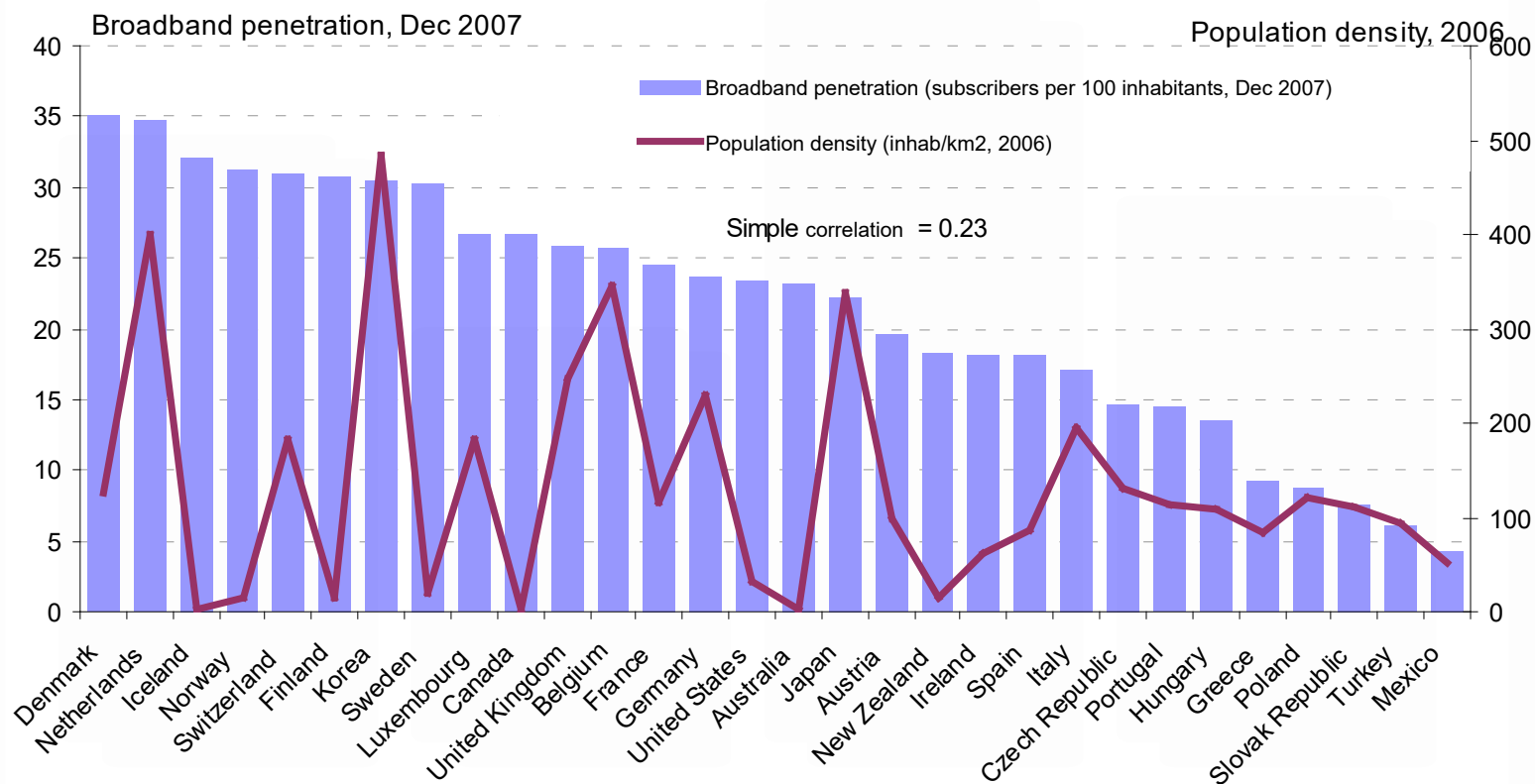




Future Challenges and the Current Role of DySPAN

Competition in the Marketplace!

OECD broadband penetration and population densities



Role of the Regulatory Agencies

>700 Lawyers
<150 Engineers



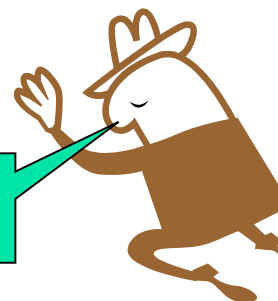
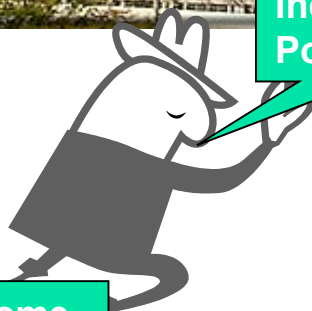
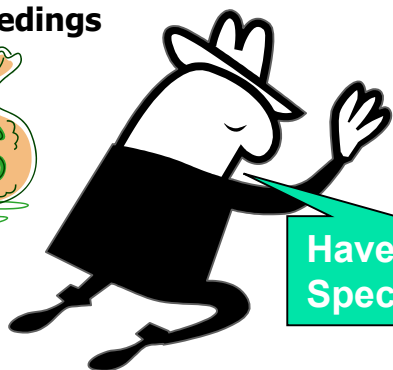
Increase My
Power?

Have Some
Spectrum?

Change the
Service?

Have Some
Spectrum?

