SUMMARY REPORT
1755-1850 MHz
COMPARABLE BAND ASSESSMENT

March 30, 2011

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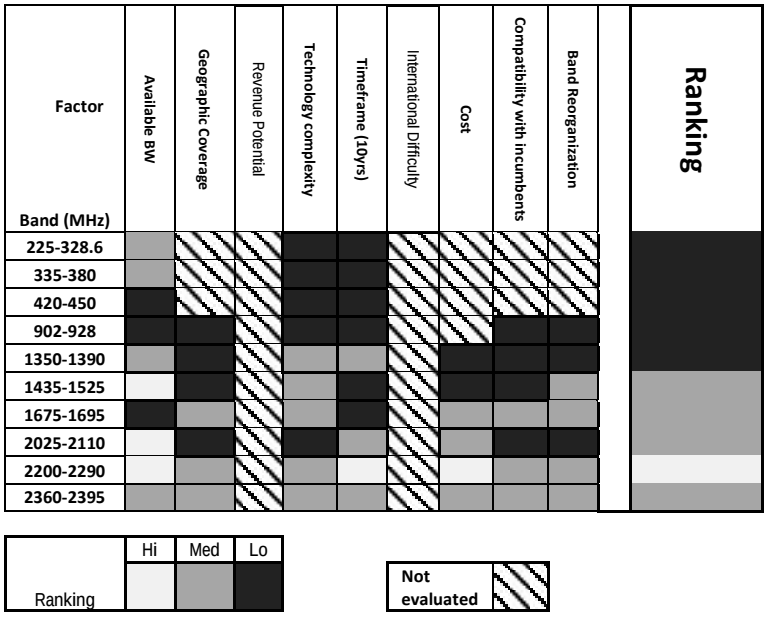
Executive Summary

The Department of Homeland Security (DHS) remains committed to supporting the President's Spectrum Initiative while maintaining capabilities to successfully execute its critical mission to protect our Nation's security and people. As part of the President's Spectrum Initiative, the National Telecommunications and Information Administration's (NTIA) Policy and Planning Spectrum Committee (PPSG) requested that Federal agencies conduct a preliminary evaluation of frequency bands for the relocation of operations utilizing the 1755-1850 Megahertz (MHz) band with a target evaluation completion of 1 April 2011. In support of this request, the Department of Homeland Security (DHS), working in concert with the NTIA and other Federal agencies, evaluated the candidate spectrum bands[1] and their potential to support the Department's mission. This document presents the preliminary evaluation of the 10 bands proposed.

As a result of this preliminary evaluation, the candidate bands in the spectrum below 1000 MHz were determined to be the least probable for relocation of operations due to the physical characteristics of the spectrum, e.g. noise, wavelength, Doppler shift, and the limited availability of replacement devices. The candidate bands in spectrum above 1000 MHz were evaluated for technical and operational viability with the 2200-2290 MHz, 2025-2110 MHz, 2360-2395 MHz, 1675-1695 MHz, and 1435-1525 MHz bands determined to present potential for relocation. While the bands present potential for relocating all or a portion of the current 1755-1850 MHz operations, each of the bands presents challenges associated with limited bandwidth and/or congestion of operations. These issues require detailed evaluation and identification of solutions prior to a transition of operations. It is recommended that further evaluation focus on the bands ranked as High or Medium in the summary figure below.



[1] The frequency bands identified by NTIA for evaluation were the 225-328.6, 335.4-380 MHz, 420-450 MHz, 902-928 MHz, 1350-1390 MHz, 1435-1525 MHz, 1675-1695 MHz, 2025-2110 MHz, 2200-2290 MHz, and 2360-2395 MHz bands.

Following this preliminary evaluation, DHS continues to recommend the approach submitted to the PPSG in January 2011. In this approach, DHS supported the thorough evaluation and detailed planning prior to any frequency band release. DHS continues to recommend the 1755-1780 MHz band be evaluated with a target for release within five years with detailed planning completed prior to release. Additionally, DHS continues to support the evaluation and subsequent detailed planning to relocate operations from the 1780- 1820 MHz spectrum with the 1820-1850 MHz band reserved for Federal only use until technologies and/or clearing of spectrum in other bands makes a full transition possible.

Current 1755-1850 MHz Utilization

Type of System, Number of Systems, and Number of Assignments by System type

DHS utilizes the 1755-1850 MHz band to support two distinct types of systems. The first system is a nationwide system of portable and mobile video surveillance devices that support Federal law enforcement investigations and protection details. The second system provides microwave data link connecting remote offices.

The mobile portable and mobile video system is used for covert and overt law enforcement operations in support of criminal investigations and protection details. The system is supported through the nation-wide deployment of thousands of devices, e.g. RF receivers, transmitters and repeaters[2]. DHS has authority on 21 United States and Protectorates (US&P) assignments in support of the Department's mobile video surveillance operations. Of the 21 assignments, seven replaced assignments that resulted from the 2007 exit of the 1710-1755 MHz band and augmented the Department's authorized assignments in the 1755-1850 MHz band for mobile video surveillance systems. These limited assignments support the thousands of transmitters and receivers deployed across the nation.

The second type of system is a fixed site microwave data-link system for transmission of data to and from field offices. This system operates on 25 spot assignments in the 1755-1850 MHz band and is located in Texas, Arizona, and Washington.

Type of assignment by system

To support the mobile covert video surveillance systems, the Department utilizes a limited number of channel assignments, 21, on a US&P basis. Transmitters are capable of operating on a subset of these channels, which are statically programmed into devices prior to deployment. This reuse of a limited set of channel assignments across the thousands of devices provides an efficient and effective means for re-use of scarce RF spectrum and a means to address localized interference issues.

To support the fixed microwave systems, the Department uses 25 spot assignments in the 1755-1850 MHz band.

Description of Operation

DHS operates two distinct types of systems in the 1755-1850 MHz band. The first system is a nationwide system of covert portable and mobile video surveillance devices that support Federal law enforcement investigations and protection details. The second

[2] Prior to 2007, the Department operated equipment across the 1710-1850 MHz band in support of its law enforcement mission. In 2007, the department identified more than 4000 portable mobile transmitter, receives and repeaters operating in the 1710-1755 MHz band that would have to be relocated to accommodate the transition. These devices were relocated and overlaid with operations in the 1755-1850 MHz band.

type of system is a fixed site microwave data-link system for transmission of data to and from field offices.

Covert Video Surveillance System Operation

The system is used for investigating criminal activities, protection of executive staff, and support for joint operations during major national events. The system operates nationwide and is composed of multiple transmitters, receivers and ancillary devices that collect, transport, and store video and audio evidentiary and intelligence information. The nature of the operations requires that the devices be highly concealable, portable, and be capable of rapid deployment.

The covert video system's operation falls into two primary categories:

- **Indoor Operations.** This operation centers on collect audio and video evidence at various types of locations (e.g., hotel rooms, offices, automobiles) during lawfully authorized investigations. Because of the operational nature of the investigations, the equipment used must be highly concealable, either on the body or within common room decorations. Further, the equipment must be designed to elude detection by both electronic and physical tools and methods so that neither the officer/agent nor the operation is jeopardized. In addition, the evidence collected must be protected from intercept during transmission to avoid exposing the operation, and it must be safeguarded during storage to conform to established evidentiary safeguarding guidelines.

  The operations are supported through the use of multiple pieces of equipment (e.g., small concealable video transmitters, portable/mobile receivers with recorders) that typically operate for short durations (usually 1-2 hours). The missions typically occur with little advance notice of the operation location, duration, or time of operation; therefore, the equipment must be highly mobile and rugged for rapid deployment.

  Operations typically require a single video transmitter statically RF linked to a single video receiver. The video transmitter consists of a small video camera, microphone, and radio frequency (RF) transmitter, each of which can be easily concealed. The transmitter's emissions are usually monitored and recorded by a receiver located nearby. The receiver usually consists of an RF receiver and video recorder that can be easily transported and installed in investigative equipment, such as surveillance vehicles. Current system transmitters, while capable of being programmed to operate on one of several channels, are simplex devices without capability to be reprogrammed during missions. This simplex operation is of concern to susceptibility to sporadic and unidentified interference at time of deployment.

- **Outdoor Operations.** This operation occurs in public areas and is focused on observation in public areas during major national events and during criminal investigations. The transmitting equipment must blend into the surroundings and must operate unattended for long periods of time while transmitting information

to receivers at remote collection locations. Information collected must be protected from intercept or corruption.

The operations are supported by multiple configurations of equipment (e.g., concealable video cameras and transmitters and portable/mobile receivers with recorders) that typically operate for long durations, usually weeks to months. The equipment operates at locations open to the environment; therefore, long-term exposure to the elements and limited access by law enforcement agents adds complexity to their design, operation, and maintenance. Transmitters are programmed in a similar manner to the indoor devices.

The covert video surveillance transmitters are typically low power (less than 1 watt) devices that are paired with nearby receivers that collect evidence and monitor activities for situational awareness. The transmitters are small, covert devices with omni-directional antennas. The receivers are small portable devices with omni-directional or low gain antennas.

Fixed Microwave Data link

Customs and Border Protection (CBP) operates several point-to-point microwave systems which provide a critical link for the various communications and surveillance technologies used by CBP field personnel. These wireless systems route communications media, voice from tactical radios, video imagery from remote video surveillance systems, and data from ground sensors to the key decision makers in central command and communications centers. The systems operate on a continuous basis. Transmitter powers vary from 2 to 10 watts with directional antenna gains from 28 to 33 dB. (See table below)

POWER IN WATTS	ANTENNA GAIN (dB)	EMISSION DESIGNATOR	POWER IN WATTS	ANTENNA GAIN (dB)	EMISSION DESIGNATOR
10.00	30	3M75D7W	3.00	31	1M60D7W
10.00	30	3M75D7W	10.00	30	3M75D7W
10.00	30	3M75D7W	10.00	30	3M75D7W
10.00	30	3M75D7W	3.00	31	3M20D7W
10.00	30	3M75D7W	3.00	30	3M75D7W
3.00	33	1M60D7W	3.00	28	1M60D7W
3.00	31	5M00W7D	3.00	31	5M00W7D
10.00	30	3M75D7W	10.00	30	3M75D7W
3.00	28	3M75D7W	3.00	31	1M60D7W
10.00	30	3M75D7W	3.00	31	1M60D7W
3.00	31	1M60D7W	10.00	28	3M75D7W
2.00	28	3M20F9W	10.00	30	3M75D7W
2.00	28	3M20F9W			

Geographical area location of assignments, assessment of time of operation

Covert Video Surveillance System Operation

DHS utilizes a limited number of US&P assignments to support more that 4000 portable and mobile systems deployed nationwide. The equipment and assignments support thousands of Federal law enforcement investigations on an annual basis. The investigative nature of the operation results in the equipment being employed where criminal activity occurs with the majority of the missions being in metropolitan areas. In addition, the nature of the missions leads to the equipment use being dynamic and centered on the covert collection of evidence during meetings with suspected criminals. The operations are typically short in duration, e.g. 1 to 2 hours, and occur at various locations in a dynamic manner. The rapid operational nature of the mission requires the equipment to be quickly deployable, highly mobile, and rugged for quick turn deployments. In addition the operations required the ability to address unforeseen RF interference issues at deployment.

The second type of video surveillance operation is centered on longer-term covert observation and collection of evidence at locations of suspected criminal activity. These operations require surveillance equipment blend into the surroundings and be capable of operating for long periods, e.g. months, while transmitting information to remote collection locations. The covert nature of the operations requires the equipment installation be inaccessible for long periods of time making addressing RF interference during deployment operationally challenging.

Fixed Microwave Data link

The Department maintains several microwave data links at fixed locations operating continuously (24/7). These systems operate on 25 spot assignments in the 1755-1850 MHz band and are located in Texas, Arizona, and Washington.

Characteristics of System Frequency Use

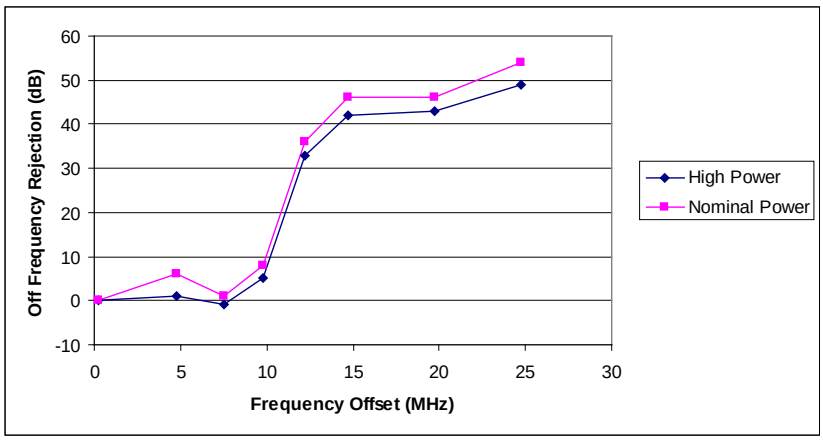
Covert Video Surveillance System Operation

The Department utilized 21 US&P channel assignments in support of its nationwide video surveillance operations. The channel assignments are located across the 1755-1850 MHz band and have channel bandwidths ranging from 6 MHz to 20 MHz with the majority of assignments being 6 MHz. The spread of channel assignments across the band provides field agents with the opportunity to address localized interference from potential operations by other agencies occurring within the vicinity of the operations. In addition, the multiple US&P channel assignments provides field agents the potential to avoid other potential harmful interference. The assigned bandwidth supports video and audio transmissions based on the National Television System Committee (NTSC) standards for analog television broadcast. The 6 MHz channel assignments provide sufficient bandwidth for RF transmission; however, the assignments provide insufficient protection from out of band interference.

The majority of the channel assignments were based on the NTSC "analog" standards without regard to out-of-band interference. In support of the 2007 exit from the 1710-1755 MHz, the NTIA, with support from DHS, DOJ, and commercial wireless carriers, conducted an evaluation of potential interference to analog video surveillance systems from commercial transmitters. The results of the evaluation were documented in the ASSESSMENT OF THE POTENTIAL INTERFERENCE FROM ADVANCED WIRELESS SERVICE HANDSETS TO VIDEO SURVEILLANCE SYSTEMS OPERATING IN THE 1710-1755 MHz BAND. The resulting recommendation was for commercial transmitters to limit operation to no closer than 15 MHz to DHS systems and no closer than 20 MHz to DOJ systems.

To address this potential interference and the anticipated demand for improved spectrum use, the Federal law enforcement community undertook efforts to identify more robust and spectrally efficient technologies. The result of this effort was the identification of the ETSI-based CODFM technologies for future deployments. The COFDM systems provide improved interference rejection and the potential to improve spectral efficiency through advanced video coding technologies. Federal agencies are currently transitioning operation to these technologies and the vendor communities are working to improve devices and technologies.

The COFDM technologies provide an improvement out-of-band rejection compared to analog technologies. Where the 2007 NTIA study measured analog video receivers out of band rejection of commercial transmitters to be approximately 10 dB at 10 MHz offset and approximately 45-50 dB for greater frequency offsets (see figure below), recent manufacturer data indicates the CODFM devices provide improved rejection of 35 dB at 10 MHz offset and rejection of 60 dB to signals greater than 15 MHz from the receiver center frequency. While this is not a direct comparison due to the differing test set-ups, it is an indication that improved rejection to interference should be expected from the COFDM devices.



NTIA Measured Out of Band Rejection

Furthermore, the COFDM technologies selected by the community is based on a 2000 carrier ETSI standard system that provides high quality transmission in less than 8 MHz of occupied bandwidth. The vendor community is making available devices operating on

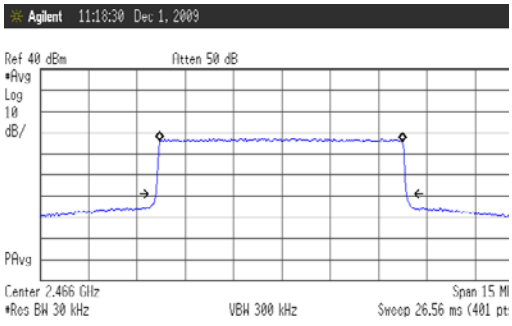
400 carrier formats that occupy 2.5 MHz of bandwidth and are developing 400 carrier devices that operate in 1.25 MHz bandwidth. While this is encouraging for increased spectral efficiency, these systems have yet to be evaluated for full operational readiness. Of concern is the potential limitation and degradation to video quality resulting from reductions in data throughput required to operate in a much narrower channel bandwidth. In addition, of concern is the degradation to RF system performance if higher levels of modulation and/or error correction coding are used to compensate for reduced RF channel bandwidth. If increased modulation levels and/or error correction coding were used, the ETSI standards for DVB-T indicate (see figure below) that increased C/N levels would be required, resulting in reduced system interference rejection and/or requirements to increase transmitter RF power.

