

Spectrum Efficient National Surveillance Radar (SENSR)



SENSR SPECTRUM TEAM (SST)

TARGET BAND SPECTRUM REGULATORY ASSESSMENT

January 13, 2020

Background

The SENSR Spectrum Team (SST) provides support to the Spectrum Efficient National Surveillance Radar (SENSR) Joint Program Office (JPO) during the acquisition process on matters related to spectrum, to include definition of spectrum requirements, spectrum band assessments, and advising on regulatory conditions for any bands proposed. The SST is comprised of Government/Contractor representatives from the Federal Aviation Administration (FAA), Department of Defense (DoD), Department of Homeland Security (DHS), and National Oceanic and Atmospheric Administration (NOAA). This support includes, but is not limited to, the following:

- Studying radio frequency (RF) spectral characteristics.
- Conducting targeted spectrum bands evaluations to assess the feasibility of spectrum access for the systems that are proposed by potential vendors.
- Analyzing the electromagnetic compatibility (EMC) between SENSR and legacy systems and identifying and assessing the methods proposed for mitigating the interference.
- Defining spectrum performance and efficiency requirements, and evaluating industry technical solutions from a spectrum perspective.
- Preparing Stage 3 and 4 spectrum certification requests.
- Specifying frequency-distance separation requirements and coordination processes for protecting long-range radars in the 1300-1350 MHz band during the SENSR transition, including the early entry period.
- Supporting the development of transition plans.

The SST outputs to the SENSR JPO support acquisition milestones (such as IID and FID) and as needed, such as when new data from vendors is provided. The SST outputs are used by the SENSR JPO in their overall efforts for feasibility assessments, as well as defining the final SENSR objective/threshold requirements that drive performance, technology risk, and cost.

The vendors in their request for information (RFI) 1 responses identified various spectrum within the L, S, C, and X bands as viable spectrum options to meet SENSR requirements under a system of systems concept. The vendors in their RFI 2.1 responses identified spectrum within the HF, VHF, UHF, L, S, C, X, and Ku bands. (Note that the SENSR coverage volume requirements have been revised which the Government believes reduces the target necessary target spectrum bands from those identified in RFI 2.1 responses.) Currently, the SENSR requirements with respect to frequency band(s) only require the vendors to identify the bands they intend to use and do not promote use of any specific bands.

Purpose

This whitepaper contains SENSR JPO-approved preferred target sub-bands within L, S, C, X, and Ku bands based on a spectrum regulatory assessment. While there has been vendor input regarding passive capabilities, and those passive capabilities continue to represent potential paths for SENSR, this document focuses on transmit frequency bands only. The narrowing of potential bands for SENSR transmissions will support the US Government (USG) in future activities, such

as the EMC analyses between incumbent systems and the still undefined characteristics of SENSr or its component systems, which will be performed once the intended characteristics of the SENSr technology are known. The SST is underway with the development of a modeling capability to support SENSr EMC analyses, which requires having updated and accurate information of existing users to model and analyze the potential impacts to and from SENSr. The identification of preferred target sub-bands would significantly reduce the workload for the USG by focusing modeling and analysis efforts to fewer possible options. Fewer options will reduce significantly the time needed to complete and provide results to the JPO, and will enable strategic engagements with Federal Communications Commission (FCC) and National Telecommunications and Information Administration (NTIA) to be more focused on allocations for specific spectrum.

An EMC analysis will be performed to assess the impact of SENSr on incumbent users in the frequency bands identified by industry in their Screening Information Request (SIR) proposals. The SST evaluates and provides the SENSr JPO feedback on proposals based on a 3-pillar approach that assesses:

1. Policy/Regulatory Information: determination of whether vendor proposals are aligned with existing policy (such as the US Table of Frequency Allocations) and if not, the level of difficulty to modify.
2. Capacity: investigate if the spectrum identified by vendors is available and sufficient to support a SENSr implementation described by each vendor.
3. Compatibility: assess the compatibility of vendors' solutions with users in and adjacent to the band(s) proposed.

