



Spectrum Management for 2003 and Beyond

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Spectrum Management Reform

Introduction

Introduction

- ❖ Why Manage Spectrum?
- ❖ Who Manages the Spectrum?
- ❖ How is Spectrum Managed?
- ❖ What is Wrong with the Process?

Reform of the Spectrum Management Process

- ❖ NTIA
- ❖ GAO
- ❖ FCC Spectrum Policy Task Force
- ❖ FCC Office of Plans and Policy

Practical Impacts of Spectrum Reforms

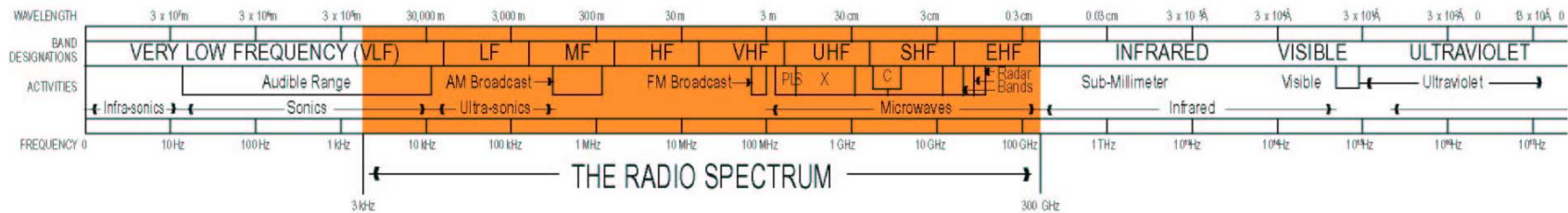


Introduction

What Is the Radio Spectrum?

Generically, electromagnetic waves having a frequency between 3 kilohertz (kHz) and 300 gigahertz (GHz)

❖ kHz, MHz, GHz?

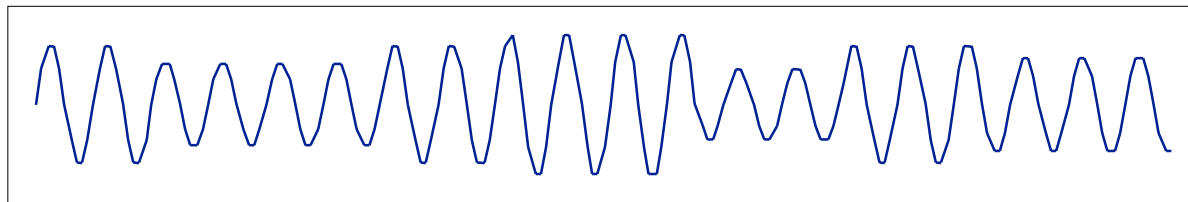




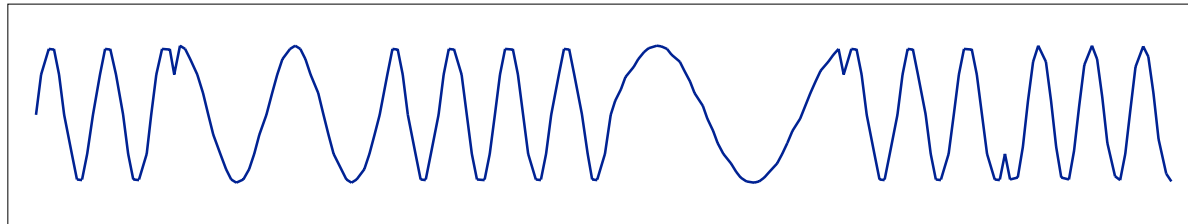
Introduction

How Is Spectrum Used?

- ❖ “Modulation” is necessary to imprint information (analog or, increasingly, digital) on spectrum



Amplitude Modulation



Frequency Modulation

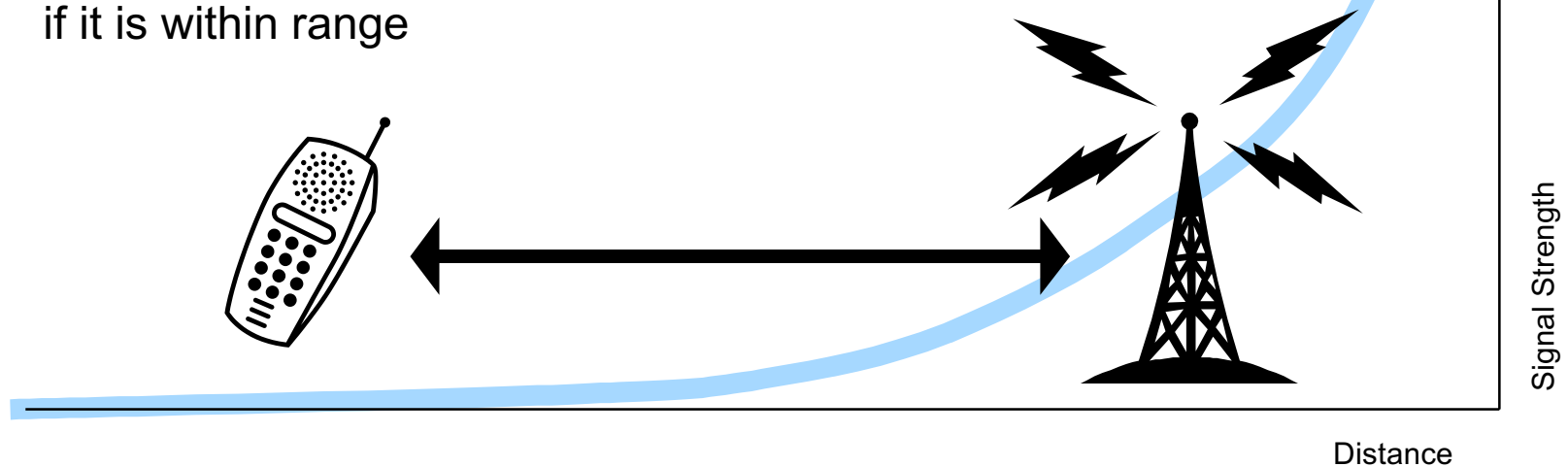
- ❖ “Bandwidth” is required to accommodate modulated spectrum



Introduction

How Is Spectrum Used?

