TOWN OF MILFORD

Office of Community Development
Planning • Zoning • Building Safety • Code Enforcement • Health
Economic Development • Active Projects

<u>Administrative Review</u>

Date: June 23, 2021

To: Jason Plourde, Chair, Zoning Board of Adjustment

From: Lincoln Daley, Community Development Director

Subject: **Case #2021-14 John and Penny Webster for the property located at 172 Federal Hill Road, Tax Map 53, Lot 16** – Special Exception Application to Exceed Maximum Structure Height

The applicant is before the Board of Adjustment seeking a Special Exception from the Milford Zoning Ordinance, Article V, Section 5.04.7.C to allow the construction of two 90 foot tall amateur radio station antenna structures (with antennas) in the rear portion of the single family residential property where a 35 foot maximum height is permitted in the Residential 'R' Zoning District. In reviewing the files for this property, I offer the following comments:

1. Existing Conditions:
   a. The subject property is approximately 2.5 acres with 224linear feet of frontage on Federal Hill Road. The property contains a 5 bedroom, two-story, single-family residence, 720 square foot detached garage, and 60 square foot shed all situated near the front half of the property. The property is primarily undeveloped with the rear half mainly wooded.
   b. The property is serviced by private well and septic.
   c. The subject property is situated an established single-family residential area. To the north, south, and west, the subject property single-family residences. To the east, the property primarily undeveloped residential lots.
   d. The property is situated at the base of the hill in close proximity to the Federal Hill Fire Watch Tower (approx. 750 feet to the east). The topography of the property runs from a high point to the east of 592 feet down to the western boundary approximately 540 feet.

2. The proposal calls for the construction of two (2) 90 foot tall amateur radio station antenna structures (with antennas) in the rear portion of the property. According to the application, the towers will be 160' from the nearest home (Tax Map 53 Lot 15) to the northern abutting and 178' to the nearest home to the southern abutting property (Tax Map 53 Lot 17). Both towers are located outside of the 15 side and rear dimensional setbacks (minimum 90 feet from the side property boundary and 49 feet from the rear boundary). The lattice structure will be comprised of approx. 16 inch wide panel and secured by cabling

3. In accordance with Section 5.04.7.A within the Residential 'R' Zoning District, the maximum height of a structure is 35 feet. Pursuant to Section 5.04.7,C, a structure may exceed the maximum height of 35 feet with the issuance of a Special Exception by the Board of Adjustment.

4. Staff Comments:

   a. The applicant should explain the total amount of area to be cleared/disturbed to construct the towers. What impact will the removal of natural vegetation/trees have on the visibility of the towers?

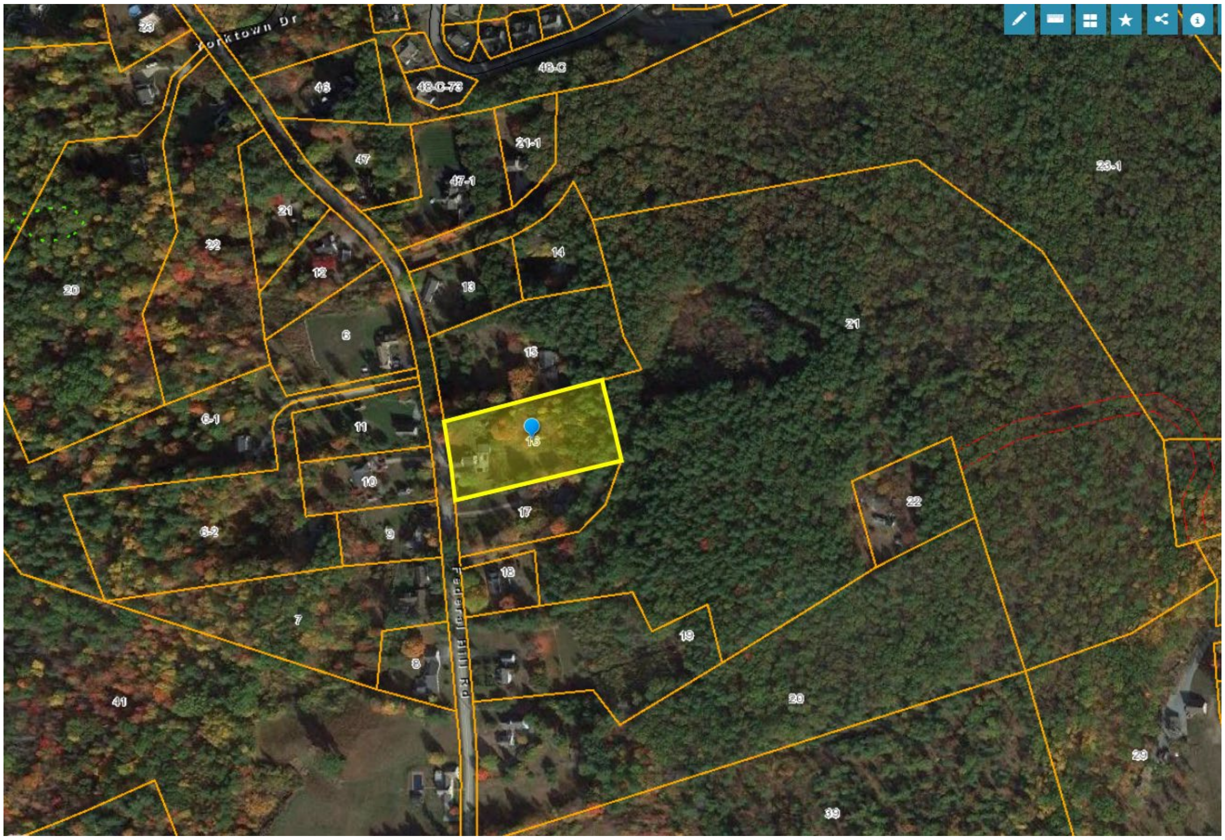
b. The applicant states that maximum height of each tower is 90 feet. The applicant should explain if additional antennas will be installed increasing the overall height of the structure.