		Required C/N (dB) for BER = 2×10^{-4} after Viterbi QEF after Reed-Solomon (see note 2)			Bitrate (Mbit/s) (see note 3)			
Constel-lation	Code rate	Gaussian Channel (AWGN)	Ricean channel (F_1)	Rayleigh channel (P_1)	Δ/T_U = 1/4	Δ/T_U = 1/8	Δ/T_U = 1/16	Δ/T_U = 1/32
QPSK	1/2	*3,5*	*4,1*	*5,9*	*4,98*	*5,53*	*5,85*	*6,03*
QPSK	2/3	*5,3*	*6,1*	*9,6*	*6,64*	*7,37*	*7,81*	*8,04*
QPSK	3/4	*6,3*	*7,2*	*12,4*	*7,46*	*8,29*	*8,78*	*9,05*
QPSK	5/6	*7,3*	*8,5*	*15,6*	*8,29*	*9,22*	*9,76*	*10,05*
QPSK	7/8	*7,9*	*9,2*	*17,5*	*8,71*	*9,68*	*10,25*	*10,56*
16-QAM	1/2	*9,3*	*9,8*	*11,8*	*9,95*	*11,06*	*11,71*	*12,06*
16-QAM	2/3	*11,4*	*12,1*	*15,3*	*13,27*	*14,75*	*15,61*	*16,09*
16-QAM	3/4	*12,6*	*13,4*	*18,1*	*14,93*	*16,59*	*17,56*	*18,10*
16-QAM	5/6	*13,8*	*14,8*	*21,3*	*16,59*	*18,43*	*19,52*	*20,11*
16-QAM	7/8	*14,4*	*15,7*	*23,6*	*17,42*	*19,35*	*20,49*	*21,11*
64-QAM	1/2	*13,8*	*14,3*	*16,4*	*14,93*	*16,59*	*17,56*	*18,10*
64-QAM	2/3	*16,7*	*17,3*	*20,3*	*19,91*	*22,12*	*23,42*	*24,13*
64-QAM	3/4	*18,2*	*18,9*	*23,0*	*22,39*	*24,88*	*26,35*	*27,14*
64-QAM	5/6	*19,4*	*20,4*	*26,2*	*24,88*	*27,65*	*29,27*	*30,16*
64-QAM	7/8	*20,2*	*21,3*	*28,6*	*26,13*	*29,03*	*30,74*	*31,67*

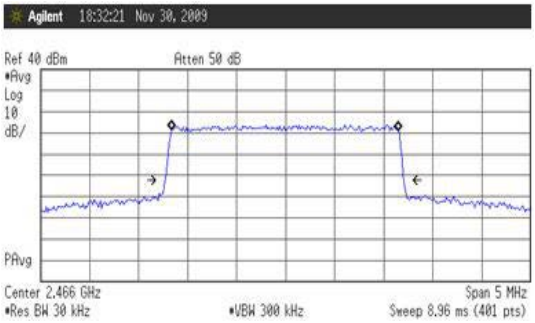
NOTE 1: Figures in italics are approximate values.
NOTE 2: Quasi Error Free (QEF) means less than one uncorrected error event per hour, corresponding to BER = 10^{-11} at the input of the MPEG-2 demultiplexer.
NOTE 3: Net bit rates are given after the Reed-Solomon decoder.

ETSI C/N for standard modulation and coding rates (EN 300 744)

The COFDM transmitter spectral mask is improved significantly compared to legacy NTSC based system. This improvement in the spectral mask points to the potential for improved channel separation as well as physical proximity; however, analysis and evaluation is needed to determine operational guidelines. The figures below present typical 8 MHZ and 2.5 MHz transmitter spectral mask.



COFDM 8 MHz Mode Transmitter Spectrum



COFDM 2.5 MHz Mode Transmitter Spectrum

In considering interference avoidance, current system transmitters, while capable of being programmed to operate on one of several channels, are not reprogrammable during missions. This characteristic leads to the potential for susceptibility to sporadic and unidentified interference at time of deployment raising concerns for officer/agent safety and mission success.

Comparable Band Evaluation Methodology

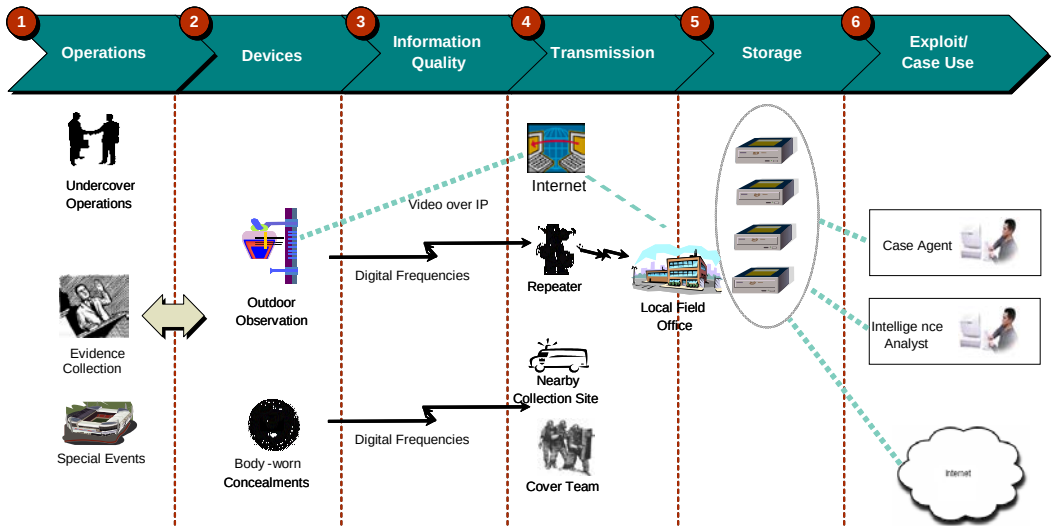
In evaluating the potential for relocating operations to the NTIA's proposed frequency bands, the Department leveraged the methodology used in analyzing technical and operational impacts from the release of 1710-1755 MHz spectrum to ascertain the achievement of comparable capabilities. The Department applied an operations-driven model to compare current and post transition operational capabilities. The model is based on the premise that, regardless of the technology, the Department should be able to maintain operations comparable to current operations. The model takes into consideration multiple technical and operational factors and focuses on the operational mission. In addition, the model assist in identifying areas where there is the potential to improve the efficiency and effectiveness of the operations.

Model Comparability Measures Overview

Current operational and technical capabilities were benchmarked and compared to operational performance for each of the proposed bands. Within each capability a series of key metrics were defined and comparability measures were considered across the video surveillance value chain. This simple model assisted in decoupling the multiple aspects of the technical and operational aspects in the determination of the similarity of capability. The individual metrics were then evaluated in accordance with the NTIA provided evaluation key.

The model below groups DHS surveillance operations into six main areas: Operations, Capture (Devices), Information Quality, Transmission, Storage, and Exploit/Case Use. By grouping operations into clearly defined segments, the agency can quantify and compare impacts to operations better and apply output/outcome-based metrics to selected approaches. The subsequent analysis allowed the agency to measure the preferred solution against pre-transition capabilities. The categories are discussed in detail below.

Video Surveillance Operational Chain



Operational Measures

	Post-Relocation Metrics	Comparability Measures
Devices	Are there replacement devices and do they provide similar performance with respect to form, fit, and function?	• Device size • DC power • Weight
Information Quality	Will the video/data quality and integrity support investigations and cases?	• Video quality • Audio quality • Susceptibility to Interference
Transmission	Does the surveillance data transmission support a number of locations and numbers of people similar to that supported currently, without compromising agent safety?	• Device physical separation and other system interference (protect agent safety)
Storage	Is the video storage capacity similar to the current systems?	• Number of storage devices • Recording time and quantity of information • Size of storage media • Storage life
Exploit/ Case Use	Is the surveillance data available for use and analysis in a similar manner as today?	• Search functionality • Data transfer/sharing techniques • Storage format
Operations	Will the relocation of operations to the band support a number of operational missions as current?	• Total number of system devices • Number of available operating channels • Potential for interference and detection • Compatibility among law enforcement agencies

- ***Devices.*** This category compares the design specifications for devices (e.g., body-worn concealment, outdoor observation) that are required to accomplish the components operational mission and that affect operational utility (e.g., size, weight, power). For example, body-worn covert devices are physically small and impacted by operating RF wavelength.

- ***Information Quality.*** This category considers the clarity of information received. For example, full motion video is essential to investigations where officer/agent safety is at risk. In other cases (e.g., building exterior monitoring), the operation may accept video at a degraded refresh rate. RF bandwidth limitations in proposed bands may reduce possible frame rates.

- ***Transmission.*** This category considers the flow of data from end-point to end-point. More specifically, this category focuses on the transmission of information from the capture devices (e.g., cameras, microphones) to a receiving point or receiving points. The receiving point is typically a short distance from the collection point, such as a

surveillance vehicle or a cover team. However, the information may be retransmitted through a microwave repeater or over commercial services to a local field office.

- ***Storage.*** This category considers the impacts of technology selection on the evidentiary storage requirements and the associated storage devices (e.g., DVD, DVRs, and hard drives).

- ***Exploit/Case Use.*** This category addresses the capabilities of case agents and analysts to search, share, analyze, and move collected evidence. Regardless of the type of operation, the collected information must meet law enforcement guidelines to fulfill the chain of custody requirements and ensure that the evidence will be admissible in court.

- ***Operations.*** This category addresses the number and type of operations conducted by the agency. As discussed earlier, the components perform undercover evidence collection and support joint operations during major national events. The category focuses on metrics centered on the agency's ability to support of these missions.

Capability Analysis

DHS documented the comparability measures analysis in a series of capability tables that assessed each of the areas of the operational model. For each key comparability measure, the capability table detailed the capability evaluation and capture comments regarding the capability. Qualitative comparison of the current and resulting operational capabilities were evaluated using the NTIA evaluation key below.

Evaluation Key Descriptors				
Value	Technical	Operations	Cost	Time
⇧	Not a Factor	Improved Operations	≤ $ 500M	≤ 10 Years
⇗	Minor Factor	Similar Operations	$ .5B < ( ) ≤ $1.5B	10 < ( ) ≤ 15
⇨	Difficult but Achievable	Slightly Degraded	$ 1.5B < ( ) ≤ $5B	≈ 15 Years
⇘	Significant Obstacles	Significant Degradation	5 < ( ) ≤ $15B	15 < ( ) ≤ 20
⇩	Success Questionable	Irreparable Degradation	> $ 15B	> 20 Years

NTIA Evaluation Key

Devices Review

The Department is currently migrating video surveillance systems to digital format system based on Digital Video Broadcast standards that utilize COFDM technologies. For consistency across all bands, the key parameters of the devices were those of COFDM devices and did not include legacy analog devices. More specifically, DHS

used the general categories of physical size, weight, and DC power in evaluating device impacts to operating in alternate frequency bands.

Video Surveillance Devices

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size				
	Weight				
	DC Power				

Information Quality Review

The quality of information obtained is a critical factor for use in investigations and criminal prosecutions. Impacts to the quality of the information could have a significant impact on the viability of the proposed frequency band. For example, if the channelization of the band were limited to a level to significantly reduce the resolution of the video and/or the video refresh rate, then the band would present a significant reduction to current capabilities. In analyzing the bands, we selected key parameters impacting information quality including frames per second, video resolution, and audio quality.

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference				
	Video Quality				
	Audio Quality				

Transmission Review

The RF transmission and the surrounding interference is a key factor in evaluating the bands. To ascertain the bands viability, the anticipated physical separation of the system's transmitters and receivers as well as the required separation from incumbent systems was evaluated.

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver				

	Minimum separation of shared system transmitter/ receiver				

Operations Review

The operational view considered key critical measures of current front end RF operational capability in the 1755-1850 MHz. More specifically, DHS used the general categories of number of available channels, bandwidth of channel, Number of systems supportable, and compatibility of the systems with other law enforcement agencies as measures for comparison.

Video Surveillance Operations

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Operations	No. of available operating channels				
	No. of "systems"				
	Compatibility with other law enforcement agencies				

Storage Review

DHS also considered impacts to the back end of the evidence collection systems that may be overlooked in a pure front end RF operational capability view. More specifically, DHS considered the impacts to the collection and storage of evidence. For example, if relocating to alternate bands required multiple cameras with multiple video streams to obtain a comparable level of video information, the result would be that operations are impacted by the need to operate, store and maintain additional secure storage devices.

Video Surveillance Storage

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Storage	No. of storage devices				
	Recording Time				
	Size of storage				
	Shelf life of recordings				

Exploit/ Case Support Review

DHS considered operational impacts to the use of evidence collected. More specifically, DHS considered the impacts to the formats of information required and the ability to

timely search for information. For example, if relocating to an alternate band required multiple formats be accommodated to support the various bandwidths available and the ability to search the information gathered increased, the result would be an impact to operations.

Video Surveillance Exploit/Case Support

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Exploit/ Case Use	Data transfer/ Sharing formats				
	Search Functionality				
	Data storage format				

Evaluation of Potential Bands

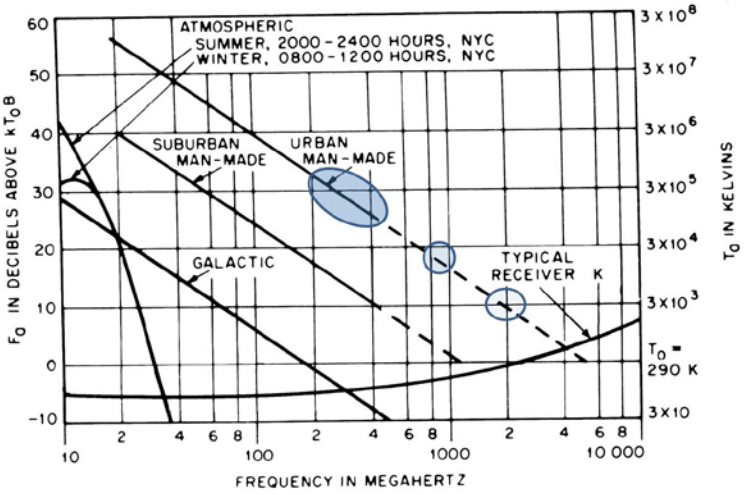
225-328.6 MHz

Technical	Operational	Cost	Time	Rank
⇩	NA	NA	NA	LO

Summary

This band was evaluated for technical viability only; operational impacts were not evaluated in detail due to the technical challenges presented.

The extreme low frequency of the band presents several challenges that would need to be addressed prior to a full migration of operations. The impacts on device and antenna size resulting from the approximately nine times increase in RF wavelength would need to be addressed. A more significant issue is the impact of the RF environment on digital modulation format changes to support the high data rates for video transmission provided in the 1755-1850 MHz band. Relocating operation to these lower frequencies would require a detailed evaluation and potential modification to the RF modulation and data format of the system to address the RF channel characteristics associated with the change in Doppler and dispersion characteristics. In addition, the approximately 20 dB increase in man-made noise in urban environments would need to be addressed. It is unclear how this 100 times increase in noise would be overcome to provide similar operational capabilities.



Noise versus Frequency from ITT Radio Engineer's Handbook

Technical Considerations

(Limitations on performance, Attributable to technical or technology shortcomings)

Devices Evaluation

The extreme low frequency of the band presents several challenges for device design including antenna size resulting from the nine times increase in RF wavelength, hardware and software modifications to address the RF environment impacts on digital modulation format changes and increased man-made noise in urban environments.

