




## Spectrum Policy and Management





San Diego, California  
November 17-19, 2008



### Role of Policy/ Management

- Technology provides the basis of **WHAT IS POSSIBLE** and is usually independent of the actual implementation
- Policy/Management provides the basis of **WHAT IS ALLOWABLE** and is in the context of what is "FAIR" and the appropriate uses of the technology
- Business-Mission Plans/Economics provides the basis of **WHAT IS PRUDENT** and is to determine if the uses of the technology provides a overall benefit for an operation measured by some success metric



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## Multi-Disciplinary

Not just in Words

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*"highest and best use"* *"transaction costs"* *"auctions"*

*"OOBE"* *"Structure Programming"*

*"LNA"* *"child processes"*

*"dB"* *"Ontologies"*

*"Intermods"* *"dynamic range"* *"Provability"*

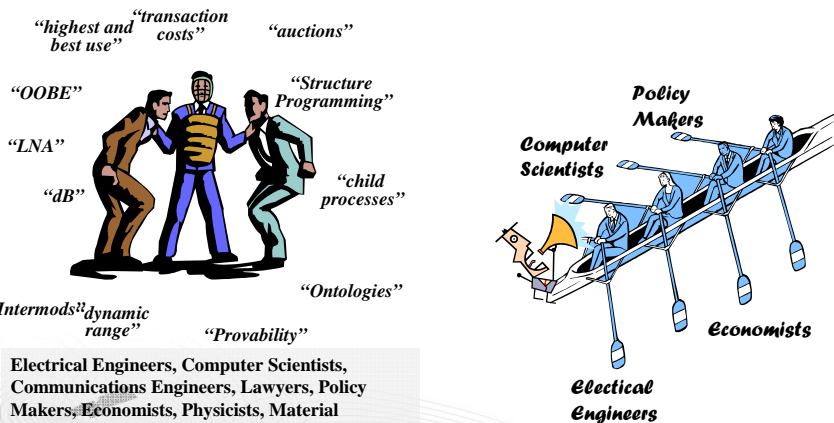
Electrical Engineers, Computer Scientists, Communications Engineers, Lawyers, Policy Makers, Economists, Physicists, Material Scientists, Pontificators

*Policy Makers*

*Computer Scientists*

*Economists*

*Electrical Engineers*




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## Policy/Management

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Which means ... demonstrating the viability of the technology is necessary but not necessarily sufficient to getting the necessary policy to use the technology



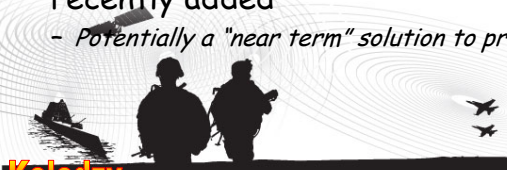
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## Cognition/Intelligence is not Only Dynamic Spectrum Access

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- Spectrum Access has been the focus of Cognitive Radios
  - Started with DARPA XG, FCC SPTF, President Spectrum Initiative, and FCC's TV WhiteSpace Proposed Rulemaking
- General Dynamics/Fette included network topology and network Awareness
- DARPA/Marshall included Policy Engines that could be made dynamic
- Dynamic Interference Management Techniques have been recently added
  - Potentially a "near term" solution to previously "unworkable" scenarios




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## Policy's Changing Landscape

