NPSTC

NATIONAL PUBLIC SAFETY TELECOMMUNICATIONS COUNCIL

Land Mobile Radio (LMR) 101

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NPSTC is a federation of organizations whose mission is to improve public safety communications and interoperability through collaborative leadership.

LMR 101 Overview

Outline

- Common Terms
- Frequency Bands
- FCC and Regulatory Matters
- Typical Types of Systems
- Major LMR Influencers – ex. 800 MHz Rebanding
- Standards Activities - Project 25
- Funding References in Public Safety LMR

LMR 101 Overview

Land Mobile Radio Frequencies Used

- Very High Frequency (VHF)
  - Low Band: 30 MHz to 50 MHz (and a bit beyond for Government) - Usually used for long range, large area coverage (States, Counties, etc)
  - High Band): 152 MHz to 174 MHz - Usually used for medium range, medium area coverage (Cities, Counties, etc)
- Ultra High Frequency (UHF): 450 MHz – 512 MHz Usually used for short range, smaller area coverage (Cities, etc)
- 700 MHz: Public Safety's largest band (24 MHz of dedicated spectrum).
- 800 MHz: Currently used by Public Safety and other Industry users
- 900 MHz: (paging)
- 4.9 GHz: Public Safety dedicated spectrum (Mesh/WiFi/WiMax architecture) - fairly new, not many deployed
- Federal Govt / Military: has other VHF and UHF bands in use.

LMR 101 Overview

Regulatory Programs – Driving Industry

- **Rebanding (State and Local):**
  - Driven by interference within the 800 MHz band (Nextel, Public Safety, and other commercial users)
  - New band plan ("who goes where" in the 806/824 MHz – 851/869 MHz band).
  - Planned to take 3 years and started June 27, 2005. Delayed, particularly along the southern border with Mexico.
- **Narrowbanding:**
  - Driven by need to increase spectrum efficiency (from 25 kHz to 12.5 kHz channels).
  - Applies to Federal government (NTIA-regulated spectrum) as well as to local/state government (FCC-regulated spectrum)
  - Public safety after 2012 is narrowband, certification of equipment for wideband (for existing systems) will be discontinued over a specific schedule
  - Federal Government: VHF was to be done by end of 2005 (did not meet deadlines), and UHF scheduled to be completed by end of 2008 (extended beyond 2011).

LMR 101 Overview

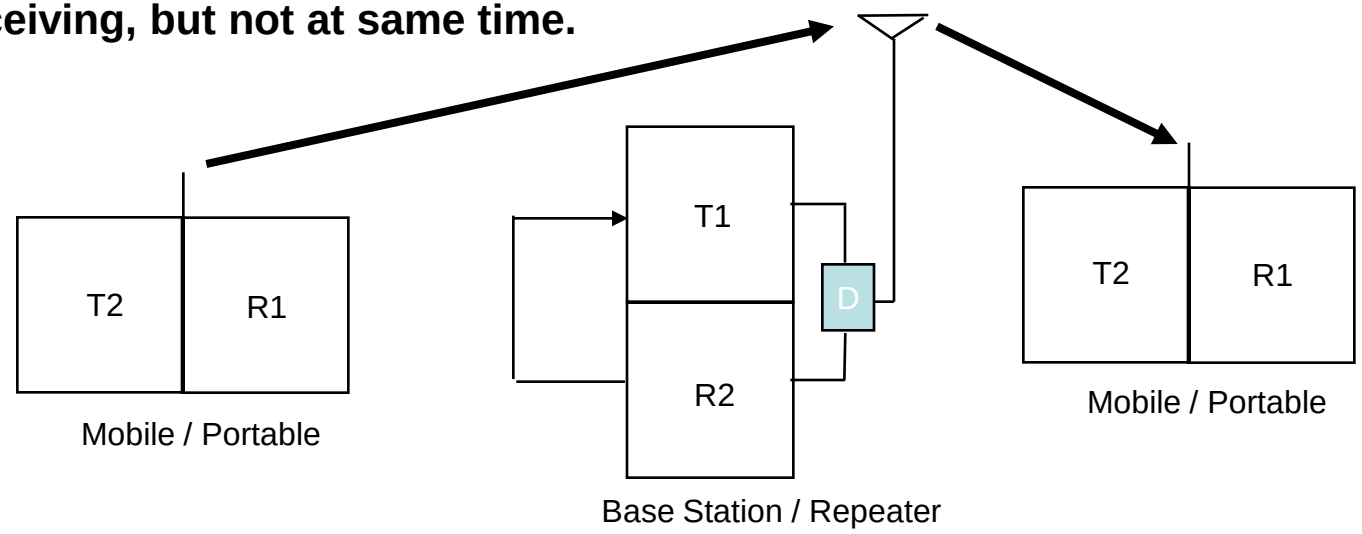
Land Mobile Radio – Typical Systems

- **<u>Simplex (or Direct / Talk-around)</u> – A base, mobile or portable station's ability to talk directly with each other without the use infrastructure (such as a repeater) "Talk-around" refers to talking "around" (e.g. not using) the repeater for direct mobile-to-mobile communications. Limited by distance between mobiles/portables and characteristics of radio band being used, and is generally line-of-sight.**

