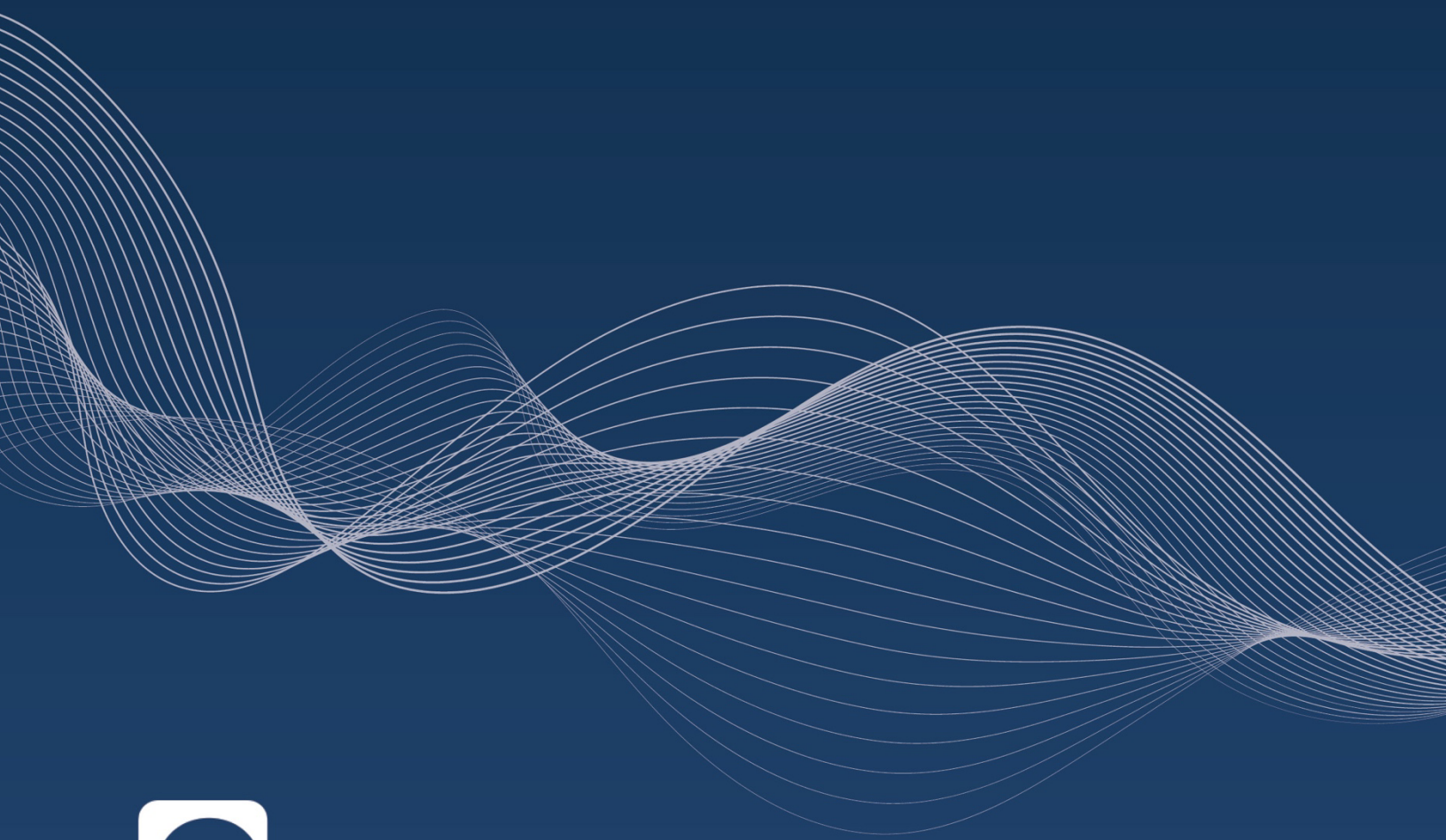
Global Coexistence

In The Lower 3 GHz Band



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Global Coexistence in the Lower 3 GHz Band

INTRODUCTION

There are over 50 countries around the world that have allocated the 3.1-3.45 GHz ("Lower 3 GHz") spectrum for full power, licensed use. Many of these countries are using this spectrum for extensive 5G deployments and are successfully coexisting and coordinating with the same radar systems utilized by the US military. The US should adopt coexistence models from these countries and work to make at least 150 megahertz of spectrum in the Lower 3 GHz band available for commercial access, which will enable both economic growth and national security. Government policymakers should implement the successful approaches pioneered by international counterparts to make the Lower 3 GHz band available for non-federal users, consistent with Congress's directives.

Technological improvements have facilitated the ability of wireless providers to do more with their spectrum holdings, but the industry's ability to continue to innovate and lead on a global stage is dependent on a reliable pipeline of new spectrum and on certainty of usage rights. The benefits realized to date have been the direct result of comprehensive national policies that support access to licensed spectrum, which in turn promote investment and innovation in next-generation technologies and networks deployed at scale. Moreover, exclusive-use licenses offer providers certainty and predictability that their investments will be protected against harmful interference and help ensure the security of the overall network infrastructure by allowing private management and network development.