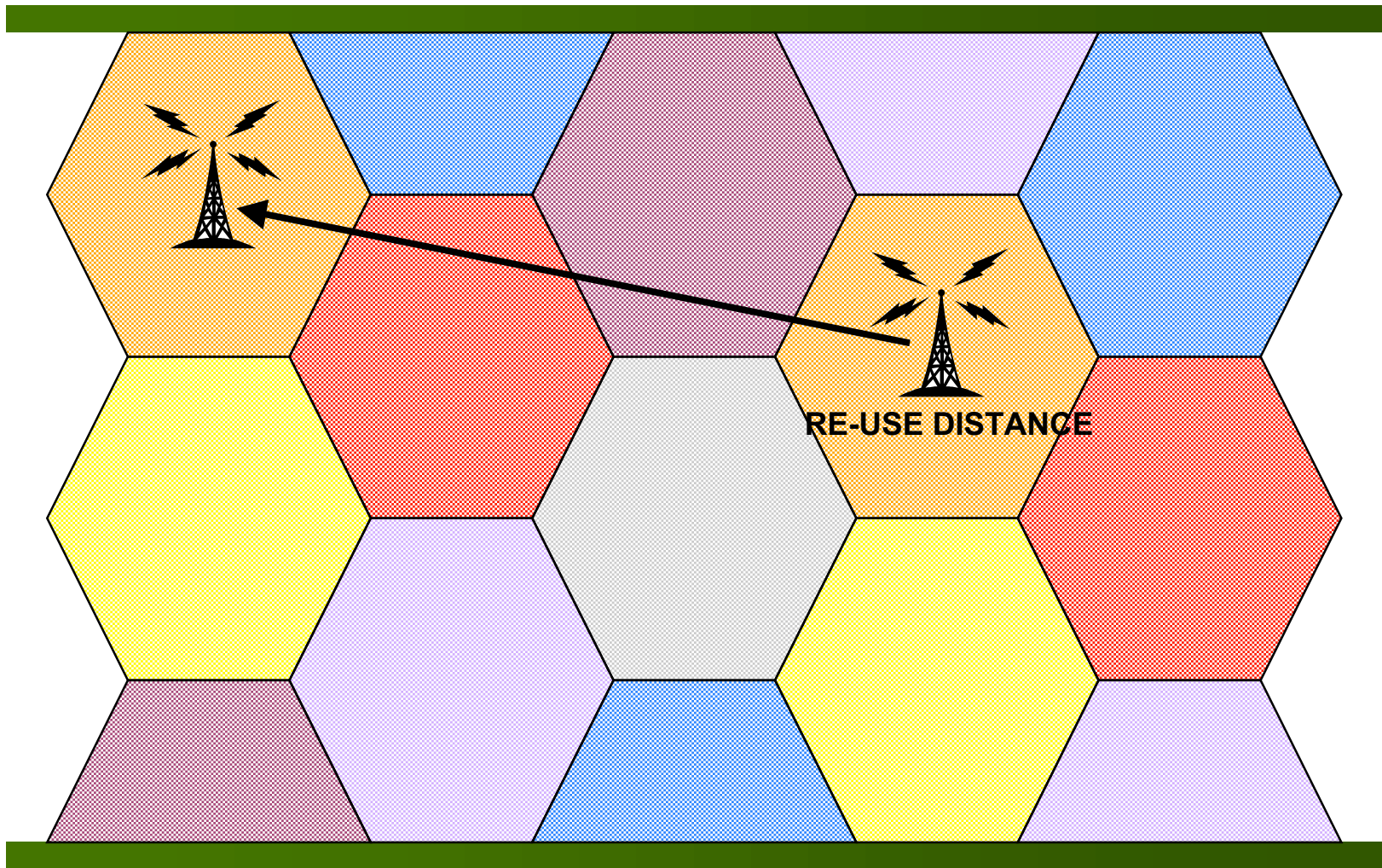
- ❖ “Power” is necessary to have radio waves carrying information propagate to distant points, but higher power will also cause interference at greater distances
- ❖ An “antenna” can direct the power of a radio transmission to reach different areas—flashlights vs. lightbulbs
- ❖ A technically compatible receiver tuned to the same frequency band as a transmitter should be able to extract information modulated in that band if it is within range





Technical Aside

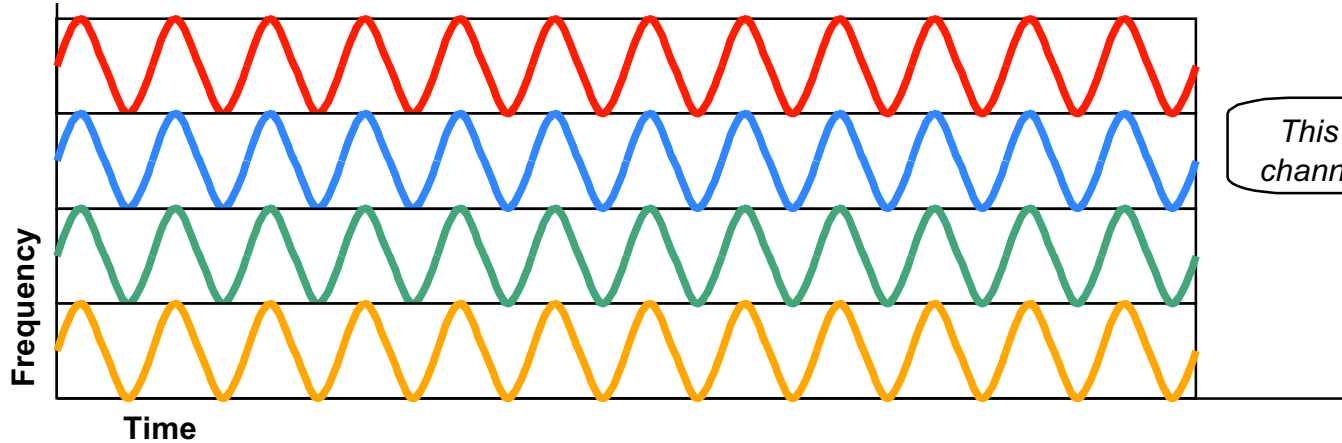
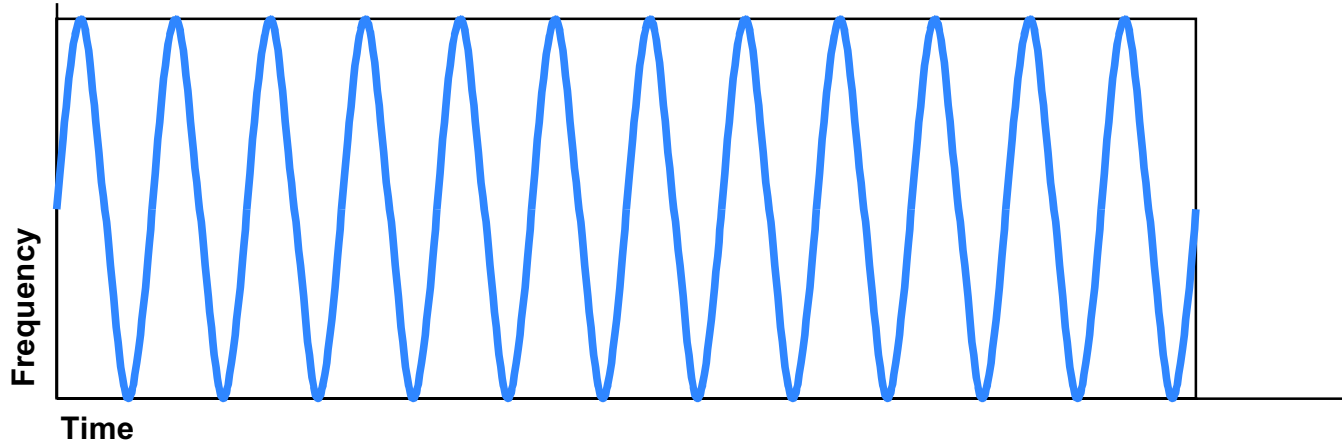
Cellularized Architectures





