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July 11, 2012

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Mr. Matthew Voit
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By Email and First Class Mail

Re: Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, § 6412 (2012)

Dear Mr. Voit:

The Fixed Wireless Communications Coalition appreciates having had the opportunity to confer with you and your colleagues on May 24 about the above-referenced statutory provision.[1]

Your agenda identified two key questions:

1. What steps has the FCC taken to ensure availability of licenses for these [common carrier fixed microwave services in the 11, 18 and 23 GHz bands] in

[1] The FWCC is a coalition of companies, associations, and individuals interested in the fixed service—i.e., in terrestrial fixed microwave communications. Our membership includes manufacturers of microwave equipment, fixed microwave engineering firms, licensees of terrestrial fixed microwave systems and their associations, and communications service providers and their associations. The membership also includes railroads, public utilities, petroleum and pipeline entities, public safety agencies, cable TV providers, backhaul providers, and/or their respective associations, communications carriers, and telecommunications attorneys and engineers. Our members build, install, and use both licensed and unlicensed point-to-point, point-to-multipoint, and other fixed wireless systems, in frequency bands from 900 MHz to 95 GHz. For more information, see www.fwcc.us.

high demand areas and to what extent do these steps provide an incentive for the efficient use of this spectrum?

2. To what extent does the FCC's approach to issuing licenses for these services in this spectrum maximize the federal government's revenue?[2]

This letter summarizes the points we made on May 24, including a brief recap of how frequency coordination works in practice. We also respond here to questions that you and your colleagues raised during the meeting.

A. INTRODUCTION

As we explain below, the "rejection rate" at the center of Congress's inquiry—the fraction of common carrier point-to-point applications not granted in the 11, 18, and 23 GHz bands due to frequency congestion—is close to zero. The frequency coordination process required under the FCC's rules has been extremely successful at fitting in a growing number of users, without creating interference.

We argue below that to uproot this highly evolved, highly successful mechanism in favor of auctioning the 11, 18, and 23 GHz bands would be a mistake.

The most successful spectrum auctions have dealt in frequencies used to provide retail customer access to wireless services: first PCS voice service, followed by 3G and then 4G data services. Other auctions that worked well, although perhaps less dramatically, include paging, satellite radio, 220 MHz, and others. Most of these have in common the prospect of a revenue stream from a paying subscriber base. Would-be bidders can make a projection of likely income from a known population, and from there can assign a present value to a given block of spectrum. Auctions work best, in short, when the auctioned spectrum is used to reach consumers directly.

The 11, 18, and 23 GHz bands are very different. These frequencies are much too high for cell-type services, all of which operate below 3 GHz.[3] But they are ideal for microwave systems that use highly directional antennas aimed at each other from both ends of a single path: point-to-point communications. A typical large system includes many such links organized into a complex network. When used to support geographically extended infrastructure, such as railroads, electrical grids, and oil pipelines, the microwave networks are generally designed to parallel the underlying facilities. Networks that support commercial operations, such as banking and other business uses, tend to connect population centers to each other and sometimes to outlying branches of a business. When used for "backhaul" between a cell carrier's central facilities and its towers, the microwave networks reflect not only the geographical distribution of cell-phone and tablet-computer users, but also the sometimes idiosyncratic layout of the carrier's wire- and fiber-based facilities. Public safety backhaul

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[2] *See also* Pub. L. No. 112-96, § 6412(b).

[3] Radio waves propagate very differently according to their frequency. Signals above about 3 GHz are poor at penetrating into or around buildings, and through terrain and other obstacles. Their use for cell-based services would result in extensive and unacceptable "dead zones."

networks, used to relay emergency calls to local police and fire stations, conform to the requirements of a particular jurisdiction. These are all highly customized, need-based configurations that fail to align with the areas used for auctioned licenses, and as such are unsuitable for competitive bidding.

As we discuss in Part C below, auctioning microwave spectrum would generate little revenue for the Treasury, but would undercut the rapidly-growing backhaul component of the nation's telecommunications facilities, and additionally would threaten many kinds of infrastructure support and commercial activity. Any hindrance in access to spectrum for backhaul would likely diminish the value of the bands that are more suitable for auction, as for 3G and 4G services. Overall, auctions would disrupt the FCC's finely tuned system of frequency sharing that today accommodates very dense usage of the microwave bands.

For the reasons given below, GAO should recommend that Congress leave the present microwave licensing regime undisturbed.

B. QUESTION 1: AVAILABILITY OF LICENSES FOR FIXED MICROWAVE SERVICES IN THE 11, 18, AND 23 GHZ BANDS IN HIGH DEMAND AREAS

1. Importance of Fixed Microwave

Fixed Service point-to-point links directly support a wide array of entities and industries. They are essential to the day-to-day operation of the nation's critical infrastructure: balancing the electric grid, coordinating the movement of railroad trains, handling communications for highways and tollways, shipping ports, and airports, controlling the safe flow of oil and natural gas through pipelines, and transmitting emergency calls to local police and fire personnel. Microwave links are a key component of larger communications systems, including traditional telephone operations among incumbent and competitive local exchange carriers and long distance carriers (ILECs, CLECs, and IXCs), cable TV systems, Internet backbone and local connections, including wireless Internet service providers (WISPs), and as discussed below, backhaul for mobile voice and data. Many state and local governments find fixed service links indispensable, as do schools, universities, and hospitals. Perhaps the largest category of Fixed Service traffic comprises a wide variety of business data. Financial companies, chain stores of all kinds, franchised restaurants, hotels, oil companies, airlines, car rental companies—any business having dispersed locations typically must move a lot of data, much of which moves at least in part over fixed microwave. The network of point-to-point facilities across the United States serves to enable the development and operation of other industries, and the economy overall, in much the same way that highways, airports, and the Internet do.[4]

Anyone who doubts the ubiquity of fixed microwave need only note the vast numbers of sideways-facing dishes and domes on radio towers, water towers, and buildings.

Most recently, fixed point-to-point links have become an essential and rapidly expanding component of the nation's mobile data infrastructure. The near-exponential growth of data

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[4] The federal government is also a heavy user of fixed microwave, although under a different regulatory regime and mostly in different spectrum.

consumed by smartphones, tablets, and 3G- and 4G-equipped laptops is well known.[5] The cell towers needed to reach those devices proliferate across the landscape. But all of that same data must also transit between the cell tower and the provider's network facilities, a step known generically as "backhaul." The ballooning use of mobile data is putting corresponding pressure on the backhaul side of the connection. The FCC has acknowledged the importance of point-to-point microwave links for this purpose as a "cost-effective alternative to traditional copper circuits and fiber optic links," noting that "[i]n certain rural and remote locations, microwave is the only practical high-capacity backhaul solution available."[6] We expect the amount of microwave-carried backhaul traffic to increase along much the same fast-growing curve as mobile data generally.