This document is intended to provide vendors with information on each of these 3 key aspects prior to the SIR to increase awareness of the potential spectrum environment in which their SENSr solution will be proposed to operate. Information on capacity is provided based on reviewing approved US frequency assignments that operate in operational or permanent status (i.e. all temporary and experimental uses that operate on a non-interference basis are not displayed) as of Nov 2019.

The SST identified a portion within each of the L, S, C, X, and Ku bands, which could be called "*Preferred SENSr Transmit Target Bands.*" This document depicts the regulatory landscape of these bands, identifies existing users in each band, and provides the rationale why the SST believes these are potentially feasible bands for SENSr.

NOTE: This assessment should not be interpreted as decisional, as it relates to target bands for SENSr. It merely highlights spectrum-related challenges identified by the Government in viable portions of the spectrum that could potentially meet SENSr spectrum requirements. Sub-bands identified are "RECOMMENDED" for consideration and are "NOT REQUIRED" landing bands for SENSr. Industry can still pursue/identify solutions outside of these preferred bands and need to ensure compliance with U.S. spectrum regulatory/policy.

Summary of Results: The following table contains a regulatory summary of the assessment. The details of the assessment are located in the appendix.

	SENSR Preferred Sub-Band (MHz)	BW (MHz)	Fed	Non-Fed	Fed	Non-Fed	Reallocation
			Aeronautical Radionavigation		Radiolocation		
L-Band	1240 – 1300	60	1	1	1		N/A-meets requirement
	1350 – 1390 *	40			1		Requires Aeronautical Radionavigation
S-Band	2700 – 2900 *	200	1		2		N/A-meets requirement
	2900 – 3100	200			1	2	Requires Aeronautical Radionavigation
C-Band	5150 – 5250	100	1	1			Requires Radiolocation
	5250 – 5255	5			1	2	Requires Aeronautical Radionavigation
	5255 – 5350	95			1	2	Requires Aeronautical Radionavigation
	5650 – 5925	275			1		Requires Aeronautical Radionavigation
X-Band	8500 – 8550	50			1	2	Requires Aeronautical Radionavigation
	8550 – 8650	100			1	2	Requires Aeronautical Radionavigation
	8650 – 9000	350			1	2	Requires Aeronautical Radionavigation
	9000 – 9200	200	1	1	1	2	N/A-meets requirement
	9200 – 9300	100			2	2	Requires Aeronautical Radionavigation
	9300 – 9500	200	1	1	1	2	N/A-meets requirement
	9500 – 9800	300			1	2	Requires Aeronautical Radionavigation
	9800 – 10000	100			1	2	Requires Aeronautical Radionavigation
Ku-Band	15700 – 16600	900			1	2	Requires Aeronautical Radionavigation

Notes: * denotes Federal (FED) Only Band; 1 = Primary Allocation, 2 = Secondary Allocation

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Introduction

The SST evaluates and provides the SENSR JPO feedback on proposals based on a 3-pillar approach that assesses:

1. **Policy/Regulatory Information:** determination of whether vendor proposals are aligned with existing policy (such as the US Table of Allocations) and if not, the level of difficulty to modify.
2. **Capacity:** investigate if the spectrum identified by vendors is available and sufficient to support a SENSR implementation described by each vendor.
3. **Compatibility:** assess the compatibility of vendors' solutions with users in and adjacent to the band(s) proposed.

Based on the 3-pillar approach described above, the following describe viable portions of the electromagnetic spectrum that could potentially meet SENSR system requirements. Each selected spectrum band provides the following information in the following template:

Spectrum Band - in Megahertz

Policy/Regulatory Information:

- a) **Allocation:** from the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management (**Redbook) - either Federal or Shared Federal and Non-Federal
- b) **Primary Allocation:** from the NTIA Redbook
- c) **Secondary Allocations:** from the NTIA Redbook
- d) **Re-allocation:** assessment based on above available system allocations

Capacity:

- a) **Usage:** number of frequency assignments, percentage provided for agencies involved in SENSR program; summation of percentage may not equal 100%
- b) **Systems:** assessment and data collection of systems in use in this band discussed to help frame future electromagnetic compatibility analysis