Technical Aside

Frequency Division Multiple Access (FDMA)



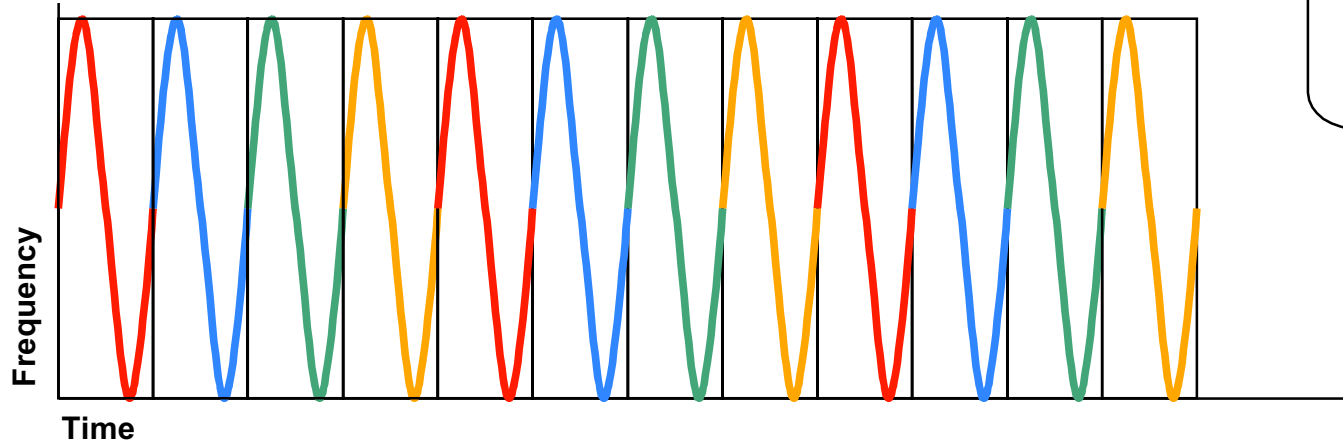
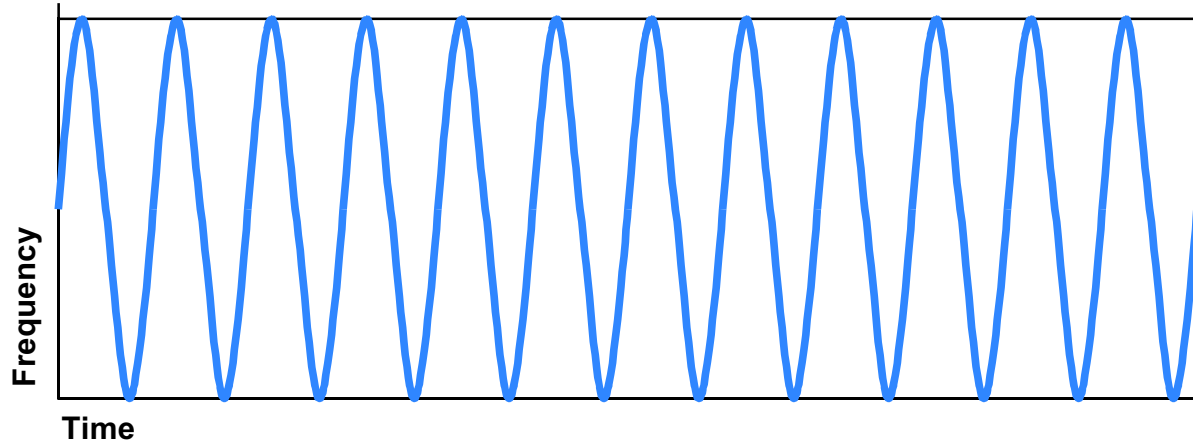
This is just smaller channelization, right?



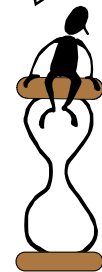


Technical Aside

Time Division Multiple Access (TDMA)



