700 MHz Wideband Interoperability

WT Docket 96-86

October 26, 2005

Three Basic Questions for NPRM

Is data interoperability needed?

If so, what is the best way to achieve interoperability?

How can Public Safety's data requirements best be met while protecting 700 MHz voice capacity?

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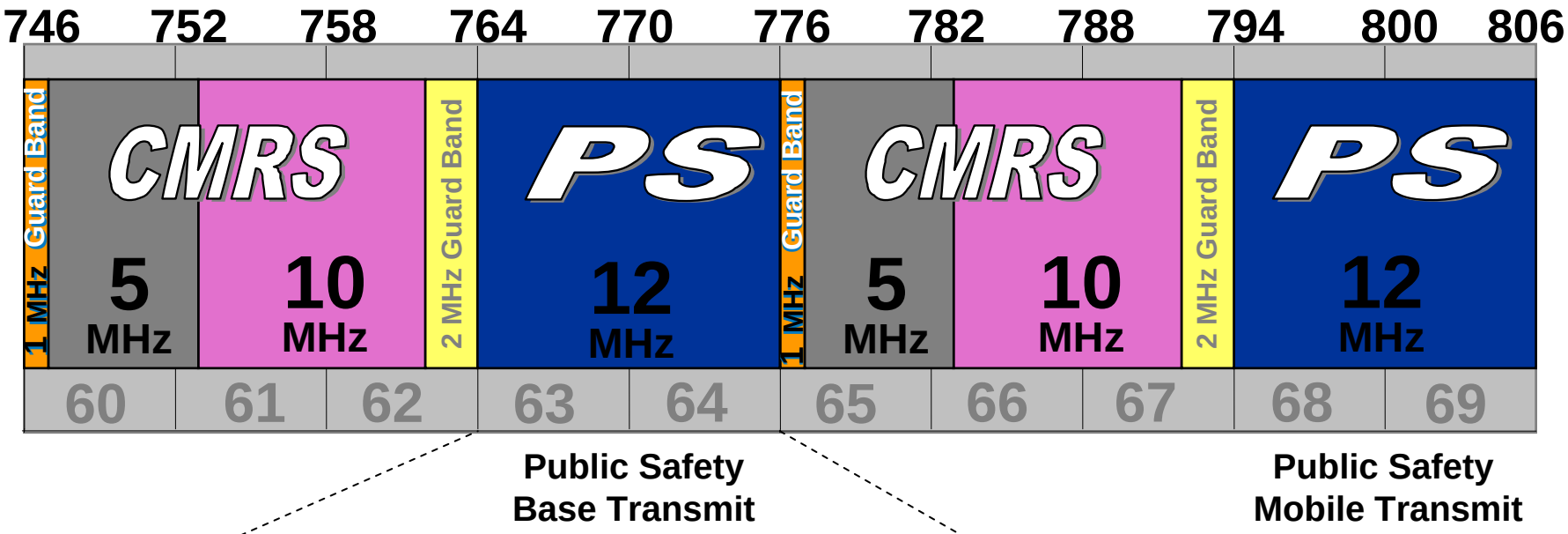
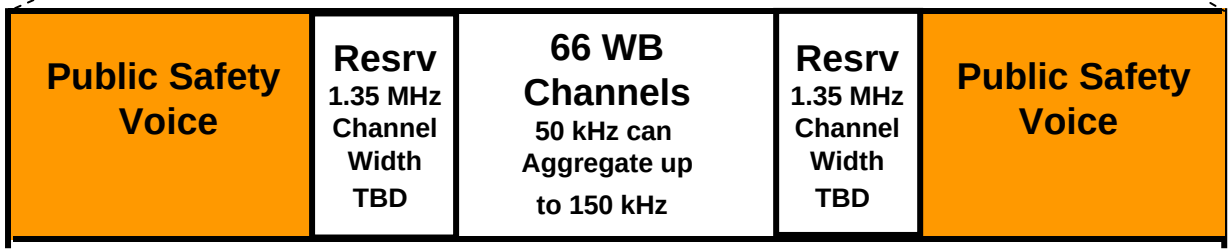
Current Band Plan





Current PS Plan:
66 WB (50 kHz) Channels
2.7 MHz of reserve
Channel width TBD

Current plan provides 6 MHz for critical voice capacity and is structured with 1 & 2 MHz guard bands outside the PS block to reduce potential for interference from commercial services

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Yes - Data Interoperability is Needed

- **Experience has shown that voice interoperability is increasingly important for prevention & response**
  - Recent hurricanes have highlighted need
- **The need for data interoperability is likely to increase as public safety relies more on data solutions**
  - Sharing data and images in a multi-jurisdictional prevention or response situation will become increasingly important
- **Establishing interoperability at the RF level provides the necessary foundation for service interoperability**
  - Interoperability foundation should be laid now - prior to widespread deployment
- **Congress has recognized the importance of interoperability as part of its funding and policy initiatives**

What's the Best Way to Provide Interoperability?

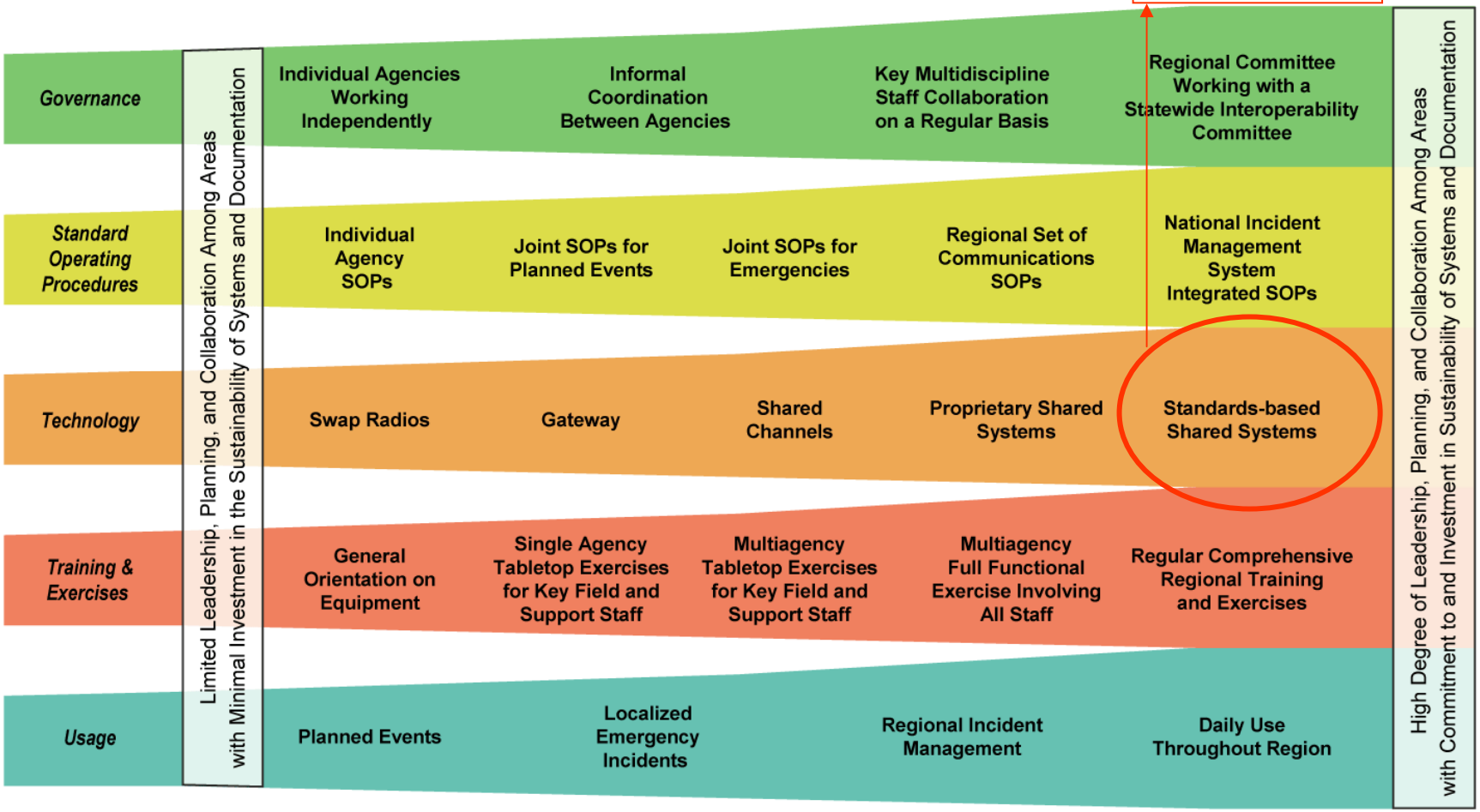
- **The System Level (common PHYSICAL/MAC layer)**
  - Example - TIA 902 SAM
  - Ensures that radios are physically capable of communicating with each other
  - Allows responders from other jurisdictions to use their radios on local system
  - ***Provides highest level of interoperability***
- **The IP Network layer**
  - Similar to switch – translates information between incompatible radio systems
  - Requires that disparate networks have overlapping coverage
- **Applications**
  - Some parties have talked about need for compatibility of applications
  - Does not eliminate the need for radio compatibility