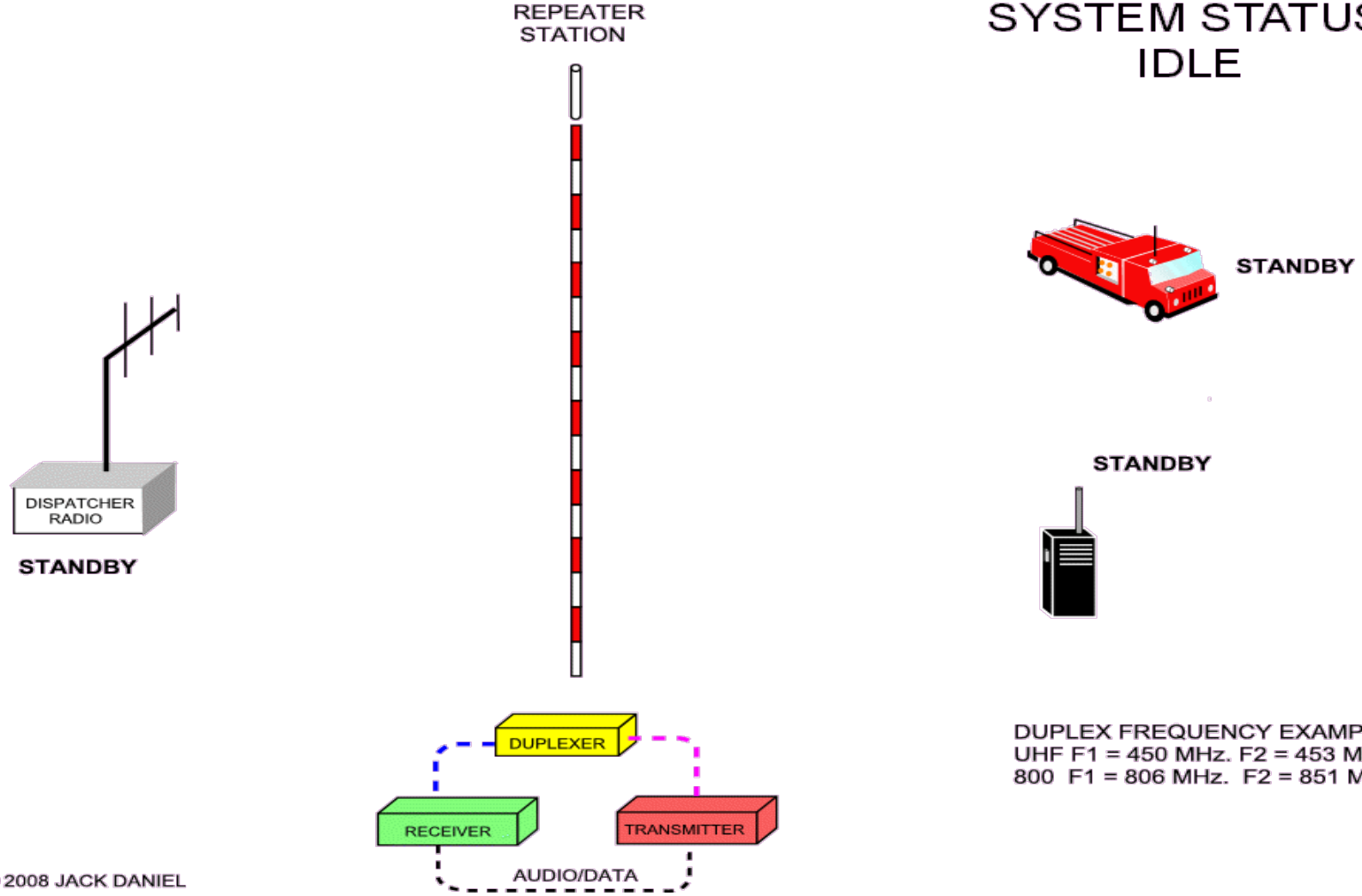
LMR 101 Overview

Land Mobile Radio – Typical Systems

- **<u>Repeater:</u> A base station or system that simultaneously retransmits the received signal/audio to other users, thus extending the range of the system (mobile to mobile coverage). Repeater stations operates in full-duplex (both receive and transmit at the same time – identical to mobile cell phone systems). Mobiles/portables operate in half-duplex mode which is either transmitting or receiving, but not at same time.**



SYSTEM STATUS: IDLE

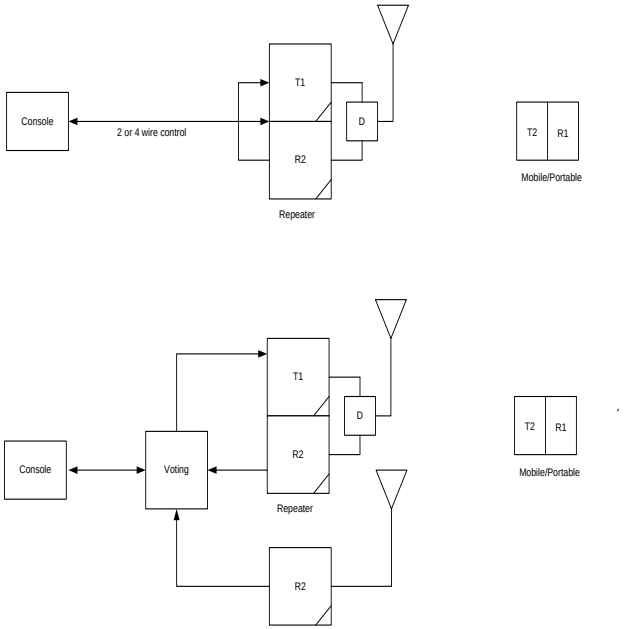


DUPLEX FREQUENCY EXAMPLES:
UHF F1 = 450 MHz. F2 = 453 MHz
800 F1 = 806 MHz. F2 = 851 MHz

LMR 101 Overview

Land Mobile Radio – Typical Systems

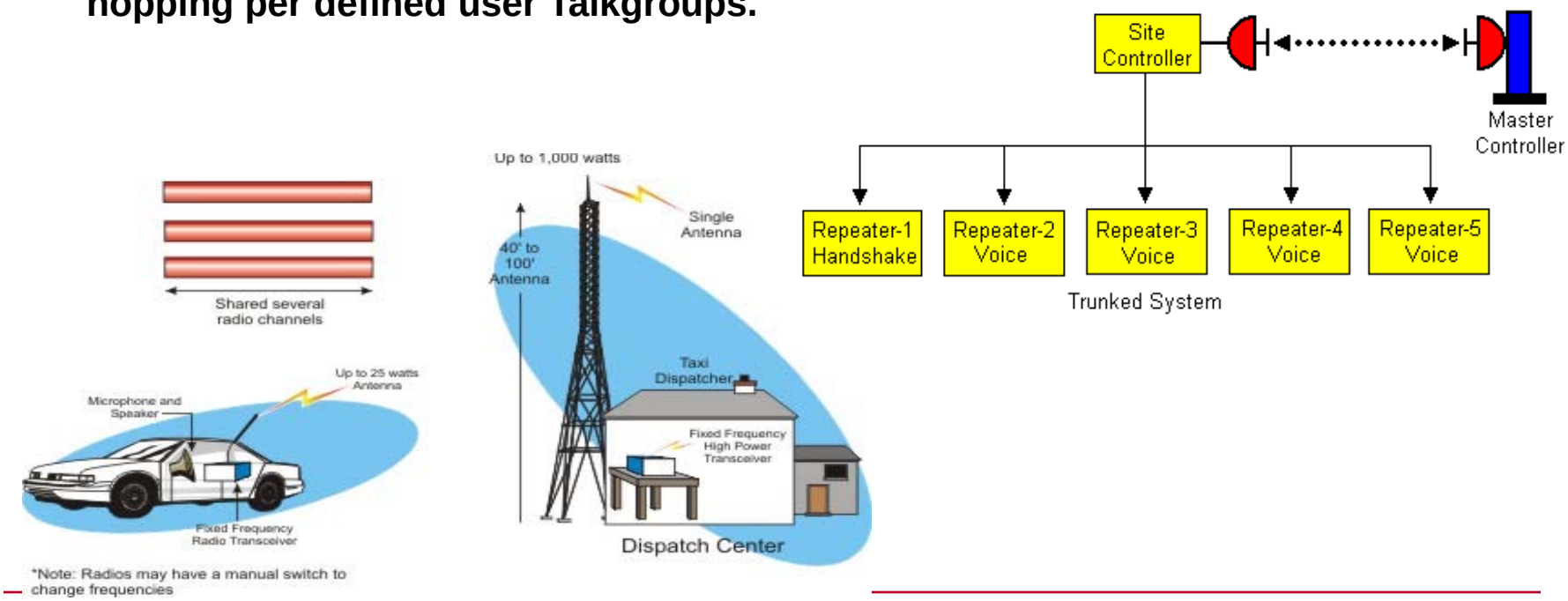
- **<u>Conventional Radio</u> – A simple wireless communications system where repeater(s) at a tower site(s) talks to as many as 70 or more subscribers (portable and mobile radios) in the area on a single channel. Typical systems are high sites & high power.**



