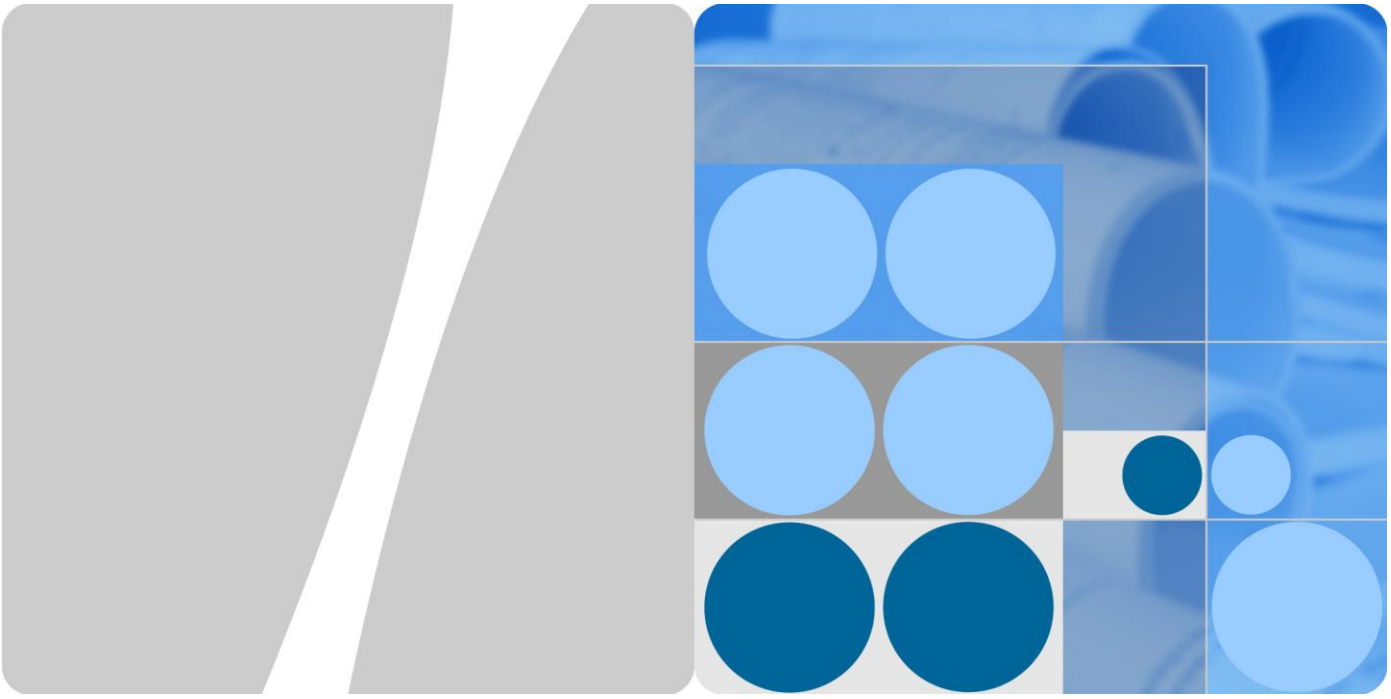


# LTE 1800MHz Ecosystem Drivers

Issue 1.0

Date 2011-3-27

**HUAWEI TECHNOLOGIES CO., LTD.**

# Contents

# 1. Executive Summary

In December 2009 Nordic operator TeliaSonera launched the world's first LTE network in 2.6GHz, since then LTE has boomed around the world. The spectrums of LTE in 2010 were mainly 2.6GHz, DD800MHz and U.S. 700MHz, whereas the 1800MHz spectrum band, even though it is widely held is underutilized because of declining 2G users.

Huawei believes refarming 1800MHz for LTE is the most feasible and cost efficient way for operators to provide high speed data services and allows early market entry. It has the following advantages:

- Access to MBB's advantage for short time to market.
- Reutilising spectrum saves CAPEX.
- 3GPP band3 is widely available globally.
- Reusing infrastructure cables, antennas & sites saves CAPEX.

2011 will see a variety of LTE1800 Multi-mode terminals, dongles and handsets, enter the market. Chipset vendor Qualcomm already provides 1800MHz Multi-mode chipsets whilst vendor Hisilicon will soon have Multi-mode & Multiband chipsets available for data modems and handsets.

