Keeping Up With Spectrum Policy: Mid-band Opportunities

BY DOUG BRAKE | NOVEMBER 2018

Mid-band spectrum will be crucial for next-generation networks, so it is important the FCC move quickly to transition portions of this spectrum to more efficient use.

Radio spectrum—the invisible waves of energy that can carry information through the air—is the lifeblood of wireless communications. This crucial input is in demand by wireless companies of all types, not the least of which include mobile carriers for new 5G deployments. In addition to mobile operators who use licensed spectrum doled out by the Federal Communications Commission (FCC), services that rely on unlicensed bands, such as WiFi, would also benefit from additional spectrum. But not all spectrum is the same. Low-band spectrum—frequencies below 1 gigahertz (GHz)—is the historic workhorse of mobile communications. It provides wide coverage areas using relatively little power, which has helped get mobile voice and broadband deployed to most of the population. But there is only so much low-band spectrum to go around, and with much of it already claimed, capacity is limited. While there is excitement around recent technological breakthroughs enabling the use of high-band spectrum above 24 GHz for 5G services, the physics of these extremely high frequencies make for limited propagation and much more costly infrastructure. Unlike bandwidth-constrained low band, and infrastructure-intensive high band, mid-band spectrum is the "Goldilocks" of frequencies—not too high, and not too low.

Falling between 1 and 7 GHz, mid-band spectrum will be crucial for next-generation networks—and it is important the FCC move quickly to transition portions of this spectrum to more efficient use.

The FCC is advancing on several fronts to help alleviate demand for mid-band frequencies. This report surveys a number of the more important opportunities to get mid-band spectrum out and into the hands of innovators. This report examines some of the major proceedings that will open up mid-band spectrum, including transitioning portions of the lower C-Band from satellite to terrestrial use, proposing to make room for unlicensed services in the 6 GHz band, and making changes to the 3.5 GHz Citizens Band Radio Service (CBRS) licenses, among other efforts.

Perhaps of most prominent interest is the lower part of the C-band from 3.7 to 4.2 GHz. Today, this spectrum is used to distribute television programming over satellite—and it could be used more efficiently. The question of how to effectively transition a portion of this spectrum from satellite wireless broadband looms large in spectrum policy today. Nearly every stakeholder across the communications landscape has an interest in the proceeding, and the FCC's broad licensing authority gives it a wide range of options for how to move forward.

GENERAL SPECTRUM POLICY PRINCIPLES TO PROMOTE INNOVATION

The continued progress of the mobile revolution depends on advances in semiconductor technology, software, and spectrum reallocation. The most important of these inputs from a policy perspective is spectrum. There has been a continual call for more spectrum to be freed up for flexible use. In 2010, President Obama called for 500 megahertz (MHz) to be made available for commercial wireless broadband before 2020. With little over a year to go, we are only about two-thirds of the way to achieving this goal.[1]

Spectrum allocation has historically been an ad hoc, piecemeal process driven by the logic of the moment: A commercial enterprise or government agency would request spectrum from the relevant regulator (the FCC in the case of commercial use, and the National Telecommunications and Information Administration (NTIA) for government agencies). Whenever regulators saw merit in an idea, they would identify unassigned or underused radio frequencies and allocate the best available fit. Spectrum policy now would do well to move beyond this ad hoc process and adopt more general policies to update its allocation—or, more importantly, its reallocation process.[2]

Reallocation of spectrum is difficult. Virtually all of the valuable spectrum under 6 GHz has already been claimed, with incumbent users having made large investments in complex radio systems scattered across the country. The long line of history has piled regulatory decision after decision in many bands, leading to fragmented rights and a thicket of regulations. Decision-making can be difficult when regulators must balance a host of competing interests under relatively limited information. Outcomes are not black and white.

Competing stakeholders can at times compound the challenge of quickly reallocating spectrum to more efficient uses. Politically powerful stakeholders may have come to rely on this or that radio service, and rightly want to see their interests protected. In other circumstances, interests in a spectrum's use may be diffuse, with no single firm able to capture the benefits a given service provides society overall. This is often the case in unlicensed bands.

Policymakers should aim for spectrum allocations wherein a single service supports a variety of applications, enables sharing between multiple end users, and allows capacity to be dynamically adjusted between these uses. For example, it makes very little sense to issue fragmented licenses for specific, narrow purposes—such as taxi dispatch services—when general IP-based networks can far more efficiently serve a broad array of different applications, including taxi dispatch. This flexibility to serve different users and applications dynamically is one of the best reasons to encourage additional spectrum allocations to support commercial mobile broadband.

