Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C.

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

COMMENTS OF SIRIUS SATELLITE RADIO INC.

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EXECUTIVE SUMMARY

The recent tests and the detailed reports submitted by Qualcomm Incorporated, the University of Texas and Johns Hopkins University, the National Telecommunications and Information Administration, and the Department of Transportation provide the Commission with important data and analysis for any eventual Commission decision in the above-captioned docket. The tests and analysis reveal crucial details about the interference effects that certain types of UWB devices have on licensed receivers, and also help to indicate the further analysis that needs to be completed. Significantly, the tests demonstrate that UWB devices can significantly interfere with both GPS and PCS systems, depending on the UWB signal characteristics and the receiver type.

The Qualcomm report concerns the interference impact that UWB devices would have on PCS networks. The conclusions of the report are absolutely clear: UWB devices operating in accordance with the Commission's proposed technical parameters would cause harmful interference to PCS handsets. Indeed, the Qualcomm report shows that UWB devices would cause harmful interference even when operating at significant distances from PCS receivers. Qualcomm's findings are of significant interest to Sirius because, in certain respects, the Qualcomm conclusions can be extrapolated to apply to the interference that UWB devices are likely to cause to satellite DARS receivers.

The three reports submitted regarding interference to GPS systems from UWB devices also have important lessons for the Commission. While the results of these reports cannot be directly extrapolated to inform the question of UWB interference to satellite DARS receivers, the results are important because they indicate that interference to GPS receivers from UWB devices is very likely in many circumstances. The reports also indicate that interference

into GPS receivers is highly dependent on the signal structure of the UWB devices, particularly those aspects that cause high density spectral lines from the UWB signal to fall in the most sensitive parts of the GPS spectrum. This variability in interference impact and the inability of the Commission's proposed UWB definition to properly account for this variability supports the position that Sirius has set forth in this proceeding on several prior occasions. Namely, that the proper approach for investigating the deployment of UWB devices is a staged investigation that focuses, in each step, on specific classes of UWB applications as they develop and are capable of definitive description, that permits adequate time for thorough testing and that culminates in a licensing procedure for UWB applications with similar interference characteristics.

We suggest that the record before the Commission indicates the following course of action:

(i) Specific categories of UWB devices must be defined, along with the technical and operational characteristics of each category;

(ii) The Commission should quickly identify areas where further testing and/or analysis is needed, including the effects of multiple UWB devices, and take action to ensure that these tests or analysis are completed expeditiously;

(iii) Based on these tests and analysis, the Commission should develop proposed specific rules for each category of UWB device, which govern its application and mode of operation, allowable average and peak power levels, the allowable ranges of pulse characteristics in the time domain, allowable spectrum masks, and other appropriate limits that govern its introduction, and should request comments from interested parties on such proposed rules before issuing a final rule.

(iv) As new categories of UWB devices are developed, the Commission should determine whether additional testing is needed before approving these categories and generally follow the procedure outlined above in order to bring these new UWB categories safely to market.

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COMMENTS OF SIRIUS SATELLITE RADIO INC.

Sirius Satellite Radio Inc. ("*Sirius*") hereby submits the following comments in response to the Commission's March 26, 2001 Public Notice[1] that requested comment on the test data submitted by Qualcomm Incorporated, the University of Texas and Johns Hopkins University, the National Telecommunications and Information Administration, and the Department of Transportation in the above-captioned docket.

These recent tests and the detailed reports submitted by each of these parties reveal crucial details about the interference effects certain types of UWB devices have on licensed receivers. All five tests show that the interference effect of UWB devices is dependent on signal structure, which varies among devices. The tests also indicate that UWB devices can significantly interfere with both GPS and PCS systems, depending on the UWB signal characteristics and the receiver type. These results add important information to a record which

[1] *Comments Requested on Reports Addressing Potential Interference from Ultra-Wideband Transmission Systems*, DA 01-753 (rel. March 26, 2001).

is still incomplete, especially regarding non-GPS devices. In this respect, Sirius believes that UWB devices will cause harmful interference into both its satellite DARS receivers and its terrestrial repeater stations. The results and analyses in these reports do help to indicate what further analysis needs to be done. The reports also indicate that the Commission should proceed in a careful manner, taking into account the technical and operational characteristics, applications, and interference effects of each category of UWB device.