Despite this, mid-band spectrum availability has increased only moderately since 2012.1 Indeed, only 450 megahertz of licensed mid-band spectrum is available today—100 megahertz in 3.7 GHz Phase I, 180 megahertz of 3.7 GHz Phase II, 70 megahertz of licensed CBRS, and 100 megahertz at 3.45 GHz—compared to over 1,900 megahertz of mid-band spectrum made available for unlicensed uses. The US is well behind key benchmark nations in the amount of mid-band spectrum licensed to commercial wireless and is the only benchmark country that has permitted use of 3 GHz spectrum on a shared or unlicensed basis. Today, the US trails its peers by an average of 378 megahertz in access to licensed mid-band spectrum,2 roughly the same amount of spectrum in the 3.45 GHz and 3.7 GHz bands combined. This comparison is just a current snapshot: the US licensed mid-band deficit as compared to other nations is expected to grow by nearly 40 percent in the next five years.3 Beyond the upcoming Phase II spectrum in C-Band—already counted in the totals above—the US is not expected to have any additional mid-band spectrum available by 2027. According to GSMA's Vision 2030, US cities need a total of two gigahertz of mid-band spectrum, on average, to enable 5G growth and capacity.4

The 3.1-3.45 GHz ("Lower 3 GHz") band—currently a federal-only band used by the Department of Defense ("DoD")—is a critical opportunity. As part of the Infrastructure Investment and Jobs Act ("IIJA"), Congress directed DoD to study this band and identify spectrum that could be made available for shared use by non-federal users.5 The IIJA appropriated $50 million to fund research and development and undertake other planning activities, such as engineering studies and economic analyses, to improve DoD spectrum efficiency and enable commercial sharing in the band. To date, DoD has taken a very narrow view of sharing that does not include clearing the band, repacking incumbent operations for more efficient use, or retuning of incumbents due in large part to concerns

regarding the potential impact of commercial operations on mission-critical radar systems and other military-related services.

US policymakers must recognize the economic and national security aspects of commercial wireless spectrum. Policymakers should identify ways to rectify the imbalance in US mid-band allocations—which currently favor federal, unlicensed, and shared use—while US commercial wireless licensed allocations increasingly fall behind rival nations and other countries. Because greenfield spectrum opportunities are increasingly rare, the US should seize the opportunity to engage Federal partners—which hold two-thirds of the mid-band spectrum—to identify and work together to reallocate bands for commercial use while ensuring mission-critical operations can continue.

MANY COUNTRIES ARE ACTIVELY USING THE LOWER 3 GHZ BAND TO SUPPORT 5G DEPLOYMENTS

Many regions around the globe are using the Lower 3 GHz band for 5G network deployments. 3GPP, the leading 5G international standards body, has an n77 band class, from 3.3 – 4.2 GHz, (along with n78 from 3.3-3.8 GHz) which is used extensively throughout the world for 5G services and to support future mid-band spectrum opportunities.[6]

Europe and Asia were early adopters of mid-band spectrum for 5G and, in particular, allocating the 3.3-3.8 GHz band for exclusive, full-power, licensed use. In Europe, countries such as the United Kingdom, France, Spain, and Germany are currently operating 5G networks in portions of the 3.4-3.8 GHz band. In total, almost 30 European countries, including many NATO allies, have allocated or are in consultation to allocate spectrum for 5G using the 3.4 GHz band.[7] In Asia, almost 20 countries have allocated or are exploring allocation of Lower 3 GHz spectrum for 5G services. As discussed in greater detail below, Japan and South Korea currently operate extensive 5G networks in the 3.4 GHz band. Likewise, in the Middle East, Saudi Arabia operates 5G networks in 3.4 GHz spectrum. Included as an appendix to this paper is a list of countries that have allocated mid-band spectrum for 5G.

Beyond that, several countries have made additional Lower 3 GHz spectrum available for 5G. For example, China, India, and Taiwan have deployed 5G networks in the 3.3-3.8 GHz range, and the Philippines has authorized use of spectrum for 5G in the 3.3-3.4 GHz band. In the Western Hemisphere, Brazil, Mexico, and Chile also have authorized spectrum using the 3.3 GHz band.

The US has taken a different approach to allocating 3 GHz spectrum. In the top portion of the band, the US reallocated 280 megahertz (3.7-3.98 GHz) on a full power, exclusive-use basis; today, this is one of the primary mid-band ranges delivering 5G service in the US Below that (3.55-3.7 GHz), the Citizens Broadband Radio Service (“CBRS”) is allocated for shared use—in this band, Federal government incumbents retain primary access while commercial users share the band at low power levels. Because of these sharing and power restrictions, the CBRS band delivers less capacity and coverage than licensed bands with full power, placing the US at a disadvantage relative to other countries vis-à-vis its use of 3.55-3.7 GHz.[8] The third portion of the 3 GHz band allocated for commercial use is between 3.45 and 3.55 GHz. Though licensed on a full power basis, the US government established protection zones around military radar locations and coordination zones to protect incumbent systems operating in the band that limit the utility of the spectrum.[9]

LOWER 3 GHZ BAND RADAR SYSTEMS AND METHODS FOR 5G COEXISTENCE

Domestically, the US government operates various types of radar systems for national defense purposes within the Lower 3 GHz band.[10] Generally, these systems fall into three categories:

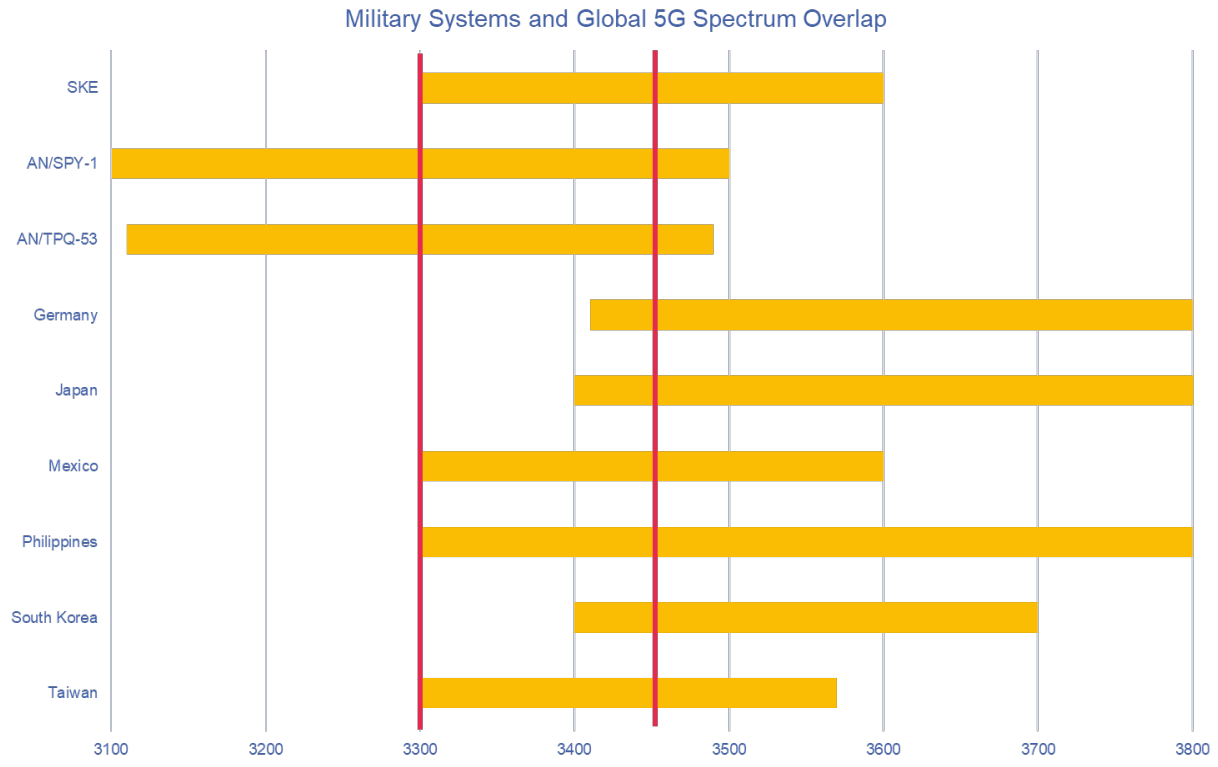
- *Land-based Radar Operations:* the US Army and US Marine Corps routinely conduct operations supported by land-based radars. Key mobile tracking radars include the AN/TPQ-53 (3.11-3.49 GHz)[11] and AN/TPS-80 G/ATOR (S-band, typically between 2 and 4 GHz) systems.[12]
- *Maritime Radar Operations:* the US Navy maintains ships that utilize air and surface search radar such as the AN/SPY-1 and its replacement the AN/SPY-6.[13] These radars generally operate between approximately 3.1 and 3.5 GHz.
- *Airborne Radar Operations*: The US Air Force's airborne operations are largely supported by the Airborne Warning & Control System (AWACS E-3 Sentry), which is scheduled to be replaced in the next few years by the E-7 Wedgetail, and Navigational Station Keeping Equipment ("SKE"). The AWACS operates between 2 and 4 GHz, while SKE generally uses the 3.3–3.6 GHz range.

These US radar systems are operated globally to protect vital interests, often on a cooperative basis with US allies. For example, many bases in Europe that are operated by member nations of the North Atlantic Treaty Organization ("NATO") deploy the same radar systems as US military forces. One key example is the AWACS, often referred to as NATO's "eyes in the skies."[14] The AWACS platform includes a fleet of fourteen aircraft based in Germany that have been deployed on missions to Turkey and other locations to protect NATO-controlled airspace following Russia's invasion of Ukraine, as well as to help with surveillance in the global fight against terrorism. Notably, the AWACS platform is planned to be updated from the E-3 Sentry to the E-7 Wedgetail version. These upgrades will include a number of features that will enhance coexistence between AWACS and 5G services in the Lower 3 GHz band, including modernization of the radar steering beam.[15] In addition to improving coexistence with commercial operations in the Lower 3 GHz band, these updates could also allow the radar to operate in a lower frequency range.

In addition to a US military presence or cooperative deployments with NATO jurisdictions, several countries have acquired and deployed the US military radar systems discussed above within their countries. The chart below provides additional detail on these systems and where they are in use, based on publicly available information.

