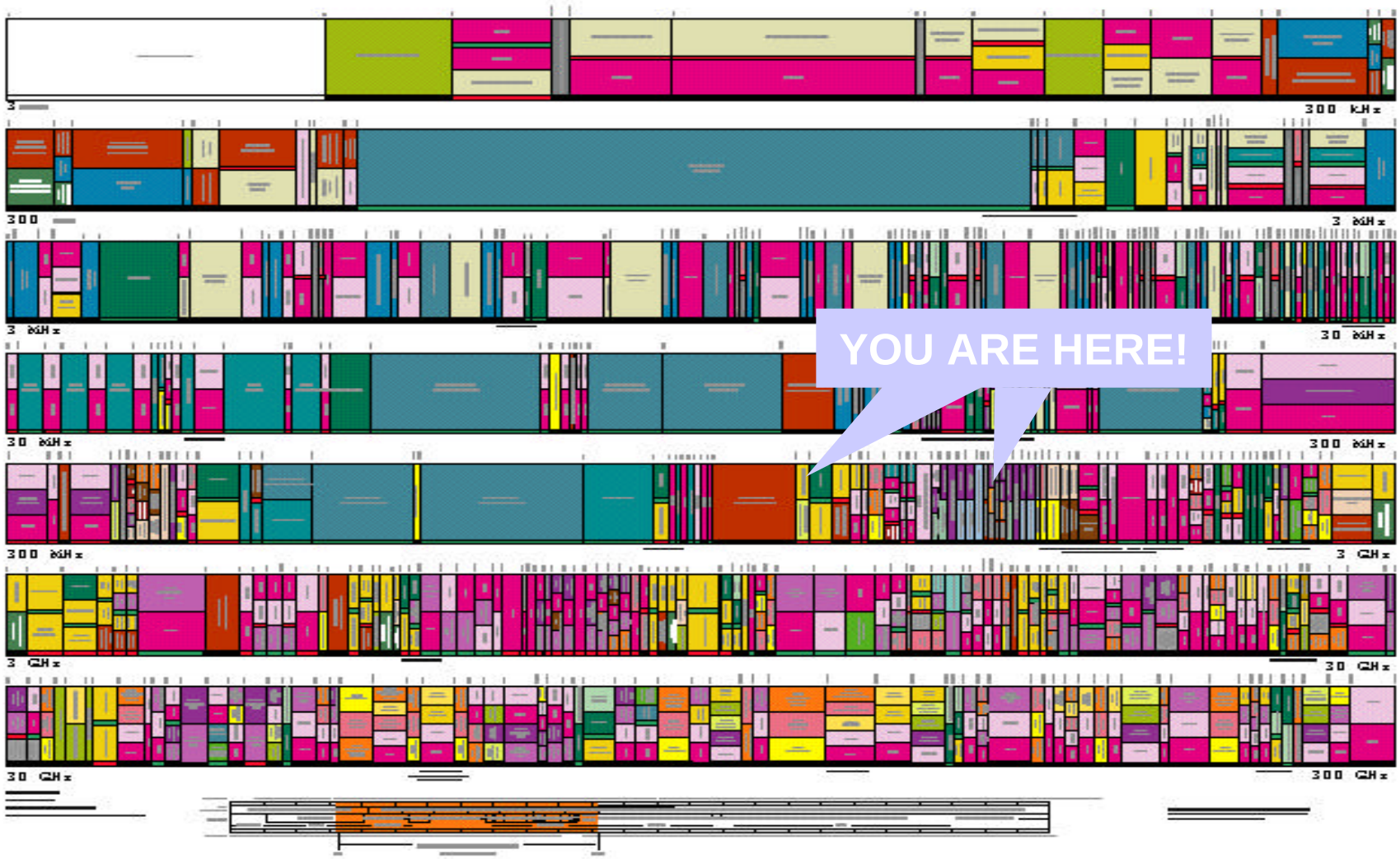
Presentation on

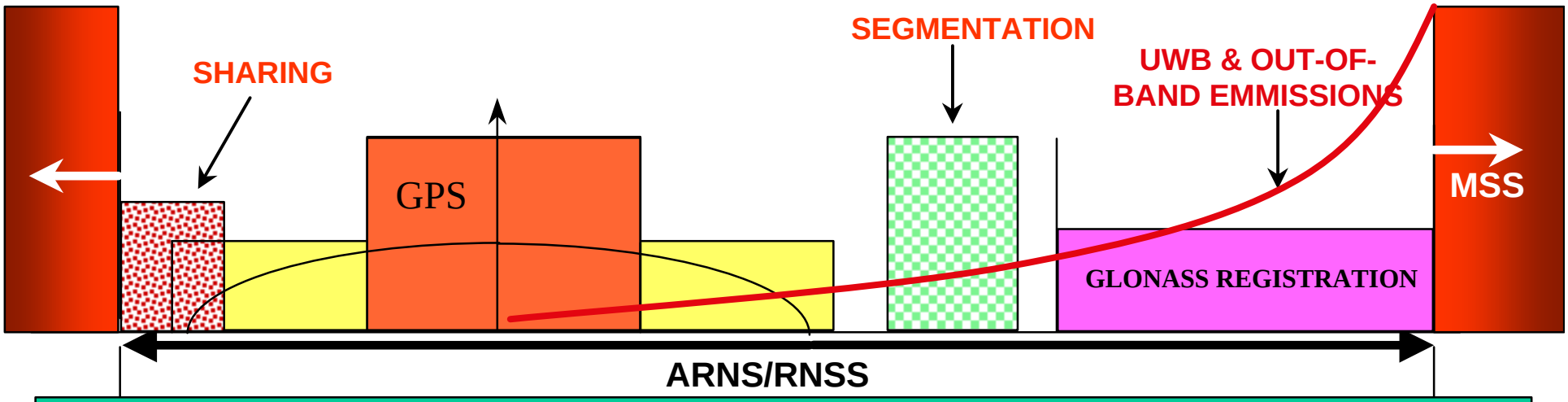
# ET Docket 98-153

By Representatives of
The U.S. GPS Industry Council

# Frequency Universe



# GPS can be Harmed Several Ways



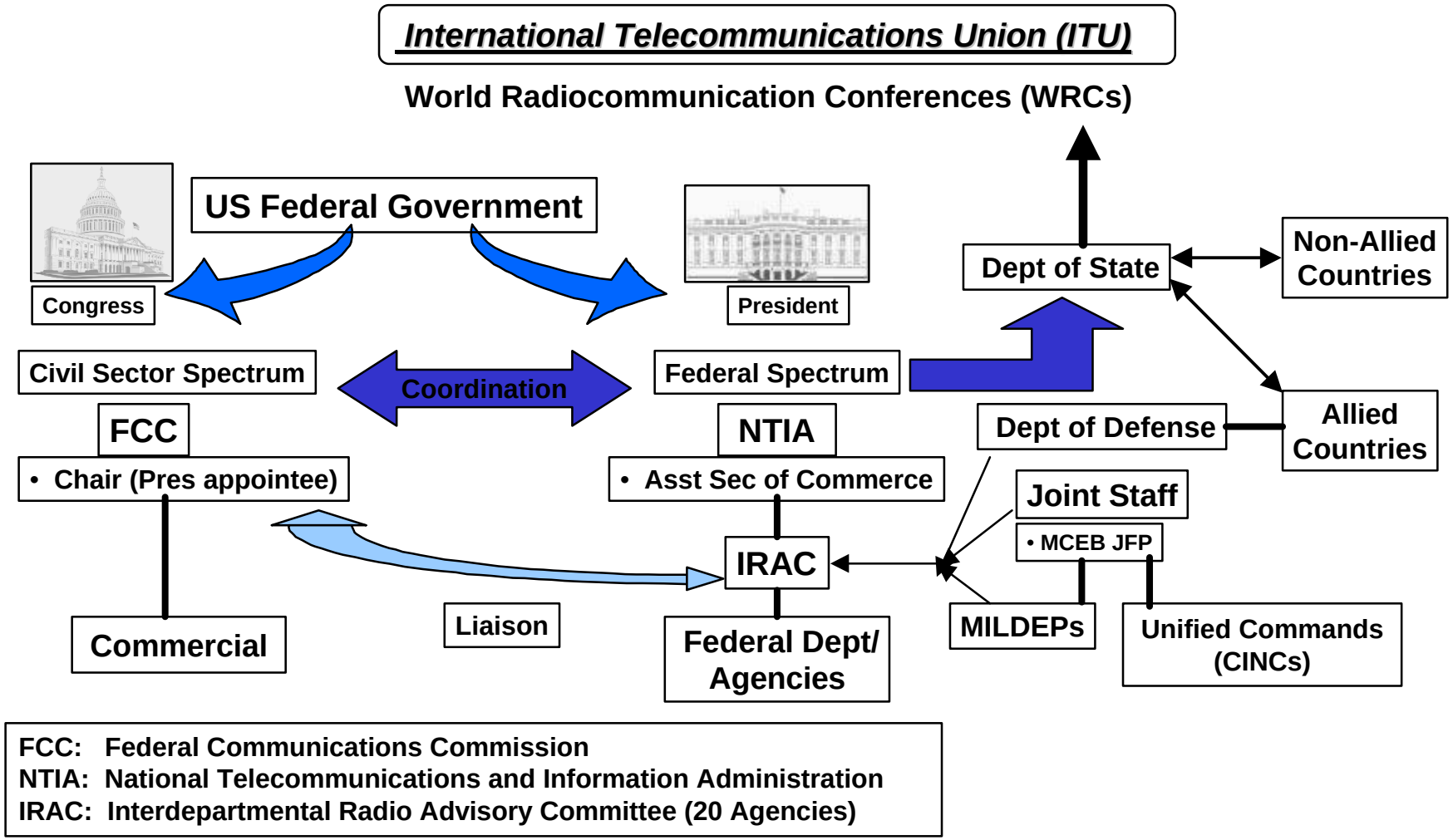

**Spectrum is a unique resource**

- **Sharing harms safety-of-life applications**
- **Out-of-band and ultra wide-band emissions raise the noise floor**
- **Segmentation prevents future evolution**

**Spread spectrum GPS signals are unlike most communications**

- **$10^{-16}$ W received power**
- **One-way broadcast without real-time adaptation**

# U.S. Spectrum Management Organizations



# Ultra wideband (UWB)

- Ultra wideband (UWB) technology uses very short radio frequency pulses spread over thousands of megahertz
  - Potential applications in imaging, positioning, and communications - some synergistic with GPS