Section I of this Comment reviews the reports subject to this pleading cycle, and highlights the major findings and analysis of each report. Section II summarizes the conclusions presented by the reports.

I. REVIEW OF INDIVIDUAL REPORTS

In this section we will address individual reports that are the subject of this Comment cycle.

A. Qualcomm Inc. Report dated March 5, 2001

This report is of great interest in this proceeding as it is one of the few that addresses the measurement of interference from UWB devices into non-GPS receivers. Furthermore, it is particularly relevant to services operating below 3 GHz with near-omnidirectional receive antennas, such as satellite DARS.[2] The conclusions of the report are absolutely clear: UWB devices operating in accordance with the Commission's technical parameters would cause harmful interference to PCS handsets. This conclusion can be

[2] The Sirius receivers use near-omnidirectional antennas because they have to receive satellite-transmitted signals at all azimuths and most elevation angles.

extrapolated to apply to the interference that UWB devices will likely cause satellite DARS receivers, because, like PCS handsets, DARS receivers are omnidirectional (or near-omnidirectional), receive relatively weak signals, and have low link margins. In fact, DARS receivers will be more susceptible to interference because they have a lower receiver noise figure than PCS handsets and are required to operate with a lower link power margin than is usually available for a terrestrial service like PCS.

The Qualcomm report demonstrates that UWB devices cause harmful interference even when operating at significant distances from PCS receivers. In section 3 of the report, the analysis demonstrates that a narrowband propagation model can be applied to UWB signals. Based on this demonstration, the report shows that UWB interference on a receiver with a noise figure of 2 dB (which is worse than is typical of a satellite DARS receiver) would degrade the receiver's performance by 3 dB at a distance of 150 feet under line-of-sight conditions,[3] or 25 feet under non line-of-sight conditions.[4]

A noise figure degradation of this magnitude would reduce the satellite link margin by more than 3 dB and seriously degrade the availability of a satellite DARS service. In the case of the PCS service, the report shows that the reduction in link margin would require a massive increase in the number of PCS base stations (up to 60% more), in order to increase system power sufficiently to maintain clear signals and to avoid dropped calls. This would have enormous financial and operational implications for a PCS service provider. However, in the case of a satellite DARS service suffering UWB interference, it would not be possible to restore the service quality by boosting system power in this manner. A DARS service provider could

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[3] Qualcomm Report, at 10

not reasonably resolve this problem by launching more powerful satellites, which is not economically feasible due to the enormous cost of satellites (and would impose an unwarranted burden on a primary spectrum licensee).[5] Therefore, satellite DARS service availability would inevitably be degraded as a result of UWB interference.

It is important to note that, despite requests made by Qualcomm, none of the UWB companies would provide (either on loan or for sale) a UWB device for use in the tests.[6] Qualcomm was therefore forced to simulate a UWB device using a pulse generator and an arbitrary waveform generator, together with associated test and calibration equipment. Under these circumstances, Qualcomm went to great lengths to replicate the signals that could be generated by an actual UWB device. Given the fact that many UWB devices are in the early stages of development and that UWB device manufacturers are unwilling to make their devices available for testing, Sirius believes that Qualcomm's approach is the only viable way to measure the potential interference from UWB devices.

The results from the measurements made by Qualcomm also show unacceptably high Frame Error Rates (FER) for a PCS receiver when UWB interference is present, with the effect depending considerably on the Pulse Repetition Frequency (PRF) of the UWB signal. Although these precise FER results may not be directly translatable to a satellite DARS receiver, it is likely that the effect of the UWB interference will be at least as damaging to satellite DARS services as to PCS services.

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[4] Qualcomm Report, at 11

[5] Because Sirius' three satellites are already in orbit, this option is purely theoretical.

[6] Qualcomm Report, at 14

Finally, Qualcomm points out that the aggregate interference effect of many UWB devices must also be taken into account. This is particularly true when the critical separation distances are of the order of hundreds of feet, as is the case for PCS and satellite DARS. In this type of situation, it is quite possible that multiple UWB devices could simultaneously be causing harmful interference to the same PCS or satellite DARS receiver. This will require the FCC rules to take account of multiple interference entries in developing appropriate rules for UWB devices.

