# Analysis of a Right-Hand Circular Polarized Conventional Antenna System for High Altitude Airborne Cellular Base Stations

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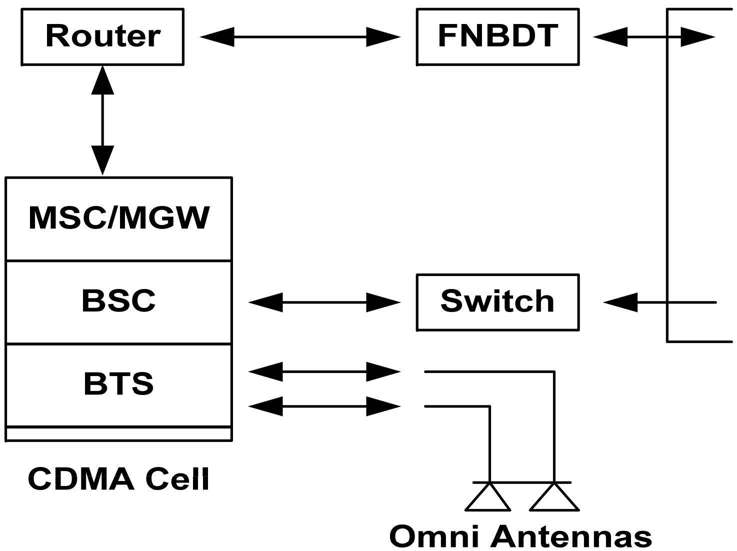
- **Conclusion**

# Overview

- A WB-57 employed an RHCP conventional antenna system coupled with a CDMA base station.
- This aimed to increase the coverage area of mobile users in remote locations.
- It has been problematic obtaining continual mobile communications coverage over two or more regions from an airborne platform.
- This is due to the resulting signal spatial structure and signal gain observed from the mobile users.
- This presentation will describe the measured results, including the antenna pattern and link budget calculations.
- It will also discuss the benefits of using a smart antenna system to obtain continual mobile communication coverage while airborne.

# Introduction

- **The WB-57 was outfitted with the following:**
  - CDMA cell
  - Router
  - Future Narrow Band Digital Terminals (FNBDT)
  - Switch
  - RHCP conventional antennas




CDMA Cellular Base Station Interface

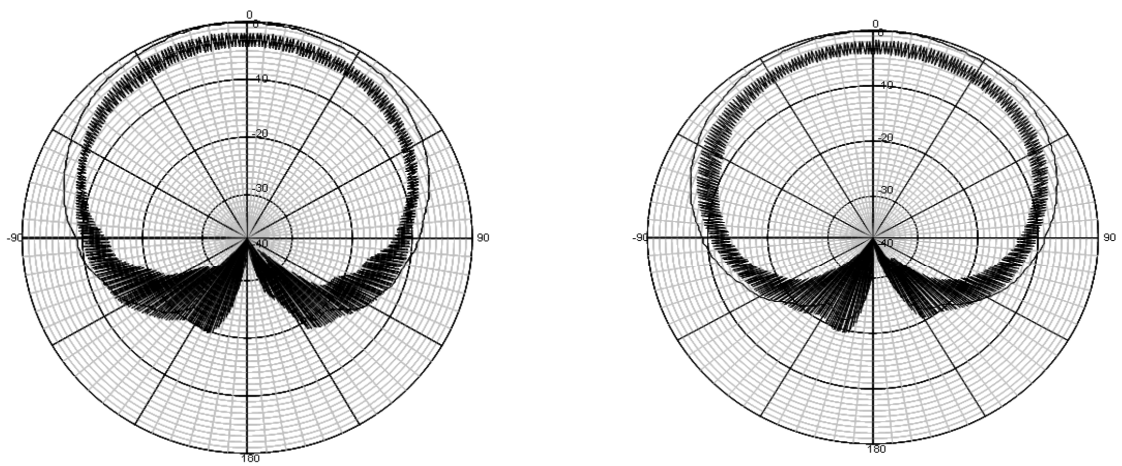
# Introduction

- **The mobile users used the dual band Qualcomm QSec-2700 Type 1 handsets (operated in the 1900 MHZ PCS band).**
- **The WB-57 had two RHCP conventional antennas:**
  - Transmit/Receive antenna
  - Receive diversity (receive only)
- **The call flow from the transmit/receive antenna through the modified CDMA cell to the voice bridge and back allowed characterization of the performance of the RHCP conventional antennas.**

# Component Testing

### *Antenna Pattern*

- The antenna pattern and gain are two of the most important antenna characteristics that affect system coverage and performance.
- The radiation pattern of an antenna describes how an antenna directs the energy it radiates or receives.
- The axial elevation cuts for the RHCP antenna are below.



