Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Expanding Access to Mobile Wireless Services Onboard Aircraft	)	WT Docket No. 13-301
	)	

REPLY COMMENTS OF VERIZON

Verizon has reviewed the record in this proceeding[1] and participated in the three workshops jointly held by CTIA and the in-flight service providers.[2] Based on that review and those discussions, Verizon believes there are interference concerns that merit further study before any system permitting the operation of mobile devices during flight, known as an "Airborne Access System," is allowed to operate in U.S. airspace. In particular, Verizon does not believe that the studies conducted by the European Conference of Postal and Telecommunications Administrations ("CEPT") adequately account for the level of signal leakage out of aircraft or consider the ability of Airborne Access Systems to control the power levels of devices using the CDMA air interface. As explained below and in the attached Technical Analysis, Verizon believes that further analysis is required to determine the extent to which Airborne Access Systems will cause harmful interference to terrestrial wireless networks

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[1] *Expanding Access to Mobile Wireless Services Onboard Aircraft*, Notice of Proposed Rulemaking, 28 FCC Rcd 17132 (2013) ("Notice").

[2] Verizon agrees with the interference concerns raised by CTIA in its comments. Comments of CTIA, WT Docket No. 13-301, filed February 14, 2014, at 4-8.

U.S. and to modify the proposed system operating parameters in order to prevent such interference.[3]

I. BACKGROUND

The Notice proposes to authorize aircraft equipped with Airborne Access Systems to operate in U.S. airspace.[4] Airborne Access Systems consist of two devices, a picocell and a network control unit ("NCU"), installed in the aircraft and designed to prevent the airborne mobile devices from communicating with and causing interference to terrestrial networks. The picocell is a low power base station transceiver that communicates with and controls the power of handsets and other transmitting devices onboard the aircraft. The picocell's function in preventing interference is to keep airborne mobiles operating at or near minimum output power. The NCU emits noise to raise the noise floor onboard the aircraft to block airborne mobiles from communicating with terrestrial networks.[5] The Commission tentatively concludes that Airborne Access Systems can be used to facilitate airborne mobile broadband access without causing harmful interference to terrestrial networks and proposes to allow airborne use of mobile devices controlled by a properly managed Airborne Access System.[6] The Commission further proposes to adopt the technical parameters for airborne picocell and NCU operation recommended in the CEPT reports and adopted by the European Commission. It seeks comment, however, as to

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[3] *See* Technical Analysis of Max Solondz, Distinguished Member of Technical Staff, Verizon, WT Docket No. 13-301, attached to these Comments ("Solondz Analysis").

[4] Notice at ¶¶ 23-24.

[5] *Id.* at ¶ 30.

[6] *Id.* at ¶ 32.

whether those limits are appropriate for operation in the United States, particularly given the different technologies deployed in domestic wireless networks.[7]

II. DISCUSSION

Whether an Airborne Access System can prevent harmful interference to terrestrial wireless networks depends largely on (1) whether the transmissions from airborne transmitters (devices, picocells and NCUs) are powerful enough to communicate with terrestrial networks; and (2) whether and to what extent the picocell can control the power levels at which onboard devices operate. Verizon has analyzed the CEPT reports and discussed the operation of Airborne Access Systems with engineers from the in-flight service providers. Based on this analysis, Verizon is concerned that Airborne Access Systems can cause harmful interference to terrestrial wireless networks and require further testing and analysis before such systems are approved to operate in U.S. airspace.

A. The CEPT Reports Do Not Adequately Account for Signal Leakage.

As discussed in the Solondz Analysis, the CEPT reports do not adequately account for the far-field effects that the aircraft windows and fuselage have on signals leaked out of the aircraft.[8] Mr. Solondz warns that the aircraft itself is hundreds of wavelengths long and is an effective radiating structure that will increase the gain of the signals emanating from the aircraft. Mr. Solondz states that the effect of the fuselage as a radiating structure will result in significant high gain spikes.[9] These spikes are never apparent in near-field measurements and are not

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[7] *Id.* at ¶¶ 36-38.

[8] Solondz Analysis at 1-9.