LMR 101 Overview

Land Mobile Radio – Typical Systems

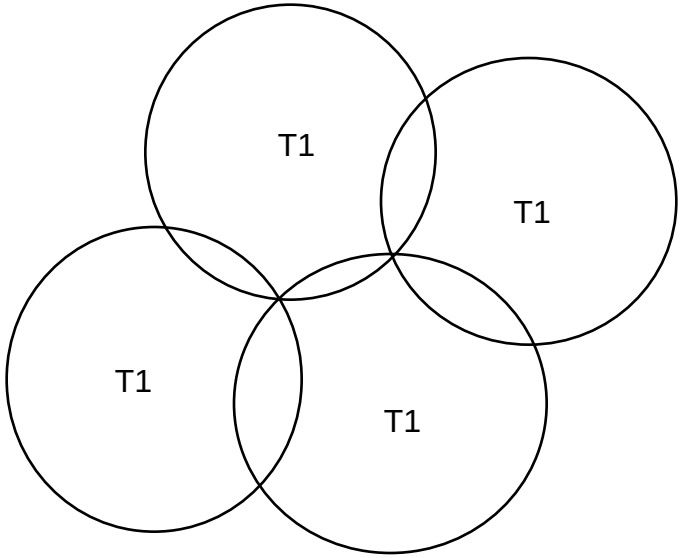
- **<u>Trunked Radio</u> – Multiple radios tied together under control of a dedicated digital system control channel, allowing 100 or more subscribers per channel. Uses a fleet map and multiple codes for subscribers. Computer controlled channel hopping per defined user Talkgroups.**



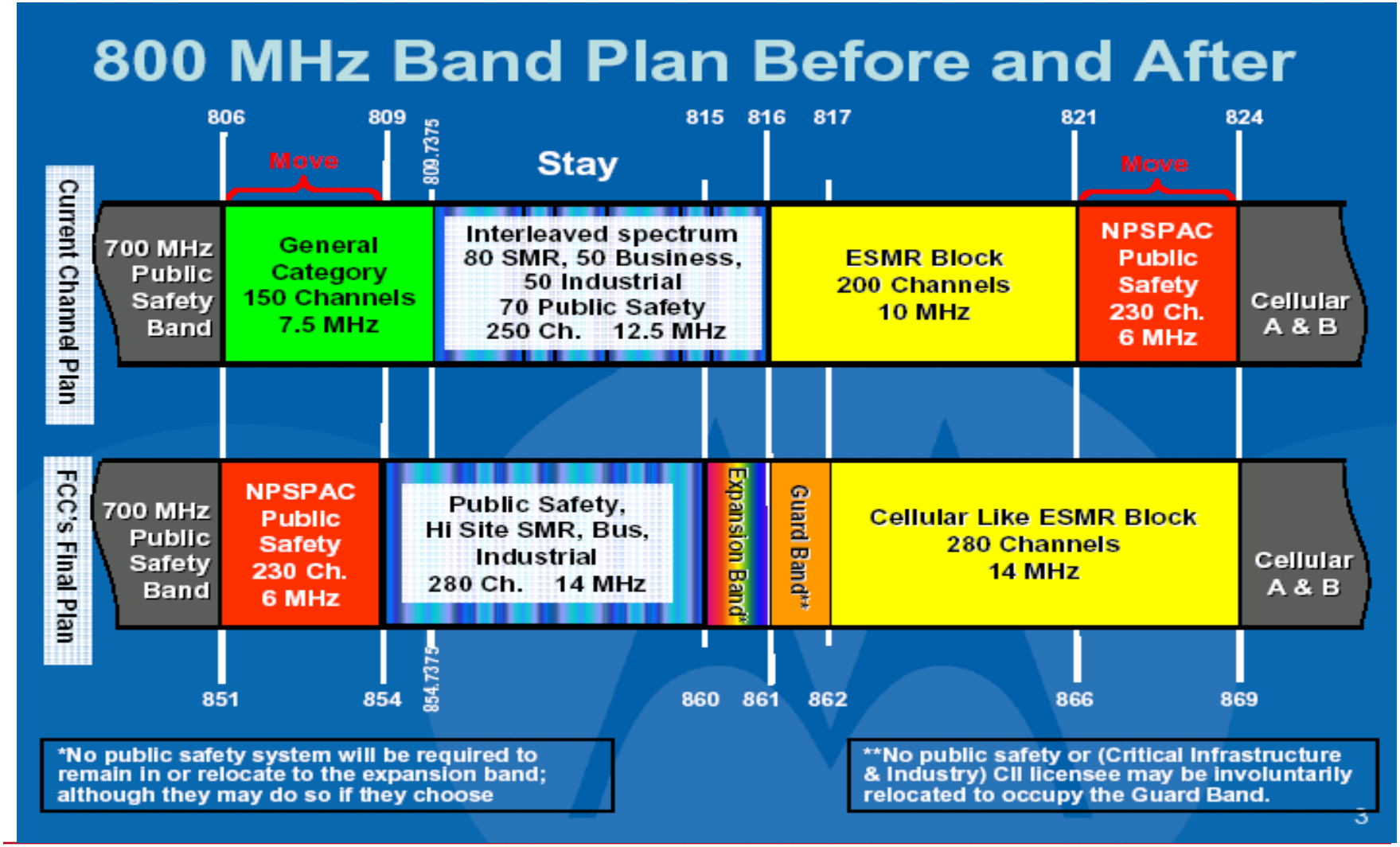
LMR 101 Overview

Land Mobile Radio – Typical Systems

- **<u>Simulcast Radio</u> – A type of wide area LMR system that uses the same frequencies from site-to-site to provide very wide-area coverage on the same channel. Multiple sites transmit simultaneously on the same RF frequency, thus extending the overall coverage footprint. Complexity added due to need to correctly align phase and frequency, and minimize overlap zones, so mobiles/portables receive correctly.**

