Two System Proposal

# AirCell Response to Nextel's Analysis on Wideband Air-to-Ground Interference

## Prepared for

Federal Communications Commission

## Prepared by

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## 1. Summary

This document contains AirCell's response to a recent filing [1] from Nextel Communications regarding Out-of-Band Emissions (OOBE) from the proposed Wideband Air-to-Ground (WATG) service. In its filing, Nextel raises concerns about potential interference from WATG service to adjacent 800 MHz and 900 MHz public safety, critical infrastructure, Specialized Mobile Radio (SMR), and cellular licensees.

AirCell appreciates Nextel's grounds for concern and agrees with Nextel that all parties involved in the WATG service should make sure that no unacceptable interference level is produced to adjacent band operations, particularly to the public safety operations under the recently released FCC Report and Order (the "*800 MHz Report and Order*") in WT Docket No. 02-55 reconfiguring the 806-824/851-869 MHz portion of the 800 MHz band. However, AirCell's initial analysis indicates that two-system WATG operations as proposed by AirCell [2] will not produce interference levels above the limits specified in the *800 MHz Report and Order*. Other proposals, such as the single operator approach advanced by Verizon Airfone, will not offer the same level of protection to adjacent-band operators.

## 2. Background

This paper provides a simple analysis of interference levels from WATG services that can be expected in the adjacent band operations. The analysis addresses all three scenarios raised by Nextel in its filing.

### 2.1. Band Plan – AirCell WATG Proposal and Adjacent Band Operations

The current ATG service and the proposed WATG service use spectrum in the 849-851 MHz (ground-to-air) and 894-896 MHz bands (air-to-ground). AirCell's proposal for the WATG service involves two systems operating with different polarization schemes. The spectrum used by two systems and the suggested polarizations (V for vertical and H for horizontal) are indicated in Figure 1. Each system has a 1.25 MHz broadband carrier with a 125 kHz guardband on either side.

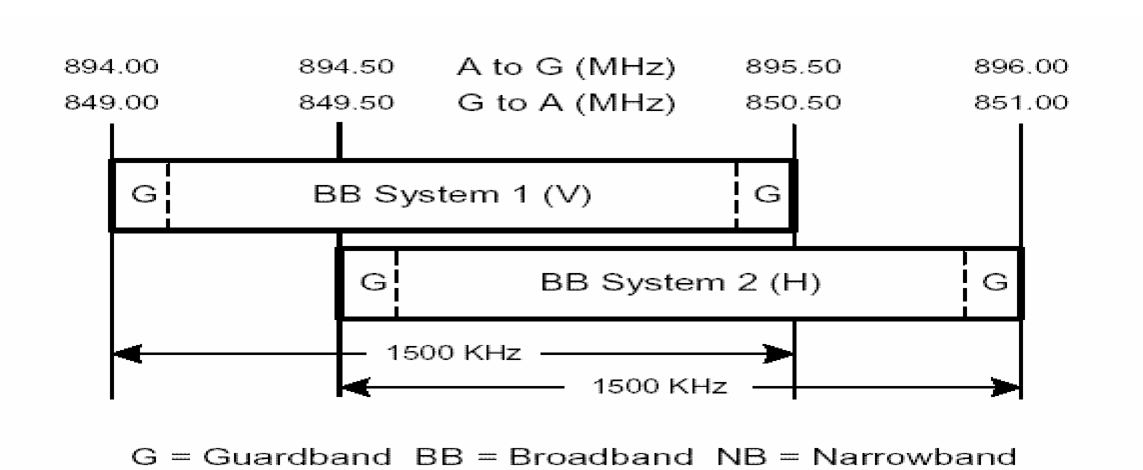

**Figure 1. AirCell proposal: WATG spectrum allocation**

Adjacent band operations are indicated in Figure 2 (reference from Nextel's filing).