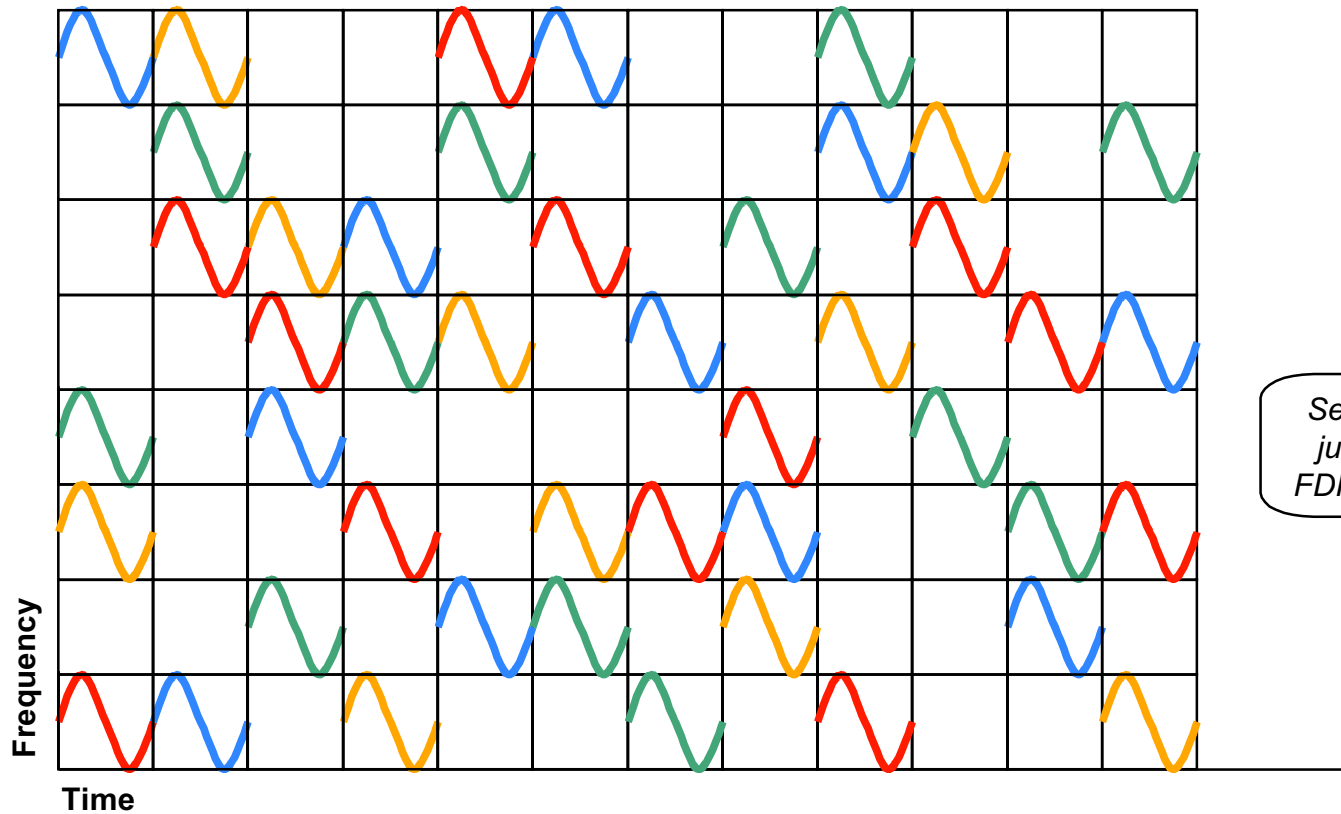
Done fast enough, you can't hear the gaps when you don't have the channel





Technical Aside

Frequency Hopping Spread Spectrum



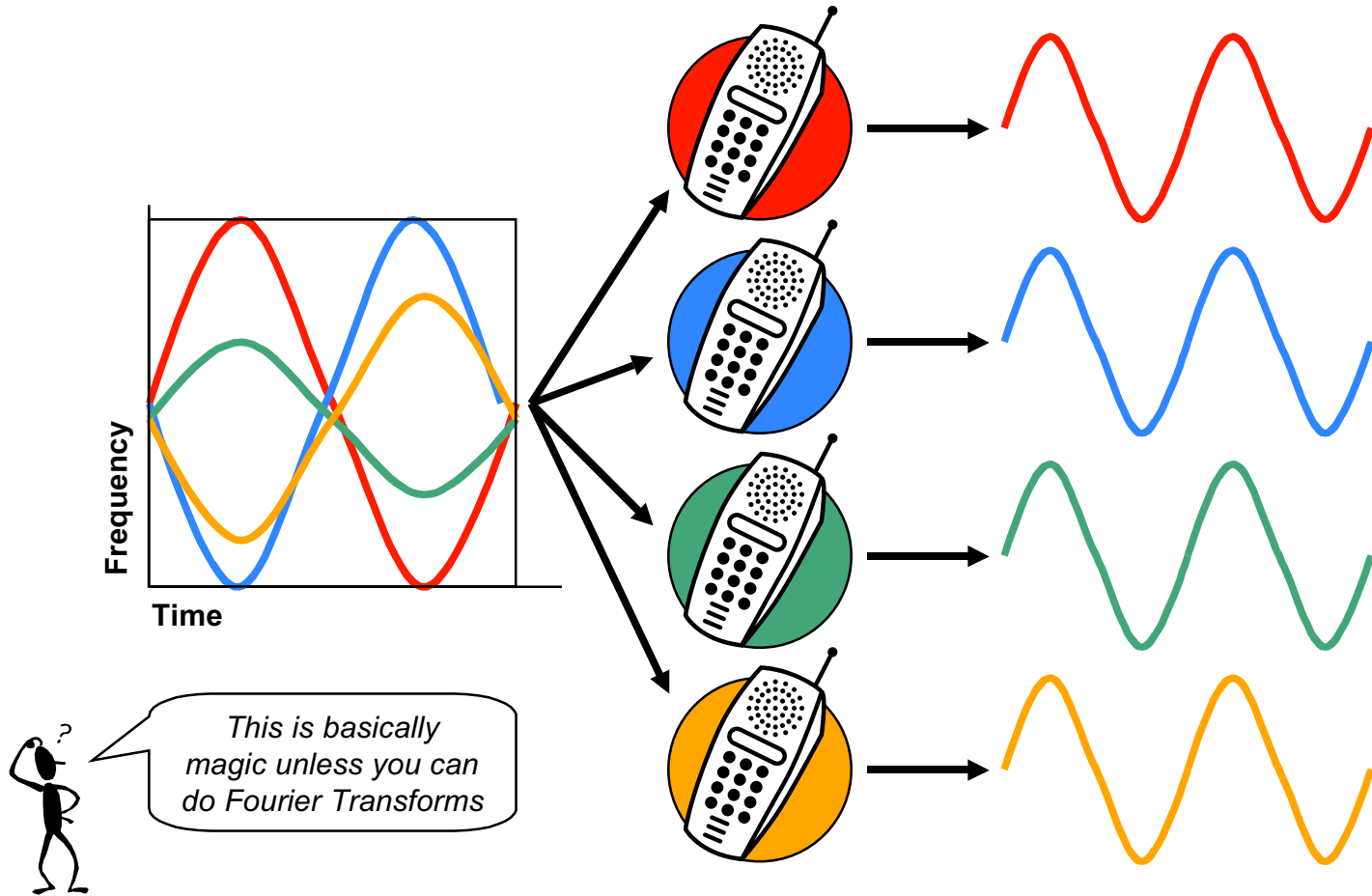
Seems a bit like
just combining
FDMA and TDMA