The regulatory regime for fixed microwave, including the requirement for frequency coordination, is one of the FCC's major success stories. The rules facilitate the dense and efficient packing of microwave links. This elasticity comes largely from the frequency coordination process, described below, which allows applicants to adjust their frequencies, antennas, polarization, and other variables to fit new links even into crowded markets. We showed you data illustrating the extraordinary high rate of spectrum re-use in the crowded market of Los Angeles (see attached copy of Comsearch's presentation).

2. Common carrier vs. private operational fixed microwave

The statutory inquiry refers specifically to common carrier fixed microwave. But there is little distinction today between common carrier and other microwave services. In an earlier era, common carrier and "private operational fixed service" (POFS) were regulated under different FCC rules (Parts 21 and 94, respectively) and operated in different portions of the spectrum. POFS licensees carried their own internal business traffic or that of small groups of customers, often related to the licensee, while common carriers handled most other third-party traffic. In 1996, however, the FCC acknowledged a trend already well underway by combining Parts 21 and 94 into a new Part 101.[7] At the same time, it merged common carrier and POFS spectrum,[8] and allowed POFS licensees to carry the traffic of unrelated entities for profit.[9] A licensee designated as POFS, although nominally prohibited from offering common carrier

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5 *See* FEDERAL COMMUNICATIONS COMMISSION, NATIONAL BROADBAND PLAN: CONNECTING AMERICA, § 5.1 (2010), *available at* www.broadband.gov.

6 *Amendment of Part 101 of the Commission's Rules to Facilitate the Use of Microwave for Wireless Backhaul and Other Uses and to Provide Additional Flexibility to Broadcast Auxiliary Service and Operational Fixed Microwave Licensees*, Report and Order and Notice of Proposed Rulemaking, 26 FCC Rcd 11614, ¶ 1 (2011).

7 *Reorganization and Revision of Parts 1, 2, 21, and 94 of the Rules to Establish a New Part 101 Governing Terrestrial Microwave Fixed Radio Services*, Report and Order, 11 FCC Rcd 13449, 13452 (1996). In adopting the new regime, the Commission anticipated it would "encourage more efficient use of the microwave spectrum by permitting more intensive use of microwave equipment." *Id.* at 13452-53. That prediction proved to be accurate.

8 47 C.F.R. § 101.101.

9 47 C.F.R. §§ 101.135, 101.603.

service,[10] may nonetheless lease excess capacity to common carriers or offer services to third parties on a private carriage basis that closely resembles common carriage. Conversely, common carriers can and do sell capacity on a private carriage basis.

The FCC's licensing database shows that approximately one-quarter of fixed point-to-point microwave licenses have been designated by the applicants as being for common carrier service.

3. Frequency coordination and "rejection rate"

Pub. L. No. 112-96, Section 6412 calls upon the Comptroller General to report to Congress on whether market forces provide adequate incentive for the efficient use of the 11, 18, and 23 GHz bands, and to ensure that the Federal Government receives maximum revenue for the spectrum.[11] A key factor in this assessment is to be the "rejection rate" of common carrier Fixed Service applications in these bands.[12]

The statute defines "rejection rate" as

> the number and percent of applications (whether made to the Commission or to a third-party coordinator) for common carrier use of spectrum that were not granted because of lack of availability of such spectrum or interference concerns of existing licensees.[13]

Although the statute refers to applications made either to the FCC or to a third-party coordinator, in fact applications are made only to the FCC. The rules, moreover, require successful frequency coordination prior to the filing of an application.[14] Thus, any application that reaches the FCC is all but certain to escape rejection, under Congress's definition. Construing the statute strictly, then, the rejection rate is essentially zero.

For the reasons explained below, only a very small number of initial frequency requests, if any, go unsatisfied. As band congestion increases, however, the techniques needed to fit new links into the existing point-to-point microwave landscape may incur additional costs.

An important element of the Part 101 rules promoting this efficient use of spectrum is the principle of access to the band on a first come, first served, interference-free basis. In effect, each new fixed service link is required to be compatible with all of those that preceded it. Two properties in particular of point-to-point microwave allow for a high degree of frequency reuse in a given area: the antennas are fixed, and are highly directional. Links can successfully operate

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10 47 C.F.R. § 101.603(b)(1).

11 Pub. L. No. 112-96, § 6412(b)(1) (2012).

12 *Id.*, § 6412(b)(2)(B).

13 *Id.*, § 6412(d).

14 47 C.F.R. § 101.21(f).

on the same frequency even in close proximity, so long as they do not both impinge on the same receive antenna from the same direction (or from different directions at overly high power).

Part 101 frequency coordinators have no special authorization from the FCC. Would-be license applicants can perform frequency coordination themselves, or they can hire a frequency coordinator to act on their behalf. Most users find it efficient and economical to engage the services of specialized firms having the needed databases, software, and expertise for frequency coordination. Most initial requests for a link go to one of these companies, and they take a variety of forms: sometimes full technical details of a proposed link, including locations, equipment, and frequency band; sometimes just a request for communications between two localities; and all levels of detail in between. In the former cases, the frequency coordinator's main job is to handle the "prior coordination notice" procedure spelled out in the FCC's rules and explained below; in the latter cases, the coordinator may provide engineering and possibly procurement services as well.

Once the link is designed, the frequency coordinator sends a "prior coordination notice" (PCN) to operators and prior applicants that might be affected.[15] The recipients then have thirty days to identify potential interference. (In urgent cases, the response period can be made much shorter.) The parties are expected to make every reasonable effort among themselves to eliminate interference issues. If needed, for example, a frequency coordinator may advise a customer to upgrade its proposed antenna to one having a more directional pattern, or perhaps to offer to upgrade the antenna of another licensee predicted to receive interference. The customer may decide to reduce its transmitter power, change frequency band, change polarization, and/or accept a specified degree of incoming interference. In more extreme situations, an intermediate repeater may be needed to change the geometry of a proposed link, so as to accommodate propagation constraints, path length limitations, or the need to avoid obstacles. The overall process is dynamic and iterative; the degree of cooperation among users, some of whom are mutual competitors, is consistently high. Almost all of these discussions end with a design for a workable, non-interfering link. In almost every instance, the coordinator is able to satisfy the customer's needs, although not always as the customer initially envisioned. The "rejection rate," even if applied to coordination requests instead of applications actually filed with the FCC, is very small by any reasonable definition.

In some instances, a customer facing the prospect of an upgrade, a repeater, or a change of band may decide not to proceed. This should not count as a "rejection," because spectrum in fact was available for the customer's communications, although sometimes at added cost or subject to additional delay.

One experienced frequency coordinator relates, as an example, the case of a customer that initially seeks one of the six 23 GHz pairs eligible for conditional licensing—*i.e.*, for

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15 47 C.F.R. § 101.103(d).

immediate operation.[16] The coordinator reports back that none of the six pairs is available, and offers a different 23 GHz pair instead. The customer responds that it cannot wait for Federal approval and license processing before it begins operation.[17] In the end, the coordinator finds an 18 GHz pair that meets the customer's need for immediate operation, albeit at potentially higher cost.

