

June 29, 1999

31030/4-3-4
1300C2

Mr. David E. Hilliard, Esq.
Wiley, Rein & Fielding
1776 K Street, N.W.
Washington, DC 20006

Dear Mr. Hilliard:

This is in response to the petition for waiver of Part 15 of the Commission's rules, filed on February 2, 1998, on behalf of Time Domain Corporation ("Time Domain"), to permit the authorization of an ultra-wideband system that will be used either as a covert communications system or to detect persons in a building environment. These systems will have an extremely wide bandwidth with a center frequency located near 2000 MHz.

Specifically, you request a waiver of the prohibition against operation within the restricted frequency bands listed in 47 CFR § 15.205(a) and of the application of a pulse desensitization factor for measurements below 1000 MHz as required by 47 CFR § 15.35(a). In support of the waiver request, Time Domain asserts that the signals transmitted using its time modulation technique will comply with the general emission limits contained in 47 CFR § 15.209. In addition, Time Domain asserts that the signals from its devices will appear noise-like. Moreover, Time Domain states that except for sales to federal agencies subject to regulation by the National Telecommunications and Information Administration, any equipment produced under this waiver request shall be sold only to law enforcement and fire fighting/emergency rescue entities eligible for licensing on the public safety pool frequencies as set forth in Part 90 of the Commission's Rules.

Time Domain also states that it shall maintain records of all entities to whom the equipment produced under the waiver request is sold and will promptly make those records available to the Commission upon request. Further, Time Domain states that operation of any equipment produced under this waiver will be subject to 47 CFR § 15.5, which among other things, require that such equipment accept any interference from and not interfere with any authorized radio service. As additional support for its waiver request, Time Domain indicates that the waiver should be limited to production of 2,500 units of its ultra-wideband system which will be divided among communication and radar systems and these systems will be widely dispersed among the United States and will be used intermittently. Finally, Time Domain states that even if all 2,500 units were to operate at the same time the total emitted power throughout the entire United States would be less than 5 watts.

As the frequencies that will be used include several frequency bands allocated to the U.S. Government, we coordinated the waiver request with the National Telecommunications and Information Administration ("NTIA"). On June 15, 1999, NTIA informed us that the waivers can be granted with certain conditions. A copy of the NTIA letter and attachment setting forth the conditions is enclosed.

It is a well-established principle that the Commission will waive its rules only if it determines,

after careful consideration of all pertinent factors, that such a grant would serve the public interest without undermining the policy which the rule in question is intended to serve. *See WAIT Radio v FCC*, 418 F.2d 1153, 1157 (D.C. Cir. 1969). In discussing the treatment of requests for waivers of established rules, the court in *WAIT Radio* emphasized that the agency's discretion in applying general rules is intimately linked to the existence of "a safety valve procedure" to permit consideration of an application for exemption based upon special circumstances. *Id.* Indeed, the court considered a rule most likely to be undercut if it does not take into account "considerations of hardship, equity, or more effective implementation of overall policy...." *Id.* at 1159.

After careful consideration we believe that the requested waiver will serve the public interest by allowing Time Domain to supply to police departments with a communications system that will provide law enforcement officers with a means of covert communication. Additionally, we believe that the requested waiver will serve the public interest by allowing Time Domain to provide radar systems that will enable fire and rescue departments to provide a system to their personnel to determine the location of persons inside damaged, burning or smoke filled buildings. Further, based upon the conditions specified in the waiver request, we believe that there is a low probability that harmful interference will be caused by these systems. Preventing interference to other radio services is the primary purpose of the standards in Part 15. Thus, it does not appear that the requested waiver would undermine the policy of our rules. Moreover, we believe that a limited waiver of our rules would, in this particular instance, be in the public interest because it will afford a real-world test of a new technology. The results of this test will create a record that will aid the Commission in making decisions regarding allowing ultra-wideband applications on a broader scale.

We wish to emphasize that grant of this waiver request does not in any way imply that the Commission's rules will be amended to provide for the authorization and use of ultra-wideband devices. Nor should it be deemed in any way to prejudge the Commission's consideration of the issues involving the operation of ultra-wideband devices in any inquiry or rule making proceeding.