Interoperability Continuum

Homeland Security

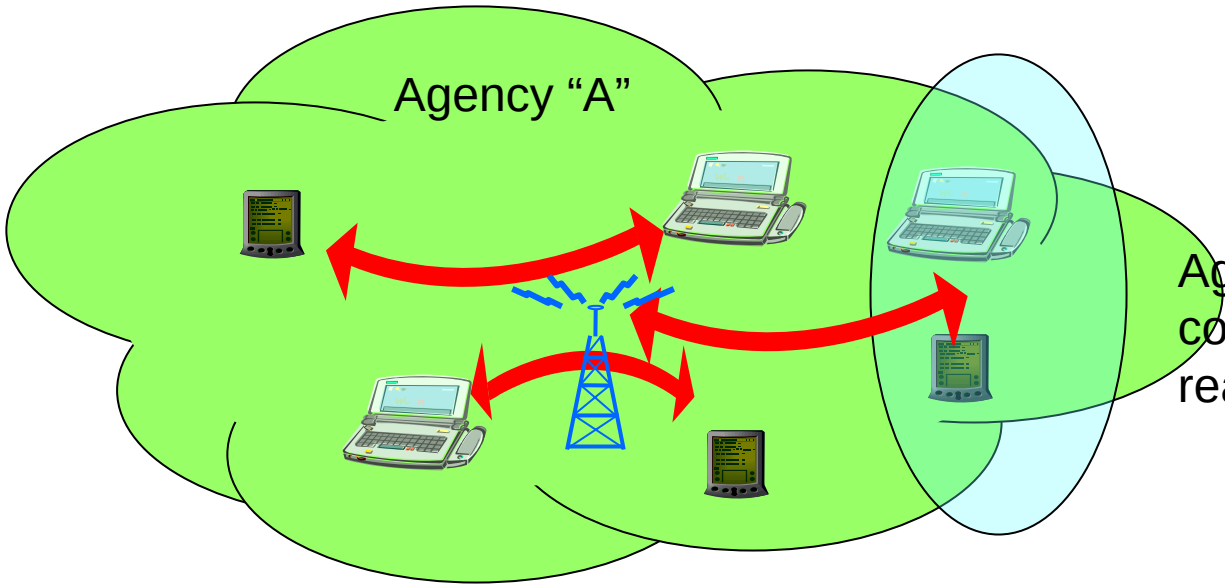
SAFECOM

Motorola Recommendation



Minimal Level — Interoperability Continuum — Optimal Level

Operation *With* a Defined Physical Layer Standard



Agency “B” roamers compliant to standard readily join the network

- Home system operation
  - Users share a channel or operate on assigned channel
  - Minimal equipment complexity
  - Minimized access and network management issues
- When a roaming situation develops:
  - Standard-compliant roamers easily join the network
  - Preplanning minimizes access and network management issues
  - Agency B can use peer-to-peer if so equipped for their own assignments

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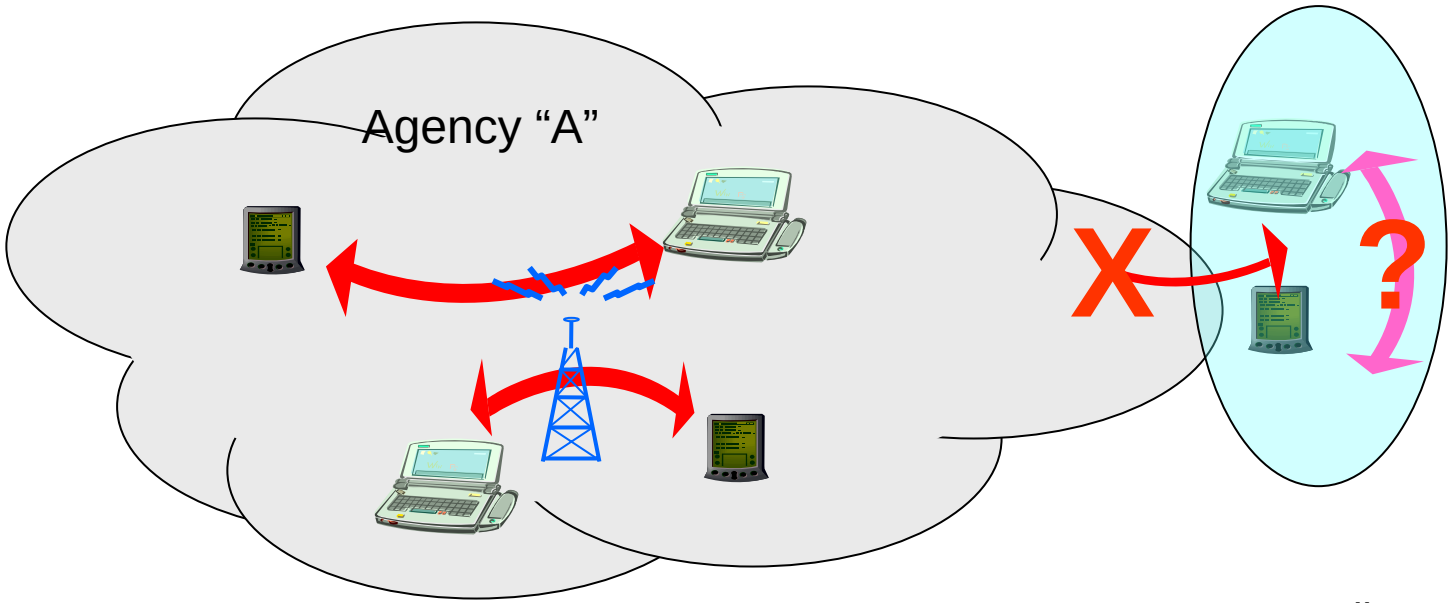
Operation *Without* a Defined Physical Layer Standard



- Agency “A” does not use a defined standard
  - Home users can share the network
  - As long as their own units access network, no issues, until:
  - An interoperable situation develops

- Agency “B” roamers compliant to defined standard attempt to join the network
  - Roamers will not communicate with Agency A network
  - Roamers may not be able to communicate with each other
  - Providing peer-to-peer increases product complexity; may not help with “home” agency

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Why TIA 902 (SAM) is the Right Standard

TIA 902 (SAM) was developed with public safety & multiple vendor input

TIA 902 (SAM) was chosen by TIA participants as the interop standard for 700 MHz wideband

TIA 902 (SAM) is a documented and published TIA and ANSI standard

- Provides definition for multiple manufacturers to participate
- Requires fair and reasonable licensing of IPR

Motorola is on record committing to license its essential IPR related to TIA 902 (SAM) on a royalty-free basis for use on the 700 interop channels.

Wideband standard provides baseline communications compatibility

- Suitable for a wide variety of applications and for wide area coverage

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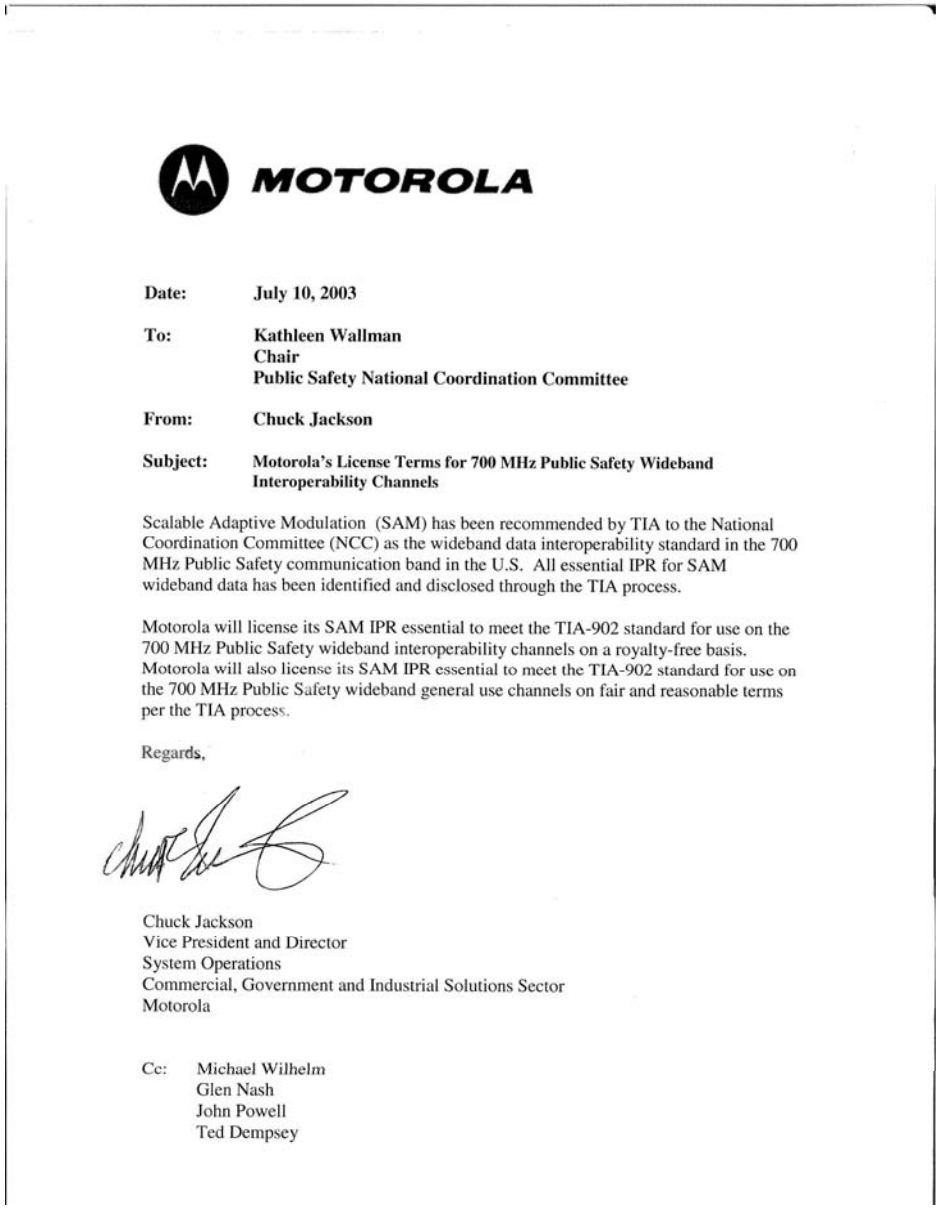
Motorola Commitment Letter Regarding IPR For TIA 902 SAM