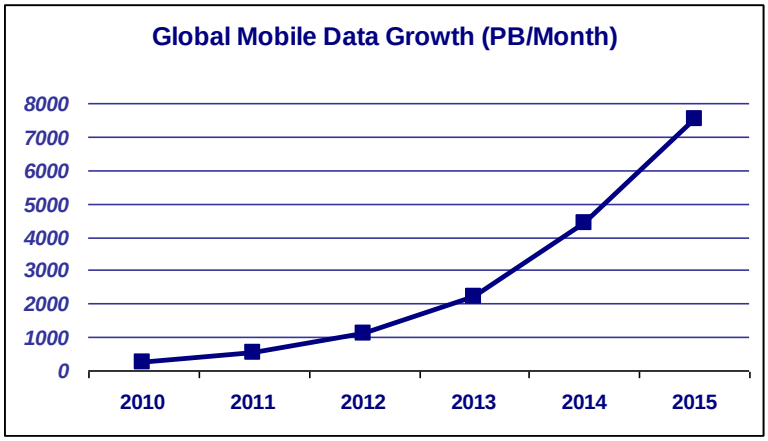
Refarming 1800MHz for LTE will employ similar techniques to those used in UMTS900 in 2008.

# 2. Introduction

## 2.1. The Challenges

Fast wireless broadband growth has seen increased levels of penetration from data devices such as smart phones, tablets, laptops & dongles. With this increase has been a rise in usage per device for access. Demand for Data has seen global traffic volumes double each year. In some cases operators are already experiencing congested networks due to high data demand by users.

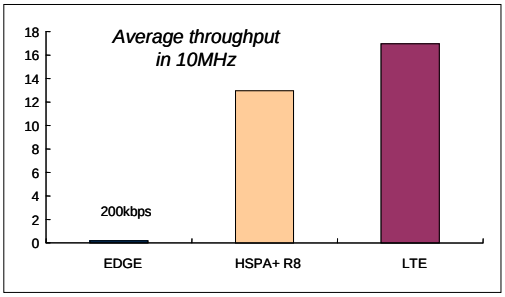
Fig1. Global Mobile Data Growth, source: Huawei

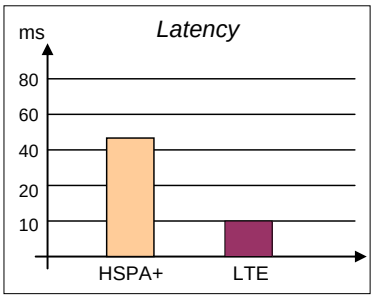



## 2.2. Why 1800MHz LTE?

### 2.2.1. Capacity Expansion Options

To meet demand for MBB capacity, solutions with multiple dimensions and options are required. This will include deploying more sites & smarter traffic management (DPI, QoS etc), more spectrum with a higher spectral efficiency (more efficient data delivery). In addition to this lower latency (deliver more data with less TCP slowdown effects) will be required. Compared with GSM/EDGE and HSPA+, LTE spectral efficiency is much higher and the latency is designed much lower than 2G/3G system. See table below: Throughput and latency.



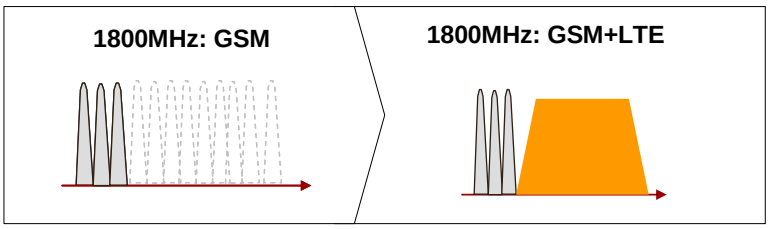




## 2.2.2. Spectrum Availability

As governments switch from Analogue to Digital TV, additional spectrum will become available. Governments are likely to auction this off, the cost to acquire additional spectrum is still a big unknown. Lack of new spectrum and the phenomenal rise in data traffic requires existing spectrum be fully utilized.

The 1800MHz band has the richest resource of spectrum and 75MHz of paired FDD spectrum has been defined in 3GPP Band3. There are 50+ operators out of 20+ European countries who have more than 10MHz of bandwidth within the 1800MHz spectrum. In Asia Pacific operators in Singapore, Hongkong and Australia have more than 10MHz. As people start to move to 3G services in the 850/900 & 2100MHz bands GSM900 has now become the main choice for voice services. The 1800MHz band is now underutilised and significant cost-savings can be made without requiring new spectrum releases. It is now practical for most 1800MHz operators to refarm their spectrum to LTE1800.

| Frequency | Bandwidth |
|---|---|
| 2600MHz | 70MHz |
| 2100MHz | 60MHz |
| 1800MHz | 75MHz |
| 900MHz | 30MHz |



# 3. Refarming LTE 1800MHz solutions

## 3.1. Frequency allocation

There are 2 types of 1800MHz Refarming, One-off Refarming and Interim Refarming.

**One- Off:** One off refarming is preferable for operators with mature and expansive 2G & 3G networks. With full GSM900 coverage & utilizing GSM1800 in areas for Voice & GPRS offloading they can consider a total refarm of 1800MHz. With 2G users declining year on year their 1800MHz spectrum traffic is lighter, therefore users can be migrated to GSM900 or UMTS. Using enticements like 3G handset upgrades through sales channels could help move users to 3G.