Under any reasonable construction, this scenario must count as a success. The customer was not rejected from 23 GHz, but voluntarily, for its own business reasons, chose to operate on 18 GHz instead. And even if 23 GHz had been completely unavailable, the fact of a successful coordination and ultimate licensing at 18 GHz still puts the case squarely in the success column.

A frequency coordinator might typically draw on one or more of the following options in order to mitigate interference to or from a proposed new link:

- frequency offset: intelligent selection from among the channels available in each of the 11, 18 and 23 GHz bands;
- cross polarization: *i.e.*, choosing different polarizations (horizontal or vertical) for desired and interfering signals; this can reduce the effect of unwanted signals by a factor of 1,000;
- Automatic Transmitter Power Control (ATPC): limits interference into the environment most of the time, but provides added power for short durations when needed to overcome transient adverse atmospheric conditions;
- adaptive modulation: allows reliable operation over longer links or at lower power, with or without ATPC, by temporarily throttling back the data rate when atmospheric conditions worsen;
- interference path blockage: taking advantage of terrain and man-made obstructions that can reduce an interfering signal;
- antenna directionality/suppression: use of antennas with improved off-axis suppression to reduce the effects of interference from directions away from the intended pointing direction;

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[16] 47 C.F.R. § 101.31(b)(1)(vii). Conditional licensing allows an applicant to begin operation as soon as the application is filed, without waiting for a grant. As soon as frequency coordination is complete, the applicant or its coordinator can enter licensee information and link particulars into the FCC's Universal Licensing System, and can then commence operation. Because the 23 GHz band is shared with Federal users, however, conditional licensing is available only on specified channels. Operation on other 23 GHz channels must await coordination with Federal authorities.

[17] Very rapid deployment is often very important to an applicant in order to respond to its own or its customers' requirements, or for competitive reasons.

- redesign: move sites, add repeaters, change antenna heights or size, change frequency band; and

- negotiation of interference rights: upgrading others' antennas; asking others to accept a greater level of predicted interference.

Given the skill of the frequency coordinators and the large array of tools at their disposal, the true rejection rate of FCC applications, or even coordination requests, is extremely small. The ability to successfully coordinate frequencies free of interference is the foundation of a frequency coordinator's success. These companies are in the business of finding practical solutions, and do so in the vast majority of cases. They have no business reason to track statistics related to "rejection rate," and in fact they do not do so.

Some of the frequency coordination techniques listed above incrementally increase the cost of link deployment. An astute designer will begin with the least-cost alternative that satisfies link performance requirements. But as point-to-point microwave bands become more congested, more costly alternatives typically become necessary. These lead to pressure for allocation of additional spectrum. The greatest need is for spectrum capable of handling long links—*i.e.*, below approximately 10 GHz. The only band available to the Fixed Service in this region, at 6 GHz, is becoming congested in populated areas.[18]

The FCC and NTIA manage the process of allocating spectrum to address emerging needs, most often through the sharing of spectrum that also serves other uses. For example, the Fixed Service has shared spectrum with satellite licensees since the 1960s. More recently, in WT Docket No. 10-153, the FCC arranged for sharing both ways between the Fixed Service and the Broadcast Auxiliary Service. Fixed microwave users also share spectrum with unlicensed transmitters in the 6 GHz band having relatively high peak power levels.

The statutory inquiry looks only to the rejection rate for "for common carrier use of spectrum." But the frequency coordinator typically does not know whether a proposed path will be designated for common carrier or other use. As a result, the frequency coordination process is completely agnostic as between common carrier and Private Operational Fixed Services. And there is no way to know whether the one-quarter ratio of granted applications identified as common carriage carries over proportionately to the exceedingly rare cases where frequency coordination fails.

4. Spectrum Efficiency

In addition to providing for very high density, flexibility, and frequency re-use through frequency coordination, the FCC's point-to-point rules promote efficient use of the spectrum through a number of other means as well. These include minimum payload throughput

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[18] The 4 GHz band is also allocated to the Fixed Service, but is shared with C-band satellite downlinks. The very large number of C-band receive-only earth stations makes it impossible to coordinate new Fixed Service 4 GHz links over much of the country.

requirements,[19] antenna directionality standards,[20] power limits,[21] and required operation within 18 months of a license grant.[22]

C. QUESTION 2: AUCTIONING THE 11, 18, AND 23 GHZ BANDS WOULD FAIL TO MAXIMIZE THE FEDERAL GOVERNMENT'S REVENUE WHILE UNDERMINING ECONOMIC GROWTH IN KEY INDUSTRY AND PUBLIC SERVICE SECTORS.

The FWCC strongly believes that auctioning the 11, 18, and 23 GHz bands would be a grave policy error.

Unlike fixed wireless auctions, mobile wireless auctions have succeeded in part because the nature of the service lends itself to area-wide exclusive licensing. Mobile operators provide ubiquitous service across their licensed area through short-range connections between the mobile device and a nearby tower, and can rely on roaming agreements when their customers travel elsewhere. In contrast, area-wide exclusive licensing for fixed point-to-point service has shown less successful results.

To date, the Commission has auctioned four Fixed Service bands: at 24, 28, 31, and 39 GHz. Many years later, all of these remain severely underutilized, with many licensees unable to construct enough links even to meet their minimum renewal requirements. The reasons for this shortfall are a matter of debate. The FWCC and others have argued that the FCC's service rules are partly responsible: in particular, that the FCC's practice of conditioning renewals on quantitative "safe harbor" standards for facility build-out can work against long-term business models, and may in fact have the perverse effect of hindering the build-out the FCC seeks to encourage.[23]

In principle, area licensing at frequencies such as 24, 28, 31, and 39 GHz, that are inherently limited to shorter links, should be suitable for a number of applications. An area-wide license offers relatively easy deployment; no frequency coordination fees or additional applications to the FCC; coverage of an entire market under one license; and suitability for small-cell installations. The smaller antennas allowed in these bands let users deploy on light structures that may not support the larger antennas required in the 11,18, and 23 GHz bands. Smaller antennas typically incur lower fees for tower rental, and allow more facilities to share a site. And licensees have built out some bands in some areas to levels that exceed the FCC renewal requirements.

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19 47 C.F.R. § 101.141(a).

20 47 C.F.R. § 101.115.

21 47 C.F.R. § 101.113.

22 47 C.F.R. § 101.63.

23 Petition for Rulemaking of the Fixed Wireless Communications Coalition, FCC Docket No. RM-11664 at 6-7 (filed May 9, 2012) (quoting comments of FiberTower, Inc.), available at http://apps.fcc.gov/ecfs/document/view?id=7021917572.

Actual practice, though, shows that an area license for fixed microwave, whether granted by auction or otherwise, does not ensure actual use of the spectrum. The FCC's efforts to provide additional flexibility through secondary markets and leasing are welcome, but have not yielded widespread activity in the auctioned bands. The additional barrier of dealing with a third party (the area licensee) has had the effect of locking out other potential users. That may change in the future; some wide-area licensees claim to be offering spectrum at prices that are effectively less than the price for coordinating and licensing a common carrier link. Unless the take-up by third parties shows great improvement, however, a licensee lacking the internal demand for enough links to meet the required build-out density is in danger of having its license cancelled. Worse, the prospect of having to either remove or abandon installed links, in the event of cancellation, creates a strong disincentive to construct in the first place. When area licenses are canceled for failure to meet the build-out requirements, or are surrendered by the licensee, the spectrum can lie completely fallow for years as the FCC sets up a re-auction.