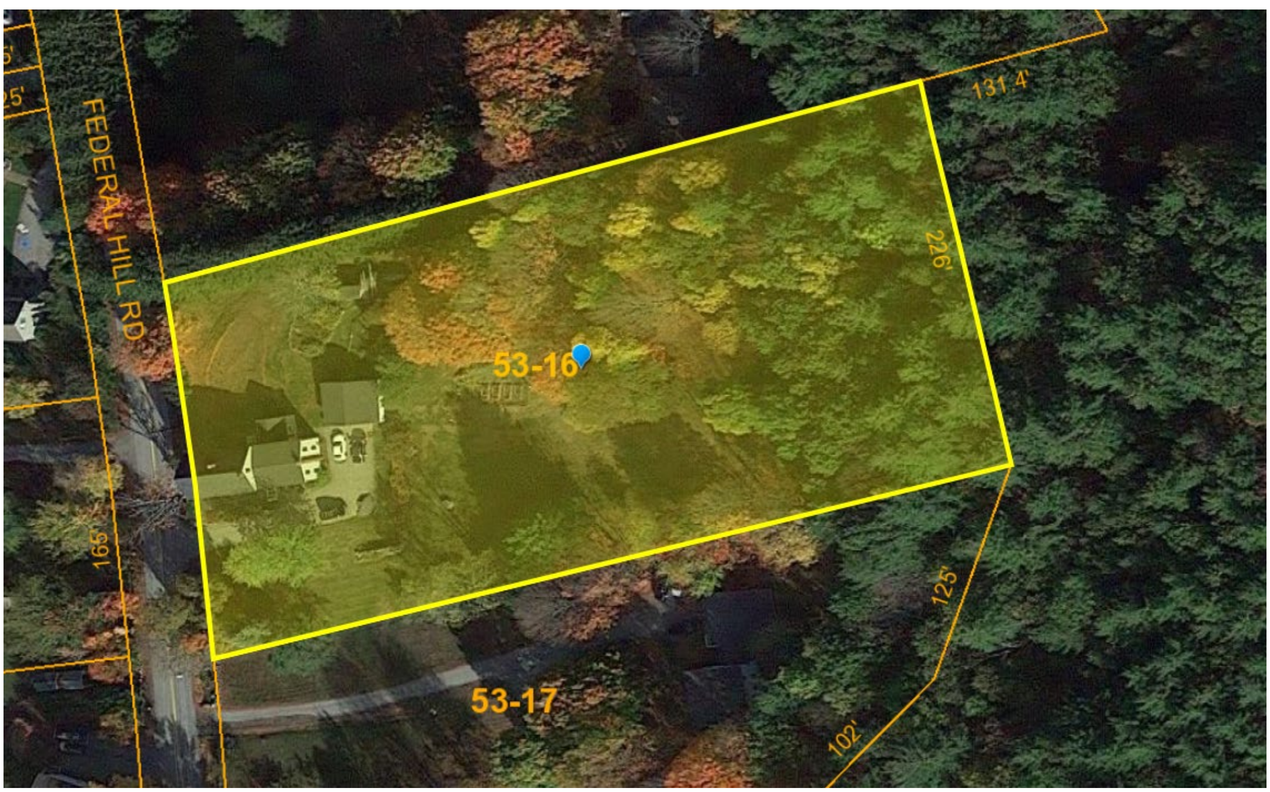
c. The applicant should provide more detail or clarification on how the towers are installed. More specifically, if each tower requires the installation of supportive cabling, please identify the location of all cabling on the property. Given the proximity of the towers to the rear and side property lines, with the cabling be located on abutting properties? In addition, the applicant should detail what steps have been taken to protect/insure safety and welfare of abutting properties within the 90 foot fall zone (e.g. easement).