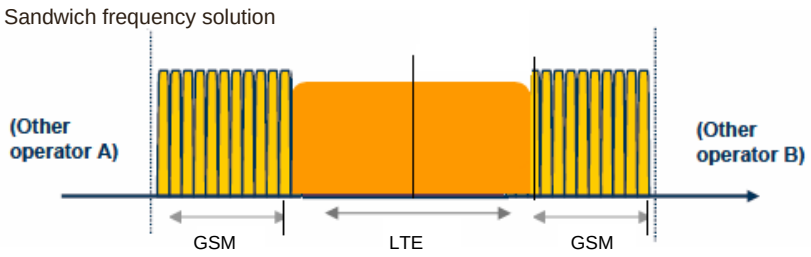
**Interim:** This solution suits operators whose spectrum resources are limited. Some operators still carry a high percentage of GSM users on 1800MHz meaning they can only refarm part of their 1800MHz spectrum to LTE. Interim refarming is a flexible solution which offers refarming in phases dependant on the decline in GSM traffic. See figure below.


1. One-off Refarming


2. Interim Refarming

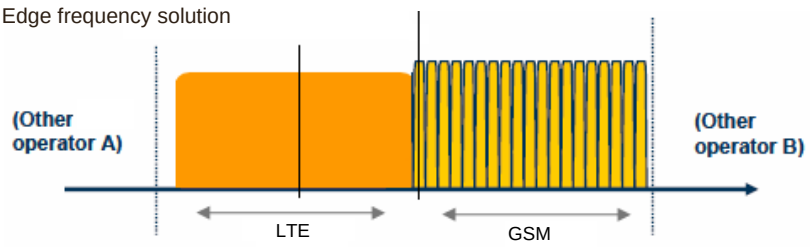
For the interim refarming, two frequency allocation modes are available, Sandwich frequency allocation and Edge frequency allocation.

**Sandwich Frequency Solution.** In the sandwich allocation mode, the LTE carrier can be arranged at any location ( not necessarily at the center) in the spectrum resources of the operator, depending on the operator's strategies. For later capacity expansion of the LTE, the operator might allocate more frequencies to LTE.




**Edge Frequency Solution.** In Edge allocation mode, the LTE carrier is allocated to the edge of the operator's spectrum. It has a lower frequency utilization since a larger guard

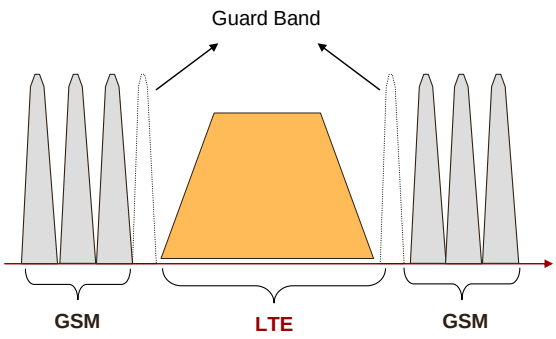
band is applied to reduce adjacent frequencies interference to other operators. See figure below.




## 3.2. Interference management for interim refarming

### 3.2.1. Guard band

Interference management aims to reduce the negative impact on GSM, and enhances LTE performance. In interim refarming, a guard band is needed to reduce the out-of-band spurious emissions. See figure below. For narrow band LTE (1.4MHz - 3MHz), typically a 0.2MHz guard band is needed because 1.4MHz - 3MHz doesn't have enough in-band guard bands. For LTE with 5MHz and above bandwidth, guard band is not necessarily required because there are enough in-band guard bands to avoid the spurious emission. See figure below.

