – and operators will be able to offer both narrowband (voice) and wideband (broadband data) services through a single frequency.

Current GSM networks will require forklift upgrades to support 3G, leading to increased capital expenditures and little forward compatibility if a hardware upgrade is chosen. Although a SDR solution will most likely be more expensive than a single technology upgrade, mobile operators

will be able to have a more efficient network, save on operational costs and also maintain compatibility with upcoming 3G+ and 4G standards.

The Global Mobile Suppliers Association (GSA) reports that there are currently several UMTS networks now operating at 900MHz, including Optus Australia, Elisa Estonia and Finland, AIS Thailand and several others in both developed and developing markets. Moreover, the Office of Communications (Ofcom) in the UK has announced plans to make spectrum acquisitions agnostic to air interface technology, meaning that operators that have already acquired spectrum at the lower 900MHz band may choose to deploy UMTS on the same frequency and migrate their subscribers to 3G. Similar developments are expected around the globe, as governments start to "relax" spectrum licences.

3G networks have inherently better spectral efficiency and coverage is better at lower frequencies, meaning that mobile operators will be able to achieve a much more efficient network. Handsets and devices are following network developments and are expected to achieve the necessary economies of scale within the next few years.

However, several operators may be unable to run both 2G and 3G networks in the same frequency band, meaning that they will have to operate in two frequency bands, similar to 3G operators in Western Europe, US, Japan and other markets where UMTS and CDMA2000 have been launched. In these markets, it is common to run 2G service at 900MHz/1800MHz and 3G services at the 2.1GHz band, meaning that a single hardware platform cannot be completely reused for both air interfaces.

In these cases, different RF components must be used for the two frequencies, but SDR is still used at baseband processing to provide flexible and upgradeable functionality to run current and future technologies. The RF front end is usually constrained by the bandwidth performance of the power amplifier; ZTE is considered to be among the pioneers for SDR in telecom networks and its power amplifier supports up to 20MHz bandwidth. This ensures that current 2G, 3G and even the upcoming LTE air interface will be supported (LTE is expected to have a maximum of 20MHz bandwidth).

Operators that are now choosing to deploy in two frequencies are increasingly looking at SDR to reuse computational functionality at the base station for future standards. Even though using two different RF platforms will be more expensive compared to using just a single hardware platform, operators will still benefit from software upgradeability in the baseband processing.

## Future SDR trends

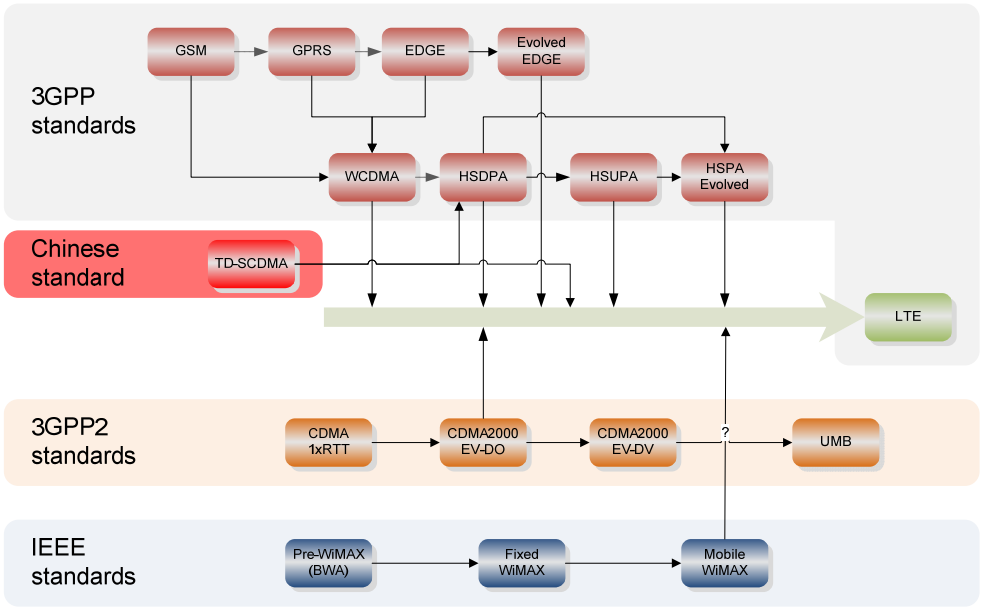
The infrastructure market currently indicates that additional cost savings and efficiency are required in networks; both are possible with SDR solutions. However, mobile operators are now seeking assurance that SDR base stations will require little capital to upgrade to future standards. Effectively, this means that current SDR solutions will need to evolve in technical efficiency in order for operators to truly regard SDR as a core component of their business model. Chipset manufacturers and infrastructure vendors are working to make SDR a better technology and are focusing on several issues, including:

- Higher bandwidth power amplifiers (PAs) to allow amplifier reuse for several technologies. Current amplifiers are cost and power efficient up to 20MHz for commercial use, a figure which is far too low to be used for more than one air interface.
- Higher computational power for baseband processing: Future technologies, - particularly LTE – will require higher bandwidth, faster data rates and lower latency, meaning that the computational burden on the base station will be several times higher than today's implementations. Chipset vendors are now working on faster DSPs and FPGA chipsets that will allow these. A faster communication bus between these hardware components is also being developed, as the communication between the hardware components is now proving to be the processing bottleneck.
- Baseband processing to take place in RF. This is the ultimate SDR concept, meaning that all aspects of the base station are implemented in software and the power amplifier will be the only component that remains in hardware. This will mean total reconfigurability and upgradeability but is currently not possible for 3G frequencies and certainly not cost efficient. Research organisations have performed this up to 800MHz but are now discovering that there is a critical limit in moving to higher frequencies, due to the unavailability of such high bandwidth RF components and the computational complexity required.

## Evolution to LTE

The majority of mobile operators have now declared that they believe LTE will be the technology of choice for the future. As of 3Q 2008, no operators have expressed interest in UMB (evolution of CDMA2000) and there is not a great deal of interest either in the operator community for WiMAX (apart from Sprint and smaller, regional operators that are deploying WiMAX for fixed services).

*Figure 3: Telecommunication network evolution*




*Source: Informa Telecoms & Media*

The vision for the evolution of HSPA to Evolved HSPA and eventually to LTE is now dominating the market and it is clear that LTE will be the preferred 4G standard. The chart above illustrates air interface evolution and possible paths for network upgrades.

Mobile operators that are upgrading their networks to new technologies or adding further capacity will be aware that current hardware may have to be replaced in order for LTE to be deployed. Although SDR may alleviate some of these concerns, there are still issues to be resolved regarding LTE.

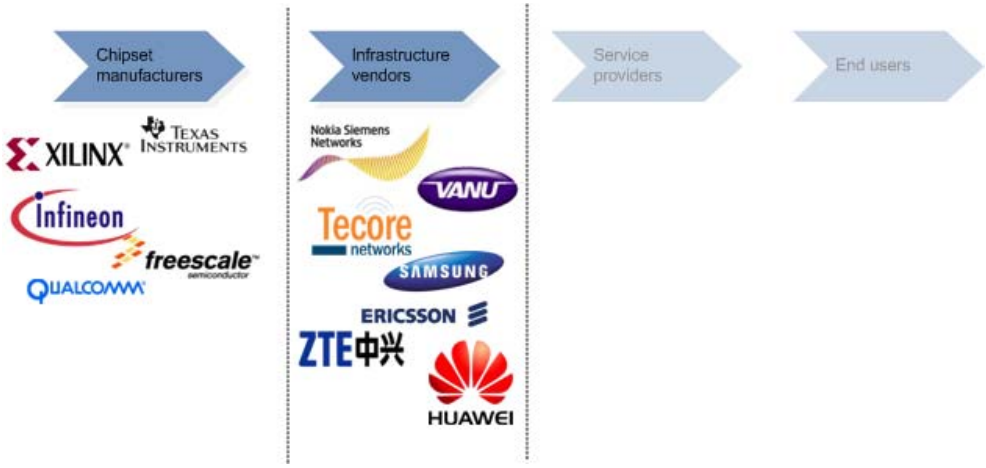
Firstly, mobile operators are not yet clear when LTE will be necessary in the market and secondly, it is unclear which spectrum holdings mobile operators will use to deploy LTE. It is expected that several frequency bands will be used worldwide, including 900MHz, 1800MHz, 2100MHz, 2.6GHz and country specific bands, including the 700MHz band in the United States and other areas where spectrum refarming will take place.

Informa Telecoms & Media expects that 2009 will be integral for operator strategies, and 2010 will see initial networks being rolled out on small scales. SDR is expected to be a major component of mobile operator strategies for LTE, as operators will come to realise that a scalable and efficient hardware platform is necessary to maintain future compatibility, achieve lower TCO and remain competitive when air interfaces are updated.

## SDR value chain

The SDR value chain is characterised by few players, mostly chipset manufacturers and infrastructure vendors. Both are innovating in the evolution of the technology, but vendors usually provide the necessary expertise and manpower to package powerful hardware platforms into upgradeable base stations. The following diagram illustrates the SDR value chain.

