Before the
Federal Communications Commission
Washington DC 20554

In the Matter of	)	
	)	
Revision of Part 15 of the Commission's Rules	)	ET Docket 98-153
Regarding Ultra-Wideband Transmission	)	DA 01-753
Systems	)	

<u>Comments of A. Peter Annan</u>

A. Peter Annan, Ph.D., P.Eng.
1091 Brevik Place
Mississauga ON L4W-3R7
CANADA
905-624-8909

May 10, 2001

Before the
Federal Communications Commission
Washington DC 20554

In the Matter of	)	
	)	
Revision of Part 15 of the Commission's Rules	)	ET Docket 98-153
Regarding Ultra-Wideband Transmission	)	DA 01-753
Systems	)	

Comments of A. Peter Annan

A. Peter Annan, Ph.D., P.Eng. hereby files these Reply Comments in response to Public Notice DA 01-753 in the above-captioned proceeding. Dr. Annan is an expert in ground penetrating radar (GPR) applications. This filing addresses only issues relating to radar, and takes no position on ultra-wideband communications applications.

Recent comments to the FCC NPRM on UWB (File 98-153) on the potential of UWB devices causing interference with GPS, PCS and other communications, positioning and navigation systems are often ill-founded as regards geophysical measurement systems such as GPR (ground penetrating radar). In the following, we show that geophysical devices are a very unlikely source of interference and that eliminating use of UWB devices in select low frequency ranges is untenable and unnecessary.

1. Limiting UWB to Greater than 3 GHz

Recent comments to the FCC by Sprint and others (filed April 25, 2001) suggest that the FCC should limit UWB devices to frequencies above 3.1 GHz. Such a suggestion is inapplicable to geophysical electromagnetic sensing requirements. Virtually all geophysical measurements require penetration into the material to some distance. At frequencies exceeding 3 GHz, the attenuation in most natural materials and related construction materials is extremely high. Figure 1 shows a typical plot of attenuation in soil versus frequency. As one can see the attenuation rises rapidly in the GHz range. Beyond 3 GHz the attenuations often become so severe as to make any substantial penetration impossible.

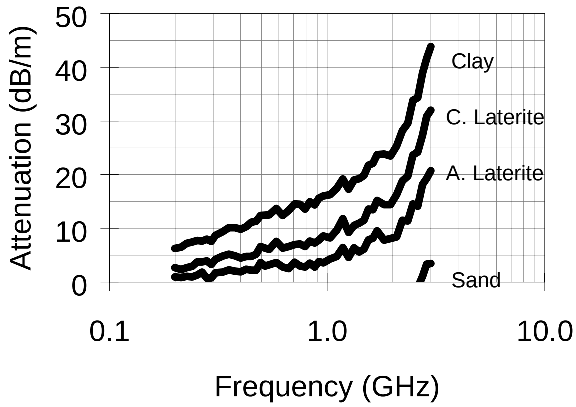

Figure 1: Examples of measured radio wave attenuations in some common soils

As a result, we recommend that the FCC disregard such statements in the context of geophysical instruments.

2. Comments on Testing Performed by NTIA

The NTIA submission on "Assessment of Compatibility Between UWB Devices and Selected Federal Systems" (NTIA special publication 01-43) includes discussion on how receivers sense interference based on the pulse width, repetition rate and dithering characteristics of a UWB transmitter. Geophysical measurement apparatus can all be considered as undithered and ungated. While geophysical systems usage may be intermittent while changes in configuration are made when in operation, the systems are essentially ungated (unless one considers gating over periods of minutes or hours).

For geophysical devices the Pulse Repetition Frequency (PRF) is normally low, typically less than 100 kHz. In general, the PRF is usually much smaller than P_{REF} which the NTIA use for their measurement bandwidth reference. In a similar fashion, virtually all geophysical instruments have PRF smaller than the victim receiver IF bandwidth.

These parameters are indicated so that assessment of the NTIA conclusions can be placed in the proper context for most, if not all, geophysical instrumentation.

3. Near-Ground Signal Correction Factor

In the NTIA report referenced in paragraph 2 above, a detailed discussion of the behavior of selected federal systems is derived based on stated assumptions. Section 3 of this report outlines the model which is used to either define the maximum EIRP of a UWB source or the minimum separation distance between a UWB source and the selected federal system.