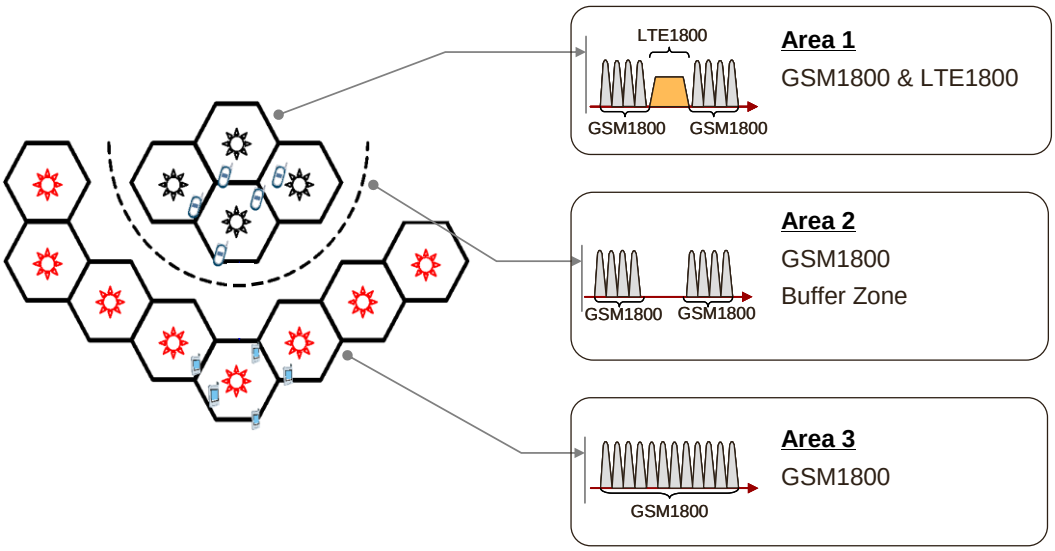



| LTE bandwidth | GL co-site guard band requirement | |
|---|---|---|
| | Theoretical | Actual |
| 1.4MHz | 0.2MHz | 0.2MHz |
| 3MHz | 0.2MHz | 0.2MHz |
| 5MHz | 0.2MHz | 0 |
| 10MHz | 0.2MHz | 0 |
| 15MHz | 0.2MHz | 0 |
| 20MHz | 0.2MHz | 0 |

### 3.2.2. GL Interference Elimination

Assuming LTE1800 is first refarmed in rural, suburban and finally urban areas it will cover the same area previously covered by GSM1800. If refarming is only applied to rural and suburban areas and if GSM1800 is not refarmed in urban areas, LTE1800 can use the same frequency as that of the GSM rural area. In-band interference cannot be eliminated between rural and suburban LTE1800 and urban GSM1800 through filtering. Therefore a geographic buffer zone must be planned between refarmed and unfarmed areas to eliminate interference.

See figure below.



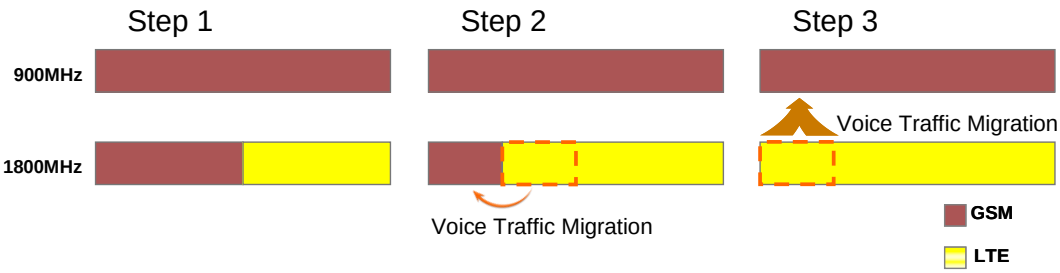

## 3.3. Voice Capacity Migration

### 3.3.1. Migration of One-off refarming

One-off 1800M refarming is adopted when an operator has a GSM or UMTS network in other spectrums, i.e. GSM900, UMTS850/900/2100 and has a small percentage of users on its GSM1800 network. It is relatively easy for the operator to migrate the small amount of GSM1800 users to other spectrums i.e. GSM900, or other system, i.e. UMTS network.

### 3.3.2. Migration of interim refarming

Some operators still have a high percentage of GSM users on their 1800MHz spectrum even though they maybe in decline. In this situation only part of 1800MHz spectrum can be refarmed to LTE. There are two methods to achieve GSM Traffic migration, **Half Rate technology** and **Tight Frequency Reuse**. The figure below shows how to adopt Half Rate technology.




*Assuming the operator has a 900MHz & 1800MHz network.

Step 1: Deploy LTE on part of 1800MHz Band.

Step 2: Increase GSM1800 HR-rate and migrate voice traffic to release more bandwidth for LTE.

Step 3: Increase GSM900 HR-rate and migrate voice traffic from GSM1800 to GSM900 releasing 1800MHz spectrum.

Another method is Tight Frequency Reuse (TFR) which can enhance utilization of the remaining unrefarmed 1800MHz spectrum. TFR can effectively reduce or eliminate network interference and increase network capacity to over 200% within limited frequency resources and guarantee speech quality. Table below shows the frequency saved after adopting TFR.

| GSM Capacity to Bandwidth Map Table | | | |
|---|---|---|---|
| Config. | Frequency bandwidth needed MHz (4x3 reuse) | Frequency needed after adopting TFR MHz (70% load) | Frequency bandwidth Saved |
| S1/1/1 | 2.4 | 2.4 | 0% |
| S2/2/2 | 4.8 | 3.6 | -25% |
| S3/3/3 | 7.2 | 4.2 | -42% |
| S4/4/4 | 9.6 | 5 | -48% |
| S5/5/5 | 12 | 5.9 | -51% |
| S6/6/6 | 14.4 | 6.7 | -53% |
| S7/7/7 | 16.8 | 7.6 | -55% |