*Figure 4: SDR value chain*




*Source: Informa Telecoms & Media*

Chipset manufacturers are providing faster DSPs and FPGAs that can run current and future algorithms. DSPs are usually used to calculate specific parameters which are fed through to FPGAs that actually run the algorithms. The latter are actually considered the most powerful computational platforms in 3Q 2008 and are expected to remain so in future SDR implementations.

Infrastructure vendors are using these components in a variety of hardware platforms in order to implement their versions of SDR base stations. The baseband processing is the heart of the base station and is usually based on a proprietary, vendor specific implementation that follows the standard dictating the air interface. Several Tier-1 vendors have started offering SDR base stations, including ZTE, Huawei and NSN.

## Infrastructure Vendors

The majority of infrastructure vendors have included reconfigurable base stations in their product lines, and are currently (during 3Q 2008) promoting their cost savings capabilities, more efficient operation of the network, environmental friendliness and future upgradeability. The following table illustrates base station offerings by the top five infrastructure vendors that include some form of reconfigurability.

*Table 3: Major infrastructure vendor SDR products*

| Vendor | Product | Details |
|---|---|---|
| **ZTE** | ZXSDR 8200, 8800, 8840, 8860 and 8900 | MicroTCA platform<br>Simultaneous GSM/UMTS<br>Software upgradeable to LTE<br>CDMA and WiMAX in future upgrades |
| **Huawei** | 4th generation BTS | GSM/UMTS dual mode operation<br>Also supports HSPA/LTE |
| **Ericsson** | RBS6000 | Supports GSM, UMTS, HSPA, LTE<br>Available end-2008<br>Modular approach for upgrades |
| **NSN** | Flexi BTS | Supports GSM, UMTS, HSPA, LTE<br>Also supports NSN's iHSPA<br>Can operate LTE and WiMAX simult.<br>LTE software upgrade available 2009 |

*Source: ZTE, Huawei, Ericsson, NSN*

ZTE was one of the first vendors to launch a SDR base station that can be upgraded to LTE through a baseband add-on and a software upgrade. Several other vendors have followed and are now launching – or have already launched – SDR base stations. The form of SDR implementation in base stations varies and each vendor may have chosen a different level of commitment for

software reconfigurability. ZTE and Huawei are the only vendors that support dual mode GSM/UMTS operation in their base stations, ZTE having released the platform first. However, dual mode SDR deployments have been limited to date and are now slowly entering the market.

ZTE claims that its base station platform saves up to 40% on power costs by using a high efficiency power amplifier and has an almost 30% lower TCO for mobile operators that deploy a SDR solution rather than a standalone base station. ZTE is also planning to continuously evolve its product line to offer advanced base stations for mobile operators, including dual and multi mode products that operate several air interfaces in one hardware platform.

# Operator views

Several operators are currently assessing the feasibility and cost savings that SDR can offer to them and are starting to include the new concepts in their networks. Flagship network operators, including Vodafone Spain, Hong Kong CSL and others, are proving that SDR can increasingly save costs in the network and are acting as greenfield attempts for SDR. Although the majority of mobile operators are now deploying SDR for future upgradeability, Hong Kong CSL has consolidated hardware from several infrastructure vendors into a single platform and is now operating a much more cost effective and efficient network.

## HK CSL case study

CSL is the largest operator in Hong Kong with more than 3 million subscribers in 3Q 2008. It operates GSM and UMTS networks under several commercial brands and is a subsidiary of Telstra, Australia's leading telecoms operator.

CSL has been operating a large, complex network with over 2000 sites that were built on hardware from different infrastructure vendors. This has eventually resulted in a large scale complex network that was difficult to manage, required separate support and transport platforms, different radio access layers and a complex hardware infrastructure. Moreover, there were limited opportunities for network evolution, since network upgrades would have to rely on a multi-vendor effort that would be very expensive.

CSL has chosen ZTE to replace existing hardware with a single, expandable and efficient SDR platform that can be easily managed. CSL has replaced multi-vendor hardware with a single platform that runs both GSM and UMTS simultaneously, leading to a much more efficient and simple network. A single hardware platform was used, with different Radio Remote Units (RRU) for each frequency that were placed near the antenna (distributed base station) for additional RF cable savings.

Although CSL has made a large investment, it has thus ensured future compatibility with HSPA and LTE without compromising its current offerings. Savings in operational expenses are expected to offset the initial capital expenditures within a short timeframe. While SDR is deployed here as a way to save costs on the current network, the CSL deployment demonstrates that mobile operators wishing to make their current networks more efficient will be able to do so with SDR.