d. The application states that there will be minimal visual impact on abutting properties given it proposed location and natural buffering. The applicant should be prepared to explain/detail what analysis has been completed to make this determination? The Board may want to consider additional analysis to determine the potential visual impact along Federal Hill Road and abutting properties

e. The applicant should explain the long-term use of the towers and possible co-location and/or structural improvement to co-locate commercial wireless service uses.

Aerial Photos of Subject Property:





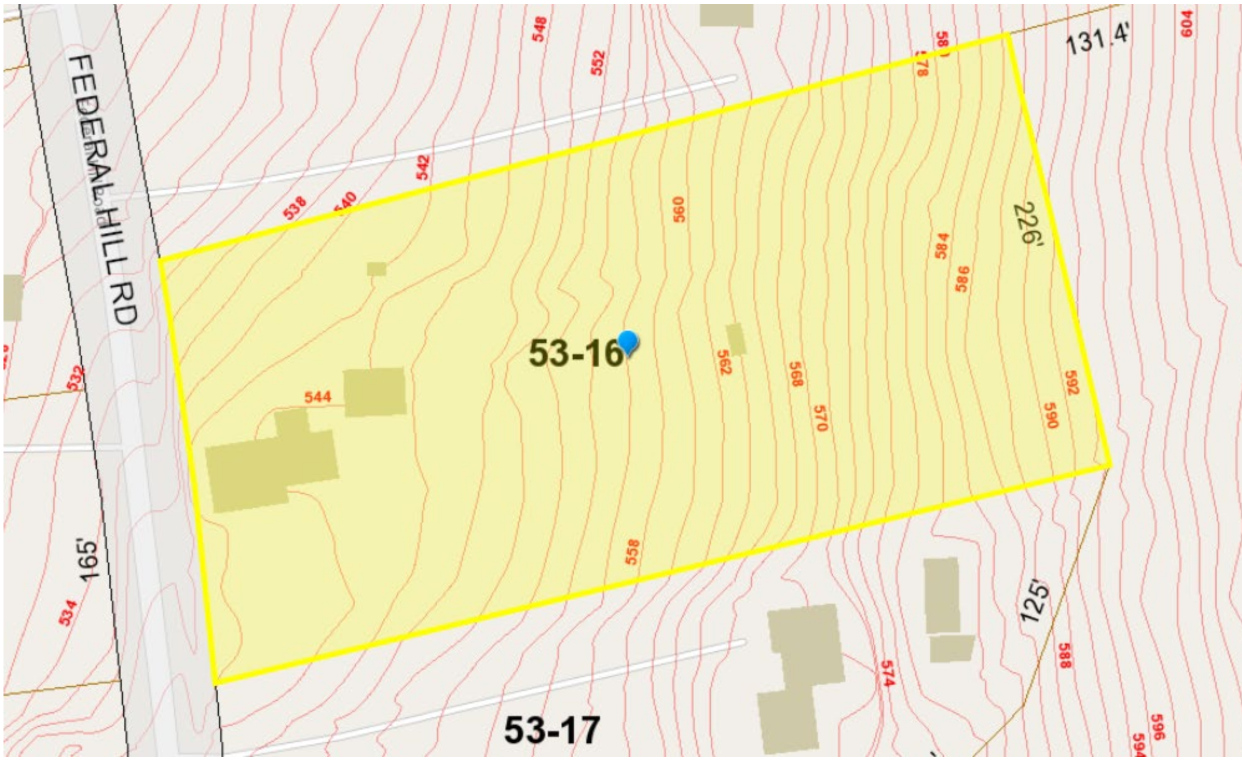
Street Photos of Subject Property:

172 Federal Hill Rd Looking Southeast

172 Federal Hill Rd Looking East

172 Federal Hill Rd Looking Northeast

Elevation Map of Subject Property:



ZBA Application

MILFORD ZONING BOARD OF ADJUSTMENT

GENERAL PROPERTY INFORMATION FOR ALL APPLICATIONS

Date Received:	
Case Number:	
Application Number :	
Hearing Date:	
Decision Date:	
Decision:	

PROPERTY INFORMATION	
Street Address: 172 Federal Hill Road	
Tax Map / Parcel #: 1338	Lot Size: 2.5 acres

PROPERTY CURRENTLY USED AS

Residence of the Applicant.

