

# Hotchips 2004

## *Introduction to UWB systems*

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9/1/2004

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## *Summary*

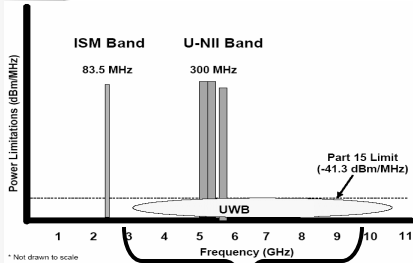
- Introduction to unlicensed spectrum and UWB
- Examples of UWB systems
- Application examples

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## Tendency to allocate more unlicensed spectrum



- UWB is about low power transmission and non-harmful co-existence with other services
- Unlicensed use sharing licensed spectrum
  - Radio systems are smarter than 70 years ago
  - Spectrum management based on old assumptions
- Future UWB systems will be different from systems analyzed before rulemaking
- UWB spectrum characteristics allow
  - high bit rate, short range (MBOA)
  - low power, location awareness (IEEE 802.15.4a)

Unlicensed bands	Frequency of operation	Bandwidth
ISM at 2.4GHz	2.4000-2.4835	83.5MHz
U-NII at 5GHz	5.15-5.35GHz 5.75-5.85GHz	300 MHz
UWB	3.1-10.6GHz	7,500MHz

Table 1. US spectrum allocation for unlicensed use.

ISM: Industrial, Scientific, Medical

U-NII: Universal National Information Infrastructure

MBOA: Multiband OFDM Alliance

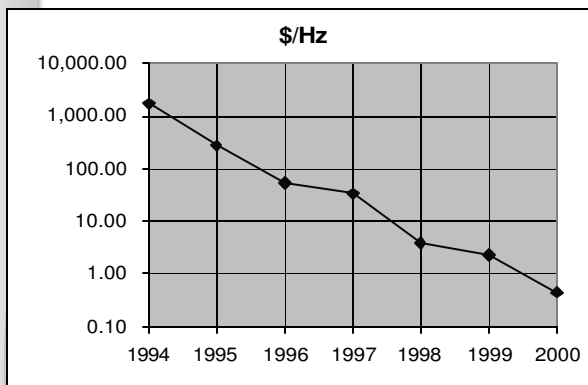
UWB: Ultra-wideband

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## The cost of licensed spectrum halves every six months



### Spectrum Auctions

**1994: 500kHz at \$213M  
Interactive Video and Data  
Services**

**2000: 12MHz at \$1.2M  
Broadcast Auction**

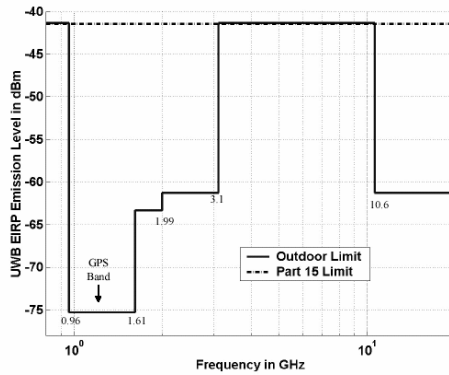
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# FCC spectrum mask

UWB Emission Limit for Outdoor Hand-held Systems



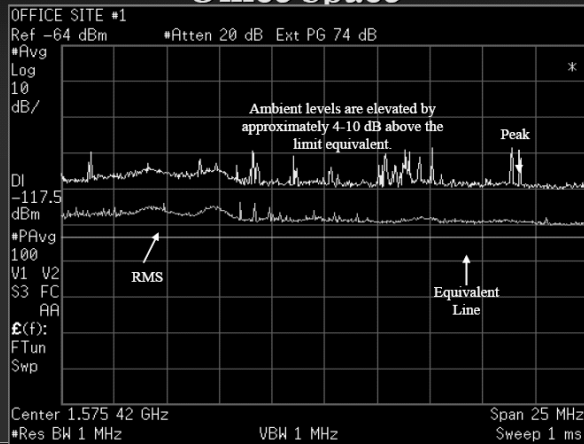
Same limit of unintentional radiator allowed by part 15 for EMI

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# Initial Results: Ambient Noise Office Space



This plot depicts measured emissions in the GPS L1 frequency band (1575.42 ± 12 MHz) in the work area of a business that utilizes a large number of personal computers in an open area. Measurements made at FCC Laboratory in Columbia, MD August 2002

EJT

Source: Ed Thomas, FCC, 2003  
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## Interference to existing signals



"...we detected no changes in the spectrum, video quality,  $E/N_0$  or pre-Viterbi BER of the FSS downlink signal when the UWB transmitter was turned on."