Compatibility:

- a) **Incoming Systems:** planned system deployments, and potential interoperability
- b) **Future Growth:** future systems that may be added to specific spectrum band

** NTIA Redbook: <https://www.ntia.doc.gov/page/2011/manual-regulations-and-procedures-federal-radio-frequency-management-redbook>

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L-Band: 1240 – 1300 MHz

Policy/Regulatory Information:

- a) Allocation: Shared Federal and Non-Federal
- b) Primary Allocation: Aeronautical Radionavigation (Shared) and Radiolocation, Earth Exploration-Satellite, Space Research (Federal)
- c) Secondary Allocations: Amateur, Earth exploration-satellite, and Space Research (Non-Federal)
- d) Re-allocation: Not required, band meets minimum requirements

Capacity:

- a) Usage: 550 operational assignments in this band, which includes assignments that support DoD (52%), FAA (38%), and DHS (4%) systems.
- b) Systems: Federal agencies operate various types of long-range radar (LRR) systems that perform missions critical to safe and reliable air traffic control (ATC) in the national airspace, border surveillance, early warning missile detection, and drug interdiction. DoD assignments are primarily for LRRs at military ranges and FAA assignments support CARSR and ARSR-4 equipment.

Compatibility:

- a) Incoming Systems:
 - LRRs that operate in this band would possess incumbency (priority access) rights.
 - The radars in the band may experience interference and must consider deconfliction from the Radionavigation Satellite Service (RNSS) systems of other administrations as they launch satellites and become operational. This could place additional limitations on the spectrum available for the radar systems operating in this band.
- b) Future Growth:
 - None identified

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L-Band: 1350 – 1390 MHz

Policy/Regulatory Information:

- a) Allocation: Federal
- b) Primary Allocation: Radiolocation, Fixed, and Mobile
- c) Secondary Allocations: None
- d) Re-allocation: Current band does not have an aeronautical radionavigation allocation. Based on regulatory policy, and incumbent use levels, obtaining authorizations for radionavigation is challenging.

Capacity:

- a) Usage: There are 822 operational assignments in this band, which includes assignments that support DoD (97%) and FAA (3%) systems.
- b) Systems: The federal agencies operate LRR systems to perform missions critical to safe and reliable ATC in the national airspace, border surveillance, early warning missile detection, and drug interdiction. The DoD operates mobile telemetry systems at test ranges to collect and disseminate data for flight operations. The DoD also operates a system that transmits Global Positioning System (GPS) position data at test ranges. The DoD operates tactical point-to-point communication systems to support battlefield command and control operations and ship-to-ship communication systems in this band. There are also operations for a nuclear burst detection system, remote sensing, and radio astronomy observations in this band.

Compatibility:

- a) Incoming Systems:
 - Radars for this band must consider deconfliction due to in-band users.
 - LRRs that operate in this band will possess incumbency rights.
- b) Future Growth:
 - Growing use for mobile operational requirements including tactical and airborne uses.
 - Problems may arise if flight safety functions are performed in this band as it undergoes changes and growth including tactical and airborne uses.

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S-Band: 2700 – 2900 MHz

Policy/Regulatory Information:

- a) Allocation: Federal
- b) Primary Allocation: Aeronautical Radionavigation, and Meteorological Aids
- c) Secondary Allocations: Radiolocation
- d) Re-allocation: None

Capacity:

- a) Usage: Less than 1150 frequency assignments in this band, which includes assignments that support DoD (44%), FAA (44%), and Department of Commerce (DoC) (11%) systems.
- b) Systems: For operating various types of radar systems that perform missions critical to safe and reliable ATC and accurate weather monitoring in the United States. This includes airport surveillance radar (ASR-8, 9, and 11) systems and meteorological radars. The ASR systems are operated by the FAA and the DoD to monitor national airspace for non-cooperative targets in and around airports. The ASRs also can have some limited weather monitoring functions. A network of NEXRAD systems are operated tri-agency Radar Operations Center (ROC) and provide quantitative and automated real-time information on storms, precipitation, hurricanes, and other important weather information (rainfall amounts and rates, wind velocity, wind direction, hail, snow) with higher spatial and temporal resolution than previous weather radar systems. The ROC is jointly funded by the DoC National Weather Service (NWS), the FAA and the DoD.