Military Systems	*Foreign Military Sales*	*Frequency Band*
AN/TPQ-53 ground-based radar[16]	Saudi Arabia, Singapore	3.11–3.49 GHz
AN/SPY-1 shipborne radar[17]	Australia, Japan, Norway, Spain, South Korea	3.1–3.5 GHz
AWACS E-3[18] AWACS E-7[19]	Chile, France, NATO, Saudi Arabia, UK Australia, South Korea, Turkey; UK in near future.	S-band (2-4 GHz)
Airborne SKE[20]	Too many to list (due to its use on the C-130 Hercules variants, which are tactical airlifters used by military forces worldwide to transport equipment and personnel[21])	3.3–3.6 GHz

In sum, many countries have allocated spectrum from 3.3 GHz and above for 5G services while permitting the use of the same radar systems that must be accommodated in the US. The charts below demonstrate the coexistence of US radar systems with spectrum allocations being used for 5G in some of the countries, with the vertical lines denoting spectrum between 3.3 and 3.45 GHz.



Understanding that coexistence is necessary to ensure continued successful operations, government agencies with spectrum authority can take measures to ensure that their military radars do not interfere with commercial or civilian uses in the band, and vice versa. Clearing the range from 3.3 to

3.45 GHz could unlock a significant, contiguous 150 MHz block of additional spectrum for 5G. If clearing is not possible across the entire range, coordination methods including geography, time, and frequency coordination, as well as spectral separation and filtering, offer alternative solutions:

- *Relocation, retuning, or compression*
  - Relocation makes spectrum available for commercial use by moving existing federal systems to different frequency bands. This has been an effective tool to encourage innovations since at least 2004.[22]
  - Retuning reconfigures existing federal systems to allow for more flexible use of spectrum and is a cost-effective way to open up more spectrum, depending on the specific circumstances present.
  - Compression frees up spectrum for commercial use by accomplishing existing federal missions in portions of federal spectrum. This approach has been utilized successfully in other frequency bands.[23]
- *Coordination Areas* (i.e., Cooperative Planning Areas ("CPAs"), Periodic Use Areas ("PUAs"))
  - Coordination Areas can be based on geographical locations, periods of times, or both, and enable spectrum sharing through pre-negotiated regulatory and technical provisions, such as temporary modifications of operations, within defined areas and/or times.
  - Geographic coordination has helped open up 100 MHz of mid-band spectrum for 5G and could make more spectrum available through continued collaboration between federal agencies and private sector.[24]
  - Time-based coordination, as utilized for PUAs, allows sharing of the spectrum through pre-coordinated interference protection during episodic periods.[25]
- *Guard Bands*
  - Frequency separation—such as the use of guard bands—is another proven technique for coexistence and requires good-faith technical discussions from all parties to formulate proper-sized guard bands.
- *Improved filtering, interference rejection, and anti-jamming*
  - Improving receiver performance through the use of better filtering and interference rejection can enable more efficient use of spectrum and lead to the availability of additional spectrum for commercial use.[26]

Government and private sector collaboration and information exchanges also have proven to be reliable methods of coordination. In particular, the US Defense Information Systems Agency ("DISA") has developed portals such as the Automated Spectrum Coordination System ("ASCS") for 3.45-3.55 GHz[27] and the v ("DACAMP") for 1755-1780 MHz[28] that enable coordination between incumbent military and commercial entities. Anecdotally, feedback on the portals has been largely positive, with one user noting that the portals have become the best method for coordination.

GLOBAL EXAMPLES OF COEXISTENCE ACROSS THE LOWER 3 GHZ BAND

A. Lower 3 GHz Band Usage in Mexico

In the Western Hemisphere, countries are demonstrating that military systems and 5G services can coexist in the Lower 3 GHz band. Mexico's Federal Telecommunications Institute (IFT) recently launched a consultation regarding plans for a multi-band 5G spectrum auction, including a 50 megahertz block between 3.3 GHz and 3.35 GHz.[29] This follows Mexico's

previous clearing of the 3.35-3.45 GHz band for 5G service.[30] The US and Mexico have a long-standing bilateral coordination process that consists of regular, semi-annual coordination meetings between the FCC and IFT, with participation from the US Department of State and NTIA, that aim to establish sharing and coordination agreements, protocols, and arrangements.

The US military has multiple training grounds and bases in southern states that are in close proximity to the US-Mexico border, such as Fort Bliss in Texas and the White Sand Missile Range in New Mexico.[31] Despite the existence of these bases and the radar operations occurring here, the proposed deployment of 5G service between 3.3 GHz and 3.35 GHz in Mexico demonstrates that coexistence is feasible. For example, geographical coordination could be successfully implemented given that the operation of the US military systems is limited to specific locations. Moreover, it is not uncommon for mobile service operators to have agreements with other users in the same frequency bands based on the time of day and/or power level for certain areas along the border. In fact, the close cooperation between US and Mexico on 5G and ICT was identified as one of the key pillar in the recent High-Level Economic Dialogue between the two countries.[32]

B. 3.4 GHz Band Usage in Europe

As explained earlier, many European nations have allocated spectrum in the 3.4 GHz band for advanced wireless services such as 5G while also permitting military radars to operate below 3.4 GHz across large swaths of NATO airspace in Europe. With sufficient coordination and a limited guard band that are suggested mitigation measures for allowing coexistence, these radars have been able to operate without causing interference to 5G networks operating in neighboring bands.33

For example, in Germany, all four major mobile carriers were awarded between 50 and 90 megahertz of mid-band spectrum in the 3.4-3.7 GHz range in 2019.34 As of 2022, 5G coverage in Germany is widespread, with one major mobile carrier claiming that its 5G network reaches 94% of the German population.[35] At the same time, as illustrated by the graphic below, the US operates several military bases in Germany that deploy radars operating across the Lower 3 GHz band,[36] and NATO operates several additional facilities across the country that utilize the same types of military radars.[37]