[Source: Infocomm Development Authority of Singapore (IDA), June 2004]

"Results have shown levels of interference similar to what is already allowed by the rules"

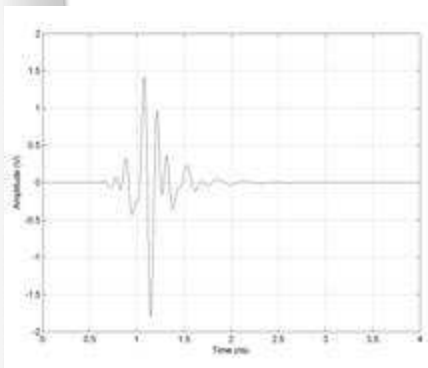
[Source: MBOA, January 2004]

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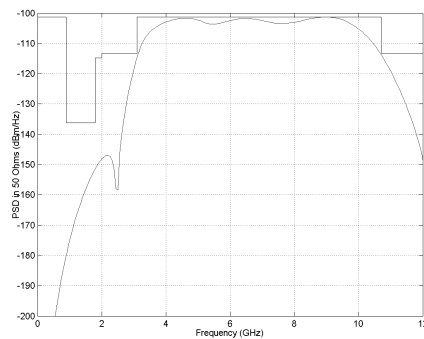
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## Example of Single Band UWB



ST Micro: doc.: IEEE 802.15-03/139r3



$BW_{-10dB} = 7.26 \text{ GHz}$

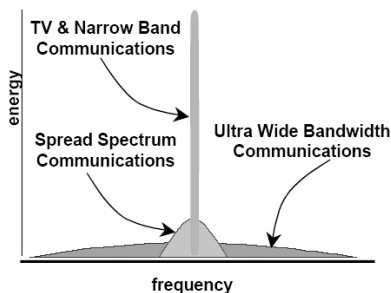
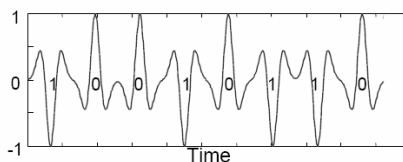
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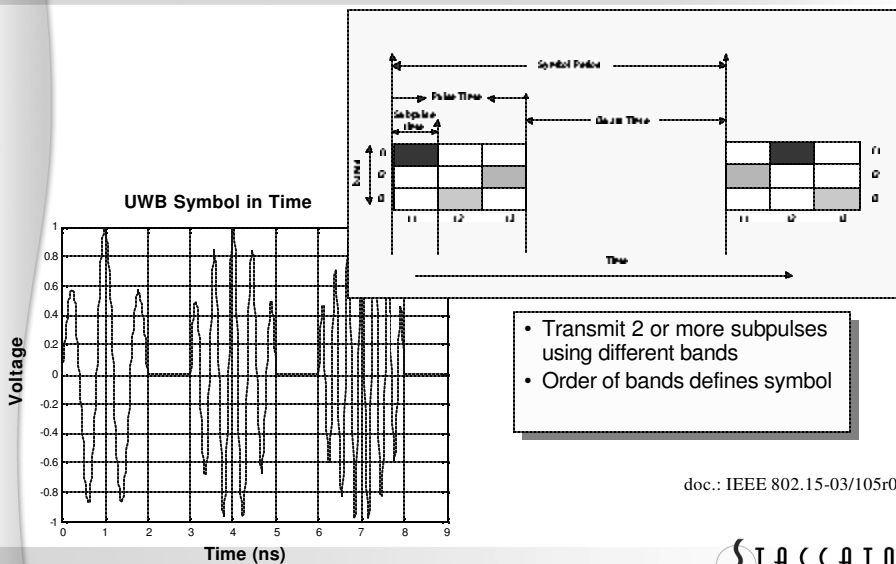
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# DS-UWB

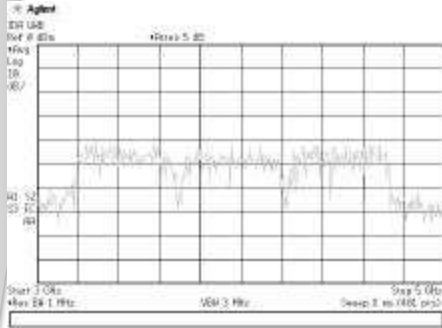
- **Coded short duration pulses spread the signal energy over frequency and time**
- **Can overlay existing FCC frequency assignments**
  - Spread is so broad, little energy gets in a narrowband
  - Short range WPAN systems can operate below the detection threshold of conventional receivers
- **Low probability of intercept (LPI) Bi-Phase not spiky in time or frequency domains**