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Date: July 10, 2003

To: Kathleen Wallman
Chair
Public Safety National Coordination Committee

From: Chuck Jackson

Subject: Motorola's License Terms for 700 MHz Public Safety Wideband Interoperability Channels

Scalable Adaptive Modulation (SAM) has been recommended by TIA to the National Coordination Committee (NCC) as the wideband data interoperability standard in the 700 MHz Public Safety communication band in the U.S. All essential IPR for SAM wideband data has been identified and disclosed through the TIA process.

Motorola will license its SAM IPR essential to meet the TIA-902 standard for use on the 700 MHz Public Safety wideband interoperability channels on a royalty-free basis. Motorola will also license its SAM IPR essential to meet the TIA-902 standard for use on the 700 MHz Public Safety wideband general use channels on fair and reasonable terms per the TIA process.

Regards,

Chuck Jackson
Vice President and Director
System Operations
Commercial, Government and Industrial Solutions Sector
Motorola

Cc: Michael Wilhelm
Glen Nash
John Powell
Ted Dempsey

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TIA-902 (SAM) Wideband Data Status

All Wideband Air Interface TIA-902 Standards are published

TIA recommended to the NCC in July 2003 that the following 6 standards should be referenced in the FCC rules for Wideband Data Interoperability:

	Approved
[1] ANSI/TIA-902.BAAB-A 2003 - SAM Physical Layer (PHY)	**- Sept 2003**
[2] ANSI/TIA-902.BAAD-A 2003 - SAM Radio Channel Coding (CHC)	**- Sept 2003**
[3] TIA-902.BAAC - WAI Media Access Control/Radio Link Adaptation (MAC/RLA) (scheduled to ballot as ANSI standard in January 2006)	**- Sept 2002**
[4] TIA-902.BAAE - WAI Logical Link Control (LLC)	**- Sept 2002**
[5] TIA-902.BAEB - WAI Packet Data Specification (PDS)	**- May 2003**
[6] TIA-902.BAAF - WAI Mobility Management (MM)	**- May 2003**

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TIA 902 Wideband Data Standards

Packet Data Specification (PDS) - services, protocol(s), and formats used for the conveyance of IP bearer service.

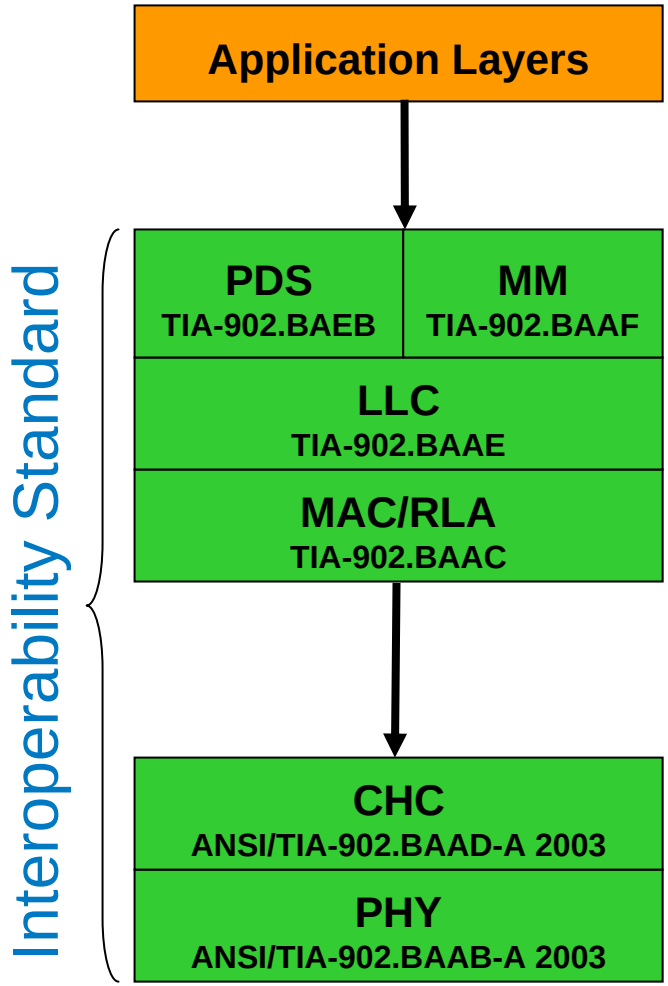
Mobility Management (MM) - procedures and message formats that facilitate mobile host RF roaming within, and between wideband networks while minimizing impacts to other services.

Logical Link Control (LLC) - procedures and message formats that allow transmission of LLC frames over the RF link. Included in the LLC are reliable and unreliable payload data transfer modes for support of the various data transmission quality of service requirements.

Media Access Control / Radio Link Adaptation (MAC/RLA) Upper MAC defines interface protocol, block structure, and logical channel structure for channel access control, radio resource management, error detection and data transfer. Lower MAC defines radio channel frame structure, block structure, scrambling, and logical channel multiplexing. RLA controls the radio link adaptation parameters.

Radio Channel Coding (CHC) - procedures, formats, and algorithms for radio medium specific functions that dynamically adapt and optimize the physical layer performance. This layer provides dynamic radio channel forward error correction and error detection.

Physical (PHY) - definition and control of transmission and encoding of bits over the physical radio frequency medium.



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Standardization & IPR Status of Various Technologies

- **TIA-902 SAM**
  - Completed Standard developed by public safety & TIA
  - Motorola has committed to license essential IPR on royalty-free basis for use on the interop channels
- **EVDO/EVDO-A**
  - Completed Standard developed for commercial needs
  - Currently involves significant IPR fees
- **1.25 MHz OFDM**
  - Current technology is proprietary
  - Documentation and IPR licensing undetermined
- **802.16**
  - Standard developed for fixed broadband
  - “e” revision underway to add mobility; estimated completion by 1Q06
  - IPR licensing undetermined

Technology adopted for interoperability should meet public safety requirements, be documented as a standard and have a clear IPR licensing commitment

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Assessing Potential for Broadband at 700 MHz

- **Key Evaluation Criteria**
  - Accommodate multiple agencies of various sizes
  - Provide protection to 700 MHz narrowband voice
  - Offer framework for interoperability
  - Accommodate data and video requirements
  - Provide efficient use of spectrum

Baseline Principles that Apply to All Technologies

- **Generally, as bandwidth increases, coverage per site decreases**
- **Data rates decrease as the user moves away from the base station**
- **The data rate for a given user decreases as the number of users per site goes up**
- **Co-locating data and voice base stations will reduce “near-far” interference conflicts**
- **The span of channels subject to intermod interference increases as bandwidth increases**
- **The level of intermod interference varies by relative power density**
- **Interference is driven by deployment**

Impact to Users that Varies by Technology

- **Scalability to fit small, medium & large agencies, and diverse application usage profiles**
- **Number of channels available to support overlapping geographies (State, County, Municipal)**
- **Balance of inbound vs. outbound data rates**
- **Interoperability/degree of standardization**
- **The specific span & level of interference into adjacent bands**

Guardband Requirements

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Guardband vs. Level of Protection

	3 dB noise floor increase in voice band (Impact: Need 1.5 X sites)	6 dB noise floor increase in voice band (Impact: Need 2.3 X sites)	10 dB noise floor increase in voice band (Impact: Need 4X sites)	17 dB noise floor increase in voice band (Impact: Need 10.5 X sites)
1.25 MHz Broadband (OFDM w/ filter)	0.95 MHz	0.825 MHz	0.68 MHz	0.5 MHz
TIA 902 SAM (150 kHz)	0.125- 0.25 MHz	0.11 MHz	0.10 MHz	0.08 MHz
TIA 902 SAM (50 kHz)	0.15 MHz	0.14 MHz	0.135 MHz	.08 MHz