[9] Solondz Analysis at 5, *citing* Report from CEPT to the European Commission, "Compatibility Between GSM Equipment On Board Aircraft and Terrestrial Networks," May 2008, *available at:*

accounted for in CEPT report 048, which was relied upon by the European Commission for determining the NCU operating levels.[10] Rather, that report employs near-field approaches that are not accurate in estimating far-field gain effects to calculate leakage out of the aircraft. Based upon the more detailed estimates in CEPT Report 093, Mr. Solondz estimates that these spikes will result in an additional 20 to 30 dB maximum peak beam gain leaking from the aircraft. As a result, the NCU may require a higher signal to mask these spikes, which in turn could require a stronger NCU signal to cover these spikes. A stronger NCU signal may result in the NCU itself causing harmful interference to terrestrial networks.[11]

B. The CEPT Reports Do Not Adequately Consider the Ability of Airborne Access Systems to Control the Power Levels of Devices Using the CDMA Air Interface.

Differences in the air interfaces used in terrestrial wireless networks deployed in the United States may also diminish the ability of Airborne Access Systems to prevent harmful interference to those networks. A key feature of the picocell deployed in Airborne Access Systems is its ability to control the power levels of all transmitting devices onboard the aircraft and keep them at or near their minimum output power.[12] Although GSM and LTE air interfaces each allow the airborne picocell to control devices uplink power to transmit below a specified maximum value, Mr. Solondz notes that the CDMA air interface deploys "fast power control" which cannot similarly be overridden by the picocell. As a result, CDMA handsets may radiate at high power levels -- significantly higher than the 0 dBm power level limit imposed by the

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http://www.erodocdb.dk/docs/doc98/official/pdf/ECCRep093.pdf ("CEPT Report 093") at Annex B: Other Approaches for Analysing the Terrestrial RF Effects of the Onboard Leaky Feeder, Section B.2.3, pp. 155-163.

[10] *See* Notice at ¶ 37.

[11] Solondz Analysis at 2-3, 5, 8-9.

[12] Notice at ¶ 30.

picocell on airborne GSM handsets. The additional power radiated causes more interference, thus limiting overall system capacity.[13]

C. Further Study Is Needed Prior to Authorizing Any Airborne Access System to Operate in the United States.

Mr. Solondz has identified potential interference concerns that should be studied prior to authorizing any Airborne Access Systems to operate in the United States.[14] These concerns, at present, are based on theoretical analysis and estimates of the potential impact to terrestrial wireless networks. More precise analysis and measurements are needed to fully understand the effects of airborne operations on terrestrial wireless networks and to develop Airborne Access System operating parameters that prevent harmful interference. Verizon therefore urges the Commission to defer action until after a group of third party independent experts review the previous studies, particularly with respect to signal leakage, consider the effects of operating Airborne Access Systems in frequency bands and on air interfaces used in the United States, and develop modified system operating parameters.

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[13] Solondz Analysis at 9-10.

[14] Notably, in addition to the concerns discussed above, Mr. Solondz has concerns that the 1800 MHz AAS downlink is co-channel to PCS uplink operations in the United States and may cause cross-band interference that has not been analyzed. Solondz Analysis at 10.

II. CONCLUSION

The studies previously conducted by the European Commission do not adequately account for signal leakage outside the airborne aircraft and significant differences in air interface technologies and band plans used in the United States. These effects should be studied prior to authorizing Airborne Access Systems to operate in the United States.

Respectfully submitted,

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TECHNICAL ANALYSIS OF MAX SOLONDZ[1]
IN-FLIGHT MOBILE SYSTEMS, WT DOCKET NO. 13-301
MAY 16, 2014

Overview:

The use of Airborne Access Systems (AAS) systems currently installed in European and other aircraft in U.S. airspace will cause AAS downlink and airborne NCU jamming interference into the US PCS uplink band at 1850-1880 MHz, an issue that has not been analyzed in previous international reports. In analyzing AAS operation and jamming, one must consider the three different air interfaces now used domestically, namely PCS CDMA (VZW, Sprint), PCS UMTS (ATT), and PCS GSM (T-Mobile) and the different cross system interference effects. The CEPT Reports fail to analyze U.S. band plans and air interfaces.