### *3.4. Inter-operability*

In 3GPP, there are definitions regarding the inter-operability. The Inter-operability between LTE1800 and other system includes the following solutions:

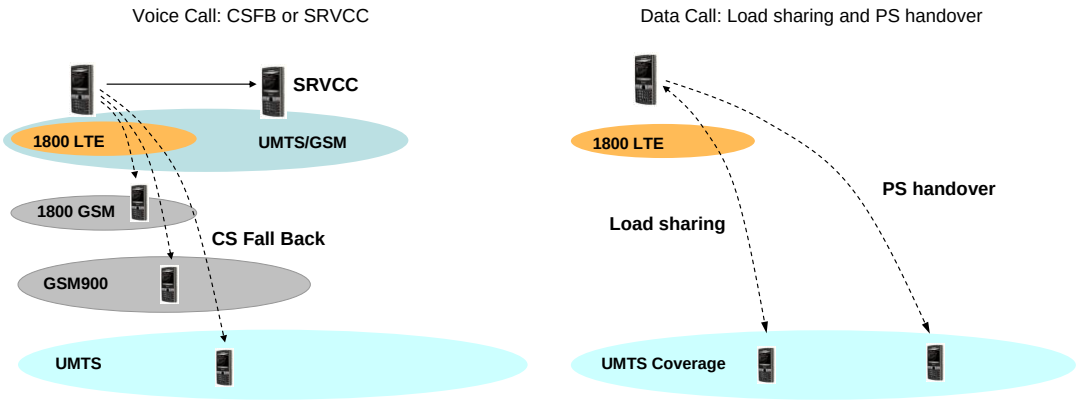
1. PS Inter-RAT Mobility between LTE1800 and UTRAN or GERAN, 3GPP R8;

2. PS Inter-RAT Load sharing to UTRAN and Intra-LTE Load balancing, 3GPP R8 & R9;

3. CS Fall Back to GERAN or UTRAN/ SRVCC to UTRAN or GERAN, 3GPP R8;

The Inter-operability requires end-to-end compatibility of functionalities for terminals, RAN and Core.

The figures below describe the scenarios.




# 4. Deployment Strategy

Deployment of LTE1800 using existing macro sites is the first step. However, coverage from existing Macro's will not provide the same level of coverage as 850/900MHz. because 1800MHz has less coverage due to an increase in penetration loss. Simply adding more spectrum and deploying Macro coverage is not enough to solve the capacity versus EBITDA conundrum. Spectrum needs to be used more efficiently. Topologies for mobile networks have been characterized by an increasing number of smaller sized cells in different coverage layers, i.e. Macro, Micro, Pico, Femto, in order to provide coverage, capacity, and enhance user experience whilst achieving a higher spectrum utilisation.

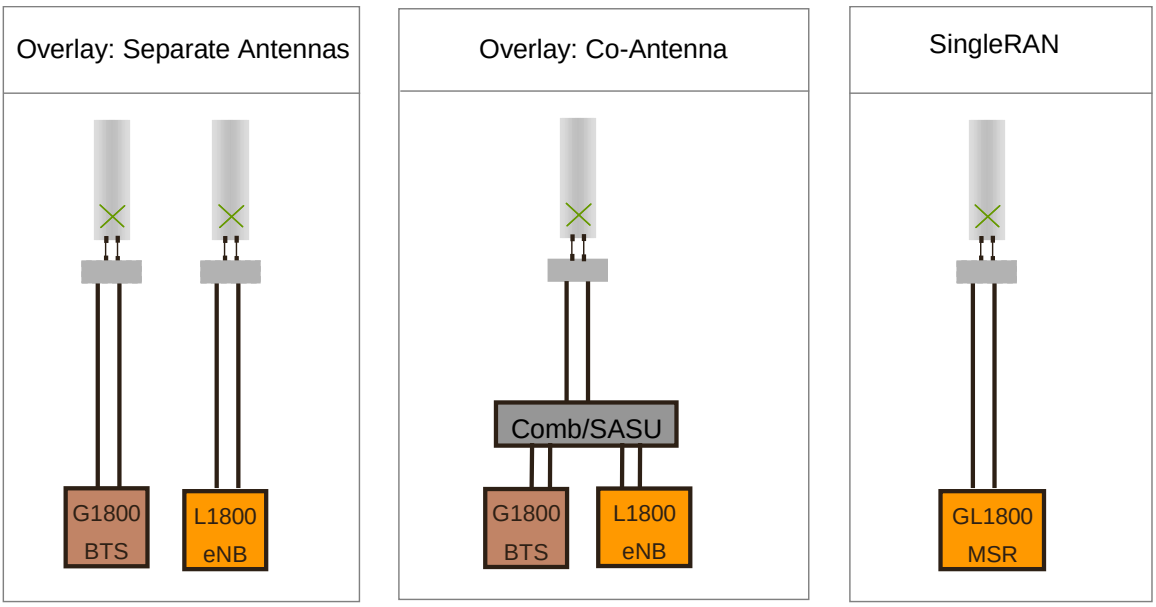
## 4.1. Macro BTS

To save CAPEX & OPEX costs and to maximize return on investment, one box supporting Multi-mode and Multi-band is an ideal solution. The concept of SingleRAN is widely accepted as a cost-effective solution for the Macro layer. SingleRAN adopts a highly flexible & configurable Base Band Unit suiting long term evolution. It supports technologies such as GUL Co-cabinet, Co-Transmission, Co-maintenance, MSR technology for Radio head supporting GUL, Co-RRM & Co-RNP.

