THE NEW GROUND PENETRATING RADAR REGULATORY ENVIRONMENT

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ABSTRACT

By its very nature, ground penetrating radar (GPR) is an ultra-wideband device (UWB), requiring a large range in frequency to penetrate the ground and image with sufficient resolution to solve practical problems. The increasing scarcity of electromagnetic spectrum and the proposed use of other UWB devices in 1998 caused the U.S. Federal Communications Commission (FCC) to initiate an inquiry (NOI ET Docket 98-153) to investigate permitting the operation of ultra-wideband devices (including ground penetrating radar) on an unlicensed basis under Part 15 of the FCC rules. Through 14 February 2002, the FCC had received over 910 comments in the inquiry (NOI 98-153) and on the Notice of Proposed Rulemaking (NPRM 00-163) issued in June, 2000. The First Report and Order (R&O 02-48) was issued on 14 February 2002. Before this, ground penetrating radar use was only officially permitted for those who had received waivers from the FCC or NTIA (National Telecommunications and Information Administration), who jointly regulate radio spectrum use in the United States. Legal waivers to manufacture ground penetrating radar were issued to U.S. Radar Inc., Time Domain Inc. and Zircon Corp. in June, 1999, and expiring with the R&O. Waivers to build or use ground penetrating radar were issued to the U. S. Geological Survey, U. S. Army and U. S. DOE by NTIA (or predecessors) from about 1976. The R&O issued on 14 February 2002 "…provides for the operation of GPRs and other imaging devices under Part 15 of the Commission's rules subject to certain frequency and power limitations. The operators of imaging devices must be eligible for licensing under Part 90 of our rules…" "At the request of NTIA, the FCC will notify or coordinate with NTIA prior to the operation of all imaging systems." "GPRs must be operated below 960 MHz or in the frequency band 3.1-10.6 GHz." The FCC "…intends within the next six to twelve months to review the standards for UWB devices and issue a further notice of proposed rule making to explore more flexible standards and address the operation of additional types of UWB operations and technology." This FCC rule impacts ground penetrating radar manufacture, sale and use in the United States (and in other countries whose rules are linked to FCC regulations).

Keywords: FCC, NTIA, regulation, UWB, ultrawideband, spectrum, interference

INTRODUCTION

To set the context, here are who the regulators are and from where their authority derives in the United States. From the FCC's website, http://www.fcc.gov, "The radio spectrum is the part of the natural spectrum of electromagnetic radiation lying between the frequency limits of 9 kilohertz and 300 gigahertz. In the United States, regulatory responsibility for the radio spectrum is divided between the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA). The FCC, which is an independent regulatory agency, administers spectrum for non-Federal government use and the NTIA, which is an operating unit of the Department of Commerce, administers spectrum for Federal government use."

"Within the FCC, the Office of Engineering and Technology (OET) provides advice on technical and policy issues pertaining to spectrum allocation and use. OET also maintains the FCC's Table of Frequency Allocations." "The International Telecommunication Union (ITU), head-quartered in Geneva, Switzerland is the international organization within which governments coordinate global telecom networks and services. The United States is a member of the ITU. The ITU maintains the [International] Table of Frequency Allocations, which is reproduced in columns 1-3 of the FCC's Table of Frequency Allocations."

"The FCC and the NTIA assist the Department of State in developing U.S. proposals to revise the ITU's Table of Frequency Allocations." "The Federal Communications Commission (FCC) is an independent United States government agency, directly responsible to Congress. The FCC was established by the Communications Act of 1934 and is charged with regulating interstate and international communications by radio, television, wire, satellite and cable. The FCC's jurisdiction covers the 50 states, the District of Columbia, and U.S. possessions." See also http://www.ntia.doc.gov and http://www.itu.int.