Video Surveillance Devices

	Capability Measure	Current Operational Capability[3]	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size	• Covert TX: 14 cubic inches	• Covert TX: Antenna size increase significant	⇩	May need to increase to address background noise issues and channel coding revisions
		• Outdoor TX: 17 cubic inches	• Outdoor TX: Antenna size increase significant	⇩	May need to increase to address background noise issues and channel coding revisions
		• Receiver: 60 cubic inches	• Receiver: Antenna size increase significant	⇩	May need to increase to address background noise issues and channel coding revisions
	Weight	• Indoor TX: 13 oz	• TBD	⇩	May need to increase to address background noise issues and channel coding revisions
		• Outdoor TX: 13 oz	• TBD	⇩	May need to increase to address background noise issues and channel coding revisions
		• Receiver: 59 oz	• TBD	⇩	May need to increase to address background noise issues and channel coding revisions
	DC Power	• Indoor TX consume 11 watts per 250 milliwatts RF output	• TBD	⇩	May need to increase to address background noise issues and channel coding revisions
		• Outdoor TX consumes 18 watts per 1 watt RF output	• TBD	⇩	May need to increase to address background noise issues and channel coding revisions

[3] Current device physical measures are from previous DHS evaluations for the 1710-1755 MHz band exit under HSHQDC-08-J-0018.

Information Quality Evaluation

The extreme deviation from frequencies utilizing with current video surveillance systems presents concerns associated with the RF environment impacts on possible digital modulation format and coding changes and the increase in man-made noise in urban environments.

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	• Modulation needs to be standardized for band	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading
	Video Quality	• DVB-T 8 MHz quality	• Modulation needs to be standardized for band	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading
	Audio Quality	• MPEG II	• Modulation needs to be standardized for band	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading

Transmission evaluation

Relocating operation to these lower frequencies raises concerns with the need to modify the RF modulation and data format of the system to address the RF channel characteristics including dispersion characteristics and man-made noise.

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver	• Devices operating in the L-band occupying 6 to 8 MHz of bandwidth with 15 to 20 MHz channel spacing required	• Modulation needs standardized in band • Increase in man-made noise	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading
	Minimum separation of shared system transmitter/ receiver	• Systems in band well established	• TBD		

Technical solutions required to overcome such limitations

Significant technology developments in not only equipment but also transmission protocols are required to address the low frequency effects.

State of availability and maturity of the technology necessary to transition

Technology currently not available

Mitigation options available

TBD

The preferred technical solution to overcome any performance limitations related to technology and the reasons why

TBD

Operational Considerations

Technology complexities would need to be addressed prior to addressing operation issues

335.5-380 MHz

Technical	Operational	Cost	Time	Rank
⇩	NA	NA	NA	LO

Summary

This band was evaluated for technical viability only; operational impacts were not evaluated due to the technical challenges.

The extreme low frequency impacts to reasonable antenna solutions, the need to standardize the modulations in the bands to accommodate the changes from Doppler shift, RF channel characteristics, urban noise, and the lack of commercially available devices in this band makes it an unlikely candidate. In addition, the operational challenges in transitioning the Department's operations to the band were determined to be sufficiently large to suggest limiting evaluation to other higher potential bands.

Technical Considerations

(Limitations on performance, Attributable to technical or technology shortcomings)

Devices Evaluation

The extreme low frequency of the band presents several challenges for device design including antenna size resulting from the increase in RF wavelength, hardware, and software modifications to address the RF environment impacts on digital modulation format changes and increased man-made noise in urban environments.

Video Surveillance Devices

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size	• Covert TX: 14 cubic inches	• Covert TX: Antenna size increase significant	⇩	
		• Outdoor TX: 17 cubic inches	• Outdoor TX: Antenna size increase significant	⇩	
		• Receiver: 60 cubic inches	• Receiver: Antenna size increase significant	⇩	
	Weight	• Indoor TX: 13 oz	• TBD		
		• Outdoor TX: 13 oz	• TBD		
		• Receiver: 59 oz	• TBD		

	DC Power	• Indoor TX consume 11 watts per 250 milliwatts RF output	• TBD		
		• Outdoor TX consumes 18 watts per 1 watt RF output	• TBD		

Information Quality Evaluation

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	• Modulation needs to be standardized for band	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading
	Video Quality	• DVB-T 8 MHz quality	• Modulation needs to be standardized for band	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading
	Audio Quality	• MPEG II	• Modulation needs to be standardized for band	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading

Transmission evaluation

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver	• Devices operating in the L-band occupying 6 to 8 MHz of bandwidth with 15 to 20 MHz channel spacing required.	• TBD	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading
	Minimum separation of shared system transmitter/ receiver	• Systems in band well established and know	• TBD		

Technical solutions required to overcome such limitations

Significant technology developments in not only equipment but transmission protocols to address the low frequency effects

State of availability and maturity of the technology necessary to transition

No known technology currently available

Mitigation options available

TBD

The preferred technical solution to overcome any performance limitations related to technology and the reasons why

TBD

Operational Considerations

Technology complexities would need to be addressed prior to addressing operation issues

420-450 MHz

Technical	Operational	Cost	Time	Rank
⇩	NA	NA	NA	LO

Summary

This band was evaluated for technical viability only; operational impacts were not evaluated in detail due to the technical challenges with operating in this band.

The low frequency impacts to reasonable antenna solutions, the need to standardize the modulations in the bands to accommodate the changes from Doppler shift, RF channel characteristics, urban noise, and the lack of commercially available devices in this band makes it an unlikely candidate. In addition, the operational challenges in transitioning the Department's operations to the band were determined to be sufficiently large to suggest limiting evaluation to other higher potential bands.

Technical Considerations

(Limitations on performance, Attributable to technical or technology shortcomings.)

Devices Evaluation

The extreme low frequency of the band presents several challenges for device design including antenna size resulting from the increase in RF wavelength, hardware and software modifications to address the RF environment impacts on digital modulation format changes and increased man-made noise in urban environments.

Video Surveillance Devices

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size	• Covert TX: 14 cubic inches	• Covert TX: Antenna size increase significant	⇩	
		• Outdoor TX: 17 cubic inches	• Outdoor TX: Antenna size increase significant	⇩	
		• Receiver: 60 cubic inches	• Receiver: Antenna size increase significant	⇩	
	Weight	• Indoor TX: 13 oz	• TBD		
		• Outdoor TX: 13 oz	• TBD		
		• Receiver: 59 oz	• TBD		

	DC Power	• Indoor TX consume 11 watts per 250 milliwatts RF output	• TBD		
		• Outdoor TX consumes 18 watts per 1 watt RF output	• TBD		

Information Quality Evaluation

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	• Modulation needs to be standardized for band	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading
	Video Quality	• DVB-T 8 MHz quality	• Modulation needs to be standardized for band	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading
	Audio Quality	• MPEG II	• Modulation needs to be standardized for band	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading

Transmission evaluation

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver	• Devices operating in the L-band occupying 6 to 8 MHz of bandwidth with 15 to 20 MHz channel spacing required.	• TBD	⇩	Frequency impacts to digital transmission format. e.g. Doppler and fading
	Minimum separation of shared system transmitter/ receiver	• Systems in band well established and know	• TBD		

Technical solutions required to overcome such limitations

Significant technology developments in not only equipment but transmission protocols to address the low frequency effects

State of availability and maturity of the technology necessary to transition

No known technology currently available

Mitigation options available

TBD

The preferred technical solution to overcome any performance limitations related to technology and the reasons why

TBD

Operational Considerations

Technology complexities would need to be address prior to address operation issues

902-928 MHz

Technical	Operational	Cost	Time	Rank
↘	NA	NA	NA	LO

Summary

The NTIA data identifies over 17,500 assignments of government assets with approximately 170 of the assignments US&P status in the 902-928 MHz band. The 20 MHz limited bandwidth and the significant number of incumbent assignments presents limited options for migrating all video surveillance from the 1755-1850 MHz band. In addition, there are significant obstacles presented by the low frequency for antenna and device design. Sharing arrangements would require significant efforts and the reduction of available bandwidth limits the utility of this band. In addition, the physical performance perspectives of the band make it a low ranking candidate.

The band is approximately 50 percent below that of the current 1755-1850 MHz range. In addition to the increased antenna length requirement, the overall device characteristics are estimated to be close to current equipment, resulting in limited DC power and weight impacts[4]. The greater concern with migrating to the band is the reduction of available spectrum and the potential for interference with the number of systems currently occupying the band.

Technical Considerations

(Limitations on performance, Attributable to technical or technology shortcomings.)

The difference in wavelength of signals in the 902-928 MHz band compared to those in the 1755-1850 MHz band makes its physical characteristics less suitable for supporting current law enforcement covert operations/missions. In addition, the limited spectrum (20 MHz) and the number of incumbent systems restrict the level of operations which may be supported in the band.

Devices Evaluation

This analysis compared currently available digital video devices to digital devices potentially operating in the 902-928 MHz band. More specifically, DHS compared the general categories of physical size, weight, and power based on an average of those characteristics of available devices. Overall, the digital equipment had comparable capabilities, with the exception of antenna size and minor requirements to modify the systems for operation to the proposed band.

[4] Estimate is based on commercial cellular device technologies that operate in the similar bands.

Video Surveillance Devices

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size	• Covert TX: 14 cubic inches	• Covert TX: Antenna size issues	⇩	Increase in antenna size and/or device matching circuits required
		• Outdoor TX: 17 cubic inches	• Outdoor TX: Antenna size issues	⇩	Increase in antenna size and/or device matching circuits required
		• Receiver: 60 cubic inches	• Receiver: Antenna size issues	⇩	Increase in antenna size and/or device matching circuits required
	Weight	• Indoor TX: 13 oz	• TBD		
		• Outdoor TX: 13 oz	• TBD		
		• Receiver: 59 oz	• TBD		
	DC Power	• Indoor TX consume 11 watts per 250 milliwatts RF output	• TBD		
		• Outdoor TX consumes 18 watts per 1 watt RF output	• TBD		

Information Quality Evaluation

The analysis of the information quality compared 8 MHz COFDM quality available in the channel assignments in the 1755-1850 MHz band to 2.5 MHz mode CODFM that would be required for operation in the 902-928 MHz band. The 2000 carriers used in the 8 MHz CODFM would be reduced to 400 resulting in reduced equivalent frames per second and video resolution; however, the audio bandwidth is not believe to be impacted due to its low bandwidth requirement. The reduction in available bandwidth and the impacts on the quality of information are major impacts to the equipment design that would have to be overcome before migration of all operations to the 902-928 MHz band.

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	• 400 carrier signal provides reduced rejection to localized narrowband interference	⇘	Factor of 5 reduction
	Video Quality	• DVB-T 8 MHz quality	• 2.5 MHz quality	⇘	Lower available bandwidth results in reduced video resolution
	Audio Quality	• MPEG II	• MPEG II	⇧	Similar to current devices

Transmission evaluation

The evaluation of the RF transmission suggests a relocation of operations to 902-928 MHz would increase the potential for interference with similar video type devices and systems currently operating in the spectrum.

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver	• Devices operating in the L-band occupying 6 to 8 MHz of bandwidth with 15 to 20 MHz channel spacing required.	• Move would require narrow-banded devices	↘	Minimum separation of similar transmitter/ receiver
	Minimum separation of shared system transmitter/ receiver	• Systems in band well established	• Move would require identifying current systems for avoidances	⇨	Minimum separation of shared system transmitter/ receiver

Technical solutions required to overcome such limitations

Technical solutions to overcome limitations will require significant reduction of available bandwidth on video quality. The solution should also provide intelligent avoidance of harmful interference among the systems sharing the spectrum.

State of availability and maturity of the technology necessary to transition

Manufactures are currently offering video systems that operate in 2.5 MHz of bandwidth and are developing 1.25 MHz bandwidth systems. These reduced bandwidth systems would required detailed evaluation before any transition of operations by the law enforcement community. In addition, the development of technologies for the intelligent avoidance of interference that may be required to address the congestion in the band is less clear and an area of potential development focus.

Mitigation options available

The limited available bandwidth limits options for a full migration to the band. Possible migration of a portion of the operations in concert with a reduction of operations in the 1755-1850 MHz band may be possible.

The preferred technical solution to overcome any performance limitations related to technology and the reasons why

The preferred technical solutions are centered on the issues resulting from the reduction in total available bandwidth on the quality of video collection and the potential for interference among the systems.

Operational Considerations

Technology complexities would need to be addressed prior to addressing operation issues.

1350-1390 MHz

Technical	Operational	Cost	Time	Rank
↘	↘	⇨	↗	LO

Summary

The 1350-1390 MHz band presents a limited option for migrating all video surveillance from the 1755-1850 MHz band. Significant obstacles to overcome before utilizing the band include addressing the limited bandwidth (40 MHz total compared to 95 MHZ) and the relocation or sharing of operations with incumbent services, e.g. radiolocation service systems[5]. Of primary technical concern is the potential interference from the incumbent high power/high bandwidth radar transmitters (Up to 258 MW power/10 MHz BW) on the video surveillance receivers. While the COFDM video systems provide some protection to pulsed interference through the use of block forward error correction (FEC) coding, the system's symbol block lengths are relatively short. The duration of radar pulse interference may be sufficient to corrupt an entire symbol block negating FEC improvements.[6] Transmitter power, bandwidth, pulse duration, and geographic separation need to be considered. Since video systems are predominantly operated within or in very close proximity to major metropolitan areas but operate in rural areas as well, evaluation of the potential interactions between the video and radar systems would be required to determine required physical separation, frequency separation and power limits as well as operational modifications before a full operational transition could occur.

The band is approximately 24 percent lower in operating frequency compared to the current 1755-1850 MHz range presenting the potential for slight improvements in receiver (RX) and transmitter (TX) separation (31 percent) or reduce RF transmitter power (approximately 2.4 dB) assuming a larger antenna for a given physical separation.[7] Unfortunately, the benefits of increased RX/TX separation or reduced RF-TX power are tempered by the necessity to increase the physical size of the transmitter antenna to maintain antenna matching characteristics, reducing the covertness of the devices. With the exception of an increased antenna length requirement, the overall device characteristics are estimated to be sufficiently close to current equipment, resulting in

[5] GMF identifies 593 assignments for various transmitters with power up to 258 Megawatts and applications such as radar test beds, UAV control, and air traffic control. This is in contrast to the 1755-1850 MHz band which has approximately 3150 assignments with the majority of transmitters being low power (< 10 watt) devices and those of significant power being associated with high gain (approx 40 dB) directional antennas for space telecomm and.

[6] DISA JSC Communications Receiver performance Degradation Handbook 7.4 TEMPORAL FLUCTUATIONS "If an undesired signal is intermittent, bit errors tend to be more numerous during the interference dwells, and less numerous between the dwells. If the interference is of sufficient strength and duration, the FEC decoder may be overloaded and the BER may approach ½ during a dwell, which means the decoder output is completely random."

[7] Propagation model used ITS model for propagation loses employed in AWS interference analysis 2007.

limited DC power, size, and weight impacts. The greater concern with migrating to the 1350-1390 MHz band is the potential interference from systems currently occupying the band. As identified for current operations in the 1755-1850 MHz band, legacy video surveillance systems require 15 to 20 MHz receiver to interfering transmitter to avoid harmful interference. Digital encoding techniques employed in currently available digital video systems have further advanced the receiver selectivity to the point where it is estimated the channel separation possibly may be reduced to 5 to 6 MHz. While these technology developments have the potential to reduce the need for spectrum, the significant reduction of the current available 95 MHz bandwidth in the 1755-1850 MHz band to the 40 MHz made available in this band makes the potential to relocate all operations unlikely.

In addition, while technology developments allowing intelligent sharing of the frequencies may be possible, the potential increased size of transmitting devices and the reduction of available bandwidth presents challenges that would need to be considered in detail before selecting this band for full relocation.

Technical Considerations

(Limitations on performance, Attributable to technical or technology shortcomings.)

The separation of the 1350-1390 MHz band from the 1755-1850 MHz band makes its physical characteristics increasing less suitable to support current law enforcement covert operations/missions. As the wavelength of the operating frequency increases so does the physical size of the radiating structure if comparable RF and DC power levels are to be maintained. While these issues may not be insurmountable, significant technology development to redesign systems to operate in this band would be required. A more significant challenge would be in addressing the reduction in available bandwidth on information quality and potential interference from incumbent radar operations.