Germany also hosts several NATO military facilities within its border. Ramstein Air Base, adjacent to the German city of Kaiserslautern, hosts the 86th Airlift Wing, which operates fourteen C-130J Super Hercules transport aircrafts.[38] SKE radars on the C-130—specifically the AN/APN-169 and AN/APN-243—allow for transport aircraft to fly safely in close formation in all weather conditions.[39] SKE radars on the C-130 use frequencies between 3.3 and 3.6 GHz, overlapping with the 5G mid-band spectrum in Germany.[40] Likewise, C-17 Globemaster transport aircraft housed at the Spangdahlem Air Base and operated by the Air Base 726th Air Mobility Squad[41] are equipped with SKE equipment.[42] Despite the presence of these radars,

mobile operators have deployed robust coverage surrounding the air bases and neighboring cities.[43]

Since 1982, NATO AWACS have been operating out of Air Base Geilenkirchen,[44] the main operating base of NATO's E-3A Component unit.[45] The E-3A Component is responsible for providing airborne surveillance during military operations and safeguarding high profile events, like the 2022 G-7 summit held in the Bavarian Alps.[46] In spite of these operations, 5G signals around the base are extensive.[47]

US ground-based troops also have a significant presence in Germany. The Grafenwoehr Training Area ("GTA") is the Army's largest permanent training area in Europe and supports tank trails, artillery and maneuver ranges, and live-fire exercises.[48] The 41st Field Artillery Brigade stationed at Grafenwoehr utilizes the AN/TPQ-53 ground-based radar for routine training, as well as for multi-national joint training exercises. Even still, 5G signals are present both inside the range of the GTA and in neighboring civilian areas.[49]

Most recently, a multinational exercise, Air Defender 23, took place from June 12 to June 23, 2023. The biggest drill of its type since NATO was formed in 1949, the exercise included approximately 250 aircrafts from 25 NATO members and partners.[50] Both the C-13051 and AWACS52 participated in this exercise. As illustrated on the map below, the exercise covers large portions of Germany with flight paths over multiple European countries, where 5G has seen rapid deployment and continues to be deployed.

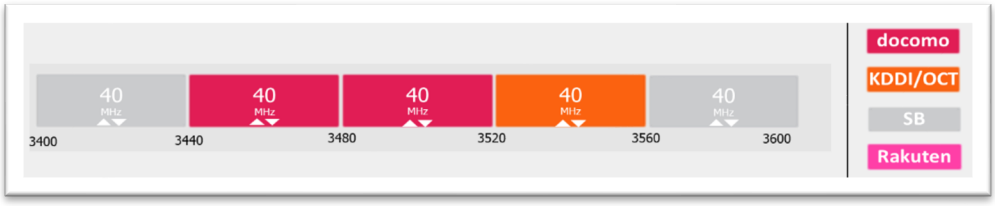
The multitude of US and allied military systems operating in and out of bases in Germany demonstrates the feasibility of coexistence of such radars with 5G services in the Lower 3 GHz band. There are several factors that likely enable this coexistence:

- *NATO Frequency Agreements*: German spectrum use typically aligns with the NATO Joint Civil and Military Frequency Agreement ("NJFA") and applicable NATO Standardization Agreements ("STANAGs"), which facilitate easier coordination within established channels.[53] For example, the German frequency allocation table specifies that military use in the 3.4-3.475 GHz band must be coordinated through the regulator.[54]

- *Geography-based Coordination Zones*: in practice, aircrafts equipped with SKE operate within 10 nautical miles of the aircraft selected as the master system, which serves as the reference point to allow multiple aircraft maintain close formation.[55] These operations will most likely only occur in selected airfields where aircrafts such as C-130 and C-17 operate. Accordingly, use of SKE is conducive to geography-based coordination zones.
- *Low PFD Levels*: the AWACS provide surveillance over a large area, but the power flux density ("PFD") from the radar directed toward territories of Allied countries would likely be at a low level given the operational height of the aircraft and the directionality of the radar signal, which should normally be focused. Similarly, in the US, the operation of AWACS during peacetime would likely produce low PFD level within the borders.

C. Lower 3 GHz Band Usage in Asia

Several countries in Asia also are utilizing spectrum in the 3.3/3.4 GHz band for 5G while successfully coexisting with radar systems. These include Japan, South Korea, Taiwan, and Philippines. In Japan, spectrum from 3.40 to 3.6 GHz has been allocated to operators in 40 MHz blocks,[56] as indicated by the chart below, and additional mid-band spectrum between 3.6 GHz and 4.6 GHz has also been made available to support 5G deployments.[57]



All Japanese operators have deployed full-power 5G networks using these key frequency bands, supplemented with high-band spectrum in certain locations.[58] Meanwhile, as demonstrated by the map below, the US military operates out of several bases in Japan.[59]

These bases largely deploy the same radar systems as bases located stateside and in other Allied countries, demonstrating that these radar systems can coexist with broadly deployed 5G networks in the Lower 3 GHz band, without interference, using one or more of the techniques mentioned above.