The criteria are formulated in Equation 3-1 of this report which treats the UWB device as an isotropic radiator placed at a given height above the ground. The analysis then derives the EIRP which would be acceptable so that no interference would be detected by the federal system or the minimum separation between the Part 15 regulated power level and the federal system.

This particular derivation ignores a fundamental characteristic of geophysical UWB devices. Geophysical systems which use electromagnetic measurements strive to induce current flow in the ground. The energization method most effect is one which creates horizontal electric fields. Electric dipoles are the common transducer element; these elements may be physically coupled to the ground, capacitively coupled or linked to form a closed loop. In all cases, current flow in the ground is maximized when the elements are parallel to the air/earth interface.

When such a transducer is used, it is normally very close to the ground interface (typically within a very small fraction of wavelength in air). For assessing interference potential, the assumption of an isotropic radiator with no ground effect on the device is invalid. In order to correctly account for the proximity of the source to the ground, a height degradation factor for the emitted field must be included in the NTIA analysis. No discussion is provided on this topic in the report. Equation 3-1, as formulated by the NTIA in its sensitivity assessment, can be augmented with an additional term when assessing geophysical subsurface imaging devices as opposed to assessing air launched point-to-point communications and data transmission devices.

A complete solution for the ground effect is complex. For discussion purposes, we consider that most of the geophysical sources can be treated as electric dipoles placed near the ground surface. If this model is assumed and the ground is assumed to be a very good conductor (the normal communications model), then the response of an electric dipole over a ground plane can be used to estimate a geophysical correction. From the text by R.S. Elliot (Antenna Theory and Design; Prentice Hall Inc. 1981) a height and orientation factor for a geophysical transducer to subtract the right side of Equation 3.1 is

$$GEO\_F(h,\theta,\phi) = 20\log_{10}(2\sin(2\pi h \sin\theta \sin\phi)) \quad (1)$$

In other words,

$$EIRP_{GEO} = EIRP_{Max} - GEO\_F(h,\theta,\phi) \quad (2)$$

where $EIRP_{GEO}$ is the maximum EIRP often allow for near ground effect, h is the height of the dipole source normalized against the excitation frequency wavelength in air, θ is the elevation angle above the horizon and ϕ is the azimuth angle with respect to the direction normal to the dipole axis. This factor indicates how the ground response reduces source emission because the ground current operates in an opposing fashion to the excitation. *When h is small the signal which reaches to a distance is greatly reduced*.

Figure 2 shows the results of varying the system transducer height above the surface from .001 to 0.1 wavelengths. In this case the elevation angle (θ) above the horizon is 1° and ϕ = 90° (maximum coupling case) in order to represent the case where the receiving system is close to the ground. In Figure 3 the effect of elevation level above the horizon for a source located at 0.02 wavelengths above the surface is shown. Both these plots demonstrate the impact of placing a geophysical UWB element near the ground surface. The factor reduces geophysical systems by many 10's of dB with – 50 dB not being uncommon.

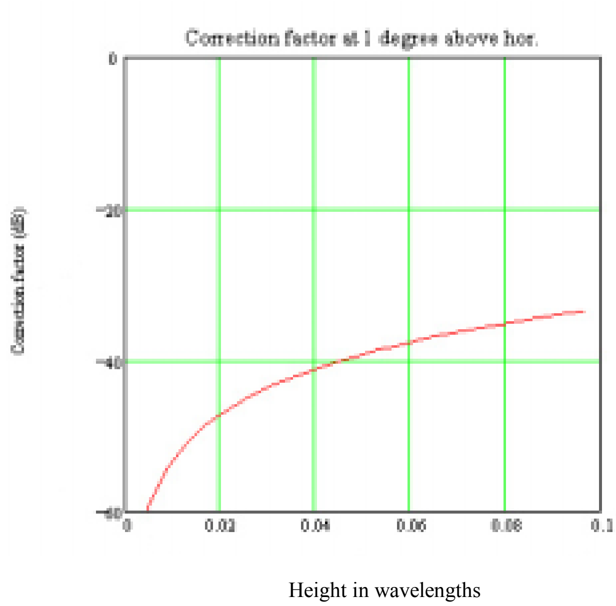

Figure 2: Plot of geophysical correction factor versus height of transducer about surface in wavelengths.