Accordingly, under the authority contained in Sections 0.31(i) and 0.241(a) of the Commission's regulations, 47 CFR §§ 0.31(i) and 0.241(a), a waiver is hereby granted to Time Domain Corporation to permit it to market the ultra-wideband communications and radar systems described in its petition. The waiver is subject to the following conditions:

- 1) The marketing of transmitters under this waiver shall not exceed 2,500 units. The waiver is granted for a period of four years. However, the cessation of marketing could be required at an earlier date should the Commission find that these radar systems cause harmful interference to other radio services. In addition, an earlier cutoff date could also be required if changes are made to the Commission's regulations following the completion of any rule making proceeding.
- 2) A grant of certification must be obtained for the equipment, demonstrating compliance with the general emission limits in § 15.209 as well as other applicable rule sections in

Part 15, before marketing can begin. The provisions of § 15.35(a) requiring the application of a pulse desensitization factor for measurements are waived and do not apply to this equipment.

- 3) Operation of equipment marketed under this waiver is subject to Section 15.5 of the Commission's Rules. Any operation shall not interfere with authorized radio services; operations shall accept any interference that may be received, including interference that may adversely affect the operation of the units authorized under the waiver. No user of the equipment sold under the waiver shall be deemed to have any vested right to any part of the RF spectrum employed by the equipment.
- 4) Except for sales to federal agencies subject to regulation by the National Telecommunication and Information Administration, the equipment will be sold only to law enforcement and fire fighting/emergency rescue entities eligible for licensing on the public safety pool frequencies set forth in part 90 of the Commission's Rules.
- 5) Time Domain Corporation is required to maintain and make available to the Commission, promptly upon request, records of all sales of equipment marketed under this waiver request. The records must include the name and address of the entity that purchased the equipment.
- 6) The design and operation of the equipment shall comply with the conditions stipulated in the request for waiver and users of the equipment are required to maintain a log of operations detailing the location where the equipment was used and how long the equipment was operated.
- 7) In addition to the standard labelling required under Part 15, the product shall be labelled with the following statement: "This equipment is authorized under a waiver issued by the FCC. If it is determined that the operation of this equipment has caused harmful interference to other radio operations, the operator shall immediately contact Time Domain Corporation at [phone number]."
- 8) The equipment should meet the appropriate conditions stipulated in the [NTIA letter of June 15, 1999](#).

If you have any further questions, please contact Rodney Conway at (202) 418-2904 or at the address on the letterhead (Room 7-A132).

Sincerely,

Dale N. Hatfield
Chief
Office of Engineering and Technology



UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and
Information Administration
Washington, D.C. 20230

JUN 15 1999

Mr. Dale Hatfield
Chief, Office of Engineering and Technology
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554

Re: U.S. Radar Inc. Request for a Waiver of Part 15 for Ground Penetrating Radar, January 28, 1998, DA 98-221.

Time Domain Corporation Request for Limited Waiver of Part 15 of the Commission's Rules to Permit Authorization of Ultra-Wideband Time Modulating Technology, February 2, 1998, DA 98-222.

Zircon Corporation Request for a Waiver of Part 15 for an Ultra-Wideband System, April 14, 1998, DA 98-924.

Dear Mr. Hatfield:

Last year, U.S. Radar Inc., Time Domain Corporation, and Zircon Corporation (collectively the "Petitioners"), each petitioned the Federal Communications Commission (FCC or Commission) for a waiver of Part 15 of the Commission's Rules. The National Telecommunications and Information Administration (NTIA) commends the Petitioners for their decision to formally seek waivers of these rules and for alerting the FCC and NTIA to the vast potential of Ultra-Wideband (UWB) technology. NTIA believes that these petitions provide an opportunity to begin a dialogue about the appropriate framework in which to authorize operation of these new products without causing harmful interference to existing authorized radio stations.

After careful consideration, NTIA, in coordination with the Interdepartment Radio Advisory Committee (IRAC), concludes that if appropriately conditioned, the waivers sought by the Petitioners can be granted. This letter articulates our reasons and details the specific conditions that each Petitioner must meet. We specifically propose conditions that would limit interference to authorized users of the radio frequency (RF) spectrum as well as help both the FCC and NTIA assess the overall value of UWB devices. We also propose that the Commission move cautiously in granting additional waivers until further analyses of UWB devices can be completed and an appropriate regulatory framework devised.