From the original FCC NOI 98-153, "On its own motion, the Commission has initiated an inquiry to investigate permitting the operation of ultra-wideband (UWB) radio systems on an unlicensed basis under Part 15 of its rules." "The current Part 15 rules pose two primary obstacles to the

implementation of UWB technology. First, the wide bandwidth of UWB systems emissions may result in their fundamental emissions being transmitted into the TV broadcast bands and into restricted frequency bands. Generally, operation within these bands is prohibited under the Part 15 rules. Second, the current emission measurement procedures specified in the Part 15 rules were developed for narrowband systems and may be inappropriate for, and pose unnecessary restrictions to, UWB technology." Based upon comments submitted to the FCC on NOI 98-153, on 10 May 2000, "the FCC adopted a proposal to consider permitting the operation of ultra-wideband (UWB) technology on an unlicensed basis, which could have enormous benefits for public safety, consumers and businesses. UWB devices appear to be able to operate on spectrum already occupied by existing radio services without raising interference."

From the Notice of Proposed Rulemaking FCC 00-163 ET Docket 98-153, 47 CFR Part 15, Federal Register, v. 65, n. 115, p. 37332, 14 June 2000, "We observe that ground penetrating radars (GPRs) must operate at frequencies below 2 GHz in order to obtain the penetration depth and resolution necessary to detect and obtain the images of buried objects. GPRs can neither avoid nor notch out the restricted frequency bands. However, it appears that the risk of interference from GPRs is negligible because the overwhelming majority of their energy is directed into the ground where most of the energy is absorbed and emissions in other directions can be easily shielded. Accordingly, we propose to allow GPRs to operate in any part of the spectrum."

DISCUSSION

Comments on these issues have been posted to the FCC website and are visible by going to http://www.fcc.gov, clicking on "e-filing" in the upper right, scroll down and click on "electronic comment filing system", click on "search for filed comments" in the upper left, and searching for comments related to Proceeding 98-153. The posted comments range from one page letters to several hundred page documents, and just a complete listing of the comments and who submitted them is over a 1 megabyte download.

The bulk of the comments against allowing the unlicensed (or in some cases any) operation of UWB devices came from people with vested interests in the existing radio spectrum allocation and restricted bands: television and radio broadcast industry, cell phone operators, aircraft operations, police and fire safety, global positioning system (GPS), and radioastronomy. The bulk of the comments for allowing UWB devices came from people desiring to use them as communications devices, from broadband wireless internet to garage door openers. On the scale of these billion dollar industries, the ground penetrating radar community is very small.

Nonetheless, the GPR community rallied and responded with comments sufficient to gain a voice at the regulatory table. The posted comments convinced most of the vested interests that GPR was useful (that there were beneficial public health and safety applications) and would not interfere with cell phones (Olhoeft, 2000) and other licensed use. On 6 June 2001, the cell phone industry began posting comments like "Sprint does not oppose ground penetrating radar (GPR) UWB applications because the risk of interference is small."

The FCC and NTIA, however, needed hard test measurement data beyond the posted, mostly anecdotal, comments. Two of the major GPR manufacturers, Sensors & Software Inc. and Geophysical Survey Systems Inc (GSSI), provided the FCC with data, and the NTIA and Department of Defense performed their own testing. This resulted in an extensive series of data and publications (posted on the FCC and NTIA web sites, a few of which are listed in the references here), and brought up pulse repetition frequency and potential interference with GPS (including e911 systems to locate cell phones) as major issues. Comments from the GPR community told of the importance of GPS and location positioning to geophysics, and showed the use of GPS antennas right on top of GPR antennas without adverse effect on positioning.

The statement in NTIA Report 01-383 (Kissick, 2001) on page 8-38 that "The signal from Device E [a ground penetrating radar system] was apparently below measurement system noise and Part 15 measurements could not be performed." supported the anecdotal comments submitted to the FCC that decades of experience in using ground penetrating radar have not produced harmful (nor even noticeable) interference. Private testing by Sensors & Software and GSSI, and submitted to the FCC confirmed that the most commonly available current commercial ground penetrating radar systems produce radiation into the air at levels lower than Part 15 Class A digital devices per Section 15.109(b). In other words, most personal computers put more radiofrequency emissions into the air than GPRs.