Compatibility:

- a) Incoming Systems:
 - Ground-based radars used for meteorological purposes are authorized to operate on a basis of equality with stations of the aeronautical radionavigation service.
 - Authorizations may be made by the FCC for non-Federal operations in these bands subject to the conclusion of appropriate arrangements between the FCC and the Federal agencies.
 - Military fixed and shipborne air defense radiolocation installations will be fully coordinated with the meteorological aids and aeronautical radionavigation services.
 - SENSr radars for this band must consider deconfliction due to in-band users.
 - Current SENSr mission areas have allocations, assignments, and primacy in the regulations, which must be preserved if they are not integrated as part of the SENSr solution.

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- b) *Future Growth*:
- None identified

S-Band: 2900 – 3100 MHz

Policy/Regulatory Information:

- a) *Allocation*: Shared Federal and Non-Federal
- b) *Primary Allocation*: Radiolocation (Federal), Maritime Radionavigation (Shared)
- c) *Secondary Allocations*: Radiolocation (Non-Federal)
- d) *Re-allocation*: Based on allocation tables, there is no Aeronautical Radionavigation in this frequency range; the addition of an Aeronautical Radionavigation allocation for this band can cause conflicts with other users, which can impede the additional allocation.

Capacity:

- a) *Usage*: 450 frequency assignments in this band, which includes assignments that support DoD (58%), non-federal (35%), DoC (4%), and DHS (1%) systems.
- b) *Systems*: For operating various types of radar systems that perform missions critical to safe and reliable maritime navigation and accurate weather monitoring in the United States. The United States Coast Guard (USCG), Federal agency and commercial vessels operate radar systems and positioning aids in this band for Maritime Radionavigation for the safe transportation of people and goods, and to facilitate the flow of commerce. The DoD develops and uses Radionavigation and Radiolocation systems for national defense purposes. A network of NEXRAD systems operating provide quantitative and automated real-time information on (rainfall amounts / rates, wind velocity, wind direction, hail, snow, etc.) with higher spatial and temporal resolution than previous weather radar systems. In addition, the NEXRAD network provides the data which is used to generate thunderstorm, tornado, hurricane, high wind and flash floods watches and warnings. The NEXRAD systems are operated throughout the United States by the tri-agency ROC.

Compatibility:

- a) *Incoming Systems*:
- Radars for this band must consider deconfliction due to in-band users.
- b) *Future Growth*:
- None identified

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C-Band: 5150 – 5250 MHz

Policy/Regulatory Information:

- a) *Allocation*: Shared Federal and Non-Federal
- b) *Primary Allocation*: Aeronautical Radionavigation (shared), Fixed-Satellite (non-federal)
- c) *Secondary Allocations*: None
- d) *Re-allocation*: Based on allocation tables, a new Radiolocation allocation would be required for SENSr operations in this band.

Capacity:

- a) *Usage*: There are 19 frequency assignments in this band, 17 that support non-federal systems and 2 that support DoD systems.
- b) *Systems*: - Tactical radars and Microwave Landing System (MLS).

Compatibility:

- a) *Incoming Systems*:
 - Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with MLS and expanded outdoor usage of WAS/RLAN for 5150-5220 MHz under World Radiocommunication Conference (WRC) 2019 Agenda Item (AI) 1.16. 5.x GHz (IEEE 802.11); Wi-Fi in this range; and Unlicensed National Information Infrastructure (U-NII) -1 band.
- b) *Future Growth*:
 - None identified.