Auction
Proceedings



Auction
Proceedings



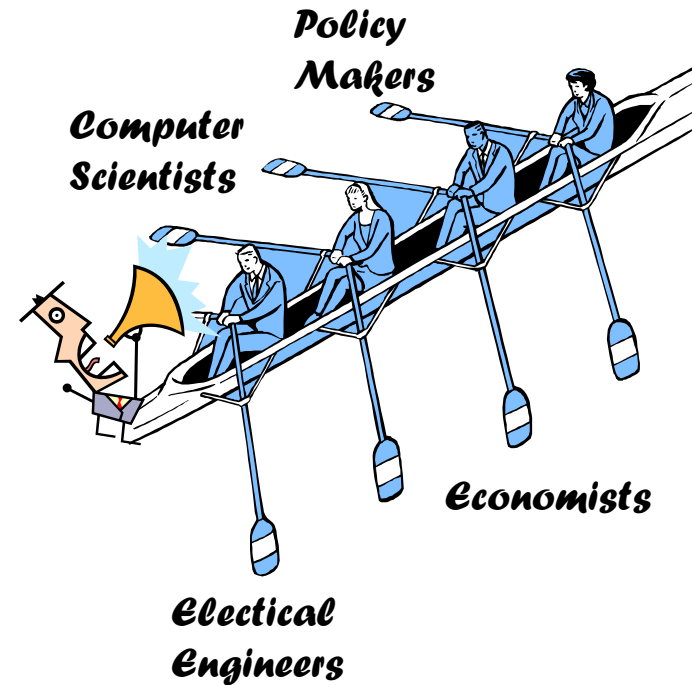
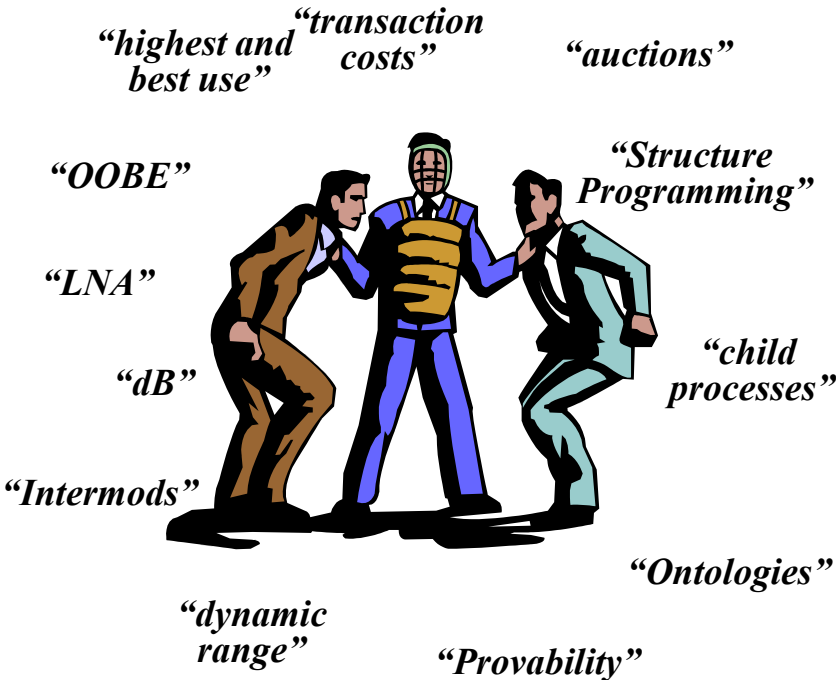
DySPAN – The Intersection of Policy, Economics, and Technology

- **The Rapid Change In Technology and the Ingenious Use of Spectrum Is Hastening**
 - **Technology Creates Regulatory Challenges**
 - **Command and Control Schemes are Too Slow**
 - **Policy needs to be made Less Reactive**
- **Regulatory Agencies are Staffed Primarily by non-Technical Personnel**
 - **Regulations should be Technology Agnostic ... not Technology Ignorant**
 - **The Regulators want to understand ... in terms that they can Understand and Use**

To Provide Preeminence for any Country's Technology and Businesses, The 21st Century must see Technologists and Economists play an Active Role along with Legal Community to Insure Policy does not Limit Technology

DySPAN - Multi-Disciplinary

Not just in Words



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

Complexity in Spectrum Operations

Communications ☺ is Key Component



***Spectrum Policy/
Acquisition***



***Network
Construction***



***Standards
Groups***

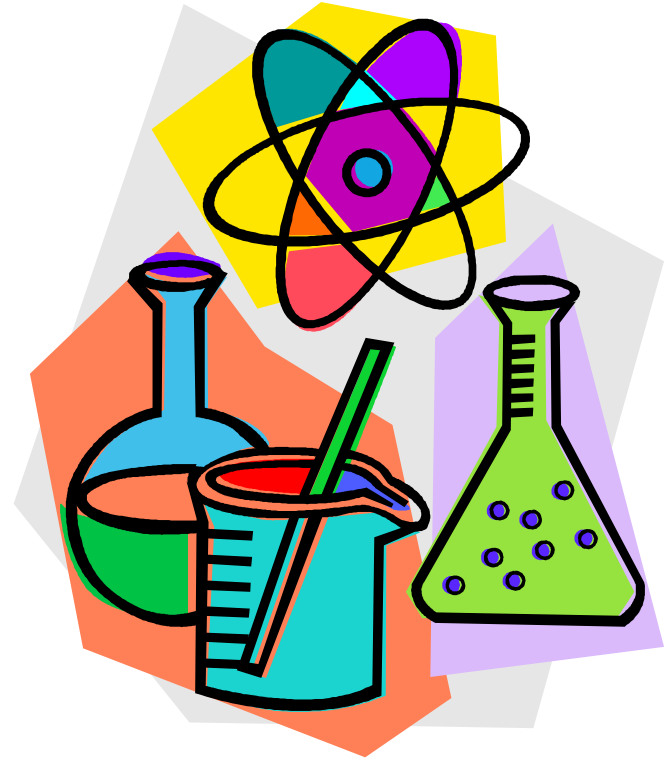


Operations



When assumptions with acquisitions do not align with standards groups or operations, how can the right groups be joined to address the issue?