The FCC scheduled a meeting for 12 December 2001 for the first reading of the new Report and Order, but the Department of Defense requested a postponement for further testing. "On 11 January 2002, Assistant Secretary of Defense John P. Stenbit sent a letter to Michael D. Gallagher, Deputy Assistant Secretary of Commerce for Communications and information stating that DoD has completed its technical studies of UWB emissions. As a result of these studies, DoD has concluded that "to protect vital DoD systems to ensure our National Security", there should be no intentional UWB emissions below 4.2 GHz

with the limited exception of imaging systems." (from the AT&T Wireless, Cingular Wireless, QUALCOMM, Sprint PCS and Verizon Wireless letter of 17 January 2002 posted to the FCC web and agreeing with the Stenbit letter).

In the latest version of the NTIA "Red Book" manual (NTIA, 2001) regulating government use of the spectrum, in chapter 10.10 Ultra-Wideband Radars, it states "Currently, none of the frequency bands allocated to the radiolocation service are wide enough to support ultra-wideband radars. Consequently, these devices may only operate on a non-interference, unprotected basis to stations operating in accordance with the allocation tables. Flexibility should be shown in permitting ultra-wideband operations in frequency bands where electromagnetic compatibility can be demonstrated." It then proceeds to describe (in less than a page) how to maintain electromagnetic compatibility.

Note that this NTIA statement only applies to Federal government users. The complete text of the Report and Order that will apply to the non-Federal manufacturers and users had not yet been published in the Federal Register and was not available as of the date of this writing (14 February 2002). However the news release summarizing its content is included at the end of this paper. In the absence of further information at publication deadline, the FCC Report and Order will be discussed in detail at the conference and posted at http://www.g-p-r.com.

From the FCC News Release alone, many questions arise: although commercial GPR UWB devices have been manufactured and sold for more than 30 years and there are no known cases of interference, the news release states, "Since there is no production UWB equipment available and there is little operational experience with the impact of UWB on other radio services, the Commission chose in this First Report and Order to err on the side of conservatism in setting emission limits when there were unresolved interference issues. The Commission intends within the next six to twelve months to review the standards for UWB devices and issue a further notice of proposed rule making to explore more flexible standards and address the operation of additional types of UWB operations and technology." This latter notice of proposed rule making should be watched carefully and commented upon by the GPR user community.

The news release also states, "Provides for the operation of GPRs and other imaging devices under Part 15 of the Commission's rules subject to certain frequency and power limitations." The preliminary emission limits are shown in Figure 1. It is not clear exactly how these emission limits will be measured and manufacturers will need to tell users how various commercial systems do or do not fit within these limits.

"The operators of imaging devices must be eligible for licensing under Part 90 of our rules, except that medical imaging devices may be operated by a licensed health care practitioner." Which section of the Part 90 rules applies? Does "eligible for" mean licenses are required? "At the request of NTIA, the FCC will notify or coordinate with NTIA prior to the operation of all imaging systems." Notify by whom to whom, when and how?

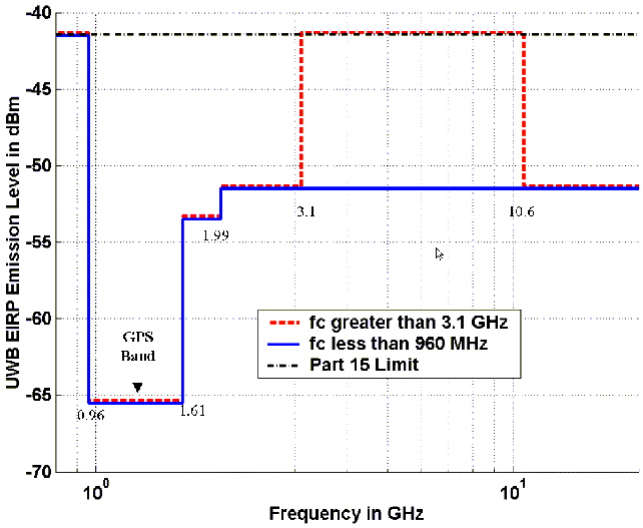

Figure 1 – From the 14 February 2002 FCC PowerPoint presentation of preliminary UWB emission limits for GPRs, Wall Imaging, & Medical Imaging Systems. Note the protection given to the Global Positioning System.