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Policy should also encourage private actors to internalize both the costs and benefits of what they choose to do with the rights to their spectrum. That is to say, we should generally encourage participants to make the decisions as to how a particular band is best used, and be incentivized to gather the information needed to make the best decision. This is why, for some services, the FCC has made rights to spectrum relatively easy to trade. Generally speaking, spectrum for commercial mobile services can be traded on a secondary market, allowing market actors to decide what slices of spectrum are best for their network in a specific geographic market.

Policymakers should apply this process more generally. More clearly defined rights and expectations around spectrum use could enable agents with the proper incentives to negotiate the most valuable use of spectrum in a particular band.[3]

Policymakers should keep these general principles in mind when examining the available opportunities to free up much-needed mid-band spectrum for commercial wireless use, on either licensed, unlicensed, or mixed use.

THE NEED FOR ADDITIONAL FLEXIBLE-USE MID-BAND SPECTRUM

The demand for additional wireless broadband service only continues to grow.[4] Cisco estimates U.S. mobile data traffic will grow fourfold from 2016 to 2021, a compound annual growth rate of 34 percent.[5] Of course, data usage from smartphones and tablets continues to grow, thanks to more and more consumers streaming high-definition video, and other bandwidth-intensive uses. But more and more devices are connected to the network every day, requiring more and more bandwidth.

Historically, it was low-band spectrum that could punch through walls and travel long distances with relatively little power that was considered "beachfront" spectrum—offering mobile broadband networks the most valuable opportunities, with wide coverage at relatively lower costs. Now that "beachfront" has moved north, with mid-band spectrum's higher bandwidth availability and moderate coverage providing just the right mix of characteristics to supplement existing mobile networks. Its modest propagation compared with low band makes it easier to reuse the same frequencies in different geographic areas. Mid-band's limited propagation compared with sub-1 GHz spectrum helps prevent network cell sites near each other from interfering with themselves. But it also does not come with the extreme challenges concrete or foliage pose to high-band spectrum propagation.[6]

Mid-band spectrum is of particular interest for 5G use, both here and abroad. Some spectrum bands are gathering intense focus internationally. For example, 35 different countries are eyeing 3,400–3,600 MHz band for 5G services, and others are looking at nearby frequencies as well.[7] The 5G radio specification works across a wide range of radio spectrum—there is not a specific "5G band." This is often a point of confusion, as recent technological breakthroughs have enabled the use of extremely high-frequency millimeter wave spectrum, which will be incorporated into some 5G networks. But as a general matter, 5G networks will leverage any and all spectrum available, as low, mid, or high band all serve different purposes. Whether operators use spectrum for 5G is more a factor of when it is made available by the FCC: If the spectrum is coming online in the next few years for commercial mobile broadband purposes, then it will almost certainly be using the 5G air interface specification.

There are significant consequences for 5G leadership—the capabilities of reliable ultra-low latency, high-bandwidth broadband and massive Internet of Things (IoT) connectivity will provide a platform for a host of important innovations. Deloitte characterized 5G as presenting countries with "the chance to lead for a decade."[8] Indeed, other countries are keen to claim this opportunity and provide the connectivity platform that will stitch together such services as augmented reality, unmanned aerial vehicles, artificial intelligence, smart cities, etc. China, in particular, is eager to gain influence over the direction of the technology, as well as deploy it at tremendous scale.[9] U.S. policy aims to achieve a successful, early deployment of 5G networks. As Michael Kratsios, deputy U.S. chief technology officer in the White House Office of Science and Technology Policy wrote, "America has consistently led the way in the deployment of next generation wireless networks, and it is more important than ever that we lead in 5G deployment."[10]

Yet is not clear there will be sufficient spectrum available for 5G deployment. In a recent report, GSMA, the global trade association for the mobile industry, issued a "5G spectrum warning" calling on regulators to make available 80 to 100 megahertz of spectrum per operator in "prime 5G mid bands."[11]