* * *

The three reports submitted regarding interference to GPS systems from UWB devices also have important lessons for the Commission. While the results of these reports cannot be directly extrapolated to inform the question of UWB interference to satellite DARS receivers, the results are important because they indicate that interference to GPS receivers from UWB devices is very likely in many circumstances. These results are relevant to Sirius because they indicate, in part, that interference into GPS receivers is highly dependant on the signal structure of the UWB devices. This variability and difficulties caused by the inability of the Commission's proposed UWB definition to account for this variability are not limited to the GPS situation, and provide a strong basis for Sirius' concern.

B. Time Domain Inc. / John Hopkins University Report dated March 9, 2001

This is the only report from the five considered in this Comment cycle that has been prepared on behalf of a UWB proponent (Time Domain Inc.). With this in mind we have the following comments:

(i) The findings of the report are very limited in scope and certainly do not address the potential interference that could occur to GPS receivers from all UWB devices. Two aspects of the Johns Hopkins University (JHU) report demonstrate this conclusion:

(a) The data on which this report is based was gathered using only two UWB device types, both from the same manufacturer, Time Domain, Inc.[7] Because UWB devices vary significantly and only two types were tested, the report provides only a limited assessment of the potential interference situation.

(b) The JHU Report is in fact limited to a study of those UWB devices least likely to cause interference to licensed systems.

The authors of the JHU Report indicate that the UWB devices they tested produce signal types which are *generally* less likely to cause interference than other UWB devices.

> The theoretical analysis and statistical data evaluation show that properly time coded UWB signals can be produced that have characteristics similar to white noise within the GPS frequency spectrum. . . .The UWB devices tested by ARL:UT produce signals that are white noise-like. . . .There exist coding schemes that can produce non-white noise-like UWB signals that may have a greater impact on GPS performance than those effects shown herein.[8]

There is no doubt that the results presented in this report concern the potential for interference from only the most benign of UWB devices (i.e., those that produce white noise-like interfering signals). The JHU Report makes clear that other UWB devices can exist that produce significantly greater interference

[7] JHU Report, at ES-1, 4-1

into GPS receivers, while still complying with the FCC's proposed technical parameters.

Furthermore, the JHU Report acknowledges that the structure of the UWB signal affects the impact on a victim receiver.[9] Both the NTIA and DOT reports indicate further that certain signal characteristics, particularly the Pulse Repetition Frequency (PRF), make a greater difference than others. In particular, the NTIA and DOT reports show that, while other signal characteristics (such as gating or dithering) affect the result, the higher the PRF, the stronger the interference effect.[10] For this reason, The NTIA Report separately analyzed the effect of signals at several PRF rates up to 20 MHz.

Nevertheless, the UT:ARL tests and the JHU analysis only studied PRF up to 10 MHz. One of the two devices tested operates with a nominal PRF from 1 MHz to 10 MHz; no separate results are given for the operation of this device at different PRF levels, and thus the effect of this device is not clearly explained. The second type of UWB device tested operates with a nominal PRF of 5 MHz. This device would be expected to show relatively less interference than a device with a PRF of 10 or 20 MHz.

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[8] JHU Report at ES-1

[9] JHU Report, ES-1. "*UWB time coding or modulation implementation determines the nature of the resulting UWB signal. This nature in turn determines the impact on a particular GPS receiver implementation and its performance. The choices of time coding parameters can produce significant differences in the amount and type of performance effect experienced by GPS receivers.*"

[10] See NTIA Report, at xiv-xv

In short, the JHU report shows the interference effect of UWB devices which, by their very nature, are less harmful to licensed systems, and does not analyze the variable interference effects that even those devices may have.

(ii) The JHU Report is self-contradictory and simply incorrect when it states that the current record is sufficiently complete to support Commission action. The report states that, "[b]ased on this report and the inputs from other organizations, JHU/APL believes that sufficient information is available for the FCC to establish criteria for regulating UWB emissions."[11] However, as we have shown above and as the JHU authors themselves acknowledge, neither the JHU Report itself nor the record as a whole contains sufficient information on the effects of UWB devices on licensed systems.