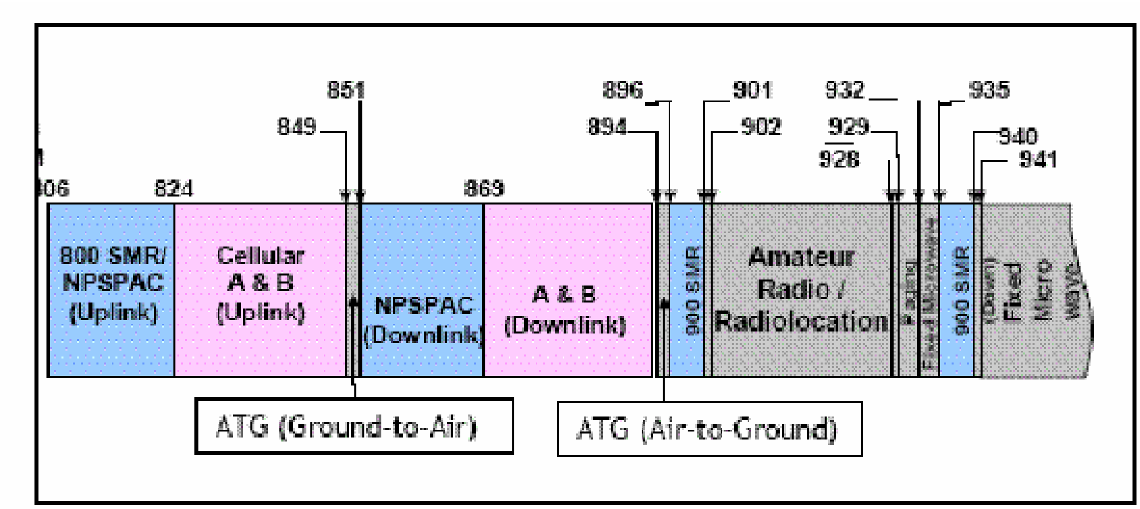


**Figure 2. ATG Adjacent Band Operations**

## 2.2. WATG System Factors

Nextel, in its filing, had considered several factors that it gathered from the *ex-parte* filings of different parties involved in the ATG proceeding (WT Docket No. 03-103). As detailed below, some of these system factors are different under AirCell's proposal. In fact, in most severe interference scenarios pointed out by Nextel, AirCell's proposal minimizes or eliminates the potential for interference to adjacent band operations. Comments are made on some of the factors considered in Nextel's analysis and how they are different in AirCell's proposal.

### 2.2.1. Ground Station EIRP

Nextel states "WATG ground stations are assumed to transmit at 56 dBm/1.25MHz EIRP. This figure is derived as follows: 43 dBm (20W) PA output + 15dBi antenna gain – 2 dB cable loss. Although not specified in the record, 2dB of cable loss is typical in current CDMA deployments." AirCell notes that 15 dBi antenna gain is the maximum that is expected at an AirCell WATG base station and the antenna gain is likely to be less near airports and other high traffic areas, where potential for small separation distances between sources and victims exist.

### 2.2.2. Aircraft Transmitter Power and Antenna Characteristics

Nextel states "WATG aircraft transmitters are assumed to use a fixed omni-directional antenna with 48 dBm EIRP of transmit power. This assumption assumes 43 dBm (20W) PA output plus 6 dBi of antenna gain minus 1 dB cable loss." Unlike the WATG system proposed by Verizon Airfone, AirCell's aircraft transmitters will not be transmitting 48 dBm EIRP of transmit power. Instead, AirCell's proposal is based on a maximum transmit power of 23 dBm EIRP from the aircraft (23 dBm PA power, 2 dBi of antenna gain minus 2 dB cable loss). It is also important to note that CDMA (EvDO) is a power-controlled system where mobiles (aircraft) are required to transmit the least power necessary to meet the communication parameter requirements. This would imply that as aircraft get closer to terrestrial systems, they are likely to be closer to an ATG base station and hence likely to transmit lower power than the maximum 23 dBm.

However, in this analysis, AirCell has used 23 dBm EIRP transmit power (0 dBi net aircraft antenna gain) from aircraft to calculate potential interference levels to adjacent band operations.

### 2.2.3. Operational bandwidth of 1.25 MHz and OOBE limits

Nextel states "Out-of-band emissions are assumed to rely on a standard FCC emissions mask of 43+10log(P) with 100 kHz of resolution bandwidth per Part 22.917." Although Nextel assumes 800 MHz cellular band rules of 100 kHz bandwidth per Part 22.917 for out-of-band emission level, AirCell expects the Commission to impose 43+10log(P) over 1 MHz of bandwidth for ATG transmitters. Therefore, AirCell has used the 43+10log(P) limit over 1 MHz adjacent spectrum bandwidth.

