Experiment Description
Response to Form 442 Question 7

Summary

AirCell, Inc. ("AirCell") proposes to evaluate the feasibility of operating a modified CDMA cellular system in high-speed commercial aircraft to provide advanced passenger telecommunications services.

Although AirCell currently operates an AMPS analog cellular system from aircraft under the terms of its Waiver (DA 98-2590), AirCell seeks to determine whether a CDMA based system will function in aircraft in flight at altitudes up to 45,000 feet and at speeds exceeding 500 MPH. The band selected to conduct these tests, the 849-851 and 894-896 MHz Air-to-Ground Radiotelephone Service band (ATG), is the most appropriate band because of its spectral similarity with the contiguous 800 MHz cellular band and because the current occupants of the ATG band have a relatively few number of cell sites across the country in specific locations that can be easily accommodated to avoid interference.

AirCell proposes to set up a single CDMA base station with a narrow beam directional antenna. The base station, controlled by a normal ground cellular switch, would use a highly directional antenna to control the area of influence, and would use a frequency range that is not used by the current ATG system in that area.

Specific Objectives

Evaluate the following:

Methods of shifting the CDMA base station operation from standard frequencies into the ATG band, including both upconverting standard cellular frequencies, as well as modifying the base station hardware to operate in the new range.

The effects of using CDMA technology for high speed, long range communications to aircraft, including Doppler shift (airborne mobile velocity) and range (distance from the cell site) as they relate to the operation of standard CDMA cellular technology, and explore options to deal with any issues found.

Test Configuration

The test will utilize standard cellular base station electronics for the ground base station. The base station will be controlled by a normal controlling switch on the ground, in a similar manner to any other CDMA base station. The switch and cell site parameters will

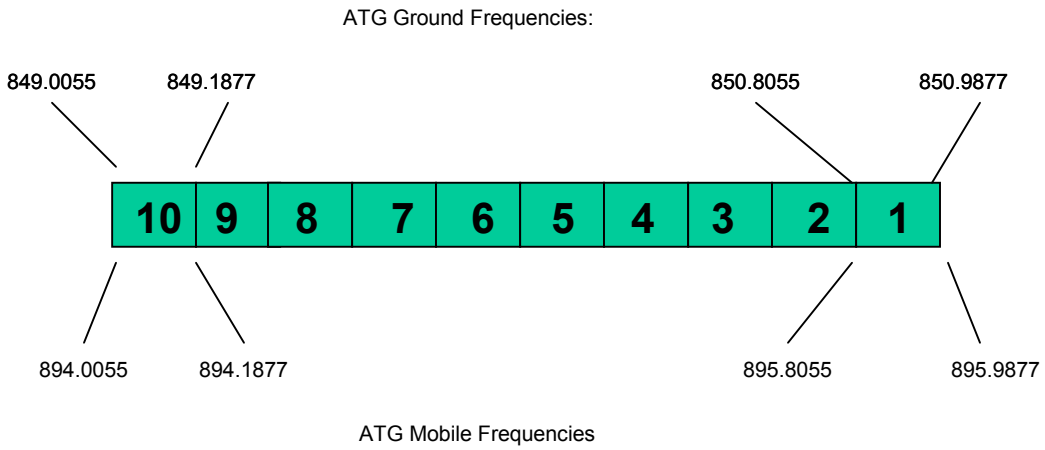
be set up separately from the ground operation, so optimization can be done for the airborne environment.

Two possible methods are contemplated to shift the standard base station electronics into the adjacent ATG band. One configuration to be tested will be to operate the base station on standard 800 MHz cellular frequencies, and upconvert the signals to frequencies in the ATG band. A second configuration to be evaluated will be to modify the base station electronics and/or software to transmit on the new frequency band directly.

Similarly, the mobile to be used in this test will be based on standard CDMA mobile phone technology, and the same techniques (up convert or software/hardware changes) will be used to move the operation to the ATG band.

Frequencies involved and interference mitigation:

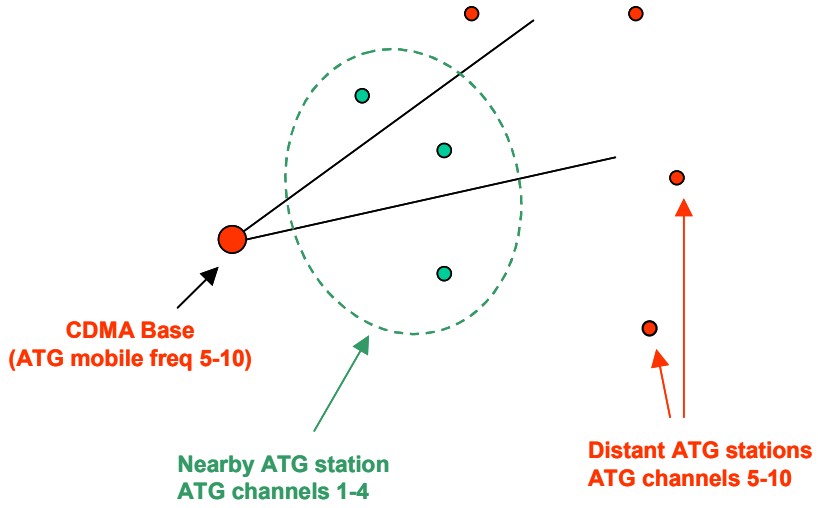
The current ATG band operation uses a frequency reuse plan defined in § 22.857, which includes 10 channel sets numbered from 1 to 10 starting from the highest frequencies and progressing down. Pictorially the center frequencies of the channel plan for the ATG Base station and mobile are as shown below:



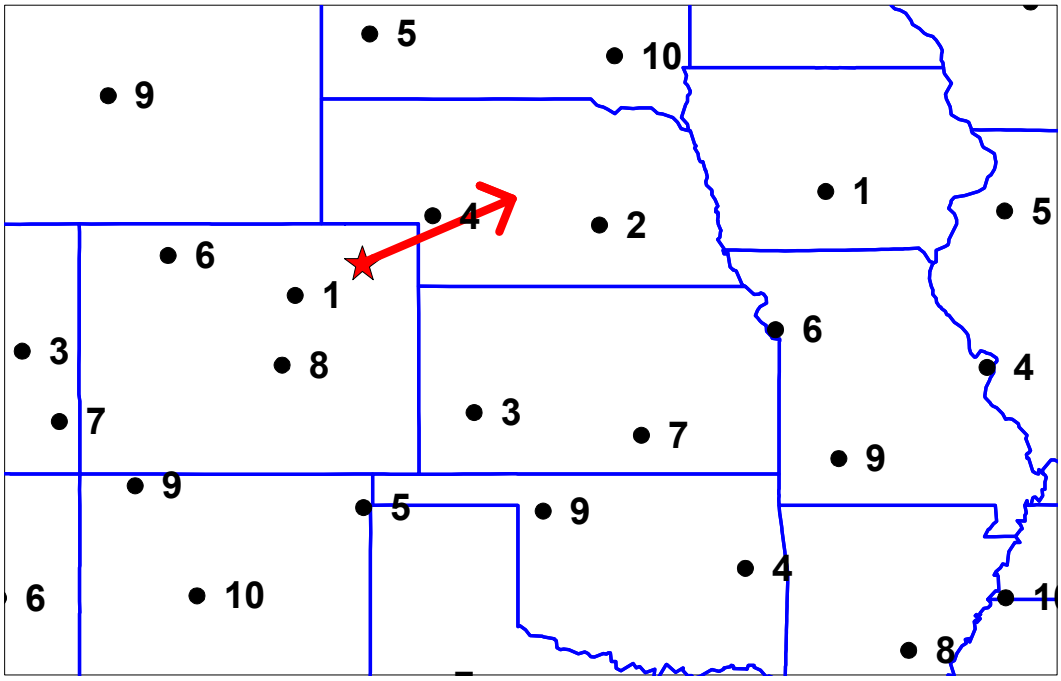
In order to eliminate any impact on the ATG operation, two concepts are proposed to be utilized. First, we propose to use opposite frequencies (ATG ground = CDMA air, etc). In this way, the CDMA base station transmissions look like ATG mobiles, and CDMA mobiles look like ATG base stations. Secondly, a directional antenna will be used to limit transmissions to a narrow beam, which limits the impact that needs to be coordinated to a small arc.

Base Station to Base Station Interference Considerations. For the CDMA base station, its potential impact is by being received at the ATG base station cochannel with an ATG mobile signal. This is prevented by two elements. First, channels are selected so that in

the region near the CDMA base station, the CDMA channels are not used at the ATG sites. In the region farther from the CDMA base station (greater than approximately 40 miles), the curvature of the earth prevents the ATG base station from seeing the transmissions from the CDMA base, so these ATG sites can use the same channel group as the CDMA base. This can be shown pictorially in the following sketch:



Assuming a base station location in Northeast Colorado, this would be configured as follows. The narrow beam antenna would be pointed approximately east. The frequency range to be utilized at the base station is selected to not overlap any of the ATG base station operating regions using frequencies in the nearby range. For the example shown above, the ATG stations in the nearby region covered by the directional antenna are groups 1-4 (actually, only group 1 is close enough to be within line of sight) and the CDMA carrier would be transmitted in the frequencies covered by groups 5-10.