C-Band: 5250 – 5255 MHz

Policy/Regulatory Information:

- a) *Allocation*: Shared Federal and Non-Federal
- b) *Primary Allocation*: Radiolocation, Earth Exploration-Satellite, Space Research (Federal)
- c) *Secondary Allocations*: Earth Exploration-Satellite, Radiolocation, Space Research (Non-Federal)

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- d) *Re-allocation*: Based on allocation tables, a new Radiolocation allocation would be required for SENSr operations in this band. Federal non-military radiolocation shall be secondary to military radiolocation, except in certain bands where it should be equal with airport surface detection equipment (ASDE). Based on allocation tables, there is no Aeronautical Radionavigation in this frequency range; the addition of an Aeronautical Radionavigation allocation for SENSr can cause conflicts with other users which can impede the additional allocation.

Capacity:

- a) *Usage*: There are less than 40 frequency assignments in this band, which includes assignments that support non-federal (81%) and DoD (19%) systems.
- b) *Systems*: This band is used by a military radar system that is an important land-based tactical radar system. The military agencies operate airborne weather navigation radar systems in this band to avoid severe weather conditions. The military agencies use the band for multi-mode test range instrumentation radars, usually to provide prime coverage for range safety purposes. The Army uses this band for mobile high-powered ground-based surface-to-air missile radar systems. The Navy uses this band for shipborne radars used for surface search, and navigation and weapons fire control.

Compatibility:

- a) *Incoming Systems*:
- Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with Wi-Fi with Dynamic Frequency Selection (DFS) and 5.x GHz (IEEE 802.11) UNII-2, tactical radars, and Law enforcement radars.
- b) *Future Growth*:
- None identified

C-Band: 5255 – 5350 MHz

Policy/Regulatory Information:

- a) *Allocation*: Shared Federal and Non-Federal
- b) *Primary Allocation*: Earth Exploration-Satellite, Radiolocation, and Space Research (Federal)
- c) *Secondary Allocations*: Earth Exploration-Satellite, Radiolocation, and Space Research (Non-Federal)

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- d) *Re-allocation*: Based on allocation tables, there is no Aeronautical Radionavigation in this frequency range; the addition of an Aeronautical Radionavigation allocation for SENSR can cause conflicts with other users, which can impede the additional allocation.

Capacity:

- a) *Usage*: 200 frequency assignments in this band, which includes assignments that support DoD (80%), DHS (17%), non-federal (2%), and DoC (1%) systems.
- b) *Systems*: This band is used for anti-air warfare radars that are part of an advanced ground-based air defense missile system. The Army uses this band for mobile high-powered ground-based surface-to-air missile radar systems. The Navy uses this band for shipborne radars used for surface search, and navigation and weapons fire control. The military agencies use this band for missile detection, imaging, synthetic aperture radar, frequency agile, and ship sensor radar systems. The military agencies use this band for test range instrumentation radars to track rockets, missiles, satellites, launched vehicles, and other targets. These radars are usually the prime coverage system for range safety.

Compatibility:

- a) *Incoming Systems*:
- Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with Wi-Fi with Dynamic Frequency Selection (DFS) and UNII-2, tactical radars, and law enforcement radars.
- b) *Future Growth*:
- The band is under consideration by the Navy for their next generation major shipborne radar.

C-Band: 5650 – 5925 MHz

Policy/Regulatory Information:

- a) *Allocation*: Shared Federal and Non-Federal
- b) *Primary Allocation*: Radiolocation (Federal), 5850-5925 MHz Fixed-Satellite, and Mobile (Non-Federal)
- c) *Secondary Allocations*: Amateur, and 5830-5850 MHz: Amateur-Satellite (Non-Federal)
- d) *Re-allocation*: Based on allocation tables, there is no Aeronautical Radionavigation in this frequency range; the addition of an Aeronautical Radionavigation allocation

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for SENSr can cause conflicts with other users, which can impede the additional allocation.