While spectrum—specifically mid-band spectrum—must be made available for 5G to flourish, it will be a long time before the FCC initiates action and spectrum is finally put to use. It makes sense to start the process as soon as possible and, where possible, to use mechanisms that allow for expedited allocation. As the FCC has put it, "A sound spectrum policy necessitates that we now begin exploring new opportunities for flexible broadband use in the mid-band frequencies."[12] Time is of the essence: The faster otherwise underused mid-band spectrum can be reallocated, the sooner the United States will see the benefits of faster mobile broadband, newly deployed 5G platforms for low-latency innovation, and less-congested home WiFi. In the words of analyst Peter Rysavy, "Midband spectrum for 5G is needed now."[13]

C-BAND—3.7 TO 4.2 GHZ

In August 2018, the FCC published a broad proposal seeking comments on how best to transition spectrum between 3.7 and 4.2 GHz in order to expand opportunities for wireless broadband services.[14] Today, this spectrum portion of what is known as the "extended C-band" is used primarily by satellite operators, such as Intelsat and SES, to distribute live television content throughout the nation.

This 500 megahertz block of spectrum is a considerable chunk of contiguous spectrum that is well suited to mobile broadband use. Indications are that current use of the band could be accomplished with significantly less spectrum while still protecting the important services within the band. It seems clear that at least a portion will be reallocated to mobile broadband services. The question is how—and how quickly?

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The fixed satellite services—which distribute television across the nation—represent a greater challenge to successfully transition compared with the relatively minimal point-to-point fixed services in the band. Significant economic value depends on reliable distribution of television programming over C-band spectrum, even if it can be done with less spectrum. By concentrating satellite use to a smaller portion of the band and gradually connecting more cable distribution points to a fiber-distribution system, or through other mechanisms, operators can reduce the spectrum needed for this service.

Intel and Intelsat have come forward with a proposal to authorize the satellite operators in the band to negotiate a transition directly with mobile operators, in lieu of a centralized auction at the FCC. This initiative has since been taken up by the C-Band Alliance, a consortium of the four satellite operators that provide the vast majority of C-band satellite services in the United States.[15] The initial proposal was met with a range of reactions. Some content-focused companies, while open to the idea of a consortium-based clearing, expressed concern the initial commitments did not "go far enough to ensure that video delivery and the critical role [satellite] spectrum plays in the video marketplace will remain fully protected."[16] On the other side of the transaction, some wireless operators, such as Verizon, support the consortium-facilitated, market-based approach, while T-Mobile, for example, is more skeptical.[17]

ITIF believes this consortium approach has merit and would be the fastest possible mechanism to identify the amount of spectrum that could be transitioned to 5G services—and have the right incentives to protect the important existing C-band services.

In their initial proposal, Intel and Intelsat suggested a few possible tools to accommodate a transition of these satellite services and free up the spectrum for terrestrial use.[18] For example, satellite operators could coordinate a relocation of some customers to a different set of frequencies on an area-by-area basis. Another option would be to physically relocate antennas that receive satellite signals to a different geographic area and make use of other technologies, such as fiber, to distribute the programming. Another possible way to facilitate the transition is to use exclusion zones or shielding to protect specific earth stations that receive the satellite signals. A wide variety of different possible mechanisms could be deployed to decrease satellite use of the band while protecting remaining incumbent services with no disruption to service. Each of these different options presents its own tradeoffs, with a different economic calculus depending on the specifics of any earth station operations.

A market-based approach empowers the relevant stakeholders with the flexibility to best balance the complex, competing interests in the band. As the FCC has acknowledged, it lacks comprehensive information on existing earth station operations, with potentially thousands of earth stations still unregistered. Direct negotiation helps avoid the particular difficulties existing nonexclusive rights pose to auction design.

The consortium proposal would likely see spectrum repurposed much more quickly than with any of the alternatives. A voluntary, market-based mechanism provides the incentive to expeditiously free up valuable 5G spectrum to those actors best positioned to gather accurate information on existing operations and most interested in protecting existing customers.

Some criticize the market-based proposal as not providing a source of money to the treasury. This concern is misplaced. Auctions should be relied on as a tool to discover the most socially beneficial uses. Auctions identify the firms that are most confident they can derive value from the spectrum. Proceeds flowing to the treasury is an added benefit (with some political significance), but it should not drive spectrum allocation decisions.

