



CDG Forum on Improving 3G Network Coverage, Capacity & Quality

Sprint Nextel Field Trial of Magnolia's DiversityPlus™ Technology for Reverse Link Capacity Improvement

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Agenda

- **About Magnolia and DiversityPlus Technology**
- **Sprint Nextel Field Trial Summary**
- **Q&A**

Magnolia Broadband

- Established in 2001 with corporate office in Bedminster, New Jersey
- Focused on Reverse-Link enhancement solutions for mobile terminals that apply for 3G and other protocols
- More than 30 corporate and technical staff members with expertise in RF ASIC and System Engineering areas
- More than \$40M in funding to date from leading venture and strategic investors

Magnolia DiversityPlus (MTD) Technology

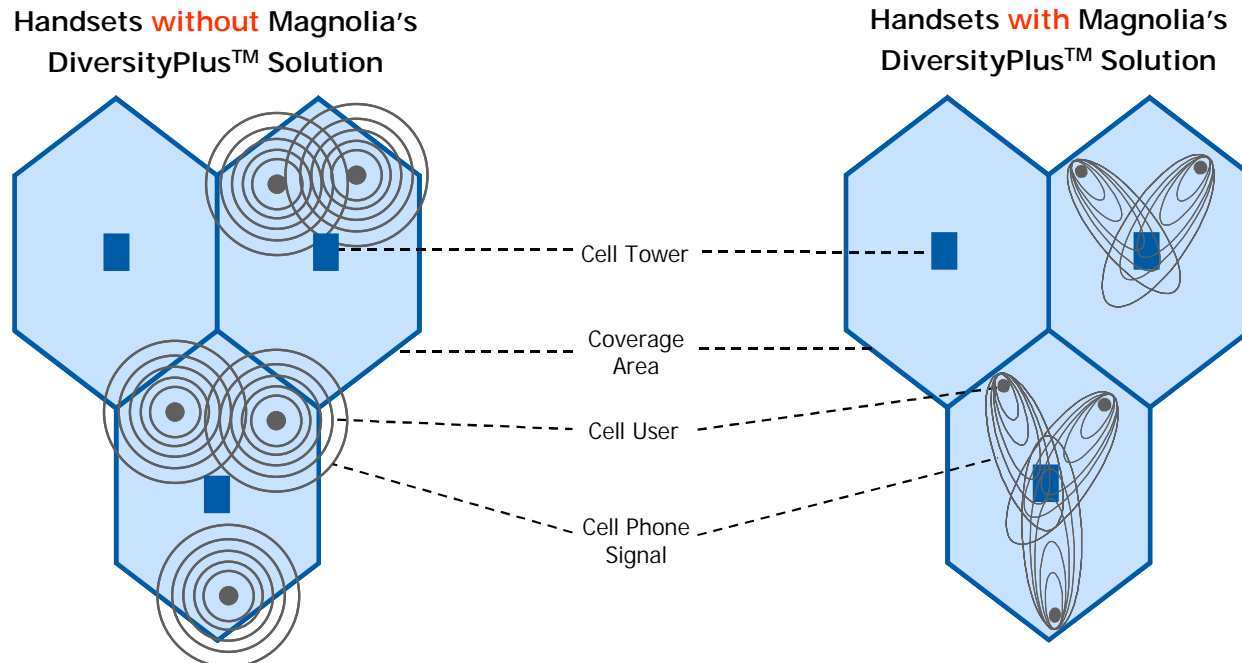


Figure 1: (Without DiversityPlus)

- Handset signals create interference and inefficiencies on the network
- Signals transmitted from handsets located far from the base station are forced to increase power output in order to ensure that their signals will reach the tower

Figure 2: (with DiversityPlus)

- Magnolia's transmit diversity solution enables more efficient sharing of network capacity by both directing and extending the handset transmissions toward the tower
- The solution reduces interference and decreases power requirements for handsets at the edge of the coverage area

DiversityPlus™ Provides Benefits...

