WCDMA Frequency Refarming: A Leap Forward Towards Ubiquitous Mobile Broadband Coverage
Executive Summary

Mobile operators seeking to deliver 3G services to sparsely populated rural areas have faced a prohibitive cost problem. To date, 3G coverage over large areas has been an expensive proposition, stalling efforts to bring broadband mobile data services to far-flung customers. Now there is a viable solution to this cost problem: Using 3G over the 900 MHz spectrum band — that is, WCDMA frequency refarming — can afford people access to more sophisticated mobile services. What is more, WCDMA refarming to 900 MHz affords operators excellent opportunities to grow their business while making the most of legacy assets, as this paper will show.

Better performance indoors and out
Operators wishing to introduce WCDMA to their GSM, CDMA, or TDMA bands can now refarm part or all of their frequencies and roll out 3G at remarkably low cost. Lower frequencies transmit over greater distances and penetrate better indoors. This means fewer sites cover greater areas, saving considerable rollout and operating costs to bring bona fide broadband to rural areas and improved data rates to metropolitan indoor locations.

Maximizing returns on legacy assets and resources
Many markets are ready for refarming today; others are poised to follow suit. Recognizing the potential of refarming early on, Nokia Siemens Networks has developed a cost- and energy-efficient solution that enables operators to adapt and adopt at their own pace. Leveraging unique hardware and software features, this solution helps operators migrate their networks to WCDMA, smoothly and seamlessly. To this end, it reuses legacy assets and resources better than any other vendor’s offering. All this, as well as Nokia Siemens Networks’ end-to-end offering of radio access equipment, functionalities, management systems, and professional services, make the transition simple and the overall solution far less complex.

For reasons of simplicity and clarity, this paper discusses 900 MHz refarming. All the statements apply equally to 850 MHz refarming.
Why WCDMA in the 900 MHz band?

Operators have many compelling reasons to deploy WCDMA in the 900 MHz band. The greatest obstacle to WCDMA 900’s deployment to date in most countries has been regulators’ practice of assigning 900 MHz bands to GSM. Tasked to handle heavy GSM traffic loads, the band frequently has little or no remaining capacity available for 3G traffic. But now, with an eye to the potential of ubiquitous mobile broadband, regulators are beginning to see the promise and benefits of WCDMA in 900 MHz bands. Countries such as France, Finland, Australia, and New Zealand have already given it the green light.

The physical advantage
The physics of radio wave propagation help explain one of the great advantages of WCDMA 900: The lower the carrier frequency, the further radio signals can travel. This means it takes fewer radio cells to cover the same area, making WCDMA 900 the perfect solution for extending coverage (see Figure 1). What is more, a radio signal traveling through the walls of a building at a lower carrier frequency is less susceptible to penetration loss. With the benefit of this property, WCDMA 900 can extend indoor coverage and improve service in metro areas. Perhaps most important to operators, it can do all this at remarkably low cost and with compelling efficiency. Measurements of and experience with the first commercial WCDMA 900 network confirm that its performance is comparable to that of WCDMA 850 networks. Because radio propagation properties at 900 MHz and 850 MHz are all but identical in the real world, WCDMA 900 is sure to follow in WCDMA 850’s successful footsteps.

WCDMA 900 vs. GSM 900
A brief review of WCDMA’s deployment in many markets such as Western Europe helps explain the potential impact of WCDMA 900 on coverage and services. Authorities opted to introduce WCDMA in the UMTS core band at 2100 MHz, a frequency reserved for IMT-2000 technologies. This put WCDMA at a disadvantage in these markets, and GSM long remained the dominant technology for the 900 MHz band. But recent upgrades to HSPA have transformed WCDMA networks into real mobile broadband access platforms. Of course, HSPA data services demand a carrier frequency that propagates further. And users typically wish to enjoy data services in buildings, and this requires a carrier frequency with better penetration. To date these two constraints have limited HSPA mobile broadband services coverage to lag significantly behind voice service coverage.