If the application involves multiple lots with different owners, attach additional copies of this page.

Zoning District *(check one):*

- ❑ Residence A
- ❑ Residence B
- ■ Residence R
- ❑ Commercial
- ❑ Limited Commercial
- ❑ Industrial
- ❑ Integrated Commercial-Industrial
- ❑ Integrated Commercial-Industrial-2

PROPERTY OWNER

Name: John S. and Penny S. Webster

Address: 172 Federal Hill Road

City/State/Zip: Milford, NH 03055

Phone: ( ) 603.249.5268

Email:

NN1SSNH@GMAIL.COM

Overlay District *(check any that apply):*

- ❑ West Elm Street Overlay
- ❑ Nashua/Elm Street Overlay
- ❑ Commerce & Community Overlay
- ❑ Open Space & Conservation
- ❑ Wetlands Conservation
- ❑ Groundwater Protection
- ❑ Floodplain Management

The applicant is the person who is making this proposal on behalf of themselves, the owner or a third party. This is usually the same as the property owner, but might be a tenant, someone who plans to purchase the property, an engineer or lawyer, etc. If the applicant is the same as the owner, just check "Same as owner" and leave the rest of this section blank.

APPLICANT/REPRESENTATIVE

❑ SAME AS OWNER

Name: Fred Hopengarten, Esq.

Address: Six Willarch Road

City/State/Zip: Lincoln, MA 01773

Email: Hopengarten@post.harvard.edu

Phone: ( ) 781.259.0088 | Cell: ( )

APPLICATION FEES

Application Fee:	$75.00
Abutters Fee: $4 x 6	24.00
Amount received:	$99.00
Date Received:	

Check X Cash ____

THE FEES ASSOCIATED WITH THIS APPLICATION DO NOT APPLY TO ANY OTHER FEES REQUIRED FOR APPROVAL OF THIS PROJECT. PLANNING, IMPACT, BUILDING AND OTHER FEES MAY APPLY.

The undersigned property owner(s) hereby authorize(s) the filing of this application and agree to comply with all code requirements applicable to this application.

_____________________________ May 21

Property Owner's signature *Date:*

Addendum to ZBA Application
General Property Information for All Applicants

The undersigned property owner hereby authorizes the filing of this application and agrees to comply with all code requirements applicable to this application.

John Webster May 21, 2021

ABUTTER LIST

Application for a Special Exception Under **§ 5.04.7.c** for Amateur Radio Station Antenna Structures protected by **RSA 674:16 IV, and 47 CFR § 97.15(b)**

Submitted by John Webster, 172 Federal Hill Road, Milford, NH 03055

Represented by Fred Hopengarten, Esq., Six Willarch Road, Lincoln, MA 01773
781.259.0088, Hopengarten@post.harvard.edu

Address	Lot Number	Owner's Name
164 Federal Hill Road	53-15	NELLIGAN, KENNETH P & LILLIAN
178 Federal Hill Road	53-17	BUCHER, DAVID L
Ponemah Hill Rd #OFF Mblu 53/ 22/ A/ / PID 4533 Tax Map I6 or I7	53-21	**Owner** MANCHESTER/NASHUA CELL TEL LP % DUFF & PHELPS, LLC PO BOX 2629 ADDISON, TX 75001-2629
165	53-11	SALZMAN, MICHAEL W
171	53-10	ZAPATKA, ROBERT L & KAREN L TRSTEES
177	53-9	CLOUSE, LARRY E & JOSEFINA L

Date Received:________________________
Case Number:________________________
Application #:________________________
Date Complete:________________________
Hearing Date:________________________
Decision Date:________________________
Decision:________________________

ZBA Application – Special Exception

MILFORD ZONING BOARD OF ADJUSTMENT

PROPERTY INFORMATION

Street Address: 172 Federal Hill Road

Tax Map / Parcel #: 1338

A Special Exception is a use which is permitted by the Zoning Ordinance, but requires approval from the Zoning Board of Adjustment. Most special exceptions have a list of additional criteria that must be met in order for the ZBA to approve the application.

***Note that in addition to the specific criteria that may be listed for a particular special exception, all special exceptions are subject to the general criteria in Section 10.02.1 of the Zoning Ordinance.**

What section of the Zoning Ordinance are you applying under?