Devices Evaluation

This analysis compared digital video devices to possible devices operating in the 1350 to 1390 MHz band. More specifically, DHS compared the general categories of physical size, weight, and power based on an average of those characteristics of available devices. Overall, the digital equipment had comparable capabilities, with the exception of antenna size, and minor requirements to modify the systems for operation to the proposed band. This modification is seen as a minor impact to the equipment design.

Video Surveillance Devices

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size	• Covert TX: 14 cubic inches	• Covert TX: 14 cubic inches no including antenna	⇨	Increase in antenna size and/or device matching circuits required
		• Outdoor TX: 17 cubic inches	• Outdoor TX: 17 cubic inches	⇨	Increase in antenna size and/or device matching circuits required

		• Receiver: 60 cubic inches	• Receiver: 60 cubic inches	⇗	Increase in antenna size and/or device matching circuits required
	Weight	• Indoor TX: 13 oz	• Indoor TX: 13 oz	⇧	Similar to current devices
		• Outdoor TX: 13 oz	• Outdoor TX: 13 oz	⇧	Similar to current devices
		• Receiver: 59 oz	• Receiver: 59 oz	⇧	Similar to current devices
	DC Power	• Indoor TX consume 11 watts per 250 milliwatts RF output	• Indoor TX consume 11 watts per 250 milliwatts RF output	⇧	Similar to current devices
		• Outdoor TX consumes 18 watts per 1 watt RF output	• Outdoor TX consumes 18 watts per 1 watt RF output	⇧	Similar to current devices

Information Quality Evaluation

The analysis of the information quality compared 8 MHz COFDM quality available in the channel assignments in the 1755-1850 MHz band to 2.5 MHz mode CODFM that would be required for operation in the 1350-1390 MHz band. The 2000 carriers used in the 8 MHz CODFM would be reduced to 400 resulting in reduced equivalent frames per second and video resolution; however, the audio bandwidth is not believe to be impacted due to its low bandwidth requirement. The reduction in available bandwidth and the impacts on the quality of information is seen as a major impact to the equipment design that would have to be overcome before migration of all operations to the 1350-1390 MHz band.

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	• 400 carrier signal provides reduced rejection to localized narrowband interference	⇘	58% reduction in available BW
	Video Quality	• DVB-T 8 MHz quality	• 2.5 MHz quality	⇘	Lower available bandwidth results in reduced video resolution
	Audio Quality	• MPEG II	• MPEG II	⇧	Similar to current devices

Transmission evaluation

The evaluation of the RF transmission suggests a relocation of operations to 1350-1390 MHz would increase the potential for interference with similar video type devices and systems currently occupying the spectrum.

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver	• Devices operating in the L-band occupying 6 to 8 MHz of bandwidth with 15 to 20 MHz channel spacing required.	• Move would require digital narrow-banded devices to near current capabilities	↘	Reduced available bandwidth results in potential for increased number of similar users in physical area
	Minimum separation of shared system transmitter/ receiver	• Systems in band well established and know	• Move would require identifying current systems for avoidances	↘	

Technical solutions required to overcome such limitations

New devices would need to be developed for operation within the 1350-1390 MHz band that are capable of supporting the miniaturized or low-profile operations required by DHS US&P assignments. As a consequence, R&D would have to be initiated to develop, procure, and deploy these devices. Technical solutions to address the impacts of the reduction in available bandwidth on video quality and the intelligent avoidance of interference may be required.

State of availability and maturity of the technology necessary to transition

Regarding the reduction of available bandwidth, manufactures are currently offering video systems that operate in 2.5 MHz of bandwidth and are developing 1.25 MHz bandwidth systems. Detailed and careful evaluation of these narrowband technologies will be required before adoption by the law enforcement community. The development of technologies for the intelligent avoidance of interference is less clear and an area of potential focus by the community.

Mitigation options available

The limited bandwidth in the band limits options for a full migration to the band. Possible migration of a portion of the operations in concert with a reduction of operations in the 1755-1850 MHz band may be possible.

The preferred technical solution to overcome any performance limitations related to technology and the reasons why

The preferred technical solutions are centered on the issues resulting from the reduction in total available bandwidth on the quality of video collection and the potential for interference among the systems.

Operational Considerations

The primary concern for DHS system relocations into the 1350-1390 MHz band is the potential for detrimental interference with radiolocation systems already resident within the band. From an operational standpoint, fixed point-to-point data link operations under some circumstances might be addressed with incumbent radiolocation activities, but the mobile US&P operations presents a more difficult challenge. US&P based operations as stated earlier are dynamic and potentially less than 24/7 in duration, placing a high degree of uncertainty on location and timing of the operations. In addition, the operations does not lend to the coordination prior to start of operations. Currently the operation model utilizes clear bandwidth with immediately available, where and when mission conditions dictate. To provide comparable capabilities, assuming no technology advance to address the sharing issues, a similar operating model would be required in the 1350-1390 MHz band

In addition, the limited bandwidth in the band (40 MHz total) would reduce DHS US&P operations to less than half of the currently available spectrum to address required channel separation and bandwidth for information quality. While DHS already experiences an "overlay" of assignments within the 1755-1850 MHz band, the reduction in available bandwidth has the potential to impact operations and reduce the total available channels compared to the 1755-1850 MHz band, increasing the potential for overlay of assignments from other agencies, and interference among system operations.

Video Surveillance Operations

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Operations	No. of available operating channels	• 21 US&P operating channels	• No more than 2 20 MHz channels or 16 2.5 MHz channels provided with the reduced bandwidth		
	No. of "systems"	• Receivers	• Slight increase in number devices to compensate for loss of available channels, e.g. two systems to cover operation previously covered by a single system		
		• Covert outdoor components • Repeaters	• Slight increase in number devices to compensate for loss of available channels, e.g. two systems to cover operation previously covered by a single system		

		• Portable TX components	• Slight increase in number devices to compensate for loss of available channels, e.g. two systems to cover operation previously covered by a single system	⇨	
		• Mobile vehicle components	• Slight increase in number devices to compensate for loss of available channels, e.g. two systems to cover operation previously covered by a single system	⇨	
		• Fixed sites	• Same	⇗	
	Compatibility with other law enforcement agencies	• Continued interoperability with other Federal Agencies or state & local task forces	Current interoperable channel is 8 MHz DVB-T	⇘	

Storage Evaluation

The storage of evidence and intelligence is an integral part of the overall video surveillance chain with front end limitations impacting backend capabilities and requirements. The number of required storage devices and the total recording time required to store a similar level of information afforded by the current 1755-1850 MHz systems would increase significantly.

Video Surveillance Storage

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Storage	No. of storage devices	• Single channel HD level info recorded stored for multiple cases	• Multiple channels of less than HD quality required to be stored	⇨	
	Recording Time	• Recording time limited to media size	• Recording time increased due to multiple feeds of information to capture similar information	⇨	
	Shelf life of recordings	• Limited to media life, but generally last the time required to keep evidence	• Limited to media life, but generally last the time required	⇗	

Exploit/ Case Support Evaluation

The increase in the number of required devices and the need to extract relevant information reduces the current capabilities with the DVT-T based devices.

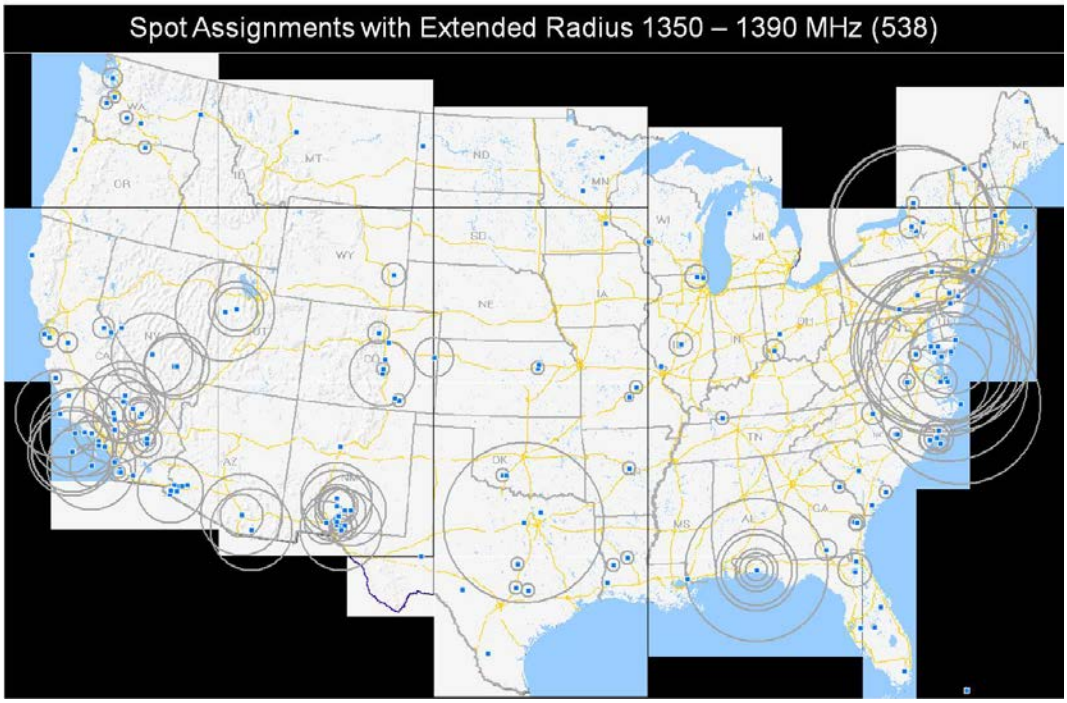
Video Surveillance Exploit/Case Support

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Exploit/ Case Use	Data transfer/ Sharing formats	• Digital storage either of DVD, DVR or other media	• Digital storage either of DVD, DVR or other media	⇨	Degradation due to increased need to maintain multiple data files
		• Video duplication handled	• Video duplication handled efforts increased	⇨	
	Search Functionality	• Single search functionality afforded with digital storage format and analytic software that can be used to enhance search	• Increased operational impact to requirement to search multiple captures of information	⇘	
	Data storage format	• Digital formats	• Digital formats, but at reduced resolution limiting exploit capabilities	⇨	

Geographic extend of operations

The geographic extend of current operation in the 1350-1390 MHz band that are of interest is driven primarily from Radiolocation services. As depicted in the following chart, the coverage area of individual systems and number of systems located near major metropolitan areas across the United States is of concern, specifically the systems along the southwest border and the northeast United States. A full analysis of the systems along with the significant RF characteristics of the locations would have to be conducted to determine potential geographic sharing of the frequency band.

Fixed site avoidance is less of an issue as depicted in the following figure.



The extent to which these limits impact mission effectiveness

The primary concern for relocating DHS systems into the 1350-1390 MHz band is interference from incumbent and relocating systems and the anticipated need to reduce operating bandwidth. Even if equipment with the ability to transmit acceptable information quality in a significantly reduced bandwidth were available, sufficiently clear spectrum would still be required under current operating models.

Mitigation options available

TBD

The preferred solution for overcoming limits on performance brought on by the operational environment and the reasons why

TBD

Other constraints impede relocation (e.g., necessary allocation changes) to a comparable band and proposed remedies

TBD

Estimate of the time required to transition to the comparable band

Less than 10 years?

10-15 years? Develop and deploy interference avoidance technologies

Greater than 15 years?

An estimate of the cost to transition to the comparable band

Less than $0.5B?

$0.5B - $1.5B?

$1.5B - $2.5B?[8] Develop and deploy interference avoidance technologies

$2.5B - $5.0B?

Greater than $5B?

Rationale for selection or non-selection

Limited bandwidth does not compare well to bandwidth available in the 1755-1850 MHz resulting in the need for technology development and possible relocation of incumbent operations.

Potential for sharing

Medium to low based on the reduction in total bandwidth available. Additional evaluation is required.

[8] Assumes intelligent interference avoidance technologies for video surveillance receivers developed within two product life cycles of 8 years with deployment during second life cycle

1435-1525 MHz

Technical	Operational[9]	Cost	Time	Rank
⇨	⇗	⇘	⇘	Med

Summary

The 1435-1525 MHz band presents a potential option for migrating all video surveillance from the 1755-1850 MHz band. The total available bandwidth is similar to that provided in the 1755-1850 MHz band and the device challenges associated with the physical characteristics of the band, while presenting challenges to the redesign of equipment, may be possibly addressed through equipment development. The overall device characteristics are of concern if intelligent interference rejection circuitry is required. While there are no current devices or technologies known to address these issues for video surveillance system, it is reasonable to assume that significant DC power, size, and weight impacts would need to be considered in the receiver design.

The potential for aeronautical telemetry devices to be operating at altitudes from near ground level to high altitudes with an associated large RF foot print, the expanse of devices deployment, and the concentration of devices being roughly proportional to population concentrations across the United States raises concerns of potential interference issues.[10]

Technical Considerations

(Limitations on performance, Attributable to technical or technology shortcomings.)

The proximity of the 1435-1525 MHz band to the 1755-1850 MHz band makes its physical characteristics closer to being suitable for supporting current law enforcement covert operations/missions than other low frequency bands; however, the interference potential with incumbent operations would need to be carefully considered prior to relocation.

Devices Evaluation

This analysis compared currently available digital video devices to digital devices potentially operating in the 1435-1525 MHz band. More specifically, DHS compared the general categories of physical size, weight, and power based on an average of those characteristics of available devices. Overall, the digital equipment had comparable capabilities, with the exception of antenna size and minor requirements to modify the

[9] Assumes interference rejection circuitry is included in devices. If no interference rejection technology is available then significant impact to operations.

[10] The GMF identifies 998 assignments for various transmitters with power up to 100 watts and applications such as telemetry system and antenna test beds. This is in contrast to the 1755-1850 MHz band which has approximately 3150 assignments with the majority of transmitters being low power (< 10 watt) devices and those of significant power being associated with high gain (approx 40 dB) directional antennas for space telecommand.

systems for operation to the proposed band. This modification is seen as a minor impact to the equipment design.

Video Surveillance Devices

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size	• Covert TX: 14 cubic inches	• Covert TX: 14 cubic inches	⇗	Increase in antenna size and/or device matching circuits required
		• Outdoor TX: 17 cubic inches	• Outdoor TX: 17 cubic inches	⇗	Increase in antenna size and/or device matching circuits required
		• Receiver: 60 cubic inches	• Receiver: 60 cubic inches	⇨	Additional circuitry for interference rejection
	Weight	• Indoor TX: 13 oz	• Indoor TX: 13 oz	⇗	Similar to current devices
		• Outdoor TX: 13 oz	• Outdoor TX: 13 oz	⇗	Similar to current devices
		• Receiver: 59 oz	• Receiver: 59 oz	⇨	Additional circuitry for interference rejection
	DC Power	• Indoor TX consume 11 watts per 250 milliwatts RF output	• Indoor TX consume 11 watts per 250 milliwatts RF output	⇗	Similar to current devices
		• Outdoor TX consumes 18 watts per 1 watt RF output	• Outdoor TX consumes 18 watts per 1 watt RF output	⇗	Similar to current devices
		• Receiver w/o interference rejection circuitry	• Receiver with interference rejection circuitry	⇨	Additional circuitry for interference rejection

Information Quality Evaluation

The analysis of the information quality compared 8 MHz COFDM quality available in the channel assignments in the 1755-1850 MHz band to 8 MHz mode CODFM that could be used in the 1435-1525 MHz band. The 2000 carriers used in the 8 MHz CODFM would be replicated in the 1435-1525 MHz band with near equivalent frames per second and video resolution.

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	⇧	Assumes interference issues addressed

	Video Quality	• DVB-T 8 MHz quality	• DVB-T 8 MHz quality	⇧	Similar available bandwidth
	Audio Quality	• MPEG II	• MPEG II	⇧	Similar to current devices

Transmission evaluation

The evaluation of the RF transmission suggests a relocation of operations to 1435-1525 MHz would increase the potential for interference similar video type devices and systems currently occupying the spectrum.