![Figure 1: Coverage-driven application scenarios for WCDMA 900](image-url)
Figure 2 compares the coverage of GSM/EDGE and WCDMA/HSPA at different frequencies. Note that it indicates cell area in a typical suburban environment in which service (voice and 1 Mbps data) is available within a building.

**WCDMA 900 vs. WCDMA 2100**

Bringing a real mobile broadband user experience to less densely populated areas has to date been deemed economically infeasible. Now operators can deliver high-revenues services profitably by running HSPA in the 900 MHz band. Savings come built-in: WCDMA 900 requires 65% fewer sites than WCDMA in the 2100 MHz band. The total cost of ownership for WCDMA in a rural environment is lower – as much as 60% lower factored over five years. Better radio propagation properties at 900 MHz translate to better services, delivered faster to more users. Even in buildings, users in a typical suburban environment can enjoy 1 Mbps data rates when HSPA 900 is deployed at GSM 900 base station sites.

**Fast facts**

The answer to the question of why WCDMA in the 900 MHz band is, in a nutshell, because it offers

- The coverage-driven rollout advantage of cells that are 2.8 times larger
- TCO reduced to 40% compared with 2100 MHz networks
- Cost-efficient 3G coverage of large areas, with 65% fewer sites compared with WCDMA in the 2100 MHz band
- Improved data rates and coverage indoors

**Figure 2:** A comparison of GSM and WCDMA coverage at different frequencies. It depicts cell area in a typical suburban environment with service (voice and 1 Mbps data) available within a building. WCDMA 900 provides 1 Mbps coverage using the GSM site grid.

**Figure 3:** Indoor penetration of HSPA at 2100 MHz and 900 MHz. The higher the penetration loss caused by the building’s walls, the greater HSPA 900’s improvement in performance compared with HSPA 2100.
Opportunity knocks for operators…
Mobile broadband is taking off. As operators and device manufacturers’ recent marketing campaigns would attest, the notion of mobile access to the full Internet has real mass-market appeal. With demand for mobile broadband services rising fast, extending broadband coverage is becoming a compelling business proposition for mobile operators. Most have already responded by upgrading WCDMA networks via HSPA to create real mobile broadband access platforms.

means of optimizing the WCDMA 900 network. I-HSPA 900 increases cost efficiency by decoupling traffic growth and network capacity costs and simplifying the user plane by streamlining it in flat, two-node-architecture. This brings to users the benefit of lower latency, which translates to faster response for many data applications.

I-HSPA’s flat architecture and air-interface improvements brought about by HSPA’s evolutionary advance can be leveraged to optimize WCDMA 900 networks’ mobile broadband performance and efficiency.

Responding to the call for action
Regulators wish to extend rural coverage, speed the uptake of mobile broadband, and improve indoor coverage. Many have seen just how instrumental refarming can be in the push for mobile broadband, and are acting to make it work. In Europe, for example, the European Commission is considering a stronger push towards refarming in the 900 MHz band with a proposed law allowing new technologies to coexist with GSM in the 900 MHz and 1800 MHz bands. The goal is to guarantee continued GSM services in the EU, while opening the door to WCDMA/HSPA.

The evolutionary path of WCDMA 900
Like WCDMA 2100, WCDMA 900 is evolving towards higher data speeds and increased efficiency. 3GPP Release 8 will bring downlink data rates up to 43 Mbps and uplink data rates up to 11 Mbps. Other evolutionary advances in HSPA will reduce mobile devices’ power consumption and therefore increase their operational autonomy.