Additionally, even though the current AAS system operators do not plan to serve devices that operate on U.S. PCS air interfaces, the airborne NCU must be designed to properly mask these air interfaces. This entails analyzing the worst case (maximum) required power to effectively jam all air interface variants, and analyzing the worst case downlink interference effects into the most sensitive air interface for noise floor rise impacts. The CEPT Reports do not perform these critical analyses.

I have two primary concerns regarding the potential for interference from Airborne Access Systems to terrestrial wireless networks. They are (1) that the analysis done in the CEPT reports and relied upon by the European Commission do not adequately account for the signals that will leak out of and into the aircraft; and (2) that the CEPT reports did not analyze the ability of the airborne picocell to control the output power of CDMA devices. Each of these concerns is analyzed below based on my review of the CEPT reports, accepted engineering principles, and information exchanged with Aeromobile as part of the CTIA/In-Flight Mobile Provider workshops.

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[1] Max Solondz is a Distinguished Member of Technical Staff / Network Infrastructure Planning Group at Verizon. He is a subject matter expert within the Advanced Technology Strategy Group at Verizon. In this role, he is responsible for network and product strategies built around new technologies and new frequency bands. Previously, Max was a product manager for RF base station products at Alcatel-Lucent, where he has held several positions in technology development, technology planning, new product initiation and demonstration. Previously, he held positions at Bell-Labs, ATT, and Lucent Technologies, over a period of 22 years, all in the development of radio systems for base station products. He holds a Master's degree from University of Massachusetts with a specialty in microwave engineering.

I. Leakage of Signals from and into Airborne Aircraft

I am most concerned about interference to the PCS CDMA air interface, whether or not CDMA devices are served by the AAS. I have very specific concerns about the analysis methods as they apply to the airborne case and to CDMA. Aeromobile's analysis is based upon the analysis in Report 048, which also refers to Report 093 and Report 187. There are six scenarios that are used in the analysis, and they are as follows:

1) Scenario 1: Impact of terrestrial NodeB BTS Downlink transmission onto airborne UE handset. *This is where the conventional terrestrial signal must be jammed (or masked or screened) by the airborne NCU so the airborne handset does not register with the terrestrial network. This analysis establishes the level of the terrestrial downlink signal as seen by the airborne handset and this is the level that must be jammed over.*
2) Scenario 2: Impact of airborne UE handset Uplink transmission onto terrestrial NodeB BTS. *This is where the airborne picocell operates with the airborne handset. The handset power level is generally low, but this energy will leak out of the aircraft fuselage. Various modeling methods are described. This is also where GSM static power control (commanded from the airborne picocell to the airborne handset transmitter) enables low power operation for the GSM handsets.*
3) Scenario 3: Impact of airborne NCU Downlink jammer and airborne picocell Downlink transmissions onto terrestrial UE handsets. *This is where the airborne NCU downlink jammer signals (at levels calculated from Scenario 1) and picocell transmissions leak out of the aircraft fuselage. This is for a single aircraft.*
4) Scenario 4: Impact of multiple airborne NCU Downlink jammers and airborne picocell Downlink transmissions onto terrestrial UE handsets. *This is where the airborne NCU downlink jammer signals (at levels calculated from Scenario 1) and picocell transmissions leak out of the aircraft fuselage. This is for multiple aircraft.*
5) Scenario 5: Impact of airborne UE handset Uplink transmissions onto terrestrial NodeB BTS. *This is for a single aircraft.*
6) Scenario 6: Impact of airborne UE handset Uplink transmissions onto terrestrial NodeB BTS. *This is for multiple aircraft.*

In the reports, these scenarios are repeated for the different bands analyzed. In all cases, the MCL (Minimum Coupling Loss) method is used as part of the analysis to calculate the signal levels leaked out of (or into) the fuselage. To simplify the discussion, I will focus on a single case as an example, but this methodology is used in all subsequent analysis. Because I believe MCL leakage analysis is fundamentally flawed, I believe this error is repeated throughout the different analyses, and that there is a consistent 20-30 dB underestimation of worst case "peak" interference to terrestrial networks.

For example, Report 048, page 17, Table 18 provides the figure used for analyzing interference by AAS GSM 1800 systems. This is for Scenario 2.