In 1800MHz the GSM/LTE MSR helps achieve a smooth transfer from GSM1800 to LTE1800. In spectrums 900/2100MHz, MSR can be implemented for example in 2100MHz which is primarily used for UMTS and can later be refarmed to LTE. For 900MHz the GSM can be refarmed to UMTS/LTE. A higher spectral efficiency can be achieved by bundling several spectrums together to provide a higher throughput. Technologies like LTE Carrier Aggregation (CA) which is part of LTE-A can be used to maximise the baseband to fully utilise its radio support.

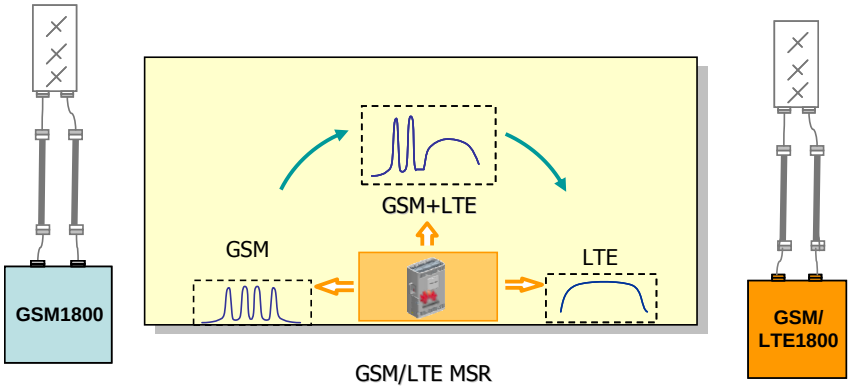
## 4.2. Antenna Solution

There are two scenarios regarding LTE1800 antenna solutions, overlay and SingleRAN. An overlay scenario happens when existing 1800GSM equipment cannot support LTE1800, and new LTE1800 equipment is needed. There are two antenna solutions for this scenario, Separate Antenna and Co-antenna. The figure below shows the applications.



Co-antenna solutions can save investment in antennas and feeders, but need extra combiners. Instead of traditional combiners which cause a 3dB signal loss, SASU (Same Band Antenna Sharing Unit) module is designed for this scenario. By using SASU a minimal insertion loss of (0.6db in DL) will be caused.

SingleRAN solutions are a cost-effective solution for LTE1800 refarming. The 1800MHz radio head supports both GSM and LTE at the same time. It provides flexibility for future evolution and the antenna system remains the same in the future to support LTE1800 2x2 MIMO. Many operators have more than 20MHz frequency in 1800MHz while some operators have discontinuous frequencies adding up to 20MHz. In a wider range 1800MHz the working Intermediate Frequency Bandwidth (IBW) should be more than 20MHz. Some vendor's RF module can provide more than 30MHz IBW, which better supports LTE1800 refarming.




## 4.3. Capacity Management – Micro, Pico and Femtocells

These solutions provide depth of coverage, better voice quality and higher data speeds to users, and offload capacity from congested Macrocells. If these technologies are introduced on the same frequency as Macrocells, interference needs to be managed properly. In LTE, the ICIC feature can reduce network interference between cells.

Micro LTE eNodeB integrates both baseband and RF components into one lightweight antenna, utilizing either patch or to separate antennas.

LTE ePico and Femtocell solutions offer operators a quick and cost effective way to improve network coverage and offload traffic, In addition they minimize site acquisition, integration and design costs whilst better utilizing spectrum. Some operators are concerned how to introduce these devices to their network due to interference, performance and optimization concerns. As these devices can be brought at retail dealerships they can be deployed by customers anywhere/anytime within the network.

Operators fear they will lose control of how these devices are deployed and the performance impact on their network.

There is a compelling case for LTE Femtocells and they have a key role in LTE services. As a new business solution/model these technologies can help operators retain market leadership. With handset upgrades to corporate accounts these can be deployed quickly and cheaply should new clients have coverage or capacity issues.

Micro eNodeB

Home / Enterprise Femtos

Enterprise ePico

With massive increases in data traffic forecast and future traffic demands from technologies like Cloud computing, smarter ways to offload capacity need to be considered. Traffic balancing will see the introduction of smaller solutions that are quickly and easily deployed. Solutions like Mini Macro's can be deployed in stealth solutions such as existing infrastructure like light poles in Urban/residential areas.