Up to now, therefore, with few exceptions, auctioning a Fixed Service band, and subjecting auction winners to existing safe harbor build-out standards, has largely amounted to taking the band out of productive use. The FWCC fears that an auction of the 11, 18, or 23 GHz bands would similarly hinder their availability to additional users. Being suitable for longer links than those previously auctioned, these bands make a poor geographic fit with area licensing. And their use under the current regime has been highly successful, resulting in extremely dense deployment where demand is high. Even those few auctioned bands currently claiming a significant level of activity still have far fewer links and carry far less traffic than these bands do.

Worse still, an auction of the 11, 18, or 23 GHz bands would put additional pressure on remaining link-by-link spectrum, resulting in congestion and a higher likelihood of coordination failure, with a consequent migration to more expensive options such as fiber-optic cable, where feasible. A drop in useful Fixed Service spectrum would reduce the incentives for innovation by manufacturers, and drive up equipment costs for the users that remain. Many of the schools and local governments that now benefit from one or two links in the 11, 18, or 23 GHz bands may not be able to afford either auctioned spectrum or the alternatives. Even entities that can afford to participate in spectrum auctions would suffer from warehousing by speculators, transaction costs, infrequent auction timing, and incompatibilities between needed service areas and the geographic areas of auctioned licenses.

Even setting these difficulties aside, we have trouble postulating an effective mechanism for auctioning the 11, 18, or 23 GHz bands. The FCC, when preparing to auction a band, has never revoked the previously issued licenses in that spectrum. Winners of some auctions, such as the 2 GHz band now used for PCS wireless phone service, accepted their licenses under an obligation to relocate the incumbent fixed microwave users to other bands. That approach cannot work at 11, 18, and 23 GHz, as there are no suitable bands available for relocation. (Due to marked differences in propagation characteristics, the 24, 28, 31, and 39 GHz bands are a poor substitute for the lower bands.) In some other bands having incumbents, the FCC left the existing licenses in place and auctioned off the "white space" around them. Given the limited revenues generated by other auctioned Fixed Service bands, a prudent bidder would not be likely to ante up much for the 11, 18, and 23 GHz bands, even if they were vacant, and heavy use of these bands in populated areas would likely depress the bidding even more. A one-time auction cannot be expected to return much revenue to the Treasury.

In short, auctioning the 11, 18, and 23 GHz Fixed Service bands would greatly decrease their utility and, worse, could significantly impair the nation's ability to meet its critical infrastructure communications requirements. The current regime, by contrast, has been highly successful. Market-based demand for microwave links provides good incentive for efficient spectrum use, within the FCC's coordination and licensing framework. The entire U.S. economy, including the Treasury, reaps the benefits.

We hope the foregoing is helpful. Please do not hesitate to contact us if we can be of further assistance.

Respectfully submitted

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Counsel for the Fixed Wireless
Communications Coalition

cc (by email and USPS): Mike Clements, GAO
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FWCC membership list (email only)

