

UNLICENSED SPECTRUM AND THE AMERICAN ECONOMY

QUANTIFYING THE MARKET SIZE AND DIVERSITY OF UNLICENSED DEVICES

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Executive Summary

In the middle of the last century, the invention of electronic computers revolutionized information processing. Then, the advent of networking infrastructure and protocols facilitated communication between computers, which allowed people to share information at a volume and speed that was never before possible. While these innovations were limited to research institutions, businesses, and the military at first, the diffusion of the Internet into every aspect of modern society irrevocably changed the way we live.

The Internet is the ultimate demonstration of the power of networks. A person can do a lot with an isolated computer, but when that person is connected to every other computer and every other person, a new world of possibilities opens up. Networks are the breeding ground of innovation.

Unlicensed radio spectrum's role in networking and innovation is perhaps less well known. Unlicensed spectrum powers the devices we now take for granted like Wi-Fi-enabled tablets (although its uses go much deeper, as this report explains). Just like the Internet, unlicensed spectrum catalyzes innovation because it allows entrepreneurs to harness a communications medium—radio spectrum—to connect people and devices wirelessly. The recent surge of connected devices that rely almost exclusively on unlicensed spectrum, called the Internet of Things, is clear evidence that unlicensed spectrum has incredible value.

This report collects sales data of the entire ecosystem of devices that use unlicensed spectrum to estimate their impact on the U.S. economy. CEA estimates that unlicensed spectrum generates \$62 billion per year in incremental retail sales value (“IRSV”) based on this comprehensive review. Moreover, we estimate that growth of devices that rely on unlicensed spectrum is extremely strong. Over the period 2011-2016, the IRSV contributed by Bluetooth, NFC, 802.15.4, and RFID technologies has a cumulative annual growth rate of about 30 percent.

We emphasize that this report accounts for the diversity of the unlicensed device ecosystem. AM radio broadcasting hardware, automatic vehicle identification systems, industrial, scientific, medical (“ISM”) devices and many more—not just ubiquitous Wi-Fi routers—are all accounted for. Additionally, we explain how standards are an essential part of unlicensed spectrum's success.

Introduction

Life without unlicensed wireless devices—garage door openers, key fobs, baby monitors, hands-free attachments, cordless phones, not to mention Wi-Fi—is almost unimaginable. All of these technologies have diffused into our daily routines so completely that they are practically invisible. We know intuitively that their impact is enormous, but has never been thoroughly quantified.¹ What is unlicensed spectrum's contribution to the U.S. economy?

At the outset, establishing precisely what should be quantified is a conundrum. Unlicensed spectrum is fragmented; it employs multiple frequency bands, has communicative and non-communicative applications, gives rise to an incredibly diverse product market, and unlicensed uses are often integrated with licensed uses in the same device. Furthermore, indirect benefits, which are derived from cost savings and intangible social value, are hard to identify and measure. Published estimates of unlicensed spectrum's value, which focus mainly on the indirect benefits of Wi-Fi alone, range from the tens to hundreds of billions of dollars, depending on what is being measured.²

The goal of this study is to quantify the Incremental Retail Sales Value (“IRSV”) of devices that use unlicensed spectrum in the United States. IRSV data is direct, easily measured, and tangible, making it a useful proxy for the value of unlicensed spectrum.³

CEA estimates that, *solely in terms of the sale of devices using unlicensed spectrum to end-users*, unlicensed spectrum generates **over \$62 billion per year** in IRSV.⁴ This figure takes into account the marginal value of unlicensed radios in devices with multiple radios. Also, CEA estimates that growth of devices that rely on unlicensed spectrum is extremely strong. Over the period 2011-2016, the IRSV contributed by Bluetooth, NFC, 802.15.4, and RFID technologies—which are found in the bulk of unlicensed spectrum-based products—has a cumulative annual growth rate of about 30 percent.

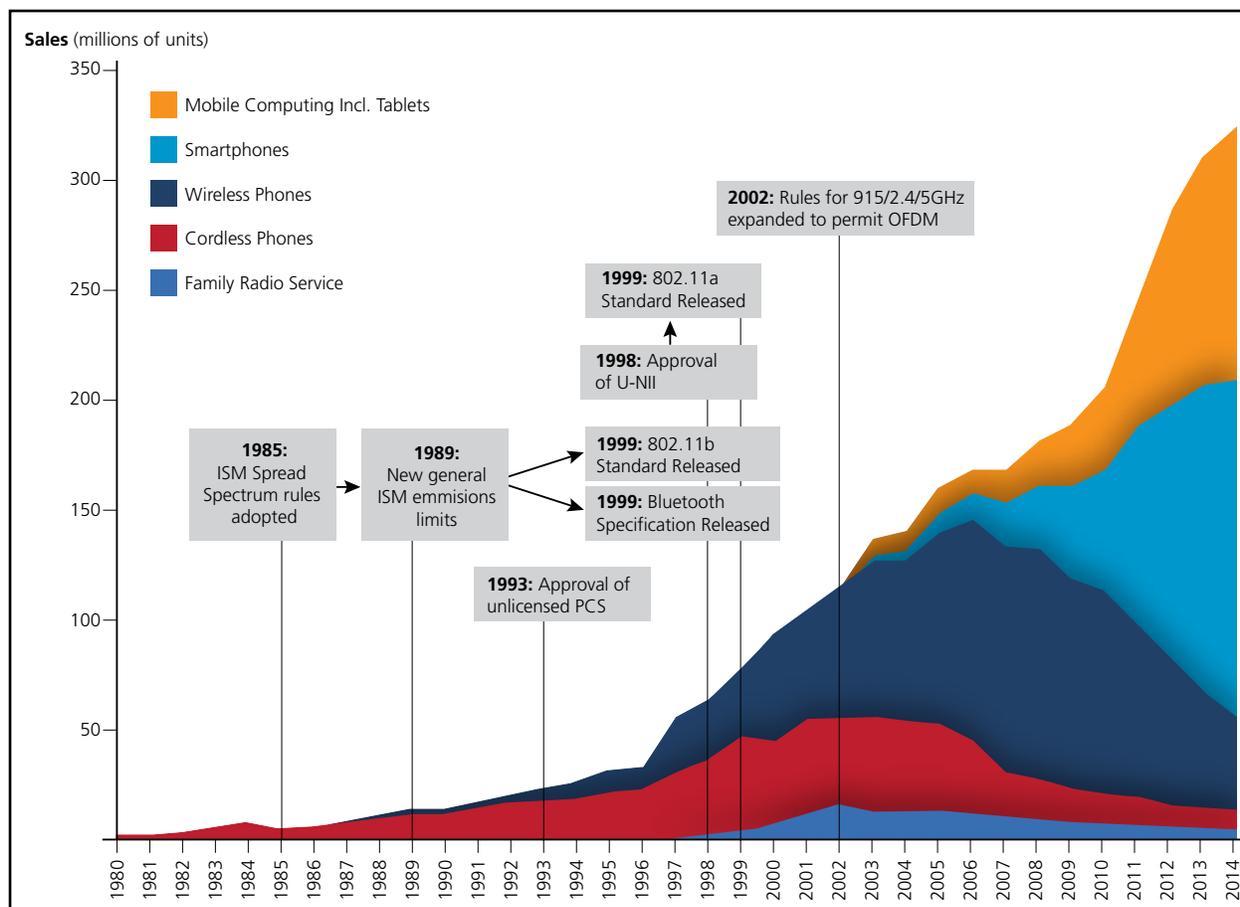
Of course, unlicensed spectrum is found somewhere within every industry, whether it is directly supporting the manufacture of goods or as an everyday technology in the home or office. By all accounts, the value of these indirect contributions in terms of savings, productivity, and utility greatly exceed, and are additive to, unlicensed spectrum’s direct input to the economy.⁵

I. The Ecosystem of Unlicensed Devices

In the United States, radio frequency spectrum is a public resource managed exclusively by the federal government.⁶ Users must obtain permission before transmitting to ensure that interference is properly managed and to prevent inefficient spectrum usage. The FCC manages commercial spectrum using two broad categories: licensed and unlicensed.⁷

Licensed spectrum can be carefully allocated and regulated. Licensees are given enough certainty to develop a minimum level of quality-of-service and can deploy technologies calibrated to the spectrum in which they are operating. Licensed spectrum is suited to applications that must deliver a known quality of service such as satellite broadcast services or cellular telephones. The disadvantage of licensing spectrum is the high cost involved in: (1) obtaining the spectrum; and (2) building a service to utilize it. Users must have sufficient resources to overcome threshold costs to deploy licensed spectrum. Also, licensees are subject to significant regulatory oversight and must comply with licensing requirements.

Figure 1: Unlicensed Spectrum Milestones and Selected Device Categories – Growth Over Time



Unlicensed spectrum complements licensed spectrum by making spectrum accessible to users who have access to fewer resources, which facilitates innovation.⁸ Users who wish to add communications capability to a device can do so at greatly reduced costs because they do not have to own spectrum—devices simply need to comply with the technical limits set forth in the FCC’s rules. The unlicensed model has been a runaway success story precisely because users are free to experiment and deploy products with minimal regulatory oversight and without the additional burden of licensing terms.

Figure 1 demonstrates growth in terms of unit sales over time for several categories of devices that rely exclusively or heavily on unlicensed spectrum. Milestones that contributed to the growth of these categories are superimposed on the chart. The exponential growth of these categories, particularly those products that use the 2.4 and 5 GHz bands, is powerful evidence that unlicensed spectrum spurs innovation. Without unlicensed spectrum, these devices could not exist or their capabilities would be significantly diminished.

II. Methodology

This report comprehensively estimates the IRSV of certain types of devices that use unlicensed spectrum.⁹ IRSV represents a component of the direct contribution of unlicensed spectrum to U.S. GDP.¹⁰

We define IRSV as the annual value of retail-level (or end-user, where appropriate) sales attributable to inclusion of an unlicensed spectrum feature in a product. For some products, this is an incremental portion of a retail sale. An example of incremental value is the Wi-Fi feature in a smartphone; the phone has utility without Wi-Fi, but the inclusion of Wi-Fi increases the price consumers are willing to pay for the device. In such cases, the incremental value of an unlicensed spectrum feature may vary from a small fraction to as high as half the value of the product.

In other cases, the whole product could not exist without unlicensed spectrum. For example, a buried cable locator works by utilizing an unlicensed spectrum signal coupled onto a buried cable. Without the use of unlicensed spectrum, this device simply does not work. Therefore, the incremental value is 100% of the retail price of the product.

Section A explains how CEA selected categories to study, and isolated those categories with available national sales data. Section B provides an overview of categories which were studied but could not be included due to lack of data fitting the study methodology. Section C explains how CEA accounts for the incremental value of unlicensed features in devices that use licensed and unlicensed radios. Finally, Section D differentiates IRSV from indirect methods of valuing unlicensed spectrum.

A. Quantifiable Device Categories

CEA generated its sales estimates by first tabulating over 40 categories of devices or services using unlicensed spectrum. These categories include some where the common name for a device type is generic, such as “walkie-talkie,” which refers to both licensed and unlicensed devices. For each category, we identified products to serve as examples of the applications of the spectrum.

To calculate IRSV, CEA used the original manufacturer’s information on device sales where it was available. Other sources of information were used to supplement manufacturer data. In most cases, unit sales estimates were used, and then we derived an estimate of retail sales revenues by multiplying device unit sales by an estimate of average sales price (“ASP”). This ASP estimate was based on separate ASP research by CEA¹¹ or other companies, or when ASP data were not available, a review of available product. This basic methodology could not be used in all cases due to the diversity of markets studied, so we individually studied the categories and modified the methodology to work with the available data. In some cases, a category’s IRSV was calculated using leading manufacturer sales and market share estimates or independent industry analyst reports.

CEA next identified all categories for which there were reliable data that fit the analysis methodology. This group includes those categories where manufacturer data, industry analysis or other sources could be found or acquired. These are referred to in this report as “Quantifiable” categories.

Table 1: Quantifiable Device Categories
AM Broadcasting Hardware
Auditory Assistance Device
Automatic Vehicle Identification Systems (AVIS)
Baby Monitors
Bluetooth
Cordless Phones
Family Radio Service
Fixed Microwave
FM Broadcast
Garage Door Openers
Home Security Systems
Intelligent Transportation Systems (ITS)
ISM Part 18 Devices
Medical Implant Communications (MICS)
Millimeter Wave Band Devices - Data Links
Multi-Use Radio Service
Near Field Communications (NFC)
Paging Devices (restaurant-type)
Radio Control Radio Service
Radiofrequency ID (RFID)
Remote Keyless Entry
Smart Meters and Mobile Meter Readers
Wi-Fi/Wireless LANs
Wireless PAN / 802.15.4

Even within the Quantifiable categories, there are cases where available data under-represents device sales. For example, Part 18 ISM band usage includes heating applications for factory processes (*e.g.*, curing paints), food service (*e.g.*, microwave cooking), and medicine (*e.g.*, microwave diathermy). However, many of these device types are not tracked or have limited data available. For example, reliable data are available for microwave oven sales, but less so for some of the other types mentioned. For categories without complete data, only the portion of sales that can be quantified is included in the device category.

In summary, our estimate of total IRSV includes only amounts estimated for the Quantifiable categories, and only for those amounts within those categories that can be reliably determined. These factors mean our estimate of total IRSV is less than the actual IRSV that would be found with perfect data.

B. Non-Quantifiable Device Categories

After identifying Quantifiable categories, the remaining categories were those where no data were available, or data could not be sufficiently validated. These 18 categories are “Non-Quantifiable”. Table 2 lists the device categories studied but deferred as Non-Quantifiable. These categories were not included in the total calculation of IRSV.

Table 2: Non-Quantifiable Device Categories
Biomedical Telemetry
Cable Locating Equipment
CB Radio
Field Disturbance Sensors
Ground Penetrating Radar
Low Powered Radio Service
Medical Imaging Systems
Millimeter Wave Band Devices - Automotive Radar
Stud Sensors and Wall Imaging Devices
Surveillance Systems (perimeter protection system)
Through-wall Imaging Systems
Toys
Unlicensed National Information Infrastructure
Walkie-Talkies
Wireless Controls
Wireless Headsets
Wireless Microphones
Wireless Thermometers

There are three main reasons why these categories were not quantifiable.

Small, Private or Fractured Markets

This group includes small markets where there is not enough sales volume to be tracked. It includes highly fractured markets of private companies, where the ease of integrating unlicensed spectrum makes it possible for many small companies to participate, but makes it difficult to quantify sales volumes.

- Biomedical Telemetry
- CB Radio
- Low Powered Radio Service
- Millimeter Wave Band Devices - Automotive Radar
- Unlicensed National Information Infrastructure devices
- Walkie-Talkies
- Wireless Headsets
- Wireless Microphones
- Wireless Thermometers

Service Industry Products

The sale of a single unit in these industries may drive months or years of service activity. The low annual sales volume of these products is not tracked and therefore not available for inclusion in this study.

- Cable Locating Equipment
- Ground Penetrating Radar
- Stud Sensors and Wall Imaging Devices
- Through-wall Imaging Systems

Merged, Indistinguishable Product Types

Some product types include a subset of products that use unlicensed spectrum. But because no data is available on that subset of products, they could not be included in this study.

- Field Disturbance Sensors
- Medical Imaging Systems
- Surveillance Systems (perimeter protection system)
- Toys
- Wireless Controls (for home lighting or appliances)

Were the Non-Quantifiable devices included in this study's aggregate numbers, they would add to the total value of IRSVs. Put differently, CEA's exclusion of certain unlicensed device categories from consideration causes our estimate of the total retail sales of unlicensed devices to be low.

C. Accounting for the Incremental Value of an Unlicensed Feature of a Device with Multiple Unlicensed Features

For each quantifiable unlicensed device category, CEA calculated a Retail Sales Value ("RSV") by multiplying annual unit sales by ASP. An RSV is sufficient for product categories such as the ubiquitous restaurant guest pager because the value of the pager is wholly attributable to unlicensed spectrum. If the unlicensed link is removed from the restaurant pager, the device has no useful function, and using a cable to replace the wireless link would not be an option. However, a methodological problem arises when a device has multiple unlicensed features.