## *4.4. Terminals*

Terminals are a very important part for LTE1800 operators, requiring Multi-mode terminals for 3G and LTE data services. In the first stage of LTE, USB dongles will be available for data support. In the near future Multi-mode handsets and Smart phones will be the mainstream devices. Chipset manufacturers Qualcomm and Hisilicon already provide chipsets to support the LTE market. In 2011, a variety of LTE1800 Multi-mode dongles and handsets will enter the market.

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# 5. LTE 1800MHz Cases

In 2010, many LTE1800 refarming projects have been implemented globally demonstrating, which shows a clear trend that LTE1800 is moving forward rapidly.

## *5.1. The world first LTE1800 commercial network*

In September 2010 the first phase of Poland's Mobyland and CenterNet's commercial LTE1800 network was deployed. Based on 1800MHz spectrum with 20MHz bandwidth on one radio unit and by upgrading software on Mobyland's existing 2G network they covered Poland's major cities. The high-quality and rapid network deployment demonstrated a smooth evolution as well as reduced TCO (Total Cost of Ownership).
Refarming Mobyland and CenterNet's existent 2G bands at 1800MHz, allowed for greater performance across bandwidth. This in turn enabled the LTE network to improve spectrum efficiency, enhance coverage quality, reduce the quantity of sites, and decrease carbon emissions.

Mobyland Poland Statement on LTE1800

Project "LTE 1800MHz" is the first commercial LTE technology network in a harmonized frequency band of 1800MHz (band 3 according to the 3GPP standard) to be launched in Poland and will allow the service to be commenced using the channel with the maximum standardized band of 20MHz.The cutting-edge technology will allow data download with an initial speed of 153 Mbps (and ultimately at 326 Mbps) and data upload of 48 Mbps (and ultimately at 86 Mbps).

The project "LTE 1800MHz" commenced in all locations where GSM 1800 has been in use, which means that the signal will be available both in large cities and smaller locations. "Our plans assume that at the end of 2010 the number of base stations in operation will reach 700 and the LTE network will cover over 7 million people," says Adam Kuriański, the President of CenterNet and a board member of Mobyland.

Mobyland's objective is to develop a wireless telecommunications network based on LTE to replace existing solutions. The build out of an independent network is made possible by The LTE project of Mobyland and CenterNet allows them to make use of their radio resources in an innovative manner to implement the LTE technology, flexible both in terms of frequency and the channel width.

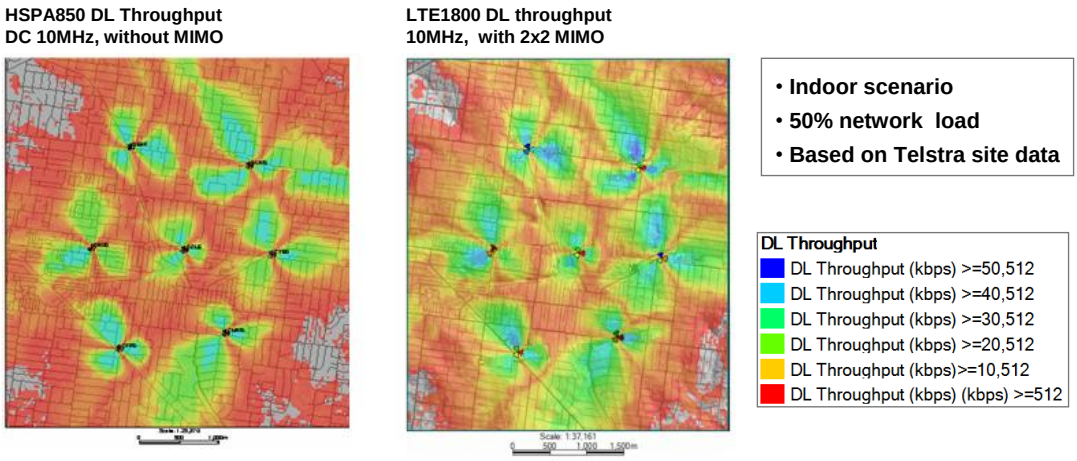
## 5.2. Telstra's LTE1800 study

The first LTE1800 trial in Australia was conducted by Telstra in 2010. During this trial many features and capabilities were evaluated such as throughput, coverage, handover, interference mitigation, latency, and jitter.