  - But UWB emissions may cross restricted spectrum bands used by GPS and cause interference

## *I have a problem/question...*

**Govt. Agency -** *We have regulations...fill out the forms...*

**International Org.-** *Convene a conference, divide into working groups.*

**Engineers -** *I can fix that...Add this...Eliminate that...*

**Lawyers -** *You did what ? This will take a lot of time ($); a lot of study ($); a lot of discussion ($); and a lot of paperwork ($). Don't do anything without talking ($) to me first.*

# Communications Act

Directs FCC to maximize access to, and efficient use of, spectrum

- To maximize access, the FCC is encouraged to speed the process of adopting new technologies and services
- To maximize efficient use, the FCC must ensure the preservation of equities of all licensed and allowed services both old and new

# Balancing Competing Goals

- All other things being equal, priority should be given to services and technologies which are efficient in terms of spectrum, particularly those relating to the nation's IT engine.
- In the case of UWB, however, things are not equal
  - Technical issues
  - Regulatory issues
  - Risk to public safety, security, and IT infrastructure

# UWB in Military

- Use
  - Clandestine communications
  - Radar
  - Intrusion detection
- Assumes
  - Low density of use
  - Spectrum efficiency not important
  - Closed system environment

# Spectrum for IT Economic Engine

- Use
  - High density
  - Maximum frequency efficiency (data rate/bandwidth)
  - Majority of users and services below 3 GHz
  - Reliability and predictability
- Assumes
  - Open environment in license-free bands (no control over who operates)
  - Band assignment maximizes number of different services
  - Grandfathering of existing services