Systems normally designed for 0 to 3 dB rise in noise floor

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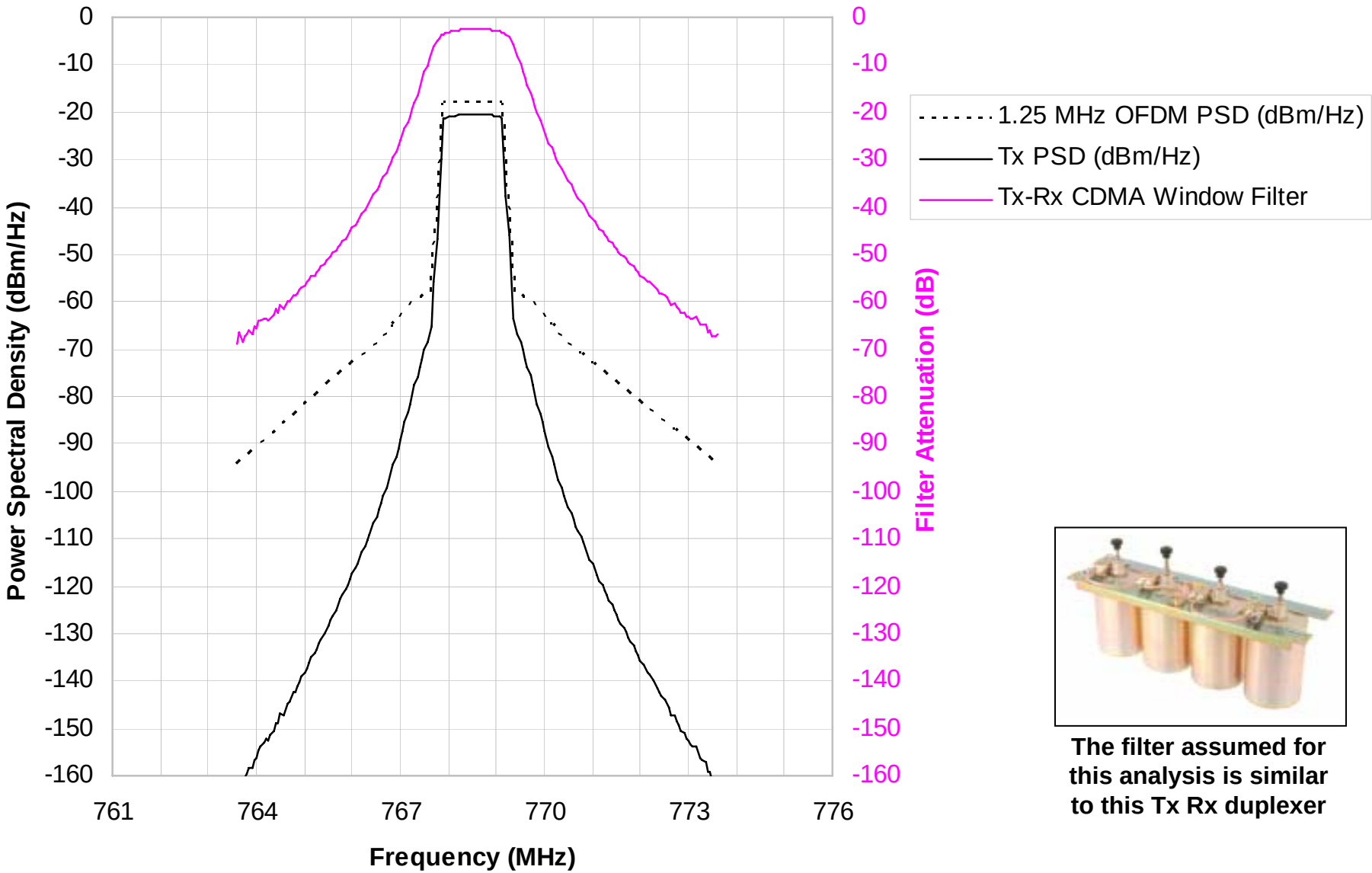
1.25 MHz BB Example: OFDM Power Spectral Density

Taken from Goldberg, WT Docket No. 03-103 (Oct. 4, 2004) and Filtered with Tx Rx 89-95-90210 Window Filter



The filter assumed for this analysis is similar to this Tx Rx duplexer

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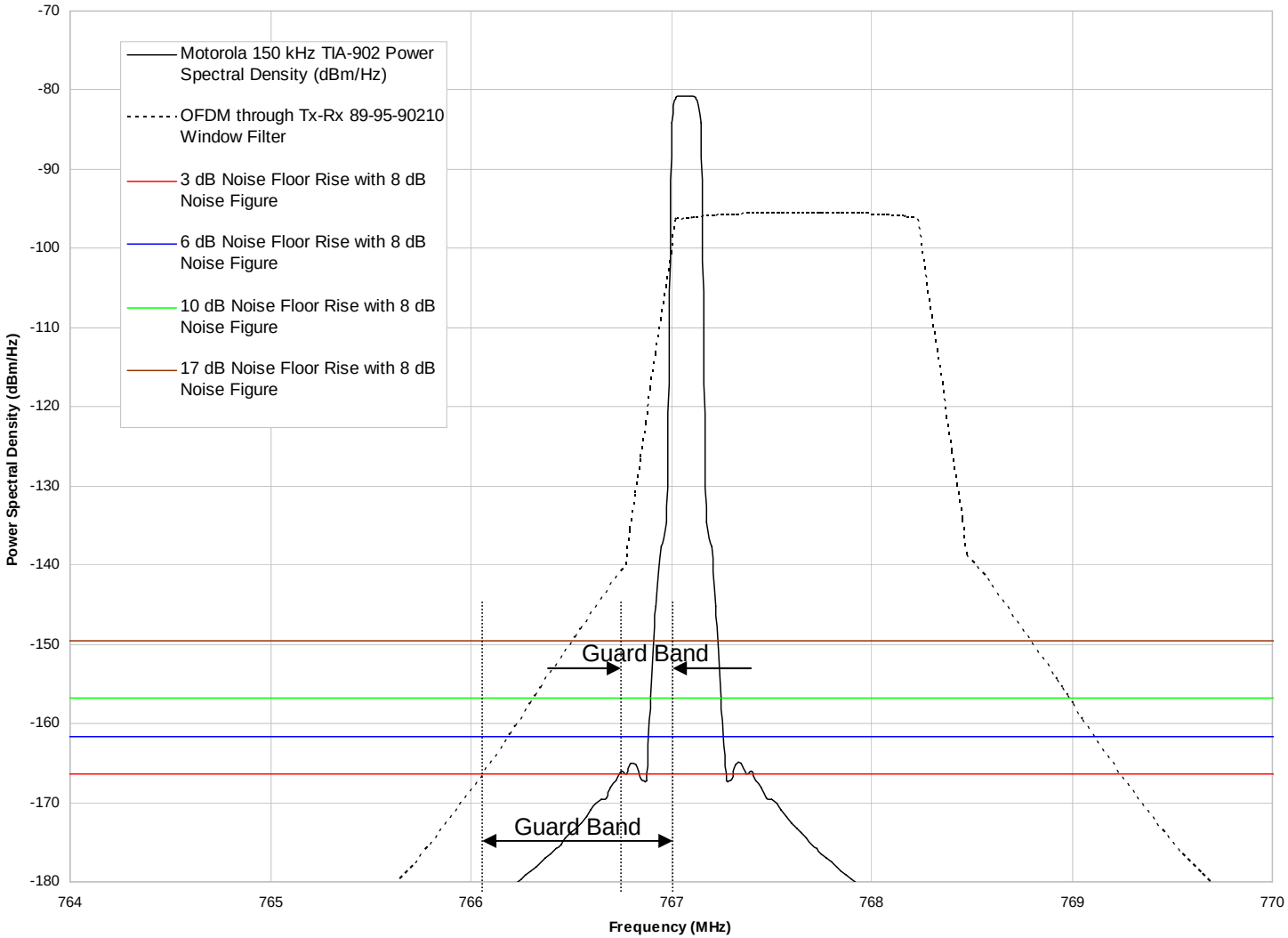
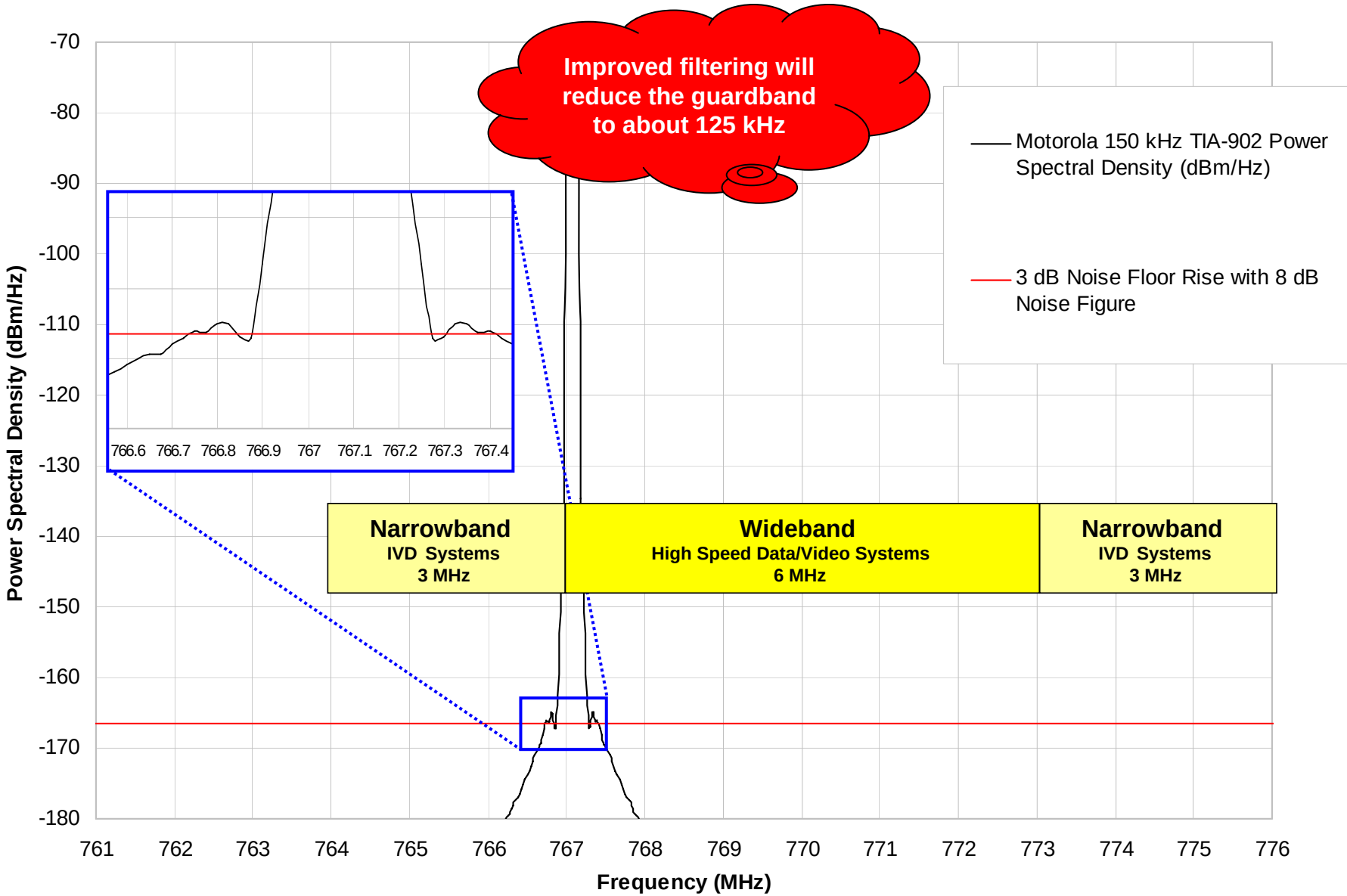
Out of Band Emission (OOBE) of TIA-902 & OFDM