Presentation to the GAO on Fixed Microwave Requirements Listed in P.L. 112-96

May 24, 2012

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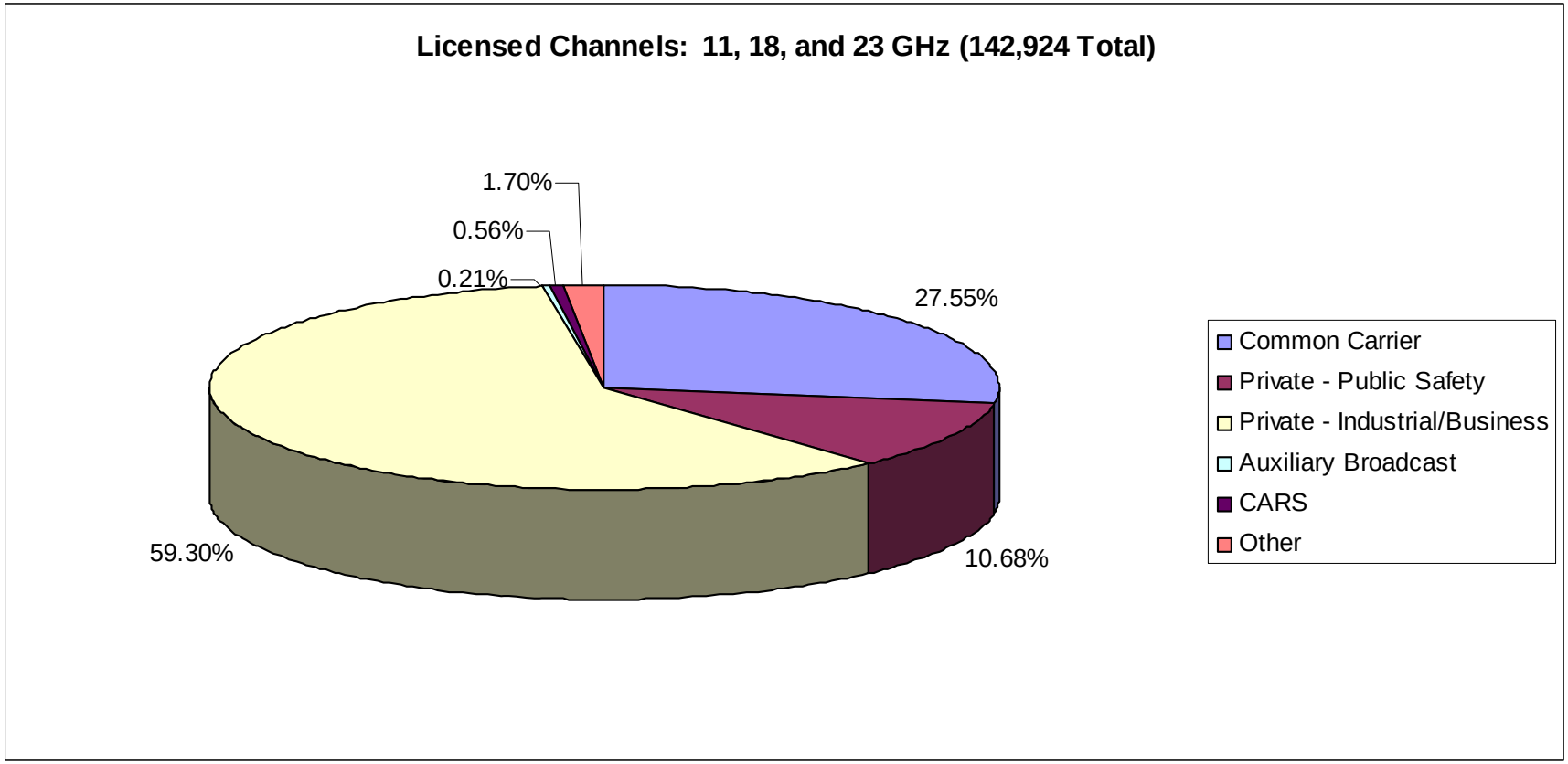
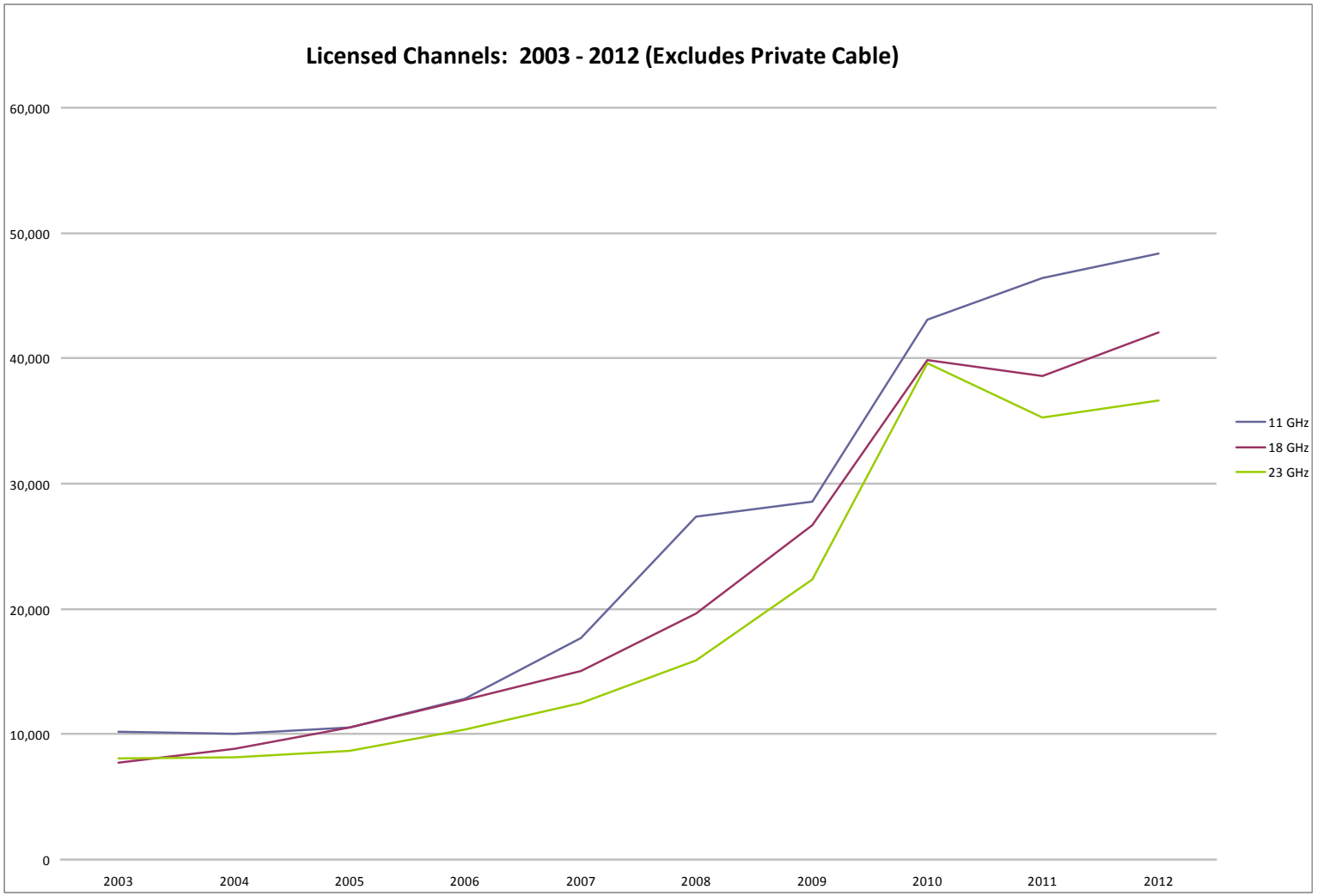
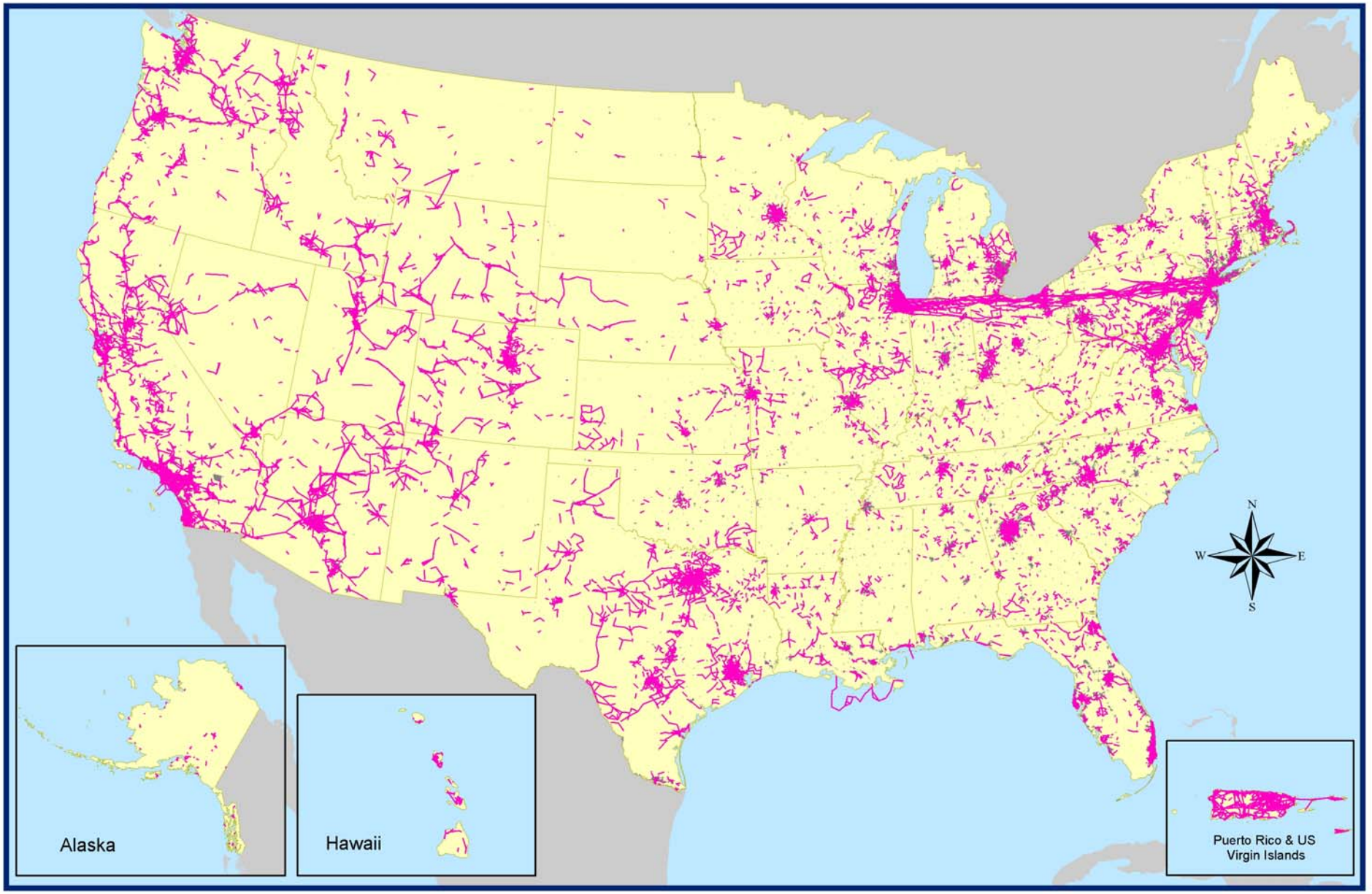
Total Licensed Channels by Service Code