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver	• Devices operating in the L-band occupying 6 to 8 MHz of bandwidth with 15 to 20 MHz channel spacing required.	• Move may require some digital narrow-banded devices to maintain current capabilities	⇧	
	Minimum separation of shared system transmitter/ receiver	• Systems in band well established and know	• Move would require identifying current systems for avoidances	⇘	Incumbent use needs to be addressed

Technical solutions required to overcome such limitations

Technical solutions to address the impacts of intelligent avoidance of harmful interference among the systems sharing the spectrum would be required.

State of availability and maturity of the technology necessary to transition

The technologies for the intelligent avoidance of interference such as, Dynamic Frequency Selection are not mature at this time and have not been introduced into video surveillance equipment.

Mitigation options available

The full evaluation of the potential interference and subsequent development and validation of interference avoidance technologies would need to be developed and deployed for a full migration to the band.

The preferred technical solution to overcome any performance limitations related to technology and the reasons why

The preferred technical solutions are centered on the issues of potential interference among the systems.

Operational Considerations

The primary concern for systems relocation into the 1435-1525 MHz band is the mutual interference systems would experience with aeronautical telemetry systems operating in the band. The dynamic nature of the DHS US&P operations, e.g. unpredictable in location and time, makes pre-coordination unlikely. The approach currently used in the 1755-1850 MHz band to maintain multiple US&P channels to address static localized interference may not be sufficient in this band where interference would be more sporadic.

Video Surveillance Operations

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Operations	No. of available operating channels	• 21US&P operating channels	• 21US&P operating channels	⇗	Number of available channels with current and know planned technologies, assuming interference issues addressed
	No. of "systems"	• Receivers	• Similar number and performance	⇗	Similar Receiver performance, assuming interference issues addressed
		• Covert outdoor components • Repeaters	• Similar number and performance	⇗	Similar performance, assuming interference issues addressed
		• Portable TX components	• Similar number and performance	⇗	Similar performance, assuming interference issues addressed
		• Mobile vehicle components	• Similar number and performance	⇗	Similar performance, assuming interference issues addressed
		• Fixed sites	• Similar number and performance	⇗	Similar performance, assuming interference issues addressed
	Compatibility with other law enforcement agencies	• Continued interoperability with other Federal Agencies or state & local task forces	• Current interoperable channel is 8 MHz DVB-T	⇗	

Storage Evaluation

The storage of evidence and intelligence is an integral part of the overall video surveillance chain with front end limitations impacting backend capabilities and requirements. The number of required storage devices and the total recording time required to store a similar level of information afforded by the current 1755-1850 MHz systems would increase significantly.

Video Surveillance Storage

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Storage	No. of storage devices	• Single channel HD level info recorded stored for multiple cases	• Single channel HD level info recorded stored for multiple cases	⇗	
	Recording Time	• Recording time limited to media size	• Recording time limited to media size	⇗	
	Shelf life of recordings	• Limited to media life, but generally last the time required	• Limited to media life, but generally last the time required	⇗	

Exploit/ Case Support Evaluation

The increase in the number of required devices and the need to extract relevant information reduces the current capabilities with the DVT-T based devices.

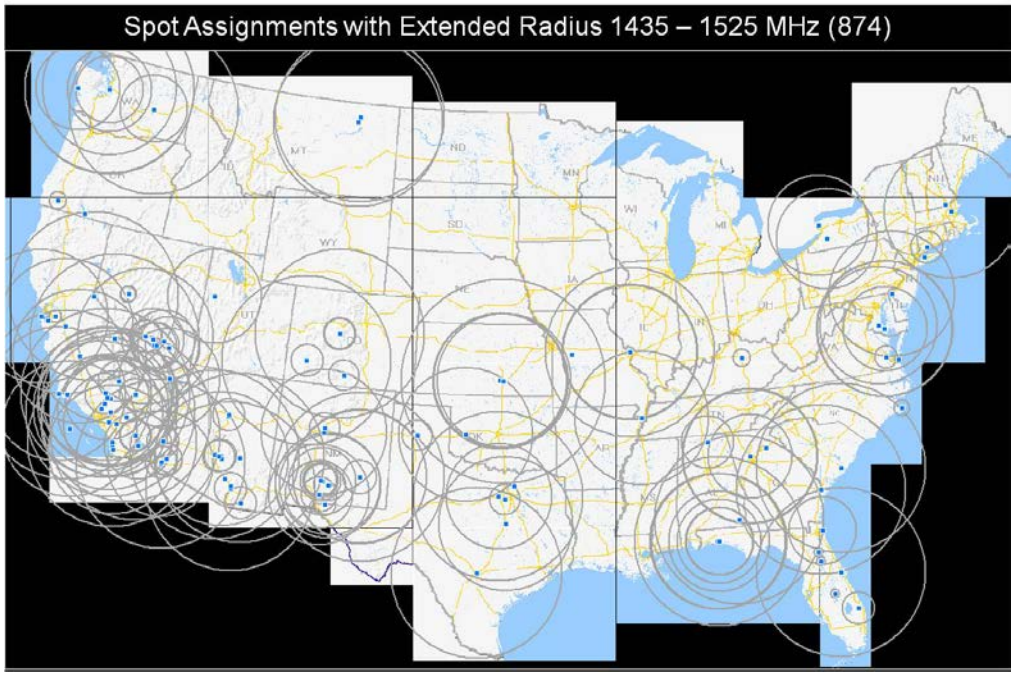
Video Surveillance Exploit/Case Support

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Exploit/ Case Use	Data transfer/ Sharing formats	• Digital storage either of DVD, DVR or other media	• Digital storage either of DVD, DVR or other media	⇗	
		• Video duplication handled	• Similar	⇗	
	Search Functionality	• Single search functionality afforded with digital storage format and analytic software that can be used to enhance search	• Similar	⇗	
	Data storage format	• Digital formats	• Similar	⇗	

Geographic extend of operations

The geographic extend of current operation in the 1435-1525 MHz band that are of interest is driven primarily by telemetry devices operating in the band. The number of devices, the dynamics of the operations, and the transmitter locations would need to be ascertained to account for the significant RF characteristics to determine potential geographic sharing of the frequency band.

Fixed site avoidance as depicted in the following figure would need to be addressed.



The extent to which these limits impact mission effectiveness

The primary concern for relocating DHS systems into the 1435-1525 MHz band is the anticipated need to reduce operating bandwidth and the incompatibility and mutual interference DHS systems would incur from and present to the incumbent systems already resident and operating within the band. Even if DHS were able to obtain equipment that provided acceptable information quality in a significantly reduced bandwidth, sufficiently clear spectrum would still not be available in many key areas of the country. As a consequence, R&D would have to be initiated to develop, procure, and deploy devices that are capable of operating in the 1435-1525 MHz band. Significant time would be required, but it is estimated that the potential for a total solution in the limited bandwidth is low.

Mitigation options available

Requires additional evaluation

The preferred solution for overcoming limits on performance brought on by the operational environment and the reasons why

Interference avoidance will be key to any relocation into the band. Records indicate incumbents operate 100 watt transmitters near metropolitan areas.

Other constraints impede relocation (e.g., necessary allocation changes) to a comparable band and proposed remedies

Requires additional evaluation

Estimate of the time required to transition to the comparable band

Less than 10 years?

10-15 years?

Greater than 15 years? Develop Interference Avoidance Technologies[11]

An estimate of the cost to transition to the comparable band

Less than $0.5B?

$0.5B - $1.5B?

$1.5B - $2.5B?

$2.5B - $5.0B? Develop Interference Avoidance Systems[12]

Greater than $5B?

Rationale for selection or non-selection

Interference issues need to be investigated in detail.

Potential for sharing

Interference issues need to be investigated in detail to ascertain potential for sharing.

[11] Estimate based on three 8 year system lifecycle change outs
[12] ibid

1675-1695 MHz

Technical	Operational	Cost	Time	Rank
⇘	⇘	⇨	⇘	Med

Summary

The 1675-1695 MHz band presents a limited option for migrating all video surveillance from the 1755-1850 MHz band. Significant obstacles to overcome before utilizing the band include addressing the limited available bandwidth (20 MHz total compared to 95 MHZ) and the relocation or sharing of operations with incumbent services, e.g. meteorological aids (radiosonde) and meteorological Satellite (space-to-earth) services.[13] While technology developments that would allow more intelligent sharing of the frequency may be possible the significant reduction on available bandwidth limits the utility of this band. While it is doubtful that all video surveillance operations could be relocated to the 20 MHz proposed, the physical performance perspectives of the band make it a candidate for a limited set of video channels.

The band is approximately 6.5 percent below that of the current 1755-1850 MHz range resulting in minor improvements to estimated received RF power at a given physical separation (approximately 0.59 dB) or a slight improvement to distance of operation (approximately 7 percent). With the exception of an increased antenna length requirement, the overall device characteristics are estimated to be sufficiently close to current equipment, resulting in limited DC power, size, and weight impacts. The greater concern with migrating to the 1675-1695 MHz band is the reduction of available spectrum and the potential to cause interference with systems currently occupying the band. As identified for current operations in the 1755-1850 MHz band, legacy video surveillance systems require 15 to 20 MHz receiver to interfering transmitter to avoid harmful interference. Digital encoding techniques employed in currently available digital video systems have further advanced the receiver selectivity to the point where it is estimated the channel separation may be reduced to 5 to 6 MHz, and systems in development may reduce this separation by a factor of 2. While these technology developments have the potential to reduce the need for spectrum, the significant reduction of the current available 95 MHz bandwidth in the 1755-1850 MHz band to the 20 MHz made available in this band makes the potential to relocate all operations to the 1675-1695 MHz band highly unlikely. It is more reasonable that a portion of the operations in the 1755-1850 MHZ may be relocated to this band to offset reductions in the 1755-1850 MHz spectrum.

[13] The GMF identifies 159 assignments for transmitters with power up to 90 watts and applications such as radiosondes and Satellite downlinks. This is in contrast to the 1755-1850 MHz band which has approximately 3150 assignments with the majority of transmitters being low power (< 10 watt) devices and those of significant power being associated with high gain (approx 40 dB) directional antennas for space telecommand.

Technical Considerations

(Limitations on performance, Attributable to technical or technology shortcomings.)

The proximity of the 1675-1695 MHz band to the 1755-1850 MHz band makes its physical characteristics suitable for supporting current law enforcement covert operations/missions; however, the limited overall spectrum severely restricts the amount and level of operations which could be supported in the band without major efforts to develop technologies that could address the need for more spectrally efficiency transmissions and interference avoidance. There are approximately 158 frequency assignments resident within the 1675-1695 MHz band and relocating all of the 1755-1850 MHz operations into this band has the potential to increase significantly the potential for interference.

Devices Evaluation

This analysis compared currently available digital video devices to digital devices potentially operating in the 1675 - 1695 MHz band. More specifically, DHS compared the general categories of physical size, weight, and power based on an average of those characteristics of available devices. Overall, the digital equipment had comparable capabilities, with the exception of antenna size and minor requirements to modify the systems for operation to the proposed band. This modification is seen as a minor impact to the equipment design.

Video Surveillance Devices

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size	• Covert TX: 14 cubic inches	• Covert TX: 14 cubic inches	⇗	Increase in antenna size and/or device matching circuits required
		• Outdoor TX: 17 cubic inches	• Outdoor TX: 17 cubic inches	⇗	Increase in antenna size and/or device matching circuits required
		• Receiver: 60 cubic inches	• Receiver: 60 cubic inches	⇗	Increase in antenna size and/or device matching circuits required
	Weight	• Indoor TX: 13 oz	• Indoor TX: 13 oz	⇧	Similar to current devices
		• Outdoor TX: 13 oz	• Outdoor TX: 13 oz	⇧	Similar to current devices
		• Receiver: 59 oz	• Receiver: 59 oz	⇧	Similar to current devices
	DC Power	• Indoor TX consume 11 watts per 250 milliwatts RF output	• Indoor TX consume 11 watts per 250 milliwatts RF output	⇧	Similar to current devices
		• Outdoor TX consumes 18 watts per 1 watt RF output	• Outdoor TX consumes 18 watts per 1 watt RF output	⇧	Similar to current devices

Information Quality Evaluation

The analysis of the information quality compared 8 MHz COFDM quality available in the channel assignments in the 1755-1850 MHz band to 2.5 MHz mode CODFM that would be required for operation in the 1675-1995 MHz band. The 2000 carriers employed in the 8 MHz CODFM would be reduced to 400 potentially resulting in reduced equivalent frames per second and/or video resolution; however, the audio bandwidth is believed to not be impacted due to its low bandwidth requirement. The reduction in available RF bandwidth and the impacts on the quality of information is seen as a major impact to the equipment design that would have to be overcome before migration of all operations to the 1675-1695 MHz band.

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	• 400 carrier signal provides reduced rejection to localized narrowband interference	↘	Factor of 5 reduction
	Video Quality	• DVB-T 8 MHz quality	• 2.5 MHz quality	↘	Lower available bandwidth results in reduced video resolution
	Audio Quality	• MPEG II	• MPEG II	⇧	Similar to current devices

Transmission evaluation

The evaluation of the RF transmission suggests a relocation of operations to 1675-1695 MHz would increase the potential for interference similar video type devices and systems currently occupying the spectrum.

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver	• Devices operating in the L-band occupying 6 to 8 MHz of bandwidth with 15 to 20 MHz channel spacing required.	• Move would require digital narrow-banded devices to near current capabilities	↘	Reduced available bandwidth results in potential for increased number of similar users in physical area

	Minimum separation of shared system transmitter/ receiver	• Systems in band well established	• Move would require identifying current systems for avoidances	⇨	

Technical solutions required to overcome such limitations

Technical solutions to address the impacts of the significant reduction of available bandwidth on video quality and the intelligent avoidance of harmful interference among the systems sharing the spectrum.

State of availability and maturity of the technology necessary to transition

Regarding the reduction of available bandwidth, manufactures are currently offering video systems that operate in 2.5 MHz of bandwidth and are developing 1.25 MHz bandwidth systems. Detailed and careful evaluation of these narrowband technologies will be required before adoption by the law enforcement community. The development of technologies for the intelligent avoidance of interference is less clear and an area of potential focus by the community.

Mitigation options available

The limited available bandwidth limits options for a full migration to the band. Possible migration of a portion of the operations in concert with a reduction of operations in the 1755-1850 MHz band may be possible.

The preferred technical solution to overcome any performance limitations related to technology and the reasons why

The preferred technical solutions are centered on the issues resulting from the reduction in total available bandwidth on the quality of video collection and the potential for interference among the systems.

Operational Considerations

Video Surveillance Operations

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Operations	No. of available operating channels	• 21 US&P operating channels	• No more than 8 2.5 MHz channels provided with the reduced bandwidth	⇩	Number of available channels with current and known planned technologies
	No. of "systems"	• Receivers	• TBD	TBD	Difficult to determine at level of reduced capability
		• Covert outdoor components • Repeaters	• TBD	TBD	Difficult to determine at level of reduced capability
		• Portable TX components	• TBD	TBD	Difficult to determine at level of reduced capability

		• Mobile vehicle components	• TBD	TBD	Difficult to determine at level of reduced capability
		• Fixed sites	• TBD	TBD	Difficult to determine at level of reduced capability
	Compatibility with other law enforcement agencies	• • Continued interoperability with other Federal Agencies or state & local task forces	• Current interoperable channel is 8 MHz DVB-T	↘	

Storage Evaluation

The storage of evidence and intelligence is an integral part of the overall video surveillance chain with front end limitations impacting backend capabilities and requirements. The number of required storage devices and the total recording time required to store a similar level of information afforded by the current 1755-1850 MHz systems would increase significantly.

Video Surveillance Storage

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Storage	No. of storage devices	• Single channel HD level info recorded stored for multiple cases	• Multiple channels of less than HD quality required to be stored	⇨	
	Recording Time	• Recording time limited to media size	• Recording time increased due to multiple feeds of information to capture similar information	⇨	
	Shelf life of recordings	• Limited to media life, but generally meet time required	• Digital storage provides for enhanced storage shelf life	⇗	

Exploit/ Case Support Evaluation

The increase in the number of required data streams and the need to compare to extract relevant information reduces the current capabilities with the DVT-T based devices.