From Table 17, it is possible to estimate the e.i.r.p. outside the aircraft with the following formula:

e.i.r.p. (dBm/Channel)= Max received signal + Radiation factor – aircraft attenuation + 5 dB (this value was used as initial assumption in the ECC Report 093 [3]).

Then, from the calculated e.i.r.p., the increase of noise level will be estimated.

Table 18: MCL calculation

Height above ground (m) ⇒	3000	4000	5000	6000	7000	8000
Max received signal level (dBm/5MHz)	-73.7	-76.2	-78.1	-79.7	-81.1	-82.2
Radiation Factor (Large Aircraft) (dB)	70	70	70	70	70	70
Aircraft Attenuation (dB)	3.3	1.1	-0.5	-1.8	-2.9	-3.8
Equivalent e.i.r.p. (as point of source) (dBm/5MHz)	-1.0	-1.3	-1.6	-1.9	-2.2	-2.4
Free Space Propagation Losses (dB)	107.3	109.8	111.7	113.3	114.6	115.8
Maximum Received Noise by g-MS (dBm)	-108.3	-111.1	-113.4	-115.2	-116.8	-118.2
System Noise Level, reference values (dB/bw)	-100	-100	-100	-100	-100	-100
Increase of the noise floor at g-MS with respect to reference values (dB)	0.60	0.33	0.20	0.13	0.09	0.06

The important figures to note here are the low aircraft attenuation factors (small numbers) and the Equivalent EIRP (as point of source). These repeat the errors from Report 093.

The long array of aircraft windows and the large external size of the aircraft fuselage imply an effective radiating structure that is hundreds of wavelengths long in multiple dimensions (wings and fuselage). This cannot be compared to an equivalent isotropic point of source without also allowing for significant margin (20 – 30 dB of additional dynamic range over the leakage values used in the reports) to account for 90%, 95% or 99% of the resulting radiation spikes that will be received on the ground. It is not adequate to use an averaged, near-field measured leakage value as a substitute for a far-field radiation pattern. Nor can near-field measured values be used in a subtractive method (using superposition measurement techniques with the leaky coax array alone, and then also measuring near-field with the aircraft) to estimate the far-field pattern. Nor can the near-field method in the Morgan paper be used. These are all near-field methods that do not adequately capture the antenna gain effects of the aircraft size itself.

This is important because of the need to guarantee that the resultant effective noise rise in the terrestrial system is at or below the noise floor in order to guarantee that the impact is less than a 1 dB effective rise in the apparent noise level. If the leaked signals appear 20-30 dB larger at the terrestrial handset receivers (downlink from airborne picocell or airborne NCU) or the BTS

(uplink from the airborne handsets), then the noise floor will be raised more than the targeted (minimal) 1 dB, and the terrestrial system will experience significant interference.

The apparent antenna gain spikes caused by the aircraft fuselage acting as a radiating structure are very narrow and are at random orientations. They may appear for various time durations as experienced by terrestrial handsets or BTS, but they are real, and they cannot be averaged out. That is, one may consider looking at the averaged levels (and the MCL and Morgan methods erroneously do that) and determine, that, on average, the terrestrial networks do not experience high levels of interference, but we do not care about averages. Those cells or cell tower antennas that do experience one of these gain spikes will experience significant interference, and the analysis must guarantee that the end-to-end signal levels are below a threshold that guarantees that each and every particular cell sees no more than a 1 dB rise (or other target) in the effective noise floor.

The EC/CEPT reports (especially Report 093) perform different analyses to derive the energy that leaks into or out of the aircraft as part of: 1) the analysis of levels required for NCU jamming; and 2) the analysis of leaked signal levels while the airborne picocell is in operation for the above enumerated scenarios (1-6).

Report 093 considers three different methodologies for how energy radiates or leaks out of (or into) the aircraft:

1) An MCL estimation method (Minimum Coupling Loss). Report 93, section A.3.1, p. 98 and Section B.1.1., p. 152. *This is a near field approach and is not valid in the far-field of the aircraft.*

2) An Estimation approach based upon the Morgan paper. Report 93, section B.1, p. 151 (based upon S.P. Morgan, "Prediction if indoor wireless coverage by leaky coaxial cable using ray tracing," IEEE Transactions on Vehicular Technology, Vol. 48(6), pp. 2005-2014, Nov 1999).