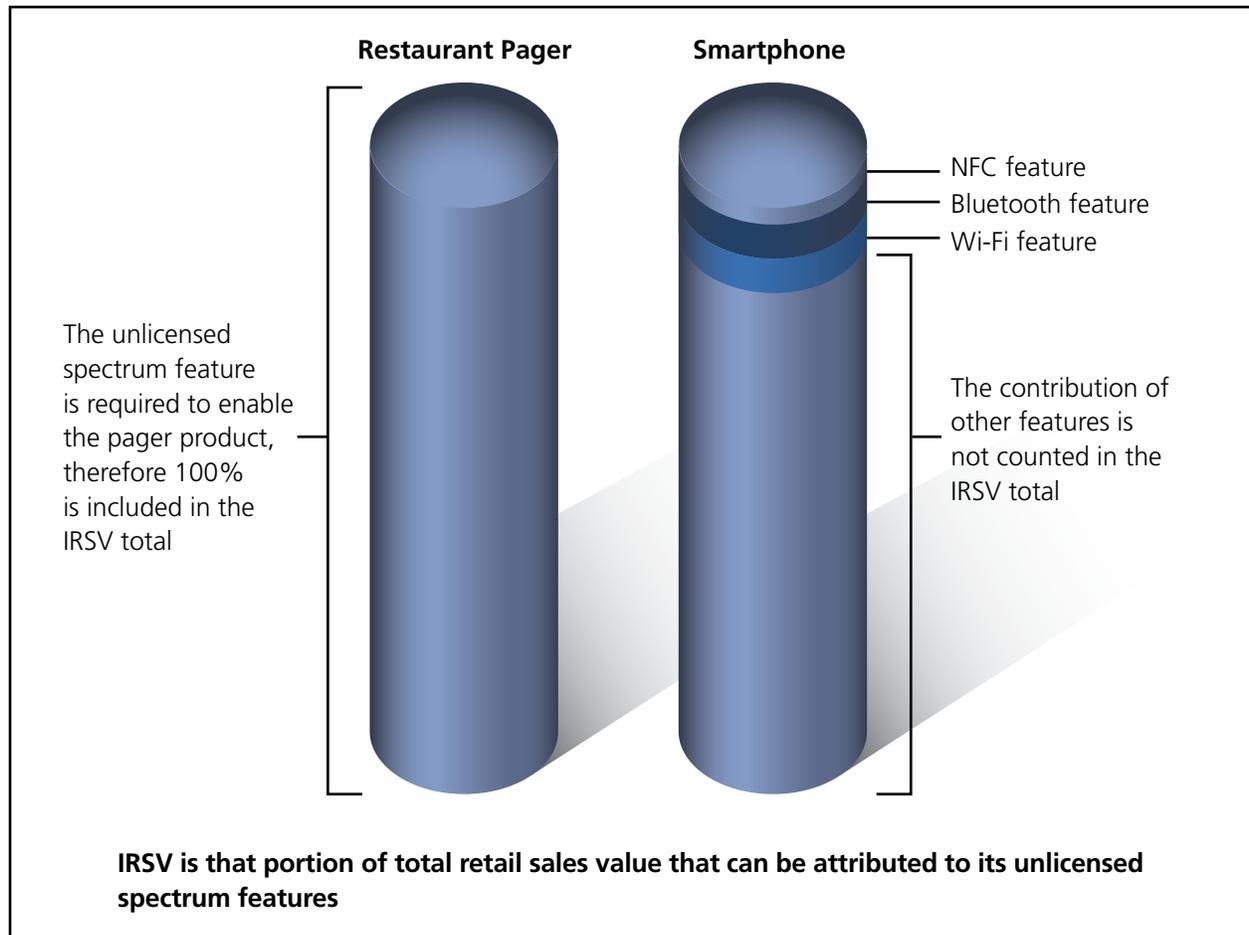
Smartphones are a common example of a device with multiple unlicensed features. The history of the smartphone market demonstrates that consumers are willing to pay one price for a smartphone without a certain unlicensed feature such as Wi-Fi, Bluetooth, or NFC, but are willing to pay more for a smartphone with those features. Thus, each feature has an incremental value.

If our analysis were to attribute the entire retail price of a smartphone to a given unlicensed device category without accounting for incremental value, its total calculation would be artificially inflated. This is because the value of one unlicensed feature would be combined with other features, such as LTE capability, media player capability, or storage capacity.

To account for incremental value, we found the difference in price paid for two devices, one with the unlicensed feature and one without. Where such direct comparisons were unavailable in the marketplace, we used an estimate.

CEA attributed only the incremental value of a device's unlicensed feature to its corresponding category. So, for example, the Wi-Fi/Wireless LANs category in Table 3 reflects only the incremental value directly attributable to the Wi-Fi feature of smartphones, plus other Wi-Fi devices. Figure 2 demonstrates the breakdown visually.

Figure 2: Incremental Retail Sales Value for Restaurant Pagers and for Smartphones



Additionally, some of the available unit sales data did not distinguish between units with and without the category feature, such as NFC. Not all smart phones carry NFC radios. Where a unit sales estimate was an aggregate of devices with and without the feature, we estimated the fraction of units carrying the feature and decreased the aggregate incremental value by this ratio to find the final number.

In sum, CEA's final IRSV estimate properly isolates unlicensed uses in those devices with mixed licensed and unlicensed features, and avoids over-counting of devices and sales.

D. The Value of Unlicensed Spectrum's Indirect Benefits is Additive to CEA's Estimate

Indirect benefit in the context of this study means the benefit that accrues in the supply chain activities leading up to the sale of an unlicensed device, or after an unlicensed device is sold. Indirect benefits include cost savings and productivity increases, as well as less tangible metrics like social value. Indirect benefits also include things like raw component sales prior to final manufacture, or shipping costs incurred to move product to the point of sale.

A commonly cited example of unlicensed spectrum's indirect value is wireless service providers' use of Wi-Fi to offload data from congested cellular networks.¹³ In this case, unlicensed spectrum supports the use of licensed spectrum, but the value of that support is a second-order benefit derived from cost savings.

Another example of indirect benefit is the value of buried-cable detectors, which prevent damage to underground cabling and the consequent loss of communications service. Their retail market is small because they are sold infrequently, but have a long useful life. Nonetheless, their indirect value is enormous when measured in terms of the costs associated with loss of communications service and repair.

Broadly speaking, unlicensed spectrum has many indirect benefits.

- It lowers costs, which fosters innovation, competitiveness, and rapid improvement, particularly for applications like machine-to-machine communication.¹⁴
- It gives device manufacturers more flexibility to respond to consumer demand.
- It improves Internet access by making wireless infrastructure more ubiquitous.¹⁵
- It has social and research value as a way to discover new uses for connecting devices wirelessly.

Collectively, these indirect benefits add to the economic contribution produced as a direct result of device sales.

III. Findings

CEA estimates that sales revenue from unlicensed devices generates over **\$62 billion per year** in IRSV. The following chart shows a breakdown of retail sales for each category of unlicensed technology from greatest to least.

Unlicensed Device Category	IRSV, 2012 (millions)
Wi-Fi/Wireless LANs	20,029
Wireless PAN / 802.15.4	12,820
Bluetooth	12,540
Medical Implant Communications (MICS)	4,700
Smart Meters and Mobile Meter Readers	2,928
Radiofrequency ID (RFID)	2,541
ISM Part 18 Devices	1,900
Remote Keyless Entry	1,500
Cordless Phones	1,060
Near Field Communications (NFC)	908
Radio Control Radio Service	665
Home Security Systems	562
Baby Monitors	102
Auditory Assistance Device	100
FM Broadcast	85
Fixed Microwave	50
Garage Door Openers	41
Family Radio Service	39
Automatic Vehicle Identification Systems (AVIS)	35
Millimeter Wave Band Devices - Data Links	24
Paging Devices (restaurant-type)	14
Multi-Use Radio Service	10
AM Broadcasting Hardware	1
Intelligent Transportation Systems (ITS)	0
Total Estimated IRSV	62,656

Figure 3: Ratio of IRSV in Quantifiable Categories to the Total

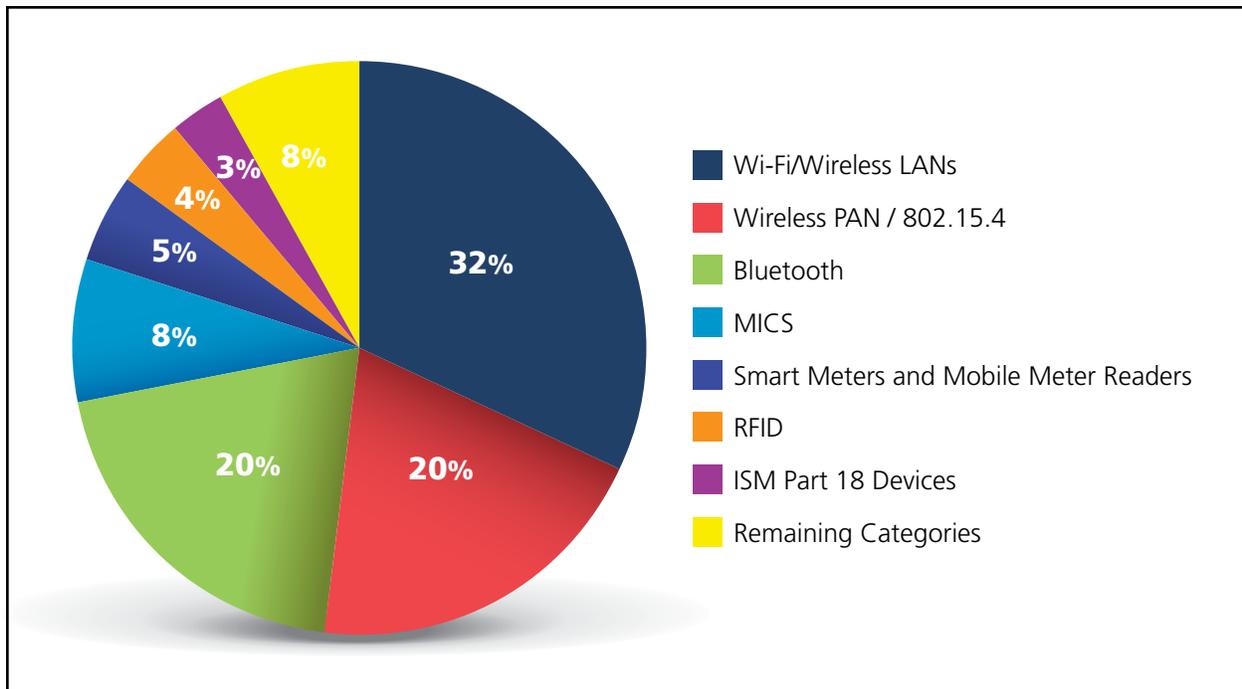


Figure 3 indicates that Wi-Fi, standing alone, shoulders just under one-third of the total IRSV of all unlicensed devices. Moreover, the top three categories—Wi-Fi, IEEE 802.15.4, and Bluetooth—together comprise nearly 75 percent of the total IRSV of unlicensed spectrum.

A. Standards Are Key

The contribution of standards to the success of Wi-Fi devices—indeed, unlicensed devices as a whole—should not be overlooked. Typically, communications networks become more valuable as more people and devices are connected to them. The telephone network is an historical example of this “network effect.” Common standards facilitate network effects. When widely adopted, standards lay the groundwork for much larger numbers of devices to be connected than would be possible if those devices were using disparate communications technologies. In the ecosystem of unlicensed devices, Wi-Fi is the prime example of the positive effect a standard can have: it is incorporated into smartphones, tablets, televisions, PCs, wearables, sensors, among many other devices, and allows them to interconnect seamlessly.

Standards that become popular give rise to economies of scale by promoting network growth, in two ways. First, they increase the size of a given network by lowering costs. If developers can use a common pool of knowledge to incorporate communications technology into their devices, they do not have to develop one-off solutions, which decreases costs. Second, standards attract other applications—a kind of “ecosystem gravity.” As devices using the standard become widely available, developers are incentivized to use the standard. Otherwise, their product risks being excluded from potentially valuable connectivity.

B. Other Unlicensed Uses Have Significant Value

So far, Wi-Fi has dominated the spotlight. But Table 4 demonstrates that other unlicensed uses should not be neglected.

Table 4: Economic Impact of Unlicensed Device Sales Compared to Unit Sales for the Same Categories (2012)

Unlicensed Device Category	Unit Sales, Millions	% of Total	Rank, based on IRSV	Change in Position from Table 3
RFID	1,802.60	61.80%	6	+5
Bluetooth	412.4	14.10%	3	+1
Wi-Fi/Wireless LANs	376.27	12.90%	1	-3
Smart Meters and Mobile Meter Readers	150.22	5.20%	5	+1
Wireless PAN / 802.15.4	66.08	2.30%	2	-3
NFC	30.36	1.00%	10	+4
Cordless Phones	21.63	0.70%	9	+2
Remote Keyless Entry	15.13	0.50%	0	No change
Radio Control Radio Service	13.58	0.50%	11	+2
ISM Part 18 Devices	9.58	0.30%	7	-3
Family Radio Service	4.9	0.20%	18	+7
AVIS	4	0.10%	19	+7
FM Broadcast	3.23	0.10%	15	+2
MICS	1.74	0.10%	4	-10
Baby Monitors	1.7	0.10%	13	-2
Home Security Systems	1.03	0.00%	12	-4
Paging Devices	0.28	0.00%	21	+4
Garage Door Openers	0.26	0.00%	17	-1
Multi-Use Radio Service	0.1	0.00%	22	+3
Fixed Microwave	0.08	0.00%	16	-4
Auditory Assistance Device	0.03	0.00%	14	-7
AM Broadcasting Hardware	0.01	0.00%	23	+1
Millimeter Wave Band Devices - Data Links	0	0.00%	20	-3

Take, for example, the positive change in position of RFID when we turn the focus from IRSV to total unit sales—in effect, from dollars to “points of presence”. RFID devices produce a fraction of the sales revenue of Wi-Fi devices, but rank number one by a large margin in terms of unit sales volume, despite that RFID devices are typically not sold directly to consumers. These shifts suggest that, when evaluating the status of the unlicensed market, it is important to recognize the diversity of the kinds of devices that unlicensed spectrum enables, and the unique value that each one brings to market.

C. Unlicensed Spectrum is a Key Component of Internet Infrastructure

Categories listed in Table 3 almost exclusively focus on consumer devices because our objective is to quantify sales to end-users. However, it is necessary to consider unlicensed spectrum’s value as infrastructure. Internet traffic may travel over multiple unlicensed Fixed Microwave and unlicensed Millimeter Wave Band Device data links before arriving at the home. Then, the consumer connects through Wi-Fi or even over a Bluetooth link, possibly paired with NFC. Since building wireless facilities to carry wireless links is less expensive than laying cable or fiber, providers can achieve better coverage at lower cost with unlicensed spectrum.

Even cabled infrastructure benefits from unlicensed spectrum devices. Cable Locating Equipment, Stud Sensors and Wall Imaging Devices, and Through-wall Imaging Systems all ensure that wired connections are not damaged.

IV. Conclusion

The value of unlicensed spectrum is difficult to quantify, yet we generally accept that it is extremely valuable. This study copes with that difficulty by choosing a narrowly-tailored metric—incremental retail sales value—for which there is concrete data. Using device sales as a proxy for the value of unlicensed spectrum, CEA concludes that it adds over \$62 billion per year in retail sales to the economy.

¹ See Press Release, Statement from FCC Chairman Julius Genachowski on House Passage of Voluntary Incentive Auction Legislation (rel. Dec. 13, 2011), http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-311528A1.pdf.