Magnolia's
DiversityPlus™
(MTD)



- Increase capacity from 35% - 50%
(Results from Commercial Network Test with Carriers)
- Increase coverage
- Increase data throughput
- Reduce radiation

- CAPEX and OPEX Savings
- Significant Improvement in Q o S
- Reduced CHURN

Carrier Views

- In order to maximize Forward Link enhancements, Reverse Link must also be improved
- Decrease the amount of CAPEX spent each year to address capacity and coverage in the network
 - Address capacity and coverage at the source of the capacity and coverage issue rather than throwing blanket solutions at the capacity & coverage challenges
- Reduce dependency on the FCC to allocate more spectrum to continue our business and reduce the amount of dollars spent to acquire new spectrum in markets where spectrum limits pose a challenge
- Improve customer satisfaction with better performance through fewer dropped calls, better data performance, and better coverage overall

Field Trials on Commercial Network Tests with Carriers...

Date	Host	Location
July 2003	SK Telecom	Greater Seoul Area
Sept. 2003	Sprint	Greater NYC Area
May 2004	Sprint	Greater KC Area
Sept. 2004	SK Telecom	Greater Seoul Area
May 2005	Sprint	Greater NJ Area
July 2005	SK Telecom	Greater Seoul Area
April 2006	Sprint	Greater NJ Area

Overall Average MTD Gain Results



July 13 – 22 2005, Seoul, Korea
SK Telecom Network

Type	Overall Avg. Gain
Voice	4.3 dB
Data	3.9 dB (10% to 144% Data Rate Improvement)
Capacity	45%

Sprint Nextel Field Test Summary

Field Test Objectives

Objectives:

- Quantify the impact of DiversityPlus™ mobile transmit diversity technology on the reverse link capacity
- Expand upon previous field testing conducted on 1X & 1xEV-DO commercial networks by conducting tests in Sprint Nextel 1X commercial network in greater Bedminster, New Jersey for reverse link voice capacity (U.S. PCS Band)
- 60 mobile terminals designed by Pantech with Magnolia's DiversityPlus™ technology

Field Test Approach

Approach

- Perform simultaneous testing (with diversity and non-diversity) of multiple transmit diversity-equipped handsets in a live network
- ROT (*RSSI*) for all cell sectors in the vicinity of the test region are monitored and recorded by Sprint Nextel
- RF Call Trace is recorded for one mobile terminal by Sprint Nextel
- Mobile's TX_adj is also recorded for two mobile terminals by PC in two vans.
- Conduct testing in two modes: (1) conventional single-antenna transmission, and (2) two-antenna transmit diversity transmission
- Compute capacity improvement for Stationary, Pedestrian and Drive scenarios