"Imaging systems include: ***Ground Penetrating Radar Systems*****:** GPRs must be operated below 960 MHz or in the frequency band 3.1-10.6 GHz. GPRs operate only when in contact with or within close proximity of, the ground for the purpose of detecting or obtaining the images of buried objects. The energy from the GPR is intentionally directed down into the ground for this purpose. Operation is restricted to law enforcement, fire and rescue organizations, to scientific research institutions, to commercial mining companies, and to construction companies." What about geophysical contractors? There are also large groups of GPR users in agriculture, transportation, ski, utility location, unexploded ordnance, environmental, and other industries that are not mentioned.

Note in the definitions listed in the glossary, the opportunity for comment and "Petition for Reconsideration" time limitation of 30 days after the R&O appears in the Federal Register. Federal agencies should comment through their NTIA representatives.

GLOSSARY

These definitions are from the FCC website unless otherwise indicated (http://www.fcc.gov).

Center Frequency: (FCC proposed definition, Federal Register, v. 65, n. 115, p. 37332, 14 June 2000) the average of the upper and lower [frequency] –10 dB points.

Further Notice of Proposed Rulemaking (FNPRM): After reviewing your comments and the comments of others to the NPRM, the FCC may also choose to issue an FNPRM regarding specific issues raised in comments. The FNPRM provides an opportunity for you to comment further on a related or specific proposal.

Memorandum Opinion and Order (MO&O): In response to the Petition for Reconsideration, the FCC may issue a Memorandum Opinion and Order (MO&O) or an Order on Reconsideration amending the new rules or stating that the rules will not be changed.

Notice of Inquiry (NOI): The Commission releases an NOI for the purpose of gathering information about a broad subject or as a means of generating ideas on a specific issue. NOIs are initiated either by the Commission or an outside request.

Notice of Proposed Rulemaking (NPRM): After reviewing comments from the public, the FCC may issue a Notice of Proposed Rulemaking. An NPRM contains proposed changes to the Commission's rules and seeks public comment on these proposals.

Petition for Reconsideration: If you are not satisfied with the way an issue is resolved in the R&O, you can file a Petition for Reconsideration within 30 days from the date the R&O appears in the Federal Register.

Report and Order (R&O): After considering comments to a Notice of Proposed Rulemaking (or Further Notice of Proposed Rulemaking), the FCC issues a Report and Order. The R&O may develop new rules, amend existing rules or make a decision not to do so. Summaries of the R&O are published in the Federal Register, which will tell when a rule change will become effective.

Restricted bands: frequencies listed in 47 CFR 15 Section 15.205 in which only spurious emissions are permitted.

Ultra-wideband (UWB): (FCC proposed definition, Federal Register, v. 65, n. 115, p. 37332, 14 June 2000) the –10 dB fractional bandwidth is greater than 0.25 or the –10dB bandwidth is greater than 1.5 GHz.

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NEWS

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NEW PUBLIC SAFETY APPLICATIONS AND BROADBAND INTERNET ACCESS AMONG USES ENVISIONED BY FCC AUTHORIZATION OF ULTRA-WIDEBAND TECHNOLOGY

Washington, D.C. – The Federal Communication Commission (FCC) adopted today a *First Report and Order* that permits the marketing and operation of certain types of new products incorporating ultra-wideband ("UWB") technology. UWB technology holds great promise for a vast array of new applications that have the potential to provide significant benefits for public safety, businesses and consumers in a variety of applications such as radar imaging of objects buried under the ground or behind walls and short-range, high-speed data transmissions.

UWB devices operate by employing very narrow or short duration pulses that result in very large or wideband transmission bandwidths. With appropriate technical standards, UWB devices can operate using spectrum occupied by existing radio services without causing interference, thereby permitting scarce spectrum resources to be used more efficiently. This First Report and Order ("Order") includes standards designed to ensure that existing and planned radio services, particularly safety services, are adequately protected. The FCC will act vigorously to enforce the rules and act quickly on any reports of interference.