As you know, NTIA and the FCC worked together to develop the regulations specifying the conditions and criteria for authorizing the operation of unlicensed devices some time ago. These regulations appear in Part 15 of the Commission's Rules¹ and, in a similar version, in NTIA's *Manual of Regulations & Procedures for Federal Radio Frequency Management* (NTIA Manual). The Part 15 rules specify the conditions and criteria for authorizing the operation of

¹ 47 C.F.R. Part 15.

unlicensed devices. NTIA believes that the Part 15 rules remain useful as a mechanism to promote the development of new and innovative radio technologies unfettered by licensing requirements while adequately controlling interference to sensitive, authorized users of the spectrum.

For example, in order to protect some of the very sensitive systems licensed by the FCC or operating under frequency assignments from NTIA,² Section 15.205 of the Commission's Rules specifically identifies several restricted bands in which only spurious emissions are permitted.³ This limits the use of those bands by any intentional, unlicensed radio systems. However, the Part 15 rules also authorize the operation of low-powered devices conforming to the rules without either licenses from the FCC or assignments from NTIA, subject to the requirement not to cause interference to or claim protection from stations with FCC licenses or NTIA frequency assignments. In this way, the regulatory costs as well as the cost and complexities incurred by the developers of these innovative devices are minimized.

We note that the UWB devices proposed by the Petitioners represent a radically different technology from that used in the conventional radios available when the Part 15 rules were developed. UWB technologies use extremely narrow pulses with their concomitant ultra-wide bandwidths, high repetition frequencies, and low duty cycles. The effects of these types of signals upon conventional systems, be they analog, digital or pulse modulated, are not well understood.⁴

According to Time Domain, Global Positioning System (GPS) receivers are subject to interference within approximately one-hundred feet of their devices.⁵ Therefore, contrary to the original objectives of NTIA and the FCC in establishing the Part 15 rules, the use of UWB systems could erode the protection currently afforded to critical services provided to the public, such as, safety-of-life communications, the Global Navigation Satellite System, Search and Rescue Satellite (SARSAT), and other sensitive satellite and terrestrial receivers operating near and below 2 GHz. Furthermore, no study has been placed in the record that has quantified the aggregate effects of many UWB devices operating simultaneously in the same place or the effects

² The radiocommunication systems authorized by NTIA and the FCC to operate in the restricted bands include those supporting safety-of-life operations (such as satellite-aided search and rescue, and navigation and control of aircraft and maritime vessels), communications satellite operations, and radio astronomy and passive satellite sensor operations. *See Also, National Table of Frequency Allocations*, Part 2 (47 CFR Part 2), note US246 (prohibiting all transmission in bands used for passive sensing and radio astronomy).

³ 47 C.F.R. § 15.205.

⁴ The signals, however, generally appear noise-like for narrowband receivers, but are pulse-like in wideband receivers, such as television or microwave receivers.

⁵ The analysis in Appendix C of the Time Domain Petition concludes that, "These calculations estimate that a Part 15.109 certified device would have to be approximately . . . 38 meters [128 feet] away from the GPS receiver to allow acquisition and . . . 14 meters [46 feet] away for tracking to occur." *Time Domain Request for Limited Waiver of Part 15 of the Commission's Rules*, Appendix C, page 5.

of permitting the peak-to-average power ratios of the devices to be over 20 dB, as requested by the Petitioners. Therefore, concerns about the uncoordinated operation of UWB devices persist.⁶

NTIA recognizes that preventing interference to critical operations of sensitive authorized radio systems remains the primary purpose of the standards in Part 15. We believe that the proliferation of UWB systems centered near 2 GHz could cause serious problems to several critical, sensitive services important to both the government and the public.⁷ Therefore, in addition to the specific conditions attached to any waiver, we strongly urge the FCC to require the Petitioners (i) to take steps to move their operations to portions of the RF spectrum above 2 GHz, and (ii) to add output filtering to the transmitter as necessary, to limit potential interference to any SARSAT or NOAA meteorological satellite earth stations, any facilities of the National Radio Astronomy Observatory (NRAO) and of the National Astronomy and Ionospheric Center (NAIC), navigable waterway or critical GPS-based radionavigation stations.⁸

After careful consideration, therefore, NTIA, in coordination with the IRAC, concludes that the FCC can grant conditional, time-limited waivers to U.S. Radar Inc., Time Domain Corporation, and Zircon Corporation. We have attached a detailed description of the conditions that should accompany these waivers. *See Conditions for Approval of Part 15 Waivers Sought*