Video Surveillance Exploit/Case Support

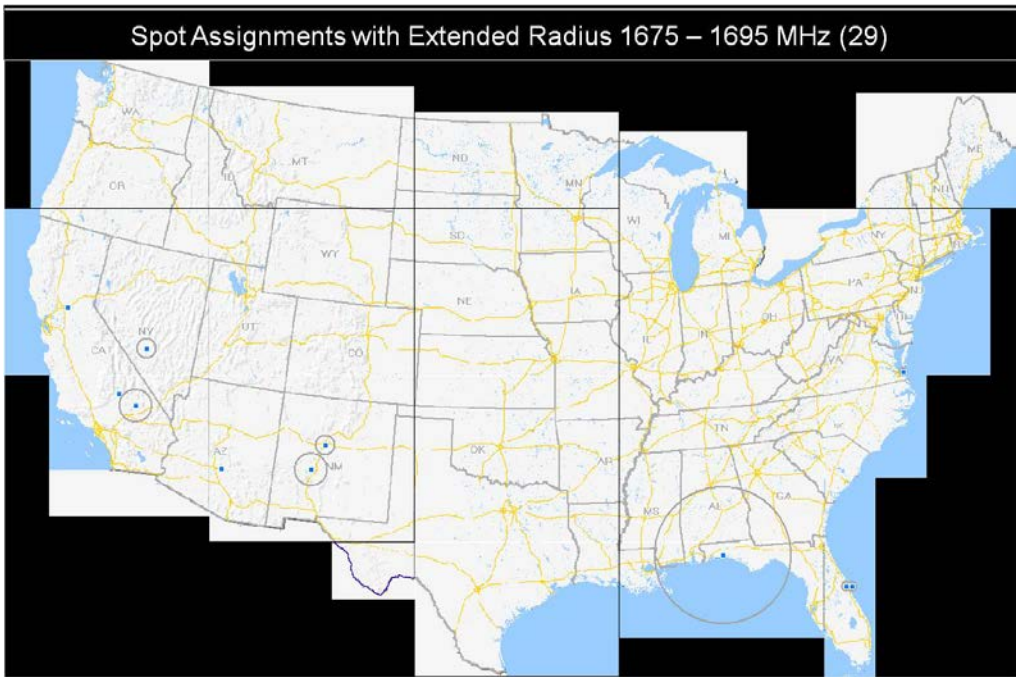
	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Exploit/ Case Use	Data transfer/ Sharing formats	• Digital storage either of DVD, DVR or other media	• Digital storage either of DVD, DVR or other media	⇨	Degradation due to increased need to maintain multiple data files
		• Video duplication handled	• Video duplication handled efforts increased	⇨	

	Search Functionality	• Single search functionality afforded with digital storage format and analytic software that can be used to enhance search	• Increased operational impact to requirement to search multiple captures of information	⇘	
	Data storage format	• Digital formats	• Digital formats, but at reduced resolution limiting exploit capabilities	⇨	

Geographic extend of operations

The geographic extend of current operation in the 1675-1695 MHz band that are of interest is driven primarily from satellite assignments and radiosondes. The number of earth station and their locations has yet to be ascertained. A full accounting of the locations and the significant RF characteristics of the locations would have to be conducted to determine potential geographic sharing of the frequency band. For the radiosondes, a better understanding of the devices operations and significant RF characteristics would have be required to estimate the potential for geographic sharing of the frequency band. Technical information for the radiosondes indicate the transmitters emit +23.8 dBm (240mW) in a 3dB bandwidth of 135 KHz with emissions falling to 58 dBc at 1 MHz offset.

Fixed site avoidance is less of an issue as depicted in the following figure.



The extent to which these limits impact mission effectiveness

The primary concern for relocating DHS systems into the 1675-1695 MHz band is the anticipated need to reduce operating bandwidth and the incompatibility and mutual

interference DHS systems would incur from and present to the incumbent systems already resident and operating within the band. Even if DHS were able to obtain equipment that provided acceptable information quality in a significantly reduced bandwidth, sufficiently clear spectrum would still not be available in many key areas of the country. R&D would be required to develop devices that are capable of operating in the 1675-1695 MHz band.

Mitigation options available

TBD

The preferred solution for overcoming limits on performance brought on by the operational environment and the reasons why

TBD

Other constraints impede relocation (e.g., necessary allocation changes) to a comparable band and proposed remedies

TBD

Estimate of the time required to transition to the comparable band

Less than 10 years?

10-15 years?

Greater than 15 years? Develop Narrowband Technologies[14]

An estimate of the cost to transition to the comparable band

Less than $0.5B?

$0.5B - $1.5B?

$1.5B - $2.5B?

$2.5B - $5.0B? Develop Narrowband and interference avoidance[15]

Greater than $5B?

Rationale for selection or non-selection

Limited bandwidth does not compare well to bandwidth available in the 1755-1850 MHz resulting in the need for significant technology development and relocation of incumbent operations. Potential exists for relocating a portion of the operations to the band. Narrow banding to the level required may not be possible.

Potential for sharing

Low to medium based on the reduction in total bandwidth available.

[14] Estimate based on three 8 year system lifecycle change outs and development of narrowband technologies
[15] ibid

2025-2110 MHz

Technical	Operational	Cost	Time	Rank
⇨	⇘	⇨	⇗	Med

Summary

The 2025-2110 MHz band presents an option for migrating video surveillance from the 1755-1850 MHz band. The total available bandwidth is similar to that provided in the 1755-1850 MHz band. However, the primary areas of concern are the reduced RF propagation characteristics in the band and the number and diversity of incumbent systems currently in the band. Calculations indicate that transmitter and receiver distances would decrease by approximately 12%. While the physical separation would be degraded, requiring 12% additional devices to roughly provide comparable aggregate operations coverage, the potential for interference from current incumbent operations is of more concern. The potential interference with and from the systems in the band, e.g. earth exploration satellite and space operations/research, radar, microwave links, experimental, and the significant number of low power TV broadcast, with maximum transmitter powers of 500W raises concerns.[16]

The full impact of the incumbent systems would need to be examined in detail prior to any relocation. As with other bands in this study, the potential development of interference avoidance systems may be required. While there are no current devices or technologies known to address these issues for video surveillance systems, it is reasonable to assume that significant DC power, size, and weight impacts would be encountered in the receiver design.

Technical Considerations

(Limitations on performance, Attributable to technical or technology shortcomings.)

The 2025-2110 MHz band has physical characteristics that limit the propagation range between transmitters and receivers. However, this is offset to some extent by the possible reduction in device size. However, other limiting factors associated with battery size and heat dissipation may significantly impact devices. In addition, the interference potential from incumbent operations would need to be carefully considered prior to relocation.

[16] The GMF identifies 333 assignments for transmitters with power up to 501 megawatts in Alaska and applications such as satellite control uplinks, and antenna and sensor test beds. In addition, more than 7000 FCC licenses exist in the band. This is in contrast to the 1755-1850 MHz band which has approximately 3150 assignments with the majority of transmitters being low power (< 10 watt) devices and those of significant power being associated with high gain (approx 40 dB) directional antennas for space telecommand.

Devices Evaluation

This analysis compared currently available digital video devices to digital devices potentially operating in the 1755-1850 MHz band.

Video Surveillance Devices

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size	• Covert TX: 14 cubic inches	• Covert TX: 14 cubic inches	⇨	Increase in antenna size and/or device matching circuits required
		• Outdoor TX: 17 cubic inches	• Outdoor TX: 17 cubic inches	⇨	Increase in antenna size and/or device matching circuits required
		• Receiver: 60 cubic inches	• Receiver: 60 cubic inches	⇨	Additional circuitry for interference rejection
	Weight	• Indoor TX: 13 oz	• Indoor TX: 13 oz	⇨	Similar to current devices
		• Outdoor TX: 13 oz	• Outdoor TX: 13 oz	⇨	Similar to current devices
		• Receiver: 59 oz	• Receiver: 59 oz	⇨	Additional circuitry for interference rejection
	DC Power	• Indoor TX consume 11 watts per 250 milliwatts RF output	• Indoor TX consume 11 watts per 250 milliwatts RF output	⇨	Similar to current devices
		• Outdoor TX consumes 18 watts per 1 watt RF output	• Outdoor TX consumes 18 watts per 1 watt RF output	⇨	Similar to current devices
		• Receiver w/o interference rejection circuitry	• Receiver with interference rejection circuitry	⇨	Additional circuitry for interference rejection

Information Quality Evaluation

The analysis of the information quality compared 8 MHz COFDM quality available in the channel assignments in the 1755-1850 MHz band to 8 MHz mode CODFM. Assuming interference issues are addressed, the information quality would be of similar levels achieved in the 1755-1850 MHz band. If interference avoidance is not assumed then the information quality would be impacted through the need to reduce the CODFM signals to a 400 carrier or less format. The reduction in available bandwidth would be a major impact to the equipment design that would have to be overcome before migration of all operations to the 2025-2110 MHz band.

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	⇧	Assumes interference issues addressed
	Video Quality	• DVB-T 8 MHz quality	• DVB-T 8 MHz quality	⇧	Similar available bandwidth
	Audio Quality	• MPEG II	• MPEG II	⇧	Similar to current devices

Transmission evaluation

The evaluation of the RF transmission suggests a relocation of operations to 2025-2110 MHz would increase the potential for interference similar video type devices and systems currently occupying the spectrum.

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver	• Devices operating in the L-band occupying 6 to 8 MHz of bandwidth with 15 to 20 MHz channel spacing required.	• Move would require some digital narrow-banded devices to near current capabilities	⇗	
	Minimum separation of shared system transmitter/ receiver	• Systems in band well established and know	• Move would require identifying current systems for avoidances	⇘	Incumbent use needs to be addressed

Technical solutions required to overcome such limitations

Technical solutions to address the impacts of intelligent avoidance of harmful interference among the systems sharing the spectrum would be required. In addition, increased transmitter power may be required to offset propagation reductions.

State of availability and maturity of the technology necessary to transition

The technologies for the intelligent avoidance of interference such as Dynamic Frequency Selection are not mature at this time and have not been introduced into the video surveillance equipment. In addition, the vendor community is working to increase transmitter power while managing the associated heat and battery consumption.

Mitigation options available

The full evaluation of the potential interference and subsequent development and validation of interference avoidance technologies would need to be developed and deployed for a full migration to the band.

The preferred technical solution to overcome any performance limitations related to technology and the reasons why

The preferred technical solutions are centered on the issues of potential interference among the systems.

Operational Considerations

The primary concern for systems relocation into the 2025-2110 MHz band is the mutual interference that systems would experience with incumbent systems. In addition, the reduced propagation characteristics would result in the need for additional transmitter/receiver pairs to maintain aggregate coverage.

Video Surveillance Operations

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Operations	No. of available operating channels	• 21 US&P operating channels	• 21US&P operating channels	⇨	Number of available channels with current and known planned technologies, assuming interference issues addressed
	No. of "systems"	• Receivers	• Increased number required	⇨	Similar Receiver performance, assuming interference issues addressed
		• Covert outdoor TX components • Repeaters	• Increased number required	⇨	Similar performance, assuming interference issues addressed
		• Portable TX components	• Increased number required	⇨	Similar performance, assuming interference issues addressed
		• Mobile vehicle components	• Increased number required	⇨	Similar performance, assuming interference issues addressed
		• Fixed sites	• Similar number and performance	⇗	Similar performance, assuming interference issues addressed
	Compatibility with other law enforcement agencies	• Continued interoperability with other Federal Agencies or state & local task forces	• Current interoperable channel is 8 MHz DVB-T	⇗	

Storage Evaluation

The storage of evidence and intelligence is an integral part of the overall video surveillance chain with front end limitations impacting backend capabilities and requirements. The number of required storage devices and the total recording time

required to store a similar level of information afforded by the current 1755-1850 MHz systems would increase significantly.

Video Surveillance Storage

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Storage	No. of storage devices	• Single channel HD level info recorded stored for multiple cases	• Multiple channels of less than HD quality required to be stored	⇨	
	Recording Time	• Recording time limited to media size	• Recording time increased due to multiple feeds of information to capture similar information	⇗	
	Shelf life of recordings	• Limited to media life, but generally last the time required.	• Limited to media life, but generally last the time required.	⇗	

Exploit/ Case Support Evaluation

The increase in the number of required data streams and the need to compare to extract relevant information reduces the current capabilities with the DVT-T based devices.

Video Surveillance Exploit/Case Support

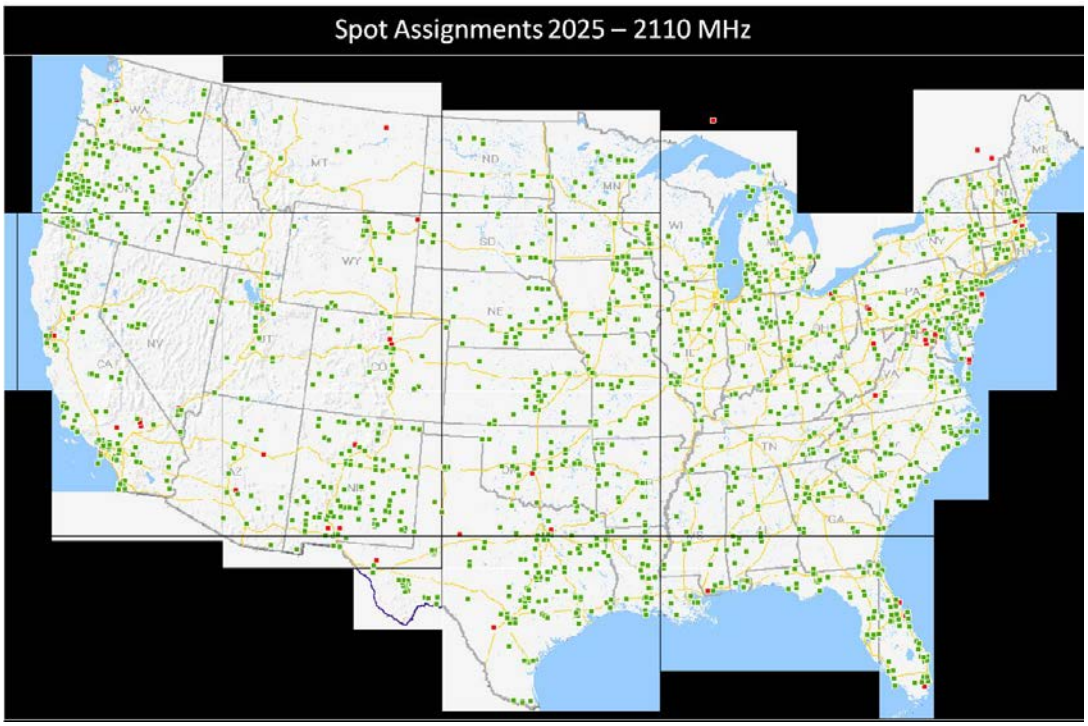
	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Exploit/ Case Use	Data transfer/ Sharing formats	• Digital storage either of DVD, DVR or other media	• Digital storage either of DVD, DVR or other media	⇨	Degradation due to increased need to maintain multiple data files
		• Video duplication handled	• Video duplication handled efforts increased	⇨	
	Search Functionality	• Single search functionality afforded with digital storage format and analytic software that can be used to enhance search	• Increased operational impact to requirement to search multiple captures of information	⇨	
	Data storage format	• Digital formats	• Digital formats, but at reduced resolution limiting exploit capabilities	⇗	

Geographic extend of operations

The geographic extend of operation in the 2025-2110 MHz band include over 400 Government frequency assignments, of which over 25% are identified as being in support

of Non-Government (NG) services. The FCC database on commercial and private licenses includes 7187 licenses within the band.

Fixed site avoidance is less of an issue as depicted in the following figure.



The extent to which these limits impact mission effectiveness

The primary concern for relocating DHS systems into the 2025-2110 MHz band is the magnitude of commercial, private, and/or non-government licenses already within the band. Most of these assignments are for high bandwidth (10-20 MHz), many are "broadcast" in nature, and the transmit power is significant. While most of the incumbent assignments are fixed, the "mobile" DHS US&P operations make it problematic to de-conflict system within specific geographic areas. In addition, since most of the licenses are non-federal, the process to de-conflict would require high level coordination between the FCC and NTIA.