Article _____V.____ Section 5.04.7.C

Describe the **use** you are proposing under the above section of the Ordinance.

Amateur radio station antenna structures, as more fully described in the Supplement.

Application for (check all that apply):

- ❏ Change/Expansion of Non-conforming Use/Structure (2.03.1.C)
- ❏ Wetland Buffer Impact (6.02.6)
- ❏ Accessory Dwelling Unit (10.2.6)
- ❏ Office in Res-A & B (10.2.7)
- ❏ Home Business (7.12.6)
- ❏ Side/Rear Yard Setback Reduction (Zoning District Specific)
- X Other

General Criteria Section 10.02.1

Describe the project you are requesting a Special Exception for:

Two amateur radio station antenna structures with antennas, in the backyard forested area.

Explain how the proposal meets the general criteria as specified in Article X, Section 10.02.1 of the Zoning Ordinance:

A. The proposed use is similar to those permitted in the district because:

Telecommunications facilities which are permitted in the Residence R District under § 5.04.1.E. There is a radio/observation tower on abutting land to the East (Lot 53-21). Comparable antenna systems may be found at residences located at 245 Colburn Road, Milford; 60 Brookview Drive, Milford; and 19 Harwood Road, Mont Vernon (see Supplement Exhibit L).

B. The specific site is an appropriate location for the proposed use because:

"New Hampshire and federal law require municipalities to accommodate amateur communications." *Marchand v. Town of Hudson*, 147 N.H. 380, 386 (2001).

C. The use as developed will not adversely affect the adjacent area because:

The towers will likely not be visible from the public way (Federal Hill Road), although there may be a spot on the street from which one might see an antenna on top of a tower.

D. There will be no nuisance or serious hazard to vehicles or pedestrians because:

The proposed use is allowed by the legislature under RSA 674.16.IV and 674.17.III. By state and federal law, this use cannot be a nuisance. Assuming inspection in accordance with the Building Code, it will not present a "serious hazard."

E. Adequate appropriate facilities will be provided for the proper operation of the proposed use because:

The proposed station antenna structures will conform to the building code, EIA/TIA-222-F, the National Electrical Code, and good engineering practice.

STATE OF NEW HAMPSHIRE

TOWN OF MILFORD

BOARD OF ADJUSTMENT

SUPPLEMENTAL INFORMATION FOR AN AMATEUR RADIO FACILITY ACCOMPANYING APPLICATION FOR A SPECIAL EXCEPTION UNDER §5.04.7.C

PID # 1338
ZONE: RESIDENCE R

SUBMITTED ON BEHALF OF:
JOHN WEBSTER
172 FEDERAL HILL ROAD
MILFORD, NH 03055
HOME TELEPHONE: 603.249.5268
WORK TELEPHONE: 603.799.6822
E-MAIL: NN1SSNH@GMAIL.COM

BY:

FRED HOPENGARTEN, ESQ.
SIX WILLARCH ROAD
LINCOLN, MA 01773
781/259-0088; FAX 419/858-2421
E-MAIL: HOPENGARTEN@POST.HARVARD.EDU

MAY 21, 2021

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EXECUTIVE SUMMARY

This is a proposal to erect and maintain two amateur radio station antenna structures on a property of 2.5 acres of Milford. Amateur radio is a permitted use in all zones in Town. The proposed station antenna structures further the purposes and community development, as well as safety, objectives of the zoning ordinance. § 1.01.0. The proposal is not a "telecommunications facility" defined in § 7.09.1.

Conclusion: Two questions are presented -- use and height. The use is an ordinary use accessory to a residence, permitted as a matter of right in the Residence R District, § 5.04.1.A. Because it is a height greater than allowed in § 5.04.7.A (35'), it requires a Special Exception. § 5.04.2.13 and § 5.04.7.C. The two towers will be 90' tall and located in a well-obscured location to the rear of the Applicant's yard, against a backdrop of forest and hardly visible from the public way.

PREAMBLE

This is an application for a Special Exception required by **§ 5.04.7.C**, for a height greater than 35' in the Residence "R" District. The Special Exception will permit the Applicant to erect and maintain private, non-commercial amateur radio station antenna structures for personal use. The Applicant is an individual and has been licensed by the Federal Communications Commission (FCC) since 1963. See **Exhibit A** for his FCC license, which qualifies him for the protections of the limited preemption for amateur radio by federal law contained in 47 CFR § 97.15(b), and the comparable preemption found at **RSA 674:16 IV.** Amateur radio station antenna structures, inherently non-commercial, are an ordinary accessory use of a residence. *Marchand v. Town of Hudson*, 147 N.H. 380, 788 A.2d 250 (N.H. 2001).