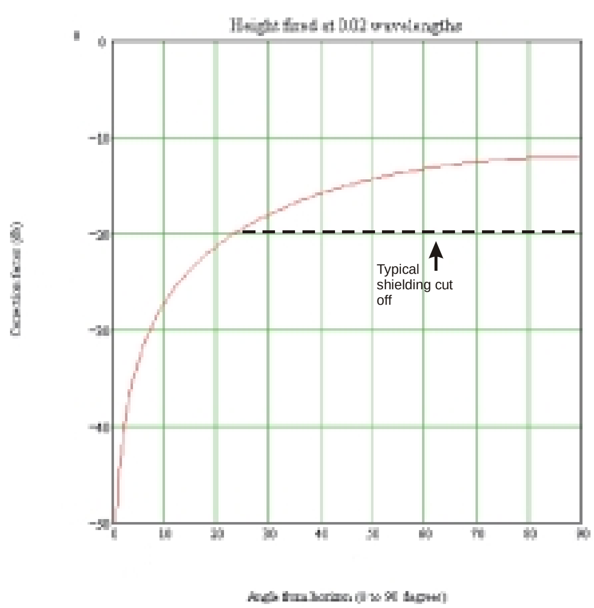

Figure 3: Variation of geophysical correction factor versus angle above horizon assuming a transducer height of 0.02 wavelengths. The dotted line shows the effect that a shield over the higher frequency geophysical devices will add to the correction.

Many geophysical sensors operate at relatively low frequencies and the normalized height in terms of wavelengths can be extremely small (i.e. much less than 0.01). The exceptional devices are the high or frequency GPR systems which might on occasion reach a normalized height of 0.05 to 0.1. When frequencies exceed 200 MHz, GPR's normally have shielding over their excitation transducers to minimize any air launched signals since air launched signals are detrimental to the geophysical measurement process. Every effort is made to minimize this effect.

For high frequency GPR systems with shielding over the transducers, typical forward to back ratios of 20 dB are common. This shielding reduction factor adds to the contribution of GEO_F. In the instance where the ground proximity factor is least effective (i.e. directly above the source), the shielding over the transducers is at its maximum.

This discussion is intended to point out that the NTIA report Tables 4-56 and 4-57 values severely under estimate the maximum EIRP allowable and overestimate the minimum distance of a Part 15 device from a federal system for geophysical UWB systems. The inclusion of a term such as GEO_F for geophysical transducers close to the surface could easily increase the acceptable EIRP by 30 to 100 dB. In a concomitant fashion, the minimum separation between a Part 15 device and a federal system would be reduced enormously.

The analysis of geophysical transducers, used in GPR and other EM systems, needs this factor to be included in any analysis of interference potential. This factor reduces emissions from geophysical EM transducers and explains why interference between geophysical devices other systems is not observed.

4. GPR Transducer Shielding

The impact of air launched signals on GPR systems can result in degraded GPR performance. Every effort is made to minimize above ground signals.

For lower frequency systems, typically below 100 MHz, the close proximity of the transducer yields the GEO_F factor in the –30 to –60 dB range. At higher frequencies, wavelengths are smaller and small spacing from the ground makes the GEO_F factor less effective. For this reason GPR systems operating above 100 to 200 MHz have shields placed over the transducers as mentioned in item 3. The GPR shielding is designed to augment the GEO_F factor where it has least reduction which is straight up (90º from the horizon). The shielding normally provides a front-to-back ratio of about 20 dB. In other words, the upward signal is –20 dB down when referenced to the signal emitted towards the ground.

We have pointed out previously (submission to FCC dated September 12, 2000) that GPR signal strength decreases with increasing frequency. All factors (GEO_F, transducer shielding and decreasing power with increasing frequency) combine to mitigate concerns of interference in other systems such as GPS.

5. Measurements Procedures for Geophysical Systems

The nature of geophysical measurements is such that representative measurements on the devices in a test facility is very difficult. Quite often the devices are much larger than the physical space at the standard test facility or the ground conditions where the transducer is placed are such that they are not representative of the application environment. Certainly the concept of holding the geophysical transducer up in the air and measuring its worst case behavior is not representative of normal use and should not be used as the criteria for making emissions measurements unless a degradation factor such as discussed in Section 3 is used.