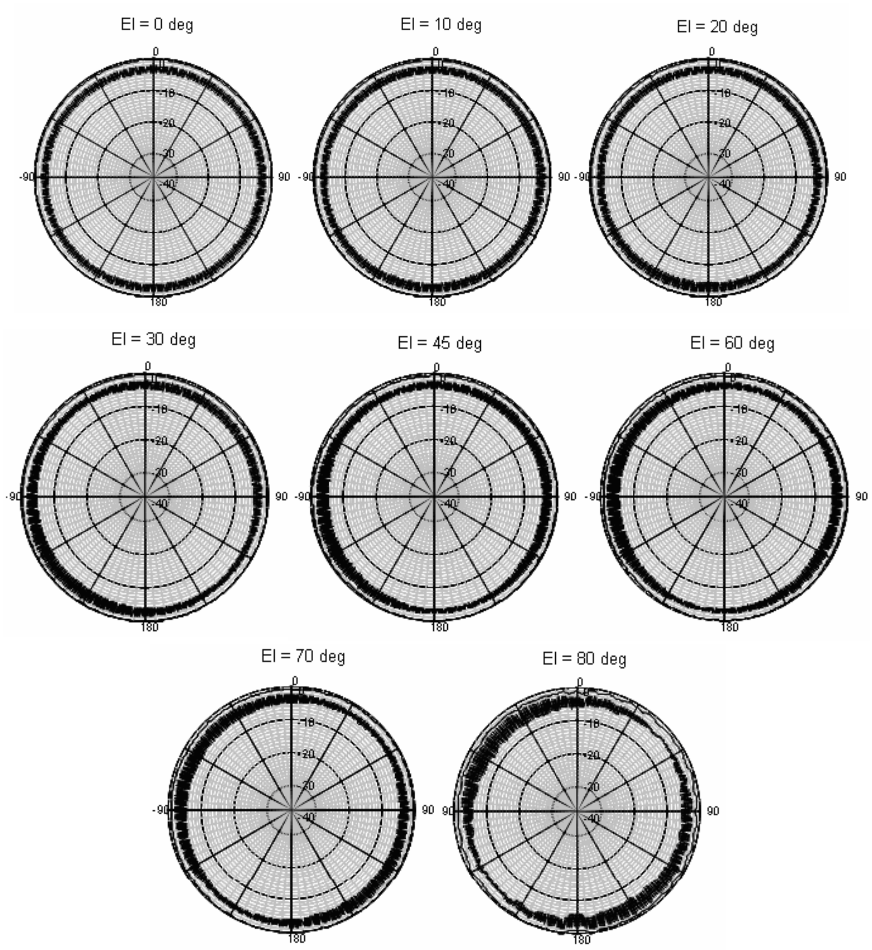
(a) E-Cut

(b) H-Cut

Axial Elevation Cuts

# Component Testing

- The axial azimuthal cuts of the RHCP conventional PCS blade antennas are shown below.




Axial Azimuthal Cuts

- The following table describes the maximum gain realized at a given elevation angle.

Elevation Angle versus Maximum Gain Realized

| Elevation Angle (degrees) | Maximum Gain (dB) |
|---|---|
| 0º | 5.43 |
| 10º | 5.23 |
| 20º | 4.80 |
| 30º | 3.75 |
| 45º | 2.04 |
| 60º | 0.57 |
| 70º | -1.44 |
| 80º | -2.97 |

# Component Testing

***Link Budget***

- **The link budget accounted for of all the gains and losses from the transmitter to the receiver.**
- **The power settings were adjusted to optimize the forward and reverse links.**
- **The link budget calculations took into consideration multiple parameters.**
- **The calculations assume the following:**
  - The antenna beam pattern is omni-directional in both the receive and transmit modes
  - Bandwidth is 1850 MHz to 1990 MHz
  - Multipath effects were negligible





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# Component Testing

- **The link budget calculations for the forward direction are provided in table below.**

