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GOLDEN, COLORADO 80401-1887

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18 September 2000

Magalie Roman Salas
Office of the Secretary
Federal Communications Commission
445 12th Street S.W. TW-A325
Washington, DC 20554

Comment on NOI ET Docket 98-153 NPRM FCC 00-163

DOCKET FILE COPY ORIGINAL

Dear Ms. Salas,

I submitted the enclosed comment on 11 September through the FCC Electronic Comment Filing System. However, as I do not see it listed in the system as one of the received comments, I am hereby resubmitting it as a paper filing and request a motion to accept the filing as timely filed.

Thank you.

Sincerely,

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Comment on NOI ET Docket 98-153 NPRM FCC 00-163

Dear Ms. Salas,

I wrote during the previous comment period for NOI 98-153 and know of the beneficial uses of ultrawideband ground penetrating radar (GPR) systems. I have used such GPR systems for over 30 years to solve a wide variety of problems, including agriculture, archaeology, geotechnical engineering (including utility detection and critical infrastructure characterization), environmental, forensics, mining, landmine and unexploded ordnance detection, permafrost, tunnel and void mapping, lunar and planetary geophysics, volcanic hazards, fracture mapping and earth-movement hazards, airport runway inspection, interstate highway inspection, and many other applications. I have been an invited keynote speaker at several of the International Conferences on Ground Penetrating Radar. More details about my credentials and applications of ground penetrating radar can be found at http://www.g-p-r.com. This comment specifically addresses several issues raised in the Notice of Proposed Rule Making 00-163.

In paragraphs 3 and 21, resonant frequency and center frequency are discussed as some of the characteristics of the UWB device antenna. In ground penetrating radar, these and other characteristic properties of the antenna (resonant and center frequencies, bandwidth, antenna pattern, etc.) are not only a function of the design and construction of the antenna, but also the properties of the soil, concrete, asphalt or other material that the antenna is placed near or against and the method in which the antenna is deployed. In general, the "ground loading" lowers the center frequency and narrows the beam of the antenna. Lifting the antenna slightly off the ground may sometimes improve the impedance match and coupling to the ground (and for other materials, make it worse). Depending upon the match and coupling, more or less energy may go into the ground or the air. Because the properties of the ground are widely variable in both complex electrical and magnetic properties, and that such properties are strongly dependent upon frequency, it is not possible to a priori predict antenna and GPR system performance without measurement under actual in situ field conditions. Further the ground electromagnetic properties change dramatically with changing environmental conditions of freeze-thaw, moisture content and salinity (among others). This variability requires electromagnetic geophysics to operate over a extremely wide band in frequency (microhertz to gigahertz), of which "ultrawideband" GPR is a small subset.

In paragraph 4, impulse systems cannot be adequately nor correctly characterized by narrowband measurement systems.

In paragraph 6 and footnote 19, I note that GPS systems are commonly used to position and locate GPR systems, and while GPR systems experience interference with real-time kinetic differential GPS, the reverse has not been a problem (otherwise the positioning would not work). (The interference to GPR comes from the RF communication link between the differential GPS units.)

In paragraph 10, there are many more applications than are listed, including such things as surveying of industrial facilities in the USEPA federal and state "brown fields" initiatives, in which the public, insurance industry and mortgage bankers have tremendous interest in legacy environmental contamination issues. The Nuclear Regulatory Commission requires GPR surveys to locate rebar in concrete before drilling holes to avoid drilling through reinforcing rebar. There are also ASTM standards for the use of GPR in determining asphalt and concrete roadway thickness, which are used for quality control and contractual or criminal fraud investigations. (More were listed in the opening paragraph of this comment.)

In paragraph 11, numerous other applications derived from UWB radar applications are listed, many of which could be accomplished in other ways (e.g. auto focus cameras could use infrared or ultrasonic methods rather than EM). In many of the applications of UWB GPR to problems in the shallow soil subsurface or concrete investigation, there are no alternatives to GPR because of the nature of the material properties.

In paragraph 13, it states "...road and runway inspection radars... buried victim rescue... will operate in the 2-8 GHz region and above." This is incorrect. Depending upon the soil conditions and the problem (inspecting concrete thickness or inspecting subgrade construction), these may require frequencies from 100 MHz to 2 GHz. The higher frequency range inspects just concrete thickness, while the lower end looks more deeply to find subsidence voids around abandoned mine workings under roadways, inspect subgrade materials, locate drainage problems and void development from soil piping, detect uneven compaction at bridge approaches, and more.