⁶ Jane F. Garvey, the Administrator of the Federal Aviation Administration (FAA), the agency responsible for the safety of the airways in this country, filed letters in October 1998 with both NTIA and the FCC, objecting to issuing the waivers requested by all three petitioners. *See Letters from Jane F. Garvey, Administrator of the FAA to The Honorable Larry Irving, Administrator, NTIA*, dated October 19, 1998, and *to The Honorable William E. Kennard, Chairman, FCC*, dated October 19, 1998. After being assured that operational controls would be instituted to protect the National Airspace System, the FAA removed their objection to Time Domain's waiver request and agreed to work with NTIA to ensure that the FCC waiver approval contains the appropriate controls to ensure that the Time Domain equipment will not adversely affect aeronautical safety devices.

However, Federal agencies associated with radio astronomy, maritime and aeronautical radio navigation, search and rescue missions using satellites, critical GPS-based services, meteorological satellite earth stations and other sensitive satellite and terrestrial systems are still concerned about uncoordinated operation of UWB devices. *See Letter from Richard Barth, NOAA*, to the Executive Secretary of the IRAC, dated November 24, 1998; *Letter from Joseph Hersey, US Coast Guard*, to the Executive Secretary of the IRAC, dated November 2, 1998; and *Letter from LTC Christopher K. Reordan, US Army*, to the Executive Secretary of the IRAC, dated August 10, 1998. In addition, the impact to other critical GPS-based services has not yet been assessed, although the US GPS Industry Council, American Airlines, the General Aviation Manufacturers Association, Stanford University (the GPS Research Program) and United Airlines have jointly filed documents alerting the FCC to these concerns.

⁷ We would also like to draw the attention of the the UWB developers to the availability of several frequency bands above 40 GHz where some of these types of systems could be operated in conformity with the applicable allocations.

⁸ These practical safeguards already have some industry endorsement. David E. Hillard, Counsel for Time Domain Corporation, proposed in a January 13, 1999, letter that Time Domain could move their center frequency from 2 GHz to 3 GHz, thereby reducing the energy in critical radio navigation bands near 2 GHz by 8-12 dB below the Part 15 general emission levels while retaining a 3-10 dB reduction in the 4200-5000 GHz range.

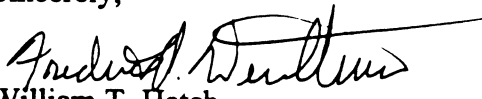
by Petitioners. Conditional approval would allow the limited marketing of products useful to the public safety and construction communities. If the conditions stipulated in the attachment are followed, interference to authorized users of the spectrum should be adequately controlled. Conditional waivers will also help in assessing the impact on the RF environment and the overall value of UWB devices—information that NTIA, the IRAC, and the FCC could use in establishing spectrum management rules for UWB operations.

We note, however, that the UWB systems proposed by the Petitioners represent only a few of the many such systems that are being marketed.⁹ We are concerned that some companies are manufacturing and marketing UWB systems without necessary authorization, and consequently waiver requests for UWB devices might proliferate rapidly before NTIA and the FCC could develop a suitable regulatory framework. Therefore, to avoid the kind of complex and lengthy coordination required for these three Petitioners, we urge that additional waivers of Part 15 rules to permit the marketing of UWB devices that emit radio frequency energy in the restricted bands be suspended or extremely limited until further analyses and measurements have been completed and a regulatory framework developed.

The apparent popularity of unlicensed UWB devices also suggests that a detailed study of UWB technology would help develop the appropriate regulatory framework for UWB devices. This study should analyze the operational experiences of the Petitioners during the conditional waiver period, test the aggregate effect of operating multiple UWB devices in one area, and determine the permitted ratio of peak to average power. These findings could help the FCC assess whether to establish a separate category of service rules for UWB devices, including the identification of specific rules and procedures for UWB devices that would minimize impact to radio stations with FCC licenses and NTIA frequency assignments. These rules could be similar to those described in Part 15 and specify permissible emission levels in the restricted bands. The rules could also require the registration or licensing of UWB systems, as appropriate for a given product, and coordination with Federal agencies operating sensitive systems.