The proposed antenna system will not cause substantial detriment to the public good; in fact, the proposed system will serve the public good due to the findings of the Congress, the FCC, the Courts, and, most particularly as displayed in this application, the availability of this station to serve in time of emergency – including power and cell phone blackouts. Recent hurricane events show how important amateur radio communications can be when cell and power outages occur. See, *e.g.*, **Exhibit K-1** (article on the Puerto Rican hurricane and amateur radio assistance).

In addition, in times of emergency (such as the recent experience in Puerto Rico, when continental American radio amateurs with good antenna systems provided critical communications by relaying messages from stricken areas of the island), amateur radio operators such as the Applicant provide invaluable local communications assistance. It is therefore no surprise that zoning regulations that impinge on the erection and maintenance of amateur radio station antenna structures are preempted by federal law. As demonstrated below, the building inspector can, and should, grant a permit for the structures as currently constituted without any further action.

A permit for the proposed system would be consistent with public policies, both state and federal, protecting the rights of licensed radio amateurs to construct and use amateur radio facilities. Granting of this application will be in harmony with the general purposes and intent of the regulations of the Zoning Ordinance.[1]

[1] The Purpose of the Ordinance, found at § 1.01.0, tells us that the ordinance was made "for the purpose of promoting the public health, safety, morals, general welfare and civil rights of the inhabitants of the Town of Milford as provided by Title 64 of the NH RSA, Chapters 672-677 inclusive and, as such may be amended from time to time." The Applicant's proposed amateur radio use promotes each of those goals.

For reasons of physics, amateur radio antenna systems have always been tall. Among the very first stations for international communications, this postcard shows the antenna system constructed by Marconi, in South Wellfleet, Massachusetts, ***in 1901***, which included a series of towers 200' tall. The physics hasn't changed since.

Title: Marconi Wireless Telegraph Station, South Wellfleet, Mass. Source: The National Park Service.

Norman Rockwell made a TV antenna famous, by putting it on the cover of the Saturday Evening Post for November 5, 1949. This oil on canvas is currently in the Los Angeles County Museum of Art.

Source: www.artchive.com/artchive/r/rockwell/thumb/rockwell_antenna.jpg

Putting antennas up in the sky is engrained in American culture.

As mentioned above, the position of a radio amateur in the permitting process is uniquely enhanced by a Congressional finding that "reasonable accommodation should be made for the effective operation of amateur radio from residences, private vehicles and public areas, and that regulation at all levels of government should facilitate and encourage amateur radio operation as **a public benefit**." Public Law 103-408, § 1 (3), October 22, 1994 *(Emphasis added.)*. While defining "effective operation" may be challenging, the Applicant is confident that, by comparison, no one would accept as "effective operation" a cell phone or TV station that was only useful six or seven days out of ten. Nonetheless, the Applicant has used that highly compromised standard as his threshold.

The Applicant and his wife own the property, which was acquired in 2016. The deed appears as **Exhibit B-1**. The Applicant's wife enthusiastically supports and encourages this application. See **Exhibit B-2, Permission of Co-Owner.**

This application presents the most viable option for the placement of the proposed system on the Applicant's property, 2.5 acres in size, in the Residence R district, on a site selected by the Applicant after a careful and exhaustive study. The Applicant believes that this siting is in the best interest of the town. It is acceptable to him as well.

THE TELECOMMUNICATIONS ACT OF 1996 (47 USC § 332 *ET SEQ.*) DOES NOT APPLY

As a preliminary matter, it should be emphasized that the Telecommunications Act of 1996 (especially § 704), the contents of which are now found at 47 USC § 332 *et seq*., regulating the cellular telephone industry (Commercial Mobile Radio Services, or CMRS, also "personal wireless services"), does not apply in this case. The Applicant is a licensed amateur radio operator whose activities are outside the provisions of 47 USC § 332.

In particular, an opponent might erroneously cite, 47 USC § 332(c)(7)(A):

> (7) Preservation of local zoning authority
>
> (A) General authority
>
> Except as provided in this paragraph, nothing in this chapter shall limit or affect the authority of a State or local government or instrumentality thereof over decisions regarding the placement, construction, and modification of **personal wireless service facilities**. *(Emphasis added.)*

An opponent might also cite (in part) 47 USC § 332(c)(7)(B):

> (B) Limitations
>
> (i) The regulation of the placement, construction, and modification of **personal wireless service facilities** by any State or local government or instrumentality thereof -
>
> (I) shall not unreasonably discriminate among providers of functionally equivalent services; and
>
> (II) shall not prohibit or have the effect of prohibiting the provision of personal wireless services.