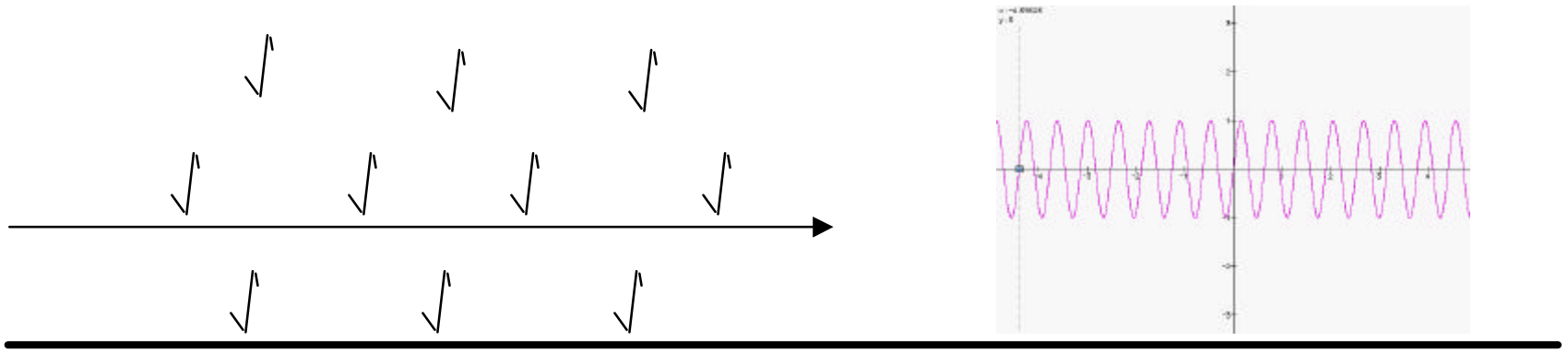
# UWB History

- Original Marconi spark-gap radio was UWB
  - One of the last commercial marine uses of spark gap radio was on the Titanic
- 1927 Radio Act divided the spectrum into 80 channels to allow multiple users in the same geographic area free of interference
  - End of terrestrial use of UWB technology for decades
- Modern UWB technology developed for the military
  - Proposed as a technology for sharing spectrum below the noise floor
  - Claims to be no noisier than a hair dryer

# That UWB Puts Out No More RFI Than a Hair Dryer Is A Red Herring

- Hair dryers are not on most of the time
- Hair dryers are rarely used outdoors
- Hair dryers are not connected to an antenna
- Hair dryers are not networked
- Hair dryers cannot be changed into GPS jammers

# Time Domain Versus Frequency Domain



Time Domain Pulse Train

Frequency Domain Continuous Waveform

Pulses of energy across wide unregulated spectrum instead of continuous waves confined to assigned regulated spectrum

If a pulse goes out earlier than the precise time prescribed by codes known to a correlating receiver, that can be communicated as a “1” -- a precise time later would be a “0”.

# Pulses are Different From Continuous Waves

- Peak power can be dramatically higher than average power
  - 1 joule/sec = 1 watt
  - 1 joule/nanosec = 1 gigawatt, but measuring over 1 second would only see 1 watt of average power
- Power of interfering spectral lines depends on the specific UWB pulse and PRF
  - one size doesn’t fit all
- Receiver vulnerability depends on individual harmonic responses

# Differences Between UWB and Conventional Receivers

- Conventional com receivers are primarily superheterodyne
  - very sensitive to variations in power as a function of frequency
- Time Domain UWB receivers are primarily homodyne
  - very sensivite to power in a given narrow time slot

# Differences Between UWB and Conventional Receivers (Continued)

Truly a paradigm shift in spectrum use, regulation, and management

- if power per time slot could have been easily managed, the 1927 Radio Act would have divided up the spectrum along channels of time as this would have grandfathered the original communications technology

# Issues Raised By The Proposed UWB Sharing

- What is the quantifiable level of known interference to existing services?
  - taxation of existing licensees?
- What proof exists of the ability to limit and control UWB interference to acceptable levels?
- What controls must be placed on UWB emitters so that they cannot easily become jammers?
- What is the ability to control composite interference in safety-of-life bands?

# Quantification of UWB Levels of Interference

1. Develop operational scenarios for UWB and existing services
2. Characterize interference susceptibility of existing services
3. Characterize interference of the proposed new UWB applications
4. Test devices against operational services

# Status of Current Testing

- NTIA is collecting operational scenarios
- GPS sensitivity is being studied by DoT/Stanford, University of Texas and NTIA
  - using a limited number of UWB pulse trains
- Some time and frequency domain measurements of limited UWB pulse trains have been collected in an attempt to establish link budgets
  - but, this assumes the applicability of frequency domain analyses and “generic” UWB pulse trains

# Current Test Approach Will Not Lead To An Understanding of How To Regulate UWB Pulse Trains

- Without a fundamental theoretical science understanding, an experimental approach must be used in the testing -- *there is no generic UWB pulse or pulse train*
- Each UWB pulse train must be tested independently--uniqueness of UWB pulse trains precludes generalization of test results
- This means that the number of tests needed, and therefore the amount of time and money involved to arrive at a reliable answer, is large and unknown.