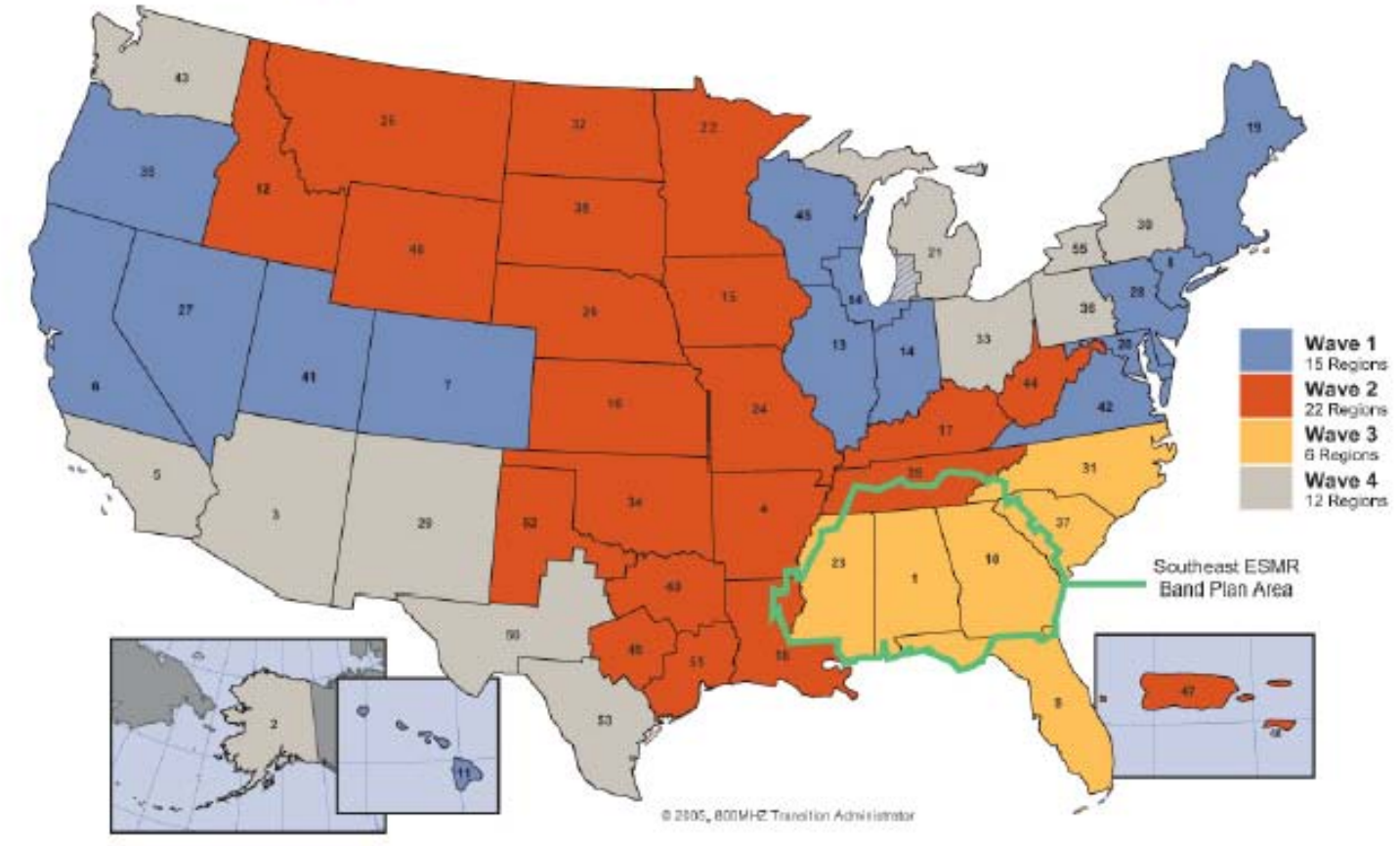


Initial 800 MHz Rebanding Details



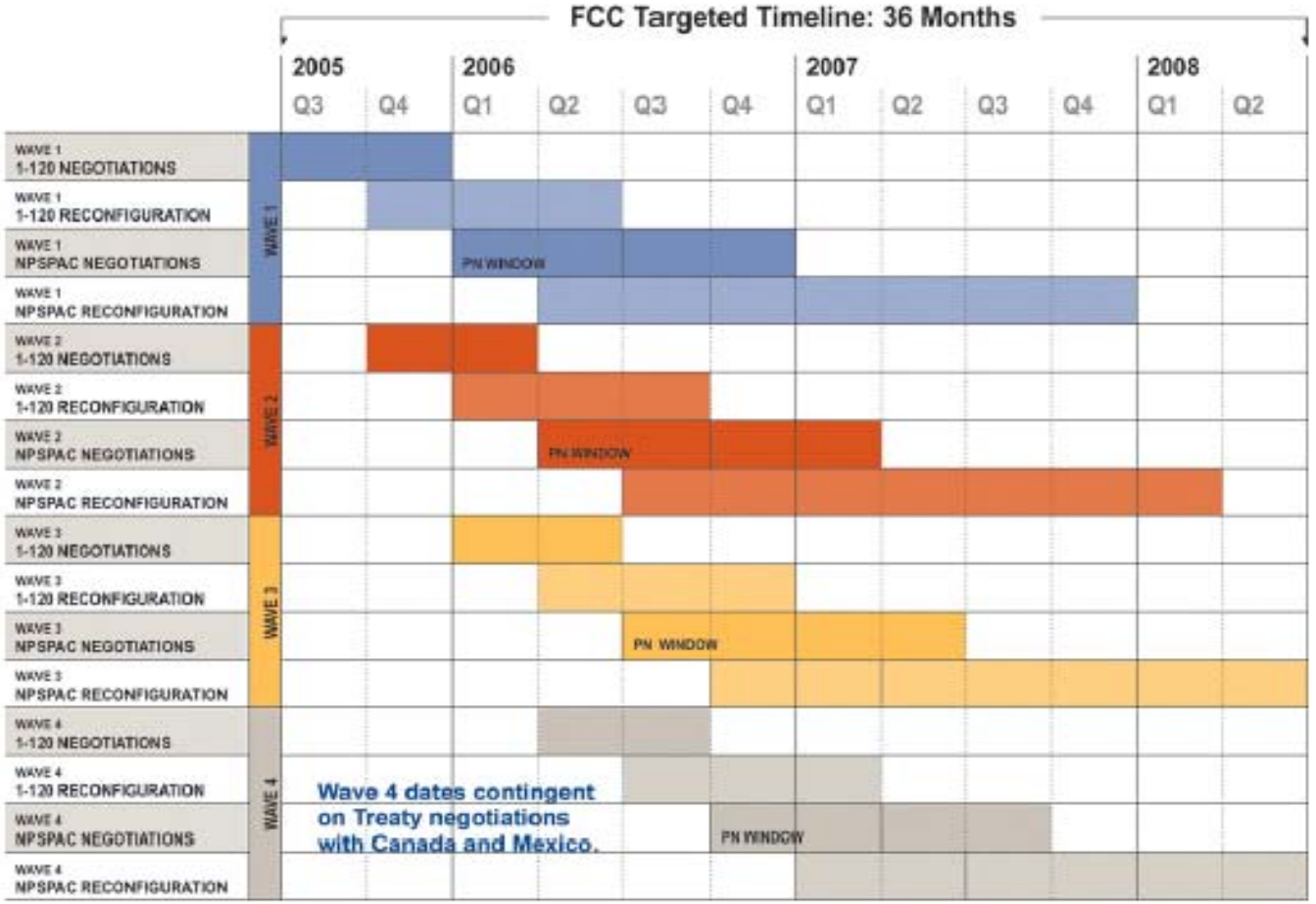
Initial 800 MHz Rebanding Details

Proposed Prioritization Waves



Initial 800 MHz Rebanding Details

800 MHz Reconfiguration Schedule



NOTE: PN window is the period during which Public Notice announces the start of NPSPAC region negotiations

Project 25 Definition

Project 25 (P25) is the Land Mobile Radio digital standard for public safety two-way wireless communications products and systems.