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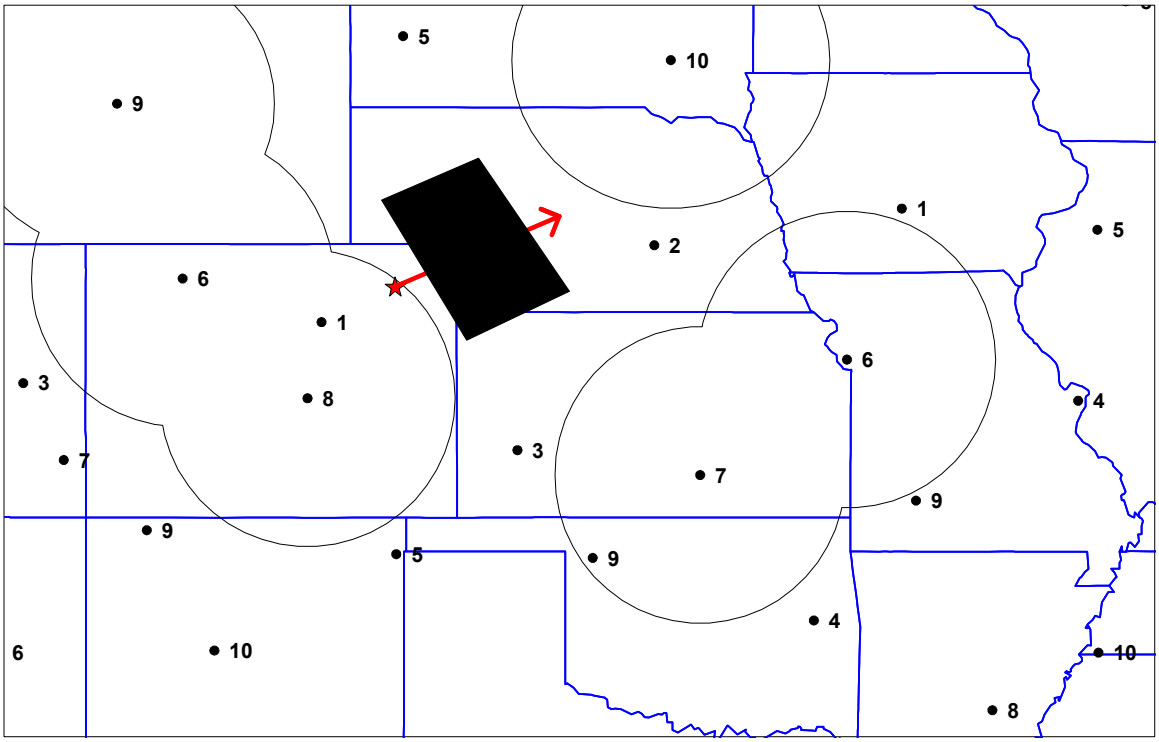
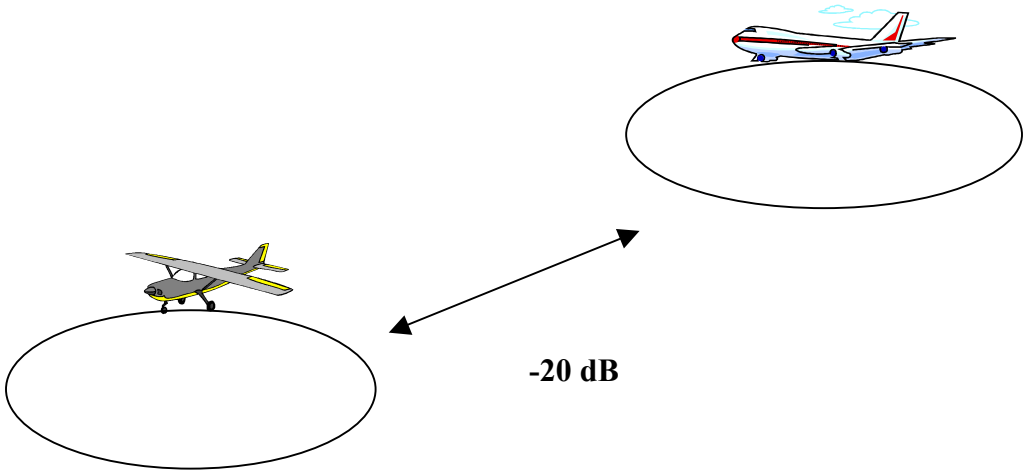
Mobile to Mobile Interference Considerations. A CDMA mobile (operating on a ATG base station frequency), could only potentially impact an ATG mobile. This is prevented in several ways.

First, the proposed test area is shown below in the cross hatched area. ATG mobiles operating in this region would be operating on channel groups 1,2,3, or most likely 4, as those sites are by far the best server. The circles around ATG sites on channels 5-10 show 150-mile radii, the approximate range of one of those sites at 18,000 feet, the approximate altitude of the planned test.