Technical Aside

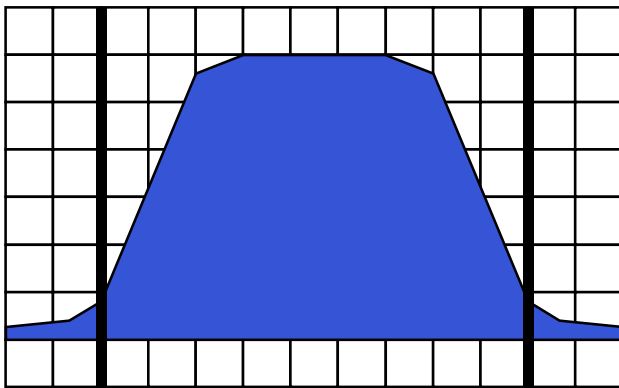
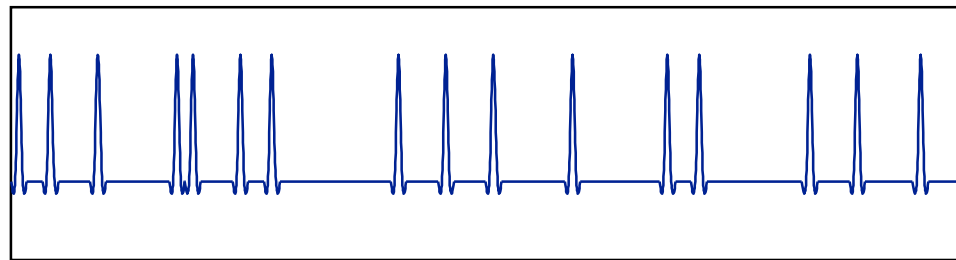
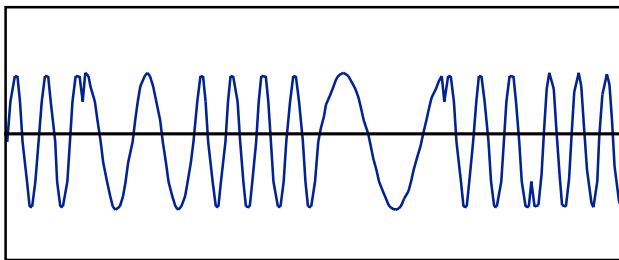
Code Division Multiple Access (CDMA)