P25 Definition

Jointly developed under local, state and Federal government guidance by the Association of Public Safety Communications Officials, Intl (APCO), the National Association of State Technology Directors (NASTD) and agencies of the Federal government in conjunction with the Telecommunications Industry Association (TIA), P25 has gained worldwide acceptance for public safety, security, public service, and commercial applications. The published P25 standards suite is administered by the TIA in their Private Radio Section (TR-8) committees.

P25 Definition

Equipment that demonstrates compliance with P25 is able to meet a set of minimum requirements to fit the needs of public safety. These include the ability to interoperate with other P25 equipment, for example, so that users on different systems can talk direct via radio.

Land Mobile Radio and Public Safety Radio History

- **One-way AM broadcast** band commercial transmissions in the 1930's were often interrupted with the **"**Calling all Cars" messages for police response
  - One of the earliest of these broadcasts was implemented in the **Detroit Police Department**
- **Two-way AM** broadcast was introduced in the 1930's
- Early implementations of current **two-way FM radio** technologies were introduced in the 1940's. Significant implementations followed the end of WW II.

Land Mobile Radio and Public Safety Radio History

- **Vehicular wireless communications** approached state-of-the-art with the intro of hand carried radios in the late 1950's
- The advent of transistors made small lightweight radios available, and by the mid-1960's the first **portable based** public safety radio systems were implemented
- Today, there are thousands of public safety radio systems in place using a variety of mobile and portable radios
- These systems serve a mixture of small, medium and large cities, counties, and states as well as the Federal government.

Land Mobile Radio and Public Safety Radio History

- The majority of these systems transmit information in the **analog format** for both voice and signaling
- Spurred by technology innovation, private land mobile systems began a migration from the analog format, to a variety of **digital formats** during the early 1980's
- During this same time period, new technologies supported the creation of **shared systems** where wireless systems provided services for mission critical first responders as well as related city, county and state government communication services.

P25 History

- From 1976 to 1979, a **functional specification** was developed for public safety trunked systems
  - This specification is **APCO Project 16 (P16),** established by the Association of Public Safety Communications Officials International, Inc. ("APCO")
- The P16 specification included definitions for public safety radio communication systems with analog voice, and radio channel trunking initially targeted at the **newly-allocated 800 MHz frequency band.**

P25 History

- The P16 functional specifications permitted development of **proprietary systems**
- Three proprietary P16 systems evolved:
  - EF Johnson's Multi-Net®,
  - General Electric's EDACS®
  - Motorola's SMARTNET®
- The subsequent deployment of proprietary systems **minimized interoperability** once an initial system decision was made.

P25 History

- In an attempt to achieve interoperability, five 800 MHz conventional mutual aid channels were designated for interoperability in the **800 MHz NSPAC channels**. NPSPAC is the abbreviation for “National Public Safety Planning Advisory Committee” and is the first band where regional planning was required by the FCC.
- While numerous local and state agencies implemented systems that complied with **P16 specifications**, the varying proprietary protocols and different public safety frequency bands **significantly impaired interoperability.**

P25 History

- In 1988, the FCC, at the direction of Congress, published a **“Notice of Inquiry”** on radio technologies for Public Safety
- Comments and Reply Comments were received and published in 1989
- Responding to the Commission’s initiative, a **large group of users**, **vendors** and other interested parties (many of whom commented on the FCC NOI noted above) met in Washington DC in December 1989, to discuss **"Public Safety Digital Radio."**

P25 History

- The result was the formation of the **APCO P25 coalition**
- This user coalition included:
  - APCO,
  - The National Association of State Technology Directors (NASTD), formerly the National Association of State Telecommunications Directors), and
  - Agencies of the Federal government.

P25 History

- A **Steering Committee** was formed to manage the process
- The P25 Steering Committee has **eleven members** and is co-chaired by APCO and NASTD
- The members include:
  - Four APCO Representatives,
  - Four NASTD Representatives, and
  - Three Federal Government representatives

P25 History

- Technology development began in 1990, when the Federal government participants, who had hired a consultant **(GTE)** to develop Digital Radio Technology recommendations (before APCO P25 began), offered the results of this study to the coalition as a **benchmark** or starting point for their process
- In response, technology recommendations from users, academia, and manufacturers caused significant **deviation from the baseline parameters** proposed by GTE.

P25 History

- In January 1992, a **first draft** was completed describing user requirements
- As part of the standards development process, **P25 requested assistance from TIA** (Telecommunications Industry Association) to provide technical advice to P25 for its standard(s)
- A Memorandum of Understanding (**MOU**) was signed between Project 25 and TIA to this effect
- A **2nd MOU was prepared for industry** to assure the proper agreements regarding Intellectual Properties (IPR)
- Both of these agreements continue in effect today.

P25 History

- TIA in concert with P25 created an **ad hoc committee** to facilitate action on items and issues raised in the process
- This committee called **APIC** (APCO Project 25 Interface Committee) is patterned after the TIA processes
- Each participating User and Manufacturer has **one vote** in the APIC deliberations
- Lengthy deliberations on **voice coding** and **digital radio modulation techniques** resulted in extensive efforts to address alternatives.

P25 History

- An **evaluation program** derived from the CTIA (Cellular Telecommunications Industry Association) **vocoder** evaluation processes was used to test proposed vocoders
- After a discussion of the **modulation alternatives** the coalition demanded a practical demonstration of the techniques eventually adopted.

P25 History

- In **1995**, the Steering Committee adopted a set of the new recommended standards now known as **Project 25 (P25)** sufficient for manufacturers to begin building Phase 1 (12.5 kHz, 9.6 kbps channel rate) equipment
- P25 specifies **features and signaling for narrow band digital data and voice** supporting both conventional and trunking modes of operation
- TIA provided the development of this suite of standards, following an industry-sanctioned and American National Standards Institute **(ANSI) accredited process.**

P25 History

With TIA's assistance, P25 was structured to specify details of fundamental digital public safety communications to allow **multi-source procurement** and **interoperability** for the life of P25 systems.

P25 Viability and Sustainability

- The events in the United States and around the world since **September 11, 2001** have spurred increased popular interest in public safety communications **interoperability**
- Growing concern has driven many country's governments - including the US Federal Government - to reorganize and create focused positions to address **Homeland Security**
- Long before these events, public safety and the LMR industry created an interoperability solution, Project 25.