   Morgan's approach is a near-field approach for calculating/estimating near field coupling losses in an indoor environment from a leaky coax feeder in close proximity to other indoor scattering sources. The additional scatterers (rich scattering environment assumptions) are used to justify the incoherent effects (the proposed calculation methods) in the near field. The paper explicitly states that such an approach is not valid in a "barren one" environment (an environment that is not a rich scattering environment). Terrestrial systems would be both in the far field of a flying aircraft, and would also be in a barren scattering environment (there would be no nearby scatterers relative to the airborne aircraft). Hence, this paper's methods cannot be used to derive estimates for far-field radiation patterns for the energy that leaks out of the aircraft. Nor can this paper be used to derive the far-field coupling into the aircraft to determine the energy that airborne

handsets would perceive from the terrestrial systems. This method may be used to estimate values within the fuselage from within the fuselage (from the leaky coax radiator). There is some discussion of using superposition to derive far field patterns from two sets of measurements (leaky coax with aircraft, leaky coax without aircraft), but this subtraction method cannot be used to derive the effective far-field array factor effect of the aircraft if the measurements are performed in the near field. *This is a near field approach and is not valid in the far-field outside of the aircraft.*

3) An estimation method based open considering leakage out of the aircraft windows as an effective array (Report 093, section B.2.3, pp. 155 – 163). ***This is the only correct method presented for estimating the effective gains in the far-field of the aircraft.*** Because the aircraft is very large compared to the RF wavelengths involved, both the array of windows and the aircraft fuselage itself must be considered as the size of the radiator. Therefore, the radiation cannot be considered to have derived from a point source nor can it be considered isotropic (low gain, non-directional). This method correctly shows narrow, highly directional gain spikes of 25 – 30 dBi.

   Applying this estimation method requires adding an additional 20-30 dB of margin over and above the typical mean coupling loss values (that are used subsequently in the interference analyses) to the –5 dB to –10 dB (values shown in the subsequent analyses of levels) to make sure these spikes are covered some percentage (90%, 95%, or 99% confidence) of the time.

   The additional 20-30 dB margin I believe must be allowed to account for leakage gain spikes is consistent with the similar large margin used to account for in-cabin field variations. This is the 65-70 dB of Radiation Factor (Report 093, pp. 39-41, Tables 21 and 22) that is used in all subsequent reports to account for in-craft picocell fading effects (near-far within the aircraft and due to destructive nulling interference (multipath) within the aircraft cabin from the airborne NCU or airborne picocell transmitters to the in-cabin airborne handsets). This dynamic range covers some percentage (say 99% confidence) regardless of where the airborne handset is within the cabin with respect to the serving airborne picocell or its leaky feeder coax radiation system. Some handsets may be closer, some may be further away in the cabin, and some airborne handsets may be in a local 'null' within the fuselage, and therefore either the airborne picocell or airborne NCU may need to radiate a much higher level to ensure that all airborne handsets aboard the aircraft receive an adequate signal or jamming signal. Hence there is a large dynamic range even though the distances are short. As with the exterior antenna array gain spikes, it is not adequate to use an average value and the analysis methodology correctly applies the Radiation Factor to account for this. This type of thinking (statistical), however, is not applied to the exterior radiation pattern in order to cover victim terrestrial cells that are in the peaks of the radiation patterns leaking from

the aircraft. Even though statistics are not presented for the Radiation Factor, this is in effect a statistical margin.

Similarly, in evaluating the energy that leaks out of (or into) the fuselage, one single average MCL coupling factor does not statistically cover all possible cases of effective far-field gain. One simple low level coupling value cannot be used to estimate the far-field radiation patterns, yet these low level coupling values are erroneously and repeatedly applied in all subsequent analysis of required jammer levels and operational leaked radiation levels. In order to cover these gain spikes as experienced exterior to the aircraft, the signal analysis methodology must use a gain value that covers 90%, 95% or 99% of the possible look angles and the possible narrow beam peaks.