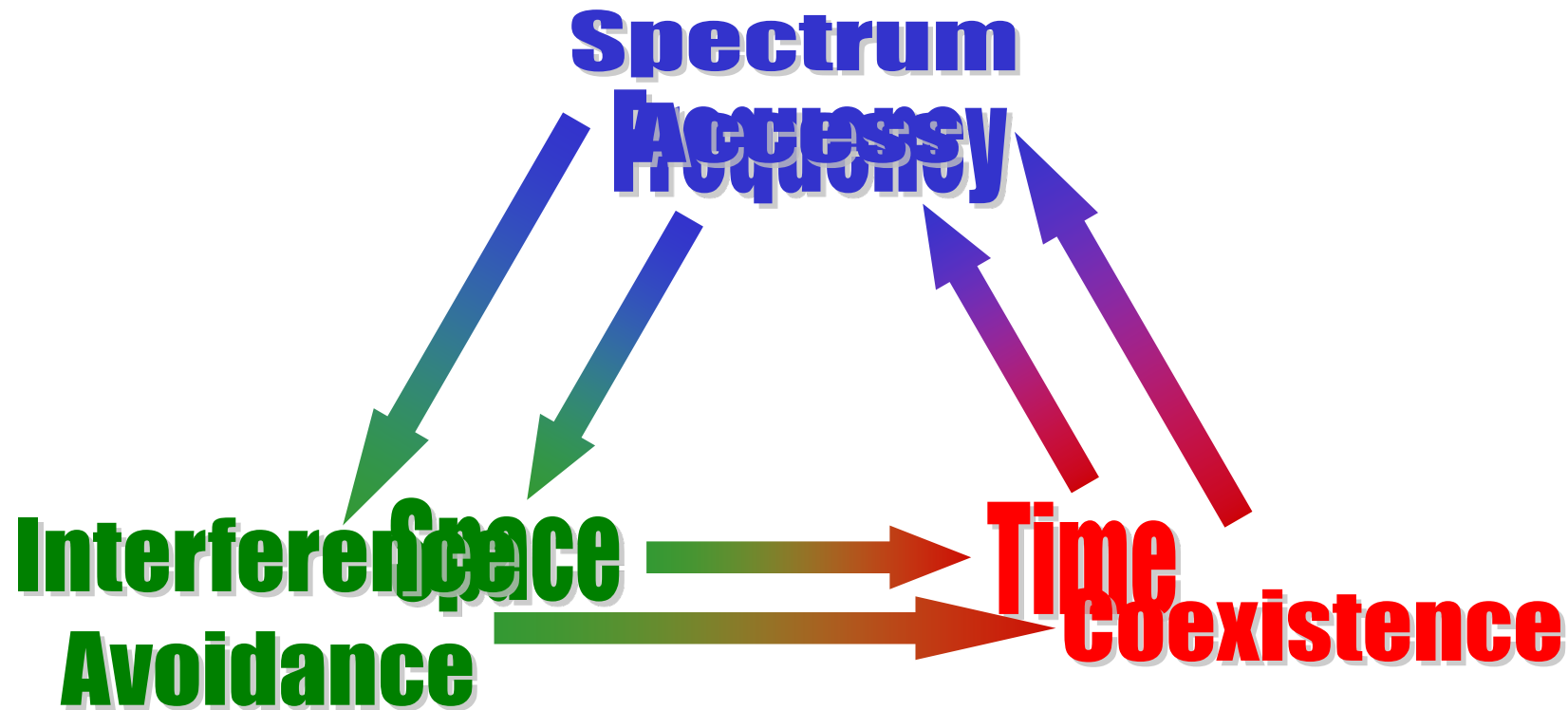
DySPAN - Cross-Synergies



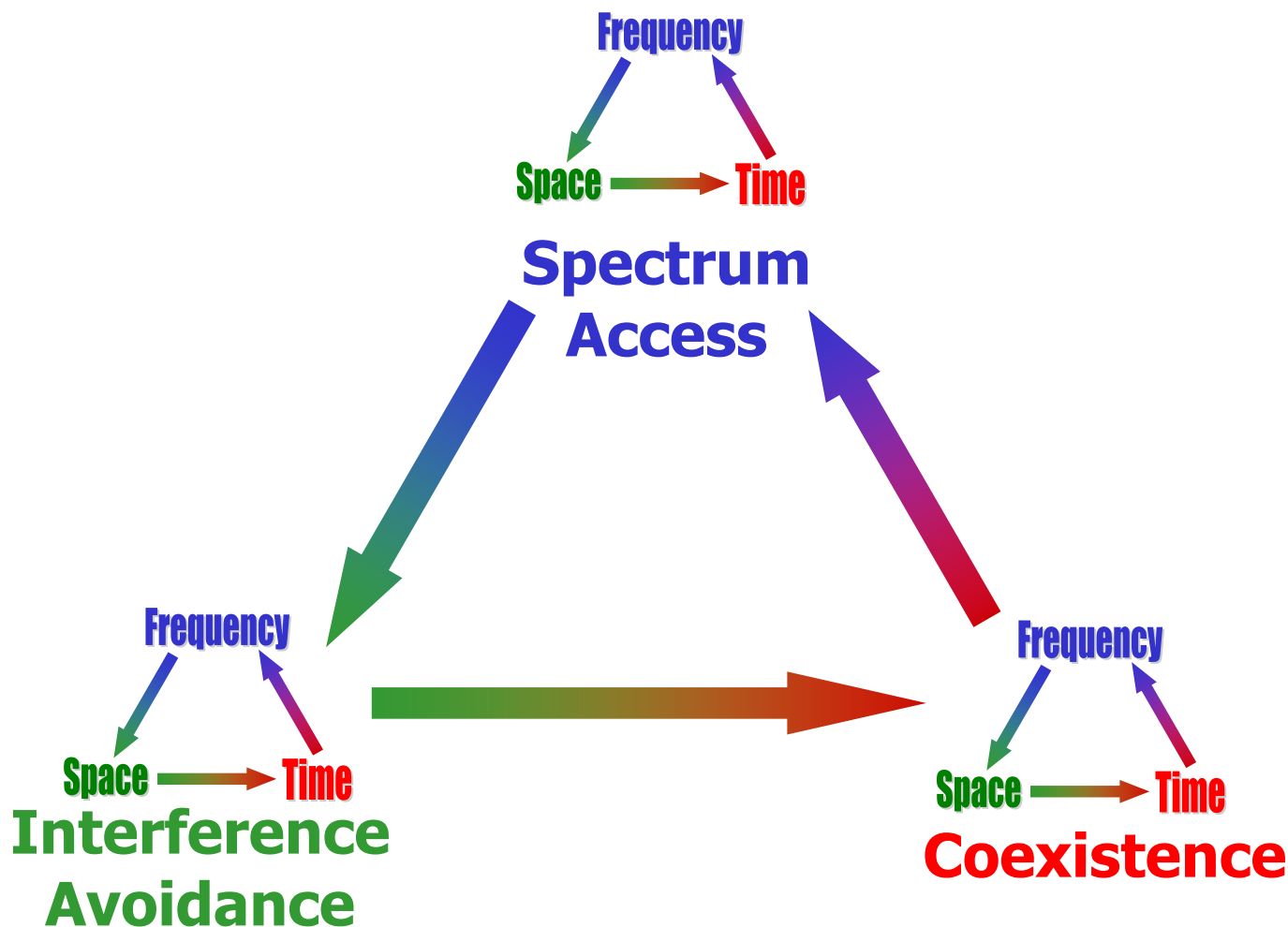
circa 2008