# Current Test Approach Will Not Lead To An Understanding of How To Regulate UWB Pulse Trains (Continued)

- Initial testing to date indicates that GPS receivers are highly sensitive to the fine spectral line structure caused by UWB pulse trains
- Unfortunately, initial testing to date indicates that the transmitted UWB pulse train is strongly affected by its antenna and external loading of the antenna
- Operationally, transmitted UWB pulse trains are unstable causing unpredictable movement in the fine spectral line structure

# Current Test Approach Will Not Lead To An Understanding of How To Regulate UWB Pulse Trains (Continued)

- There is a recipe on how to convert a UWB device into a GPS jammer on the FCC website
- Mere proximity of the UWB antenna to human and inanimate objects alters the UWB pulse train
  - this invalidates any link budget analysis to protect existing services because the fine UWB spectral line structure changes depending on the proximity of objects

# Current Test Approach Will Not Lead To An Understanding of How To Regulate UWB Pulse Trains (Continued)

- Limiting power, either peak or average, on a device basis does not limit the power of a network
- The precise aggregation effect (including multipath) of large networks of UWB communications devices is unknown, but it is clear that the total radiated power per unit area cannot be controlled for unlicensed devices
- It is hard to understand how a networked communication system could be designed without some form of synchronization and therefore the composite effect of network synchronization must be understood

# Summary

- Radiated UWB pulse trains are unstable due to variation in antenna loading and near-field coupling, therefore their effect on current services cannot be predicted
- Networking of UWB devices, especially in multipath environments, means that the total interference cannot be easily measured, predicted or controlled
- The instability and aggregation issues pose major obstacles to the development of a rational regulatory environment

# FCC Is In An Impossible Position

The FCC is under strong pressure to allow UWB technology to be introduced into the market

- Before the basic science of the interference with the Nation's IT engine is understood
- In the face of initial tests indicating unpredictable spectral characteristics of UWB pulse trains and the inability to limit the total noise power of a network of UWB devices
- Given a documented example of UWB interference with broadcast television
- Given a documented example of how to build a GPS jammer from a UWB emitter

# Solution

- The U.S. GPS Industry Council is not opposed to UWB technology and believes that it should be allowed the test of the marketplace
- The solution is to perform a strategic experiment
  - Use conventional band-segmentation
  - Choose a 3 GHz-wide band above 3 GHz that does not contain a safety-of-life service and designate it as a band to use for UWB devices on a non-interfering basis
  - Use the experience gained to try to develop a regulatory environment for UWB devices

# Managing Risk and Reward from New Technologies

- The demand for commercial spectrum is intense
- The attraction of technological “silver bullets” is obvious, but
- The nation’s IT engine (and critical and other services in restricted bands) must not, and need not, be exposed to technical and regulatory “Russian roulette.”

# *UWB Regulatory Status*

- *FCC Issued Notice of Proposed Rule Making (NPRM) in May 2000*
- *Initial comments filed on September 15, 2000*
- *Reply Comments filed on October 27, 2000*
- *Technical Test Data due on October 30, 2000*

# *REPLY COMMENTS - SUMMARY*

## Good Science, Comprehensive Testing, and/or Avoidance of Restricted Bands

| | | |
|---|---|---|
| ARINC | Aerospace Industries Assoc. | Alloy, LLC |
| AT&T Wireless | Daimler-Chrysler R&T | US DoT |
| Garmin | IGEB | Interlogix |
| Lockheed-Martin | Motorola | |

National Business Aviation Association
National Safe Skies Alliance
National Spectrum Managers Association
National Association for Amateur Radio

| | | |
|---|---|---|
| NTIA | NovAtel | Rockwell |

Satellite Industry Association

| | | |
|---|---|---|
| SiRF Technology | Sirius Satellite Radio | Sprint |
| USGIC | Verizon | WorldCom |

## *REPLY COMMENTS - SUMMARY*

**Support Licensing of UWB and/or Avoidance of Restricted Bands**

Fantasma

Intel

Kohler

Multispectral Solutions Inc.

# *REPLY COMMENTS - SUMMARY*

## Propose Unlicensed UWB Operations and Operation Across Restricted Bands

Time Domain, Inc.

## *UWB Regulatory Status... A Long Way from Home*

- *October 30, 2000: No test results were submitted:*

  *NTIA - February 2001*

  *Stanford/DoT - no announcement*

  *University of Texas - raw data only, no analysis; not officially submitted.*

## *UWB Regulatory Status... A Long Way from Home*

- *Spring 2001:*

  *Test results received by FCC*

  *FCC Issues Public Notice on Test Results*

  *Comments Received*

  *Reply Comments received*

## *UWB Regulatory Status... A Long Way from Home*

*Summer 2001:*

*FCC issues Report and Order on NPRM*

*FCC issues Further Notice of Proposed Rule Making*

*Fall/Winter 2001:*

*Possible ruling, conclusion.*

## *Outstanding Factors*

**Politics -** *New administration = new FCC Commissioners (unknown)*

**STA's**- *Special Temporary Authorizations. Time Domain has received more than 40 thus far, with more applications each week. Allow use/test of UWB devices* **without** *conditions and restriction specified under previous waivers.*

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