Capacity:

- a) Usage: There are approximately 10300 assignments in this band (with almost 10,000 being non-federal user assignments that have been added), which include assignments that support non-federal (92%), DoD (5%), FAA (1%), DHS (0.5%), and NASA (0.5%) systems.
- b) Systems: This band is used for anti-air warfare radars that are part of an advanced ground-based air defense missile system. The band is also under consideration by the Navy for their next generation major shipborne radar. The Army uses this band for mobile high-powered ground-based surface-to-air missile radar systems. The Navy uses this band for shipborne radars used for surface search, and navigation and weapons fire control, and the Navy uses its main shipborne surface search radar in the band. Hundreds of the radars have been deployed and regularly modernized. The military agencies use this band for fixed, transportable, and mobile radars for search, surveillance, airborne transponders, and experimental radar testing. The military and NASA use this band for test range instrumentation radars to track rockets, missiles, satellites, launched vehicles, and other targets. These radars are usually the prime coverage system for range safety. The FAA use is mainly located in Alaska for VITACOM satellite frequency converter units designed for providing a satellite communications network.

Compatibility:

- a) Incoming Systems:
 - Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with tactical radars, expanded outdoor usage of 5.x GHz (IEEE 802.11) Wi-Fi in this range; in particular the Extended UNII-2 and part of UNII-3 Extended UNII-2, Part UNII-3 bands.
- b) Future Growth:
 - The band is under consideration by the Navy for their next generation major shipborne radar.

X-Band: 8500 – 8550 MHz

Policy/Regulatory Information:

- a) Allocation: Shared Federal and Non-Federal
- b) Primary Allocation: Radiolocation (Federal)
- c) Secondary Allocations: Radiolocation (Non-Federal)

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- d) *Re-allocation*: Based on allocation tables, there is no Aeronautical Radionavigation in this frequency range; the addition of an Aeronautical Radionavigation allocation for SENSR can cause conflicts with other users, which can impede the additional allocation.

Capacity:

- a) *Usage*: There are approximately 600 frequency assignments in this band, which includes assignments that support non-federal (97%) and DoD (3%) systems.
- b) *Systems*: Extensive non-government use. Use by the federal agencies for military and non-military radar systems, including meteorological, airborne navigation, transportable artillery-locating, weapons fire control, and ballistic missile defense imaging.

Compatibility:

- a) *Incoming Systems*:
- Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with tactical radars and ground interdiction radars.
- b) *Future Growth*:
- None identified

X-Band: 8550 – 8650 MHz

Policy/Regulatory Information:

- a) *Allocation*: Shared Federal and Non-Federal
- b) *Primary Allocation*: Radiolocation, Earth Exploration-Satellite, and Space Research (Federal)
- c) *Secondary Allocations*: Earth Exploration-Satellite, Radiolocation, Space Research (Non-Federal)
- d) *Re-allocation*: Based on allocation tables, there is no Aeronautical Radionavigation in this frequency range; the addition of an Aeronautical Radionavigation allocation for SENSR can cause conflicts with other users, which can impede the additional allocation.

Capacity:

- a) *Usage*: There are 6 frequency assignments in this band, which includes assignments that support DoD (50%) systems.

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- b) *Systems*: This band is used by the federal agencies for military and non-military radar systems, including meteorological, airborne navigation, transportable artillery-locating, fire control, and ballistic missile defense imaging. The band is used for weapons control radars onboard military aircraft. Federal agencies operate radars in this band to map ocean currents in harbor areas.

Compatibility:

- a) *Incoming Systems*:
- Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with tactical radars and ground interdiction radars.
- b) *Future Growth*:
- None identified.

X-Band: 8650 – 9000 MHz

Policy/Regulatory Information:

- a) *Allocation*: Shared Federal and Non-Federal
- b) *Primary Allocation*: Radiolocation (Federal)
- c) *Secondary Allocations*: Radiolocation (Non-Federal)
- d) *Re-allocation*: Based on allocation tables, there is no Aeronautical Radionavigation in this frequency range; the addition of an Aeronautical Radionavigation allocation for SENSr can cause conflicts with other users, which can impede the additional allocation.

Capacity:

- a) *Usage*: There are approximately 275 frequency assignments in this band, which includes assignments that support DHS (62%), DoD (32%), non-federal (4%), and DoC (1%).
- b) *Systems*: This band is used by the Federal agencies for military and non-military radar systems, including meteorological, airborne navigation, transportable artillery locating, weapons fire control, and ballistic missile defense imaging.