We will continue to work with the FCC to assess the UWB technology and to develop a appropriate regulatory framework for all UWB devices. Thank you for your consideration.

Sincerely,


 William T. Hatch
 40r Acting Associate Administrator
 Office of Spectrum Management

⁹ For example, there are many Internet Web sites maintained by manufacturers and others seeking to sell UWB devices to the public. Several commenters in the FCC's current Notice of Inquiry on UWB devices indicate that they have used them for many years. These devices are generally of the ground penetrating or through-wall radar variety. The Federal government also operates UWB radar devices of these and other types under tightly controlled conditions, including detailed coordination, as described in Part 10.10 of the NTIA Manual.

CONDITIONS FOR APPROVAL OF PART 15 WAIVERS SOUGHT BY PETITIONERS, U.S. Radar Inc., Time Domain Corporation, and Zircon Corporation

CONDITIONS FOR APPROVAL – Federal government concurrence for the FCC to grant conditional approval of these requests for waivers does not in any way imply that the Federal government can agree to the general authorization and use of all UWB devices. Nor should it be deemed in any way to prejudice the Federal government's consideration of the issues involving the operation of UWB devices in any inquiry or rule making proceeding undertaken by the FCC. Nor does NTIA in any way waive its regulation of the use of these devices by the Federal agencies as described in Part 10.10 of our *Manual of Regulations and Procedures for Federal Radio Frequency Management*.

GENERAL – All of the petitioners or users of the petitioners' UWB devices will meet the following conditions.

1. The petitioners must cease manufacturing and marketing these UWB systems if they cause harmful interference to other radio services, or if the FCC adopts new rules that would in effect prohibit operations of such devices.
2. The petitioners must obtain a grant of certification from the FCC using the procedures discussed in sections 2.1031-2.1045 of the Commission's Rules before they can market any UWB equipment.
 - a. The certificate must show that the equipment complies with the conditions specified here and does not exceed the emission limits in section 15.209 of the Commission's Rules.¹
 - b. All certification measurements must be confirmed at the FCC Laboratory in Columbia, MD.
 - c. All certification measurements must be made using the procedures given in ANSI C63.4-1992, entitled *Methods of Measurement of Radio-Noise Emissions from Low-Voltage Equipment in the Range 9 kHz to 40 GHz*. The average power measurements above 1000 MHz shall use the video filtering procedures contained in Hewlett-Packard Application Note 150, *Spectrum Analysis: Basics*.
 - d. Measurements of the peak levels of the UWB devices be made above 1000 MHz. Resolution bandwidths of the inverse of the pulse width must be used.²

¹ Preliminary measurements indicate that the experimental version of the Zircon equipment emits signals 19 dB or more below the radiation levels of 47 C.F.R. § 15.209 required above 1 GHz while the experimental versions of the equipment proposed by Time Domain and U.S. Radar exceed those levels in several parts of the spectrum.

² All three petitioners have asked for waivers of the 20 dB peak to average ratio permitted under 47 C.F.R. § 15.35 and the impact of this waiver is poorly understood. The measurements required here will allow a more complete assessment.

e. The Petitioners must file the operating characteristics of their marketed equipment and their FCC certification number with NTIA.

3. The Petitioners must apply for a new grant of certification for equipment modifications that would affect the conformity of the actual radiated levels to the requirements of section 15.209 of the Commission's Rules. In addition to the requirements of section 2.1043 of the Commission's Rules, these changes include variations in center frequency and radiated power, or in other spectrum related characteristics, *e.g.*, pulse width and pulse repetition frequency. Changes in design that would bring a petitioner's system out of conformity with section 15.209 of the Commission's Rules are prohibited.

4. The Petitioners and their authorized sales agents must maintain records of all users to whom they sell, lease or otherwise distribute UWB equipment and make them available to NTIA on request. These records must include the nomenclature used in the FCC's grant of certification, a user point of contact, and the intended area of operation.

5. To avoid interfering with authorized Federal radio stations, the users of the Petitioners' UWB equipments must coordinate detailed operational areas through the FCC. The FCC's representative to the Frequency Assignment Subcommittee (FAS) of the IRAC will coordinate these operations with NTIA and the affected Federal agencies. NTIA will record the particulars of such operations in the Government Master File (GMF), following established procedures for reviewing and recording frequency assignments for non-Government entities.³ The GMF record will include the address of the user and the authorized geographical area of operation, the characteristics and nomenclature of the petitioners' UWB devices, and any requirements to coordinate day-to-day operations near radio stations authorized to operate in the restricted bands within the intended operating area of the UWB device.