The Dimensions of DSA



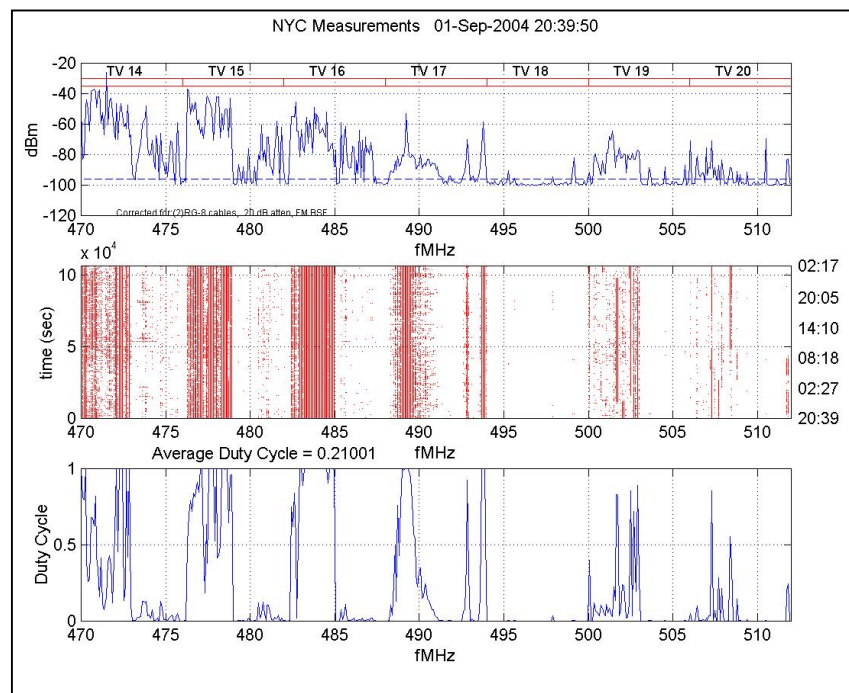
How does DSA Impact these Telecommunications Needs?



