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Wireless Technology Seminar

cdma2000 Basics

presented by:

Dave Whipple
Wireless MSU

cdma2000 Basics

Agenda

- **Technology Drivers**
- **Technology Roadmap**
- **Acronym Definitions**
- **Technology Migration**
- **Technology Implementation**
- **Implementation Challenges**

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What Is the Driving Force for cdma2000?

- **US**   **- Voice Capacity, some Data**

- **Korea**   **- Voice Capacity, Data**

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The cdma2000 system has gained wide acceptance by the IS-95 community worldwide due to its compatibility with the existing IS-95 system. cdma2000 can be substantially more efficient than current systems, either for voice or data. The improvements in voice capacity alone justify the rapid migration to cdma2000. In addition, the data capabilities will allow future services. Although IS-95 began in the US, Korea
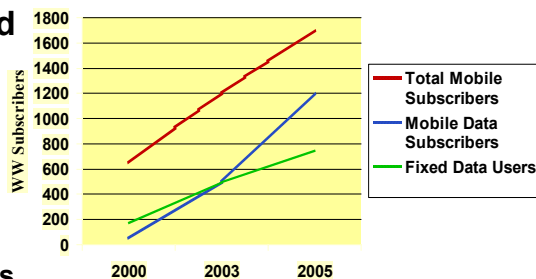
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Market Demand for Data Services

- **Demand for wireless data services expected to grow significantly**
- **Driven by new services:**
  - **e-mail/messaging**
  - **m-commerce**
  - **location-based services**
  - **entertainment**

Source: Arc Group, Oct. 2000

- **Low availability of applications will limit the customer use of data services**
- **Network Operators are looking to promote data services to increase revenues**

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Data services are seen as a key growth area for wireless mobile communications. The huge growth in the internet market is seen as key driver for the wireless market. Wireless Access Protocol (WAP) is a newly defined standard that allows wireless devices to efficiently access the internet. Providing mobile internet access is seen as service that mobile users would be willing to pay for.