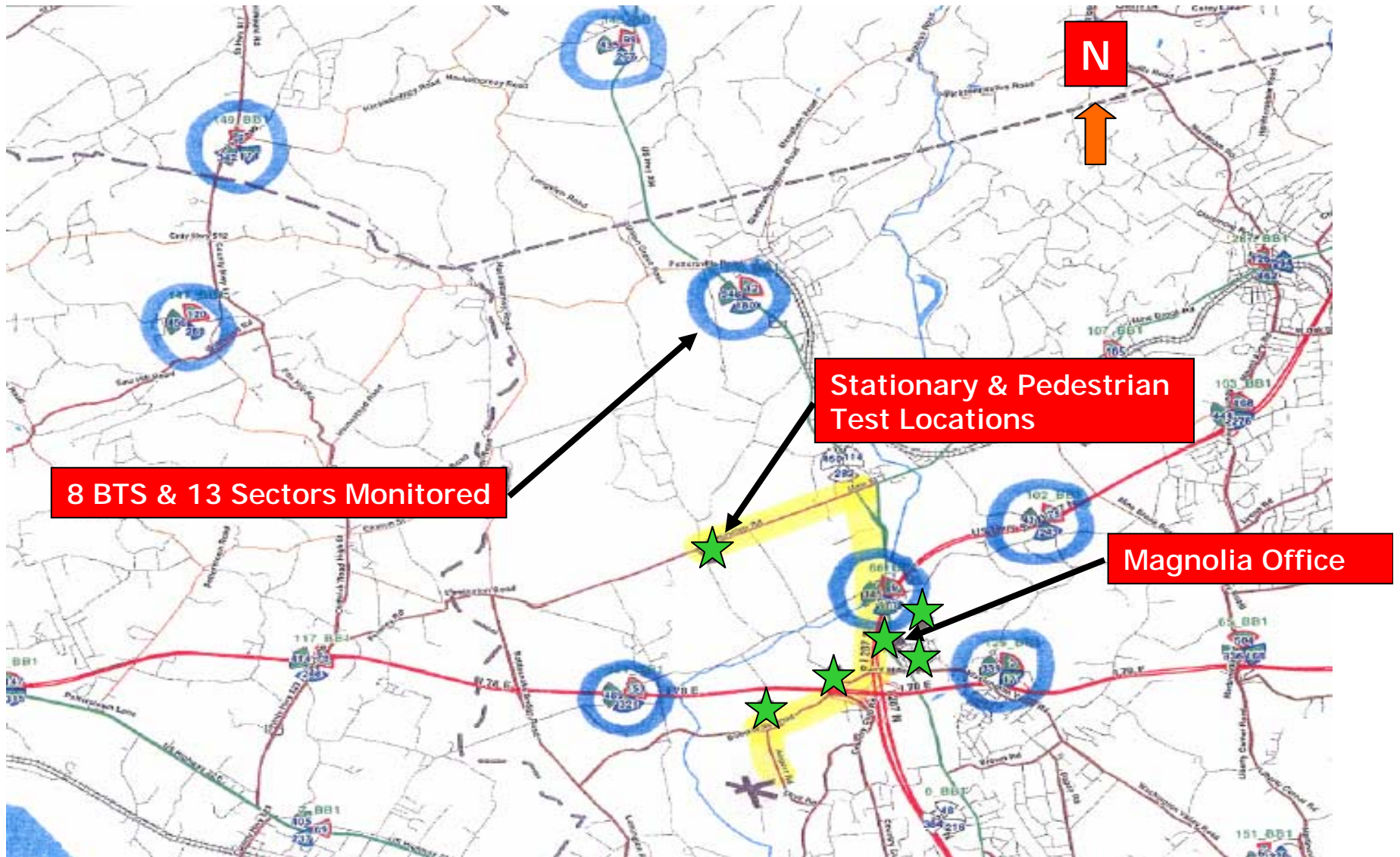
Schedule Overview

- Test Dates & Times: evening of March 27 & March 28
 - 2 cycles each evening for Stationary, Pedestrian & Drive modes
 - 5 vans with 10 mobile terminals each
 - 10 Mobile Terminals In-doors - Magnolia office (turned off for Drive test)
- Testing divided into “cycles”, each comprised of two test sessions:
 - 15 minute session (data collection) each for non-Diversity & Diversity mode
 - Total of 3 hours of data collected each evening
 - Starting at 00:30 and ending at 03:45 for each evening, including 15 minutes break for vans to move to the starting location for the driving test
 - Same scenario repeated for the two days to confirm repeatability

Test Area

- The capacity test conducted in Sprint Nextel commercial network in greater Bedminster area
 - 13 sectors in 8 BTS monitored
 - The test area is equipped with one carrier (frequency channel)
- Mobile terminals are intended to be evenly distributed in the coverage area permitting terrain

BTS/Sector Location & Test Route/Location



Network Capacity Test: Mobile Terminals



- A total of 60 MTD - equipped mobile handset devices are used
- All devices are capable of supporting both diversity and non-diversity operation, and changing the antenna configuration (non-diversity and diversity) *simultaneously*
- Continuous DTMF Tone used to generate constant traffic (full rate)