Spectrum Access

Active – TV Whitespace, Spectrum Brokers, etc

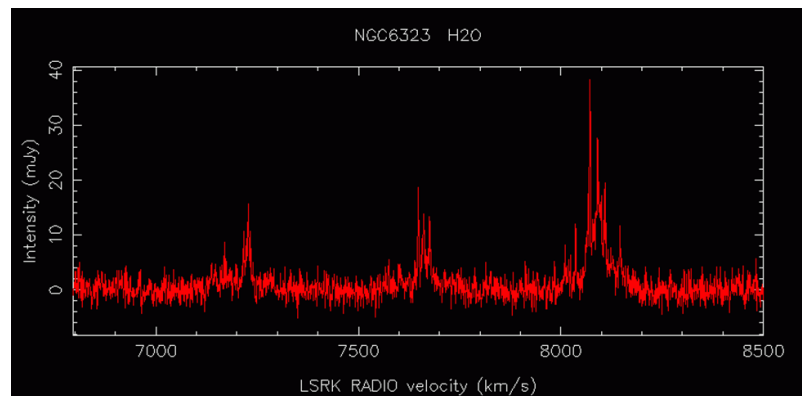
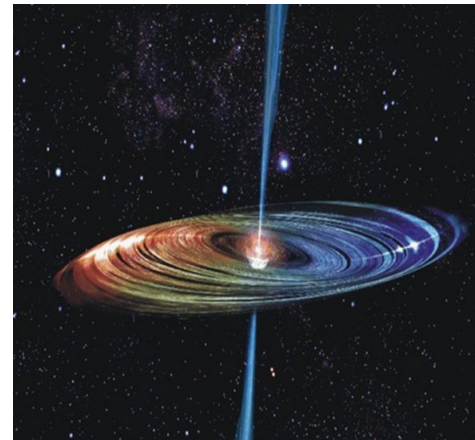
- **Interference Limited Operations**
- **Time-Space Availability of Spectrum**
- **Billions Invested**
- **US Dominated, Worldwide Interest**
- **Spectrum Usage Patterns are non-uniform**
- **Frequency-Space-Time DSA**



Spectrum Access

Passive – Radio Astronomy Sensing (RAS)

- **Extreme Sensitivity – Noise Limited**
- **Limited Locations**
- **Billions Invested**
- **International Community**
- **Some Bands Protected, but many are not**
 - Spatial Isolation
 - Temporal Isolation
- **Space-Time DSA?????**

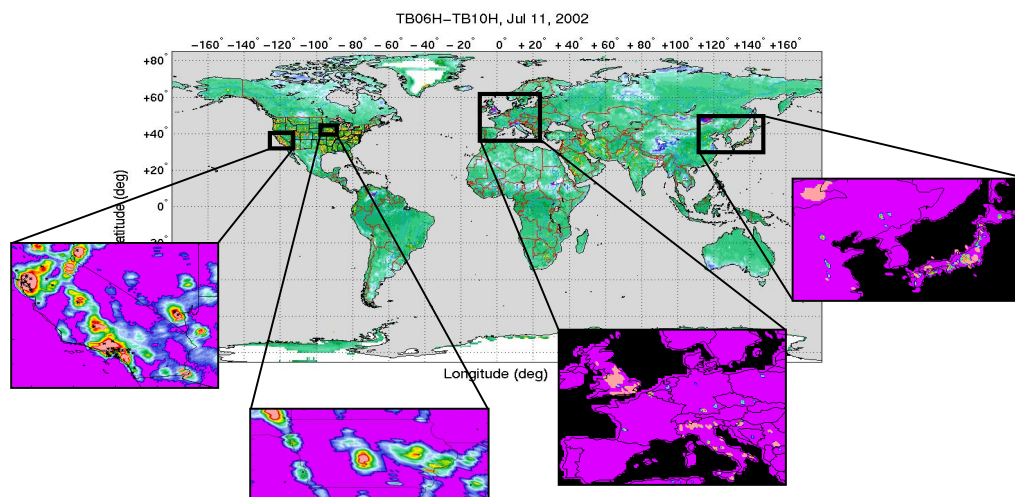
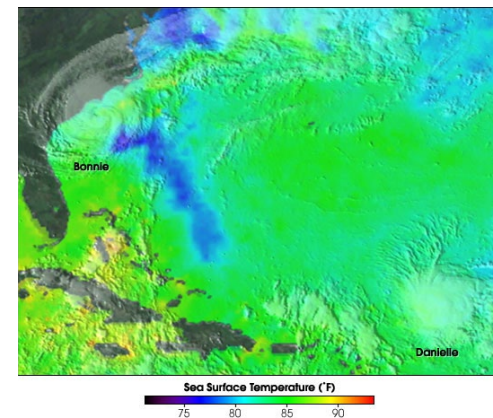


$$\text{mJy} = -260 \text{ dBm/m}^2 \text{ Hz}$$

Spectrum Access

Passive – Earth Exploration Satellite Service (EESS)

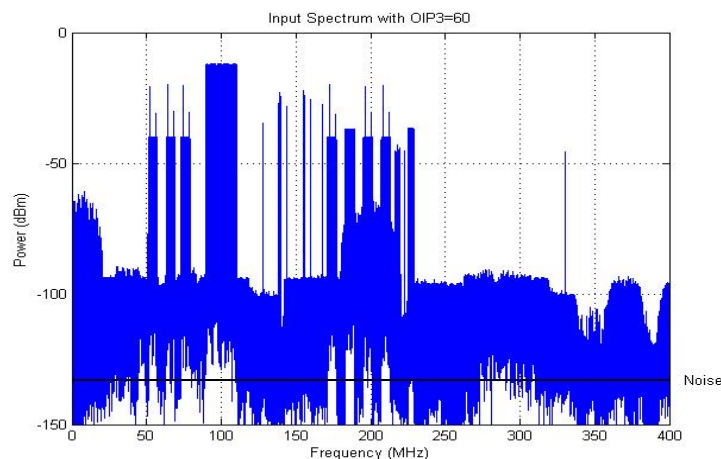
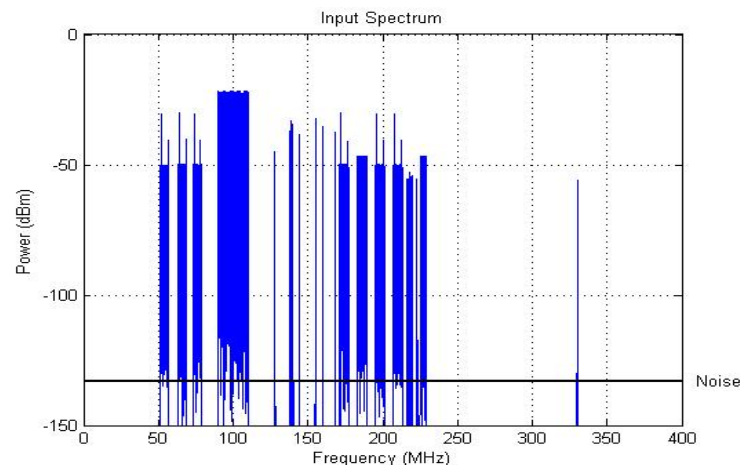
- **Extreme Sensitivity**
- **Limited Numbers, follows Keplerian Physics**
- **Billions Invested**
- **International Community**
- **Some Bands Protected, but many are not**
 - Spatial-Time Coordination
- **Space-Time DSA?????**