Compared with GSM 900, the single biggest advantage of WCDMA 900 is its superior mobile broadband capability. Bearing this in mind, the I-HSPA’s flat architecture is another

Market and regulatory conditions

... and vendors alike
Compelled to respond to fast-growing demand, device vendors are doing their part to commercialize mobile broadband: HSPA-enabled user devices are on the verge of hitting the consumer mass-market price point. Vendors had rolled out more than 120 WCDMA 850 user devices by November 2007, and the first WCDMA devices supporting 900 MHz are now available, among them Nokia’s debut WCDMA 900-enabled device launched in June 2007. 2008 will see many multi-band WCDMA devices make their way into the market. Industry players expect all vendors to offer data cards and USB modems very soon, and WCDMA 900 to feature in a significant number of 3G terminals sold in Europe. WCDMA 900 is likely to become a standard feature by 2009.
WCDMA refarming initiatives around the world

Many national regulators recognized the potential of WCDMA/HSPA at 900 MHz, and are working to enable WCDMA’s introduction in the 900 MHz band. By December 2007, Finland, France, and Switzerland, a non-EU country, had adopted the European Commission’s policy. Another case in point is CEPT, which sanctioned WCDMA on 900 MHz and 1800 MHz bands in December 2006. In the Asian Pacific region, Australia, New Zealand, and Indonesia have given permission to proceed with WCDMA 900. Aiming to promote more flexible use of the spectrum, Britain’s communications and media regulator Ofcom has proposed freeing up the 900 MHz band and awarding spectrum in this band in 2009 without technology-specific restrictions. Decisions on WCDMA refarming are pending in several other EU countries, Spain and Portugal among them. Israel as well as some Asian Pacific and Latin American countries are aiming to refarm WCDMA to the 850 MHz band.

Proven in commercial deployments

Countries in many other parts of the world awarded spectrum without technology-specific restrictions. WCDMA 850 networks are up and running successfully in the Americas and Australia, providing proof of the technology’s outstanding performance at lower frequencies. WCDMA has thus proven its merits and commercial viability at lower frequencies.

Now a WCDMA 900 network has debuted. In November 2007, the Finnish network operator Elisa launched commercial operations with the world’s first WCDMA 900 network. In view of fast rising demand for ubiquitous mobile broadband, regulatory bodies’ endorsement, and the availability of devices supporting WCDMA 900, many more are sure to follow.

Figure 5: The main WCDMA frequency bands and near-term refarming potential.
Operators seeking to capitalize on the potential of WCDMA 900 refarming must first protect legacy business interests, sustain current operations, and find a way to contain rollout costs. In other words, operators aiming to refarm frequencies must resolve three major issues; that is, how to:

- Minimize the impact of WCDMA frequency allocation on their GSM business
- Sustain business with users who have GSM-only phones
- Cut operational expenditures associated with the added WCDMA 900 radio access layer

Making the most of narrowly defined spectrum

The 900 MHz band, denoted as Band Class VIII, is defined as the paired bands from 880 to 915 MHz in the uplink direction, and from 925 to 960 MHz in the downlink. This means overall band potential comes down to just two times 35 MHz, compared with two times 60 MHz in the UMTS core band (band I) at 2100 MHz. Operators are compelled to share this spectrum; what is more, it must also support continued GSM/EDGE operation.

“Improved customer experience is our objective when we are now widening the coverage of our 3G services. Elisa has been the leader in driving the mobile broadband market in Finland. This launch further underlines our commitment to continuous development of our service offering. Thanks to the Nokia Siemens Networks frequency refarming solution, we are now running WCDMA and GSM efficiently in our 900 MHz frequency allocation, enabling us to extend our 3G services cost-effectively from cities to the less populated areas of Finland.”

Veli-Matti Mattila, President and CEO, Elisa Corporation
A clear action plan…

Operators looking to extend their 3G network’s reach by means of WCDMA 900 need a clear action plan that helps them rise to the three key challenges of refarming. As the supplier of the world’s first commercial WCDMA 900 network, Nokia Siemens Networks has a proven end-to-end solution engineered specifically to tackle these challenges. This solution combines unique radio access equipment and features with an integrating OSS and professional services to introduce WCDMA 900 smoothly.

…to tackle three big challenges

A closer look at these three challenges, and Nokia Siemens Networks’ approach to each, follows.