Licensed Channel Growth: 2003 - 2012





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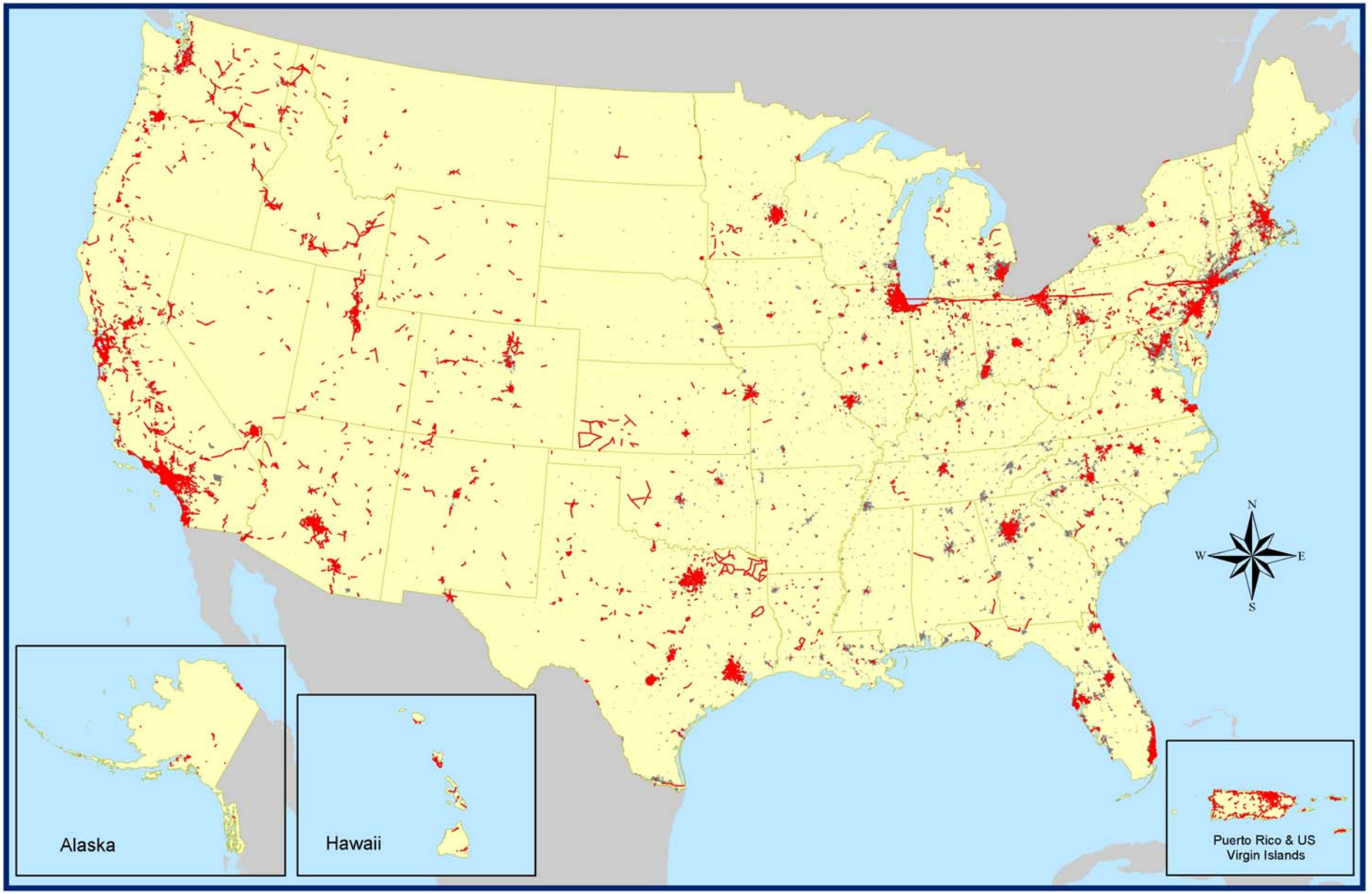
11 GHz Microwave Paths