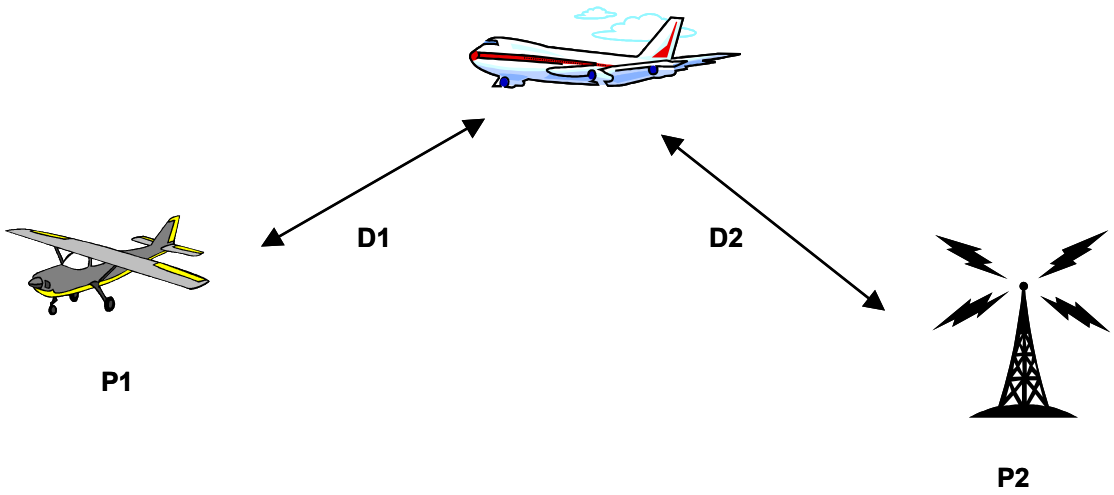
Further mobile-to-mobile isolation comes from the geometry involved. In both cases, the antennas utilized for the systems are belly-mounted antennas. These antennas have poor coverage towards the top of the aircraft. Thus a ATG mobile flying over a CDMA mobile would not have a clear line of sight to the antenna on the CDMA mobile.



The ATG mobile (aircraft) are typically equipped with a vertically polarized omni-directional antenna which we will assume has a nominal gain of 0 dB at or below horizon. The CDMA antenna would be a standard AirCell antenna which has a nominal gain at or above horizon of about – 5 dB or less. Combining this -5 dB of gain with –15 dB of isolation due to the CDMA antenna being horizontally polarized and the ATG

being vertical, the resulting gain between aircraft antennas is around –20 dB. Geometrically, the ATG equipped aircraft generally fly at 18,000 ft or above, while the CDMA test aircraft will be at 18,000 feet or below, which causes the ATG aircraft to either be at the same altitude or higher than the CDMA aircraft.

Computing relative signals received at the ATG mobile, the relative distances and powers are shown schematically below.



Typical ATG base station gains are approximately 12 dBi, and the ATG mobile antenna is assumed to be at least 0 dBi, so at max range when both antennas are approximately at peak gain, the relative gain should be at least 10-12 dB. If we assume that P2 = 50 watts, P1 = 1 watt, and the relative antenna gain between the ATG base and its mobile to be 10 dB, and the relative gain between the CDMA mobile and ATG mobile to be –20 dB, we can solve for C/I as it relates to the relative distances D1 and D2.

$$C/I = 30\ dB + 10 \log (D2/D1)\ ^{-2}$$

The test location shown in cross hatch in the above figure is selected to be basically directly over one of the ATG sites operating on a non-cochannel frequency relative to the CDMA test, so that the test area is the maximum distance from one of the cochannel (to CDMA test) ATG sites. Therefore, aircraft operating cochannel to the CDMA test aircraft would normally hand off to this non-cochannel ATG site (and thus not be cochannel with the CDMA mobile) at about half the distance between that site and the adjacent ATG site cochannel to the experiment operation. By keeping the test CDMA aircraft within about 50 miles of the non-cochannel ATG site as shown in this diagram, an ATG aircraft operating on a cochannel ATG site would be at best equidistant from the CDMA test aircraft and its host site, and typically much closer to the host site.

Solving for equal distances between the two mobiles and the ATG mobile and its base, the C/I would be about 30 dB in this worst-case condition, which should be adequate separation to not cause any harmful interference to the ATG system. This should preclude any possible harmful interference to the ATG system from the experiment.

However, to further reduce the probability of an interference event, the proposed testing could be done in the hours between midnight and 5 am, when traffic on the ATG is known to be minimal, thus reducing the possibility of interference events to approximately zero.