Mitigation options available

TBD

The preferred solution for overcoming limits on performance brought on by the operational environment and the reasons why

TBD

Other constraints impede relocation (e.g., necessary allocation changes) to a comparable band and proposed remedies

TBD

Estimate of the time required to transition to the comparable band

Less than 10 years?

10-15 years? Develop Interference Avoidance Technologies[17]

Greater than 15 years?

An estimate of the cost to transition to the comparable band

Less than $0.5B?

$0.5B - $1.5B?

$1.5B - $2.5B? Develop Interference Avoidance Technologies [18]

$2.5B - $5.0B?

Greater than $5B?

Rationale for selection or non-selection

Limited bandwidth does not compare well to bandwidth available in the 1755-1850 MHz resulting in the need for significant technology development and relocation of incumbent operations. Potential exists for relocating a portion of the operations to the band.

Potential for sharing

Low to medium based on the reduction in total bandwidth available.

[17] Estimate based on three 8 year system lifecycle change outs
[18] ibid

2200-2290 MHz

Technical	Operational	Cost	Time	Rank
⇗	⇨	⇗	⇧	High

Summary

The Department currently utilizes the 2200-2290 MHz band to augment its operations in the 1755-1850 MHz band through the use of 8 US&P assignments. Technical characteristics of devices, e.g. occupied bandwidth, modulation format, are similar to those in the 1755-1850 MHz band. However, the 20 percent reduction in transmitter and receiver separation resulting from the physical characterizes of the band present challenges. Other obstacles to overcome in using the band include sharing of operations with current operations and incumbent services, e.g. Satellite and Space Operations. Technology developments that would allow for more intelligent sharing of the frequency may be required in addition to technologies to reduce the channel bandwidth requirements for video surveillance operations.[19]

Technical Considerations

(Limitations on performance, Attributable to technical or technology shortcomings.)

While the Department has a limited number of devices that operate in the 2200-2290 MHz band, this use is currently limited and migrating of all operations to the band would present challenges in addressing the influx of devices and also the reduction on propagation. Device characteristics would degrade slightly in battery life, but the physical size and weight would slightly improve or remain the same as the 1755-1850 MHz devices. The quality of the video would remain relatively consistent assuming interference issues are avoided, but physical separation between transmitters and receivers would degrade.

Devices Evaluation

Overall, the digital equipment has comparable capabilities with the exception of minor differences in size and DC current for the transmitters.

[19] The GMF identifies over 2895 assignments for transmitters in the band with the majority being low power devices for applications such as test beds, telemetry, and point to point communications. This is in contrast to the 1755-1850 MHz band which has approximately 3150 assignments with the majority of transmitters being low power (< 10 watt) devices and those of significant power being associated with high gain (approx 40 dB) directional antennas for space telecommand.

Video Surveillance Devices

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size	• Covert TX: 14 cubic inches	• Covert TX: 14 cubic inches	⇧	Similar to current devices
		• Outdoor TX: 17 cubic inches	• Outdoor TX: 17 cubic inches	⇧	Similar to current devices
		• Receiver: 60 cubic inches	• Receiver: 60 cubic inches	⇧	Similar to current devices
	Weight	• Indoor TX: 13 oz	• Indoor TX: 13 oz	⇧	Similar to current devices
		• Outdoor TX: 13 oz	• Outdoor TX: 13 oz	⇧	Similar to current devices
		• Receiver: 59 oz	• Receiver: 59 oz	⇧	Similar to current devices
	DC Power	• Indoor TX consume 11 watts per 250 milliwatts RF output	• Indoor TX consume 11 watts per 250 milliwatts RF output	⇧	Similar to current devices
		• Outdoor TX consumes 18 watts per 1 watt RF output	• Outdoor TX consumes 18 watts per 1 watt RF output •	⇧	Similar to current devices

Information Quality Evaluation

The available bandwidth and availability of COFDM devices suggest that the quality of information would be similar to that in the 1755-1850 MHz band with the exception that some reduced bandwidth channels would be required. This assumes that interference levels do not increase significantly as devices migrate into the band.

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	• Possibly have to reduce to 400 carrier signal to accommodate total of 29 channels with reduction to localized narrowband interference	⇗	

	Video Quality	• DVB-T 8 MHz quality	• DVB-T 8 MHz quality with some 2.5 MHz channels	⇗	
	Audio Quality	• MPEG II	• MPEG II	⇧	

Transmission evaluation

The evaluation of the RF transmission suggests the use of the band would reduce current transmitter and receiver separation by approximately 20%. The level of interference from incumbents and systems relocating would need to be evaluated.

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver	•	• Reduced separation by approx 20%	⇗	
	Minimum separation of shared system transmitter/ receiver	• Systems in band well established and know	• Move would require identifying current systems for avoidances	⇗	Anticipate some additional interference but limited to space systems operating on line of site basis

Technical solutions required to overcome such limitations

Technical solutions to address the impacts of the reduction in TX/RX separation and the intelligent avoidance of harmful interference among the systems may be required. In addition, some use of 2.5 MHz channels is possible to accommodate full capabilities.

State of availability and maturity of the technology necessary to transition

Manufactures currently offer video systems that operate in the band and are working to enhance their devices' operation with narrowband technologies being introduced and developed.

The development of intelligent avoidance of interference is less clear and an area of potential focus by the community.

Mitigation options available

This band has potential for the full migration of operations; however, the increased potential for harmful interference as the band becomes more crowded needs careful consideration.

The preferred technical solution to overcome any performance limitations related to technology and the reasons why

The preferred technical solutions are centered on narrow-banding while maintaining the quality of video and developing solutions to potential interference among the systems.

Operational Considerations

Video Surveillance Operations

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Operations	No. of available operating channels	• 21 US&P operating channels in 1755-1850 • 8 US&P channels in 2200-2290 MHz	• 29 US&P channels placed in 2100 – 2190 MHz increase overlap	⇨	
	No. of "systems"	• Receivers	• Increased number required	⇨	
		• Covert outdoor components • Repeaters	• Increased number required	⇨	
		• Portable TX components	• Increased number required	⇨	
		• Mobile vehicle components	• Increased number required	⇨	
		• Fixed sites	• Similar number and performance	⇗	
	Compatibility with other law enforcement agencies	• Continued interoperability with other Federal Agencies or state & local task forces	• Current interoperable channel is 8 MHz DVB-T	⇗	

Storage Evaluation

The storage of evidence and intelligence is an integral part of the overall video surveillance chain with front end limitations impacting backend capabilities and requirements. The number of required storage devices and the total recording time required to store a similar level of information afforded by the current 1755-1850 MHz systems would increase significantly.

Video Surveillance Storage

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Storage	No. of storage devices	• Single channel HD level info recorded stored for multiple cases	• Multiple channels of less than HD quality required to be stored	⇨	

	Recording Time	• Recording time limited to media size	• Recording time increased due to multiple feeds of information to capture similar information	⇨	
	Shelf life of recordings	• Limited to media life, but generally last the time required	• Limited to media life, but generally last the time required	⇗	

Exploit/ Case Support Evaluation

The increase in the number of required data streams and the need to compare to extract relevant information reduces the current capabilities with the DVT-T based devices.

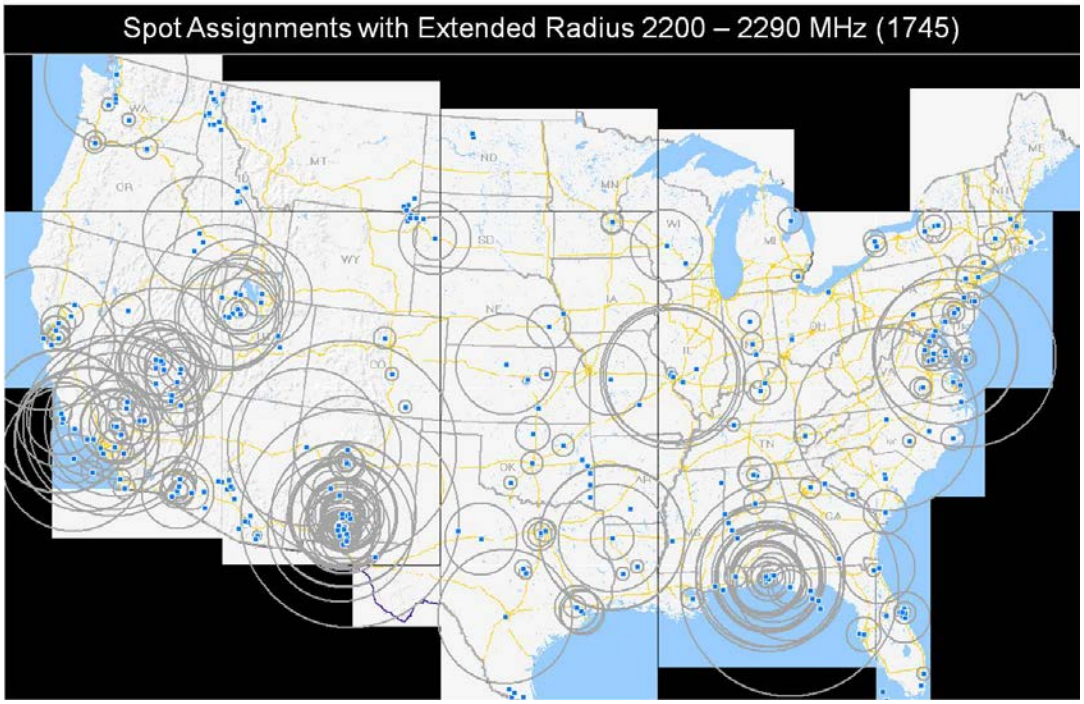
Video Surveillance Exploit/Case Support

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Exploit/ Case Use	Data transfer/ Sharing formats	• Digital storage either of DVD, DVR or other media	• Digital storage either of DVD, DVR or other media	⇨	Degradation due to increased need to maintain multiple data files
		• Video duplication handled	• Video duplication handled efforts increased	⇨	
	Search Functionality	• Single search functionality afforded with digital storage format and analytic software that can be used to enhance search	• Increased operational impact to requirement to search multiple captures of information	⇨	
	Data storage format	• Digital formats	• Digital formats, but at reduced resolution limiting exploit capabilities	⇨	

Geographic extend of operations

The geographic extend of 2200-2290 MHz band is below. A full accounting of the locations and the significant RF characteristics of the locations would have to be conducted to determine potential geographic sharing of the frequency band.

Fixed site avoidance is less of an issue as depicted in the following figure.



The extent to which these limits impact mission effectiveness

The primary concern for relocating DHS systems into the 2200-2290 MHz band is the extent of the space operations and the impact to mobile devices. While there is an anticipated need to reduce operating bandwidth of mobile video surveillance systems, the increased potential for mutual interference with incumbent and relocating systems is of concern. Even if DHS were able to obtain equipment that provided acceptable information quality in a significantly reduced bandwidth, sufficiently clear spectrum would still not be available in many key areas of the country.

Mitigation options available

TBD

The preferred solution for overcoming limits on performance brought on by the operational environment and the reasons why.

TBD

Other constraints impede relocation (e.g., necessary allocation changes) to a comparable band and proposed remedies

TBD

Estimate of the time required to transition to the comparable band

Less than 10 years?

10-15 years?

Greater than 15 years?

An estimate of the cost to transition to the comparable band

Less than $0.5B?

$0.5B - $1.5B?

$1.5B - $2.5B?

$2.5B - $5.0B?

Greater than $5B?

Rationale for selection or non-selection

Limited bandwidth does not compare well to bandwidth available in the 1755-1850 MHz resulting in the need for significant technology development and relocation of incumbent operations. Potential exists for relocating a portion of the operations to the band.

Potential for sharing

Medium to High based on current use of band.

2360-2395 MHz

Technical	Operational	Cost	Time	Rank
⇘	⇘	⇨	⇨	Med

Summary

The 2360-2695 MHz band presents a limited option for migrating all video surveillance from the 1755-1850 MHz band. Significant obstacles to overcome before utilizing the band include addressing the limited available bandwidth (35 MHz total compared to 95 MHZ) and the relocation or sharing of operations with incumbent services, e.g. telemetry systems. While technology developments that would allow more intelligent sharing of the frequency may be possible, the significant reduction on available bandwidth limits the utility of this band for a full transition. While it is doubtful that all video surveillance operations could be relocated to the 35 MHz provided, the physical performance perspectives of the band make it a candidate for a limited set of video channels assuming the potential interference to telemetry systems is addressed.[20]

The band is approximately 48 percent above the current 1755-1850 MHz range resulting in significant reductions in RF propagation. Devices are estimated to be similar to those currently available since the limitation to device size, weight, and power are related to characteristics other than antenna size. The greater concern with migrating to the 2360-2695 MHz band is the reduction of total available spectrum and the potential interference with systems currently occupying the band and those entering the band. As identified for current operations in the 1755-1850 MHz band, legacy video surveillance systems require 15 to 20 MHz receiver to interfering transmitter to avoid harmful interference. Digital encoding techniques employed in currently available digital video systems have further advanced the receiver selectivity to the point where it is estimated the channel separation may be reduced to 5 to 6 MHz, and systems in development may reduce this. While these technology developments have the potential to reduce the need for spectrum, the significant reduction of the currently available 95 MHz bandwidth in the 1755-1850 MHz band to the 35 MHz makes the potential to relocate all operations highly unlikely. It is more reasonable that a portion of the operations in the 1755-1850 MHZ may be relocated to this band to offset reductions in the 1755-1850 MHz spectrum.

Technical Considerations

(Limitations on performance, Attributable to technical or technology shortcomings.)

[20] The GMF identifies 590 assignments for transmitters with all but three assignments for transmitters with TX power less than or equal to 100 watts for applications such as telemetry and test beds. This is in contrast to the 1755-1850 MHz band which has approximately 3150 assignments with the majority of transmitters being low power (< 10 watt) devices and those of significant power being associated with high gain (approx 40 dB) directional antennas for space telecommand.

The limited overall spectrum severely restricts the number and level of operations which could be supported in the band without major efforts to develop technologies that could address the need for more spectrally efficiency transmissions and interference avoidance.

Devices Evaluation

This analysis compared currently available digital video devices to digital devices potentially operating in the 2360-2395 MHz band. More specifically, DHS compared the general categories of physical size, weight, and power based on an average of those characteristics of available devices.

Video Surveillance Devices

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Devices	Physical Size	• Covert TX: 14 cubic inches	• Covert TX: 14 cubic inches	⇨	Increase in device size to address possible increased RF TX power
		• Outdoor TX: 17 cubic inches	• Outdoor TX: 17 cubic inches	⇨	Increase in device size to address possible increased RF TX power
		• Receiver: 60 cubic inches	• Receiver: 60 cubic inches	⇧	Similar to current devices
	Weight	• Indoor TX: 13 oz	• Indoor TX: 13 oz	⇨	Increase in device size to address possible increased RF TX power
		• Outdoor TX: 13 oz	• Outdoor TX: 13 oz	⇨	Increase in device size to address possible increased RF TX power
		• Receiver: 59 oz	• Receiver: 59 oz	⇧	Similar to current devices
	DC Power	• Indoor TX consume 11 watts per 250 milliwatts RF output	• Indoor TX consume 11 watts per 250 milliwatts RF output	⇨	Increase in device power to address possible increased RF TX power
		• Outdoor TX consumes 18 watts per 1 watt RF output	• Outdoor TX consumes 18 watts per 1 watt RF output	⇨	Increase in device power to address possible increased RF TX power

Information Quality Evaluation

The analysis of the information quality compared 8 MHz COFDM quality available in the channel assignments in the 1755-1850 MHz band to 2.5 MHz mode CODFM that would be required for operation in the 2360-2395 MHz band. The 2000 carriers used in the 8 MHz CODFM would be reduced to 400 resulting in reduced equivalent frames per second and/or video resolution; however, the audio bandwidth is not believed to be impacted due to its low bandwidth requirement. The reduction in available bandwidth and the impacts on the quality of information is seen as a major impact to the equipment design that would have to be overcome before migration of all operations to the 2360-2395 MHz band.