Compatibility:

- a) *Incoming Systems*:
- Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with tactical radars and ground interdiction radars.

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- b) *Future Growth*:
- None identified.

X-Band: 9000 – 9200 MHz

Policy/Regulatory Information:

- a) *Allocation*: *Shared Federal and Non-Federal*
- b) *Primary Allocation*: Aeronautical Radionavigation (Shared) and Radiolocation (Federal)
- c) *Secondary Allocations*: Radiolocation (Non-Federal)
- d) *Re-allocation*: None

Capacity:

- a) *Usage*: There are approximately 450 frequency assignments in this band, which includes assignments that support DoD (84%), FAA (15%), and non-federal (1%) systems.
- b) *Systems*: The military agencies operate radar systems in this band for precision approach radars, airborne search and rescue, law enforcement, navigation, and surveillance. The Federal Aviation Administration and the military agencies use this band for ASDE radars to monitor aircraft and vehicles on the ground near airports for airport safety.

Compatibility:

- a) *Incoming Systems*:
- Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with tactical radars, ground interdiction radars, ASDE, and approach radars.
- b) *Future Growth*:
- None identified.

X-Band: 9200 – 9300 MHz

Policy/Regulatory Information:

- a) *Allocation*: *Shared Federal and Non-Federal*
- b) *Primary Allocation*: Maritime Radionavigation (Shared)

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- c) *Secondary Allocations*: Radiolocation (Shared)
- d) *Re-allocation*: All Federal non-military radiolocation shall be secondary to military radiolocation, except in certain bands where it should be equal with ASDE. Note that based on allocation tables, there is no aeronautical radionavigation in this frequency range; the addition of an aeronautical radionavigation allocation for SENSr can cause conflicts with other users, which can impede the additional allocation.

Capacity:

- a) *Usage*: There are approximately 100 frequency assignments in this band, which includes assignments that support non-federal (58%), DoD (36%), and DHS (3%) systems.
- b) *Systems*: The Coast Guard uses this band for maritime radionavigation radar systems to observe harbor and coastal traffic.

Compatibility:

- a) *Incoming Systems*:
 - Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with ground interdiction radars.
- b) *Future Growth*:
 - None identified.

X-Band: 9300 – 9500 MHz

Policy/Regulatory Information:

- a) *Allocation*: Shared Federal and Non-Federal
- b) *Primary Allocation*: Radionavigation (Shared), Radiolocation, Earth Exploration-Satellite, and Space Research (Federal)
- c) *Secondary Allocations*: Meteorological Aids (Shared), Radiolocation, Earth Exploration-Satellite, and Space Research (Non-Federal)
- d) *Re-allocation*: None

Capacity:

- a) *Usage*: There are approximately 1150 frequency assignments in this band, which includes assignments that support DoD (51%), non-federal (33%), DHS (10%), and DoC (1%).

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- b) *Systems*: The Coast Guard uses this band to operate maritime radio navigation radar systems in congested harbor areas to observe harbor and coastal vessel traffic as part of the vessel traffic control system providing harbor traffic safety. The Coast Guard and other federal agencies use this band extensively for shipboard radars in maritime radio navigation. The Coast Guard shipborne and harbor maritime radars in this band can detect search and rescue transponders (SARTs) installed on large vessels. These transponders respond when interrogated by the shipborne radar and can be used to locate the distressed vessel. The SART devices are also used onboard survival craft. Federal agencies operate meteorological radar systems in this band. Many federal agencies use aircraft with weather navigation radar systems in this band.

Compatibility:

- a) *Incoming Systems*:
- Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with ground interdiction radars and Maritime/ Ground Master/ Air Surveillance Radar Operations.
 - Radars shall not cause interference to ships; search and rescue transponders (SART) may be used, having due regard to the appropriate International Telecommunication Union-Radiocommunication Sector (ITU-R) recommendation.
 - Earth exploration-satellite services cannot expect protection from radio navigation services.
 - Meteorological aids service is limited to ground-based radars.
 - Low-powered maritime radionavigation stations shall be protected from harmful interference caused by the operation of land-based equipment.
- b) *Future Growth*:
- None identified.