Mobile operators would like to put this spectrum to use for 5G services that will advance U.S. innovation and productivity. Satellite operators are willing and able to give up some spectrum while also protecting existing services. Allowing such a significant repurposing of spectrum to take place through the secondary market would be a big step for the FCC. ITIF agrees with Commissioner O'Rielly's statement that, "It is rare that you can see the stars align to be able to execute such a large change in spectrum policy."[19] Rather than micromanaging an auction, overseeing a long, drawn-out repacking, and likely hosting years of ex parte meetings, a market-based approach would quickly and efficiently free up this spectrum.

UNLICENSED OPPORTUNITIES IN 6 GHZ

Unlicensed spectrum allows unregistered users to operate radio devices without having to obtain a license. Instead, the Commission uses technical limitations on the types of equipment that can be sold to help limit interference. Unlicensed services have been a source of booming innovation under a number of different wireless standards—WiFi and Bluetooth are the latest, with a wide range of consumer products relying on unlicensed spectrum. Hobbyist drones, home surveillance cameras, baby monitors, audio speakers, and garage door openers all use unlicensed spectrum. Other unlicensed technologies, such as Zigbee and Weightless, focus on IoT devices and connecting the growing number of sensors.

For years, spectrum policy was mired in an academic debate over which model would best serve the United States: licensed or unlicensed.[20] Strong believers in the free market push for exhaustive licensing of exclusive, flexible rights in spectrum, while believers in more communal economic arrangements eschew property rights in favor of a more open, unlicensed model. The key difference between licensed and unlicensed spectrum is the right to protection against interference.[21] Just like demand for mobile broadband running over licensed networks, the appetite for unlicensed spectrum continues to grow.

Today, it is difficult to deny that the two licensing regimes are both successful in their own right, and complement each other. Neither should completely dominate spectrum planning, as we need more spectrum—both licensed and unlicensed—suitable for broadband.

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In some areas, such as crowded apartment buildings, the capacity of existing unlicensed allocations is reaching its limit—and interference is a real factor. WiFi is a considerable factor in this seemingly insatiable demand. Over three-quarters of North American households use WiFi as the primary connection technology; and nearly two-thirds of mobile traffic is off-loaded to WiFi routers instead of the mobile network.[22] IoT devices and other connections will likely become a growing portion of unlicensed data traffic.

To alleviate this demand, the FCC and other stakeholders have identified the 6 GHz band as a potential candidate for unlicensed services. This band has numerous benefits in its favor as an unlicensed band, and the FCC's inquiry into the band saw significant support from a variety of chipmakers, equipment suppliers, and network operators—for good reason. The 6 GHz band is near the already widely used 5 GHz unlicensed band, and according to chipset manufacturers, the wireless components used to support unlicensed broadband operations at 5 GHz can readily be extended to or reused for 6 GHz band operations. This means greater economies of scale in devices, and ultimately lower costs for consumers. Unlicensed operations in 6 GHz would also avoid a new standards-setting process. Instead, existing tried and true successful technologies like WiFi could quickly make use of the band.

Like other mid-band spectrum, 6 GHz has its fair share of incumbent services—some more important to protect than others. Various parts of this frequency range are used by microwave links that serve public safety. Other frequencies are used by satellite services. The FCC's proposal commits to protecting these incumbents while at the same time opening the band to increased numbers of unlicensed devices where they can most easily coexist.

In some bands, where it is too difficult to relocate incumbent services, the FCC is looking to mitigate interference, either by limiting the use of unlicensed radios to indoors or through other mechanisms. In the 6 GHz range, these signals do not propagate easily through buildings. And by keeping WiFi routers indoors, for example, the potential for interference to nearby systems is greatly diminished. In other bands, the FCC is proposing complex sharing technology known as “automated frequency control” that would query a database to determine whether such transmissions are permitted, with the goal of avoiding harmful interference to licensed operations.

Hopefully the Commission will act with speed to open up the 6 GHz band for unlicensed operations. The FCC should try to relocate outdated, narrow-purpose spectrum systems with the goal of enabling more general-use, spectrally efficient technologies. Furthermore, unlicensed allocations work best when the rules are as simple as possible. Complicated sharing regimes add significant cost to already low-margin devices. Simple rules would allow for simpler devices, encouraging widespread adoption and use of this otherwise underutilized band.