Current wireless systems (GSM, IS136, IS95) have relatively low data rate capabilities. For example the maximum data rate achievable over GSM is only 14.4kbps. This is considered a significant barrier to the successful adoption of data services by wireless users.
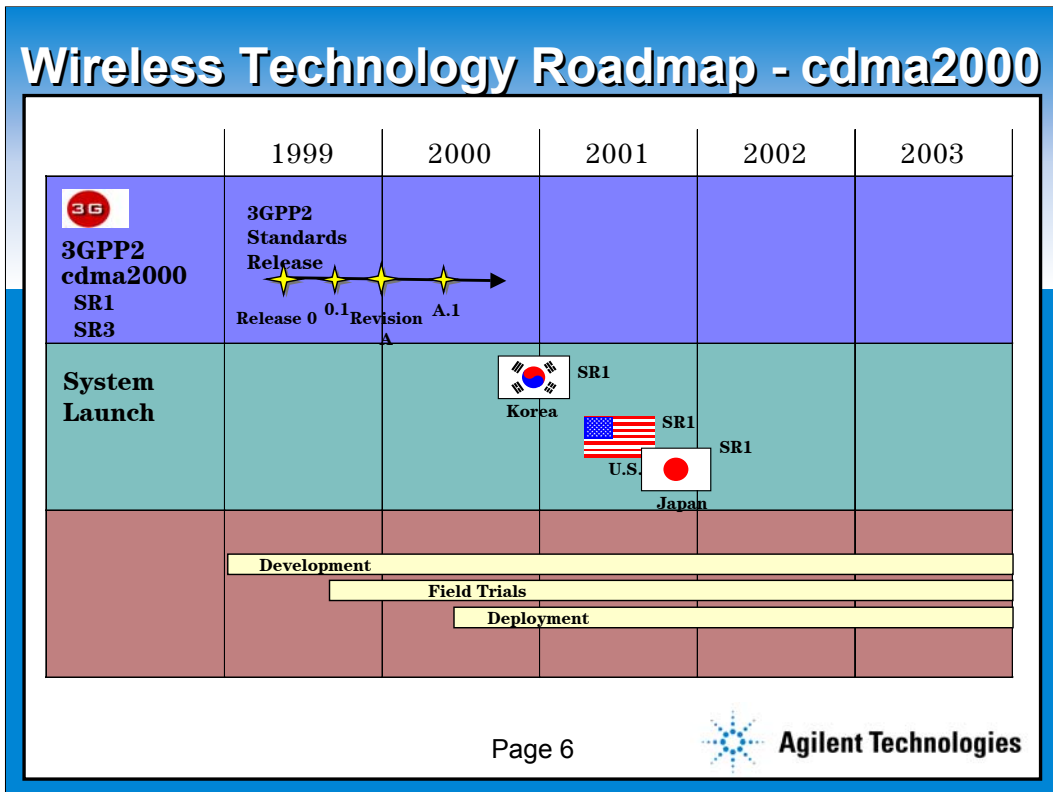
The network providers are keen to look for ways to increase revenues - data is seen as a huge opportunity to do this.
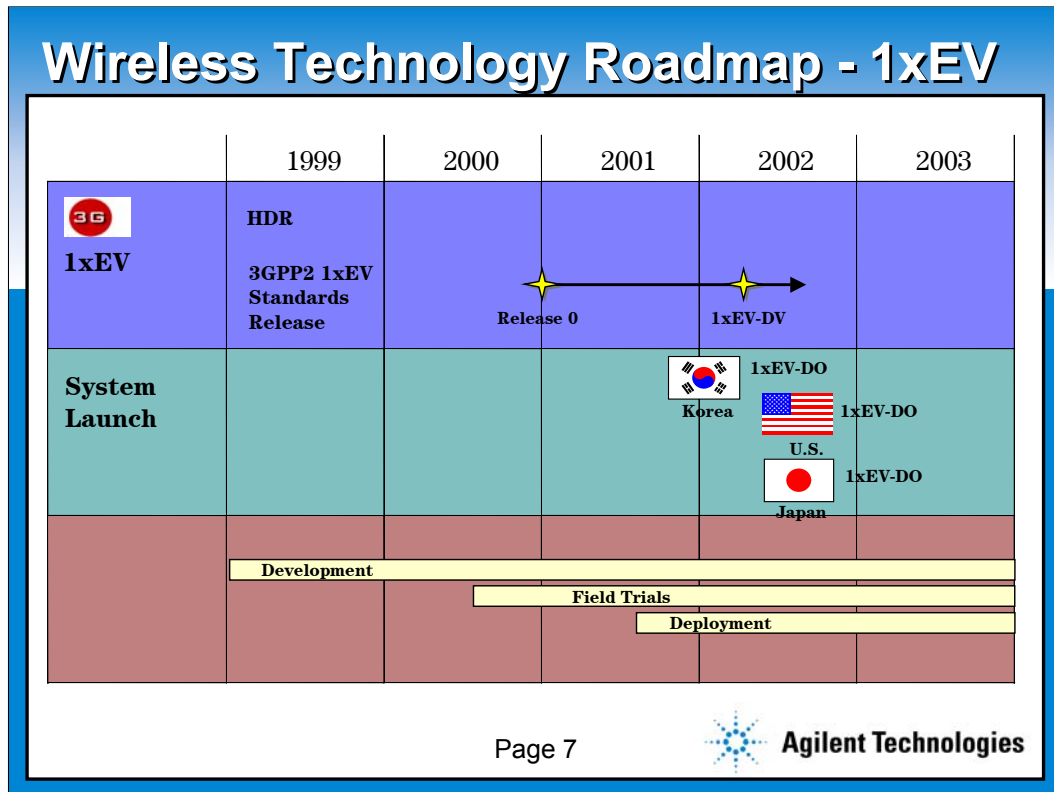
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Wireless Technology Roadmap - cdma2000

	1999	2000	2001	2002	2003

3G

3GPP2 cdma2000 SR1 SR3

3GPP2 Standards Release

Release 0   0.1 Revision A   A.1

System Launch

Korea SR1

U.S. SR1

Japan SR1

Development

Field Trials

Deployment

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cdma2000 is going to undergo a rapid rollout. This technology is an upgrade to the existing IS-95 systems, and generally can be installed with card changes at the base stations rather than all new equipment. The conversion of handsets from IS-95 to cdma2000/IS-95 will be very quick once service starts. SK Telecom in Korea is ahead in their rollout plans, with the rest of the world showing schedules at least 1 quarter

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Wireless Technology Roadmap - 1xEV

		1999	2000	2001	2002	2003
3G 1xEV		HDR 3GPP2 1xEV Standards Release		Release 0	1xEV-DV	
System Launch					Korea 1xEV-DO U.S. 1xEV-DO Japan 1xEV-DO	
		Development	Field Trials	Deployment		

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1xEV D.O. is a new coding format that is useful for packet data only. It cannot carry voice or any circuit switched application. It requires dedication of one IS-95 channel. The capacity for data delivery is six to ten times IS-95, and three times cdma2000.