(Emphasis added.)

Reliance on these provisions is instantly defeated by a focused reading of **47 USC § 332(c)(7)(C):**

> (C) Definitions
>
> **For purposes of this paragraph -**
>
> **(i) the term "personal wireless services" means commercial mobile services, unlicensed wireless services, and common carrier wireless exchange access services;**
>
> (ii) the term "personal wireless service facilities" means facilities for the provision of personal wireless services.

(Emphasis added.)

The Applicant is not a commercial mobile service, an unlicensed wireless service, or a common carrier. The Applicant is a non-commercial, FCC-licensed, radio amateur, in a wholly different service and subject to a wholly different set of regulations (47 CFR Part 97), and the beneficiary of a wholly different preemption (47 CFR § 97.15(b)). A discussion of the law that applies to amateur radio generally – and the Applicant in particular – is found later in this document, in the section entitled "Preemption."

Amateur radio is a permitted use in all zoning districts because amateur radio cannot be forbidden. "Except as provided in RSA 424:5 or RSA 422-B or in any other provision of Title XXXIX, no city, town, or county in which there are located unincorporated towns or unorganized places shall adopt a zoning ordinance or regulation with respect to antennas used exclusively in the amateur radio service that fails to conform to the limited federal preemption entitled Amateur Radio Preemption, 101 FCC 2nd 952 (1985) issued by the Federal Communications Commission." RSA § 674:17.III. The Amateur Radio Preemption mentioned was promulgated as a federal regulation: "State and local regulation of a station antenna structure must not preclude amateur service communications." 47 C.F.R. § 97.15(b). It is a use, a use accessory to a residence, permitted as a right. Zoning Ordinance § 5.04.1.A.

This proposal is not regulated by the Dimensional Requirements of § 7.09.4, which apply to "carriers." For this reason, the "fall zone" requirements of § 7.09.4 also do not apply.

AMATEUR RADIO IS NOT A COMMERCIAL USE

This particular use and the structures involved are permitted as a matter of right. Nonetheless it is important to point out what this is NOT.

This is NOT a Telecommunication Facility under **§ 7.09.0**, by definition found in **§ 7.09.1**: "**Telecommunications facility:** A facility for the provision of personal wireless services as defined by the Telecommunications Act of 1996, as amended. Telecommunications facilities include a mount, antenna, equipment shelter, and other related equipment. **Telecommunications facilities do not include private or non-commercial wireless communication facilities such as amateur ham radio** and citizen band radio." By the way, all amateur radio uses are inherently non-commercial, under the terms of the license. *Emphasis added.* See especially 47 CFR §97.1 (a):

> PART 97--AMATEUR RADIO SERVICE
>
> Subpart A--General Provisions
> Sec. 97.1 Basis and purpose.
>
> The rules and regulations in this part are designed to provide an amateur radio service having a fundamental purpose as expressed in the following principles:
>
> (a) Recognition and enhancement of the value of the amateur service to the public as a **voluntary noncommercial communication service, particularly with respect to providing emergency communications**.
> (b) Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.
> (c) Encouragement and improvement of the amateur service through rules which provide for advancing skills in both the communication and technical phases of the art.
> (d) Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.
> (e) Continuation and extension of the amateur's unique ability to enhance international goodwill. *(Emphasis supplied.)*

The station antenna structures are for amateur radio, not broadcasting, cellular telephone, paging, or any other commercial purpose. The Applicant will accept a permit condition to the following effect: "The station antenna structure shall not be used to support common-carrier cellular telephone or any other commercial purpose antennas."

In the case of antennas, as the FCC and the courts have said, height affects propagation. Height may be required for effective communications that the individual radio amateur desires. Here the station antenna structures are 95 feet tall. As described below, those heights are critical to ensuring that the underlying purpose of this amateur radio station are fulfilled and that the amateur radio operator is reasonably accommodated. See "Showing of Need for Height of an Amateur Radio Antenna Support Structure with Propagation Maps," by Dennis Egan, and "Antenna Height and Communications Effectiveness," prepared by the technical staff at the American Radio Relay League. Both of those documents accompany this Supplement.

The antennas are all within the forest behind the applicant's home.

PERMITTED BY SPECIAL EXCEPTION UNDER §§ 5.04.2.13 AND § 5.04.7.C

A Special Exception in accordance with **§§ 5.04.2.13 and § 5.04.7.C.** The tests for a Special Exception are found at **§ 10.02.1**, which appears here with responses from the Applicant.