P25 Viability and Sustainability

- **Published by TIA** and approved by Federal, state/provincial and local public safety users, the **P25 standards enable a feature-rich, scalable digital radio technology**
- The availability of radio equipment **compliant to P25 standards** is now providing a basis for radio communications **interoperability** that is necessary for First Responders.

P25 Viability and Sustainability

- The **P25 standard** has been adopted by the National Telecommunications and Information Administration (**NTIA**), which manages spectrum for the U.S. Federal government
- In addition, **NTIA** also specified use of **P25 narrow band by the year 2005** for the VHF Hi bands (162-174 MHz), and by 2008 for all other bands
- Many **US government agencies** (e.g. Defense, Interior, Justice and Treasury) have **specified P25** for procurements of new radio systems and equipment – beginning with Grant Guidance in 2011, **DHS requires P25** for grant funds sent to state and local government for new radio systems.

P25 Viability and Sustainability

- **P25 compatibility** has become a significant **purchasing factor** for local and state public safety and public service radio communication systems
- As local and state public safety users **change or upgrade** their existing analog systems to comply with new FCC regulated bandwidths (Narrowbanding), **demand for P25 compliant digital public safety systems increases**
- This is partly due to the **ability of P25 systems to be configured for compatibility with older analog mobile and portable radios**, allowing adopters of the P25 standard to purchase new system equipment without replacing all of their subscriber radios.

P25 Viability and Sustainability

- P25 Standards are now a **benchmark** in public safety radio communications for First Responders
- P25, as defined in the published ANSI/TIA102 series of documents, enables **migration from today's radio systems to desired levels of interoperability** directly impacting first responders
- It is the first user-driven standard of its kind to allow graceful, scalable migration to **standards based interoperable systems.**

P25 Viability and Sustainability

- **P25 Phase 1** published standards define public safety radio communications in **12.5 kHz channels**
- **FCC rulings in the VHF and UHF** frequency bands require more spectral efficiency through the use of narrower radio channels, i.e. **12.5 kHz**, by 2013**.**
- While a **stay was granted** to users regarding the decision by the FCC to ban new licenses for 25 kHz channel equipment after January 2004, **FCC rules requiring narrow band type accepted equipment still remain.**

P25 Viability and Sustainability

- **Additionally FCC rules give public safety users in the 700 MHz band until January 1, 2018** to convert their systems to meet the spectral efficiencies of 6.25 kHz or equivalent.
  - Numerous petitions have been filed with the FCC by NPSTC and local/state agencies in recent years to extend this deadline to 2024
- These rulings present **requirements** for users to upgrade their systems to meet the FCC mandated efficiencies.

P25 Viability and Sustainability

- Both the **FCC and NTIA narrowbanding rules** increase public safety and Federal agency **interest** in P25 systems and equipment since it meets these requirements,
- **P25 compliant radio systems** and equipment offer the opportunity to implement public safety radio **interoperability**
- Today, many **public safety wireless communications planning efforts** are based on using P25 compliant systems and equipment for **interoperability** and to meet **narrowband** spectral efficiency required by NTIA and the FCC.

P25 Viability and Sustainability

- Emergency Medical Technicians, Firefighters, Law Enforcement, Public Safety Dispatchers and others involved in **incident response** as well as combined agency operations benefit from the **interoperability offered by using the Common Air Interface (CAI)**
- Operating in 12.5 kHz, the **CAI** is enhanced by functions provided in published **trunking, encryption, Over-The-Air-Rekeying (OTAR) and data P25 standards.**

P25 Viability and Sustainability

- **P25 encryption** uses interoperable crypto algorithms called **DES-OFB (64 bits) and AES (256 bits)**
- The P25 standard enables **short-burst packet type data** useful for database inquiries and applications such as **GPS**
- **End-to-end encryption of voice and data** is enabled in P25 systems. Interoperability, regardless of system type, for first responders is assured when the network supports the P25 standard CAI protocol.

P25 Viability and Sustainability

- **Rising interests in P25 as a facilitator of interoperability is driving increasing market acceptance**
- A growing number of vendors announcing P25 products are the result of several significant public safety events:
  - **Post September 11** renewed focus on first responders
  - FCC **narrow band** public safety rules and regulations
  - Continuing Association **support** ranging from recommendation to purchase of compliant P25 communication systems and products.

P25 Viability and Sustainability

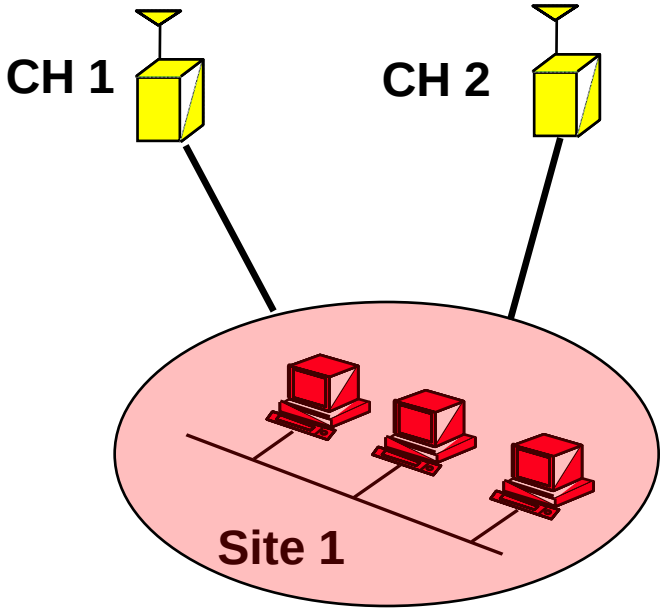
- These agencies/associations include, but are not limited to:
- APCO and FCC
- National Association of State Technology Directors (NASTD)
- Association of American Railroads (AAR)
- Federal Law Enforcement Wireless Users Group (FLEWUG)
- International Association of Chiefs of Police (IACP)
- International Association of Fire Chiefs (IAFC)
- National Telecom and Information Administration (NTIA)
- National Sheriff's Association (NSA)
- U.S. Departments of Defense, Homeland Security, Interior, Justice and Treasury.