As with cdma2000, SK Telecom leads the rest of the world by about one quarter. Sprint and Verizon plan to launch service in the US early 2002.

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The Acronyms...

- **ITU** - International Telephony Union
- **IMT2000** - International Mobile Telephone 2000
- **IS-2000** - Next Generation CDMA System based on IS-95

- **cdma2000** - Branding Name for IS-2000
- **SR1** - Spreading Rate 1 (x time IS-95 spread rate)
- **SR3** - Spreading Rate 3 (x time IS-95 spread rate)
- **1xRTT** - 1 times (IS-95) Radio Telephone Technology
- **3X MC** - 3 times (IS-95) Multi Carrier
- **1xEV** - 1 times (IS-95) EVolution
- **HDR** - High Data Rate

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Here is a list of some of the more common acronyms. Many, such as IS-2000, SR1, and SR3 come directly from the standards. Others come more from the ITU and its documentation.

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2nd to 3rd Generation Migration

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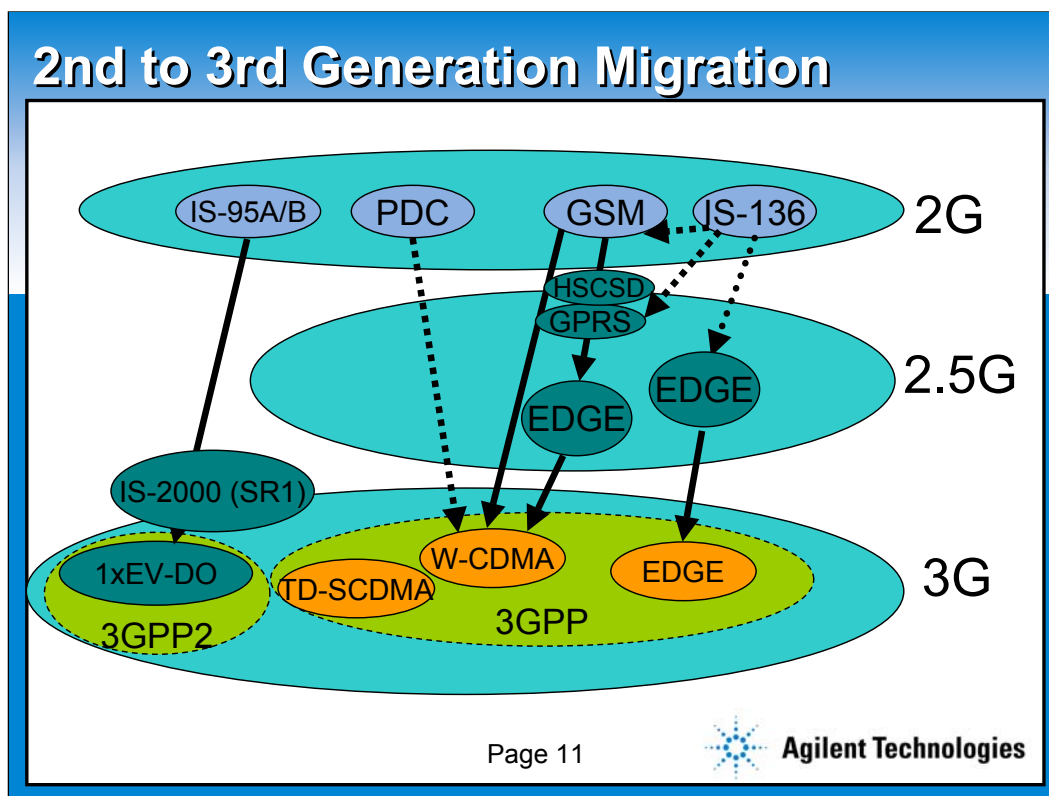
A look at the evolutionary path from 2G to 3G shows the likely migration path for service providers of each major format. The W-CDMA system looks like it will receive the most subscribers as operation is started in the IMT-2000 band.   The SR3 (Spread Rate 3) multi-carrier standard appears to be dead. The delivery of higher data rates for the current IS-95 community will be met with 1x Evolution (1xEV). The first version of this is Data Only (1xEV-DV). Future versions of this will be capable of data and voice (1xEV-DV). The IS-136 operators do not have a direct evolution path to 3G. Instead, they will transition first to GPRS-capable networks then on to W-CDMA.