Legend

Microwave Paths

Urban Areas



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18 GHz Microwave Paths

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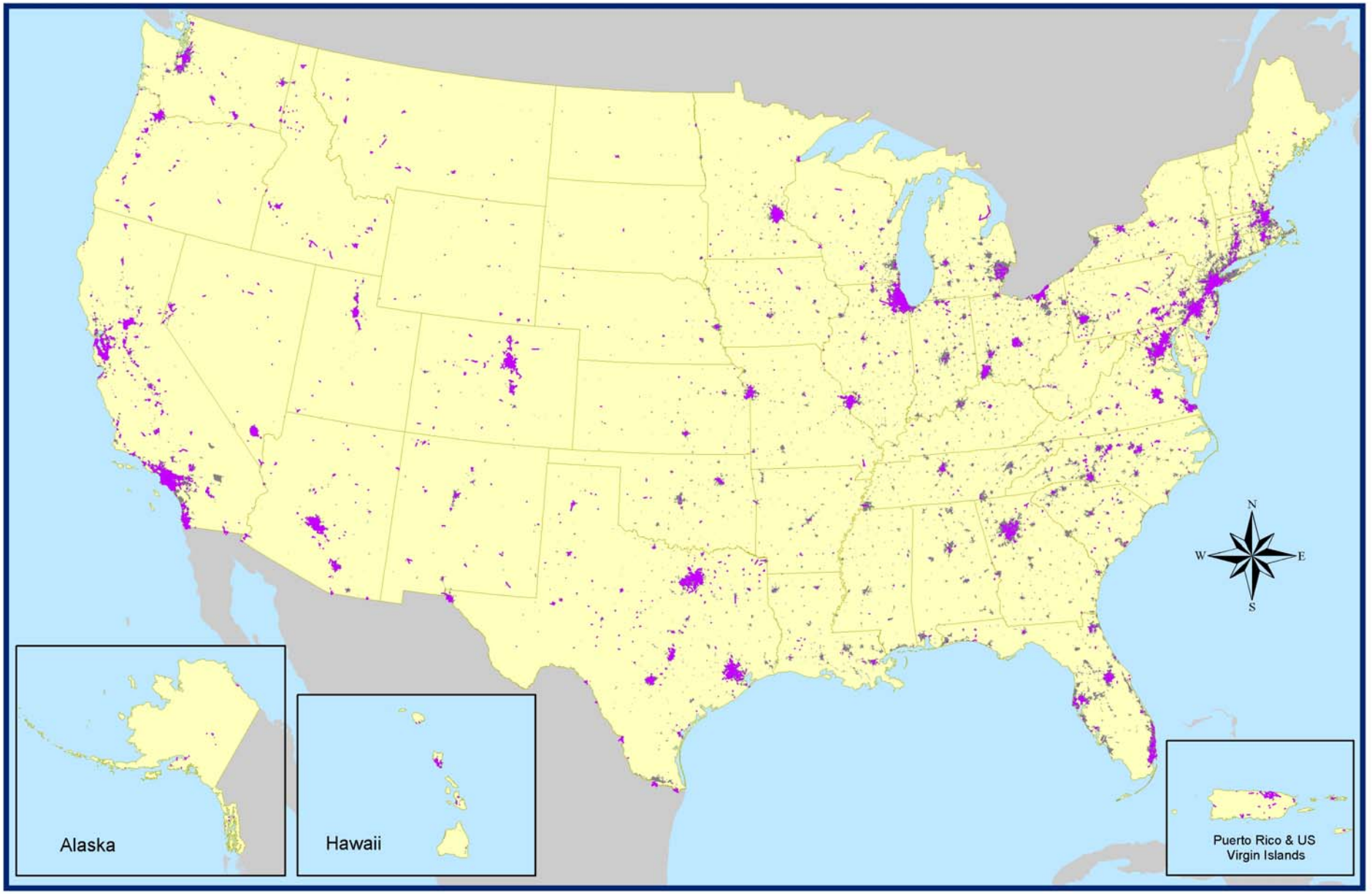
Microwave Paths

Urban Areas



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23 GHz Microwave Paths

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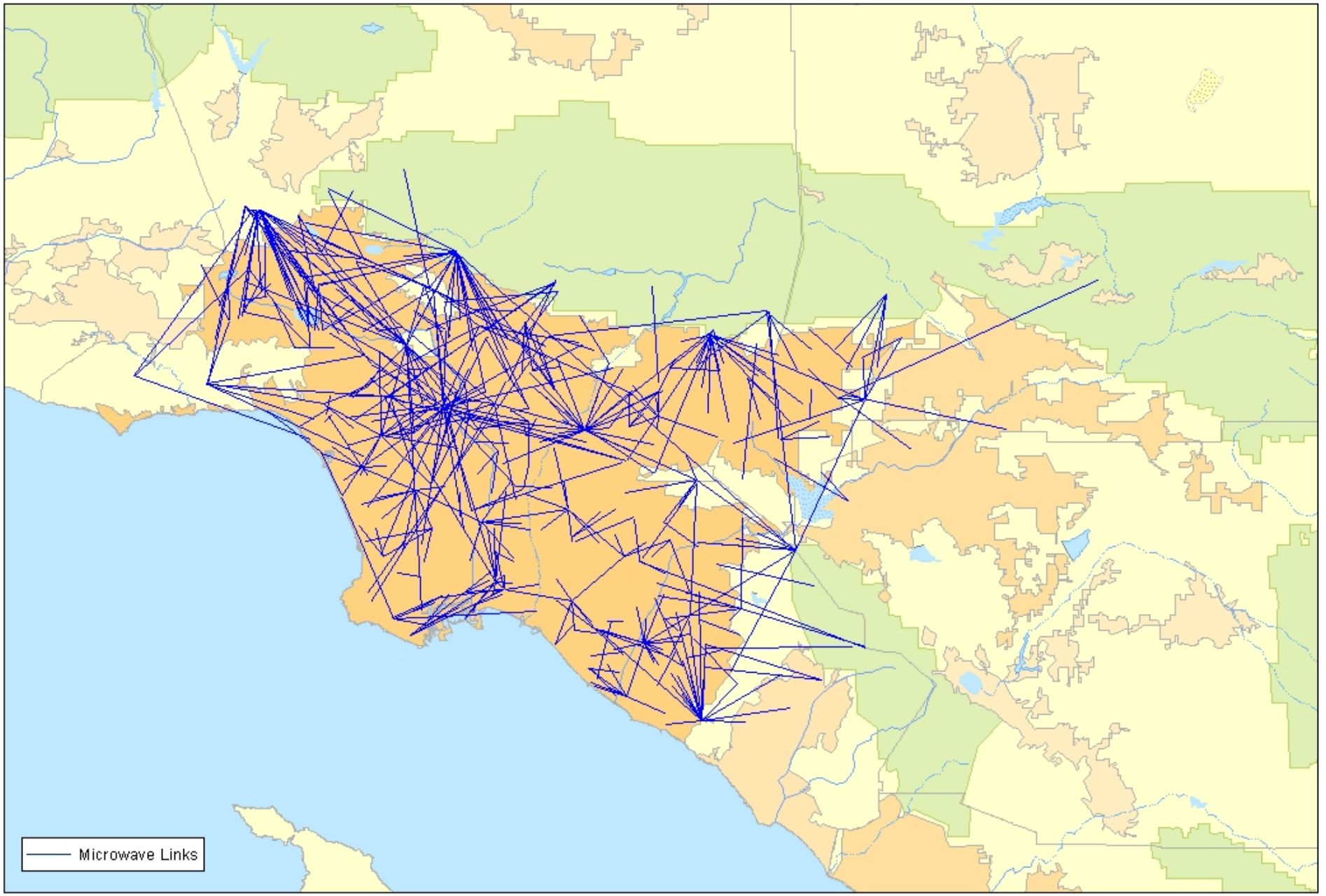
Microwave Paths

Urban Areas

Los Angeles Spectrum Usage – 11, 18, and 23 GHz (October 2010 Data)

	11 GHz	18 GHz	23 GHz	Total
Links	594	1350	1204	3148
Channels	1444	3373	3253	8070
Unique Licensees	53	66	84	
Maximum Re-use per Channel	56	171	296	