The Federal Communications Commission (“FCC”) has been actively exploring the possibility of allocating additional unlicensed spectrum for some time. See *Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Notice of Proposed Rulemaking and Order, 27 FCC Rcd 15594 (2012), http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-12-148A1_Rcd.pdf; *Revision of Part 15 of the Commission’s Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, Notice of Proposed Rulemaking, 28 FCC Rcd 1769 (2013), http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-13-22A1_Rcd.pdf; *Unlicensed Operation in the TV Broadcast Bands; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, Notice of Proposed Rulemaking, ET Docket Nos. 04-186, 02-380, FCC 04-113 (2004), http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-113A1.pdf.

² Hal Varian, *Unleashing Unlicensed Spectrum*, GOOGLE (Feb. 2013),

<http://www.siliconflatirons.com/documents/conferences/2013.02.10%20DBM/Unleashing%20unlicensed%20spectrum.pdf>; Richard Thanki, *The Economic Significance of Licence-Exempt Spectrum to the Future of the Internet* (June 2012), http://research.microsoft.com/en-us/projects/spectrum/economic-significance-of-license-exempt-spectrum-report_thanki.pdf; Mark Cooper, *Efficiency Gains and Consumer Benefits of Unlicensed Access to the Public Airwaves* (Jan. 2012), <http://www.markcooperresearch.com/SharedSpectrumAnalysis.pdf>; Mark Cooper, *The Consumer Benefits of Expanding Shared Use of Unlicensed Radio Spectrum*, CONSUMER FEDERATION OF AMERICA (Nov. 29, 2011), <http://www.consumerfed.org/pdfs/Consumer-Benefits-of-Shared-Use-Spectrum.pdf>; Paul Milgrom, Jonathan Levin, and Assaf Eilat, *The Case for Unlicensed Spectrum*, STANFORD INSTITUTE OF ECONOMIC POLICY RESEARCH (Oct. 12, 2011), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1948257.

³ As explained in greater detail below, CEA could not capture every conceivable device category because some did not yield enough data to allow a conclusive analysis.

⁴ The term “end-user” refers to consumers purchasing devices at retail as well as a broader range of purchasers, such as hospitals, factories, professionals, and governments.

⁵ CEA is mindful that its findings capture only one factor contributing to the overall value of unlicensed spectrum.

⁶ 47 U.S.C. § 151.

⁷ See 47 C.F.R. § 15.101 and 15.201.

⁸ Thanki, *supra* note 2, at 6 (“This paper argues that the unique technical and commercial innovation found in licence-exempt (or unlicensed) spectrum has the potential to play a vital, if not predominant, role in meeting each of these connectivity challenges.”); 158 CONG. REC. S889 (daily ed. Feb. 17, 2012) (statement of Sen. John Rockefeller).

⁹ As explained in greater detail below, this report is representative of a majority of the overall sales, but not all, because a portion of these retail sales are not tracked or reported upon.

¹⁰ There are other ways in which a product could make contributions to GDP. For example, to produce a wireless headset, there may be mining operations for raw materials like copper; the copper may be sold to a company which produces wire; the wire is sold to the headset maker; the headset is sold to a retailer; and the retailer sells it to a consumer. Each stage implies multiple contributions to an overall economic value, such as the fuel purchased by the truck driver delivering copper wire. CEA has limited the scope of its inquiry to sales revenue for simplicity.

¹¹ CEA Market Research produces product sales statistics across all major consumer technology categories. See *Industry Sales Data*, CEA, <http://www.ce.org/Research/Products-Services/Industry-Sales-Data.aspx> (last visited Feb. 28, 2014).

¹² Since virtually all smartphones carry Wi-Fi as a feature, the “direct comparison” method could not be used, so an estimated incremental value of 5% was applied in the case of Wi-Fi-enabled smartphones.

¹³ Thanki, *supra* note 2, at 107 *et seq.* (documenting the value of Wi-Fi to fixed broadband by country). Thanki estimates that, globally, in terms of Wi-Fi offload only, households may derive a total economic gain of \$52 to \$99 billion annually. *Id.* at 8. In the United States, that figure is \$15.5 billion. *Id.* at 111.

¹⁴ See FCC, *CONNECTING AMERICA: THEN NATIONAL BROADBAND PLAN 79* (2010).

¹⁵ Milgrom, *The Case for Unlicensed Spectrum*, *supra* note 2, at 2 (“unlicensed spectrum is an enabling resource”).

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ANNEX A: QUANTIFIABLE CATEGORIES FOR U.S. UNLICENSED SPECTRUM DEVICES

This Annex expands on 24 categories of unlicensed spectrum devices included in the preceding report. Each section explains the device category; gives examples of the devices, their uses, and their suppliers; discusses market segments; and estimates annual incremental retail sales value (“IRSV”). CEA used original manufacturers’ information where it was available.

Where possible, the categories are separated by the frequency band of interest.¹ This is particularly important where the common name for a device type is generic. For example, products called “walkie-talkies” can be found in multiple bands, some licensed and some unlicensed.

Each category was studied individually to determine an estimate of its annual retail sales. No single methodology could be applied universally to all cases. The report discusses these methods in greater detail.

A primary source of material in this study came from CEA. The *U.S. Consumer Electronics Sales and Forecasts* report is published twice a year, in January and July.

Other industry analyst reports were used to supplement CEA’s data. These included available analyst reports on hardware sales in dollars; analyst reports on hardware sales in units, with a separate average sales price (“ASP”) used to calculate total dollar sales; and individual interviews with manufacturers. CEA also employed direct interviews with manufacturers.

These sources yielded either dollar sales or unit sales. A primary goal of this report was to estimate annual end-user hardware sales dollar figures. Sometimes it was necessary to combine an external estimate of hardware unit sales with an estimate of average end-user sales price.

It is important to note that IRSV is calculated as the increase in sales due to the unlicensed spectrum feature of a product. Where the product relies entirely upon the unlicensed feature—in effect, where the product would not exist without the unlicensed capability—the retail sales are included in the study at 100% of calculated value.

However, where the product includes the unlicensed feature as one of multiple features, as is the case with Wi-Fi on a smartphone, CEA estimated a fractional value. This estimate was taken as the percentage price difference between the product with, and without, the unlicensed spectrum feature. Therefore, this study considers annual IRSV in the United States. See Section II of the report for an in-depth discussion of IRSV.

A.1. AM BROADCASTING HARDWARE

A.1.1. Overview

Unlicensed AM transmissions use the U.S. broadcast AM band, 530-1700 kHz. Licensed AM radio stations operate in this band, but consumers and small businesses may operate “unlicensed AM” low power transmissions in the band as long as the licensed stations do not experience interference. Because the unlicensed power level is quite low, application of unlicensed AM falls into two kinds of implementations.

First, there is transmission by a single antenna for a single locale. A typical example is that of covering a parking lot at a historical monument, or the property of a house that is for sale.

The second kind of implementation is so-called “carrier current” transmission. In this case, the AM signal is fed into the power lines. An example of this is a high school campus. Anyone within a few tens of meters of a power line at the school can receive the signal. The signal is blocked by power company transformers, so the transmission can be controlled to one campus.

These unlicensed applications fall into FCC rules under a section commonly called “Part 15”, so these applications are sometimes referred to as “Part 15 transmitters.”

A.1.2. Applications

The following are common applications for unlicensed AM (adapted from [The Radio Source \(products\)](#)).

- Holiday: Lighting displays that synchronize with broadcast music, typically for holidays, especially Christmas, Fourth of July, and Halloween.
 - [Lightorama](#)
 - [Planet Christmas](#)
 - [Wow Lights](#)
- Outdoor Spaces: Signs in theme parks, historical sites and societies, churches, national parks and outdoor recreation for interpretation and visitor information (parking, programs and events, historical or nature information).
- Industry/Military: Critical information for visitors or truckers at loading docks, facility gates, weigh-stations or check points.
- US Borders and Highway Checkpoints: Regulations and procedures for motorists.
- Hospitals and Public Health: Broadcast updates on health status, procedures and patron information.
- Tourism Industry: Information and translation for area of interest. All of the following sites use unlicensed AM transmission for visitor information and translation:
 - Zane Grey House (Upper Delaware Scenic & Recreational River)
 - Montana Department of Fish, Wildlife and Parks
 - US Fish & Wildlife Refuge - Crab Orchard Wildlife Refuge in Illinois
 - Nez Perce National Historical Park in Idaho
- Departments of Transportation: Information at rest areas, toll collection areas, weigh stations.
 - The Massachusetts Bay Commuter Railroad Company uses Part 15 (unlicensed) low power AM transmitters to inform commuters of train arrivals and other daily information at 81 of their rail stations: [MBCR Radio List](#).
- Outdoor Advertising: In association with billboards along highways and in cities.
- Real Estate: “Talking Houses”, to speak with prospective buyers about properties 24 hours a day.
- Theaters: Show times and upcoming attractions.
- Auto Dealers: Speak to shoppers in their lots when sales representatives are not present.
- Bank, pharmacies and restaurants: Promote specials to patrons in drive-through lines.
- Micro-broadcasters and Hobbyist applications (low power operators in general): Niche programming not available commercially, *e.g.* religious programming and campus stations (K-8, high school or college campus radio broadcasting).
 - [Hobby Broadcaster -- Directory](#)
 - [Unlicensed Weather Radio](#)

A.1.3. Market Segments

The primary impact of this category comes from transmitter hardware sales. There is a secondary impact on the perceived value of CE devices that include an AM radio feature. There is also a secondary impact on businesses using such services in place of other forms of advertising or consumer information. Finally, there is an industry of installers for business microbroadcasters.

A.1.4. Suppliers

In application, Hamilton and Ramsey have good market share, but they are by no means alone. Here are a number of suppliers:

- [RangeMaster](#)
- [Ramsey](#)
- [TheRadioSource InfoSpot](#)
- [SSTran](#)
- [Chez Radio](#)

A.1.5. Market Size Determination

The companies in this segment are small private companies. Public information is not available. Based on interviews, we estimate that this market is under \$1M/year in total, including both assembled product and “kit” product.

A.2. AUDITORY ASSISTANCE DEVICE

A.2.1. Overview

These systems provide enhance audio or supplemental information, especially translated dialog, to the public at events. FM systems operating in the 72-74 MHz band have been in use from the 1970s. In 1992 the FCC expanded the band due to increasing problems with interference to include 74-76 MHz. The 216-217 MHz band is also used under Part 95 (Low Power Radio Service) of the FCC's rules, but is considered in a later section.

A.2.2. Applications

These devices use unlicensed spectrum to broadcast the auditory portion of an event, or other auditory assistance, at places of public gatherings such as churches, theaters or sporting events. The 1990 passage of the American Disabilities Act improved the sales of these devices, because the law requires any business with 50 or more seats in an area of public assembly, such as an auditorium, theater, or movie house, to make such devices available. With over 38,000 movie screens alone, there are many sites requiring these devices.

By providing stronger, cleaner, and enhanced audio, these systems minimize the effects of background noise and reverberation on speech that would be otherwise be received via a loudspeaker system. Persons with hearing difficulties benefit from these systems. Those who also have hearing aids can, in some cases, connect the hearing aid directly to the auditory assistance receiver.

The 72-76 MHz products (under Part 15) are used for smaller spaces. An inductive loop plugs into a hearing accessory to pick up the audio program.

The following are common applications for auditory assistance systems:

- Churches
- Conference Centers
- Schools
- Auditoriums
- Theaters
- Meeting halls
- Sporting events

Another important application is simultaneous translation. In May 2013, the Commission modified the definition of "auditory assistance device" to permit these devices to be used by anyone at any location for simultaneous language interpretation (that is, simultaneous translation, where the spoken words are translated continuously in near real time).

A.2.3. Market Segments

These systems are sold and installed in public places. Hardware sales and installation are the primary impact.

A.2.4. Suppliers

- [Comtek](#) provides assistive technologies at 72-76 MHz (Part 15) and at 216-220 MHz (Part 95 Low Power Radio Service)
- [Listen Technologies](#) provides assistive technologies at 72-76 MHz
- [Nady](#) provides assistive systems as well as professional sound products
- [Sennheiser](#) provides unlicensed systems under their "Conference" category.
- [Williams Sound](#)
- In addition, [AudioLinks](#), [Barinas](#) and [Centrum Sound](#) are distributors for Williams, Listen and others.

A.2.5. Market Size Determination

We estimate that sales of these devices amount to approximately \$100M/year, of which \$50M/year alone is the 72-76 MHz category. Various unlicensed frequencies make up the remainder of sales, including the 49 MHz category. This application is also served by Bluetooth and other ISM band applications.

A.3. AUTOMATIC VEHICLE IDENTIFICATION SYSTEMS (AVIS)

A.3.1. Overview

These systems automatically identify vehicles using RFID tags.

A.3.2. Applications

In residential use, AVIS can be used to control access to parking lots; in commercial use, it can help track fleet vehicles and other transportation systems vehicles. In public use, along with the other commercial applications mentioned, they are used for automatic toll collection. The hardware consists of a tag (RF identification device, placed on the asset to be tracked) and a reader (a device, hand-held or mounted in a fixed place, capable of collecting data from the tag device). The tag may require an antenna. For these applications, distances are typically limited to a few tens of meters or less.

The following are common applications for AVIS:

- Gated and Assisted Living Communities
- Condominium Parking
- Commercial Parking
- Airports & Seaports
- Universities
- Hospitals
- Fleet control (in/out access and management)
- Train location/positioning
- Toll collection

A.3.3. Market Segments

This is another “installed” category. This category business comes from tag and reader hardware makers, distributors and system integrators.

A.3.4. Suppliers

Here are a number of systems and suppliers:

- [E-ZPass](#) is the RFID-based toll collection system used in 14 states. The hardware for E-ZPass is manufactured by [Kapsch](#).
- [TagMaster](#) products are used in AVIS, fleet and train management. They operate at the 2.4GHz ISM band.
- [Telematics-Wireless](#) has an electronic toll system as well as AVIS products.
- [Intermec](#) makes both tags and readers.

A.3.5. Market Size Determination

In toll collection, E-ZPass is the largest segment of this market. There were over 22,000,000 E-ZPass hardware devices in use in 2012. The transponders cost states approximately \$8.90; approximately 4M units are sold per year for an annual amount of \$35.6M.

A.3.6. For Further Consideration

Other than E-ZPass, AVIS applications include parking garage access, security and train positioning. Individually, these applications are smaller than E-ZPass, but combined they are potentially a large segment. Some data on these components is included in Section A.19, *Radio Control Radio Service*.

A.4. BABY MONITORS

A.4.1. Overview

Transmitter and receiver that allows audio and/or video monitoring of children by parents using wireless technology.

A.4.2. Applications

This category is fairly straightforward, in that “baby monitor” is simultaneously the category name and the primary application. These systems use unlicensed spectrum to broadcast audio and possibly video of the child’s room to a receiver/monitor.

It should be noted, however, that the consumer category of “Baby Monitors” includes both licensed and unlicensed technologies. “Analog”, “Digital”, “DECT”, and “Wi-Fi” monitors are typically unlicensed devices. “Cellular”, “CDMA”, “GSM”, etc. are terms indicating licensed spectrum.

A.4.3. Market Segments

The primary impact of this category comes from hardware sales.

A.4.4. Suppliers

Here are a number of suppliers of baby monitors:

- [First Years](#)
- [Graco](#)
- [Lorex](#)
- [Philips](#)
- [Platinum Angelcare](#)
- [Safety 1st](#)
- [Samsung](#)
- [Sony](#)
- [Summer Infant](#)

A.4.5. Market Size Determination

Sales of baby monitors are estimated to be 1.7M units per year. This leads to a market impact of \$102M/year.

A.5. BLUETOOTH

A.5.1. Overview

Bluetooth is a short-range wireless technology in the ISM band from 2400–2480 MHz. Bluetooth technology allows devices to interact at a range of up to 30 feet. Bluetooth Low Energy (“BLE”) is an ultra-low-power version for short bursts of data.