The standards adopted today represent a cautious first step with UWB technology. These standards are based in large measure on standards that the National Telecommunications and Information Administration ("NTIA") believes are necessary to protect against interference to vital federal government operations. Since there is no production UWB equipment available and there is little operational experience with the impact of UWB on other radio services, the Commission chose in this First Report and Order to err on the side of conservatism in setting emission limits when there were unresolved interference issues. The Commission intends within the next six to twelve months to review the standards for UWB devices and issue a further notice of proposed rule making to explore more flexible standards and address the operation of additional types of UWB operations and technology.

The Order establishes different technical standards and operating restrictions for three types of UWB devices based on their potential to cause interference. These three types of UWB devices are: 1) imaging systems including Ground Penetrating Radars (GPRs), wall, through-wall, medical imaging, and surveillance devices, 2) vehicular radar systems, and 3) communications and measurement systems.

- ***Imaging Systems***: Provides for the operation of GPRs and other imaging devices under Part 15 of the Commission's rules subject to certain frequency and power limitations. The operators of imaging devices must be eligible for licensing under Part 90 of our rules, except that medical imaging devices may be operated by a licensed health care practitioner. At the request of NTIA, the FCC will notify or coordinate with NTIA prior to the operation of all imaging systems. Imaging systems include:

- ***Ground Penetrating Radar Systems*:** GPRs must be operated below 960 MHz or in the frequency band 3.1-10.6 GHz. GPRs operate only when in contact with or within close proximity of, the ground for the purpose of detecting or obtaining the images of buried objects. The energy from the GPR is intentionally directed down into the ground for this purpose. Operation is restricted to law enforcement, fire and rescue organizations, to scientific research institutions, to commercial mining companies, and to construction companies.

- ***Wall Imaging Systems*:** Wall-imaging systems must be operated below 960 MHz or in the frequency band 3.1-10.6 GHz. Wall-imaging systems are designed to detect the location of objects contained within a "wall," such as a concrete structure, the side of a bridge, or the wall of a mine. Operation is restricted to law enforcement, fire and rescue organizations, to scientific research institutions, to commercial mining companies, and to construction companies.

- ***Through-wall Imaging Systems*:** These systems must be operated below 960 MHz or in the frequency band 1.99-10.6 GHz. Through-wall imaging systems detect the location or movement of persons or objects that are located on the other side of a structure such as a wall. Operation is limited to law enforcement, fire and rescue organizations.

- ***Medical Systems*:** These devices must be operated in the frequency band 3.1-10.6 GHz. A medical imaging system may be used for a variety of health applications to "see" inside the body of a person or animal. Operation must be at the direction of, or under the supervision of, a licensed health care practitioner.

- ***Surveillance Systems*:** Although technically these devices are not imaging systems, for regulatory purposes they will be treated in the same way as through-wall imaging and will be permitted to operate in the frequency band 1.99-10.6 GHz. Surveillance systems operate as "security fences" by establishing a stationary RF perimeter field and detecting the intrusion of persons or objects in that field. Operation is limited to law enforcement, fire and rescue organizations, to public utilities and to industrial entities.

- ***Vehicular Radar Systems*:** Provides for the operation of vehicular radar systems in the 24 GHz band using directional antennas on terrestrial transportation vehicles provided the center frequency of the emission and the frequency at which the highest radiated emission occurs are greater than 24.075 GHz. These devices are able to detect the location and movement of objects near a vehicle, enabling features such as near collision avoidance, improved airbag activation, and suspension systems that better respond to road conditions.

- ***Communications and Measurement Systems*:** Provides for use of a wide variety of other UWB devices, such as high-speed home and business networking devices as well as storage tank measurement devices under Part 15 of the Commission's rules subject to certain frequency and power limitations. The devices must operate in the frequency band 3.1-10.6 GHz. The equipment must be designed to ensure that operation can only occur indoors or it must consist of hand-held devices that may be employed for such activities as peer-to-peer operation.

Action by the Commission February 14, 2002, by First Report and Order (FCC 02-48). Chairman Powell, Commissioners Abernathy, Copps and Martin, with Commissioners Abernathy, Copps and Martin issuing separate statements.

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