Commercial Mobile Terminals Used in the Test

- MBJ-6500 DiversityPlus Chipset – Magnolia
- MSM-6500 Baseband – Qualcomm
- 2nd Internal Antenna – Hitachi
- RFT & IFT RF Products - Qualcomm

Data Collection and Tools

- RSSI Measurements (Lucent Special Engineer tool) at base station
 - “PLM dump” reports the most recent 15 minutes RSSI values
 - This reporting (each for 15 minutes data) should synchronize with each test session
 - To ensure the synchronization of the RSSI data and mobile antenna configuration, Sprint set a cron tap (jobs) to automate the RSSI dump command and write the data into the files automatically
- Noise Floor Measurement, N_o
 - Based on RSSI measurements made during “baseline” sessions when all the mobiles power off
 - The minimum observed RSSI value for each sector used as the N_o estimate
- ROT Measurements: computed as $RSSI / N_o$
- RF CallTrace of one mobile terminal collected at BTS (FER, Received Power, etc.)
- Mobile TX_adj (for diversity Gain) will be collected for two mobiles.

Data Analysis

- Average ROT, per Test Period, per Sector
 - For each 15-minute test session, we discard the data of beginning and the ending minute to ensure the synchronization between the measured *ROT* and the mobile antenna configuration.
 - The remaining 13 minutes ROT data is then averaged for each session (antenna configuration) and for each sector.
- ***The capacity improvement for each sector can be estimated from the ROT values of diversity and non-diversity operation.***

Data Analysis

- Average ROT, per Test Period, per Cell Sector
 - The average ROT is computed for each test period and each cell sector
 - The capacity gain for the sector can be computed as:

$$G_{\text{diversity}} = \frac{(\text{ROT}_{\text{non-diversity}} - \text{ROT}_{\text{diversity}})}{\text{ROT}_{\text{non-diversity}} (\text{ROT}_{\text{diversity}} - 1)}$$

where $\text{ROT}_{\text{non-diversity}}$ is the average ROT for a given test session and cell sector when only non-diversity test calls are active, and $\text{ROT}_{\text{diversity}}$ is the corresponding average ROT when all test calls employ transmit diversity

Test Results

3/27/06 to 3/29/06	Cluster Reverse Link Capacity Gain (Average over the cycles and all the sectors*)		
Overall	Static	Pedestrian	Vehicular
42%	42%	59%	24%

- * 1. The data for the sector with the average ROT less than 0.3 dB is not included in the average. The data is in the measurement noise range and hence not reliable.

- 2. The data for the “over loaded” sector (average ROT > 6 dB) is also not included in the average. The data in the over loaded sector may be skewed by the overload control actions in the base station

Thank You...

Backups...

Reverse Link Capacity

- Reverse Link capacity for a **sector** can be defined as the (pole) maximum users (N_{max}) can be support in the sector from noise aspect.
- Noise rise (τ) is the total received power (**RSSI**) over the thermal noise at the cell site.
- It can be associated by the cell loading ($\mu = N/N_{max}$),

$$\tau = \frac{1}{1 - \mu}$$

N is the number of users.

- Magnolia mobile TX diversity Technology reduces the interference to other cells (sectors) and hence increase the reverse link capacity.
- One viable way to measure the capacity improvement is to compare the “noise rise” for the surrounding cells with same number of mobiles operating with and without diversity antenna.

Reverse Link Capacity

- τ is the measured noise rise for a sector with the fixed number of mobiles operating without diversity antenna.
- τ' is the measured noise rise for the sector with the same mobiles operating with diversity antenna.
- The capacity improvement for the sector can then be presented by the new pole capacity (N_{max_DIV}) and the original pole capacity (N_{max}),

$$\frac{N_{max_DIV} - N_{max}}{N_{max}} = \frac{\tau - \tau'}{\tau (\tau' - 1)}.$$