For example, US Navy Fleet Activities Yokosuka, is a large, forward-deployed base roughly 40 miles south of Tokyo and is home to several ships of the US Seventh Fleet.60 These ships include major combatant ships such as the USS. Ronald Reagan, guided missile cruisers and destroyers, frigates, and other ships equipped with AN/SPN-43 (soon to be upgraded to the AN/SPN-50) and AN/SPY-1/6 radars that operate in the Lower 3 GHz band. Despite the presence of these radars, the coverage maps from Japanese wireless operators show current 5G coverage or planned 5G deployments in areas surrounding the base.61 While the radars are primarily expected to be used by ships operating at sea, the nearby 5G deployments suggest that coexistence is being coordinated.

The US also maintains an amphibious force operating out of Sasebo on the island of Kyushu in the south of Japan that includes several amphibious and mine countermeasures ships along with a Japan Maritime Self-Defense Force ("JMSDF") destroyer equipped with the AN/SPY-1 radar system.62 Despite the presence of these radars, coverage maps from multiple Japanese wireless operators show current 5G coverage or ongoing 5G deployments in areas surrounding both naval bases.63

The US Air Force also has a significant presence at Kadena Air Base on the western coast of Japan, including the 18th Wing with an E-3 Sentry AWACS aircraft and F-15 fighter jets.64 Additionally, the Japanese Air Self-Defense Base at Hamamatsu is home to several aircrafts, including a Boeing E-767 equipped with the same AWACS provided to other US allies around the world.65 The radars used by crafts at both Kadena and Hamamatsu are operational despite the presence of 5G networks deployed in these areas.66

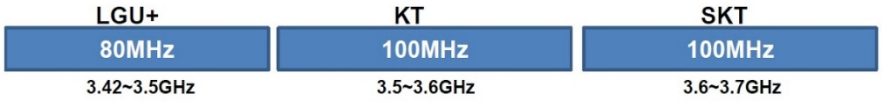
US and Japanese forces regularly conduct joint operations intended to safeguard interests in the region during which radar systems are operated in a coordinated fashion—with no power or geographic protection zones—to avoid interference with 5G networks deployed across Japan. For example, in November 2022 the US and Japan conducted Keen Sword, a biennial, large-scale joint military exercise involving 30 ships and 270 aircraft to increase combat readiness and interoperability.67 Likewise, earlier this year, US air forces based in Kadena conducted joint operations with the Japanese Air Self-Defense Force, with aircraft from both forces including an E-3 Sentry equipped with AWACS.68 More recent exercises include Iron Fist 2023, which included amphibious forces from the US Marines and Japan Self-Defense Force,69 and Sea Dragon 23, a multinational exercise consisting of forces from the US, Japan, South Korea, Canada, and India that included 50-70 ships and 150 aircraft to preserve open access in the Indo-Pacific region.70

The significant presence of US military systems and the considerable experiences of operations of those systems in and around Japan demonstrate that coexistence between 5G service and military systems in the Lower 3 GHz band is feasible. There are a number of factors that likely contribute to this successful coexistence:

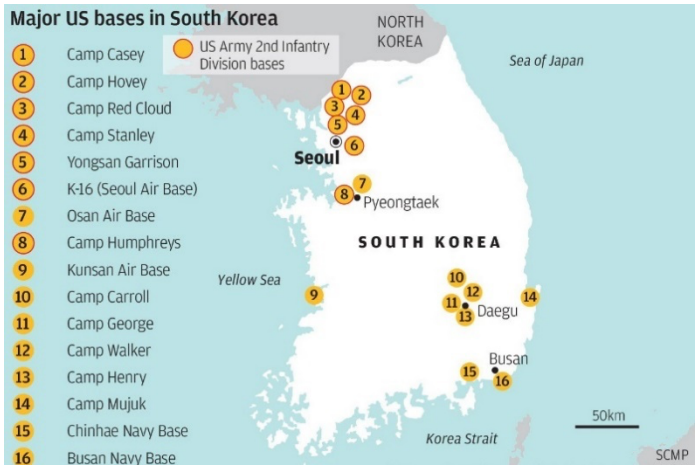
- *Pre-coordination*: the US and Japan have a well-established host nation coordination process for military systems, including for visiting vessels while in port.

- *Defined Frequency Allotment*: Japan has a sophisticated frequency allotment plan that provides clear guidance to the use of certain frequency bands.[71] For example, 3.4-3.456 GHz is allocated to commercial telecommunication service on a primary basis and may also be used for the radiolocation service.
- *Time-based Coordination*: while power and geographical limitation is unlikely, time-based coordination was typically carried out prior to exercises between US and allies.
- *Low PFD Levels*: similar to Germany, potential interference from AWACS toward territories of Allied countries, such as Japan or the US, would likely be mitigated by the operational altitude and directionality of the radar signal.