Interference Avoidance

Overcome Device Limitations, Environmental Sensing, etc

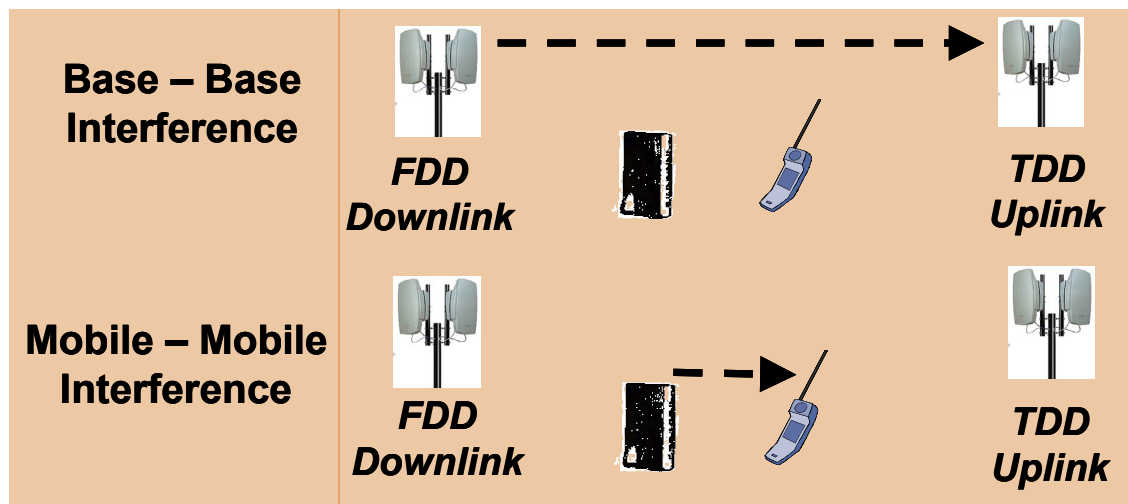
- **Device Characteristics are well known**
 - OOB E
 - IP3 – PA/LNA
- **Trade-Space between better devices and using more spectrum**
- **Focus of Marshall Presentations**
- **Frequency-Time DSA**



Coexistence

Address Dynamic Interference

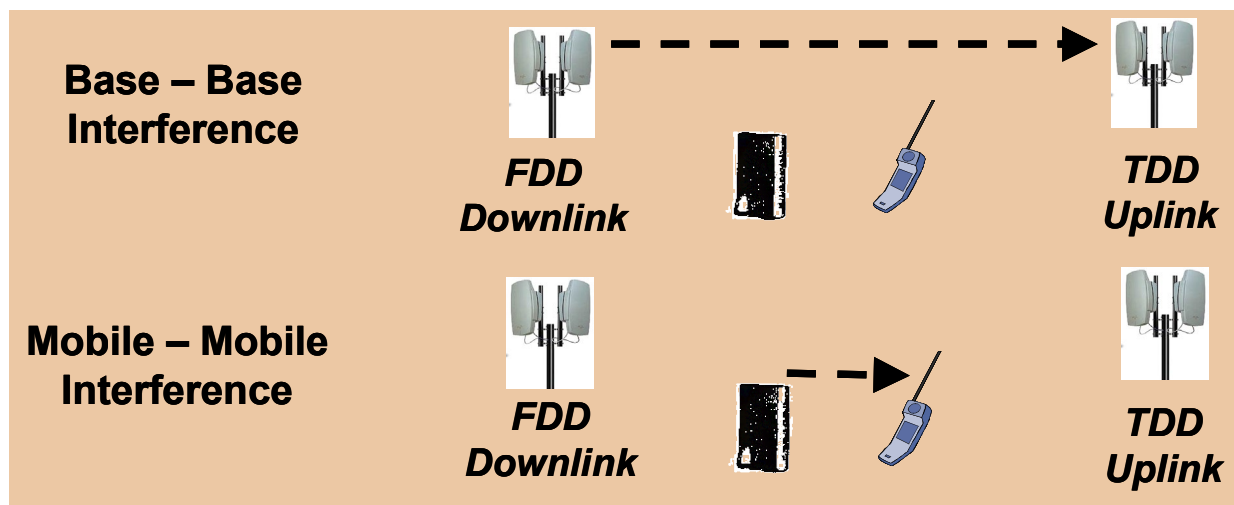
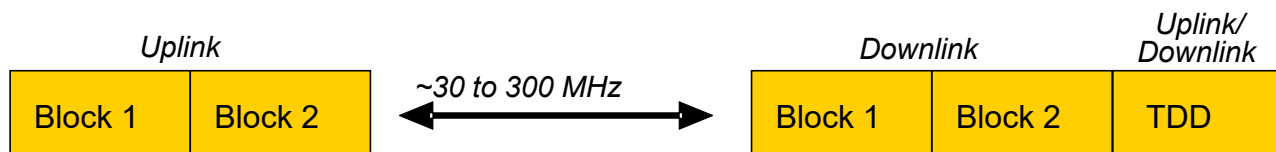
- Consolidation in Spectrum holdings provides DSA potential within carrier's band
- Mobile-to-Mobile interference is Statistical
- Can DSA provide some answers?