In paragraph 17, regulation depends in part also on where and when the UWB device is used. In the middle of an urban street to map utilities, inside a hospital to map and characterize concrete structural building supports, at an archaeological dig in the middle of the desert, at an airport to certify runway integrity, at an environmental site with anti-terrorist intrusion detection devices, at a construction site with electrical blasting caps all present different scenarios of interference and thus regulation.

In paragraphs 18 and 19, this regulatory setting depends entirely on the definition of "low power" and how it is to be measured.

In paragraph 21, the bandwidth and other antenna and UWB system characteristics discussed need to be measured with the device in use as it is intended to be used, in the same logistical deployment (in contact with the ground, of the same ground conditions, in the same orientation, etc.).

In paragraph 25, because the earth is a filter and we cannot a priori predict the frequency dependence of the filter, there can be no restriction on frequency region or the devices will not return the required information. The statement "We also propose to require GPRs to include a switch or other mechanism ... aimed directly down at the ground." needs to be modified as the ground is not always down, it is sometimes a cliff face or even an overhang. Delete the "down". "Ground" should be understood to include any naturally occurring material such as soil, rock, ice, and snow, but also concrete and asphalt.

In paragraph 26, GPRs are often used to characterize large concrete structures such as dams, bridges, and building foundations with walls that may be meters thick. In such cases, restricting the frequency range will make the device inoperative for the same reason as trying to image through meters of soil. The same arguments as in paragraph 25 apply. The last sentence about requiring "...incorporate automatic power control features that would reduce power levels to the minimum necessary to function based on the composition of the surface and its absorption of RF energy." is not currently done by any GPR manufacturer, but it is certainly possible.

In paragraphs 28, 29 and 30, I've already commented on the use of GPS positioning of GPR systems in the 1 MHz to 2 GHz region routinely without interference to the GPS. I know of no cases of a commercial GPR system operating in the 1 to 1,000 MHz region as normally deployed interfering with any other device. The reverse is certainly true, that AM/FM radio, TV, cell phones and other things below 2 GHz interfere with GPR operations. There can be no restriction if GPRs are to image and penetrate through meters of soil, rock, concrete and asphalt, as the frequency dependent filter nature of these materials changes dramatically with composition, water content, temperature and so forth in a manner that requires the use of electromagnetic geophysical equipment with frequencies of operation from the microHertz to the gigaHertz. There could be restrictions on when such devices are operated – for example, runway inspection radar surveys are usually run at night when airports are not operating.

In paragraphs 31 and following, I see no mention of polarization issues. Also, I have operated several impulse GPRs simultaneously in close proximity during teaching exercises and have seen multiple radars of impulse, chirp and FMCW types being simultaneously operated within tens of meters of each other at demonstrations at the International Conferences on Ground Penetrating Radar. These radars have low pulse repetition or frequency sweep scanning rates, low duty cycles, and low power levels and they do not interfere with each other, nor was there any noticable degradation of operation.

In paragraph 36, I see no problem in selecting system parameters to minimize interference.

In paragraphs 39 through 44, testing of UWB devices in operation as they would normally be used with measurements made by potential "victim" receiver devices should

be used to determine these emission limits. I think they can be higher than commonly believed.

In paragraph 45, it's not just AC power lines, but also cable TV lines, telephone lines, internet lines, and almost anything metallic. I also think the limit can be reasonably made higher and should be determined by experiment. Guided waves and multipathing could also be issues.

In paragraph 46, because of the many ways these UWB devices will be deployed, the possibility of guided waves, and multipathing, the noise floor will only be determined experimentally.

In paragraph 48, I see no mention of polarization, ground loading, and logistical deployment issues.

In paragraphs 50 through 55, I don't think any of the proposed measurements are useful in characterizing low duty cycle, low repetition rate short-pulse UWB devices with many modes of deployment, polarization, ground loading and so forth. The interference issues must be dealt with in terms of normal modes of deployment and operation of the UWB device against normal modes of operation and deployment of the potential "victim" receiver, including consideration of statistical likelihood in timing simultaneity.

I applaud your efforts to deal with these issues in a reasonable manner.

Sincerely,

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