75 dB Site Isolation Assumed; 40 W TxP for 902 & 20 W TxP for 1.25 OFDM or EV-DO



TIA 902 (SAM) at 150 kHz OOBE into PS Narrowband Receiver



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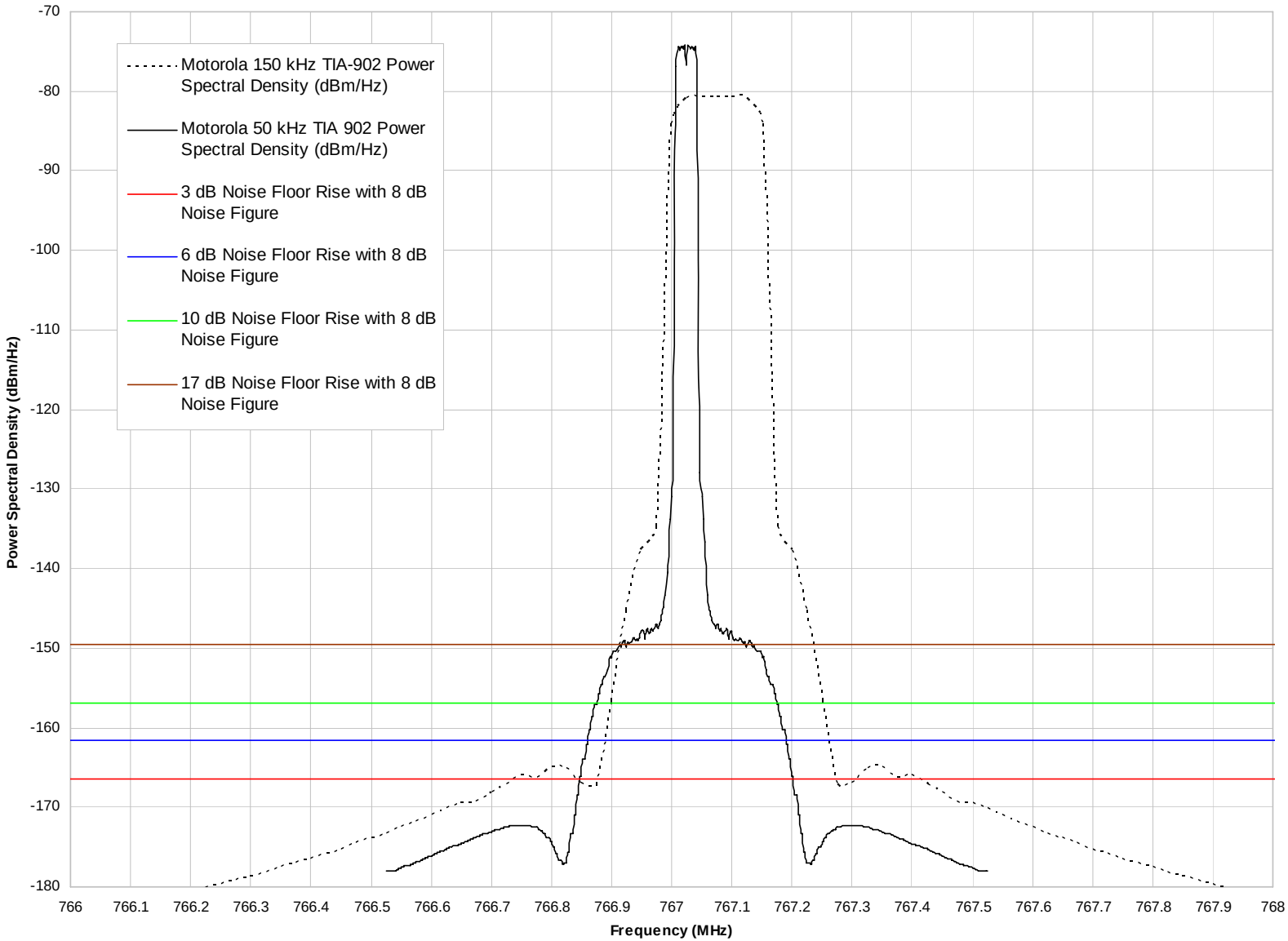
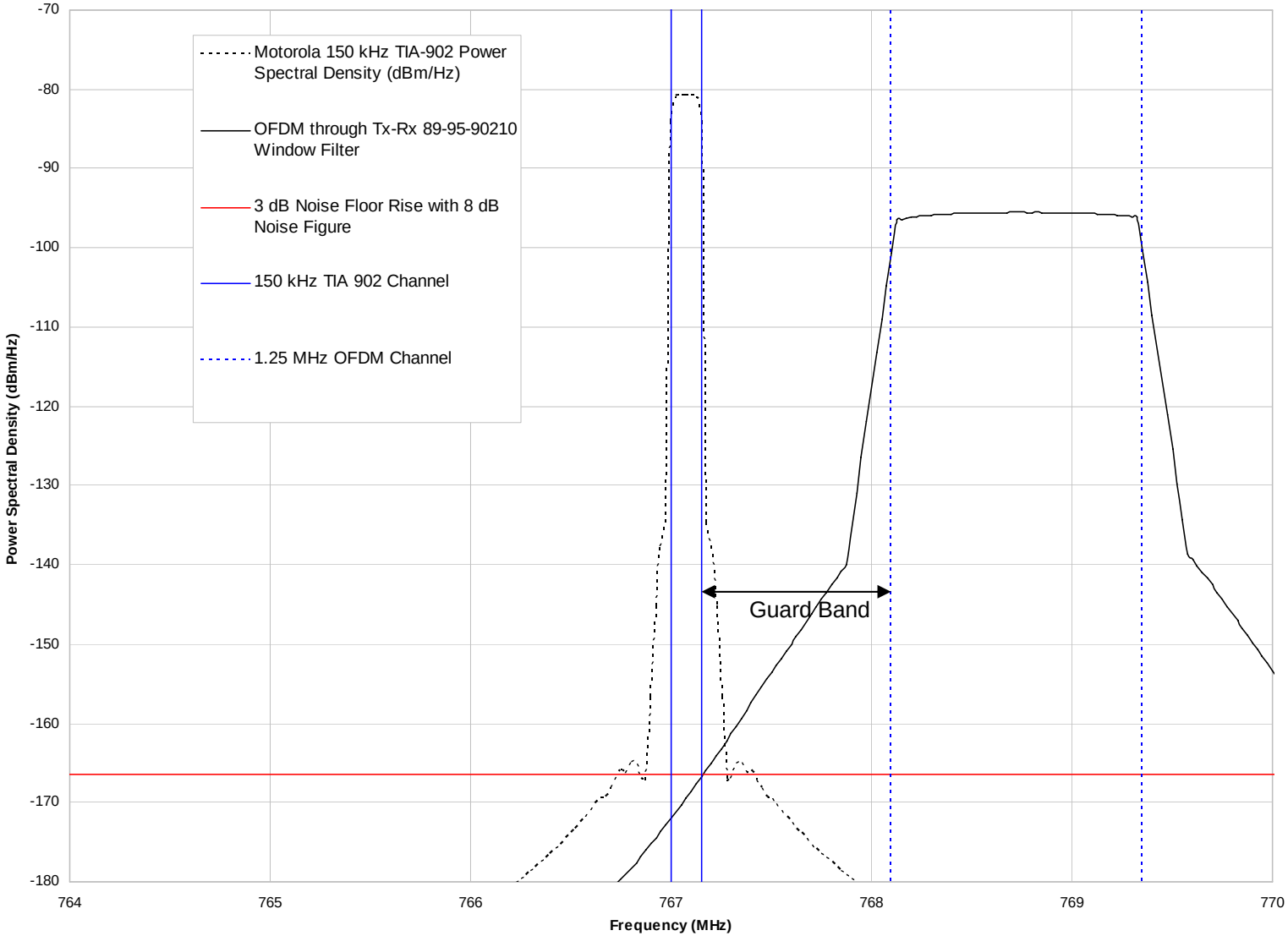
Out of Band Emission (OOBE) of 50 & 150 KHz TIA-902