(iii) The JHU Report's conclusion that GPS receivers exhibit "severe degradation when the separation between the GPS receiver and the UWB devices is less than about 3 meters"[12] is arbitrary and misleading because it understates the danger of interference. This statement creates the impression that the onset of unacceptable interference *only* occurs at 3 meters or less, whereas in fact it starts to occur much farther away. Based on the results presented in chapter 6 of the report, interference that could jeopardize the viability of a safety-of-life service (GPS) is exhibited *at distances of up to 15 meters in some cases.*[13] Furthermore, as the JHU Report indicates, those devices actually tested were less likely to cause interference than other types of UWB devices which might be deployed near GPS receivers.

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[11] JHU Report, at ES-2

[12] JHU Report, at ES-1

[13] See generally JHU Report, at 6-9 through 6-28

(iv) The tests reported by John Hopkins University do not take into account the fact that the GPS receiver will likely be already operating in a background noise environment before the UWB interference is encountered. An accurate assessment of UWB interference should therefore be made by adding the UWB interference to representative background noise, rather than the idealized noise-free environment that was used in these tests. The lack of background noise has the likely result of further understating the interference effect of the benign UWB devices tested.

(v) In a March 16, 2001 *ex-parte* submission, the US GPS Industry Council reports that there appear to be errors in the JHU report, including the use of improper factors for the conversion of attenuator settings from the test to the range results reported in the results, and other significant errors in measurements. These referenced errors have not been corrected.

C. NTIA Report dated March 9, 2001

This report provides an account of the measurements performed, the results obtained, and the conclusions made by NTIA regarding the interference potential from UWB devices into GPS receivers. The main points arising from this considerable work are as follows:

(i) Interference into GPS receivers is highly dependent on the signal structure of the UWB devices, particularly those aspects that cause high density spectral lines from the UWB signal to fall in the most sensitive parts of the GPS spectrum. The Commission's proposed way of defining UWB emission limits do not take account of this phenomenon and are therefore insufficient to adequately protect GPS while still allowing the flexibility for the development of UWB devices.

(ii) For cases where the UWB signal causes the highest level of interference into GPS, the proposed Part 15 limits would need to be reduced by as much as 35 dB in order to ensure the necessary protection of GPS receivers.

D. DOT / Stanford University Reports dated March 21, 2001 and October 30, 2000

This report contains the results obtained so far by Stanford University on behalf of the U.S. Department of Transportation, and recognizes the need for further measurements and analysis in order to enable an informed rule-making process to proceed. It includes the results of measurements and analysis for a single UWB device and does not consider aggregate interference from multiple UWB devices. The main points concluded by this report are as follows:

(i) The interference into GPS receivers is highly dependent on the signal structure of the UWB devices, a fact that has repeatedly been shown by the measurements so far reported. The report attempts to quantify this phenomenon by the introduction of a "noise equivalence factor," which is the amount by which the UWB signal can be worse than white noise.

(ii) The noise equivalence factor becomes much worse as the pulse repetition frequency of the UWB device is increased, and a pulse repetition frequency of approximately 20 MHz results in a noise equivalence factor of 23.5 dB when measured across the 24 MHz GPS band (i.e., the UWB signal is 23.5 dB worse than white noise of the same power in the GPS band).

II. CONCLUSIONS FROM THE REFERENCED REPORTS

The following conclusions can be drawn from the reports considered in this Comment cycle:

A. Effect of interference from UWB devices can be very dependent on the UWB signal structure and its interaction with the wanted signal in the victim receiver.

UWB signals are typically generated by a series of energy pulses. By their very nature, these pulse trains produce wideband signals (whose bandwidth depends on the sharpness of the pulse edges and the duration of the pulses) with periodic narrow high-density spectral lines (whose spacing depends on the pulse repetition frequency). These high-density spectral lines can cause devastating effects in certain types of receivers, especially in systems such as GPS, but potentially in other receiver types as well. The exact location of the spectral lines will vary with the UWB modulation and clock accuracy, and it is very unlikely that practical spectral location can be controlled in a low-cost UWB device sufficient to prevent very high levels of interference from occurring. Therefore any FCC rules must ensure adequate protection of licensed services under the conditions where they are experiencing the UWB high density spectral lines at frequencies that cause maximum interference.

B. Only a very limited number of types of UWB devices have been tested and this does not provide sufficient evidence concerning the interference that will be caused by the full range of UWB devices that will ultimately be used.