With 20 watts of PA output, the out-of-band emissions level shall be less than –13 dBm / 1 MHz (43dBm – (43+10log(20))), instead of the –3 dBm/MHz used in Nextel's analysis.

### 2.2.4. Victim location and probability of interference

Though smaller separation distances between source (WATG transmitters) and victim (adjacent band receivers) are considered in this analysis, the probability of such small separation distances is very low with the AirCell approach where deck-to-deck service is based on hand-off (below about 500 feet) to terrestrial service providers. Under the AirCell approach, moreover, the minimum separation distance can be managed through base station location coordination and antenna selection/engineering.

Even with a small separation distances assumption, the impact of interference is further reduced by the fact that the victim will be affected only if those frequencies/channels are in use in the area when significant interference is present and if the victim system does not have the capability to overcome such interference to maintain a required C/(N+I).

### 2.2.5. Deck-to-deck coverage

As in the model system that Nextel analyzed, AirCell's proposal offers deck-to-deck coverage providing broadband services to aircraft. Unlike Verizon Airfone's WATG proposal, however, AirCell's proposal[3] offers a superior deck-to-deck solution by handing-off the WATG service to a terrestrial based wideband service below altitudes of about 500 feet. The hand-off-based deck-to-deck coverage offers the ability to serve the high number of aircraft likely to be present at an airport using much larger spectrum capacities of the terrestrial service providers instead of the single broadband carrier that the WATG service provider can offer. In addition, hand-off-based deck-to-deck solution avoids the severe adjacent band interference potential arising from serving aircraft that are on or near ground. With AirCell's approach, aircraft on or near ground will not be transmitting in the ATG spectrum/band and WATG base stations need not be downtilted to provide coverage to aircraft on ground.

Because of these factors, in this analysis, WATG base station antennas are assumed to offer some discrimination towards adjacent band mobiles and base stations. AirCell believes that a zero dB (0 dB) of antenna gain towards the victim is a reasonable value to use instead of 13 dB WATG base station antenna gain towards victim.

AirCell agrees with Nextel's observations that offering deck-to-deck coverage from loading, taxi, takeoff, flight, landing, docking, and disembarkation will significantly increase the potential for interference to adjacent band operations from WATG services. This is because to provide service to aircraft on or near ground, WATG base station antennas have to be downtilted, increasing the interference levels to the adjacent band downlink operations (mobiles) compared to the situation of uptilted antennas at WATG base stations. More significantly, multiple aircraft will be present in a small geographical area on ground at airports, and OOBE transmissions from those aircraft have the potential of being received in the main lobe of the base stations of adjacent band operation. The potential for the uplink interference dramatically increases in this situation from two factors: (a) aircraft can be much closer to adjacent band base stations and their out-of-band emissions will be received in the direction of maximum antenna gain of these base stations, (b) multiple aircraft (e.g., 50 is not uncommon) may be present at about the same small distance from an adjacent band base station, thereby increasing the interference level (e.g., by 17dB with 50 aircraft).

### 2.2.6. Polarization isolation and additional transmit filtering

In order to keep the WATG OOBE interference to adjacent band operations at acceptable levels, additional filtering (bandpass or notch) can be deployed at WATG base stations and aircraft. AirCell believes that at least 20 dB of further attenuation or isolation can be achieved with such filtering mechanisms. More isolation from filtering will be available if there is sufficient bandwidth for roll-off of filter response.

In addition to the out-of-band emissions attenuation, AirCell proposes that System #2, operating near 851 MHz and 896 MHz, use horizontal polarization while System #1 uses vertical polarization. Use of horizontal polarization is likely to offer extra isolation to the adjacent band operations, which are based on vertical polarization, particularly in the interference scenarios analyzed here (line-of-sight propagation with small separation distances between source and victim). With System #1 base stations and aircraft, additional transmit filtering isolation can be provided in cases where interference potential to adjacent band operations is likely to be higher. The partial overlap feature of AirCell's proposal offers additional bandwidth for System #1 for transmit filter roll-off, thereby offering additional interference protection.

AirCell assumes that 30 dB of total isolation/attenuation can be achieved from polarization and additional filtering at a WATG base station, while 20 dB of total isolation/attenuation can be achieved from polarization and additional filtering at a WATG aircraft. The lower attenuation assumption for aircraft is consistent with the goal of keeping the aircraft equipment deployment costs to a minimum, whereas the cost of extra filtering capability for base stations is expected to be only a fraction of a licensee's total base station deployment costs, given the small number of base stations in a network.