A.5.2. Applications

Bluetooth has been used primarily to connect mobile devices to cars, headsets and computers. There are a wide variety of smaller market solutions in every conceivable category. These categories include mobile (smartphones, feature phones, headsets, e-readers, media players, digital cameras); computer (personal computers, laptops, netbooks, notebooks, ultrabooks, tablets, printers, mice, keyboards, headphones, access points); gaming (consoles, controllers of all types, headsets); home A/V (TVs, set-top boxes, optical disc players, remote controls, active 3D glasses, digital photo frames, wireless headphones); automotive (in-dash systems, mobile phone “car kits”, diagnostic adapters for under-the-hood application); and health/fitness/medical applications (remote biosensors for sports or diagnostic purposes, personal sound amplification products).

The release of the Bluetooth Low Energy (“BLE”) standard in October 2011 has enabled a slew of new products. BLE is intended for applications which produce small bursts of data occasionally. One main application is expected to be health/fitness/medical solutions, but a remote sensor with potentially years of battery life is attractive for things like weather monitoring sensors, remote thermometers, smart home and smart meter solutions.

A.5.3. Market Segments

The primary impact of this category comes from hardware sales.

A.5.4. Suppliers

The Bluetooth Special Interest Group has extensive information on markets and applications by their 16,500 members: [Bluetooth SIG](#)

A.5.5. Market Size Determination

Bluetooth is widely deployed. BLE is much less so, but expected to grow. For both kinds of Bluetooth, the combined market impact exceeded \$15B in 2011 and continues to climb.

Incremental Retail Sales (Millions)					
2011	2012	2013	2014	2015	2016
\$ 15,510	\$ 18,203	\$ 26,656	\$ 38,036	\$ 44,147	\$ 50,434

A.6. CORDLESS PHONES

A.6.1. Overview

This category refers to phones that use unlicensed frequencies to eliminate the wired connection between the handset and the base station. Unlicensed PCS (Personal Communications Service) is a band allocated by the FCC for short range personal communications (phone) service. Digital Electronic Cordless Telephone (DECT) is the digital cordless access technology standardized by ETSI and used worldwide. DECT-PCS refers to use of the band and standard together. A low power version of DECT is also under development.

A.6.2. Applications

Cordless phones are used widely in consumer and small business cordless phone applications. DECT-PCS has had some success in wireless Private Access Branch Exchange (PABX) systems. Wireless headsets also operate using DECT-PCS. Low power DECT is envisioned for smartphones.

A.6.3. Market Segments

The primary impact comes from hardware sales of the main units, plus accessories such as headsets.

A.6.4 Suppliers

- Business systems
 - [Avaya](#)
 - [Cisco](#)
 - [EnGenius](#)
 - [Alcatel-Lucent](#)
 - [Panasonic](#)
 - [Plantronics](#) (headsets)
 - [Telematrix](#)
- Consumer products
 - [AT&T](#)
 - [ClearSounds](#)
 - [Geemarc](#)
 - [Motorola Mobility](#)
 - [Northwestern Bell](#)
 - [RCA](#)
 - [Serene](#)
 - [Siemens Gigaset](#)
 - [Uniden](#)
 - [Verizon](#)
 - [Vtech](#)
- Consumer and Business DECT Cordless Phones and Wireless Handsets
 - [AT&T](#)
 - [Avaya](#)
 - [Clarity](#)
 - [Clearsounds](#)
 - [Gigaset](#)
 - [Motorola](#)
 - [NEC](#)
 - [Panasonic](#) (consumer)
- [RCA](#)
- [Uniden](#)
- [VTech](#)
- DECT-PCS PABX
 - [Alcatel](#)
 - [Qualitel](#)
 - [Panasonic](#)
 - [NEC](#)
- Headsets and earpieces using Unlicensed DECT/PCS
 - [Logitech](#)
 - [Plantronics](#)
 - [Sennheiser](#)
 - [VXi](#)

A.6.5. Market Size Determination

We estimate the total US Incremental Retail Sales Value of cordless phones of all types to be \$1,407M in 2011, \$1,060M in 2012, and forecast \$925M in 2013.

A.7. FAMILY RADIO SERVICE

A.7.1. Overview

Family Radio refers to longer-range handheld two-way radios using the Family Radio Service (FRS) bands allocated by the FCC.

A.7.2. Applications

These were originally intended for consumers, although small businesses have adopted them for their unlicensed nature as much as their utility. The small portable units have similar convenience in size and battery operation as the older walkie-talkie technology, but with significantly greater range.

Some FRS radios operate only on that band. Others are bundled with GMRS (General Mobile Radio Service) capability as well, as the two bands overlap.

Consumers use these radios to keep in touch at theme parks, national parks, ski resorts and the like. Geocaching enthusiasts use these radios to connect at local competition sites. Organizers and staff at events like soccer tournaments also use these radios.

There are also FRS radios in use in the military.

A.7.3. Market Segments and Impact

The primary impact of this category comes from hardware sales.

A.7.4. Suppliers

Here are a number of suppliers. Note that the industry refers to these products typically as “two way radios” or “walkie-talkies”, and include either FRS or GMRS/FRS in the specifications.

- [Cobra](#)
- [Garmin](#)
- [Icom](#)
- [Midland](#)
- [Motorola](#)
- [Uniden](#)

A.7.5. Market Size Determination

Annual sales of FRS radios are declining due to the growth of mobile phones, but FRS is still in excess of \$39M per year in 2012.

A.8. FIXED MICROWAVE

A.8.1. Overview

Fixed microwave, as the name implies, means point-to-point communications between two fixed (installed, not mobile) antennas. These communications can include voice, data and video, over short ranges.

A.8.2. Applications

These systems are used to connect buildings and sites for users in Government, Municipal, Healthcare, Education, Banking, Financial, Utilities and Energy industries. More specifically, large corporations use such systems to connect two buildings in a city; small broadcasters connect studios to transmitter sites. Large multi-building health care campuses and universities connect buildings to share data.

The application is simply to establish communications between two points when it is inconvenient, expensive, or impossible to run cable. Identifying terms include “unlicensed” or “license-exempt”, combined with “microwave point-to-point” or “wireless backhaul”.

Typically these systems use the familiar dish antenna. Such antennas can be seen scattered along the tops of buildings and radio towers all across the country. However, smaller in-building or local applications use other antennas.

A.8.3. Market Segments

These are installed systems. In some cases, the user can do the installation, but there are quite a few companies that perform the service as well. Therefore, the impact comes from hardware sales and integration business. The unlicensed 60 GHz band (57 GHz – 64 GHz) is becoming a key enabler for 4G systems. Where 2G/3G was all about coverage, 4G is about speed. As a result, carriers are beginning to deploy small cells. In parallel, the public is consuming more and more wireless data. The need for backhaul has risen dramatically. The unlicensed 60 GHz band can be used for small cell backhaul, base-to-base backhaul, and base-to-switch backhaul. The lack of FCC antenna gain and pattern mandates allows vendors to offer concealable antennas, which can be popular with municipalities.

A.8.4. Suppliers

- [Alcatel-Lucnet](#)
- [Barco](#)
- [DragonWave](#)
- [NEC](#)
- [Proxim](#)
- [RadUSA RadMux](#)
- [Trango Systems](#)

A.8.5. Market Size Determination

The market size for 60 GHz backhaul is currently approximately \$50M, but this is mostly enterprise. While mobile carriers see the value, they have not embraced it yet because small cell is only just now taking off. Over the next few years, we anticipate on the order of 40% growth in this sector, \$50M in 2012, \$70M in 2013, \$100M in 2014, \$140M in 2015 and \$200M in 2016 for the U.S. And as of 2016, worldwide sales should be approaching \$1B.

A.9. FM BROADCAST

A.9.1. Overview

FM Broadcast describes unlicensed, low power broadcast of FM signals in the licensed 88–108 MHz FM band.

A.9.2. Applications

This category includes both “products” and “features within products”. For example, there are FM devices that only perform the function of wireless audio transmission from an audio output device to a television. There are also complete products with many features, only one of which is FM transmission; an example of this is a full-featured satellite radio receiver that includes an FM transmitter.

There are two primary applications. The first is to move audio from a personal audio player (MP3 player, iPhone, portable CD player) to another system (car stereo, headphones). These applications crop up wherever consumer audio occurs. For example, gyms (like Gold’s Gym) use FM transmitters to broadcast the audio from televisions and consumers wear FM receivers while they work out. Personal audio devices broadcast FM sound to car stereos, so that the driver can enjoy audio using the higher quality car speakers.

The second primary application is for auditory assistance. Some hearing aid systems put a microphone and transmitter on the person speaking (*e.g.*, a teacher), and an FM receiver on a hearing-impaired person (*e.g.*, a student). Some hearing aids are made specifically compatible with this approach by including either a telecoil input or DAI (direct audio input).

FCC rules (47 C.F.R. § 15.239) effectively limit the range of these devices to about 200 feet.

A.9.3. Market Segments

For the reasons mentioned above, this category includes stand-alone devices and functions of other devices. Generally there are no integrators, so this category is primarily about hardware sales.

A.9.4. Suppliers

Here are a number of suppliers. Considering the low barriers to market entry (low cost, no significant patent protection, ease of design), there are far too many suppliers to do an exhaustive list.

- Personal Audio Player Accessories (transmitters for smartphones/MP3/iPod/Car Stereo/Television audio)
 - [Belkin](#)
 - [Coby](#)
 - [Maximo](#)
 - [Plantronics](#)
 - [Scosche](#)
 - [Sony](#)
 - [Whole House](#)
- Audio Assistance
 - [AVR Sonovation](#) (see Logicom FM)
 - [Phonic Ear](#)
 - [Williams Sound](#)

A.9.5. Market Size Determination

We estimate the U.S. Incremental Retail Sales Value of accessories with this feature as \$85M per year.

A.10. GARAGE DOOR OPENERS

A.10.1. Overview

These unlicensed spectrum devices allow short-range remote opening of garage doors.

A.10.2. Applications

This category is fairly self-explanatory, although “Garage Door Opener” could be generalized to “Intermittent Control Signal Devices.”² However, garage door opener is the more common category name.

Of course, garage door openers are a main application. Also there are home automation and security systems, audio-video system RF remote controls and extenders, and a variety of smaller applications where some light data traffic for control is required.

The rules permitting unlicensed operation of these devices call out over 60 frequency bands. However, in the market, devices operate most often on 100-400 MHz, with 310 MHz, 315 MHz, 318 MHz, 360 MHz, 390 MHz and 433 MHz being common. Some operate on higher frequencies as well.

A.10.3. Market Segments and Impact

Products sold in this category include retail and professional garage door systems, plus automakers include HomeLink RF remotes as part of the vehicle interior equipment. HomeLink has been installed in over 50M vehicles in the past 15 years.

Home automation and control is sold both as direct hardware sales to consumers and by services such as ADT.

A.10.4. Suppliers

Here are a number of suppliers and products.

- Garage Door Openers
 - [Chamberlain](#)
 - [Comlit](#) (includes Cyrex)
 - [Community Controls](#)
 - [DigiCode](#)
 - [DoorKingEMX](#)
 - [Flash2Pass](#)
 - [Genie](#) (for Genie Brand, also Alliance, BlueMax, Code-Dodger, Crusader, Excelerator, Hercules, Intellicode, Lift-a-Door, Norelco, OverHead Door, Pro-Max, and Python)
 - [GTOHeddolf](#) (for Heddolf, Keystone)
 - [Helton](#)
 - [HomeLink](#) (Johnson Controls)
 - [LiftMaster](#)
 - [Linear](#) (for Linear, also Allstar, Allister, Challenger, Moore-O-Matic, Multicode, Multi-Elmac, MVP, Pulsar)
 - [Marantec](#)
 - [Remocon](#)
 - [Sears 315MHz GDOs](#) (modify the search to find 300MHz, 318MHz, etc.)
 - [Skylink](#)
 - [Transmitter Solutions](#)
- Home Automation and Control
 - [Fusionsea](#) (generic switch suitable for home controls)
 - [X10](#) (wireless home automation system sensor and control signals)
- Home A/V Remotes
 - [NextGen](#) (remote extender)
 - [Universal Remotes](#) (RF remote for audio-video systems)

A.10.5. Market Size Determination

The combined estimated annual sales and annual replacement sales of remote controlled garage door operators are \$41.9M.

A.11. HOME SECURITY SYSTEMS

A.11.1. Overview

This category covers products implementing a wireless link from various entry points, appliances, lights and HVAC systems in the consumer's residence to a central hub in the home. This can be done using Intermittent Control Signals spectrum that cannot carry significant data. Information carried includes controls signals and occasional data signals (audio, video).

A.11.2. Applications

These systems are used in homes, small businesses, and large corporations. The national service providers listed below in particular handle larger installations. Wireless technology obviates the need for cabling from door and window sensors, motion detectors, smoke detectors, control panels and hubs.

A.11.3. Market Segments

This category is split between the hardware sales and the service providers.

A.11.4. Suppliers

These companies are national and regional full home security service providers.

- [ADT](#) (national)
- [FrontPoint](#) (national)
- [Security Networks](#) (national)
- [CPI](#) (regional, Southeast)
- [Protection1](#) (national)
- [Vivint](#) (national)
- [ProtectAmerica](#) (national)
- [Slomins](#) (regional, East Coast)
- [Honeywell](#) (national)

These companies provide wireless components for do-it-yourself homeowners and private installers, and supply the service providers listed above.

- [AAS](#)
- [Chamberlain](#)
- [Dakota Alert](#)
- [Defender](#)
- [GE / UTC Fire and Security](#) (includes Interlogix, Lenel, Unity, Supra brands)
- [JMC](#)
- [Logitech](#)
- [Mace](#)
- [SecurityMan](#)
- [Skylink](#)
- [SVAT](#)
- [Swann Communications](#)
- [Visonic](#) (interestingly, their PowerG wireless technology uses frequency hopping on three bands simultaneously: 433-434MHz, 868-869MHz, and 912-918MHz bands)
- [Wansview](#)

A.11.5. Market Size Determination

Working from the CEA Forecast as of January 2013, we estimate the total U.S. Incremental Retail Sales Value of Wireless Multi-Room AV units of all types to be \$348M in 2011, \$562M in 2012, and \$872M in 2013.

A.12. INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

A.12.1. Overview

ITS are a variety of information and communications solutions intended to reduce traffic congestion and increase safety on the roadways. Wireless systems planned for ITS include licensed spectrum (mobile phone technology, 2G/3G/4G) and unlicensed spectrum (DSRC, Digital Short-Range Communications).

A.12.2. Applications

There are applications for both licensed (*i.e.*, mobile broadband) and unlicensed spectrum in connected vehicles. One advantage of unlicensed broadcast for ITS is that it does not rely on mobile carriers, who upgrade their service too quickly for a safety infrastructure. For example, carriers are scaling back 2G service in favor of deploying 4G services.

The following list of top-level applications is adapted from Wikipedia's [Dedicated Short-Range Communications](#) page:

- Adjustable speed limits and signal timings for traffic flow management
- Wireless control of traffic lights by public vehicles (fire engines, buses)
- Electronic toll or parking payment (*e.g.*, E-ZPass; see also Section A.3, *Automatic Vehicle Identification Systems*.)
- Vehicle diagnostics and security
- Wireless shipping inventories and manifests
- Expedite the extra traffic generated by special events.
- Safety applications: Crash avoidance and mitigation technologies

These safety-oriented applications are taken from [The Safety Promise of Vehicle-to-Vehicle Wireless Communications: Research in the United States](#):

- Cooperative Forward Collision Warning
- Pre-Crash Sensing and Collision Mitigation
- Emergency Electronic Brake Lights
- Lane Change Warning
- Stopped Vehicle Ahead Warning
- Enhanced autonomous forward collision warning systems
- Cooperative forward collision systems
- Avoiding missed detections, determine in/out of path lead vehicles, determine forward road geometry, and lead vehicle user intent

A.12.3. Market Segments

The group [Intelligent Transportation Society of America](#) has a great deal of information on this topic on their website. In particular, the [ITS Market Data Analysis Phase 1 Report](#) has extensive information on this topic. Note also that the DoT has proposed a national infrastructure of DSRC communications using unlicensed spectrum to enable this technology.