EDGE, originally envisaged as a high data rate, evolutionary path for GSM, was for a while adopted as a way for IS-136 operators to offer data services to existing subscribers. This now looks much less certain to happen but it is still expected that EDGE will be implemented to complement data services in 2G and combined 2G/3G networks.

Note, there is no technical evolution from PDC to W-CDMA, and there are no plans for dual-mode PDC/W-CDMA terminals unlike most all other evolution paths.

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Where will cdma2000 be Deployed?

- **United States**
- **Latin America**
- **Korea**
- **Japan**
- **Scandinavia**
- **China?**

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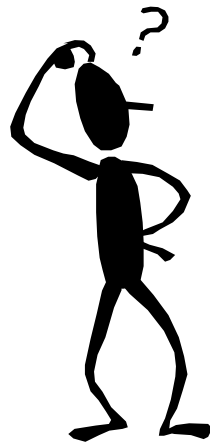
In the Americas, existing IS-95 operators will migrate to cdma2000 for increased voice capacity and the added bonus of data capabilities. Korea has the highest concentration of IS-95 users in the world. They will continue in this technology with the rollout of cdma2000. Japan will deploy its cdma2000 system in the IMT2000 band. Scandinavian operators will displace the existing NMT system that operates in the 450 MHz band. If China deploys a

Question and Answer Session

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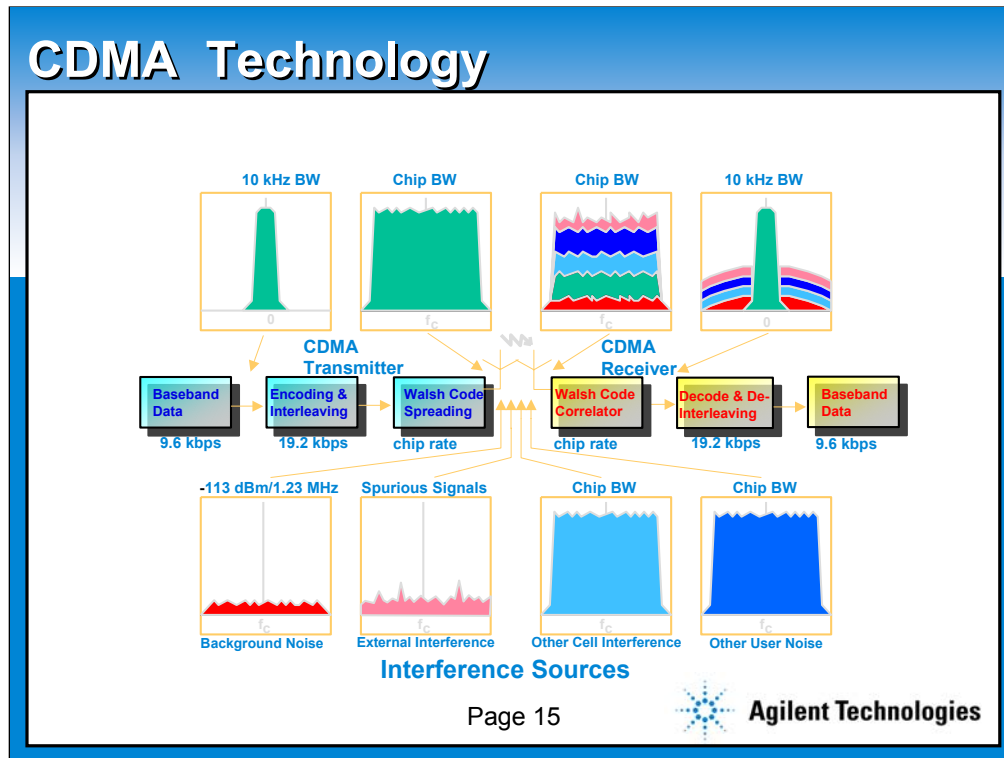## cdma2000 Basics