Geophysical devices are produced in small quantities, their operational configuration is complex and both the manufacturers and the users are generally small businesses. As a result, standardized measurement and characterization processes must be kept as simple as possible to be affordable. The following are some recommendations.

a) For UWB geophysical instruments, the quantity to regulate is the output of the transmitter electronics unit. The measurement can be made with the electronics energizing a standard load. The measurement objectives would be to quantify the maximum output power deliverable (at maximum PRF). An oscilloscope can characterize the pulse width, PRF and other waveform transient characteristics, and a spectrum analyzer is used to examine the excitation spectral distribution. Such measurements are relatively simple and can be done in a controlled setting, are a normal part of instrument design and manufacture, and can provide needed quantitative results inexpensively.

b) The regulation of geophysical UWB devices should place a maximum on the average or RMS transmitter output power when connected to a standard load and operated at the maximum PRF of the device. The total output power can be easily measured. The spectral and waveform character of power can be derived from the measurements described in item 4a. The power level should recognize that ground response degrades emission as frequency decreases as shown in Figure 4.

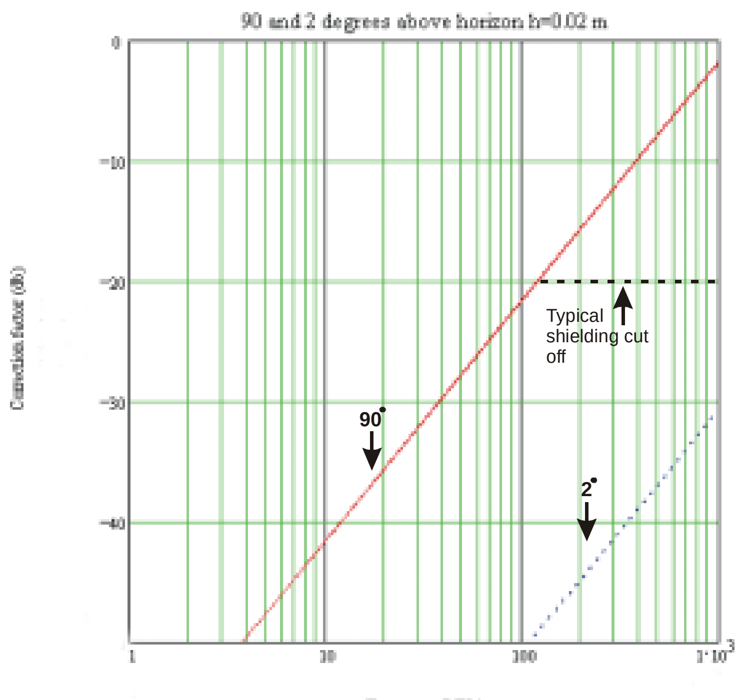

Figure 4: Geophysical correction factor as a function of frequency for transducer 0.02 m above the ground. Note dashed line indicates typical impact of shielding for signals at high angles above the horizon

c) There should be no limit on the peak-to-average ratio as long as the PRF is kept below a specified maximum such as 100 kHz. The reason for this is that many of the geophysical measurements require long wait times for the responses to be observed. The fundamental physical measurements can require a substantial delay between emissions. As the time delay between emissions is increased, the peak-to-average ratio will increase without limit although peak power output by the transmitter remains fixed. Attempting to limit the peak-to-average ratio is a penalty which yields no benefit. The average emitted power will always be less then that specified in 4b. Geophysical UWB devices normally have a maximum peak power while the duty cycle (PRF) is dependent on the application need.

In summary, the maximum average power (or peak power) is the quantity to regulate. The key is to specify a maximum power at the maximum PRF of the system – not the maximum peak-to-average ratio.

Respectfully submitted,

A. Peter Annan, Ph.D., P.Eng.
1091 Brevik Place
Mississauga ON L4W-3R7
CANADA
905-624-8909

May 10, 2001

SERVICE LIST

Chairman Michael Powell
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Commissioner Harold Furchtgott-Roth
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Commissioner Susan Ness
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Commissioner Gloria Tristani
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Bruce Franca, Acting Chief
Office of Engineering and Technology
Federal Communications Commission
445 12th Street, S.W., Room 7C-155
Washington, D.C. 20554

Dr. Michael Marcus
Associate Chief of Technology
Office of Engineering & Technology
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Julius P. Knapp, Chief
Policy & Rules Division
Federal Communications Commission
445 12th Street, S.W., Room 7B-133
Washington, D.C. 20554

Karen E. Rackley, Chief
Technical Rules Branch
Federal Communications Commission
445 12th Street, S.W., Room 7A-161
Washington, D.C. 20554

John A. Reed
Senior Engineer
Technical Rules Branch
Office of Engineering and Technology
Federal communications Commission
445 12th Street, S.W., Room 7A-140
Washington, DC 20554