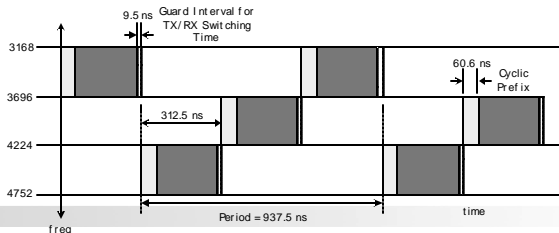
## Spectral Keying™ Modulation



## Example of multiband UWB: OFDM



Source: Infocomm Development Authority of Singapore (IDA)



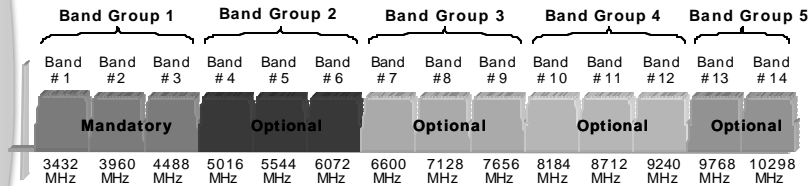
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Credits: TI TG3a proposal

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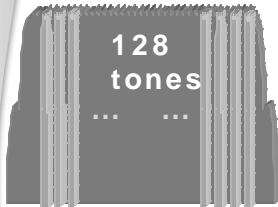
## MBOA(\*) specification summary



Link Margin Ref. (0 dB) -02.7 dB

-04.9 dB

-06.5 dB



Channel Number	Band Group 1 Length 6 TFC					
	1	2	3	1	2	3
1	1	2	3	1	2	3
2	1	3	2	1	3	2
3	1	1	2	2	3	3
4	1	1	3	3	2	2

### MBOA PHY Specification 1.0

- Band Switching
  - Within Band Set #1
  - 3.168 – 4.752 GHz
- Bands 1, 2 and 3
  - Each occupy 528 MHz
- Band Subcarriers
  - 128 tone OFDM
  - Tone width: 4.125 MHz
  - Tone modulation: QPSK

**Global Solution:** Flexible band plan and use of OFDM subcarriers allows for "spectrum shaping" which can be used to meet worldwide regulatory requirements

(\*) [www.multibandofdm.org](http://www.multibandofdm.org)

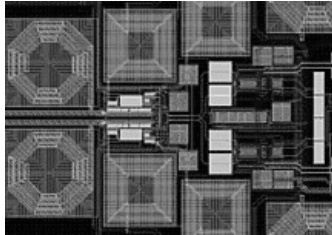
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## RF CMOS for UWB

Using appropriate design techniques and optimizations an ultrawideband multiband-OFDM analog front end can be implemented in low-cost standard CMOS.



### Standard CMOS Ultrawideband Single-Chip Solutions

By Dan Meacham and Krishnamurthy Soumyanath

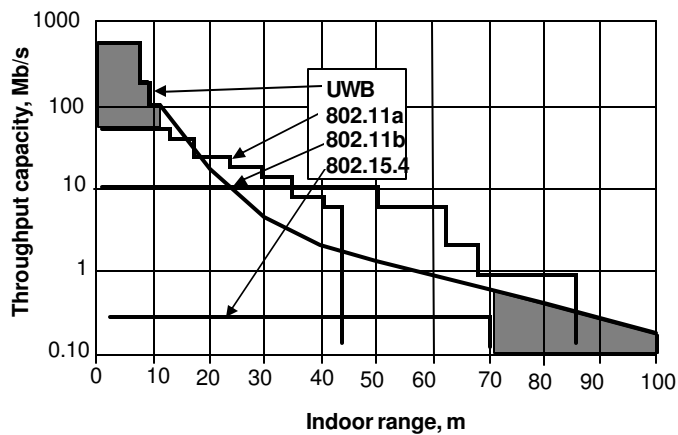
*EE Times*  
May 17, 2004

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## Main interest in two areas