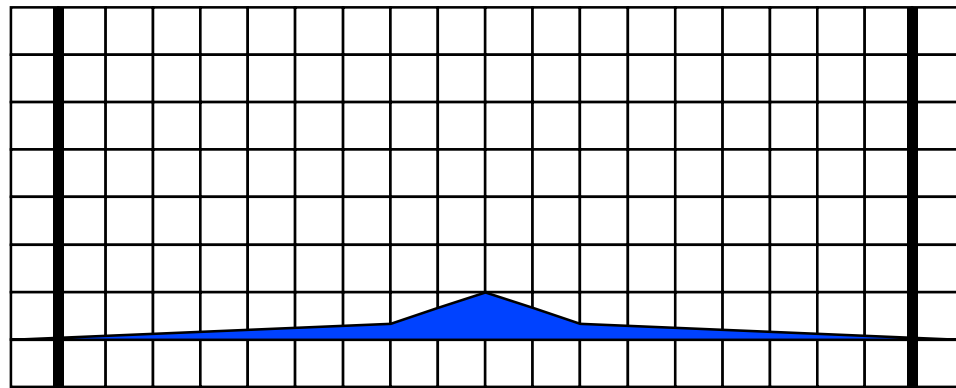
Technical Aside

Ultrawideband (UWB) Systems



kHz

f

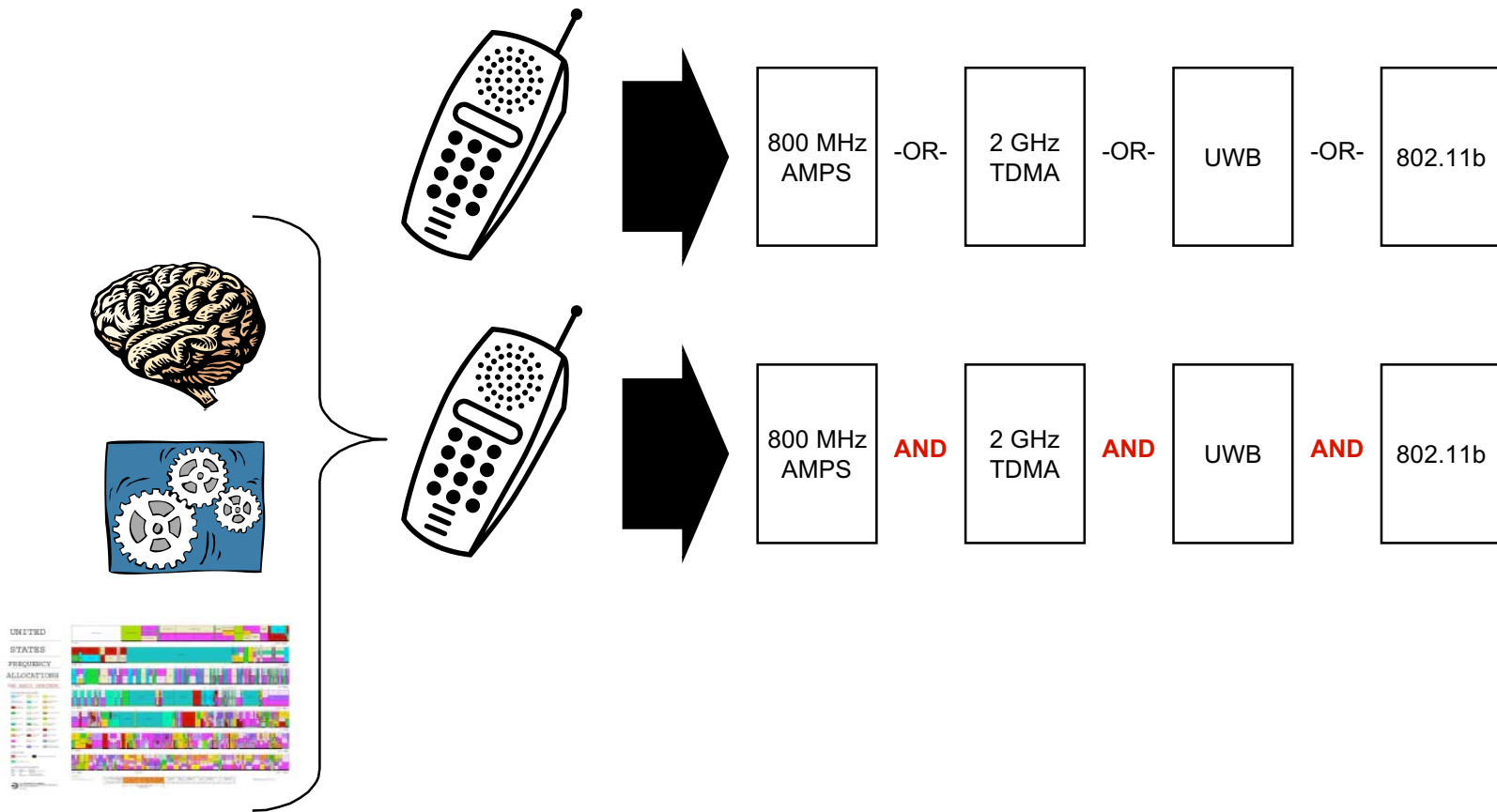


GHz



Technical Aside

Software Defined Radio (Cognitive Radio/SDR)



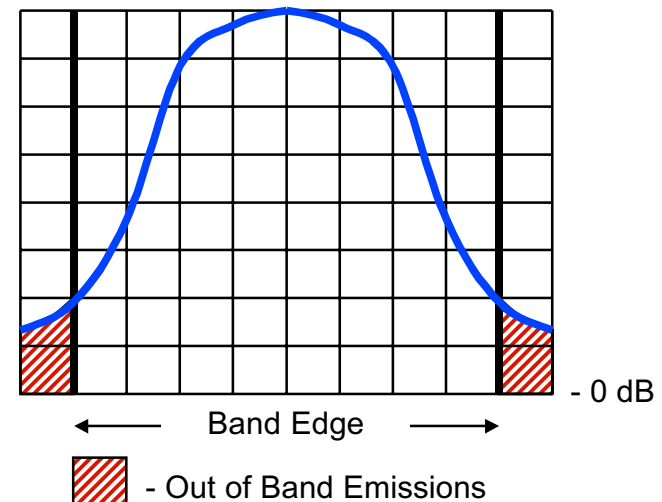


Existing Spectrum Management

Why Manage Spectrum?

Spectrum Management Is About Rights *vis-a-vis* Other Transmitters (Users)

- ❖ Because getting two FM stations at the same time sounds lousy (co-channel interference)
- ❖ Because we live in a world without brick wall filters (adjacent channel interference)

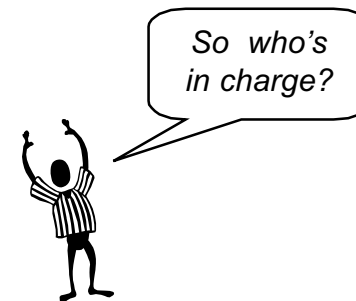




Existing Spectrum Management

Who Manages the Spectrum?

- ❖ Federal Communications Commission (FCC)
- ❖ Nat'l Telecommunications & Information Administration (NTIA)
- ❖ Int'l Telecommunications Union-Radiocom. Sector (ITU-R)
- ❖ To a lesser degree:
 - Department of State
 - General Accounting Office





Existing Spectrum Management

FCC Spectrum Management Goals

- ❖ Maximize Use of Limited Resource for Non-Government Users By Allowing Radio Users to Operate with Minimal Interference from Other Users



- Not all spectrum is created equal—differences in resonant frequencies, propagation modes, building penetration, rain fade, etc
 - “Zoning” can increase property values
- ❖ Mandate to Manage Spectrum in the “Public Interest, Convenience and Necessity”—Finding the “Highest” and “Best” Uses of Radio Spectrum for Society
 - Economic: most valued uses from monetary perspective
 - Societal: e.g., Public Safety uses
 - Development and Research: amateur radio services, experimental use, radio astronomy, and uses dictated by physics (e.g., microwave ovens)
 - Common Use: Part 15 and ISM Bands



Existing Spectrum Management

NTIA Spectrum Management

- ❖ NTIA's Mission: To "make effective, efficient, and prudent use of the radio spectrum in the best interest of the Nation, with care to conserve it for uses where other means of communication are not available or feasible"; interpreted as encompassing the overall benefits the American public derives from radiocommunication services
- ❖ NTIA Has Dual Roles
 - Spectrum Policy Advocate for the Administration
 - Spectrum Manager for Federal Users (DoD, DoJ, etc.)
- ❖ In recent times, NTIA has assumed greater importance as the arbiter of spectrum use disputes—Ultrawideband, 3G, UNII





Existing Spectrum Management

ITU-R and International Spectrum Management

- ❖ The ITU-R and the Need for Larger Scale Management of Radio Resources
- ❖ Impacts of the Globalization of Production Markets
- ❖ Inherently International Spectrum Uses: e.g., LEO MSS
- ❖ Transborder Coordination Activities





Existing Spectrum Management

Agency Tools for Spectrum Management

Spectrum Allocation

- ❖ Allocations define class rights, as opposed to licensing, which defines licensee rights
- ❖ The International Table of Frequency Allocations (47 C.F.R. 2.106, defining certain classes of operation—mobile, fixed, radiolocation, broadcast, satellite) sets forth the FCC spectrum allocations
- ❖ The “Pecking Order”
 - Primary Users
 - Secondary Users
 - Unintentional Radiators & Unlicensed Uses
- ❖ Changes to the Table of Frequency Allocations must be done by rulemaking