A.12.4. Suppliers

As this technology is not yet deployed, there are no established providers of record. Please refer to the ITSA report (see above) for market projections.

A.12.5. Market Size Determination

As mentioned, this technology is not yet deployed. However, these systems are in transition from research to initial deployment. As of this writing, DoT has not ruled on a Federal Motor Vehicle Safety Standard. Should this occur, by the next decade we would expect deployment of devices in vehicles at annual volume equivalent to that of U.S. new car sales, meaning on the order of 15M units per year. Per-unit pricing could be roughly estimated to be in the \$25 - \$50 range, putting the aggregate component value at \$375M - \$750M.

A.12.6. Other Resources

Please refer to the [ITSA](#) website.

A.13. ISM PART 18 DEVICES

A.13.1. Overview

The Industrial, Scientific and Medical (ISM) bands are radio bands reserved internationally for industrial, scientific and medical purposes other than communications.

A.13.2. Applications

These are not voice or data devices. These devices are generally heating systems for one purpose or another. Examples of applications in these bands include industrial process heating, microwave ovens, medical diathermy machines, electrosurgery, and a variety of laboratory and scientific equipment.

Because there are so many sub-categories under this main category, a more detailed list of applications with a sample product for each is provided in a following section.

MRI fits into this category, but is covered more completely in Section B.8, *Medical Imaging Systems*.

A.13.3. Market Segments and Impact

As can be imagined from the breadth of this category, the hardware market cuts across many kinds of suppliers, including: food service equipment, general manufacturing equipment, laboratory equipment, and healthcare systems.

A.13.4. Suppliers

Here is a more detailed list of applications with a sample product shown for each item (list adapted from www.telecomabc.com/i/ism.html):

- Heating (1-100 MHz)
 - drying, molding, welding and thawing: [Litzler Radio Frequency Ovens & Dryers](#)
- Medical equipment
 - short-wave and microwave diathermy and hyperthermia equipment: www.mettlerelectronics.com/category/auto-therm/
 - electrical surgical units (ESU): [Megadyne Mega Power Generator](#) (main component for their ESU system)
 - magnetic resonance imaging (MRI): [Philips MRI](#)
- Microwave equipment (above 900 MHz)
 - domestic microwave ovens: [Samsung Microwave Ovens](#)
 - commercial microwave ovens: [Microdry Applications](#); [Thermex Microwave Systems](#)
 - food tempering, thawing and cooking: [Panasonic Heavy Duty Microwave Ovens](#)
 - UV paint and coating curing: [Microcure/Lambda Thermal Applications \(Curing\)](#)
 - rubber vulcanization: [Rubicon Microwave Vulcanization Lines](#)
 - pharmaceutical processing: [CaMWave Microwave-Assisted Reaction Line](#)
- Laboratory and scientific equipment
 - signal generators: [Anritsu Microwave Signal Generator](#)
 - flow meters: [Matusima Powder Flow Meter](#)
 - electronic microscopes: [Hitachi TEM Microscope](#)

A.13.5. Market Size Determination

This category wraps up a wide variety of products and applications under a relatively small section of rules. Domestic microwave ovens alone account for \$1.92B in annual sales. Product groups which could not be quantified for this report include commercial microwave (food) ovens, factory heating systems, medical applications, lab and scientific signal generators, and various other important tools in the industrial and medical areas. These categories do not require compatibility with each other, and so their use of spectrum is not a “headline” element of the product. For an alternative example of this, consider the Wi-Fi router. “Wi-Fi” is an essential element of the product title. This is not so with, for example, medical diathermy units which use unlicensed spectrum.

As a result, non-communications applications of unlicensed spectrum are much less likely to promote the nature of their spectrum characteristics. This makes it difficult to track them.

However, the value of these unassociated, untracked markets is clearly quite high, and future efforts on such quantitative studies may be able to shed more light on the magnitude of the market size here.

A.14. MEDICAL IMPLANT COMMUNICATIONS SERVICE

A.14.1. Overview

Medical Implant Communication Service (MICS) band radios are very low powered systems used for communications between implanted medical devices and nearby (~5m) monitoring equipment.

Newer ICDs can communicate at both the older 175 kHz frequency and in the 402–405 MHz MICS band. MICS is intended for longer-range communications than 172 kHz, which allows for more flexibility in home and clinical settings. MICS is found in cardiac pacemakers, implantable cardioverter defibrillators, neurostimulators, hearing aids and automated drug delivery systems.

In 2009, a New York woman became the first person to receive a pacemaker wirelessly connected to her doctor using MICS.³

A.14.2. Applications

MICS implants are used to wirelessly connect implanted medical devices such as pacemakers, neurostimulators and insulin pumps with programming and monitoring equipment. MICS is also used for ingested devices and in other sensor applications requiring ultra-low-power streaming data performance.

A.14.3. Market Segments and Impact

This segment includes implantable devices, monitoring systems, and services (hospital and surgery, but also outpatient monitoring services).

A.14.4. Suppliers

Here are a number of suppliers and developers of wireless medical implants and wireless implant monitoring systems.

- [Biotronik](#)
- [Medtronic Conexus](#)
- [Microsemi Zarlink](#)
- [St. Jude Medical / St. Jude Medical Accent SR RF](#)

A.14.5. Market Size Determination

Millions of Americans have an implanted pacemaker or defibrillator, with hundreds of thousands more being implanted every year. MICS wireless cardiac pacemakers and implantable neurostimulators account for \$4.7B in sales annually in the United States.

A.15. MILLIMETER WAVE BAND DEVICES – DATA LINKS

A.15.1. Overview

Millimeter band is the 30 GHz to 300 GHz range, and these frequencies are useful for point-to-point, line-of-sight, and high-speed data transfer with fixed antennas.

A.15.2. Applications

A major application of millimeter wave is that of data links. Although devices exist at various frequencies, manufacturers frequently use 60 GHz, which has useful properties for short-haul (up to about 2 mile) point-to-point data links. Also available are 24 GHz (actually, the range 6–26 GHz) and 80 GHz bands (between the frequencies identified as 70-80-90 GHz Millimeter Wave Services).

Note that the 60 GHz frequency is unlicensed, but the 70-80-90 GHz Millimeter Wave Services category does require some minimal licensing. While the latter does not strictly qualify as “unlicensed”, it is useful to consider the impact of the availability of this spectrum under such minimal licensing requirements.

Finally, the [WiGig Alliance WirelessHD](#), two competing industry groups, are developing desktop and in-home data link standards. Both groups intend to connect computing, communication and entertainment devices (*e.g.*, PCs, smartphones, tablets, televisions) with a high-speed wireless link at 60 GHz. The two technologies are not interoperable.

A.15.3. Market Segments and Impact

Adaptive cruise control is sold as a standard feature on some car models, but most often it is an expensive option sold via dealers. The subcategory of millimeter wave bridges/links encompasses hardware sales and integration services. The device connectivity subgroup (WiGig/WirelessHD) will potentially impact all the hardware sales in their target categories (*e.g.*, smartphones, tablets, PCs, televisions, etc.).

A.15.4. Suppliers

- Some automobile models with adaptive cruise control:
 - [Audi](#)
 - [Cadillac](#)
 - [Hyundai](#)
 - [Infiniti](#)
 - [Porsche](#)
 - [Volvo](#)
- Millimeter wave data links/bridges for the unlicensed 24 GHz, 60 GHz, and 80 GHz bands:
 - [Athena 60GHz](#)
 - [BridgeWave 60GHz](#)
 - [Elva-1 60GHz and 80GHz](#)
 - [Exalt 24GHz](#)
 - [LightPointe Wireless 60GHz and 80GHz](#)
 - [Ligowave 24GHz](#)
- [MMWave 11-38GHz](#), [MMWave 24GHz](#), [MMWave 60GHz](#)
- [Proxim 60GHz](#)
- [SAF Tehnika 24GHz](#)
- [Stella Doradus 24GHz](#)
- [Sub10 60GHz Wireless Backhaul](#)
- [Ubiquiti Networks AirFibre 24GHz](#)
- [Vubiq millimeter wave products](#)
- WiGig and WirelessHD
 - [WirelessHD Products](#)
 - [WiGig Alliance members](#) (the technology is not yet broadly deployed)

A.15.5. Market Size Determination

Unlicensed fixed millimeter at 60 GHz will account for \$24M in 2013, increasing to \$316.8M in 2016.

A.15.6. Other Resources

The 70-80-90 Millimeter Wave Services require licensing, and so are out of scope of this report. However, there can be some confusion about which products are unlicensed at these frequencies, and which require licensing.

These upper bands require licensing, but the requirements are minimal enough that the economics are essentially equivalent to unlicensed. The 70 and 80 GHz allocations are each 5 GHz wide and can be paired for full-duplex operation. The 92–95 GHz allocation is not heavily used, due to technical and regulatory disadvantages. The 90 GHz band is smaller than either the 70 or 80 GHz bands, so it cannot match them for speed. Also, 90 GHz products must avoid 94–94.1 GHz, which is reserved for space and satellite communications. This exclusion band splits the allocation into two unequal portions. This further reduces the maximum full-duplex speed, makes pairing more difficult, and increases filtering complexity and cost.

See also the discussion of millimeter wave vehicle radar in Section B.9, Millimeter Wave Band Devices—Vehicle Radar.

A.16.MULTI-USE RADIO SERVICE

A.16.1. Overview

Multi-Use Radio Service (MURS) radios are low power two-way walkie-talkies often used in buildings and on construction sites.

A.16.2. Applications

MURS uses narrowband FM and is limited to 2W maximum transmit power. At 151 and 154 MHz, this service can reach a few miles between handheld units, and ten miles or more with external building-mounted antennas.⁵

Because MURS is lower-frequency than FRS, MURS has better propagation characteristics outdoors and FRS has better indoor performance. This coverage capability, plus the license-free nature of the service, has made MURS a natural for building and construction trades. MURS radios are also used for device alerts and for specific point-to-point voice applications.

Similar in use to MURS are Part 90 business radios. MURS (under Part 95) requires only equipment approval, not an operator license as do Part 90 systems. Many Part 90 two-way radios can operate on MURS frequencies, leading to potential confusion about what is “MURS-capable”.

A.16.3. Market Segments and Impact

The primary impact of this category comes from hardware sales.

A.16.4. Suppliers

Here are a number of suppliers:

- [Amplivox](#)
- [Centerfire Antenna](#)
- [Dakota Alert](#)
- [Firestik Antennas](#)
- [Motorola](#)
- [Ritron](#)

A.16.5. Market Size Determination

There are only a few companies selling MURS product, and one dealer calls MURS “the best-kept secret of two-way radios and wireless intercoms since their introduction.” There is little available literature on the size of this market, but it appears to be on the order of \$10M annual sales.

A.17. NEAR FIELD COMMUNICATIONS (NFC)

A.17.1. Overview

Near field communication (NFC) is a set of standards for smartphones and similar devices to establish radio communication with each other by touching them together or bringing them into close proximity, usually no more than a few centimeters.

A.17.2. Applications

Present and anticipated applications include contactless transactions, data exchange, and simplified setup of more complex communications such as Wi-Fi. Communication is also possible between an NFC device and an unpowered NFC chip, called a “tag”. One major application already deployed is vehicle keyless entry.

A.17.3. Market Segments and Impact

NFC is driving chipsets, software, and adding features to phones. Readers are being deployed at retailers.

A.17.4. Suppliers

Here are a number of suppliers in the NFC ecosystem.

- NFC Readers and NFC-specific Test and Instrumentation
 - [Comprion](#)
- Software
 - [Applications on Google Play](#)
 - [Inside Secure](#) (software stack)
 - [OpenNFC](#) (software stack)
- Phones and Credit Cards
 - [MasterCard PayPass](#)
 - [Visa PayWave](#)
 - [NFC-Phones.org](#) (list of phones with NFC)
- Semiconductor Vendors
 - [Broadcom](#)
 - [Inside Secure](#)
 - [MStar Semiconductor](#)
 - [NXP Semiconductors](#)
 - [Polaric](#)
 - [Renesas](#)
 - [Samsung](#)
 - [STMicroelectronics](#)
 - [Texas Instruments](#)
- Alliances, Forums, Initiatives, Joint Ventures
 - [Google Wallet](#) (American Eagle, Guess, Macy’s, OfficeMax, ToysRUs, others)
 - [Isis](#) (initial deployment at various retailers in Austin, TX and Salt Lake City, UT)
 - [Moversa](#) (NXP, Sony)
 - [MCX](#) (7-Eleven, Best Buy, CVS, Lowes, Sears, Shell, Target, Wal-Mart, others)
 - [NFC Forum](#)

A.17.5. Market Size Determination

NFC is growing dramatically, particularly with the inclusion of the technology in smartphones. The estimated market for 2012 is “only” \$908M. Considering the estimated CAGR of 93%, this seems small compared to the penetration and impact we will see a few years from now.

A.18. PAGING DEVICES

A.18.1. Overview

These are one-way devices capable of receiving short messages from a nearby transmitter, most commonly seen in restaurants for customer paging (“your table is ready”).

There are also licensed paging frequencies, including 457 MHz, cellular pagers and satellite pagers. These licensed applications are not included here.

A.18.2. Applications

Examples include consumer devices (pagers provided by restaurants to alert customers of table availability) and enterprise (in-building paging systems developed exclusively for a company).

When reviewing pagers and paging services, it is not always clear whether a product is intended for licensed or unlicensed operation. The FCC explains that the licensed frequencies are allocated as follows: “Commercial paging operates in the 35-36, 43-44, 152-159, and 454-460 MHz bands (sometimes referred to as the “Lower Band”) and the 929 and 931 MHz bands (sometimes referred to as the “Upper Band”).”⁶

For unlicensed operation, however, the bands most commonly used are 33-49 MHz, 410-470 MHz, and the ISM bands (902-928 MHz and 2.4-2.485 GHz).

Typically, paging systems for smaller operations—such as restaurant pagers—run on unlicensed bands, as the cost and effort of licensing are prohibitive for smaller businesses. Larger operations tend to prefer the security and reliability of licensed frequencies.

A.18.3. Market Segments and Impact

As discussed above, small businesses use unlicensed paging extensively. Hardware sales and integration services are the major impact.

A.18.4. Suppliers

Here are a number of suppliers:

- Hardware suppliers
 - [Apollo Wireless](#)
 - [HME](#)
 - [JTech](#)
 - [Long Range Systems](#) (LRS)
 - [Motorola Solutions](#)
 - [SCA Alps](#)
- Integrators
 - [Interpage](#)

A.18.5. Market Size Determination

This category is familiar to anyone who has dined out at any of a number of restaurants that use short-range pagers to manage guest waiting times. Since this is not typically a consumer-facing technology, sales are limited to restaurant new installations and replacements. We estimate the annual U.S. sales as \$14M, with potential upside due to under-reporting as high as \$84M.

A.19. RADIO CONTROL RADIO SERVICE

A.19.1. Overview

The Radio Control Radio Service is a private, one-way, short distance, non-voice communications service for the operation of remote-controlled models (*e.g.*, “R/C cars”).

A.19.2. Applications

The R/C Radio Service is intended for model planes, boats, cars, trucks and the like.

A.19.3. Market Segments and Impact

This category covers hardware sales of models with integrated radios, radio subassemblies and components, and transmitter units.

A.19.4. Suppliers

Vendors in this category are numerous. Here is a sample of suppliers:

- [Futaba R/C](#)
- [GoHobbies](#) (list of R/C control units from various vendors)
- [Hobby Zone](#) (list of R/C models from various vendors)

A.19.5. Market Size Determination

We estimate the total U.S. Incremental Retail Sales Value of Radio Control Radio Service products to be \$665.4M in 2012.