UPDATES TO 3.5 GHZ CBRS

No discussion of mid-band spectrum would be complete without mention of the Citizens Band Radio Service. CBRS is a complex system—probably the most complicated radio experiment in the world—that introduces a new slew of acronyms into already acronym-heavy spectrum policy. First established in 2015, CBRS has three tiers of users with different permissions in the band.[23] Users receiving the highest level of protection are the federal incumbents. These Navy RADARs along the coasts receive complete protection. The next level down, known as Priority Access Licenses (PALs), are akin to traditional licenses, and must be bought at auction. The PALs are in the middle of the three-tier system. They must not interfere with the federal incumbents, but are also protected against interference from the tier below, known as General Authorized Access (GAA). The GAA set of users is similar to those that are unlicensed.

This three-tier system is held together by a database that grants authorizations to specific radio users to use certain frequencies at a particular time and place. This database is known as the Spectrum Access System (SAS). SAS is informed of where incumbent RADARs are operating through an Environmental Sensing Capability (ESC).

This overly complicated system was initially designed with the aim of offering a new type of licensing that was something of a blend of licensed and unlicensed spectrum. The original PAL licenses conceived under the Obama administration were designed to be something less than a traditional license. They were quite small geographically, had no expectation of renewal, and were only good for three years. These stunted licenses were potentially useful for a company that wanted to build a small private network with clean, protected spectrum, but was unlikely to attract large-scale investment or have broad deployment.

While there is real value in giving firms the ability to internalize their own private wireless systems for industrial IoT or factory automation, for example, the tremendous excitement internationally for this spectrum for 5G justified reexamining the initial licensing decisions.

Thankfully, the Commission did just that, and last October voted on a rule change that expanded the size of license areas from census tract to counties, increased the term of licenses from 3 to 10 years, and added a renewal expectancy for license holders.[24]

Otherwise, the main thing holding back the CBRS system is getting all the SAS and ESC equipment tested, authorized, and up and running. NTIA should prioritize its work with SAS and ESC administrators to make sure this system can be lit up as soon as possible. This is key spectrum for 5G, and the United States is leading the world with this innovative new licensing system. There is significant momentum behind the equipment and services that will use this band—and the government should ensure everything is in place and working as expected to see investment and 5G deployment using this band.

LIGADO AND THE L-BAND

A small chunk of mid-band satellite spectrum in the so-called "L-band"—between 1,500 and 1,700 MHz—has been tied up in regulatory limbo for years. The rights to this spectrum are owned by Ligado, but much of the L-band saga took place under their predecessor, LightSquared.

In 2011, LightSquared aimed to change its business plan and repurpose the satellite spectrum licenses it held to become a wholesaler of LTE services. The most important impact of this pivot was the use of higher power transmission throughout the United States. Testing indicated that this new mode of operation would have an adverse impact on LightSquared's spectrum neighbors, GPS navigation systems, in large part because many GPS receivers are overly sensitive to frequencies outside their assignment. This dispute, between LightSquared and GPS interests, dragged on for years, eventually pulling the company into bankruptcy.

Ligado, the successor company, has come forward with a different business model, looking to provide industrial IoT, tracking, and customized private networks for industrial uses. A terrestrial network with mid-band spectrum, backed up by an L-band satellite would provide reliable, redundant connectivity, but at a lower power and with less bandwidth than the original broadband network conceived by LightSquared.

Ligado has worked to address the various concerns around potential sensitive receivers in adjacent bands. The company has collaborated with the FAA to protect certified aviation GPS—just the latest in a long line of work with GPS device manufacturers to restructure the band and allay concerns. The company has relinquished the originally proposed 1,545–1,555 MHz downlink to expand the lower Global Navigation Satellite System (GNSS) guard band, and has significantly lowered power levels across the board. The most significant concession in the firm's recently proposed amendments would lower the terrestrial base station power more than 99.3 percent from the original modification applications.[25]

These power reductions, coordinated with the FAA, should address any remaining concerns around certified aviation GPS, eliminating the potential for interference to helicopters and first responders within dense urban environments, for example.

Radio services must have certainty in their protection against interference if we are to see the massive investment needed for large-scale operations. But if the Commission is driven by worst-case-scenario thinking in attempting to minimize any possible interference, innovation and introduction of new services would grind to a halt. Some commenters watching this debate have called for extremely strict protection criteria that would set a bad precedent, inhibit future spectrum negotiations, and undermine the real value of this spectrum.[26] The FCC's policymaking should be driven by risk-based assessment, and aim for clear, reasonable expectations of where responsibilities lie to protect against interference. The efforts of Ligado go above and beyond to protect sensitive neighbors, and it is time to see this spectrum put to a more socially beneficial use.