1. Minimizing the impact of WCDMA frequency allocation on GSM business

The 3rd Generation Partnership Project calls for a carrier spacing of 5.4 MHz between WCDMA and GSM carriers. 3GPP’s assumption bases on the performance of typical RF filters in base stations and on a worst-case power level scenario in adjacent carriers. 3GPP’s recommended carrier spacing poses a challenge for a 2G/3G operator wishing to introduce WCDMA 900. If the operator has a total of 10 MHz paired spectrum in the 900 MHz band available, this carrier spacing leaves just 4.6 MHz bandwidth to sustain ongoing GSM operations.

The answer is, of course, to spare bandwidth by condensing carrier spacing. Nokia Siemens Networks’ advanced WCDMA filter solution and coordinated GSM-WCDMA network planning, together with intelligently allocated power-controlled traffic channels (non-BCH) in GSM sites reused for WCDMA, can reduce carrier bandwidth from 5.4 MHz to 4.2 MHz. This leaves 1.2 MHz more of the valuable spectrum to be devoted to GSM use. Standard terminals support this reduction because nearly all signal energy in a modulated WCDMA carrier is within this 4.2 MHz range.

Coverage-based handovers enable continuous service provisioning, ensuring potential discontinuities in cell coverage go unnoticed by subscribers. With Nokia Siemens Networks’ service- and load-based intersystem handovers, the operator can strike an optimum balance of the system load between GSM and WCDMA networks.

2. Sustain business with users who have GSM-only phones

Using GSM spectrum more efficiently is another way of mitigating the impact of WCDMA 900 refarming on ongoing GSM operations and making the most of the remaining GSM carriers’ capacity.

Frequency hopping techniques, dynamic power control, and discontinuous transmission are just three of the many means of boosting GSM spectral efficiency.

Other advanced functionalities such as Adaptive Multi Rate (AMR) speech coding and Dynamic Frequency and Channel Allocation (DFCA) serve to further boost GSM spectral efficiency by ensuring tighter reuse factors in network planning. In practice, AMR may be used to double GSM capacity, and DFCA can serve to double AMR-enabled capacity gain. For example, if AMR alone can boost TRX capacity by two from two to four, the combination of AMR and DFCA extends TRX capacity to six.

3. Cut operational expenditures associated with the added WCDMA 900 radio access layer

Introducing another radio access layer adds to the operational effort. The extra effort may be minimized by making intelligent use of synergies at all levels. Site overhead, mainly driven by site rental, energy, and transmission costs, is another major expense. Compact, energy-saving WCDMA 900 base stations that are able to utilize legacy site hardware such as antennas and accessories can augment existing GSM sites without significantly adding to these costs. And a common backhaul architecture and infrastructure for GSM and WCDMA can reduce transmission costs.

Planning a network and setting parameters are big cost factors at the start of a project. Later, assurance and optimization processes become part of the operating equation, and drive network management costs accordingly. An integrated planning and operations solution, automated and proven many times over, speeds up the initial phase, prevents errors, and slashes start-up costs. A common OSS solution for GSM and WCDMA in all bands reduces operational costs because shared procedures translate to less training effort, better resource utilization, fewer errors, and greater efficiency.
Nokia Siemens Networks sees WCDMA 900 as the perfect platform for bringing the mobile broadband experience to users in rural areas. The lower frequency offers the fringe benefit of closing suburban and urban mobile broadband coverage gaps, especially within buildings. This is a side-effect operators and metro users alike will value.

Because the company believes so strongly in the merits of frequency refarming, it has developed network planning services and powerful tools for analyzing traffic and the legacy network’s design. Armed with this insight, Nokia Siemens Networks engineers tailor the best refarming solution for the given scenario, selecting WCDMA spectrum allocation and spectral efficiency features specifically to satisfy the operator’s needs. This solution approach reduces WCDMA bandwidth from 5.4 MHz to 4.2 MHz and serves to increase GSM spectral efficiency.

Every WCDMA network delivered by Nokia Siemens Networks, including WCDMA 900 MHz, is HSDPA- and HSUPA-enabled with a simple software download. Nokia Siemens Networks’ refarming solution supports flat I-HSPA network architecture and is ready for the HSPA air interface’s further evolution.