6. The Petitioners (or their authorized sales agents) must also inform users of their equipment of the requirement to undertake detailed coordination of operational areas with the FCC and NTIA as discussed in paragraph 5 above.

7. Users of Petitioners' UWB equipments may transfer them to other qualified users and to different locations upon notification of change of ownership or location to the FCC and coordination with Federal operations as described in paragraph 5 above.

8. In addition to the labeling requirements of section 15.19 of the Commission's Rules, the Petitioners must label their products with the following statements:

The operation of this equipment is authorized under a waiver issued by the FCC. If it is determined that the operation of this equipment causes harmful interference to authorized

³ In the coordination process, the Federal government agencies will generally prohibit these devices from operating within 1 statute mile of the perimeter of any airport, any SARSAT or NOAA meteorological satellite earth stations, any facilities of the National Radio Astronomy Observatory (NRAO) and of the National Astronomy and Ionospheric Center (NAIC), navigable waterway or critical GPS-based radionavigation stations without specific event coordination with the national spectrum management staffs of the FAA, Department of Commerce, National Science Foundation, and the US Coast Guard as appropriate.

radio operations, the operator shall immediately cease operations and contact the Compliance and Information Bureau of the FCC, (telephone number).

9. Airborne operation of the Petitioners' equipments shall not be permitted.
10. All of the Petitioners' equipments marketed under these waivers must contain a "dead-man" switch, or a "push-to-talk" switch and when appropriate to the intended use, a "proximity switch," so that positive control of operations is guaranteed.

PETITIONER-SPECIFIC CONDITIONS

US Radar – NTIA concurs in FCC approval of a four-year, conditional waiver of Part 15 of the Commission's Rules to permit U.S. Radar Inc. to sell the SPRscan ground penetrating radar manufactured by ERA Technology of Leatherhead, UK. In addition to the conditions outlined above, NTIA's concurrence in approving such a waiver is subject to the following conditions:

1. U.S. Radar must ensure that the SPRscan radiated signals are directed toward the ground, and the UWB device is RF shielded to minimize radiation in any direction except toward the ground. The device waveform peak to average ratio of section 15.35(b) of the Commission's Rules shall not exceed 30 dB.
2. U.S. Radar must market no more than 25 SPRscan radars per calendar year as specified in their Petition.

Time Domain Corporation—NTIA concurs in FCC approval of a four-year, conditional waiver of Part 15 of the Commission's Rules to permit Time Domain to market 2,500 UWB systems to fire and police departments eligible for licenses in the Public Safety Pool of frequencies only.⁴ The device waveform peak to average ratio of section 15.35(b) of the Commission's Rules shall not exceed 23 dB for the communication systems and 26 dB for radar systems.

Zircon Corporation – NTIA concurs in FCC approval of a four-year, conditional waiver of Part 15 of the Commission's Rules to permit Zircon to market no more than 5,000 UWB systems used for through-wall imaging radar systems in construction environments if the average field strength of their emissions remains at or below the following levels: above 1 GHz (63 μ V/m average @ 3 m measured in 1 MHz), for 960-1000 MHz, 63 μ V/m quasi-peak @ 3m measured in 100 kHz, for 216-960 MHz, 63 μ V/m quasi-peak @ 3m measured in 100 kHz, for 88-216 MHz, 8.4 μ V/m quasi-peak @ 3 m in 100 kHz, and in the 30-88 MHz, 5.6 μ V/m quasi-peak @ 3m in 100 kHz. The device waveform peak to average ratio of section 15.35(b) of the Commission's Rules shall not exceed 23 dB. The General Conditions of paragraphs 5, 6, 7 and 8 should not apply to the Zircon devices authorized by this waiver.

⁴ Since the signal characteristics of Time Domain's proposed UWB communications device are not fully defined, coordination of specific operations will be strongly dependent on their final design. In addition to the data collected for the Commission's Grant of Certification, NTIA and the Federal agencies need a detailed description of the operating concept and whether Time Domain expects to use multiple, simultaneously transmitting synchronized devices whose effects are unknown.