Also, as specifically warned in Report 093, section B.2.6, p. 162):
"Making measurements related to the topic of window effects on fuselage leakage is very challenging; the radiation pattern of an antenna ***can only*** *be measured properly in its far field. For a typical aircraft, the far field distance for the aperture of the length of an aircraft (30 / 50 m) would be over two kilometres. As the main lobes are narrow, it is also necessary to make measurement with a high angular resolution. To date no array effect has been observed in measurement campaigns. However these measurements have been made at a distance of less than 100m, and generally with an angular resolution that is less than the expected beamwidth of a phased array of windows.*" [Emphasis added.]

Hence, the measurements reported and analysis techniques are not adequate to properly characterize the leakage out of the aircraft, yet they are repeatedly used and cited. It appears there is a missing 20 – 30 dB of array gain from the subsequent calculations. This may require higher NCU jamming levels to adequate mask terrestrial signals and, in turn, may cause higher levels of leakage out from the airborne NCU and from airborne picocell operation above the elevated noise floor. This error applies to all the six scenarios, because they all involve leakage out of (or into) of the aircraft fuselage.

It is important to note that not only is there a near field coupling value, but there is also an array of windows (apertures) that couple energy out over a distance. Once the electrical field leaks out, it will impress currents onto the fuselage and wings of the aircraft such that the resultant effective re-radiator is very large and will produce a very spikey far-field radiation pattern.

For example, Report 187 table 23, p. 26, provides another typical example of the calculation methodology:

Table 23: MCL calculation

height above ground (km) ⇒	3	4	5	6	7	8
Max received signal level (dBm/5MHz)	-73.7	-76.2	-78.1	-79.7	-81.1	-82.2
Radiation Factor (Large Aircraft) (dB)	70	70	70	70	70	70
Aircraft Attenuation (dB)	3.3	1.1	-0.5	-1.8	-2.9	-3.8
Equivalent e.i.r.p. (as point of source) (dBm/5MHz)	-20	-2.3	-2.6	-2.9	-3.2	-3.4
Free Space Propagation Losses (dB)	107.3	109.8	111.7	113.3	114.6	115.8
Maximum Received Noise by g-MS (dBm)	-109.3	-112.1	-114.4	-116.2	-117.8	-119.2
System Noise Level, reference values (dB/bw)	-100	-100	-100	-100	-100	-100
Increase of the noise floor at g-MS with respect to reference values (dB)	0.48	0.26	0.15	0.10	0.07	0.05

The 70 dB Radiation Factor in this chart is the interior fading factor discussed above.

The aircraft attenuation factor and the equivalent EIRP account for radiation from within the aircraft to outside the aircraft. Together, these values are overly low and represent an average MCL (Minimum Coupling Loss), not the peak gain.

At various points, statements are made that at suitable long distances, the aircraft can be considered an isotropic point source. This is not correct. Distance does alter the radiation pattern, and, in fact, the true directional gain of large radiating structures does not actually become apparent until one measures them from the far field. The far field criterion is defined as 2 D^2/lambda (distance away), where D is the largest dimension of the structure, and lambda is the wavelength of interest.

For example (from Report 093, p. 158, Figure 80), the figures below show the estimated spikiness of far-field radiation patterns from the aircraft windows acting as an array. Subsequent analysis does not account for covering the spikiness of these radiation patterns. It is clear from these patterns that a simple isotropic (low gain or low coupling factor, non-directional) pattern cannot be assumed in the far-field, but the applied methodology seems to

assume exactly that. It is not clear why the methodology laid out in Appendix B.2.3 from Report 093 was not followed.