P25 System Defined Standard Interfaces

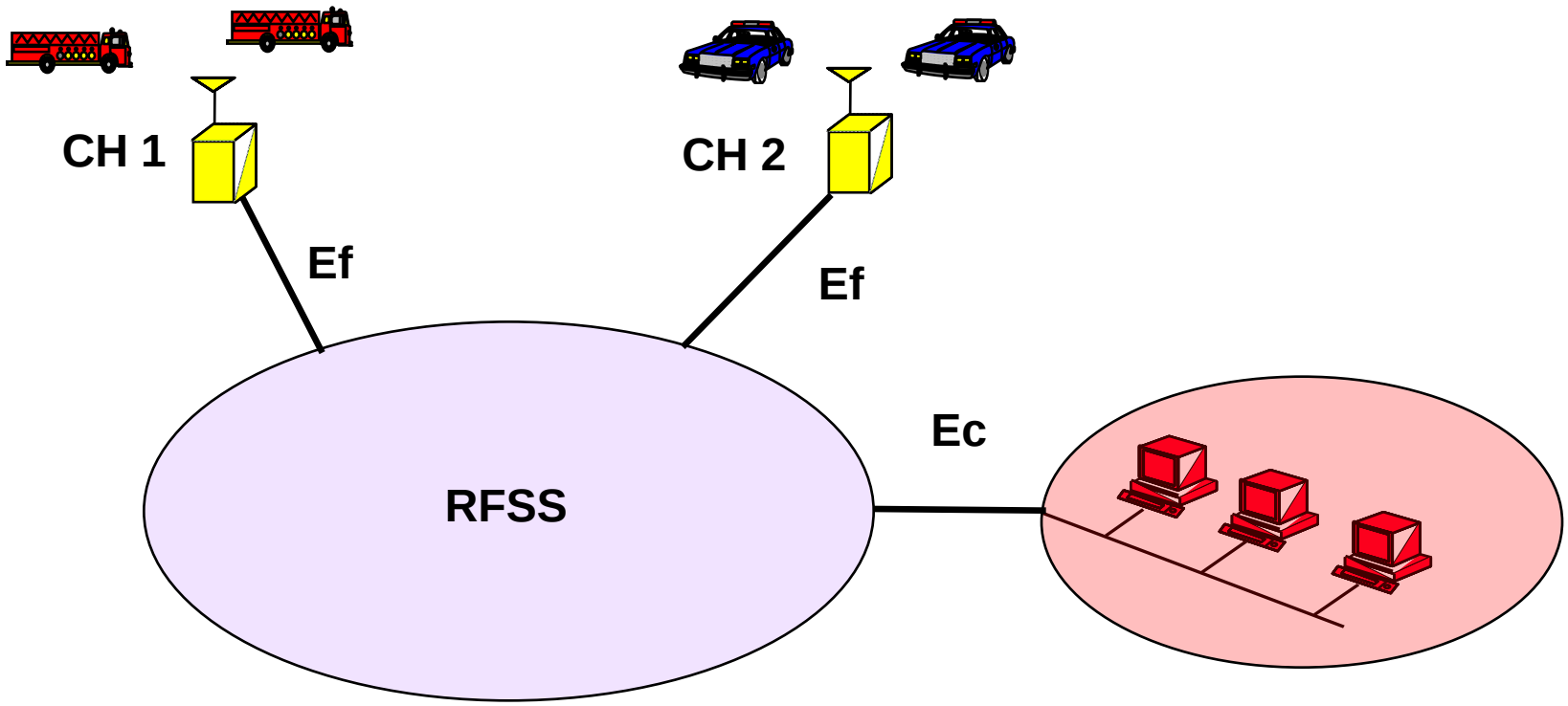
- RF Sub-System (RFSS) – Core Infrastructure
- Common Air Interface (CAI) – Radio to Radio protocol
- Inter-Subsystem Interface (ISSI) – RFSS to other systems
- Telephone Interconnect Interface (Et) – PSTN to RFSS
- Network Management Interface (En) – Network to RFSS
- Data Host Interface (Ed) – CAD to RFSS
- Data Peripheral Interface (A) – Radio to Data Peripheral
- Fixed Station Interface (Ef) – BTS to RFSS/Console
- Console Sub-System Interface (Ec) – Console to RFSS