75 dB Site Isolation Assumed; 40 W TxP for TIA 902



Guardband is also needed between BB and WB



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"Near-Far" OOBE Interference Conflicts Increase as Opportunities to Co-locate Data & Voice Stations Decrease

	No of sites for equivalent coverage (designed for portable coverage)	Max % of data & voice co-location (designed for portable coverage)	No of sites for equivalent coverage (designed for mobile coverage)	Max % of data & voice co-location (designed for mobile coverage)
P25 Voice	40[0]	Reference	10[0]	Reference
50 kHz TIA 902(SAM)	82[1]	49%	5[2]	100 %
150 kHz TIA 902(SAM)	158[1]	25%	10[2]	100 %
1.25 MHz OFDM	240[1]	17%	15[2] 39[4] 158[3]	67% 25% 6%
5 MHz 802.16e				
1.25 MHz EVDO	362[1]	11%	23[2] 60[4] 240[3]	43% 17% 4%
1.25 MHz EVDO-A				

More Near-Far Conflicts

[0] 3 W Portable/30W mobile
[1] 200 mW PCMCIA Card & 3 dB antenna loss w/r portable
[2] 10 W Mobile
[3] 200 mW PCMCIA Card with external antenna (i.e., available technology)
[4] 1 W Mobile (higher availability that a 10 Watt mobile)

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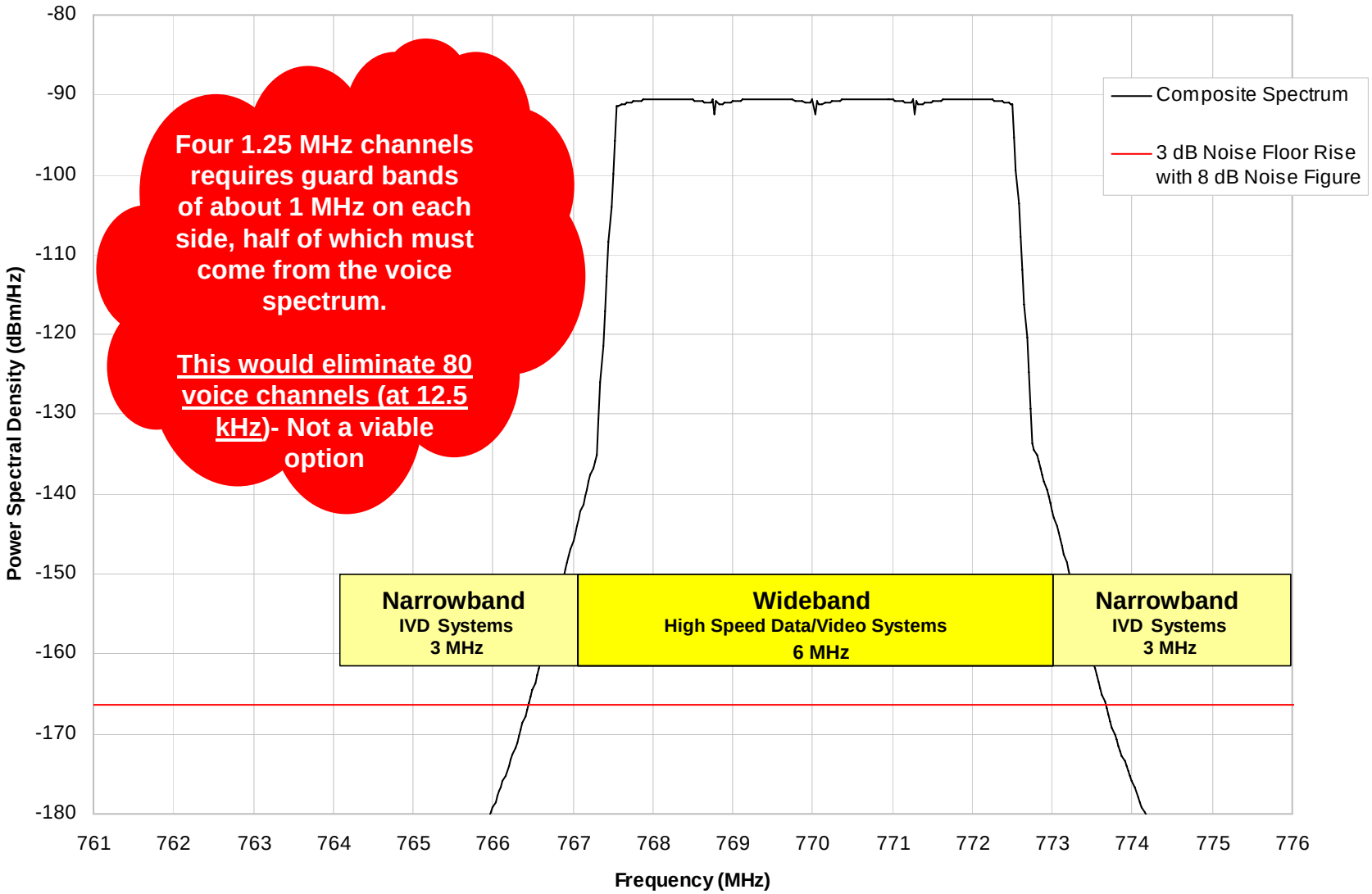
1.25 OFDM OOBE Interference to PS Narrowband

Four 1.25 OFDM Carriers with 20 W TxP, 3 dB Filter Loss and 70 dB Site Isolation Each



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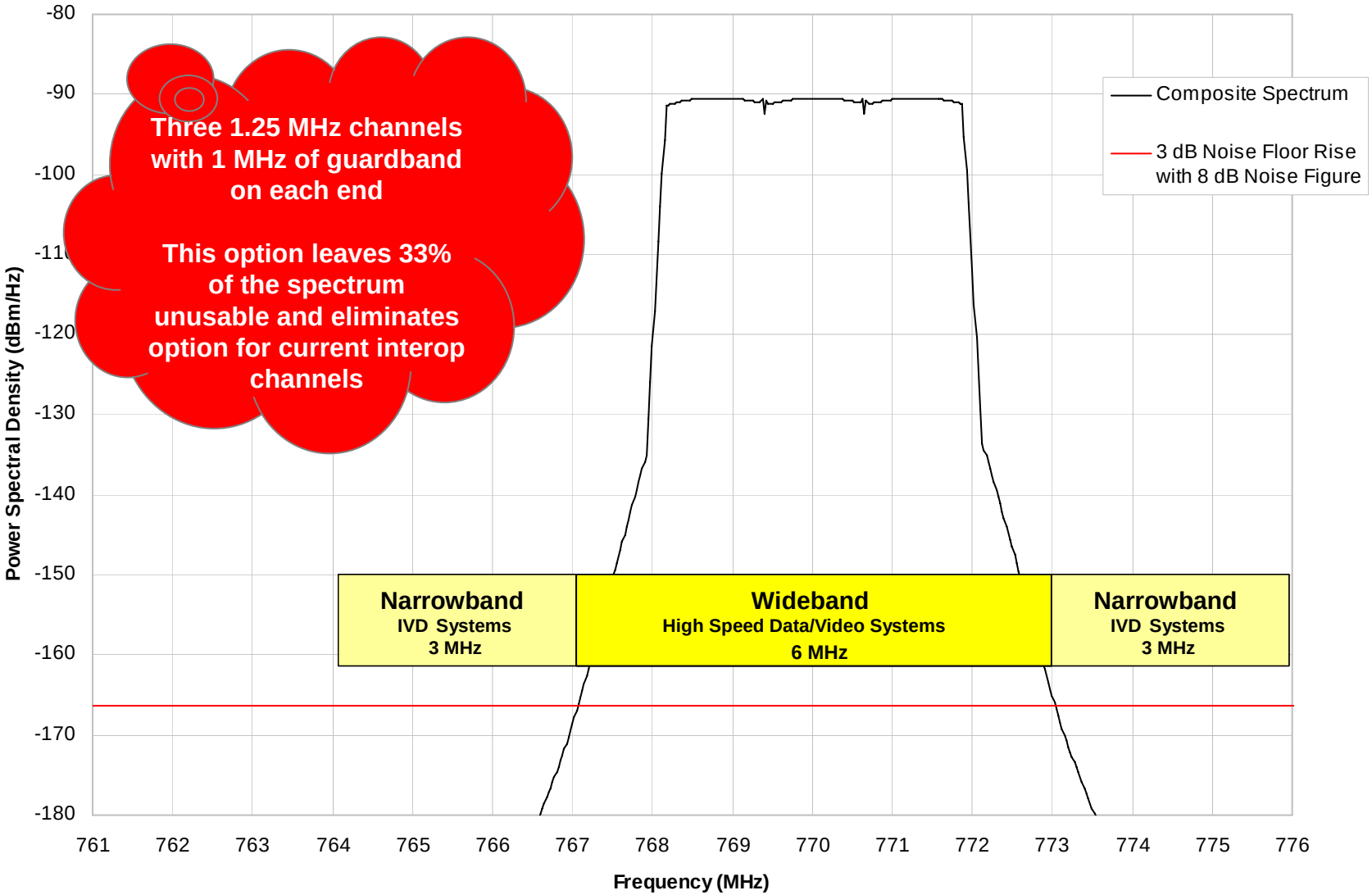
1.25 OFDM OOBE Interference to PS Narrowband