Link Budget in Forward Direction

| Features | Metric |
|---|---|
| Traffic channel signal to noise plus interference ratio | 8.16 dB |
| Paging channel signal to noise plus interference ratio | 12.08 dB |
| Pilot channel signal to noise plus interference ratio | -10.83 dB |
| Sync channel signal to noise plus interference ratio | 18.25 dB |

- **The requirements for the link budget in the forward direction were satisfied by the margins shown in the table below.**

Forward Direction Antenna System Margins

| Features | Metric |
|---|---|
| Traffic channel margin | 3.16 dB |
| Paging channel margin | 7.08 dB |
| Pilot channel margin | 3.17 dB |
| Sync channel margin | 13.25 dB |



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# Component Testing

- **The link budget calculations for the reverse direction are provided in table below.**
- **The same power settings were used as in the forward direction.**

Link Budget in Reverse Direction

| Features | Metric |
| --- | --- |
| Traffic channel signal to noise plus interference ratio | 12.50 dB |

- **The requirements for the link budget in the reverse direction were satisfied by the margins shown in the table below.**

Reverse Direction Antenna System Margins

| Features | Metric |
| --- | --- |
| Traffic channel margin | 7.50 dB |

# Benefits of Smart Antenna Utilization

***Smart Antennas***

- **There are two main types of smart antennas**
  - Switched beam smart antennas
  - Adaptive array smart antennas
- **Communicate directionally by forming specific antenna beam patterns.**
- **When a smart antenna directs its main lobe with enhanced gain in the direction of the user, it forms side lobes and nulls in directions away from the main lobe.**
- **Both switched beam and adaptive smart antenna systems are different in the way they control the lobes and the nulls with varying degrees of accuracy and efficiency.**



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# Benefits of Smart Antenna Utilization

*Switched Beam Approach*

- **Switched beam antenna systems generate many fixed beams with increased sensitivity in specific directions.**
- **They detect signal strength, choose from one of several predetermined, fixed beams, and switch from one beam to another as the mobile moves throughout the sector.**
- **The antenna radiation pattern is an extension of the cellular sectorization method of splitting a cell.**
- **Offers higher capacity due to design over conventional antennas.**



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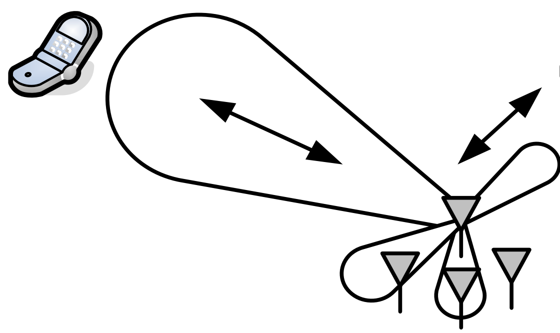
# Benefits of Smart Antenna Utilization

*Adaptive Array Approach*

- An adaptive antenna system uses signal processing algorithms that take advantage of locating and tracking various types of signals.
- It reduces interference and maximizes the signal strength.
- It provides the best possible gain while identifying, tracking, and minimizing interfering signals over conventional antenna systems.
- Adaptive antennas can alter the antenna response pattern to optimize the performance of the wireless system by adjusting to the RF environment as it changes.

# Benefits of Smart Antenna Utilization

- The figure shows how an adaptive antenna reacts to a user with an interferer present in its known environment.




Adaptive Array Coverage

- Adaptive arrays use refined signal-processing algorithms to continuously distinguish between desired signals and interfering signals.
- It updates its strategy based on changes in both the desired and interfering signal locations.

# Benefits of Smart Antenna Utilization

*Summary of Antenna Design Options*

- The conventional antenna system proved to be worse than either smart antenna system.
- Both the switched beam approach and the adaptive array approach provide noteworthy advantages over conventional antenna systems.

# Conclusion

- **The mobile to voice call test conducted characterized the performance of the RHCP antennas.**
- **The antenna radiation patterns were analyzed, and the link budget calculations performed satisfied the requirements of the antenna system desired for the WB-57 application.**
- **However, improvements to the resulting signal spatial structure and signal gain to maximize the coverage area and duration of coverage can be made.**
- **Future work will include a performance test utilizing smart antennas with the same CDMA base station to provide optimal coverage.**
- **Additional work in aircraft link budget simulation will occur.**



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# Questions/Comments



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