A.20. RADIOFREQUENCY ID (RFID)

A.20.1. Overview

RFID is technology used for a variety of monitoring and tracking applications in logistics and retail. RFID systems uniquely identify something by a data code read wirelessly.

A.20.2. Applications

Typical applications include access control, asset management and supply chain management. Systems consist of a small transponder with encoded information, an antenna, and a transceiver equipped with a decoder. The antenna emits a radio signal to read or write data from or to the tags attached to the items to be tracked.

In retail, WalMart has been a major proponent of RFID tags, increasingly requiring it on products sold in their stores.⁷ Best Buy also requires RFID tags on electronics sold via their stores. Major retailers like these have pushed RFID from corporate and government logistics into the consumer chain.

Government and corporate applications include asset tracking and logistics. The U.S. military uses millions of RFID tags worldwide, primarily for asset tracking.

Automotive applications are described in AVIS (Section A.3, *Automatic Vehicle Identification Systems*), and ITS (Section A.12, *Intelligent Transportation Systems*). RFID is also used in keyless entry systems.

RFID is used in building access control (card keys); for animal tracking; and for baggage, cargo and container tracking.

A.20.3. Market Segments and Impact

RFID systems require transponders, readers, software, and services (integration).

A.20.4. Suppliers

There is an extensive vendor list at [RFID Connect](#).

A.20.5. Market Size Determination

RFID is used with apparel; for asset tracking and management, such as for spare parts and tools; for IT and medical assets; and for real-time location systems in a variety of industries. It is growing at a healthy pace and we estimate the RFID impact for 2012 as \$2,541M.

A.21. REMOTE KEYLESS ENTRY

A.21.1. Overview

A small transmitter fob on the user's key ring allows keyless entry into cars and other vehicles. Various known as "Remote Keyless Entry" (RKE), "Remote Keyless System", and "Keyless Entry System", it is also known under descriptive and/or trademarked names at dozens of vehicle manufacturers (e.g., Ford's "Intelligent Access with push-button start"; Lexus' "SmartAccess System").

This category also includes tire pressure sensors, which use some of the same technologies and frequencies, and are found on the same kinds of vehicles.

A.21.2. Applications

This category is rather straightforward. The key fob unlocks the car door at a minimum. Other features are trunk unlock, remote car start, and panic alarm. In the application space, this category overlaps with RFID and NFC. Remote start is particularly popular in the northern climes.

Tire pressure sensors use similar frequencies and circuitry. A transmitter and sensors are included in the valve stem of the tire and transmit pressure and temperature data periodically.

A.21.3. Market Segments and Impact

This technology is shipped primarily through new vehicle sales, but aftermarket security systems also offer RKE features.

A.21.4. Suppliers

Here are a number of suppliers:

- Chips
 - [Atmel](#)
 - [Infineon](#)
 - [Maxim](#)
 - [Micrel](#)
 - [Microchip](#)
 - [Semtech](#)
 - [Silicon Laboratories](#)
 - [Texas Instruments](#)
- Vehicles (Original Equipment and Replacement)
 - There is a good list on Wikipedia in the entry for [Smart Key](#) (Nomenclature).
 - Replacements at [Keyless-Remotes](#)
- Automotive Security and Remote Start
 - [Audiovox](#) (Prestige, Code Alarm)
 - [Clifford](#)
 - [Directed Electronics Viper](#)

A.21.5. Market Size Determination

Based on 2012 car, light truck and heavy truck sales, we estimate Remote Keyless Entry sales to contribute approximately \$1.5M annually.

A.21.6. Other Resources

There is a good overview of RKE/RKS on the Clemson website, see [Remote Keyless Entry Systems](#).

A.22. SMART METERS AND MOBILE METER READERS

A.22.1. Overview

This category covers water, power and gas meters that are wireless-enabled to allow utility personnel to remotely obtain data.

A.22.2. Applications

Residential and commercial water, gas and electric meters can be fitted with short range radios, commonly but not exclusively in the 902-928 MHz ISM band. Hand-held devices can then read data off the meter at a short distance. This makes entering the property unnecessary. Wireless meter reading is also more efficient—a van can simply drive through a neighborhood, rather than a technician making an in-person visit to manually read the meter.

A.22.3. Market Segments and Impact

The main market segment for this group is hardware sales to the utility companies.

A.22.4. Suppliers

The following is a list of meter reader equipment suppliers:

- [Itron](#)
- [Kamstrup](#)
- [Neptune](#)
- [Sensus](#)

A.22.5. Market Size Determination

There are over 300M gas, electric and water meters installed in the U.S. Smart meters have good penetration, approximately half of the current installed base and rising. Shipments of smart meters in the U.S. for 2012 are approximately \$2.93B.

A.22.6. Other Resources

- [LA Times - Edison Taps Into Wireless Meter-Reading Options](#)
- [NY Times - City Turns to Wireless for Water Bills](#)

A.23. WI-FI/WIRELESS LAN

A.23.1. Overview

Wi-Fi is a family of wireless LAN (local area networking) technologies based on the 802.11 standards from the Institute of Electrical and Electronics Engineers (IEEE). The term “Wi-Fi” is a trademark of the Wi-Fi Alliance.

A.23.2. Applications

Wi-Fi products enable wireless network access for computers, devices and peripherals through short-range communications. In the computer industry, Wi-Fi transceivers are found as stand-alone hardware, in computers, laptops, tablets, smartphones, game devices, printers, network drives, modems and other hardware.

More generally, Wi-Fi has become a general link used when there is a need for data traffic and an access point can be available. For example, consumer home security systems use Wi-Fi to bring security camera video into the home; in this case the consumer’s own Wi-Fi router may be used as part of the system.

Some cordless phones use Wi-Fi. Novatel has several applications of portable bridges. These allow the consumer to connect to another technology via their smartphone Wi-Fi transceiver. One of the best-selling phones in the aftermarket is the MiFi 2200. This device bridges Verizon CDMA mobile broadband with Wi-Fi.

Wi-Fi is also being deployed as a way to off-load mobile broadband traffic from the carriers’ networks.

The list of existing and potential applications for Wi-Fi could go on and on. Wi-Fi has become a major part of the designer’s toolkit across all industries.

A.23.3. Market Segments and Impact

This category influences hardware sales. There are custom chipsets and products.

A.23.4. Suppliers

The [Wi-Fi Alliance](#) website has a great deal of information.

A.23.5. Market Size Determination

This is a significant category with equally-significant impact. We estimate that the total U.S. Incremental Retail Sales Value of Wi-Fi in 2012 was \$20,029M. Furthermore, the category is growing at an estimated 6% CAGR.

A.24. WIRELESS PAN / 802.15.4

A.24.1. Overview

This category includes devices which use small, low-power digital radios based on an IEEE 802 standard for personal area networks. This includes standards including ZigBee, ISA100 and Wireless HART, which are protocol stacks that run on top of the 802.15.4 physical and data-link layers.

A.24.2. Applications

Applications include wireless light switches, wireless smoke detectors, electrical meters with in-home displays, and other consumer and industrial equipment that require short-range wireless transfer of data at relatively low rates.

ZigBee is targeted at radio frequency applications that require a low data rate, long battery life, and secure networking. The ZigBee Alliance lists major categories, such as:

- Appliances
- Audio
- Closures
- Development Tools
- Energy Efficiency
- Health & Fitness
- Information Systems
- Lighting
- Networking Devices
- Security

Wireless HART and ISA100 systems are targeted at industrial control applications.

A.24.3. Market Segments and Impact

This category cuts across many product categories. Hardware, software and services are all involved.

A.24.4. Suppliers

The ZigBee Alliance has an extensive list of products on their [product page](#).

The HART Communication Foundation lists products [here](#).

The ISA100 Wireless Compliance Institute lists registered products [here](#).

A.24.5. Market Size Determination

This category has home and factory segments. However, the high cost of factory components coupled with good deployment makes market size impact disproportionately in the industrial sector. We estimate that the economic impact for 802.15.4-category devices in 2012 was \$12,820M, with a CAGR of over 30%.

ANNEX B: NON-QUANTIFIABLE CATEGORIES FOR U.S. UNLICENSED SPECTRUM DEVICES

This Annex expands on 18 categories of unlicensed spectrum devices not included in the total calculation of IRSV in the preceding report. Reliable data that are compatible with the analysis methodology were not available for one or more of the following reasons.

Small, Private or Fractured Markets

This group includes small markets where there is not enough sales volume to be tracked. It includes highly fractured markets of private companies, where the ease of integrating unlicensed spectrum makes it possible for many small companies to participate, but makes it difficult to quantify sales volumes.

- CB Radio
- Biomedical Telemetry
- Low Powered Radio Service - 216 MHz
- Millimeter Wave Band Devices - Automotive Radar
- Unlicensed National Information Infrastructure devices
- Walkie-Talkies
- Wireless Headsets
- Wireless Microphones
- Wireless Thermometers
- Unlicensed National Information Infrastructure devices

Service Industry Products

The sale of a single unit in these industries may drive months or years of service activity. The low annual sales volume of these products is not tracked and therefore not available for inclusion in this study.

- Cable Locating Equipment
- Ground Penetrating Radar
- Stud Sensors and Wall Imaging Devices
- Through-wall Imaging Systems

Merged, Indistinguishable Product Types

Some product types include a subset of products that use unlicensed spectrum. But because no data is available on that subset of products, they could not be included in this study.

- Field Disturbance Sensors
- Medical Imaging Systems
- Surveillance Systems (perimeter protection system)
- Toys
- Wireless Controls (for home lighting or appliances)

B.1. BIOMEDICAL TELEMETRY

B.1.1. Overview

In general, this category covers devices used to transmit measurements of either human or animal biomedical phenomena to a receiver.

B.1.2. Applications

Common implementations are heart, blood pressure and respiration monitors. The main markets are the medical and consumer electronics industries.

Applications are primarily for the professional healthcare industry, clinical and in-home monitoring and telemetry, the consumer electronics industry, and in sports training and personal health and fitness.

For the professional healthcare industry, wireless patient monitoring devices allow patient movement without tethering the patient to a bedside monitor with a hard-wired connection. Typical monitoring functions include ECG (Electrocardiogram), NBP (Noninvasive Blood Pressure) SpO₂ (Saturation of Peripheral Oxygen), and EEG (Electroencephalogram). Of course, any monitored condition is a candidate for wireless transmission. Aging patients can wear a wireless pendant that transmits an emergency signal in case of accident (*e.g.*, fallen and can't get up) or health incident (*e.g.*, cardiac arrest).

The FCC permits Wireless Medical Telemetry Service (WMTS) at 600 MHz and 1400 MHz.⁸ WMTS use is limited to authorized health care providers. This includes licensed physicians, healthcare facilities, and certain trained and supervised technicians. The healthcare facilities eligible for the WMTS are defined as those that offer services for use beyond 24 hours, including hospitals and other medical providers. Ambulances and other moving vehicles are not included within this definition.

In consumer applications, this is generally considered the “health and fitness” category, where applications are primarily for athletes—*e.g.*, casual runners all the way up to marathoners; dieters; and anyone interested in watching their own vital statistics. Data collected can include heart rate, blood pressure, stride, location and other statistics that might be interesting. Typically consumer applications use Bluetooth, ANT/ANT+, or other WPAN (Wireless Personal Area Network) protocols. Bluetooth Low Energy (BLE) has had recent success in gaining applications.

B.1.3. Market Segments

On the professional healthcare side, this category is very vertically oriented. There are, as in other categories, systems integrators. In addition, there are hardware makers and distributors of antennas, signal dividers/splitters, power supplies, patient monitors, receivers, even databases.

Consumer devices typically use low-power WPAN protocols like Bluetooth, ANT/ANT+, and ZigBee and are sold through Internet and brick-and-mortar stores (*e.g.*, Best Buy, Target, Sears).

B.1.4. Suppliers

Here are a number of suppliers of some of the many products involved in this category.

- Professional healthcare industry
 - [Alere](#)
 - [Cardiocom](#)
 - [Healthsense](#) (using Wi-Fi in remote patient/pendant applications)
 - [Marmax Distribution](#) (supplies infrastructure components)
 - [Philips Patient Monitoring](#) (1.4 MHz WMTS, 2.4 GHz ISM, 2.4 GHz 802.11, 5 GHz)
 - [Roche Diagnostics](#)
 - [Toumaz Group](#)
 - [Viterion](#) (uses Bluetooth)
 - [Vignet Corporation](#) (press release on ANT usage in healthcare with Vignet)
- Consumer Electronics
 - [Bio-Signal Group](#) (uses Bluetooth)
 - [Biomedical Systems](#) (uses Bluetooth)
 - [BodyMedia](#)
 - [FitLinxx](#)
 - [Garmin \(Dynastream Innovations\)](#)
 - [Ideal Life](#) (uses Bluetooth)
 - [Nike](#)
 - [Polar Electro](#)
 - [Suunto](#) (makes fitness monitor watches that use ANT wireless)
- Industry groups for further research include:
 - [Bluetooth SIG](#) (healthcare page)
 - [Continua Healthcare Alliance](#) (includes a list of certified products)
 - [ZigBee Alliance](#) (healthcare page)

B.1.5. Other Resources

- [InnerWireless](#) - Healthcare Systems Deploying WMTS Patient Monitoring Over InnerWireless Infrastructure

B.2. CABLE LOCATING EQUIPMENT

B.2.1. Overview

This technology entails coupling a radio frequency signal onto cables, pipes, etc. and using a receiver to detect the location of that structure or element.

B.2.2. Applications

These products are used by trained operators to locate buried cables, lines, pipes and similar structures or elements. This equipment is used by utilities prior to digging to service pipes or avoid them. Broadcasters use them to find buried cables and copper ground plane wires. Builders use them to avoid utilities pipes and cables.

B.2.3. Market Segments

In this category, hardware sales tell only part of the story. When not owned by large companies (e.g., builders, broadcasters and utilities) this equipment is used by small businesses who are brought in on an ad-hoc basis to the site of interest. These products prevent service disruptions in Internet services, electricity, landline phone, gas, water, and sewer systems.

B.2.4. Suppliers

Here are a number of suppliers:

- [3M](#)
- [CableMaster](#)
- [DitchWitch](#)
- [Goldak](#)
- [Rycom](#)
- [Schonstedt](#)
- [Vivax-Metrotech](#)

B.3. CITIZENS BAND RADIO

B.3.1. Overview

Citizens Band (CB) radio was commonly used in cars and trucks and very popular in the 1970s. Today, this is a shrinking category, but still significant to many people.

B.3.2. Applications

CB is used by truckers socially and to communicate information about road construction, accidents and police activity. It has an advantage over mobile phone technology in that it is always local, due to the RF coverage limitations.

B.3.3. Market Segments and Impact

The primary impact of this category comes from hardware sales. Radios are the main product, but there is also a healthy market of 27 MHz antennas.

B.3.4. Suppliers

Here are a number of suppliers:

- [Cobra](#)
- [Midland](#)
- [Ranger Communications](#)
- [Uniden](#)

B.4. FIELD DISTURBANCE SENSORS

B.4.1. Overview

A field disturbance sensor establishes a radio frequency field in its vicinity and detects changes in that field resulting from the movement of persons or objects within its range, possibly with a tag that the sensor is designed to detect.

B.4.2. Applications

In retail applications, store owners use Electronic Article Surveillance (EAS) systems to control shoplifting. These systems use field disturbance sensors that detect the article leaving the store. These are common in clothing stores, drug stores, liquor stores, “big box” and department stores, and supermarkets.

Also, the home, business and automotive security industries use field disturbance sensors to detect motion, indicating unauthorized access. Besides stand-alone motion detectors, cameras and lights are available with such motion detectors that combine to turn on the camera or light when motion is detected.