Three 1.25 OFDM Carriers with 20 W TxP, 3 dB Filter Loss and 70 dB Site Isolation Each



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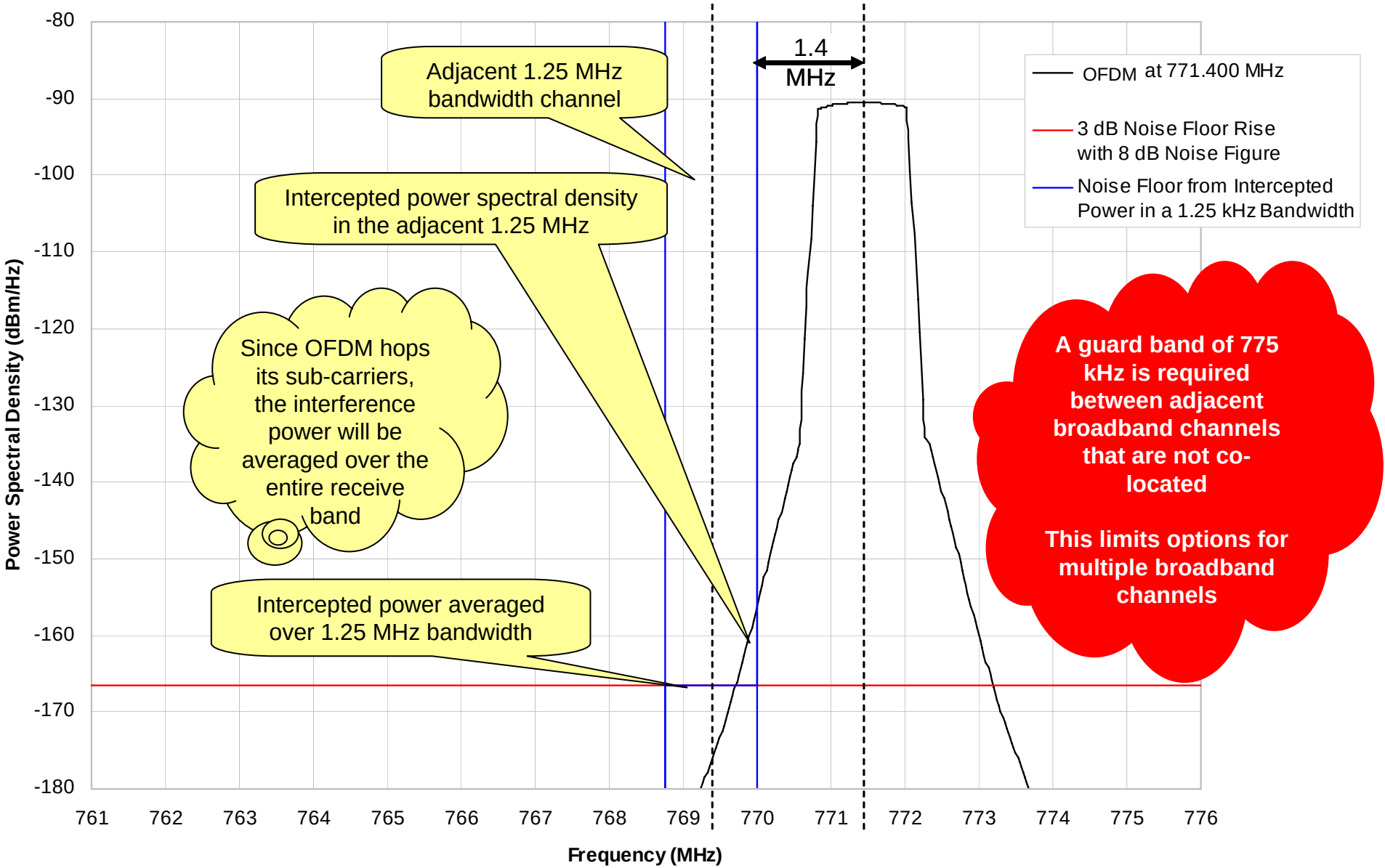
Guardband Between Broadband Channels not Co-located on Same Site



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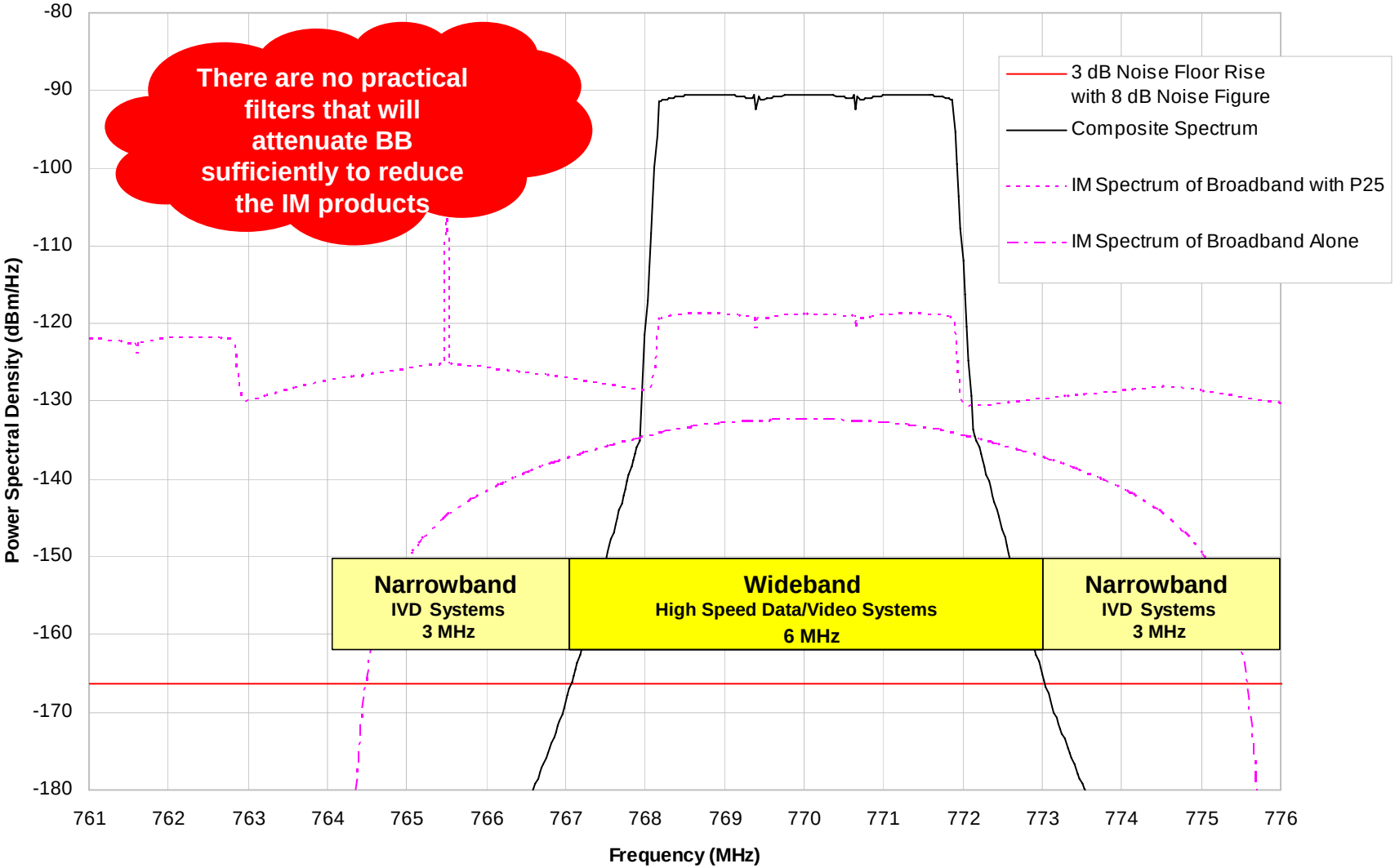
1.25 OFDM IM in PS Narrowband Receiver

Three 1.25 OFDM Carriers with 20 W TxP, 3 dB Filter Loss and 70 dB Site Isolation Each; P25 Carrier at -25dBm