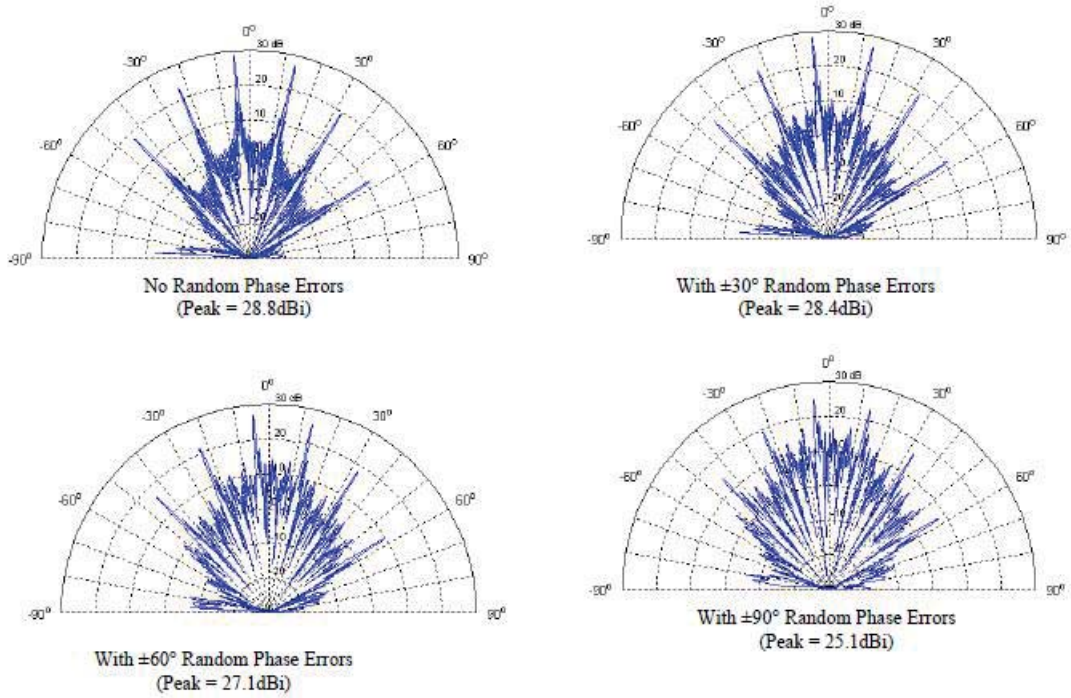

Figure 80: Azimuth plots of aircraft aperture and array gain for varying amounts of phase noise. Azimuth slices are at the elevation angle of maximum gain, 37.2° below horizontal

This erroneous isotropic point of source methodology is repeated in Report 187 in Tables 23 (p. 26), 25 (p. 27), 37 (p. 33), 43 (p. 36), 47 (p. 39), and 51 (p. 41) to arrive at various interference levels. These levels do not account for the appropriate far-field gain values that will make these signals appear 10-30 dB stronger to terrestrial systems.

<u>In Summary:</u>

The real radiation leakage patterns from airborne aircraft are not adequately represented in the analysis to include the proper effect of the far-field radiation patterns. I believe the near-field analysis techniques used in previous reports submitted underestimate the maximum peak beam gains by 20 – 30 dB. This error impacts the analysis in a number of areas:

1) The initial calculation of received downlink energy from the terrestrial CDMA system to the airborne handset may be too low, and may require a higher level (than reported) NCU jammer signal to mask the signal and prevent registration with the terrestrial system.

2) The airborne NCU downlink jammer signal will therefore need to be higher, and it likewise will leak out of the aircraft at a higher level and with random directive spikes (high effective antenna gain) into the terrestrial base stations, thus elevating the downlink noise floor more than the previously submitted analysis show. Even at the existing AAS NCU levels, the highly directive leakage levels will be higher than the MCL calculations show and will raise the noise floor of some terrestrial cells (terrestrial cells in the aircraft radiation pattern spikes) to levels higher than the targeted 1 dB noise floor rise (maximum allowable noise floor rise).

3) The operational airborne picocell transmissions and airborne handset transmissions will also leak out of the aircraft at a higher level and with random directive spikes (high effective antenna gain) into the terrestrial base stations, thus elevating both the downlink noise floor and the uplink noise floor more than the submitted calculations show.