X-Band: 9500 – 9800 MHz

Policy/Regulatory Information:

- a) *Allocation*: Shared Federal and Non-Federal
- b) *Primary Allocation*: Earth Exploration Satellite, Radiolocation, Space Research (Federal)
- c) *Secondary Allocations*: Earth Exploration Satellite, Radiolocation, Space Research (Non-Federal)
- d) *Re-allocation*: Note that based on allocation tables, there is no aeronautical radionavigation in this frequency range; the addition of an aeronautical

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radionavigation allocation for SENSr can cause conflicts with other users, which can impede the additional allocation.

Capacity:

- a) Usage: There are 177 operational assignments in this band, which includes assignments that support non-federal (52%), DoD (38%), DHS (4%), and DoC (1%) systems.
- b) Systems: NASA performs Earth observations in this band and operates spaceborne active sensors such as synthetic aperture radars (SAR) imaging radars.

Compatibility:

- a) Incoming Systems: None identified.
- b) Future Growth: NASA plans to operate altimeters and scatter meters.

X-Band: 9800 – 10000 MHz

Policy/Regulatory Information:

- a) Allocation: Shared Federal and Non-Federal
- b) Primary Allocation: Radiolocation (Federal)
- c) Secondary Allocations: Radiolocation (Non-Federal), 9800-9900 MHz: Earth Exploration-Satellite and Space Research (Shared)
- d) Re-allocation: Based on allocation tables, there is no Aeronautical Radionavigation in this frequency range; the addition of an Aeronautical Radionavigation allocation for SENSr can cause conflicts with other users, which can impede the additional allocation.

Capacity:

- a) Usage: There are 60 operational assignments in this band, which includes assignments that support DoD (53%), DHS (45%), and non-federal (2%) systems.
- b) Systems: This band is used by the military for weapons control radars onboard aircraft. NOAA uses this band for radar systems onboard meteorological satellites.

Compatibility:

Appendix – Detailed Assessment Results

- a) Incoming Systems:
 - Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with ground interdiction radars and Maritime/ Ground Master/ Air Surveillance Radar Operations.
- b) Future Growth:
 - None identified.

Ku-Band: 15700 – 16600 MHz

Policy/Regulatory Information:

- a) Allocation: Shared Federal and Non-Federal
- b) Primary Allocation: Radiolocation (Federal)
- c) Secondary Allocations: Radiolocation (Non-Federal)
- ⊕ Re-allocation: Based on allocation tables, there is no Aeronautical Radionavigation in this frequency range; the addition of an Aeronautical Radionavigation allocation for SENSR can cause conflicts with other users, which can impede the additional allocation.

Capacity:

- a) Usage: There are 113 operational assignments in this band, which includes assignments that support DoD (71%) and FAA (29%) systems.
- b) Systems: The Federal Aviation Administration operates ASDE-3 radars in this band to monitor aircraft and vehicles on the ground near airports. The military agencies use this band for radars for guided weapons systems, combat surveillance, mortar locating, airborne weapons control radars, and radars on Unmanned Aerial Vehicles (UAVs). The Army uses the 15.7-17.3 GHz band for: UAVs tactical endurance radars (TESAR); the UAV small tactical synthetic aperture radars (STACSAR); terrain following radars; forward looking multimode radars on helicopters; and the LANTRIN terrain following radars. Federal agencies use this band for security perimeter surveillance radar systems.

Compatibility:

- a) Incoming Systems:
 - Radars for this band must consider deconfliction due to in-band users.
 - Interoperability concerns with various airborne radars for functions such as terrain following, forward looking radars, tactical aeronautical radionavigation.

Appendix – Detailed Assessment Results

- Agencies employ transportable aircraft MLS in this band. Deconfliction required as ASDE uses radiolocation in 15.7-16.2 GHz.
- b) Future Growth:
- None identified.

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