Existing Spectrum Management

Agency Tools for Spectrum Management

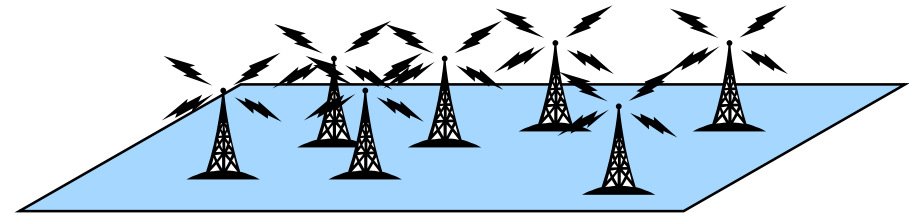
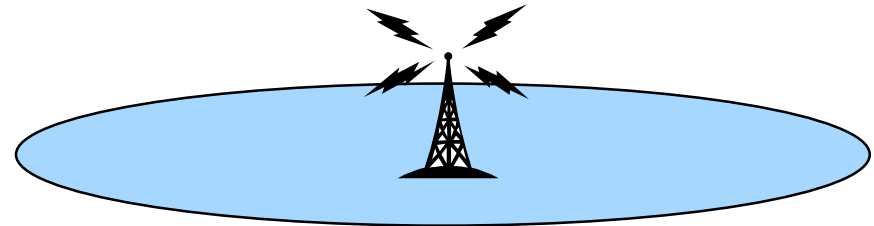
Spectrum Licensing

❖ Licensing Models

- Site-specific
- Market based
- Exclusive vs. shared

❖ Evolution of distribution mechanisms:

- First-come, first-served
- Comparative evaluation
- Lottery
- Auction (competitive bidding)





Existing Spectrum Management

Other Spectrum Management Tools

Equipment Authorization Process

- ❖ Transmitters must behave in accordance with allocation (class) rules;
- ❖ Only “regulation” of Part 15 devices and unintentional radiators

Interference Resolution Process

- ❖ FCC can arbitrate disputes among licensees
- ❖ But, sometimes arbitration is not enough—800 MHz rebanding

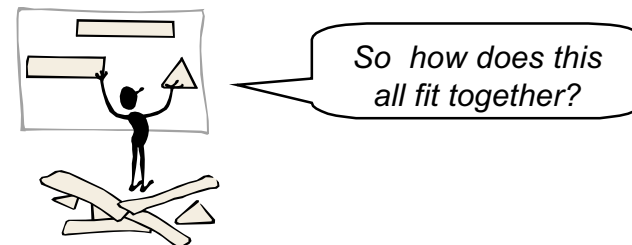


Spectrum Management Reform

Reform Initiatives

In recent years, several notable spectrum policy initiatives have been undertaken:

- ❖ NTIA Spectrum Summit
- ❖ GAO Spectrum Management Report
- ❖ FCC Spectrum Policy Task Force Report
- ❖ FCC Office of Plans and Policy





Spectrum Policy Reform

The NTIA Spectrum Policy Summit

Key Findings:

- ❖ Better intergovernmental coordination is necessary
- ❖ Process for new allocations is too lengthy and not sufficiently proactive
- ❖ Insufficient clarity exists with respect to license rights
- ❖ Dealings with incumbent users for reallocations must be dealt with more rationally
- ❖ Better use should be made of more efficient technologies—frequency hoppers and SDR



Spectrum Policy Reform

The GAO Report

Key Findings:

- ❖ NTIA and the FCC should carry out formal, joint planning activities to develop a clearly defined national spectrum strategy to guide domestic and international spectrum management decision making
- ❖ The Department of State, NTIA, and the FCC should review the adequacy of the process used to develop and promote the U.S. positions at WRC conferences
- ❖ Management and accountability of the federal government's use of spectrum should be increased
- ❖ NTIA should develop a strategy for enhancing its oversight of federal agencies' use of spectrum

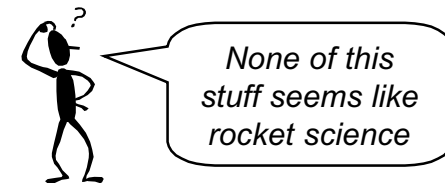


Spectrum Policy Reform

The FCC's Spectrum Policy Task Force Report

Key Findings:

- ❖ Many gaps in space and time
- ❖ Technology is improving
- ❖ Rights are ill-defined





Spectrum Policy Reform

The FCC's Spectrum Policy Task Force Report

FCC SPTF Key Recommendations

- ❖ Move to flexible, consumer-/market-oriented policies
 - Provide incentives for efficient spectrum use by both licensed and unlicensed users through flexible rules and facilitating secondary markets
 - Clearly and exhaustively define spectrum users' rights and responsibilities
 - Investigate rule changes that promote more flexible power limits in rural or less congested areas
- ❖ Adopt quantitative standards to provide interference protection
 - The Task Force recommends the creation of a quantitative standard for acceptable interference that provides both greater certainty for licensees and greater access to unused spectrum for unlicensed operators.
 - Interference temperature is a measurable quantity and can be capped to protect primary users



Spectrum Policy Reform

The FCC's Spectrum Policy Task Force Report

- ❖ Improve access through the time dimension—time sharing of spectrum
- ❖ Shift from “command and control” model to exclusive and commons models
 - Balance three spectrum rights models: an exclusive use approach, a commons approach and, to a more limited degree, a command-and-control approach
 - The command-and-control model currently dominates today’s policy
 - To the extent feasible, more spectrum should be identified for both licensed and unlicensed uses under flexible rules and existing spectrum that is subject to more restrictive command-and-control regulation should over time be transitioned to these models.

“Command and Control” is work-speak for what?

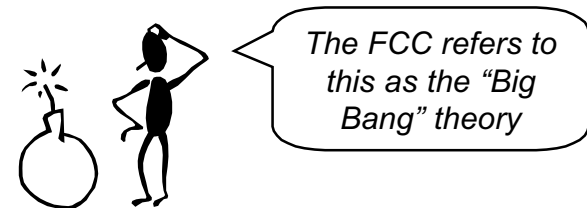




Spectrum Policy Reform

The FCC/OPP Working Paper on Market Allocation

- ❖ The FCC’s internal “think tank”—the Office of Plans and Policy—recently issued a working paper titled “A Proposal for a Rapid Transition to Market Allocation of Spectrum”
- ❖ The WP recommends, with limited exceptions, the use of auctions to transition even allocation to market mechanisms
 - The FCC would auction off “whitespace” for existing services, along with incumbent rights that are voluntarily included, with incumbents entitled to keep a portion of the auction revenues
 - The limited exemptions would include unlicensed technologies and certain societally beneficial services, such as public safety





Real World Reform

The Trillion Dollar Question

The overarching problem: How do we introduce new radio systems and technologies in an allocation scheme where the “good” spectrum is all allocated with ill-defined rights, yet without excessive market disruptions and wholesale dislocation of existing uses?