Many have extolled the virtues of UWB technology based on the wide-ranging benefits to society that will result from the very diverse applications for this technology. Despite this apparently limitless range of UWB possibilities, however, there are remarkably few UWB devices available to test today for compatibility with licensed services. Therefore, the experimental evidence obtained using actual UWB devices is very small, and some of the entities

that have performed compatibility testing have been forced to use pulse generators and other test equipment to simulate the UWB signals. The inability to test actual UWB devices complicates the design and execution of the tests, but it is the only way to proceed for the time being. However, great care must be taken to ensure that these "UWB simulators" do indeed accurately represent the full range of UWB devices that could eventually be deployed under the Commission's resulting rules.

Sirius is developing a combined measurement and analysis program intended to quantify the susceptibility of its receivers to UWB interference that uses test equipment to simulate UWB signals (due to the presumed unavailability of UWB devices). Upon Commission action indicating that it is prepared to take into account the results, the program will commence and the results will be reported to the Commission as soon as they are available. The measurement and analysis plan is described in more detail in Annex 1 to these Comments.

In considering the reports that are the subject of these Comments, as well as the evolution of the collective understanding of UWB interference throughout the course of this proceeding, it has become very apparent that any "one size fits all" approach to regulating UWB devices will be so ineffective as to be useless. While we appreciate the Commission's desire for the simplest set of rules possible, this objective must inevitably be compromised in the interests of maximizing the compatibility between UWB and other services. It is in every party's interest to recognize that, although UWB devices might share certain features in common, they will exhibit other features that are very diverse in their interference-causing characteristics, due primarily to the different applications foreseen for them.

We therefore believe that the Commission should now define different categories of UWB devices and create appropriate rules for each category. These categories should be more specific than "radar" versus "communications" devices, and should depend on factors that determine interference effect. Factors related to the intended application and intended use are crucial in this respect. For example, how many such devices will be deployed in a given area? Will they be used or installed near devices with which they could interfere? Are the devices intended only for use by qualified people (law enforcement, or emergency personnel) or are they intended to be consumer devices? Ground penetrating radar could constitute one such category as many of these factors are understood (the device is intended for use by qualified emergency or law enforcement personnel; generally only one, or very few, devices will operate in a given area; operating frequencies, signal characteristics, and power levels are known; the signal is directed into the ground and can be shielded.) Interference scenarios applicable to such UWB devices will be vastly different from those applicable to, for example, a car collision sensor, particularly for a victim service such as satellite DARS that is intended to operate in automobiles and will necessarily be in close proximity to one, and possibly several, UWB devices. Based on a careful categorization of UWB devices, testing and analysis results will be much more useful and should result in a rapid convergence on UWB rules that are acceptable to all parties.

C. Most measurements available so far deal with interference to GPS; The effects on non-GPS services have not been adequately addressed.

The vast majority of test and analysis efforts in this proceeding so far, and particularly the set of reports that are the subject of these Comments, have focussed on the UWB

interference to GPS receivers.[14] This is due primarily to the fact that potential interference to GPS affects a very wide range of interested parties including equipment manufacturers, operators and the US government, all of whom are concerned with the same well established victim system. By contrast, satellite DARS for example is a fledgling service with only two operators and limited resources to devote to the vague and open-ended task of testing for UWB compatibility. However, in light of the tests and analysis results now available, specific system operators, such as satellite DARS, are better able to embark on a test program that will yield results that are useful in formulating the rules for UWB devices. It is imperative that the Commission allow these types of further tests to be completed before issuing any rules in this proceeding.

D. Those tests that have been completed for non-GPS devices indicate substantial interference.

Although the analysis is far from complete, the Qualcomm tests indicates that UWB devices can seriously degrade the operation of PCS devices. Sirius' licensed satellite DARS system is, like a PCS system, based on low-power, onmi-directional receivers, and therefore Sirius is particularly concerned by these results. Moreover, operators of DARS or similar systems cannot compensate for UWB interference by adding infrastructure to increase the system's power, so the public will suffer significant reduction in service quality. It is crucial that the Commission allow sufficient testing and analysis of non-GPS services, especially those whose devices share relevant characteristics with PCS and would be similarly susceptible to UWB signals.