South Korea has also made key mid-band spectrum starting at 3.40 GHz available for terrestrial mobile wireless services, including 5G. As shown in the figure below, South Korea has made a total of 280 megahertz (3.42-3.7 GHz) available to the country's three main operators—SK Telecom, LG U+, and KT Corp.—between 3.42 and 3.7 GHz,[72] with LG U+ expected to deploy another 20 megahertz between 3.4 and 3.42 MHz in near future.[73]



As the map below demonstrates, South Korea houses a similar US military presence as Japan and is home to several bases that utilize US military radar.[74]



Just south of Seoul, Camp Humphreys houses the 2nd Infantry Division Artillery, which utilizes the AN/TPQ-53 ground-based radar system.[75] The Busan Naval Base located on the southeast coast of the country can accommodate US Navy aircraft carriers that enter the port for combined training and pilgrimage.[76] These aircraft carriers are typically accompanied by cruisers or destroyers equipped with the AEGIS AN/SPY-1/6 radar system.[77] South Korea has extensive 5G networks, as the country surpassed 90% nationwide population coverage as early as 2020, and more recent testing indicates that the three main South Korean operators have significantly increased coverage in and around both Seoul and Busan.[78]

From these bases, as well as bases in nearby Japan, US and South Korean forces often conduct joint military exercises. The US military typically operates the same radar systems in a coordinated fashion to avoid interference with 5G networks deployed across South Korea. In March 2023, US and South Korean forces conducted their largest field exercise in five years in response to escalating nuclear threats from North Korea.[79] The operations consisted of both a computer-simulated, coordinated exercise and a joint field exercise. Also in the spring of this year, the US, South Korea, and Japan conducted joint trilateral maritime exercises involving the USS Nimitz, its carrier air wing, and guided-missile cruisers and destroyers equipped with the AN/SPY-1 radar system.[80] More recently, the US and South Korea conducted Korea Flying, joint air exercises involving US Air Force and Marine Corps fighter aircraft operating in coordination with approximately 100 aircraft from Japan and South Korea.[81] These exercises involved airborne platforms such as E-3 and C-130 with radar systems in the lower 3 GHz bands operating in and around coastal areas.[82]

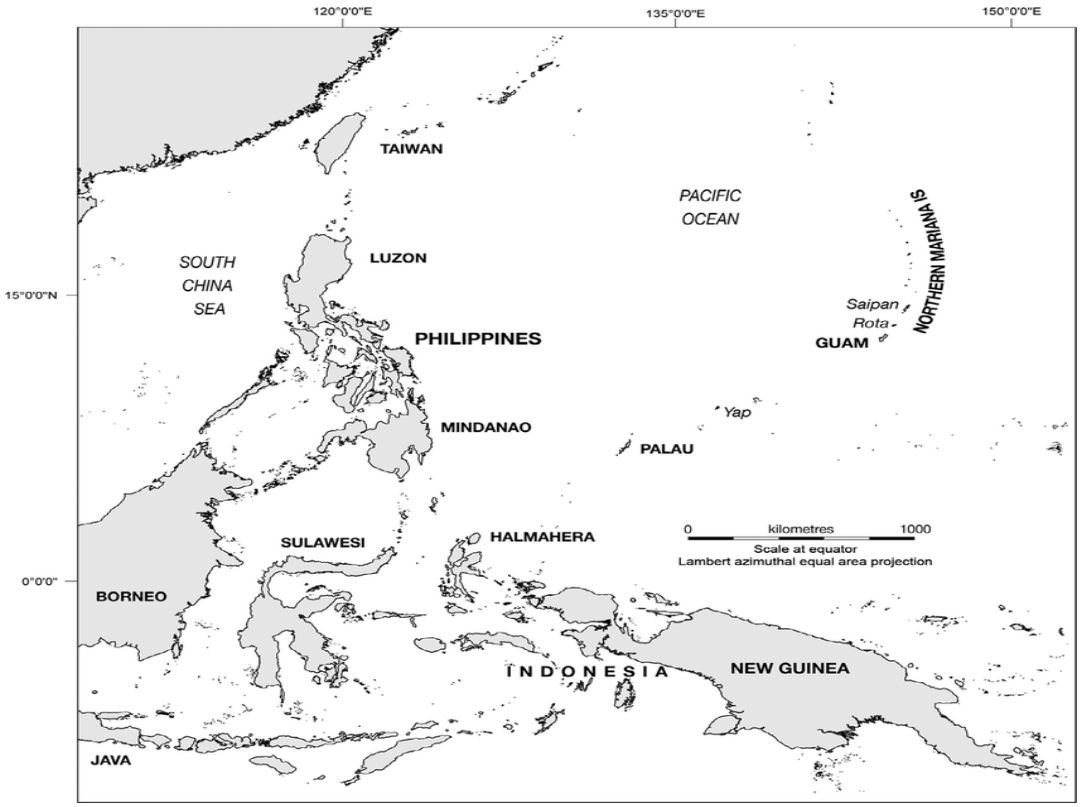
South Korea represents another example of successful coexistence between US and Allied military systems and 5G services. Several factors likely contribute to this coexistence:

- *Pre-coordination*: US and South Korea have a well-established host nation coordination process for military systems, similar to the US and Japan. Additionally, there are ground-based radars stationed in South Korea on a semi-permanent basis.
- *Increasing Expertise*: South Korea has developed into prominent exporter of military systems,[83] resulting in an increased emphasis on spectrum-related issues within the country's Military Spectrum Policy Division and a partnership with NATO.[84]
- *Time-based Coordination*: similar to Japan, experiences with multiple exercises that involve military radars coexisting with 5G services in the 3 GHz band suggest that coexistence is coordinated based on the timing of the exercises, without major power reductions to 5G base stations and/or geographic coordination zones.

D. Usage Below 3.4 GHz in Asia

In addition to the 3.4 GHz band, other countries are operating military radars in the 3.3 GHz spectrum band and coexisting with 5G services, highlighting the potential for an additional 100 megahertz of spectrum that could be allocated for 5G deployments.