II. CDMA-Specific Concerns

I have concerns that the use of airborne picocell uplink power control (the GSM ability to restrict the airborne operational handsets to their lowest transmitter power setting, static power control) is not available in the CDMA interface where uplink fast power control is used. Note that CDMA power control is very fast. LTE has similar power control mechanisms that allow per user transmission level adjustments, but they are slower than CDMA adaptation, and, most importantly for the airborne picocell application, the LTE automatic power control may be over-ridden and set by the picocell. That is, similar to GSM, the LTE picocell base station can instruct the served airborne handset to transmit below a specified maximum value. This prevents the handset from radiating at high levels. CDMA systems cannot override CDMA fast power control. If the served airborne CDMA handset moves into an in-cabin local null, and the received signal level or bit error rate ("BER") as received at the picocell falls below target, the picocell control loop will automatically instruct the served airborne handset to radiate at a higher level so that all simultaneous receptions at the picocell are at roughly the same power level. Thus the full dynamic range of the CDMA device transmitter may be invoked. The in-cabin picocell dynamic range cited is 60 dB, so an operational airborne CDMA device could be instructed by the system to radiate at power levels significantly higher than picocell GSM handsets (which would be limited to power levels of 0 dBm).

I am also concerned that the 1 dB targeted noise floor rise metric is not suitable for CDMA systems deploying fast power control mechanisms to control in-cell and adjacent cell interference and to maximize capacity. Even a small rise in the CDMA noise floor will have significant capacity effects as the various CDMA transmitters raise the power levels (fast power control) to maintain adequate BER performance. The additional power radiated causes more interference, thus limiting overall system capacity. Although not catastrophic in terms of controlling the radio access network, there will be a significant capacity reduction.

It appears that thermal noise rise effects into operational terrestrial CDMA systems have not been adequately analyzed and have instead been modelled identically to narrowband GSM systems, with only a scaling factor for bandwidths, and little attention to fast power control issues. Unlike GSM narrowband TDMA systems which, because of carrier-to-interference levels, operate at 12 – 15 dB above the thermal noise floor, CDMA systems operate completely co-channel and much closer or below the thermal noise floor (spreading gain). Use of fast power control allows each individual handset link to be power optimized to use the least amount of transmitted power in order to mitigate creating more interference to other co-channel users in the same cell and in adjacent cells. Small elevations in the effective thermal noise floor from other sources of interference (like the NCU), can have a major impact on performance and capacity. When coupled with effects from the spikiness of the leaking radiation patterns, the noise floor elevation will be worse than predicted.

LTE systems in the US also use a form of fast power control, so the terrestrial systems capacity and performance may be upset by the noise floor rise, especially if the effect is more than a 1 dB noise floor rise. This requires further detailed review. But for airborne operation, the airborne LTE picocell can invoke static power control so that airborne served LTE devices are instructed to remain at lowered power levels, thereby radiating less interference power into terrestrial networks (LTE or other networks). This is more similar to GSM picocell operation.

III. Other Concerns

Some other portions of the analysis methods are unclear and may be in error. These issues also require further review:

A. In a number of reports, 450-CDMA is quoted as having a 20 dB required jam-to-noise margin, but in subsequent analysis it is unclear what jammer margin has been applied. The GSM value (lower) appears to have been used for AAS and this would be incorrect for domestic jamming.

B. Additionally, use of the European AAS airborne picocell, and its associated airborne NCU jammer, will cause AAS downlink interference into the US PCS uplink band, which will impact US CDMA (and other) PCS systems. This cross-band interference was not analyzed in the ECC/CEPT reports.

LIST OF REFERENCES:

[1] ECC Report 187 'COMPATIBILITY STUDY BETWEEN MOBILE COMMUNICATION SERVICES ON BOARD AIRCRAFT (MCA) AND GROUND-BASED SYSTEMS' January 2013

[2] ECC Report 093 'COMPATIBILITY BETWEEN GSM EQUIPMENT ON BOARD AIRCRAFT AND TERRESTRIAL NETWORKS' May 2008

[3] ECC Report 048 'REPORT FROM CEPT TO THE EUROPEAN COMMISSION IN RESPONSE TO THE SECOND MANDATE TO CEPT ON MOBILE COMMUNICATION SERVICES ON BOARD AIRCRAFT (MCA)' March 2013

[4] S.P. Morgan, "Prediction if indoor wireless coverage by leaky coaxial cable using ray tracing", IEEE Trans Veh. Tech., Vol. 48(6), pp. 2005-2014, Nov 1999.