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The fundamental concept of CDMA is that each user is assigned a unique code. The data for that user is spread from a low data rate (shown here as 10 kbps) to the final spreading rate, either 1.2288 or 3.84 MCPS (Mega Chips per second). Many users share the same frequency. When the de-code is applied, the proper code goes back to the 10 kHz bandwidth, while every other code stays at the full bandwidth. The portion of energy from the wide signal that falls

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How To Get Higher Data Rates

- **Code domain power display - Hadamard display**
- **Higher data rate channels occupy multiple code channels**
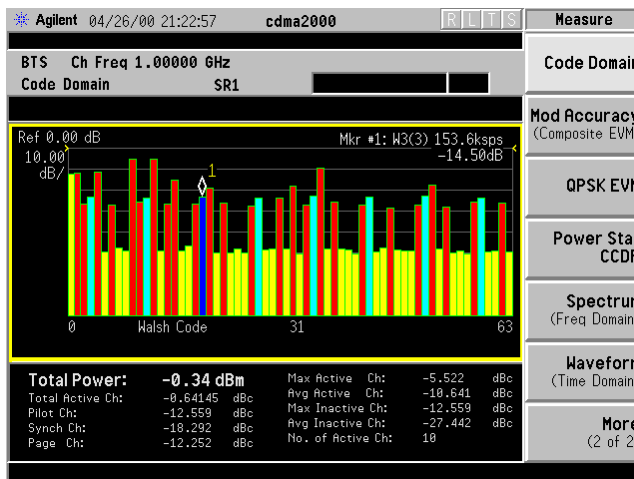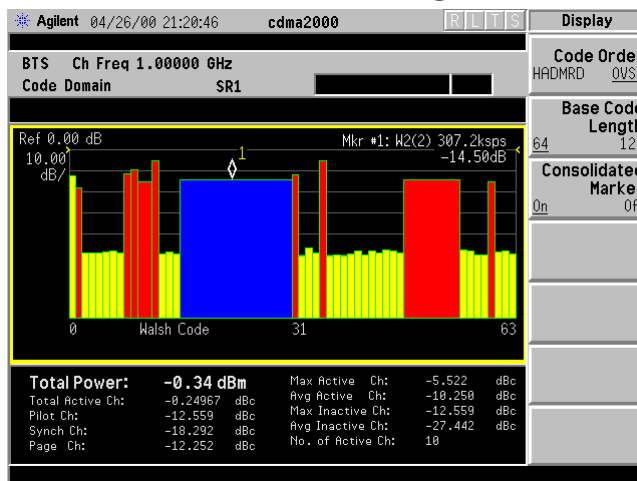

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This is a display of the Code Domain Power curve of a cdma2000 system signal. Code Domain Power is an indicator of modulation quality. Using this measurement, you can verify that each Walsh channel is operating at its proper level and can quantify the inactive traffic noise level.

This cdma2000 base station signal has been broken down into the base codes. Channels with higher data rates have shorter code lengths and occupy more

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How To Get Higher Data Rates