CONCLUSION

These are just a few of the more important opportunities to free up additional mid-band spectrum to be put to more valuable use. Mid-band spectrum is rightly a policy priority right now. With some creativity, ingenuity, and policy entrepreneurship, the opportunity to transition several hundreds of megahertz of spectrum is at hand. Freeing up mid-band spectrum will be a boon to the economy and productivity, and help advance U.S. leadership in early and widespread 5G deployment.

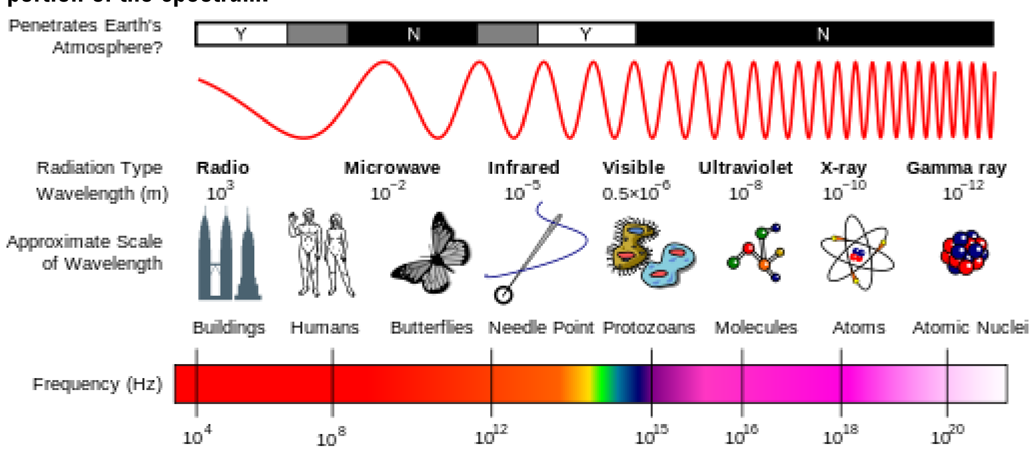
APPENDIX A: RADIO SPECTRUM 101

Talk of electromagnetic spectrum can be esoteric, but, while there is a bit of a learning curve, spectrum is a key factor in the 21st century economy, and deserves core policy attention. This appendix serves as a brief introduction to radio spectrum and how it is managed by the government.

What Is Spectrum?

When discussing telecom policy, the term "spectrum" inevitably comes up—it is an essential input to wireless services, a constraining factor in the growth of mobile broadband, and an exceedingly peculiar type of resource. In the context of wireless policy, "spectrum" is shorthand for a portion of the broader spectrum of electromagnetic radiation with properties useful for wireless applications. In physics terms, electromagnetic radiation is a self-propagating transverse oscillating wave of synchronized electric and magnetic fields. Electromagnetic spectrum is the physics behind not just radio waves, but also infrared, visible, and ultraviolet light, as well as x-rays and gamma rays. The waves in radio spectrum management are bigger and repeat less quickly— they are part of the same physical phenomenon of the light we see.

Figure 1: Different portions of the electromagnetic spectrum have different properties but are part of the same physical phenomenon. Spectrum management is concerned with the radio portion of the spectrum.



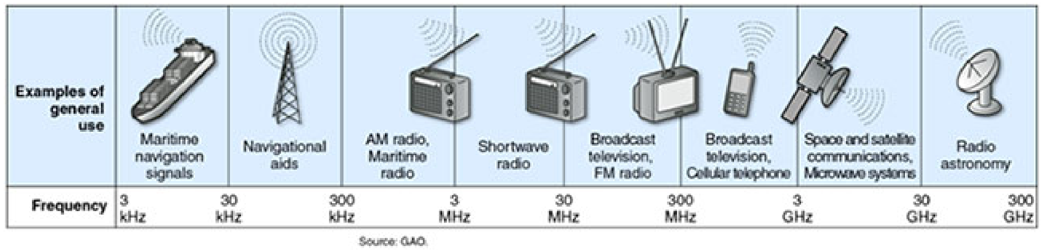
All radio technologies use spectrum in a similar way. For example, a basic radio communication link is composed of a transmitter and a receiver. The transmitter sends out a wave that is "modulated" to be encoded with information. The wave propagates through the air. The distance and direction the wave travels depend on a number of different factors, such as the power at which the signal was transmitted, the frequency of the wave, and whether there is any "clutter," such as trees or buildings, in the way. The receiver then "listens" to the signal and decodes the message (assuming it is close enough to hear it).