B.4.3. Market Segments

The automotive segment is relatively small. However, home and business security systems use large numbers of such units with identifying terms such as “doppler radar motion detector”, “microwave motion detector”, and of course “field disturbance sensor”. Products are sold directly to consumers (*e.g.*, motion detector security lights at big-box hardware stores) and via system installers (*e.g.*, companies that install office security systems). Note that some motion detector products use infrared sensing instead of field disturbance sensing, however.

Retail EAS systems are sometimes sold through systems integrators, as are motion detectors for corporate or industrial security systems. Automotive and home security systems are sold by installers and as components for do-it-yourself projects.

B.4.4. Suppliers

Here is a sample of suppliers:

- Home and Car Security and Anti-Theft (motion detectors)
 - [Black Widow](#) (car security)
 - [Bosch](#) (home/business security)
 - [Directed Viper](#) (car security)
 - [Megatronix](#) (car security)
 - [Parallax](#) (home/business security)
 - [Southwest Microwave](#) (business security)
 - [Utilitech](#) (home security)

- Retail EAS Systems (detectors, labels, tags, detachers and deactivators) are available from:
 - [CheckPoint Security](#)
 - [Ketec](#)
 - [Samzai](#)
 - [Sensormatic](#)
 - [Tag Company](#)

B.5. GROUND PENETRATING RADAR

B.5.1. Overview

Ground Penetrating Radar (GPR) is a radar system designed to operate in close proximity to the ground for the purpose of detecting or obtaining the images of buried objects. Both metallic and non-metallic materials can be detected and outlined, at depths of 1m to 100m for substrates other than sea water (which dissipates the signal) and freshwater ice (which carries it well over 100m).

Ground Penetrating Radar is also sometimes known as Ground Probing Radar.

B.5.2. Applications

GPR is used to for a wide variety of underground and in-structure applications. The following list is adapted from US Radar's [Applications](#) page:

- UTILITIES: Pipes, conduit, cable, wire, manholes, water boxes, abandoned lines, illegal or unknown connections, fiber optic lines, missing valves
- STRUCTURAL: Reinforcing, cracking, voids, water infiltration damage in concrete, slab/wall thickness, asphalt thickness
- GEOPHYSICAL: Strata layers, ground water, root mass, disturbed soil, buried wood, bedrock, boulders or rocks, density changes, fill replacement
- ARCHEOLOGICAL: Artifact locating, structural mapping, gravesite locating
- ENVIRONMENTAL: Buried drums, landfill or rubble limits, high saturation levels
- MILITARY: Unexploded ordnance, bunkers, tunnels, weapons caches
- LAW ENFORCEMENT: Contraband, objects hidden in walls, buried caches, forensics

B.5.3. Market Segments and Impact

Of course, there are hardware sales. As the hardware is expensive and requires training, there is also a service industry of companies doing GPR work with their equipment on behalf of customers in all of the above applications.

B.5.4. Suppliers

Here are a number of suppliers:

- [3D-Radar](#)
- [GeoTek Services](#)
- [Geophysical Survey Systems](#)
- [Geoscanners AB](#)
- [Groundvue](#)
- [K-S Analysis](#)
- [IDS SpA](#)
- [MALÅ](#)
- [NIITEK](#)
- [Penetradar](#)
- [PipeHawk](#)
- [Proceq](#)
- [Radar Systems](#) (Zond, Python)
- [Sensors & Software](#)
- [US Radar Inc.](#)

B.6. LOW POWERED RADIO SERVICE

B.6.1. Overview

Low Power Radio Service products use 216 MHz for tracking, data communications and one-way voice.

B.6.2. Applications

Part 95 of the FCC's rules defines LPRS eligibility to include only tracking signals, data or one-way voice. The rules mention applications such as auditory assistance, health care-related communications for the ill, law enforcement tracking signals, and AMTS point-to-point network control.⁹

In practice, small LPRS radios combined with GPS enable tracking of high-value packages, cargo and assets in the field.

Auditory assistance devices use LPRS. Please see Section A.2, *Auditory Assistance Device* for more information on that category.

B.6.3. Market Segments and Impact

This category impacts LPRS module hardware sales, auditory assistance device sales, and a variety of smaller device categories.

B.6.4. Suppliers

Here are a number of suppliers:

- [Comtek](#)
- [Sendum](#)
- [Wildlife Tracking](#)

B.7. MEDICAL IMAGING SYSTEMS

B.7.1. Overview

X-ray radiography systems have a specific allocation by the FCC in 47 C.F.R. § 15.513. The use of the equipment in this category must be “at the direction of or under the supervision of a licensed health care practitioner.”¹⁰

MRI systems use large magnetic coils in conjunction with RF coils to create 3D images and operate at frequencies from about 5 MHz to 300 MHz under ISM rules (47 C.F.R. § 18).

B.7.2. Applications

X-ray radiography is used in health care for hard tissue diagnostic purposes, *e.g.*, a full mouth X-ray at the dentist, or a wrist X-ray at the emergency room. Common soft tissue applications include mammography and angiography.

In the electronics industry, X-ray radiography is used to inspect solder joints and to look inside semiconductor packages. X-ray inspection is also useful for failure analysis. Inspection is used in manufacturing processes in food and pharmaceutical industries as well. Across many industries, X-ray inspection is used on packaging, include cans, bottles, trays and boxes. Geological surveys use X-ray tomography to inspect samples.

In law enforcement, X-ray radiography is used for bomb and weapon detection.

B.7.3. Market Segments and Impact

In economic terms, this category is responsible for significant revenues for manufacturers, and for significant service revenues for entities like health care providers.

B.7.4. Suppliers

For X-ray radiography:

- Health Care
 - [CareStream mobile X-ray](#)
 - [GE Radiography](#)
 - [Philips](#)
 - [Toshiba Cardiovascular X-ray](#)
- Industrial
 - [GE Phoenix X-ray](#)
 - [Inspix ScanTracs](#)
 - [Mettler/Toledo X-ray Inspection Systems](#)
 - [Nikon X-ray](#)
 - [Teledyne/Dalsa Industrial X-Ray Inspection](#)
- Law Enforcement
 - [American Innovations bomb detection](#)
 - [Comet X-ray Screening](#)

For MRI:

- Health Care
 - [GE MRI Systems](#)
 - [Philips MRI Systems](#)
 - [Toshiba MRI Systems](#)

B.8. STUD SENSORS AND WALL IMAGING DEVICES

B.8.1. Overview

These are unlicensed spectrum devices designed to detect support beams and fasteners in structures for purposes of consumer or construction use.

B.8.2. Applications

Until 2002, stud sensing technologies included ultrasound, magnetic and capacitive sensing. FCC action in 2002 permitted the use of unlicensed UWB (Ultra Wide Band) RF under certain restrictions. The advantage of UWB is that a relatively inexpensive system can find ferrous and non-ferrous materials in buildings deeper than capacitive technology.

B.8.3. Market Segments and Impact

Commercially available stud sensors and wall imaging systems that can find studs and pipes at depths of 2 inches or more.

B.8.4. Suppliers

Examples of suppliers include:

- [Bosch](#)
- [Zircon](#)

B.8.5. Other Resources

An FCC Order contains background information on the use of the band 3.1–10.6 GHz for stud sensors and wall imaging.¹²

B.9. MILLIMETER WAVE BAND DEVICES – VEHICLE RADAR

B.9.1. Overview

Millimeter band is in the 30 GHz to 300 GHz range. Vehicle radar is permitted under Part 15 in the bands 46.7-46.9 GHz and 76.0-77.0 GHz and (as ultra-wide-band radar) in the band 22-29 GHz.

B.8.2. Applications

Vehicle radar applications are becoming more common in automotive applications as “adaptive cruise control”. Typically the system uses millimeter wave radar at about 77 GHz to keep a constant following distance from the vehicle ahead. At first these were available on luxury brands like Jaguar and Mercedes; but Ford, Audi and other mass-market makes have the feature available. The radar transducer (signal transmitter) is available from semiconductor companies like Infineon and Mitsubishi.

Note that radar is only one way to build adaptive cruise control. The other common choice is laser (used by Toyota, Lexus and BMW).

B.9.3. Market Segments and Impact

Adaptive cruise control is sold as a standard feature on some car models, but most often it is an expensive option sold via dealers.

B.9.4. Suppliers

- Some automobile models with adaptive cruise control:
 - [Audi](#)
 - [Cadillac](#)
 - [Hyundai](#)
 - [Infiniti](#)
 - [Porsche](#)
 - [Volvo](#)

B.10.SURVEILLANCE SYSTEMS

B.10.1. Overview

This category defines a system that operates as a “security fence” by establishing a stationary RF perimeter field.

B.10.2. Applications

This is primarily a security application. The sensor can detect the intrusion of persons or objects in the RF field. In the band defined by the FCC, the use of these products is limited to law enforcement, fire and rescue organizations, public utilities and industrial entities.

B.10.3. Market Segments and Impact

This category has significant hardware sales and integration sales.

B.10.4. Suppliers

Here are a number of suppliers:

- [Advanced Perimeter Systems](#)
- [CIAS](#)
- [Forteza](#)
- [Sectron](#)
- [Southwest Microwave](#)
- [Stekop SA](#)
- [Weiku](#)
- [Wireless Alert](#)

B.11.THROUGH-WALL IMAGING SYSTEMS

B.11.1. Overview

These systems use ultra wide band (“UWB”) to determine the position or movement of persons or objects that are located on the other side of structures such as walls.

B.11.2. Applications

The use of these systems is limited to law enforcement, fire and rescue organizations. Law enforcement includes the Department of Homeland Security, and these systems are considered candidates for anti-terrorism work. There are also military applications.

In dangerous environments, including places where explosives may be in use, “stand-off” systems are preferred. These systems can be used at a short distance from the outer edge of the volume of interest.

B.11.3. Market Segments and Impact

This category is primarily about hardware sales.

B.11.4. Suppliers

Although this is a relatively new area, there are some deployed systems and some coming to market.

- [Akela](#)
- [Cambridge Consultants](#)
- [Camero](#)
- [Physical Optics Corporation](#)

B.12.TOYS

B.12.1. Overview

This is a broad category that supports all wireless-enabled toys. Examples would be remote controlled devices and walkie-talkies. Note that the Remote Control Radio Service category covers remote-control model cars, trucks and planes.

B.12.2. Applications

This category includes low-end remote controlled cars, boats, planes, helicopters and the like; remote controlled toy pets and robots. This category includes product marked “R/C” or “Remote Control” although that does not imply the Part 95 Remote Control service.

There are toy walkie-talkies, headsets and karaoke machines. Gaming consoles use wireless controllers.

B.12.3. Market Segments and Impact

The primary impact of this category comes from hardware sales at retail.

B.12.4. Suppliers

This category is very extensive in suppliers and types of product. However, here are a number of retailers.

- [Target](#)
- [ToysRUs](#)
- [WalMart](#)

B.13.UNLICENSED NATIONAL INFORMATION INFRASTRUCTURE

B.13.1. Overview

Unlicensed National Information Infrastructure (U-NII) devices are intended to provide short-range, high-speed wireless digital communications for applications like wireless LANs and to facilitate wireless access to the NII.

B.13.2. Applications

The U-NII radio band is an unlicensed band divided into three spectrum segments in the 5 GHz range: 5.15–5.35 GHz, 5.47–5.725 GHz and 5.725–5.825 GHz.

U-NII devices provide high data rate mobile and fixed communications for individuals, businesses, and institutions. The 802.11a standard uses U-NII frequencies. ISM bands and U-NII bands have some overlap, but different technical requirements in the FCC Rules.¹⁴

U-NII devices are permitted in three sub-bands at 5.8 GHz:

- U-NII Low, 5.15–5.25 GHz
- U-NII Mid, 5.25–5.35 GHz
- U-NII Worldwide, 5.47–5.725 GHz (professional installation only)
- U-NII Upper (a.k.a. U-NII ISM), 5.725–7.825 GHz

These different bands come with different requirements for antennas and installation.

B.13.3. Market Segments and Impact

These devices are not difficult to install for IT professionals. The primary impact of this category comes from hardware sales (*e.g.*, routers, access points, antennas, amplifiers). However, because of the professional installation requirement for U NII Worldwide, there are also integration sales. Finally, some wireless ISPs use U-NII bands.

B.13.4. Suppliers

Here are a number of suppliers:

- [Alvarion Breezenet](#)
- [Arc Wireless](#)
- [CISCO Aironet](#)
- [HP Procurve](#)
- [Motorola](#)
- Wireless Internet Service Providers Association, [WISPA.org](#)

B.14.WALKIE-TALKIES

B.14.1. Overview

These are personal handheld devices that allow wireless communications between two transmitters and receivers over a short range. This category is distinct from Family Radio.

B.14.2. Applications

Walkie-Talkies in this category have a short range. Depending on conditions, range can be limited to a few hundred yards. Prior to the advent of cellphones, push-to-talk systems, and longer-range bands and power levels, like Family Radio Service, Walkie-Talkies were used to connect people on a local site or in a local recreational area (*e.g.*, a mountain trail).

With so many longer-range options, Walkie-Talkies with only short range capability are more commonly seen in the toy category.

B.14.3. Market Segments and Impact

The primary impact of this category comes from hardware sales.

B.14.4. Suppliers

These retailers have a selection of walkie-talkies:

- [Amazon](#)
- [ToysRUs](#)
- [WalMart](#)

B.15.WIRELESS CONTROLS

B.15.1. Overview

Wireless actuated switches for lights and appliances.

B.15.2. Applications

Wireless lighting is installed as part of a home or building automation system. The advantages include power savings, energy conservation, and ease of use. This category overlaps with home security in that the same kinds of systems control lights and detect door openings.

B.15.3. Market Segments and Impact

The primary impact of this category comes from hardware sales and integration products.

B.15.4. Suppliers

Here are a number of suppliers:

- [AMX](#)
- [Lutron](#) ([white paper](#) on their 434 MHz Clear Connect technology and others)
- [Inland Products NuGiant](#)

B.16.WIRELESS HEADSETS

B.16.1. Overview

These devices are wireless-enabled headsets used for voice communications. Common examples are headsets used in fast food and retail settings to enable employee communications.

B.16.2. Applications

Unlicensed wireless headset systems are used in supermarkets, shops, restaurants and drive-thrus. This category uses ISM band (900 MHz, 2.4 GHz) and DECT PCS (1.9 GHz).

B.16.3. Market Segments and Impact

The primary impact of this category comes from hardware sales. However, these systems are frequently installed by integrators.

B.16.4. Suppliers

Here are a number of suppliers:

- [3M XT Series](#)
- [Clear-Com](#)
- [Delphi Display](#)
- [HME](#)
- [Panasonic](#)
- A list of integrators: [QSR Magazine List of Drive-Thru Headsets/Timers](#)

B.17.WIRELESS MICROPHONES

B.17.1. Overview

These are the familiar handheld or lavalier audio pickup devices using radio frequency to transmit to an audio system, typically to amplify the voice.

B.17.2. Applications

They are widely used for concerts, sporting events, churches, etc. At the low end are wireless microphones bundled with \$199 karaoke systems at Wal-Mart; at the high end are the headsets worn by professional entertainers in front of huge crowds.

B.17.3. Market Segments and Impact

The primary impact of this category comes from hardware sales.

B.17.4. Suppliers

Here are a number of suppliers:

- [Audio Technica](#)
- [Azden](#)
- [Polycom](#)
- [Pyle Audio](#)
- [Shure](#)
- [Sony](#)
- [Telex](#)

B.18.WIRELESS THERMOMETERS

B.18.1. Overview

Wireless thermometers periodically transmit temperature data. Note that these devices frequently use 802.15.4 technology, and those units are included in Section A.24, *Wireless PAN / 802.15.4*.

B.18.2. Applications

Wireless thermometers are used to monitor temperature of food, typically on a grill; to monitor water temperature in a pool; or to monitor weather temperature. Some consumer products bundle additional sensors as “weather stations”. Factories use wireless thermometers when cabling is impractical.