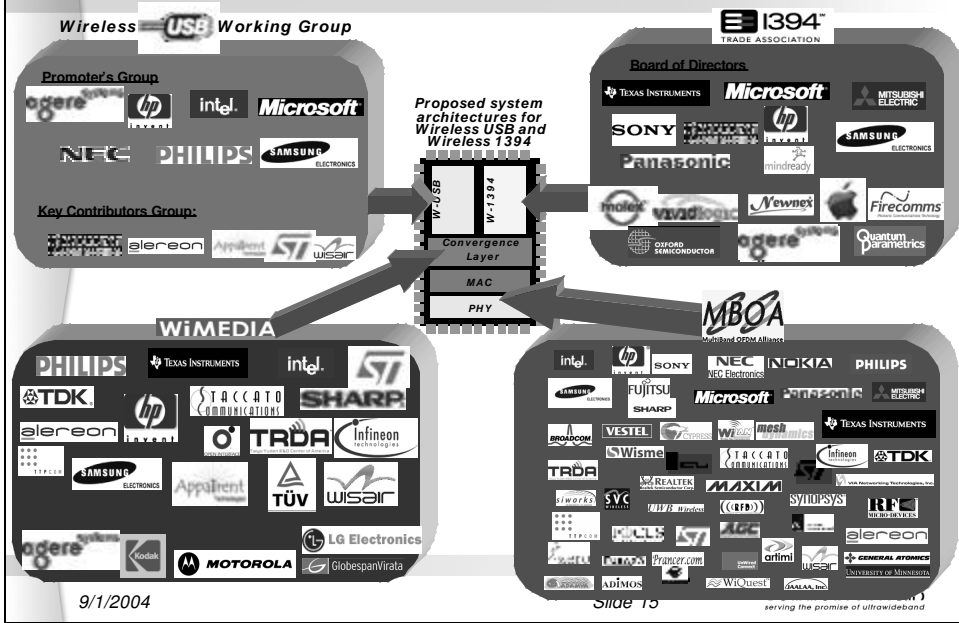


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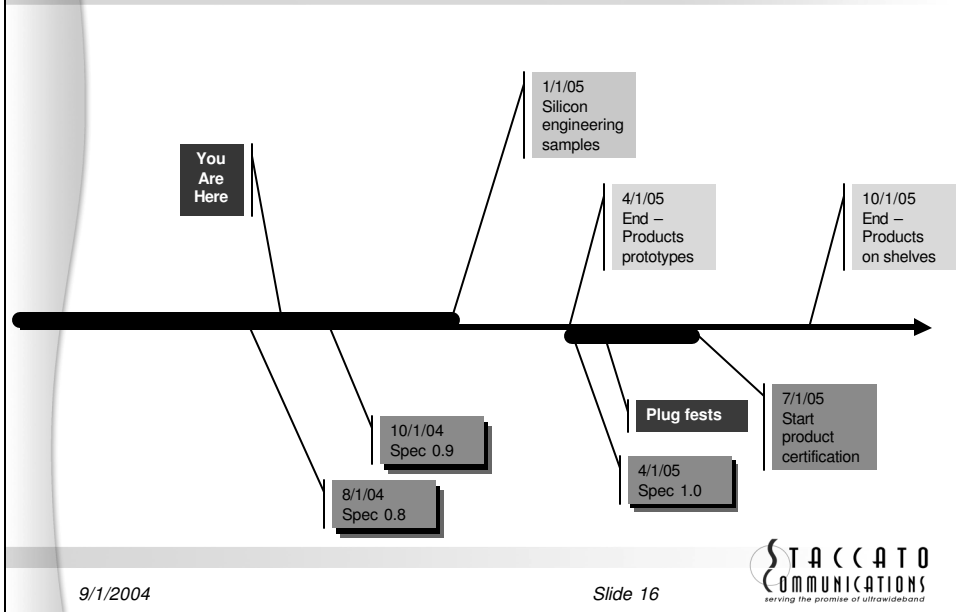
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# Many stars need to be aligned

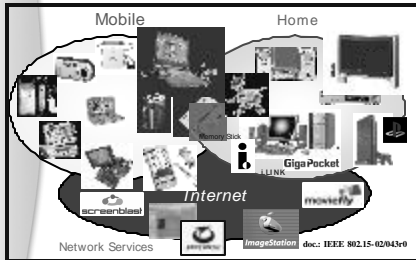


# Industry timeline for WUSB





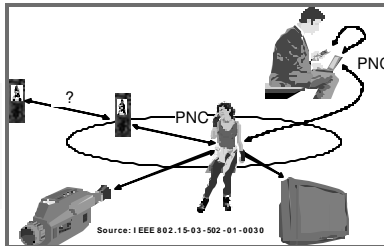
## High bit rate applications



### Sony's View

#### Consumer Electronics Wireless Multimedia

- Supported data Rates  
110, 200, 480 Mbps
- Range: 10m, 4m, 4m
- Power: 100mW, 250mW



### Intel's View

#### Personal Computing Wireless Desktop

#### Nokia's View Mobile Connectivity

Value Proposition: Hundreds of Mbps operating at low power and provided at low cost enabling wireless multimedia and high speed cable replacement

## Conclusions

- Opportunity for spectrum sharing
- High performance, low cost systems are feasible
- Commercial opportunity for high bit rate applications
- Strong industry support worldwide