- **Code domain power display - Bit reversed display**
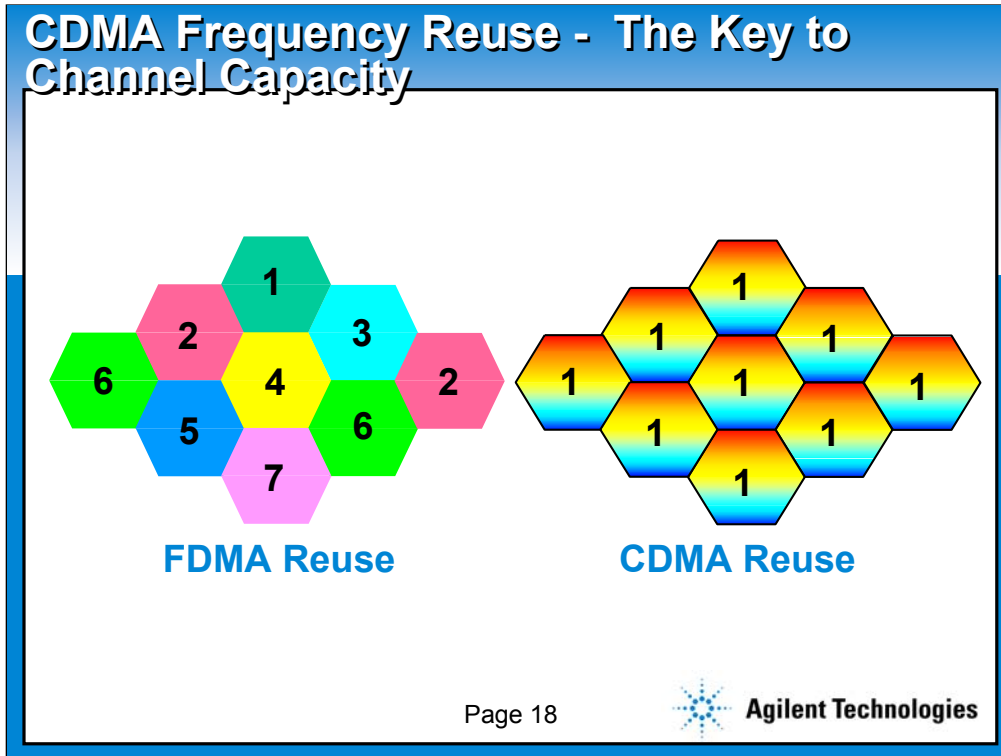- **Wider code channels have higher data rates**

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This is a "Bit-reversed" display of the Code Domain Power curve of the same cdma2000 signal. The fat blue bar in the center is the same high data rate traffic channel that occupied the many blue colored code channels on the previous slide. The total power is the area under the curve. To accomplish this simplified display, the order of the code channels on the display is altered to a "bit-reversed" order.

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CDMA Frequency Reuse - The Key to Channel Capacity

FDMA Reuse

CDMA Reuse

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The major capacity advantage of CDMA is realized by many technical innovations. One of the most important is the reuse of the same frequency in every sector of every cell. In IS-136 and analog cellular systems, there is a 7 cell repeat factor, with 3 sectors. This means that only one out of every 21 channels is available to each sector. GSM usually uses a repeat of 4, with 3 sectors, for a reuse of one out of twelve. This is not the only factor that has

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Differences Between cdma2000 and W-CDMA

cdma2000	W-CDMA
Overlay IS-95	Clear Spectrum only
1.2288, 3.6864 MCPS	3.84 MCPS
Upgrade existing	New equipment

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The cdma2000 system is an upgrade to IS-95. It has been designed to share the same frequency in each sector of each cell. For each user that uses cdma2000 coding rather than IS-95, the system is more efficient. Existing equipment can be upgraded to install the new technology.

The compatibility requires the chip rate to be identical to or an integer multiple of the IS-95 chip rate. China is the only exception to cdma2000 being overlaid

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What is 1xEV-DO or HDR?

- **A high-speed, data only network that supports data rates up to 2.4 Mbps**
  - **Based on cdma2000 technology**
  - **Uses existing spectrum and base station equipment**

Data

Voice Voice

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1xEV D.O. is a high-speed, data only network that supports data rates up to 2.4 Mcps and is based on cdma2000 technology. This system operates in existing spectrum, utilizes existing base station equipment, and is on the fast track to reach the market. The 3GPP2 standards body spent only 6 months developing Release 0 of 1xEV D.O. This data only version will be soon followed by a system that can handle both data and voice. This version is

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The Test Domains for Cellular

- ASIC
- RF
- Upper layer Protocols
- Integration
- Conformance
- Manufacturing

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The need of our customers have been broken down into six areas. Certainly, more areas exist, but these are the major ones.

The ASIC domain is covered by Agilent's Automatic Test Group (ATG). This topic is beyond the scope of this presentation.

Agilent's strengths are in RF test, with different needs for Integration, Conformance, and Manufacturing test.