B.18.3. Market Segments and Impact

The primary impact of this category comes from hardware sales.

B.18.4. Suppliers

Here are a number of suppliers:

- [Cooper-Atkins](#)
- [Emerson Rosemount](#)
- [Mantracourt](#)
- [Oregon Scientific](#)
- [Springfield](#)
- [Taylor](#)

- ¹ This Annex makes references to parts of the Federal Communications Commission's ("FCC") rules throughout. For example, 47 C.F.R. § 15 is referred to as "Part 15."
- ² See 47 C.F.R. § 15.231.
- ³ Ben Gruber, *First Wi-Fi Pacemaker in US Gives Patient Freedom*, REUTERS (Aug. 10, 2009), <http://www.reuters.com/article/2009/08/10/us-pacemaker-idUSTRE5790AK20090810>.
- ⁴ At 60 GHz, there is a peak in transmission loss due to oxygen in the atmosphere. This means that any signal leakage is naturally dissipated relatively close to the transmission beam. This is handy for using these devices without worrying about unintentional signal transmission problems like crosstalk or interception.
- ⁵ FCC Encyclopedia, *Multi-Use Radio Service*, <http://www.fcc.gov/encyclopedia/multi-use-radio-service-murs-0> (last visited May 16, 2014).
- ⁶ *About Paging*, FCC (Sept. 20, 2002), <http://wireless.fcc.gov/services/index.htm?job=about&id=paging>.
- ⁷ *400 More Stores to be RFID Enabled this Year; CIO Discusses Current and Future Benefits at RFID Conference*, WAL-MART (May 1, 2007), <http://news.walmart.com/news-archive/2007/05/01/wal-mart-continues-rfid-technology-expansion>.
- ⁸ See *Wireless Medical Telemetry Service (WMTS)*, FCC, <http://www.fcc.gov/encyclopedia/wireless-medical-telemetry-service-wmts> (last visited Mar. 18, 2014).
- ⁹ See 47 C.F.R. § 95.1009. AMTS stands for Automated Maritime Telecommunications System. See *Avista Corporation*, DA 12-45, Order, FCC File Nos. 0004076538, 0004076539, 0004076544, ¶ 2 (2012) ("AMTS service was established to meet the communications needs of vessels on inland waterways, but the Commission's rules now permit AMTS stations to provide service to units on land, including private land mobile (PLMR) service."). AMTS per se is not part of this category, but nodes may be controlled via radios in the LPRS band, which is adjacent to AMTS.
- ¹⁰ 47 C.F.R. § 15.103(e).
- ¹¹ *New Public Safety Applications and Broadband Internet Access Among Uses Envisioned by FCC Authorization of Ultra-wideband Technology*, Press Release, FCC 02-48 (Feb. 14, 2002), http://transition.fcc.gov/Bureaus/Engineering_Technology/News_Releases/2002/nret0203.html.
- ¹² *Robert Bosch, GmbH; Request for Waiver of Part 15 Ultra-wideband Rules for a Wall Imaging Device*, DA 11-899, Order, ET Docket No. 10-253 (2011).
- ¹³ 47 C.F.R. § 15.510(b).
- ¹⁴ Although both Part 15 ISM rules and Part 15 U-NII rules for WLANs allow operation in the 5.8 GHz band, there is a technical difference in the requirements. ISM devices are required to use spread spectrum, but U-NII devices are allowed to use more advanced signaling like OFDM. Because of this, the devices (ISM vs. U-NII) have difference performance characteristics and slightly different applications in the field—and therefore different markets.
- ¹⁵ See *Smart Wireless Field Network Solutions*, EMERSON PROCESS MANAGEMENT, at 3, http://www2.emersonprocess.com/siteadmincenter/PM%20Central%20Web%20Documents/SmartWirelessSolutionsforField_brochure.pdf.

ANNEX C: ACRONYMS AND DEFINITIONS

AMTS.....	Automated Maritime Telecommunications System
ANT	A low-power short-distance wireless technology (also ANT+)
BLE.....	Bluetooth Low Energy
CEA.....	Consumer Electronics Association
DECT	Digital Electronic Cordless Telephone, the digital cordless access technology standardized by ETSI and used worldwide
DECT-PCS.....	Use of DECT on Unlicensed PCS bands
EAS.....	Electronic Article Surveillance
FCC.....	Federal Communications Commission of the US
FRS.....	Family Radio Service, an unlicensed Part 95 Personal Radio Service for consumer walkie-talkie use
GDO	Garage Door Opener
GPR.....	Ground Penetrating Radar
ISM	Industrial, Scientific and Medical; a reference to the 900 MHz and 2.4 GHz unlicensed spread-spectrum bands
ITS.....	Intelligent Transportation Systems
Microbroadcaster	A consumer or business that operates a low-power transmitter for a very small area, e.g. a single home or a parking lot
MICS.....	Medical Implant Communication Service
MRI.....	Magnetic Resonance Imaging, technology combining powerful magnetic fields and lower-power RF fields for 3D medical imaging
MURS	Multi-Use Radio Service, an unlicensed Part 95 Personal Radio Service for private, two-way, short-distance voice or data communications service for personal or business activities of the general public
NFC.....	Near Field Communications, a very short range data communications technology
NII.....	National Information Infrastructure, not a specific piece of infrastructure or single piece of legislation, but more the concept of the US internet infrastructure and legislation pertaining to it
PAN.....	Personal Area Network, a low-power RF network that covers only the region immediately around the user
Part 15.....	Code of Federal Regulations, Title 47, Part 15, concerning unlicensed radio transmissions
PCS	Personal Communications Services, category name of digital wireless services that provide advanced cellular and paging
PRS.....	Personal Radio Service, a group of services under Part 95 that includes MURS, WMTS, FRS and others
RFID	RF (Radio Frequency) Identification, technology to uniquely identify something by a data code read wirelessly
U-NII	(Also UNII) Unlicensed National Information Infrastructure, spectrum set aside by the FCC for wireless access to the NII
UWB	Ultra Wide Band, a signaling system that uses very low power combined with a wide swath of spectrum, typically more than 500 MHz
WMTS	Wireless Medical Telemetry Service, an unlicensed Part 95 Personal Radio Service for the healthcare industry
WPAN.....	Wireless PAN

ANNEX D: UNLICENSED FREQUENCIES

Category	Description	Spectrum Band(s)
Part 15 Radio Services	These are considered “intentional radiators” and do not require any end-user license.	
AM Broadcast	Low power broadcast of AM signals.	535-1705 kHz
Auditory Assistance Device	Used to provide auditory assistance at places of public gatherings such as a church, theater or sporting events.	49 MHz 216-220 MHz 902-928 MHz 2400-2483.5 MHz
Automatic Vehicle Identification Systems (AVIS)	Used to automatically identify vehicles, especially those used in transportation. Also used to track and position trains, and for vehicle fleet management.	902-928 MHz 2400-2483.5 MHz 2.9-3.26 GHz 3.267-3.332 GHz 3.339-3.3458 GHz 3.358-3.6 GHz
Baby Monitors	Transmitter and receiver that allows monitoring of children by parents using wireless technology.	49 MHz 902-928 MHz 1910-1920 MHz 2400-2483.5 MHz
Biomedical Telemetry	Used to transmit measurements of either human or animal biomedical phenomena to a receiver. Common implementations are heart, blood pressure and respiration monitors.	174-216 MHz 470-698 MHz 608-614 MHz 902-928 MHz 1395-1400 MHz 1429-1432 MHz 2400-2483.5 MHz
Bluetooth	Short-range wireless technology that allows devices to interact at a range of up to 30 feet. Used primarily to connect mobile devices to cars, headsets and computers.	2400-2483.5 MHz
Cable Locating Equipment	Used by trained operators to locate buried cables, lines, pipes and similar structures or elements. Entails coupling a radio frequency signal onto cables, pipes, etc. and using a receiver to detect the location of that structure or element.	9-490 kHz
Cordless Phones	Phones that do not require a wired connection between the handset and the base station.	49 MHz 902-928 MHz 1910-1920 MHz 2400-2483.5 MHz
Field Disturbance Sensors	A device that establishes a radio frequency field in its vicinity and detects changes in that field resulting from the movement of persons or objects within its range. Common implementation are the sensor tags used in department stores to prevent theft.	902-928 MHz 2435-2465 MHz 5785-5815 MHz 10500-10550 MHz 24075-24175 MHz

Fixed Microwave	Fixed point-to-point communications, including voice, data and video, over short-ranges.	902-928 MHz 2400-2483.5 MHz 5725-5875 MHz 24.0-24.25 GHz
FM Broadcast	Low power broadcast of FM signals.	88-108 MHz
Garage Door Openers	Unlicensed device that allows remote opening of garage doors.	288 MHz-433 MHz 860 MHz-980 MHz See also (1) for all references to Intermittent Control Signals
Ground Penetrating Radar	A radar system designed to operate in close proximity to the ground for the purpose of detecting or obtaining the images of buried objects.	Varied spectrum bands depending upon depth of penetration required. Typically 25 MHz to 2 GHz.
Home Security Systems	Wireless link from various entry points, appliances, lights and HVAC systems in the consumer's residence to a central hub in the home.	433 MHz 902-928 MHz 2400-2483.5 MHz
Intelligent Transportation Systems (ITS)	A variety of solutions intended to reduce traffic congestion and increase safety on the roadways.	2400-2483.5 MHz 5725-5875 MHz 5.85-5.925 GHz
ISM Part 18 Devices	The industrial, scientific and medical (ISM) radio bands are reserved internationally for the use of radio frequency (RF) energy for industrial, scientific and medical purposes other than communications. Examples of applications in these bands include radio-frequency process heating, microwave ovens, and medical diathermy machines.	Specific allocation is made for 6.765-6.795 MHz 13.553-13.567 MHz 26.957-27.283 MHz 40.660-40.700 MHz 902-928 MHz 2400-2483.5 MHz 5725-5875 MHz 24.0-24.25 GHz 61.0-61.5 GHz 122.0-123.0 GHz 244.0-246.0 GHz; however, any frequency above 9 kHz is acceptable except for a few bands prohibited in 47 C.F.R. 18.303
Medical Imaging Systems	X-ray: Under 47 CFR 15.513, limited to use by medical practitioners, use of ultrawideband technology to produce body imaging. These Rules also define a frequency of 3100-10600 MHz, therefore X-ray. MRI: Operates under ISM rules, 47 CFR 18, with RF coils under 300 MHz.	5 MHz to 300 MHz 3100-10600 MHz

Millimeter Wave Band Devices	Used for short-range computer-to-computer connections and wireless connections in the home (such as replacing wires from television to stereo receiver or speakers). Also used for wireless bridges or links (point-to-point) at ranges of about 1-2 miles, and for vehicle radar.	24.25-24.45 GHz 25.05-25.25 GHz 46.7-46.9 GHz 57-64 GHz 76-81 GHz 86-92 GHz
Mobile Meter Readers	Meters that are wireless enabled to allow utility personnel to remotely obtain data from consumer meters.	902-928 MHz
Near Field Communications (NFC)	Near field communication (NFC) is a set of standards for smartphones and similar devices to establish radio communication with each other by touching them together or bringing them into close proximity, usually no more than a few centimeters. Present and anticipated applications include contactless transactions, data exchange, and simplified setup of more complex communications such as Wi-Fi. Communication is also possible between an NFC device and an unpowered NFC chip, called a "tag".	13.56 MHz
Paging Devices	One-way devices capable of receiving short messages from a nearby transmitter. Examples include consumer devices (pagers provided by restaurants to alert customers of table availability) and enterprise (in-building paging systems developed exclusively for a company).	33-49 MHz 902-928 MHz 2400-2483.5 MHz
Radiofrequency ID (RFID)	RFID is used for a variety of monitoring and tracking applications in logistics. Typical applications include access control, asset management and supply chain management. Systems consist of a small transponder with encoded information, an antenna, and a transceiver equipped with a decoder. The antenna emits a radio signal to read or write data from or to the tags attached to the items to be tracked.	13.56 MHz 433 MHz 902-928 MHz
Remote Keyless Entry	Allows keyless entry into cars and other vehicles.	260-470 MHz 850-950 MHz; most common are 315, 418, 433-434 and 868 MHz
Stud Sensors	Unlicensed devices designed to detect support beams in structures for purposes of consumer or construction use.	3.1-10.6 GHz
Surveillance Systems	A system that operates as a "security fence" by establishing a stationary RF perimeter field and detecting the intrusion of persons or objects in that field. Limited to law enforcement, fire and rescue organizations, public utilities and industrial entities.	1990-10600 MHz

Through-wall Imaging Systems	Systems designed to detect the location or movement of persons or objects that are located on the other side of structure such as a wall. Limited to law enforcement, fire and rescue organizations.	1990-10600 MHz
Toys	Broad category that supports all toys that are wireless-enabled. Examples are remote controlled devices and walkie talkies.	49 MHz 902-928 MHz 2400-2483.5 MHz
Unlicensed National Information Infrastructure (U-NII)	U-NII devices are intended to provide short-range, high-speed wireless digital communications such as wireless LANs (Local Area Networks) and to facilitate wireless access to the NII.	5.15-5.25 GHz 5.25-5.35 GHz 5.47-5.725 GHz 5.725-5.825 GHz
Unlicensed PCS/DECT	UPCS is a band allocated by the FCC for unlicensed short-range phones; DECT is widely used on this band for cordless phones and some headsets. Includes Wireless PABX (Private Access Branch Exchange).	1920-1930 MHz
Vehicular Radar Systems	Devices able to detect the location and movement of objects near a vehicle, enabling features such as near collision avoidance, improved airbag activation, and suspension systems that better respond to road conditions.	16.2 - 17.7 GHz 23.12-29.0 GHz 46.7-46.9 GHz 76.0-77.0 GHz
Walkie Talkies	Personal handheld devices that allow wireless communications between two transmitters and receivers.	27 MHz 49 MHz 902-928 MHz 2400-2483.5 MHz
Wi-Fi/Wireless LANs	Wireless Fidelity (Wi-Fi) allows for wireless network access for computers, devices and peripherals through short-range communications.	2400-2483.5 MHz 5725-5850 MHz
Wireless Controls	Wireless actuated switches for lights and appliances	433 MHz
Wireless Headsets	Wireless enabled headsets used for voice communications. Common examples are headsets used in fast food and retail settings to enable employee communications.	49 MHz 902-928 MHz 2400-2483.5 MHz
Wireless Microphones	Handheld wireless devices used to amplify the voice. Widely used for concerts, sporting events, churches, etc.	TV Bands 49 MHz 902-928 MHz 2400-2483.5 MHz
Wireless Thermometers	Used by consumers to monitor temperature of food, typically on a grill or to monitor weather temperature.	49 MHz 433-434 MHz 902-928 MHz 2400-2483.5 MHz

ZigBee	ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks. Applications include wireless light switches, electrical meters with in-home-displays, and other consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking.	2400-2483.5 MHz
Part 95 Radio Services	These are “licensed by rule” but do not require any station license to be sought by the end-user.	
CB Radio	The ubiquitous Citizens Band radios commonly used in cars and trucks	27 MHz
Family Radio	Handheld walkie-talkies	462 and 467 MHz
Med Radio Devices	Very low powered systems used for communications with medical devices such as pacemakers, neurostimulators and insulin pumps	401 - 406 MHz
Low Powered Radio Service	Tracking systems and certain radio control, data communications, and one-way voice	216 MHz
Multi-Use Radio Service	Low powered two-way walkie-talkies often used in buildings and on construction sites	151 and 154 MHz
Remote Control Radio Service	Remote control of model aircraft and model surface vehicles	27 MHz 72 MHz 75 MHz

Supplemental Documents:

(1) Understanding the FCC Regulations for Low-Power, Non-Licensed Transmitters, OFFICE OF ENGINEERING AND TECHNOLOGY, FCC (Oct. 1993), http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet63/oet63rev.pdf