# 3. Interference Cases

## 3.1. Interference Case 1: ATG Ground Station to Public Safety Mobile Terminals and SMR Handsets

As discussed in Nextel's filing [1], the prospective WATG ground-to-air (base transmit) frequencies would be immediately adjacent to the new NPSPAC channel allocation. In this analysis, adjustments and revisions were made to Nextel's analysis based on AirCell's WATG proposal and the impact of that proposal on the factors considered in the analysis (Section 2.2).

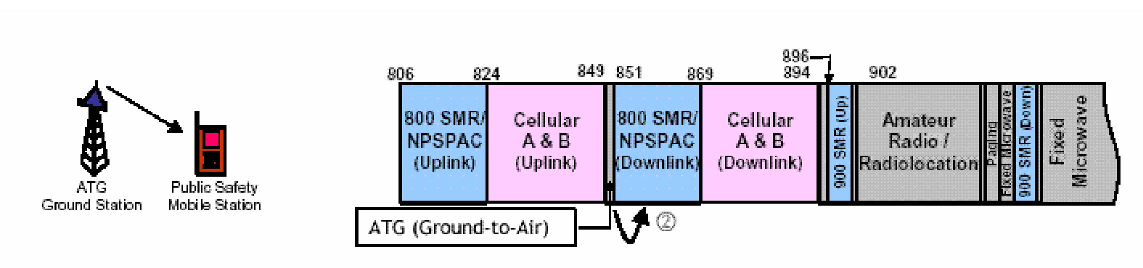


**Figure 3. Interference case 1: WATG base station to Public Safety Mobiles**

As explained in Section 2.2.6, under AirCell's WATG proposal, an extra 30 dB of isolation/attenuation to OOBE can easily be provided through a combination of polarization isolation and extra transmit filtering. The cost for such a solution can be expected to be a tiny fraction of the total base station cost of the WATG system.

For small separation distances considered in this analysis, WATG base station antenna gain is assumed to be zero (0) dBi since the WATG antennas will be uptilted for the most part. In cases of larger separation distances (such as at the horizon from a WATG base station), increase in path loss will offset any gain from antenna pattern variations.

| Adjacent Channel Interference Level (dBm/MHz) | ATG ground station antenna gain (in the direction of victim) | Distance separation (meters) | Free space loss (dB) | Isolation from polarization and/or additional transmit filtering | Public safety mobile antenna gain (dBi) | Resulting Interference Level (dBm / MHz) | PS Signal level to protect (dBm / MHz) | Interference Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| -13 | 0 | 50 | 65 | 30 | 0 | -108 | -108 | 0 |
| | | 100 | 71 | | | -114 | | 6 |
| | | 500 | 85 | | | -128 | | 20 |

**Figure 4. Interference levels from WATG base station to Public Safety Mobiles**

As the above table indicates, AirCell's WATG deployment proposal, while offering deck-to-deck, broadband, always-on voice and data service to aircraft, does not increase the noise floor above that anticipated by the Commission in the 800 MHz reconfiguration proceeding in WT Docket No. 02-55.

### 3.2. Interference Case 2: WATG Aircraft into 900 MHz SMR Base Stations

Nextel contends that WATG service aircraft transmissions (894-896 MHz) might cause interference to the 900 MHz SMR operations where the SMR base stations are receiving in the frequency band of 896-902 MHz.