- Frequency-Time DSA

The Challenge: Mobile XMT – Mobile RCV

FDD-TDD, TDD,TDD

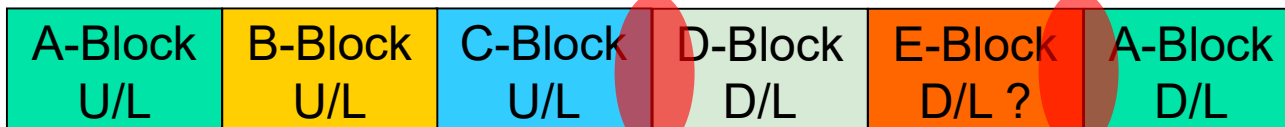


FDD and TDD in adjacent bands will become a reality, what technologies will enable such operation? ... This is also true for TDD-TDD in adjacent bands

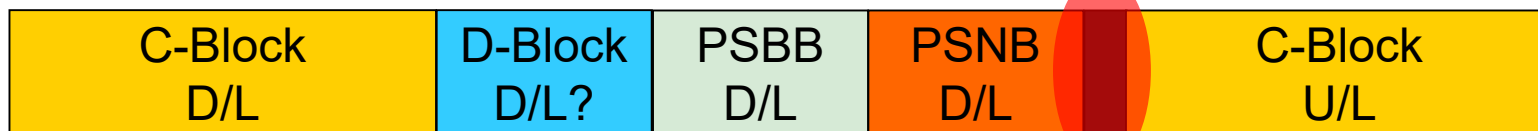
TDD-TDD and TDD-FDD Interfaces



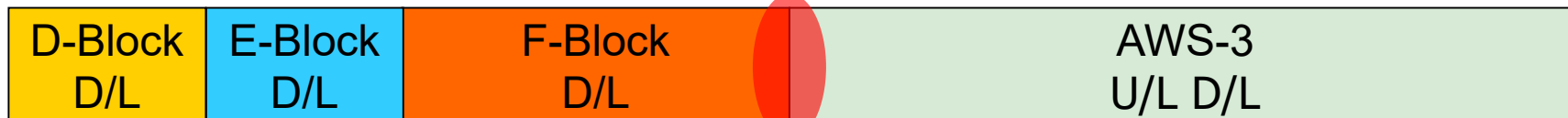
BRS (TDD-TDD)



Lower 700 MHz (Mobile-Mobile FDD)