- ❖ Introduce real market-based reforms where possible
 - Define rights with greater specificity
 - Create better secondary markets
 - Adopt flexibility policies allowing market to find highest valued use
- ❖ Facilitate transition of other allocations
 - Create programs designed to promote technologies that re-mine existing spectrum
 - Incentivize existing users to transition to more efficient systems
- ❖ Watch the big picture
 - Have a national use plan balancing unique needs, global interactions, reasonable zoning

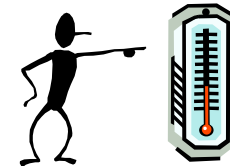


Real World Reform

Defining Spectrum Rights with More Specificity

- ❖ General theory is that a prerequisite for a functional marketplace is strict definition of rights—what *exactly* are you buying or selling
 - Existing standard is that licensees are protected from “harmful” interference—is any added noise “harmful”?
 - The SPTF proposes to create an objective metric for services that identifies what constitutes “harmful” interference based on thermal temperature, a measureable quantity
- ❖ Having a measurable threshold would assist certain new technologies:
 - Ultrawideband, for example, does not fit well within the existing allocation scheme
 - Low power unlicensed Part 15 systems would also potentially benefit

Temperature is just a measure of energy, in this case, added noise-like energy in a band

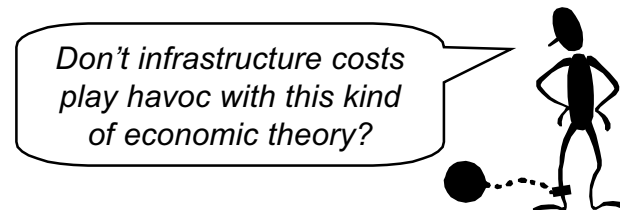




Real World Reform

Creating Better Secondary Markets

- ❖ General theory is that a second prerequisite for a functional marketplace is ease of transferability
 - Current processes impose significant transaction costs
 - Current processes also hamper breaking bulk—resizing big chunks for more smaller scale use
- ❖ Reform is already underway
 - The FCC has a pending item that would permit spectrum leasing
 - The FCC has also recently approved “band manager” licensing schemes designed to promote secondary marketing





Real World Reform

Spectrum Flex

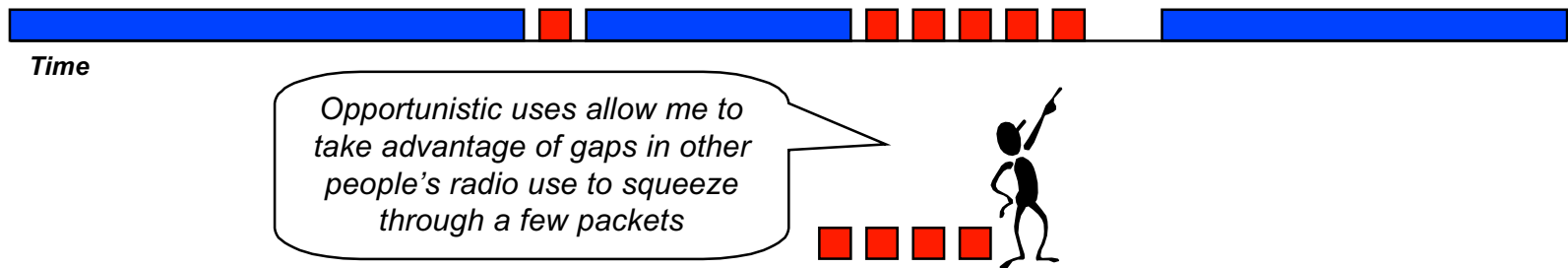
- ❖ General theory is that a third prerequisite for a functional marketplace is minimal use regulation
 - The “older” model—which the SPTF deems the “command and control” model—is to extensively regulate use; e.g., the original analog AMPS standard
 - The “newer” model is to license spectrum subject only to minimal regulatory constraints (that are well-defined) designed limit interference
 - Freedom of use allows licensees to convert spectrum to a more valued purpose without regulatory intervention
- ❖ Spectrum flex has been adopted as a policy in many, many newer allocations



Real World Spectrum Reform

Re-Mining Existing Spectrum

- ❖ In some bands, imposition of market-based reforms may be inequitable; in those bands, a mechanism is needed to transition the spectrum to better use
- ❖ Means of increasing efficiency in existing bands
 - Facilitate excess capacity leasing and other secondary market mechanisms
 - Exploit further trunked and joint radio systems
 - Allow for opportunistic radio uses
 - Create disincentives for “bad” uses—regulatory fees, lease fees, inefficiency fees—designated to “encourage” transition to more efficient mechanisms
 - Limit expectation of windfall from changed uses





Real World Spectrum Reform

Discourage Inefficient Users

- ❖ Transitioning the band to better uses may include relocation of incumbents to different spectrum or technologies
- ❖ Means of facilitating relocation
 - Create disincentives for “bad” uses—regulatory fees, lease fees, inefficiency fees—designated to “encourage” transition to more efficient mechanisms
 - Limit expectation of windfall from changed uses
- ❖ When should a user be entitled to profit from a use conversion that creates new value?
 - MSS
 - MMDS

You mean, I shouldn't be entitled to a windfall for having sat on my spectrum since the early 70's?





Real World Reform

National Spectrum Planning

- ❖ The U.S. is not “in charge” internationally anymore; spectrum is too intrinsically linked to economic growth and health to not show up at the WRC without an integrated national policy
- ❖ Spectrum scarcity means government and non-government users are increasingly conflicting over spectrum use, but there is no one to arbitrate between the two
- ❖ Already there are signs of increased interagency coordination, rumors of a possible interagency arbitration board, and even potential for development of unified spectrum management institution





Real World Reform

National Spectrum Planning

- ❖ Not everything fits in a market-based model-
 - The SPTF recognizes “commons” allocations for things like unlicensed technologies
 - The SPTF—and everyone else—also recognizes that certain non-economic, but valued, applications still have radio needs; .e.g., public safety, scientific applications
- ❖ Until the advent of SDR, spectrum policy also has to be cognizant of certain limits
 - Some benefits to standardization imposed by allocations for consumers
 - Dangers of balkanizing radio spectrum—its always easier to break it up than to reassemble it



Lets see, to get CBS TV in HD in Washington, D.C., I tune to 525.375 MHz, 6 MHz channelization and use 8VSB modulation, right?



The End

Any Questions?