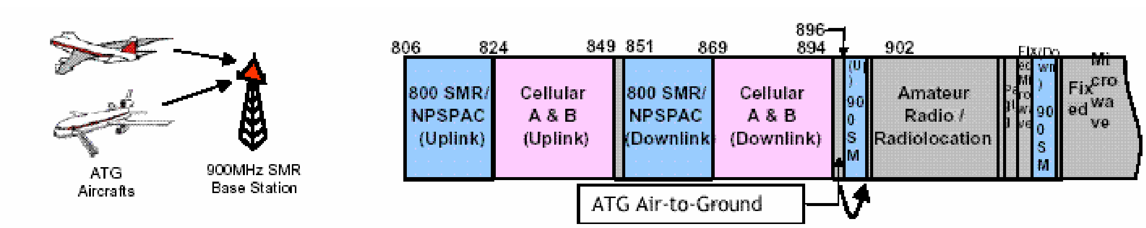


**Figure 5. Interference case 2: WATG aircraft to 900 MHz SMR base station**

In referring to the most severe case of this interference, Nextel points out that "Although the 894-896 MHz band is allocated for 'air-to-ground,' the name is something of a misnomer in the context of 'deck-to-deck' operations." Nextel adds that "with a transmit power of 48 dBm EIRP for aircraft equipped WATG transmitters, the airborne facility operates more like a flying base station than a mobile handset." As explained in Section 2.2.5 of this document, AirCell's proposal almost eliminates this interference potential through a hand-off-based deck-to-deck solution and a more realistic/reasonable value for mobile transmit power of 23 dBm.

With AirCell's hand-off-based approach, the probability of an aircraft coming within a 1-mile distance from an adjacent band (SMR) base station is minimal. It is even more improbable for multiple aircraft to be at a short distance from a SMR base station, whereas under Verizon's deck-to-deck proposal, an SMR base station at an airport is likely to see a huge number of aircraft transmitting in the ATG spectrum all located within a short distance from the victim base station. Hence, separation distances of 1, 2 and 5 miles are considered in this analysis.

It is not clear how Verizon plans on achieving 48 dBm EIRP transmit power from aircraft, but this analysis assumes aircraft transmit power of 23 dBm EIRP (23 dBm PA power, 2 dBi antenna gain, 2 dBi cable loss). Therefore, the effective OOBE level would become (-13 dBm/MHz + 0 dBi) = -13 dBm/MHz EIRP. Standard free space path losses valued in dB are assumed.

For this analysis, AirCell has assumed the SMR base station antenna gain in the interference direction to be 13 dBi, just to illustrate a worst-case scenario. Under AirCell's proposal with hand-off-based deck-to-deck coverage, SMR base stations will not see any interference from aircraft at or near ground. As one can imagine, the probability of a scenario of aircraft being 1-mile away from a SMR base station and being at the main beam of the SMR base station antenna is very low. Even in the low probability case, it is not likely to last for any significant duration as the aircraft is likely to be landing or taking off and will leave the main beam of the victim base station antenna in a very short time. Interference during such a short duration will be a problem to the 900 MHz SMR operation only if any of those channels receiving interference are in use at that particular base station during that interference duration and if the SMR mobiles using that channel(s) at that base station do not reach the base station with enough signal strength to overcome the interference and maintain the required C/(N+I).

| Adjacent Channel Interference Level (dBm/MHz) | ATG airborne transmitter net Gain (dBi) | Distance separation (mi) | Free space loss (dB) | Isolation from polarization and/or additional transmit filtering | SMR base station antenna gain (dBi) | Resulting Interference Level (dBm / MHz) | Receiver Noise Floor dBm (4dB of NF is assumed) | Interference Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| -13 | 0 | 1 | 95 | 20 | 13 | -115 | -110 | 5 |
| | | 2 | 101 | | | -121 | | 11 |
| | | 5 | 109 | | | -129 | | 19 |

**Figure 6. Interference levels from WATG base station to Public Safety Mobiles**

The above table indicates that OOBE interference from WATG operations, for the most part, will be below the thermal noise floor of the 900 MHz SMR base stations.

Furthermore, with respect to this interference case, Nextel comments that multiple aircraft visible to the SMR base station will significantly increase the interference – "assume 10 airplanes simultaneously landing, taking off or taxiing at an airport each spectrally 'visible' to a nearby 900 MHz SMR base station. If each plane generates -123 dBm/MHz of interference, the aggregate interference to the SMR base station *increases by 10 dB*." As explained earlier, AirCell's approach – unlike other proposals – avoids or minimizes this problem of multiple aircraft and interference in the main lobe of the SMR base station antenna.

### 3.3. Interference Case 3: Cellular Base Station into WATG Ground Station

In this interference case, Nextel comments "…cellular A and B band downlink base station transmissions are causing substantial interference to Nextel's 900 MHz base station receivers and that cellular base station filtering is necessary to correct that problem. Given that the proposed WATG air-to-ground (uplink) would be immediately adjacent to the cellular A and B band downlink frequencies, cellular base stations' OOBE will fall into the 894-896 MHz band. Given Nextel's experience with cellular OOBE in the 900 MHz SMR band 2 MHz above the Cellular A & B Downlink band (discussed above), these cellular emissions appear likely to degrade the ability of ATG providers to offer the high capacity throughput that broadband service requires."