[14] Four out of five of the subject reports deal with interference to GPS receivers. In the previous seven reports submitted to the Commission, five deal with interference to GPS only.

E. The test results and analysis of UWB signals indicates the appropriate approach for the Commission's further action.

The five tests that are the subject of these comments do more than provide specific data on UWB signals and interference on licensed systems. The Commission and interested parties have long been aware that UWB devices have various signal structures and potential applications. Now, however, the Commission has a more detailed record concerning how these variations affect licensed devices. The Commission should proceed towards rulemaking in a careful and incremental manner designed to produce conclusive results, and the rulemaking proceedings should relate to each category of UWB devices that have been defined as described above. We suggest that the record before the Commission indicates the following course of action:

(i) Specific categories of UWB devices must be defined, along with the technical and operational characteristics of each category;

(ii) The Commission should quickly identify areas where further testing and/or analysis is needed, including the effects of multiple UWB devices, and take action to ensure that these tests or analysis are completed expeditiously;

(iii) Based on these tests and analysis, the Commission should develop proposed specific rules for each category of UWB device, which govern its application and mode of operation, allowable average and peak power levels, the allowable ranges of pulse characteristics in the time domain, allowable spectrum masks, and other appropriate limits that govern its introduction, and should request comments from interested parties on such proposed rules before issuing a final rule.

(iv) As new categories of UWB devices are developed, the Commission should determine whether additional testing is needed before approving these categories and generally follow the procedure outlined above in order to bring these new UWB categories safely to market.

In closing, Sirius again notes its appreciation for the efforts of the parties responsible for in all of the recent tests, and looks forward to a continued dialog with the Commission, UWB proponents, and other interested parties.

Respectfully submitted,

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Technical and Engineering Certification

I hereby certify that I am the technically qualified person ultimately responsible for the preparation of the technical and engineering information contained in this filing, that I have either prepared or reviewed that engineering information, and that it is complete and accurate to the best of my knowledge and belief.

Richard Barnett

Dr. Richard J. Barnett
President
Telecomm Strategies LLC

Annex 1: Proposed Measurement and Analysis Plan to Assess the Effects of UWB Interference on Satellite DARS

In this annex we provide details of the Sirius Satellite Radio's proposed UWB interference measurement and analysis plan. This proposal has been prepared in light of the latest measurements and analyses reported by others and which are addressed in the main part of this submission.

Due to the limited number of UWB devices available for testing, Sirius has concluded that the only way to assess the potential interference from UWB devices into the Sirius receivers is to simulate the interfering UWB signals rather than attempt to use actual UWB devices. This simulation approach has recently been used by others, including Qualcomm. The UWB test signal will be generated using a pulse generator, pulse trigger/modulator and filters, together with appropriate test and calibration equipment.

Phase 1 is the measurement phase. The purpose of this measurement phase will be to determine which UWB waveforms cause the most serious interference to the Sirius receivers. The UWB simulated signal will be injected directly into the front end of the Sirius receivers at a carefully controlled power level. Since it is not possible at this time to determine what categories or types of UWB devices will be deployed or permitted under the Commission's resulting rules, a wide range of waveform types will be tested, consistent with the Commission's broad definition of UWB devices. Based on the experience of others it is to be expected that there are some combinations of UWB pulse characteristics that cause more destructive interference to the Sirius receivers than others. Once the crucial UWB waveform characteristics have been established, the power level of the UWB signal will be adjusted to a reference level which is considered to be the onset of unacceptable interference.

Phase 2 is the analysis phase. Sirius will analyze the interference geometry that will exist for the UWB devices (to the extent known) interfering with the Sirius receiver. Again at this stage it will be of great benefit to categorize the UWB devices in terms of their operational characteristics. For example, the interference scenario for a ground-penetrating radar will be significantly different from that of an automobile collision sensor or a mobile network communications device. The output of this analysis will be an allowable power level for the UWB device, coupled with an acceptable separation distance (and UWB orientation if appropriate), which together ensure that the interference to the Sirius receiver is maintained at acceptable levels. The UWB waveform assumed will be the one that resulted from the simulation measurement performed in the first phase as described above. This analysis will also take into account the potential for aggregate interference from multiple UWB devices in scenarios where this is likely.