Los Angeles - 11 GHz

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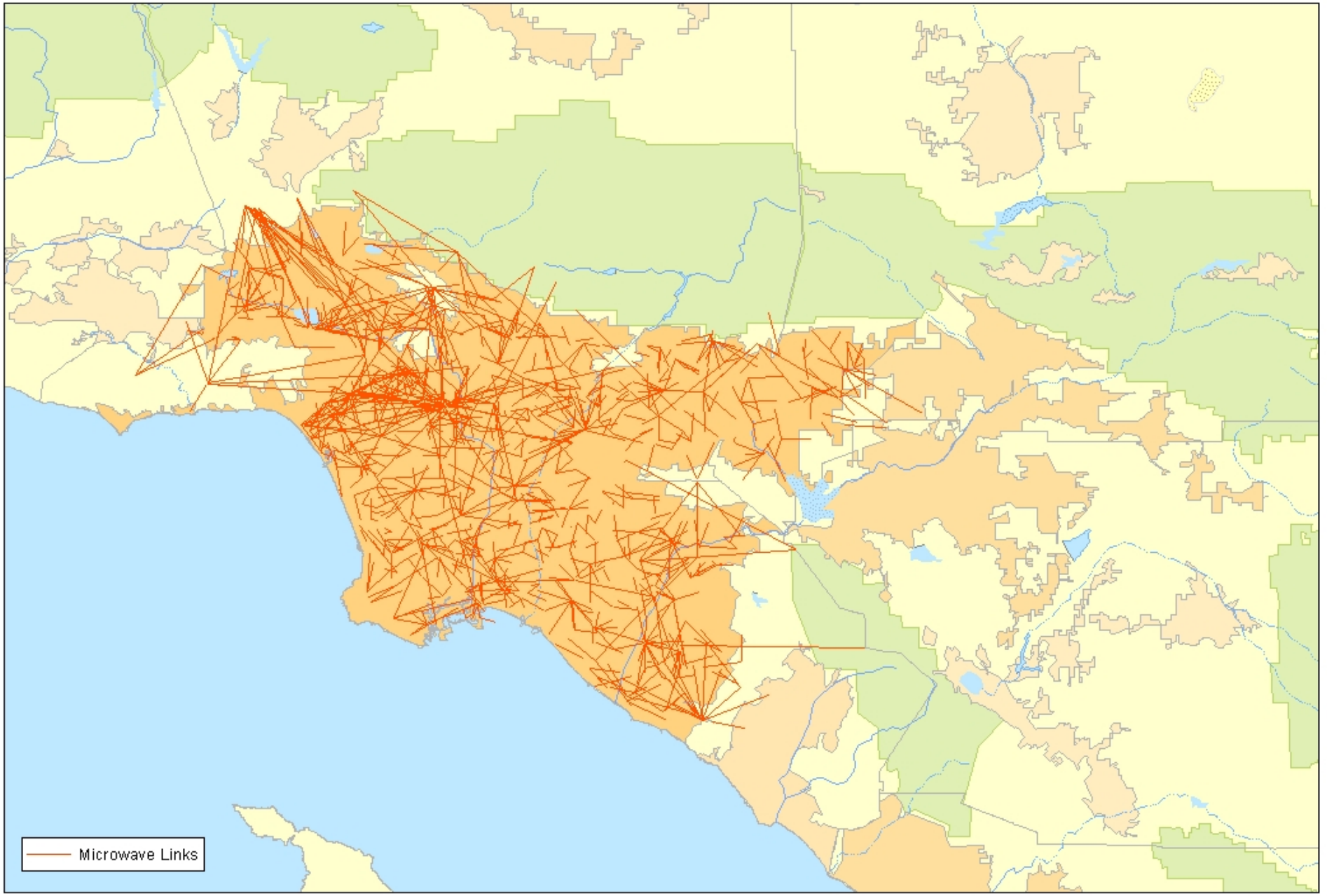

Los Angeles - 18 GHz

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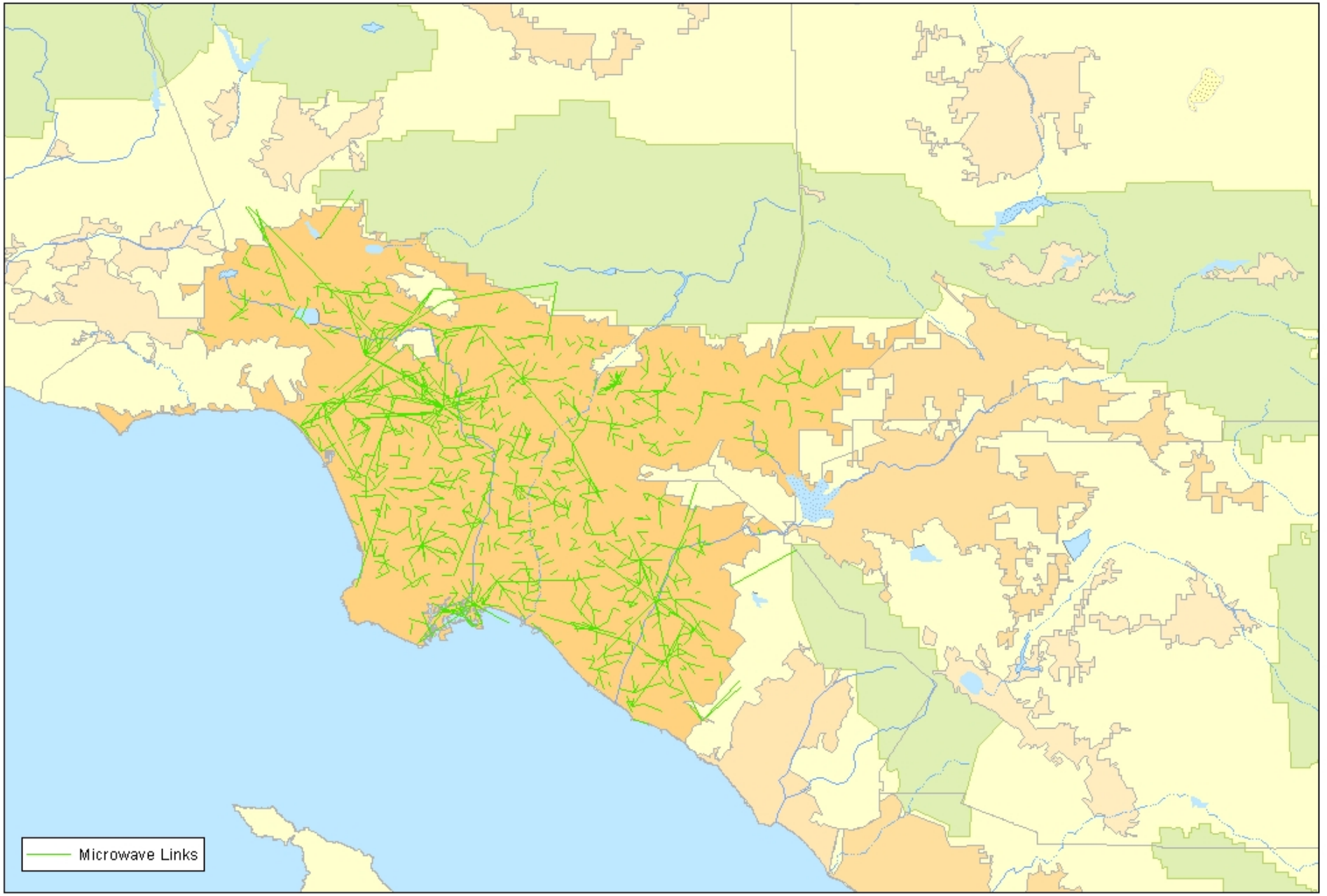

Los Angeles - 23 GHz

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Thank you!

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