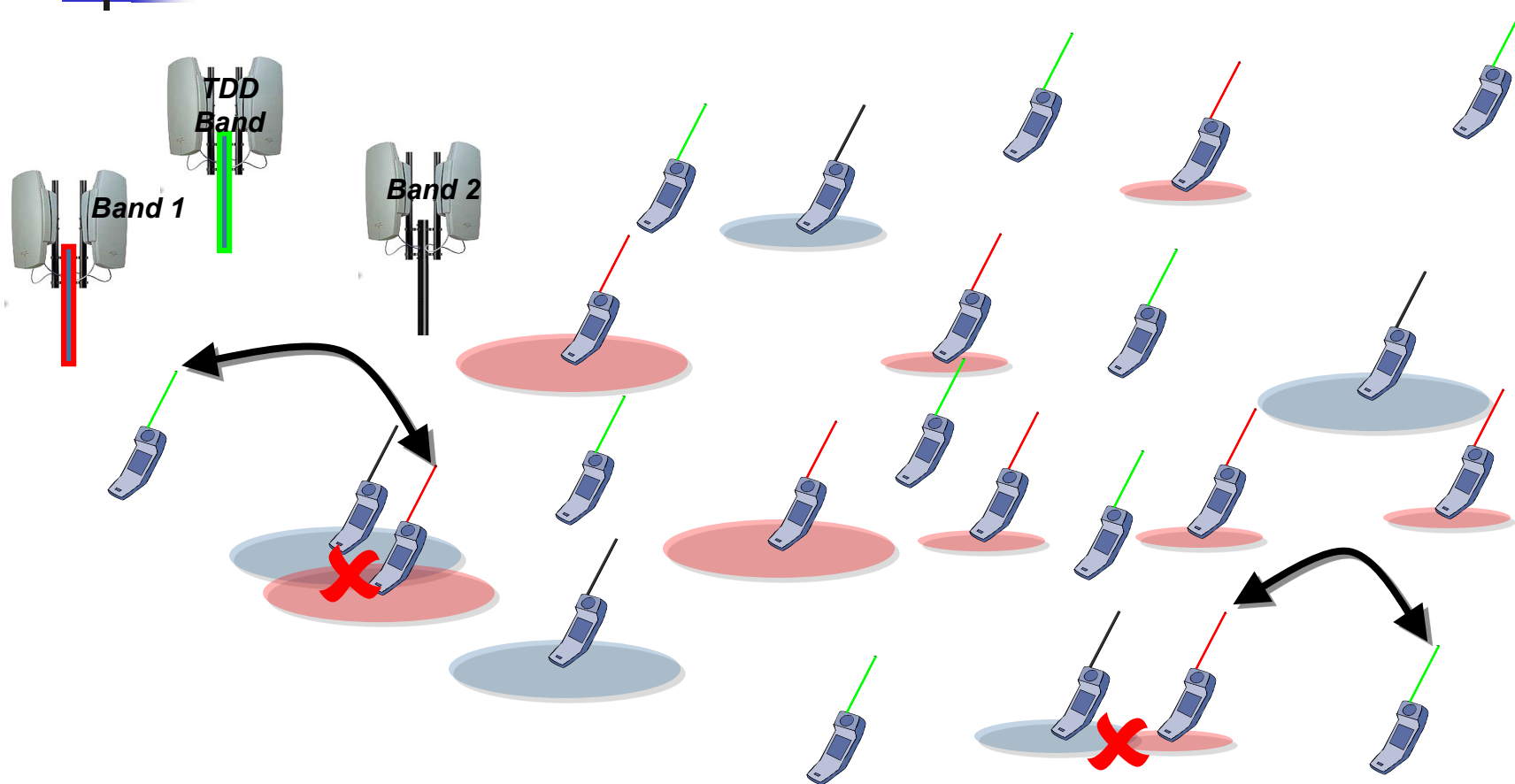


Upper 700 MHz



AWS-1 / AWS-3

DSA to enable Coexistence?



The Policy Issues

- What is the protection level provided to a licensee?
 - Noise-limited versus interference-limited operations?
 - What are the Spectrum Rights and Responsibilities?
 - How does DSA impact those rights?
- How to compute the impacts?
 - Static, worst case analysis versus statistical analysis

?????

% Capacity Loss

Interference Floor

Practical Noise Floor

KTB (aka noise floor)

Statistical Analyses: Understand the Device Characteristics (e.g. ERA Study for Ofcom)

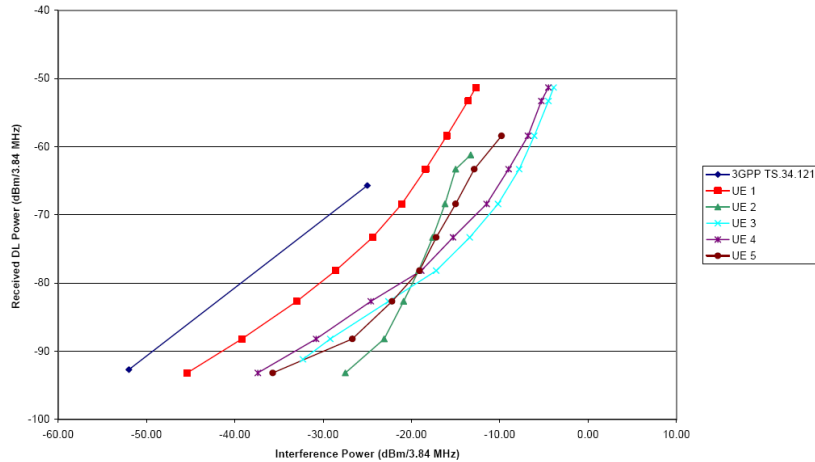


Figure 5: Received DL power vs. interferer power for +5 MHz channel offset

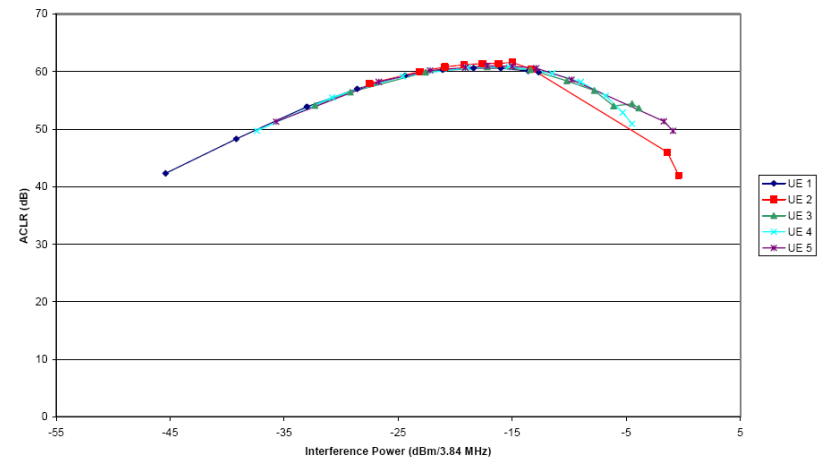


Figure 11: Measured ACLR of the interferer at the adjacent channel (+5 MHz)

- Ofcom characterized operational equipment to fit in statistical models to determine interference potential

Next Steps ...

- **DySPAN is the convergence of technology, legal, and economic analysis. These roles are key to be successful with new concepts for telecommunications**
- **Technologist and economists need to play a role in the policy world ... learn from the legal community**
- **Look carefully at the Passive community and the impact of DSA ... Look at NASA, NSF, and others for what is possible**
- **Look carefully at Coexistence ... it is where the Gedanken Experiments meet the Market**
- **... This is your community ... Shape it, Grow it, Profess it!**