In Taiwan, four operators—Chungwa Telecom, Taiwan Mobile, Taiwan Star Cellular, and Far EasTone—are authorized to deploy 5G in the 3.3 GHz spectrum band. According to recent data, the operators have considerable 5G coverage throughout the region.[85] Taiwan is an area of significant concern in the geopolitical landscape, particularly given increasing threats by the Chinese military and reported exercises that rehearsed encircling Taiwan.[86] In response, the US has increased its support for Taiwan, including by stationing additional troops on the island.[87] The map below shows the relative position of China, Philippines, Taiwan, Guam, and other countries in southeast Asia.



US naval warships have routinely transited the Taiwan Strait, some of which are equipped with AN/SPY-1/6 radar.88 Taiwanese network operators are expected to continue to operate full-power 5G networks, even while the U.S carries out freedom of navigation exercises in the area.

The scenario in Taiwan shows that coexistence between US military systems and 5G service could be feasible down to 3.3 GHz. Taiwan is a uniquely situated, as multiple countries—both cooperative partners and non-cooperative adversaries—operate military systems outside Taiwan's terrestrial waters at the same time 5G service is deployed in the country using the 3.3 GHz band. Even though the US does not publicly perform host nation coordination with Taiwan, there is evidence of increasing partnership in the form of the US helping Taiwan upgrade to NATO's Link-22, which is a secure tactical data link used by NATO forces and partners.89

Another example of the feasibility of coexistence between military systems and 5G services in the Lower 3 GHz band is The Philippines, which has allocated over 200 megahertz of spectrum between 3.3 GHz and 3.6 GHz to more than a handful of operators. Given the increase in geopolitical tensions in Asia, the US recently regained access to four military bases in the Philippines—three on the island of Luzon near Taiwan and one in Palawan in the South China Sea.[90] The nine total US bases facilitate interoperability between the US and the Philippines and address a range of challenges in the Indo-Pacific region.[91]

The US-Philippines Mutual Defense Treaty, signed in 1951, is America's longest-standing defense treaty in the Indo-Pacific region.[92] US and Philippine forces routinely conduct joint military exercises; most recently, the forces held Balikatan 2023, an annual bilateral exercise between the countries and the largest iteration of Balikatan to date, indicating a heightened level of collaboration between the two countries.93

The Philippines provides another example of the feasibility of coexistence between military systems and 5G services in the Lower 3 GHz band. With the reopening of multiple military bases in the Philippines, it is expected that US military system will operate in the immediate vicinity of 5G services in the 3.3–3.6 GHz frequency range. The long history of exercises in the area consisting of naval ships equipped with radar systems such as the AN/SPY-1demonstrates that coexistence is possible with no or only time-based coordination.

Taiwan and Philippines provide key coexistence examples. Each of these countries is deploying 3.3 GHz spectrum for 5G, and both are doing so in a region where military radars have been and will continue to be prevalent given geopolitical tensions. It is critical that military radar operations and wireless operators continue to coordinate based on the circumstance of the locales around the globe to foster an environment of coexistence.

CONCLUSION

Around the world, nations are utilizing Lower 3 GHz spectrum for broad deployment of 5G. These 5G systems are coexisting with military and NATO systems identical to the radar systems operated in the US. Given the critical need for more dedicated mid-band spectrum in the US and proven methods to allow for coexistence developed abroad, it is important for all domestic stakeholders to work collaboratively to investigate options for clearing, tuning, or coordination in the Lower 3 GHz band. This could enable 150 MHz of additional key mid-band spectrum for 5G, which is critical spectrum to provide the 2 GHz of capacity needed for cities across America by 2030. For the US to continue to have a key role in 5G commercial wireless innovation and deployment, coexistence in the Lower 3 GHz band must be considered thoroughly and expeditiously.

Appendix

COUNTRIES THAT HAVE ALLOCATED MID-BAND SPECTRUM FOR 5G*

Country	Frequency Range (MHz)	Total Spectrum (MHz)
Australia	3400 – 4000	600
Austria	3410 – 3800	390
Bahrain	3400 – 3700	300
Belgium	3410 – 3800	390
Brazil	3300 – 3690	390
Bulgaria	3440 – 3800	360
Canada	3450 – 3980	530
Chile	3300 – 3700	400
China	3300 – 3600	300
Croatia	3400 – 3800	400
Czechia	3400 – 3800	400
Denmark	3410 – 3800	390
Estonia	3410 – 3800	390
Finland	3410 – 3800	390
France	3410 – 3800	390
Germany	3410 – 3800	390
Greece	3410 – 3800	390
Hungary	3410 – 3800	390
Iceland	3424 – 3800	376
India	3300 – 3800	500
Italy	3437 – 3800	363
Japan	3400 – 4100	700
Latvia	3400 – 3800	400
Lithuania	3410 – 3710	300
Luxembourg	3420 – 3750	330
Mexico	3300 – 3600	300

Norway	3400 – 3800	400
Philippines	3300 – 3800	500
Portugal	3400 – 3800	400
Romania	3400 - 3800	400
Saudi Arabia	3400 – 3800	400
Singapore	3450 – 3650	200
Slovakia	3400 – 3800	400
Slovenia	3420 – 3800	380
South Korea	3400 – 3700	300
Spain	3420 – 3800	380
Taiwan	3300 – 3570	270
United Arab Emirates	3300 – 3800	500
United Kingdom	3410 – 3800	390
United States	3450 – 3980	430

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