Video Surveillance Information Quality

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Information Quality	Susceptibility to Interference	• 2000 carrier signal provides robust rejection to localized narrowband interference	• 400 carrier signal provides reduced rejection to localized narrowband interference	↘	Factor of approx. 2.5 reduction
	Video Quality	• DVB-T 8 MHz quality	• 2.5 MHz quality	↘	Lower available bandwidth results in reduced video resolution
	Audio Quality	• MPEG II	• MPEG II	⇧	Similar to current devices

Transmission evaluation

The evaluation of the RF transmission suggests a relocation of operations to 2360-2395 MHz would increase the potential for interference similar video type devices and systems currently occupying the spectrum.

Video Surveillance Transmission

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Transmission	Minimum separation of similar transmitter/ receiver	• Devices operating in the L-band occupying 6 to 8 MHz of bandwidth with 15 to 20 MHz channel spacing required.	• Move would require digital narrow-banded devices to near current capabilities	↘	Reduced available bandwidth results in potential for increased number of similar users in physical area
	Minimum separation of shared system transmitter/ receiver	• Systems in band well established	• Move would require identifying current systems for avoidances	⇨	

Technical solutions required to overcome such limitations

Technical solutions to address the impacts of the significant reduction of available bandwidth on video quality and the intelligent avoidance of harmful interference among the systems sharing the spectrum.

State of availability and maturity of the technology necessary to transition

Regarding the reduction of available bandwidth, manufactures are currently offering video systems that operate in 2.5 MHz of bandwidth and are developing 1.25 MHz bandwidth systems. Detailed and careful evaluation of these narrowband technologies will be required before adoption by the law enforcement community. The development of technologies for the intelligent avoidance of interference is less clear and an area of potential focus by the community.

Mitigation options available

The limited available bandwidth limits options for a full migration to the band. Possible migration of a portion of the operations in concert with a reduction of operations in the 1755-1850 MHz band may be possible.

The preferred technical solution to overcome any performance limitations related to technology and the reasons why

The preferred technical solutions are centered on the issues resulting from the reduction in total available bandwidth on the quality of video collection and the potential for interference among the systems.

Operational Considerations

Video Surveillance Operations

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Operations	No. of available operating channels	• 21 US&P operating channels • BW ranging from 20 to 6 MHz	• No more than 8 2.5 MHz channels provided with the reduced bandwidth	↘	
	No. of "systems"	• Receivers	• Additional receivers required	↘	Reduced RX/TX distance
		• Covert outdoor Components • Repeaters	• Additional repeaters required	↘	Reduced RX/TX distance
		• Portable TX components	• Additional transmitters required	↘	Reduced RX/TX distance
		• Mobile vehicle components	• Additional transmitters required	↘	Reduced RX/TX distance
		• Fixed sites	• TBD		
	Compatibility with other law enforcement agencies	• Continued interoperability with other Federal Agencies or state & local task forces	• Current interoperable channel is 8 MHz DVB-T	↘	

Storage Evaluation

The storage of evidence and intelligence is an integral part of the overall video surveillance chain with front end limitations impacting backend capabilities and requirements. The number of required storage devices and the total recording time required to store a similar level of information afforded by the current 1755-1850 MHz systems would increase significantly.

Video Surveillance Storage

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Storage	No. of storage devices	• Single channel HD level info recorded stored for multiple cases	• Multiple channels of less than HD quality required to be stored	⇨	
	Recording Time	• Recording time limited to media size	• Recording time increased due to multiple feeds of information to capture similar information	⇨	
	Shelf life of recordings	• Limited to media life, but lasts the time required	• Limited to media life, but lasts the time required	⇗	

Exploit/ Case Support Evaluation

The increase in the number of required data streams and the need to compare to extract relevant information reduces the current capabilities with the DVT-T based devices.

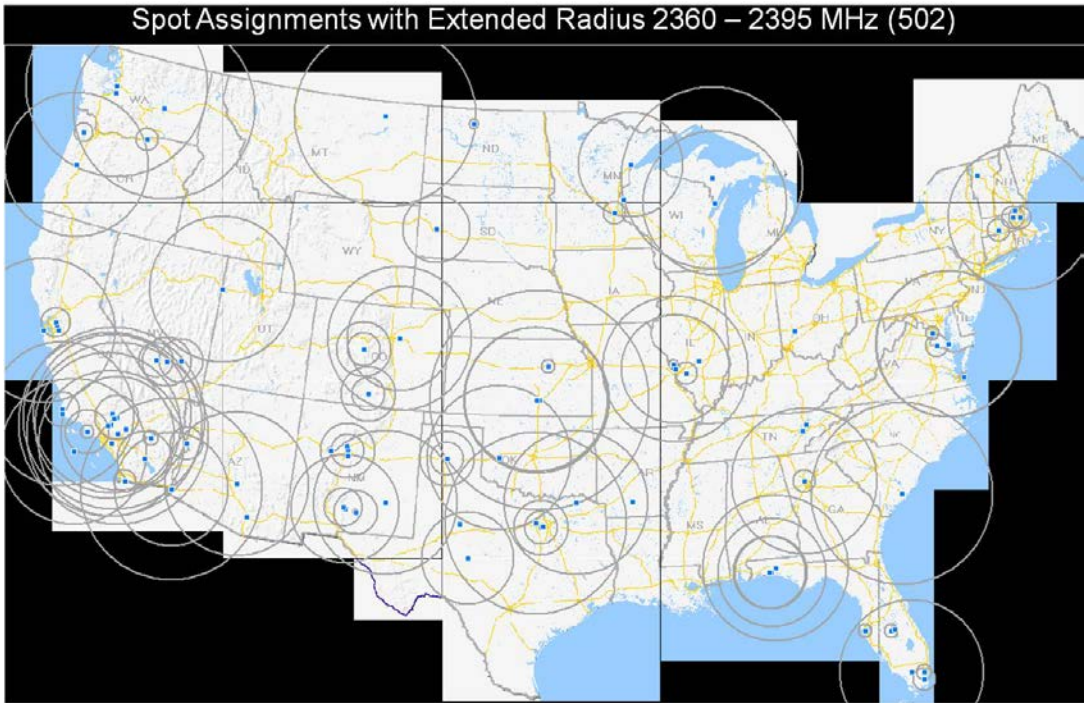
Video Surveillance Exploit/Case Support

	Capability Measure	Current Operational Capability	Resulting Operational Capability	Capability Assessment	Comments
Exploit/ Case Use	Data transfer/ Sharing formats	• Digital storage either of DVD, DVR or other media	• Digital storage either of DVD, DVR or other media	⇨	Degradation due to increased need to maintain multiple data files
		• Video duplication handled	• Video duplication handled efforts increased	⇨	
	Search Functionality	• Single search functionality afforded with digital storage format and analytic software that can be used to enhance search	• Increased operational impact to requirement to search multiple captures of information	⇘	
	Data storage format	• Digital formats	• Digital formats, but at reduced resolution limiting exploit capabilities	⇨	

Geographic extend of operations

The geographic extend of current operation in the 2360-2395 MHz band that are of interest is driven primarily from telemetry systems. The number of systems and their locations has yet to be ascertained. An evaluation of the locations and the significant RF characteristics would have to be conducted to determine potential geographic sharing of the frequency band.

Fixed site avoidance is less of an issue as depicted in the following figure.



The extent to which these limits impact mission effectiveness

The primary concern for relocating DHS systems into the 2360-2395 MHz band is the anticipated need to reduce operating bandwidth and the incompatibility and mutual interference DHS systems would incur from and present to the incumbent systems already resident and operating within the band. Even if DHS were able to obtain equipment that provided acceptable information quality in a significantly reduced bandwidth, sufficiently clear spectrum would still not be available in many key areas of the country. As a consequence, R&D would have to be initiated to develop, procure, and deploy devices that are capable of operating in the 2360-2395 MHz band. Significant time would be required, but it is estimated that the potential for a total solution in the limited bandwidth is medium to low.

Mitigation options available

TBD

The preferred solution for overcoming limits on performance brought on by the operational environment and the reasons why

TBD

Other constraints impede relocation (e.g., necessary allocation changes) to a comparable band and proposed remedies

TBD

Estimate of the time required to transition to the comparable band

Less than 10 years?

10-15 years?

Greater than 15 years?

An estimate of the cost to transition to the comparable band

Less than $0.5B?

$0.5B - $1.5B?

$1.5B - $2.5B?

$2.5B - $5.0B?

Greater than $5B?

Rationale for selection or non-selection

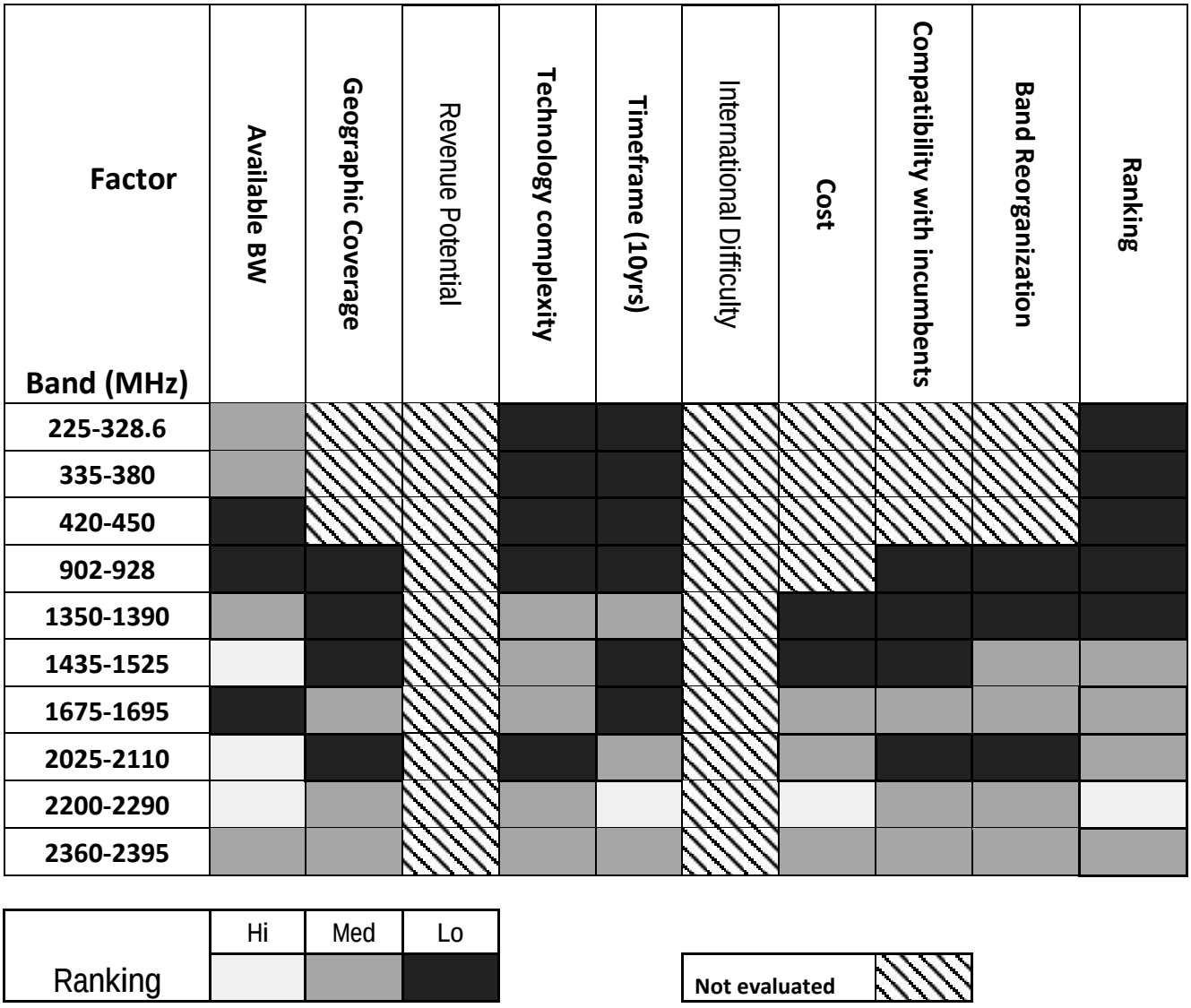
Limited bandwidth does not compare well to bandwidth available in the 1755-1850 MHz resulting in the need for significant technology development and relocation of incumbent operations. Potential exists for relocating a portion of the operations to the band.

Potential for sharing

Low to medium based on the reduction in total bandwidth available.

Summary of Evaluation (Ranking Preferences and Corresponding justifications**)**

The figure below provides a top level summary of DHS's alternate band evaluation including a ranking of the bands. DHS utilized the ranking guidance provide by NTIA and included two categories for Compatibility with incumbents and difficulty in reorganizing the band to further refine the analysis. In addition, DHS did not address revenue potential, which appeared to be out of scope for the capabilities of the Department and also did not address specifically the international coordination difficulty since focus of operations were primarily well within the United States borders.



- **<u>225-328.6MHz</u>**
  Low. The lower operating frequency raises technical concerns with required antenna length for small devices, the impacts of Doppler shift and RF channel parameters on digital modulation, the increase in man-made noise, and the lack of available devices.

- **335.4-380 MHz**
  Low. The lower operating frequency raises technical concerns with required antenna length for small devices, the impacts of Doppler shift and RF channel parameters on digital modulation, the increase in man-made noise, and the lack of available devices.

- **420-450 MHz Band**
  Low. The lower operating frequency raises technical concerns with required antenna length for small devices, the impacts of Doppler shift and RF channel parameters on digital modulation, the increase in man-made noise, and the lack of available devices.

- **902-928 MHz Band**
  Low. The technical concerns are required antenna length for small devices, the impacts of RF channel parameters on digital modulation, and the lack of available devices.

- **1350-1390 MHz Band**
  Low. The frequency of the band presents some potential issues with the antenna size of some devices. The reduction in available bandwidth would require development of devices capable of providing comparable video quality and reliability in reduced bandwidth. The vendor community is currently developing technologies toward this goal but it is yet to be validated. In addition, the potential interference from radar systems currently operating in the band would need to be addressed through a technology development currently not offered in the video devices or some other mechanism.

- **1435-1525 MHz Band**
  Med. The band presents potential since there is similar available bandwidth; however, the extent of radio telemetry systems needs to be evaluated in more detail.

- **1675-1695 MHz Band**
  Med. The frequency band presents potential for migration of some of the operations. The major challenge would be the required reduction in channel bandwidth to provide comparable video quality and reliability in the reduced total bandwidth. The vendor community is currently developing technologies toward this goal but it is yet to be validated. In addition, the potential interference from systems migrating into the band would need to be addressed through a technology development currently not offered in the video devices or some other mechanism.

- **2025-2110MHz Band**
  Med. The frequency band presents potential for migration. The major challenge would be the need to more fully understand the potential for interference from

incumbent systems assigned by FCC and if required to develop and deploy intelligent interference avoidance systems or some other mechanism.

- **2200-2290 MHz Band**

  High. The frequency band is currently used on a limited basis so devices are available. The major challenge would be the possible reduction in channel bandwidth to accommodate the additional 21 channels with the current 8 presently in the band. Comparable video quality and reliability in the reduced total bandwidth would be required. The vendor community is currently developing technologies toward this goal but they are yet to be validated. In addition, the potential interference from systems migrating into the band would need to be addressed through a technology development currently or some other mechanism.

- **2360-2395 MHz Band**

  Med. The frequency band presents potential for migration of some of the operations. The major challenge would be the reduction in channel bandwidth required to provide comparable video quality and reliability in the reduced total bandwidth. In addition, the potential interference from systems currently in and migrating to the band would need to be addressed through a technology development or some other mechanism.

Operations that could transition from the 1755-1780 MHz portion of the 1755-1850 MHz band in less than 5 years?

DHS continues to recommend a phased approach to vacating the 1755-1850 MHz band with fixed microwave backhaul systems and US&P video surveillance operations in 1755-1780 MHz band be targeted for release within five years. Microwave operations may possibly migrate to frequency bands in the 7 GHz range. The US&P video surveillance operations in the 1755-1780 MHz band may possibly migrate to a portion of the 1780-1850 MHz band reserved by NTIA or other portions of bands identified and confirmed following further evaluation and detailed planning.