Nokia Siemens Networks’ load- and service-based handover parameters adapt efficiently to enable dynamic traffic allocation and ensure best-case traffic balancing for the combined GSM and WCDMA networks across all frequencies. In addition, Nokia Siemens Networks provides a comprehensive set of GSM spectrum efficiency features that help shift some frequencies from GSM to WCDMA.

Compact, modular, and engineered to consume less power, the Flexi base station enables effective site acquisition and re-use. But small base stations are just part of the savings equation. This approach allows operators to reuse GSM sites for WCDMA and HSPA to contain rental costs. Beyond that, these ultra efficient base stations are much cheaper to operate because they minimize the site’s overall power consumption, keep heat dissipation in check, and reuse legacy site equipment, including antennas, antenna lines, and power systems. And with proven network implementation services steering and supporting rollout, an easy and orderly transition is assured.

This refarming solution builds on one-pipe backhaul architecture, enabling operators to scale transport capacity to suit HSPA services’ bandwidth demand, and migrate traffic smoothly from GSM to HSPA. The common NetAct OSS for 2G and 3G automates planning and parameter optimization, and harmonizes operational procedures. The common OSS approach for GSM and WCDMA 900 and 2100 facilitates northbound integration.
Committed to WCDMA frequency refarming
Deeply confident in the validity of WCDMA frequency re-allocation, Nokia Siemens Networks has made a strong commitment to refarming. Some markets are ready today; others will be soon, and device vendors are gearing up to support refarming. Thus the company’s cost- and energy-efficient refarming solution lets operators deliver a genuine broadband experience to rural users’ handsets. Nokia Siemens Networks’ solution can lower the site count by a remarkable 65%, and total cost of ownership by an equally noteworthy 60% over five years. Users in suburbia can enjoy data rates of 1 Mbps, even inside buildings. And HSPA 900 MHz will support the same data rates as HSPA 2100 MHz in upcoming 3GPP releases.

Strong arguments…
All these arguments and the many more discussed throughout the paper speak strongly in favor of WCDMA frequency refarming. And Nokia Siemens Networks’ role in helping the Finnish communications service company Elisa launch the world’s first commercial WCDMA 900 MHz network speaks strongly in favor of its ability to deliver on the promise of frequency re-allocation.

…for a strong solution
With its WCDMA Frequency Refarming Solution, Nokia Siemens Networks aims to help operators efficiently provide 3G coverage by deploying WCDMA into 900 MHz and sharing bandwidth with GSM. This end-to-end solution for smooth WCDMA frequency refarming ensures GSM capacity and service quality remain unchanged, enabling 3G and GSM to co-exist. Best of all, operators can make the most of legacy assets and resources while capitalizing on promising new broadband business opportunities.
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AMR</td>
<td>Adaptive Multi Rate</td>
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<td>BCCH</td>
<td>Broadcast Control Channel</td>
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<tr>
<td>CAPEX</td>
<td>Capital Expenditure</td>
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<td>CEPT</td>
<td>Conférence Européenne des Administrations des Postes et des Télécommunications</td>
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<td>DFCA</td>
<td>Channel Allocation</td>
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<td>EDGE</td>
<td>Enhanced Data Rates for GSM Evolution</td>
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<td>GSM</td>
<td>Global System for Mobile Communications</td>
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<td>HSDPA</td>
<td>High-Speed Downlink Packet Access</td>
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<td>HSPA</td>
<td>High-Speed Packet Access</td>
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<td>IMT</td>
<td>International Mobile Communications</td>
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<td>OPEX</td>
<td>Operating Expenditure</td>
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<td>OSS</td>
<td>Operations Support System</td>
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<td>TDMA</td>
<td>Time Division Multiple Access</td>
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<td>UMTS</td>
<td>Universal Mobile Telecommunications System</td>
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<td>WCDMA</td>
<td>Wideband Code Division Multiple Access</td>
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