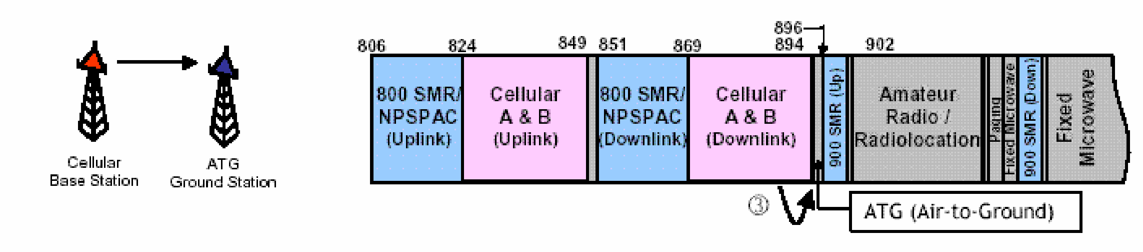


**Figure 7. Interference case 3: Cellular base station to WATG base station**

It is clear that if cellular A and B band base stations only meet the minimum standard FCC OOBE mask, there is potential for significant interference to WATG operations. However, there are several factors that are different between the interference potential from cellular A and B band base stations to 900 MHz SMR base stations, and the interference potential from cellular A and B band base stations to WATG base stations.

- Total number of WATG base stations are likely to be a few hundred in number throughout the country. WATG base stations have large radii (typically 100 miles) compared to SMR base stations. This implies that there is more flexibility in the location of WATG base stations with respect to a cellular A and B band base station.
- Even in cases of interference scenarios, the small number of WATG base stations imply that expenses associated with interference mitigation (such as additional filtering or antenna engineering techniques) is limited to select locations, no matter which party bears the cost associated with such mitigation mechanisms.
- WATG base stations (under AirCell's proposal) are likely to have uptilted antennas and need not have antennas pointed towards the ground, particularly at airports since aircraft on the ground are not served with the ATG spectrum. This offers the potential for further isolation between cellular A and B base stations and WATG base stations due to discrimination from antenna patterns.
- Nextel is likely to add 900 MHz operations to its existing base stations instead of building new base stations for 900 MHz operations, whereas WATG base stations are likely to be new additions offering a lot more flexibility for base station and antenna location coordination.

That said, however, AirCell agrees with Nextel on the possibility of this interference and requests the FCC to consider rules or mechanisms which provide for cellular A and B band operators to limit the OOBE into the ATG band and cooperate with WATG operators to mitigate any interference that may exist.

## 4. Conclusion

Simplified analysis such as provided above indicates that, under AirCell's proposal, the OOBE interference from WATG to adjacent band Public Safety and SMR operations is, for the most part, at or below the acceptable interference levels prescribed by the Commission in the 800 MHz reconfiguration proceeding in WT Docket No. 02-55. AirCell's proposal offers unique advantages in mitigating the interference potential from WATG services to adjacent band Public Safety and SMR operations. In the rare cases of interference, sufficient flexibility exists due to the nature of WATG services to mitigate or eliminate interference through coordination efforts between the parties involved. Unfortunately, the same cannot be said of the Verizon Airfone proposal, which continues to present many of the worst case scenarios that Nextel has correctly identified.

AirCell supports the concept of holding WATG operators responsible to comply with the interference level and standards prescribed by the Commission in the 800 MHz reconfiguration proceeding in WT Docket No. 02-55 and deploy WATG services without compromising the objectives of the *800 MHz Report and Order*.

**References**


[1] Michael Ha, "Wideband Air-to-Ground Interference – Analysis of Nextel Communications," Nextel Communications, November 16, 2004, WT Docket No. 03-103.

[2] Anand Chari, Joe Cruz, Ivica Kostanic, and Grant Saroka, "Deployment of Two Cross-Polarized Systems in the ATG Band," AirCell, Inc., October 25, 2004, WT Docket No. 03-103.

[3] Anand Chari, Joe Cruz, Ivica Kostanic, and Grant Saroka, "Further Notes on the Deployment of Two Cross-Polarized Systems in the ATG Band and Response to Verizon Airfone/Telcordia," AirCell, Inc., November 23, 2004, WT Docket No. 03-103.