Scientists first proved the existence of electromagnetic spectrum in the late 19th century, with commercialization of radio following soon after in 1897.[27] Since then, the pace of innovation has been astounding.

Why Is Spectrum Important?

Spectrum by itself is not so important—it is the uses we put it to that bring value. Indeed, the technologies we have built using radio have fundamentally changed the way we interact.

Figure 2: Examples of radio spectrum use by frequency (Source: U.S. General Accounting Office).



The diagram above shows a handful of the different technologies that rely on spectrum, along with the rough range of frequencies they use. These different radio technologies—such as RADAR, broadcast television and radio, satellite communications, and GPS—have had a profound effect on our lives. These technologies also play a sizeable role in the economy.

Historically, as new wireless technologies were developed, there was plenty of spectrum to go around. Not so anymore. Virtually all the useful spectrum has been claimed, and in most cases, significant investment has been made in various types of equipment, with reliance on having access to that band.

But technology never stops progressing, and now many of the initial assignments of spectrum are obsolete. The task of spectrum regulation has become one of reassigning already utilized spectrum to new technologies that have more social and economic value than old ones. The greatest example of this tension has been the rise of mobile broadband. The challenge of finding the spectrum needed to meet the demand for mobile data is one of the key projects for spectrum managers.

The demand for mobile data is growing rapidly. In the United States, mobile data traffic grew 63 percent in 2014. It is estimated that in 2019, U.S. mobile data traffic will be equivalent to 210-times the volume of mobile traffic 10 years earlier (in 2009).[28] This demand is not unique to the United States.

U.S. consumers and businesses value mobile services quite a bit. For example, spending on mobile services reached of $172 billion in 2013, generating an estimated $400 billion in total economic activity.[29] Essentially, every dollar spent on wireless services generated $2.32 in total spending, and every job in the wireless sector generated 6.5 jobs.[30]

Wireless services also touch a number of different sectors, enabling innovation throughout the economy. Take, for example, agriculture. Beyond the regular communications technologies we all enjoy, farmers rely on GPS to guide large-scale equipment through fields. Also, government-operated earth exploration satellites beam down detailed information regarding environmental, atmospheric, and climatic conditions. Companies are also working to create private satellite networks to collect and provide information to improve crop production, while unmanned aerial vehicles will inspect and monitor crops and livestock. IoT will soon be leveraged to monitor many different aspects of agricultural processes. By some estimates, IoT and big data analytics will soon save 50 billion gallons of fresh water a year globally.[31]

All of these technologies require spectrum, and in order for them to work properly, that spectrum use has to be coordinated to some degree. Spectrum management is a key part of enabling efficient industrial organization as well as supplying innovative new spectrum technologies the bandwidth to grow.

How Is Spectrum Managed?

Spectrum is indeed a peculiar sort of resource. In a sense, it is infinitely renewable—always there, ready to be put to use. The problem with unmanaged spectrum is interference.

If a radio receiver tries to interpret two different signals in the same place, at the same time, on the same frequency, it essentially gets confused, and neither message goes through clearly. This is how we get interference.

To protect against interference, different entities have to work together to ensure multiple senders do not transmit on the same frequency at the same time in the same place. This is where spectrum management comes in. Spectrum management involves a variety of different rules, such as limitations on the power of signals that can be transmitted, or geographic limitations on where transmitters can be placed, all with the aim of minimizing interference.

One of the most important tools in spectrum management is the license. Licenses are subject to a variety of service rules, but give the license-holder exclusive rights to one operator to a defined band of spectrum in a given area. Many different methods have been used to assign licenses, but today, regulators auction spectrum licenses. Spectrum licenses allow operators a clean environment and some flexibility to build their radio architecture as they think best.

Mobile operators rely on licensed spectrum to run their networks. Operators require interference-free spectrum to provide reliable service. Likewise, all the other operations that rely on spectrum, such as RADAR, broadcast television, GPS, and satellite communications, have to be separated through technical rules to ensure smoother operation. This is the role of spectrum managers.

ENDNOTES

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