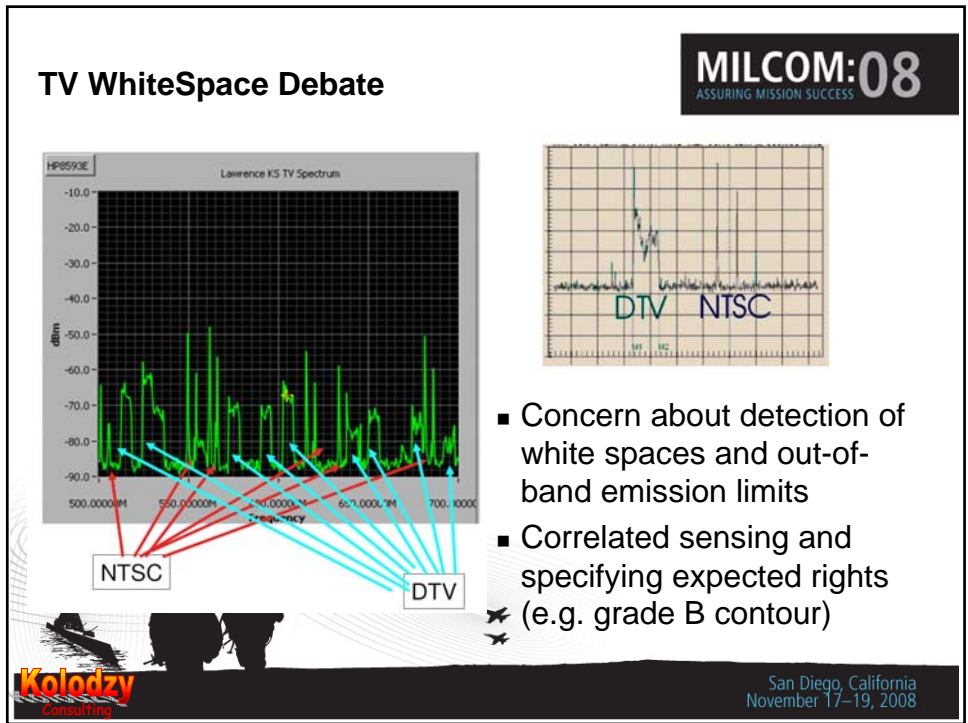
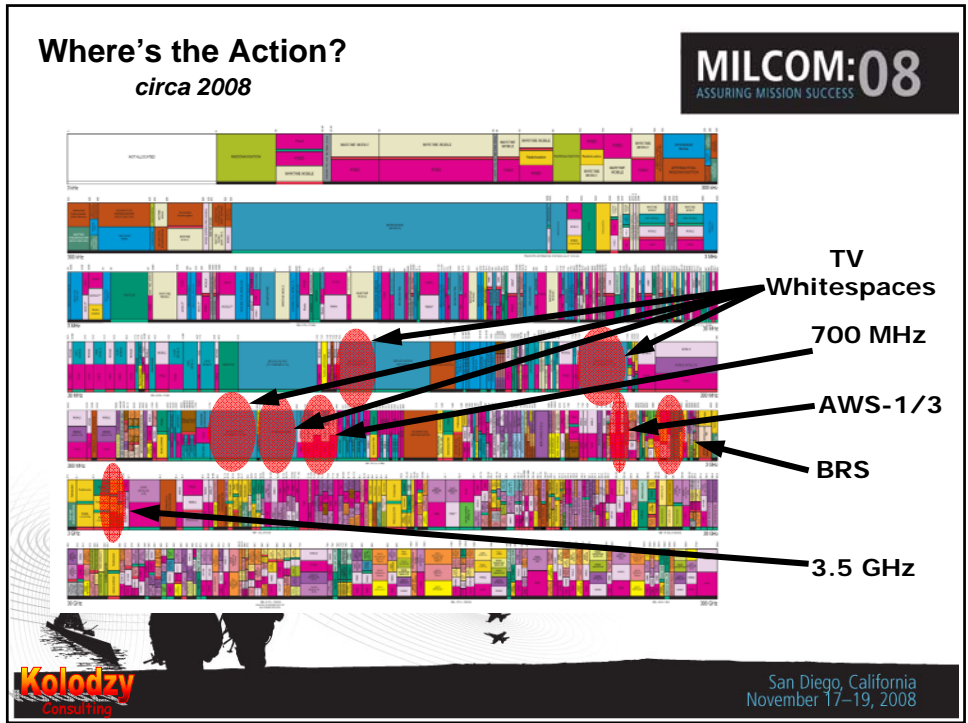
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- ✓ DTV Transition and TV White Space
  - Dynamic Spectrum Access and Statistical Analysis
- DTV Transition and the Deployment in 700 MHz
  - Dynamic Interference Avoidance
- AWS-1 and AWS-3 Co-Existence
  - Interference Metrics, Interference Avoidance and Statistical Analysis
- BRS and 3650 MHz - not covered
  - Interference avoidance and Licensed/Unlicensed
- Federal-Use, Commercial, and Coalition Coexistence
  - TDD and FDD Interoperability and Statistical Analysis



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## 700 MHz Allocation

A 6 MHz	B 6 MHz	C 6 MHz	D 6 MHz	E 6 MHz	A 6 MHz	B 6 MHz	C 6 MHz	C 11 MHz	A 5 MHz	D 5 MHz	BB 5 MHz	NB 3	NB 3	C 11 MHz	A 5 MHz	D 5 MHz	BB 5 MHz	NB 3	NB 3
52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69		

Uplink for FDD
Downlink for FDD
Downlink for FDD
Uplink for FDD

- Lower 700 D-Block and E-Block are single, unpaired blocks
- All other blocks are paired but can be used as unpaired blocks

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## Promoting Access to Spectrum The New Model – 700 D-Block

D Block      Public Safety      Public Safety Narrowband

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### The New Challenge

#### FDD (Commercial) – TDD (DoD)

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Uplink: Block 1, Block 2 (-43 dBW)  
~30 to 300 MHz  
Downlink: Block 1, Block 2, AWS -3 (-43 dBW)

**Base – Base Interference**  
FDD Downlink → TDD Uplink

**Mobile – Mobile Interference**  
FDD Downlink → TDD Uplink

FDD and TDD in adjacent bands will become a reality, what technologies will enable such operation?

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### Dynamic Interference Avoidance

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NG Radios that are Aware of Interference Effects Can Adapt to Mitigate Effects

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### TDD-FDD Coexistence Studies

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- FDD-TDD Coexistence has major impact on future spectrum allocations
- Standards Community (3GPP), ITU, CEPT, Ofcom, and US all using statistical methods to understand impact of interference

The graph plots the probability of FDD downlink throughput being less than a given value on the y-axis (ranging from 0 to 1) against the FDD downlink throughput in kbits/s on the x-axis (logarithmic scale from 10<sup>1</sup> to 10<sup>3</sup>). The legend includes: No TDD (black solid line), Interferer in block #35 (red solid line), Interferer in block #36 (blue solid line), Interferer in block #37 (green solid line), Interferer in block #38 (cyan solid line), Interferer in block #24 (magenta dashed line), Interferer in block #23 (yellow dashed line), Interferer in block #22 (orange dashed line), Interferer in block #21 (light blue dashed line), and Interferer in all blocks (black dashed line). The 'No TDD' curve is the highest, while the 'Interferer in all blocks' curve is the lowest. Annotations indicate the '1<sup>st</sup> adjacent block (hypothetical)' and '2<sup>nd</sup> adjacent block' regions.

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### Policy and Cognitive Radios

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- There are significant spectrum allocation and interference mitigation challenges facing the Policy community
- Cognitive Radio provides additional degrees of freedom to provide the necessary protection for more intensive use of the spectrum
- The policy community is struggling with the methodology to analyze adaptive systems
- Statistical methodologies are being developed to address these challenges, but the path forward is unclear.

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