The testing of the air link protocols is an

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RF Testing

- **Wide Dynamic Range**
- **Real Time Control**
- **Calibration Data Required for Each Phone**
- **Battery Life vs Performance**
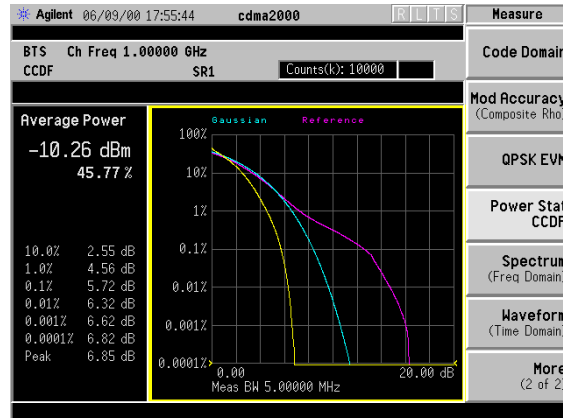
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There are several differences in CDMA technologies from analog or either of the TDMA technologies. The biggest difference is the dynamic range requirement. GSM phones have about 40 dB range. CDMA phones have about 80 dB. In addition, there are design specs on the accuracy of this level, as well as the accuracy of the phone to measure the receive level over this entire range.

Typically, calibration of power on a per

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Power Amplifier Testing

**CCDF curves of noise and cdma2000 signals with different number of code channels**

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This is a measurement of 2 different cdma2000 base station signals. The blue line in the center is Additive White Gaussian Noise for comparison. The plot on the left is the base station signal containing only a few code channels. The plot on the right is a fully loaded base station signal.

This curve is called the Complimentary Cumulative Distribution Function (CCDF). We all remember the cumulative distribution function (CDF)

The Key Test Measurements for cdma2000
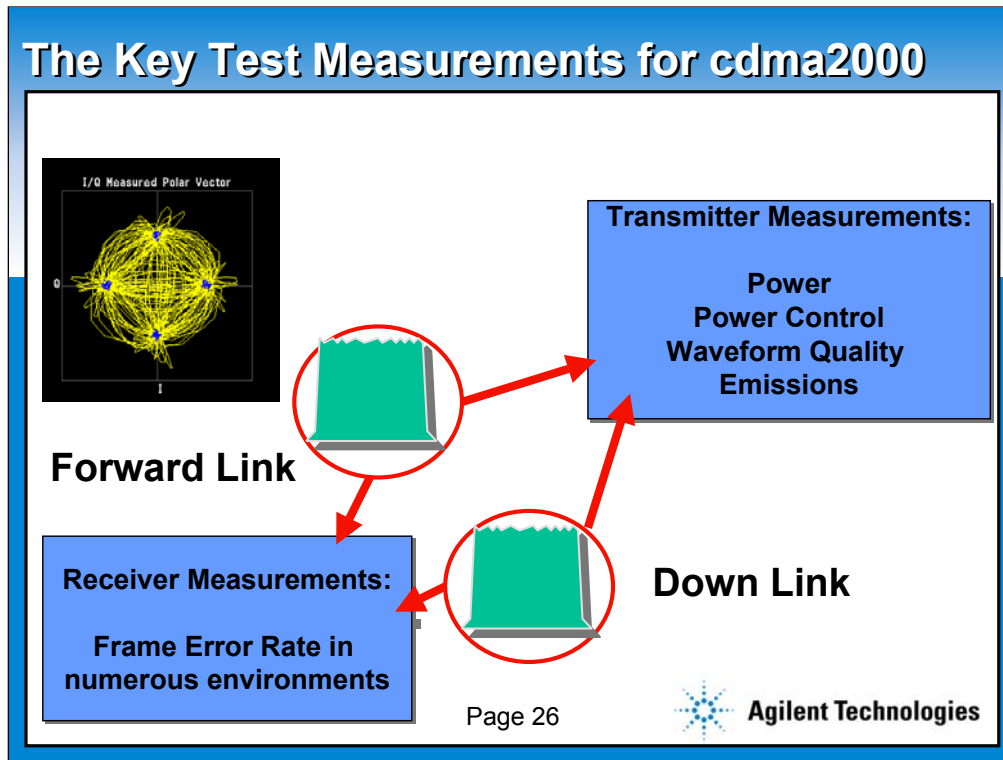
The important RF measurements for
cdma2000 are shown here
- Power   Wide dynamic
Range
- Power Control   Open Loop and
Closed Loop
- Waveform Quality   New metrics for
both standards
- Emissions   Tight specs with
trade-offs
- Frame Error Rate   Requires call
processing or test modes

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