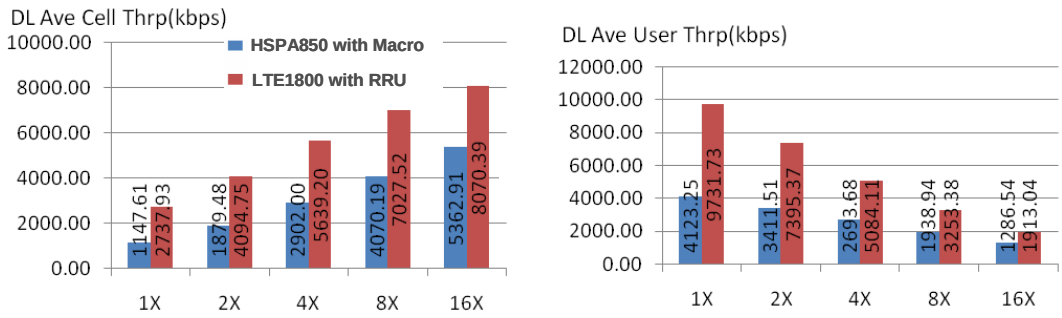
The trial showed that LTE1800MHz technology is ready for commercial launch with download speeds up to 149.4Mbps being achieved in lab environment.

Telstra also conducted an HSPA+ and LTE coverage and capacity study for Melbourne using Forsk's Atoll RF simulation tool.

Considering coverage, it was shown that an LTE configuration using a 2x40W RRU per sector can match or exceed the coverage (for equivalent broadband data throughput) of dual carrier HSPA+ at 850MHz (each HSPA+ carrier has 20W plus 3dB of feeder loss). See figure below.




Considering capacity, the study showed that cell throughput of LTE1800 (2x2 MIMO, 10MHz with RRU) as 1.5~2.3 times HSPA850 (Without MIMO, 10MHz with Macro BTS) and user throughput also 1.5~2.3 times. The figure below multiples of capacity (loading) on the x axis versus cell and user throughput on the y axis.




The learning's Telstra gained from the LTE1800 trial gave Telstra the confidence that LTE1800 would provide a solid user experience. Telstra announced it will deploy a

commercial LTE1800MHz network in 2011.

### 5.3. Other operators LTE1800 approaches

In Europe: Bouygues of France and Cosmote of Greece had LTE1800 trials in 2010.

Finnish operator Elisa & Deutsch Telecom showed high interest in deploying LTE1800.

In Asia Pacific: After launching 2.6GHz LTE in 2010, CSL in Hongkong deploys a 2nd stage LTE1800.

VHA of Australia had an LTE1800 trial in 2010.

Telkomsel of Indonesia completed LTE1800 trials in June 2010.

Asia Pacific: Operators EMobile, StarHub and M1 show strong interest in LTE1800.

# 6. Conclusions

With increasing demands on mobile capacity there needs to be an improvement in technology. A newly developed technology is LTE which has been proven for MBB since TeliaSonera launched in 2009.

Spectrum is an important asset to operators and refarming existing spectrum can help gain a market advantage. Many operators already hold 1800MHz spectrum used for their GSM1800MHz networks. As GSM1800MHz users are declining this spectrum is now underutilized refarming to LTE1800MHz is an approach many operators are taking.

1800MHz is defined in the 3GPP Band3 and Refarming to LTE is the most cost efficient way to provide high speed data services. The Refarming techniques are similar to those of UMTS900 which has been implemented by operators globally since 2008. SingleRAN solutions and MSR technology can better utilize spectrum and reduce TCO.

# 7. Acknowledgement

We would like to acknowledge and thank Telstra for allowing us to publish information obtained from LTE1800 Trial and Monte Carlo simulation studies.

# 8. Abbreviations

3GPP – Third Generation Partnership Project
bps – Bits per Second
CAPEX – Capital Expenditure
CSFB– Circuit Switched Fallback
DL – Downlink
DPI –Deep Packet Inspection
EDGE – Enhanced Data Rates for GSM Evolution
EU – European Union
EBITDA – Earnings Before Interest, Taxes, Depreciation and Amortization
FDD – Frequency Division Duplex
GSM – Global System for Mobile communications
HSPA – High Speed Packet Access (HSDPA with HSUPA)
HSPA+ – High Speed Packet Access Plus (also known as HSPA Evolution or Evolved HSPA)
ICIC – Inter-Cell Interference Coordination
Kbps – Kilobits per Second
LTE – Long Term Evolution (evolved air interface based on OFDMA)
LTE-A – LTE Advanced
MBB – Mobile Broadband
MHz – Megahertz
MIMO – Multiple Input/Multiple Output
ms – Millisecond
OPEX – Operating Expenses
RAN – Radio Access Network
Rel. 'X' – Release '99, Release 4, Release 5, etc. of 3GPP Standards
RF – Radio Frequency
RNP – Radio Network Planning
RRM – Radio Resource Management
RRU – Remote Radio Unit
SRVCC – Single Radio Voice Call Continuity
TCO – Total Cost of Ownership
TCP –Transfer Control Protocol
TX – Transmit
UL – Uplink
UMTS – Universal Mobile Telecommunications System