P25 Technically Speaking

Inter System Connectivity



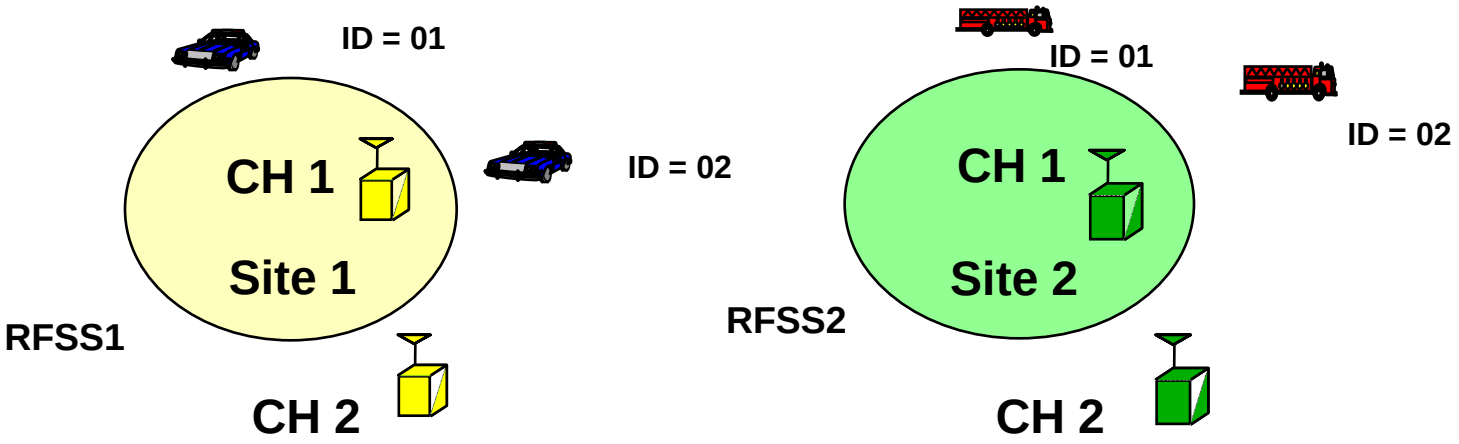
P25 Technically Speaking



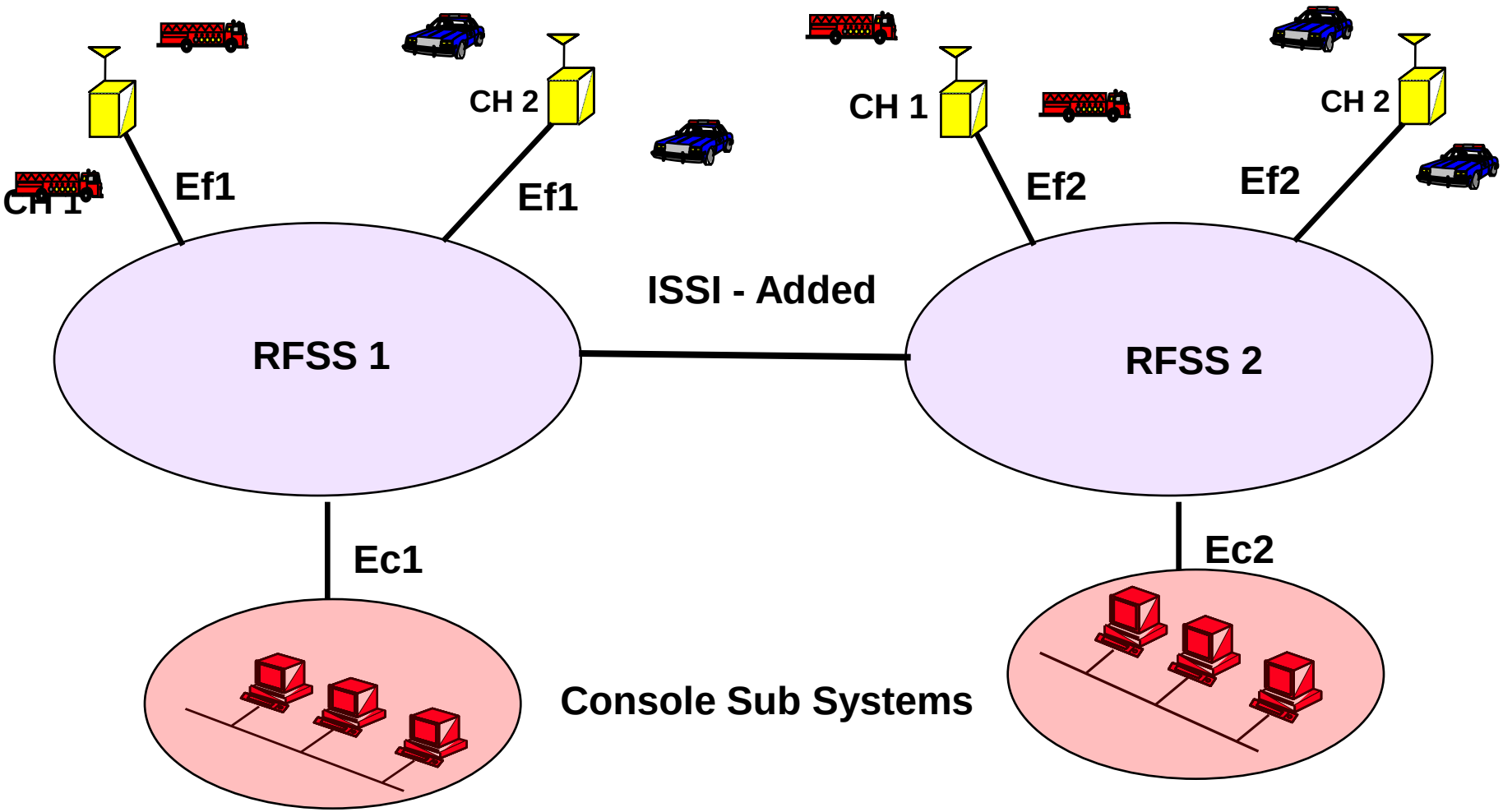
With Console Sub System Added

P25 Technically Speaking – Before ISSI

Intra-System or System to System Connectivity



P25 Technically Speaking – After ISSI



P25 Compliance

What is Required for P25 **Compliance**?

At a minimum, a P25 radio system must provide **interoperability** with these **two** mandatory P25 Standard interface components:

1. The Common Air Interface (**CAI**) - enables P25 radios to interoperate and communicate digitally across P25 networks and directly
   - This portion of the P25 standard suite was selected to meet the unique radio system needs of the public safety environment; coverage reliability, system design flexibility, and inter-vendor compatibility

P25 Compliance

2. The **Improved Multi-Band Excitation (IMBE) vocoder**
   - The IMBE vocoder sets a uniform standard for **converting speech into the** digital bitstream
   - IMBE was selected as the coding scheme most successful at making male and female voices audible against background noises such as moving vehicles, sirens, gunshots, and traffic noise – the conditions of public safety use

P25 Compliance

- These two components, when used together enable P25 users to **interoperate and communicate digitally** directly between units and across networks, agencies, and vendors.
- P25 has also defined standard **modes of operation** to enable multi-vendor interoperability for additional system functions:
  - trunking,
  - encryption,
  - over-the-air rekeying, and
  - others

P25 Compliance

- P25 also continues to develop a set of defined system interfaces to allow the P25 system elements to communicate with **host computers, data terminals and the public switched telephone network (PSTN)**
- These interfaces are critical to assure that P25 systems maintain **compatibility with the evolving telecommunications and data-communications world.**

P25 Benefits

What Are the **Benefits** of P25?

P25 has, from its inception, targeted five primary objectives:

- Ensure **competition** in system life cycle procurements so agencies can choose from multiple vendors and products, ultimately saving money and gaining the freedom to select from the widest range of equipment and features.

- Allow effective, efficient, and reliable interagency communications **interoperabilit**y so organizations can easily implement seamless joint communication in both routine and emergency circumstances.

P25 Benefits

- Provide for **graceful migration**, both backward and forward
- Improve radio **spectrum efficiency** so systems will have enough capacity to handle calls and allow room for growth, even in areas where the spectrum is crowded and it is difficult for agencies to obtain licenses for additional radio frequencies
- Provide **user-friendly equipment** so users can take full advantage of their radios' lifesaving capabilities on the job – even under adverse conditions – with minimal training.

P25 Benefits

- The clear statement of these **five objectives** at the onset of the project has **focused the standard directly at the needs of the public safety community**

- This **“needs-based”** approach to standards development assures that, when implemented, the system will succeed at meeting these objectives.

P25 Status

What is the **Status** of P25 Today?

- P25 systems are **available today** and being deployed globally
- Many organizations have **mandated** that new land mobile radio system purchases follow P25 standards
- P25 is ongoing
- The **standard continues to evolve** as the needs of users and the capabilities of technology advance
- Both **manufacturers and users** have an important role to play in shaping P25.

P25 Future

Looking to the **Future**

- There are **two phases of P25** development:
  - **Phase 1** specifies the CAI and vocoder requirements for 12.5 kHz bandwidth operation along with several additional functions
  - Phase 1 is now **mostly complete** and many systems are being implemented using these technologies.

P25 Future

Phase 2 is currently completing development, with most standards in the suite completed to the point that significant equipment development and manufacturing is underway for **trunked** (but not yet conventional) radio systems.

- Phase 2 specifies additional **air interface specifications** to provide **6.25 kHz** (or equivalent) bandwidth operation to allow better spectrum efficiency
- Since Phase 2 will continue to maintain the focus on the five primary objectives, you can be assured of **compatibility with Phase 1 systems for interoperability and backward/forward migration.**

Credits

EADS North America – Secure Networks, Inc.

LCC International

National Public Safety Telecommunications Council

Wireless Facilities, Inc.

TIA International, Inc.

Jack Daniel

Technical Resources/Credits

- www.ptig.org
- www.apco.org
- www.tiaonline.org
- www.eads-ps.com

Funding for Public Safety/LMR

Possible Sources of Funds Beyond Taxation

- DHS:
  - www.grants.com and www.grantsoffice.com
  - Two white papers available on DHS website on how to apply for funds, 2005grantforecast.pdf and 2006grantforecast.pdf
- Monies collected from local crime prevention – Asset Forfeiture
- Bonds

Closing

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