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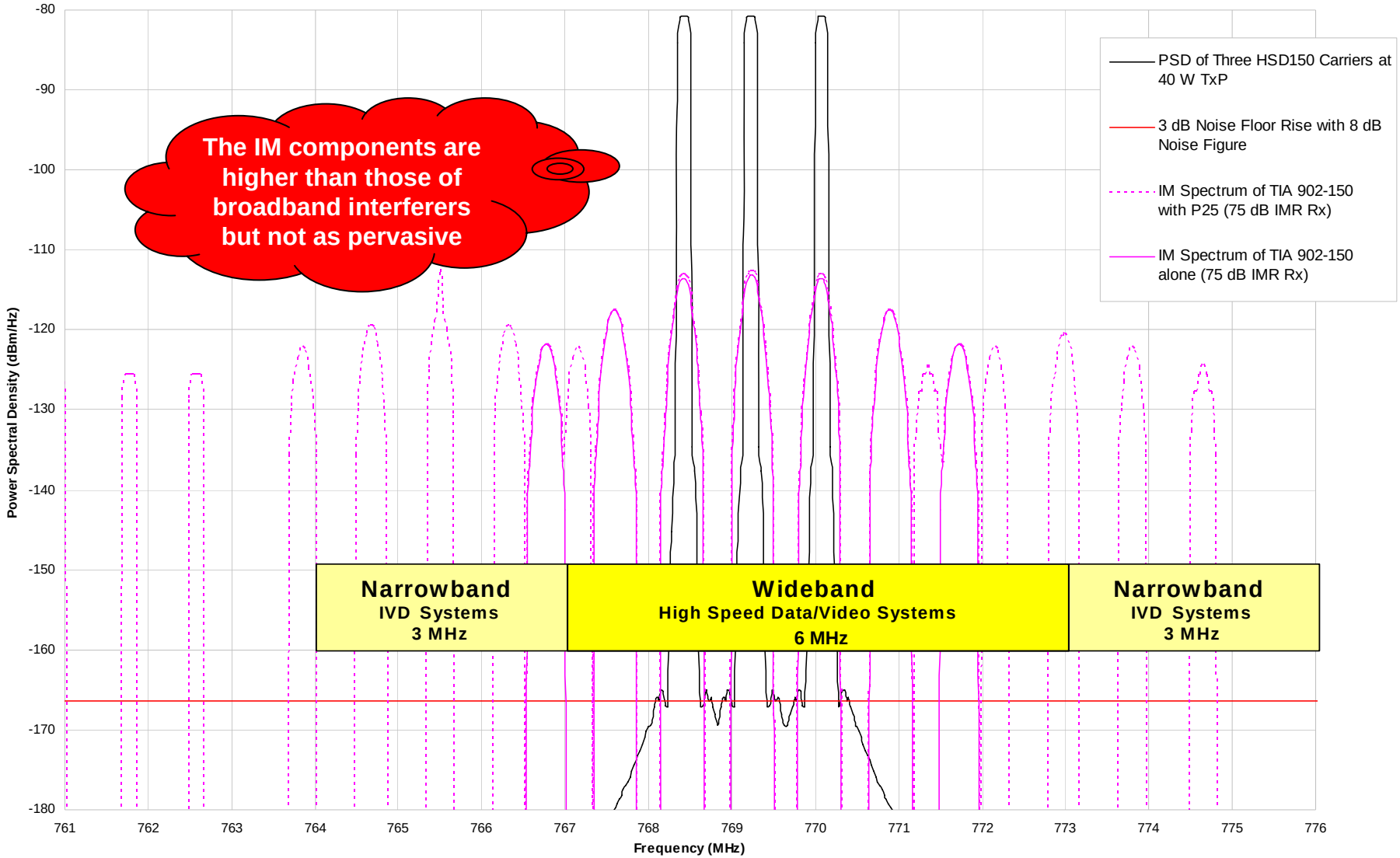
TIA-902 150 MHz IM in PS Narrowband Receiver

Three HSD150 40W TxPs, 70 dB Site Isolation; P25 Carrier at -25dBm



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Guardband Summary (page 1 of 2)

- **A 1 MHz guardband is needed between a 1.25 MHz BB channel and the narrowband channels**
- **A 250 kHz guardband is needed between a 150 kHz wideband channel and the NB channels, but better filtering can reduce to 125 kHz**
- **Co-locating data & voice sites where possible would minimize near-far interference problems and reduce need for guardband**
  - Because broadband requires many more sites than voice or wideband, only a small % of the sites could be co-located
  - Wideband requires fewer sites so the opportunities for co-location with voice sites is much greater
- **A guardband of approx. 1 MHz would also be needed between a 1.25 MHz BB channel and a wideband channel if they were not co-located**

Guardband Summary (page 2 of 2)

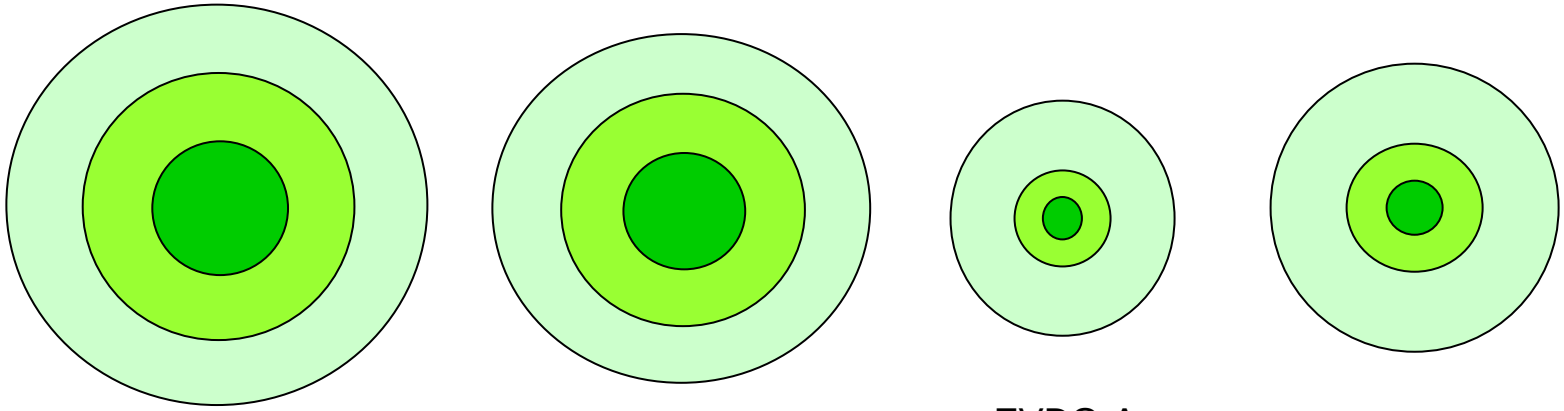
- **A guardband of about 775 kHz is needed between adjacent 1.25 MHz BB channels when they are not co-located with each other**

- **The potential for intermod (IM) interference spreads across the narrowband voice blocks regardless of guardband or technology**
  - BB intermod covers all voice channels whenever a given transmitter is keyed
  - WB intermod covers a small subset of voice channels when a given transmitter is keyed
  - WB intermod signals alone are generally higher level than BB intermod signals alone
  - A BB intermod mixing with a narrowband signal as experienced at 800 MHz will also have a high level

Technology Comparisons

- **Data Rates**
- **Coverage**
- **Costs**
- **Accommodating Multiple Types of Agencies**

Outbound Data Rate Performance



TIA 902 (SAM)
50 kHz

TIA 902 (SAM)
150 kHz

EVDO-A
1.25 MHz

802.16/WiMax
5 MHz

Peak User Speed [1]	**70K**	**290K**	**2,000K**	**2,000K+**
Ave. Channel Throughput [2]	**36K**	**145K**	**300K**	**600K**
Edge Speed [3]	**18K**	**76.8K**	**76.8K**	**76.8K**

[1] One user on channel, standing under antenna [2] Based on 50% inbound, N=1 for EVDO or 802.16 [3] 95% Reliability

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Technology Comparison Summary

- **Data rates:**
  - Data rates decline as you move away from site
  - Contour & User Speed Is As Critical As Peak Speed
  - The Public Safety 700 MHz band does not include sufficient spectrum to support ubiquitous MBPS speeds
- **Coverage/Cost:**
  - Higher data rates yield a penalty of less coverage per site and higher overall costs
- **Accommodating Multiple Types of Users**
  - Different Types of users are likely to require different data rate/coverage/cost options

Recommendations

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Summary Recommendations

- **Channelize reserve at 50 kHz for consistent plan across the band**
- **Relocate the 18 – 50 kHz wideband interop channels next to NB spectrum**
- **Establish a protection level for NB channels & WB interop channels : max 3 dB rise in noise floor**
- **Require TIA-902 SAM operation on the interop channels and capability in each WB & BB radio**
- **Continue to seek additional broadband solutions, i.e., additional public safety spectrum**
  - Placing BB in the upper 700 PS band has significant interference risks and capacity constraints
  - No more than 3 MHz of the 6 MHz could be usable for broadband; 2 MHz would be needed for guardband and 1 MHz for the interop channels.
  - Using the 6 MHz for wideband channels avoids wasting 1/3 of the spectrum for guardbands