> The Board of Adjustment may in appropriate cases and subject to appropriate conditions and safeguards as determined by the Board, grant permits for such special exceptions as allowed in the various zoning districts as set forth in Article II. The Board may refer all applications for special exceptions to the Planning Board for its review and recommendations prior to holding public hearing on the application. The Board of Adjustment, in acting on an application for a special exception shall take into consideration the following conditions: (1992)

A. The proposed use shall be similar to those permitted in the district.

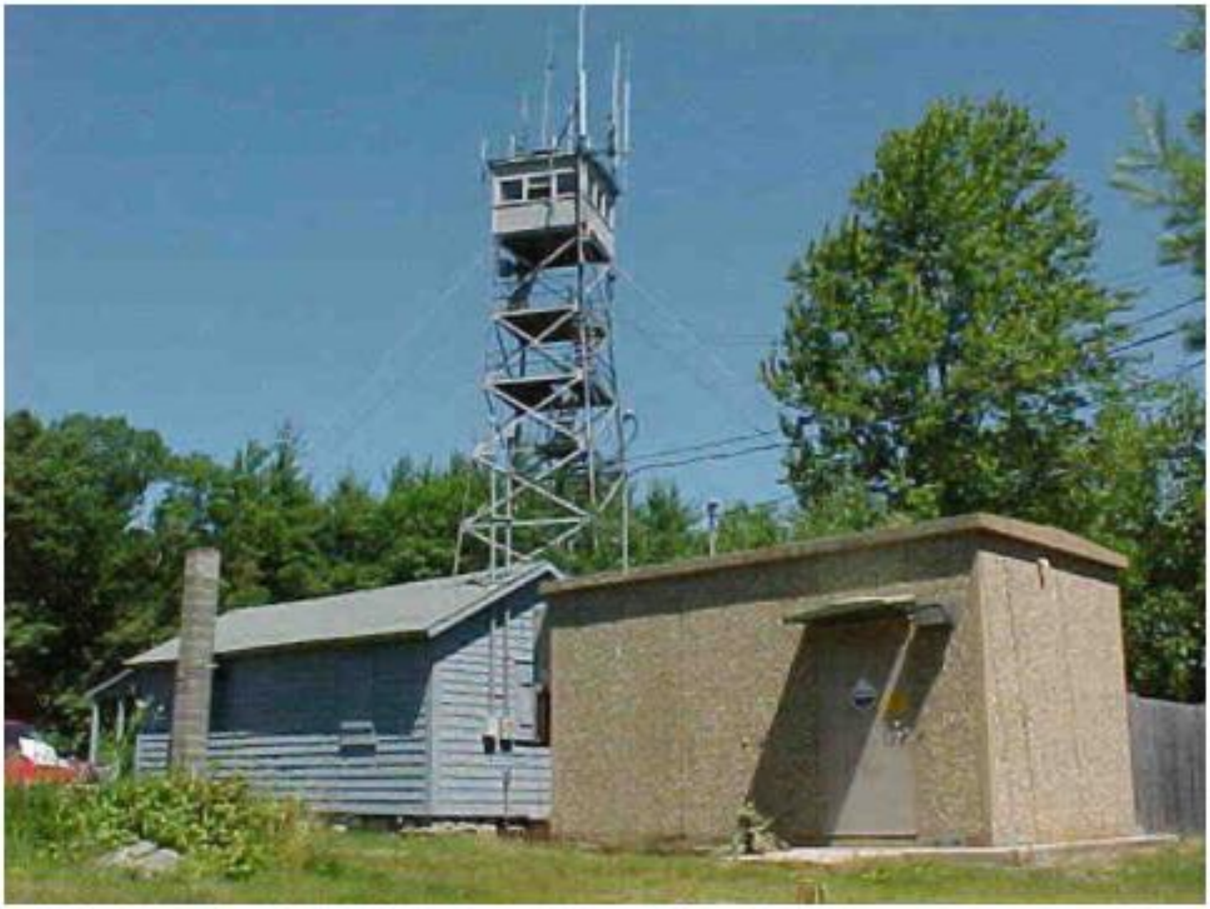
> *Response:* The proposed use is similar to telecommunications facilities, which are permitted in the Residence R District under § 5.04.1.E. In addition, the photo below portrays a use on abutting land to the East, on Lot 53-21. In addition, comparable amateur radio station antenna systems may be found at residences located at 245 Colburn Road, Milford; 60 Brookview Drive, Milford; and 19 Harwood Road, Mont Vernon (see **Exhibit L**).

B. The specific site is an appropriate location for the proposed use.

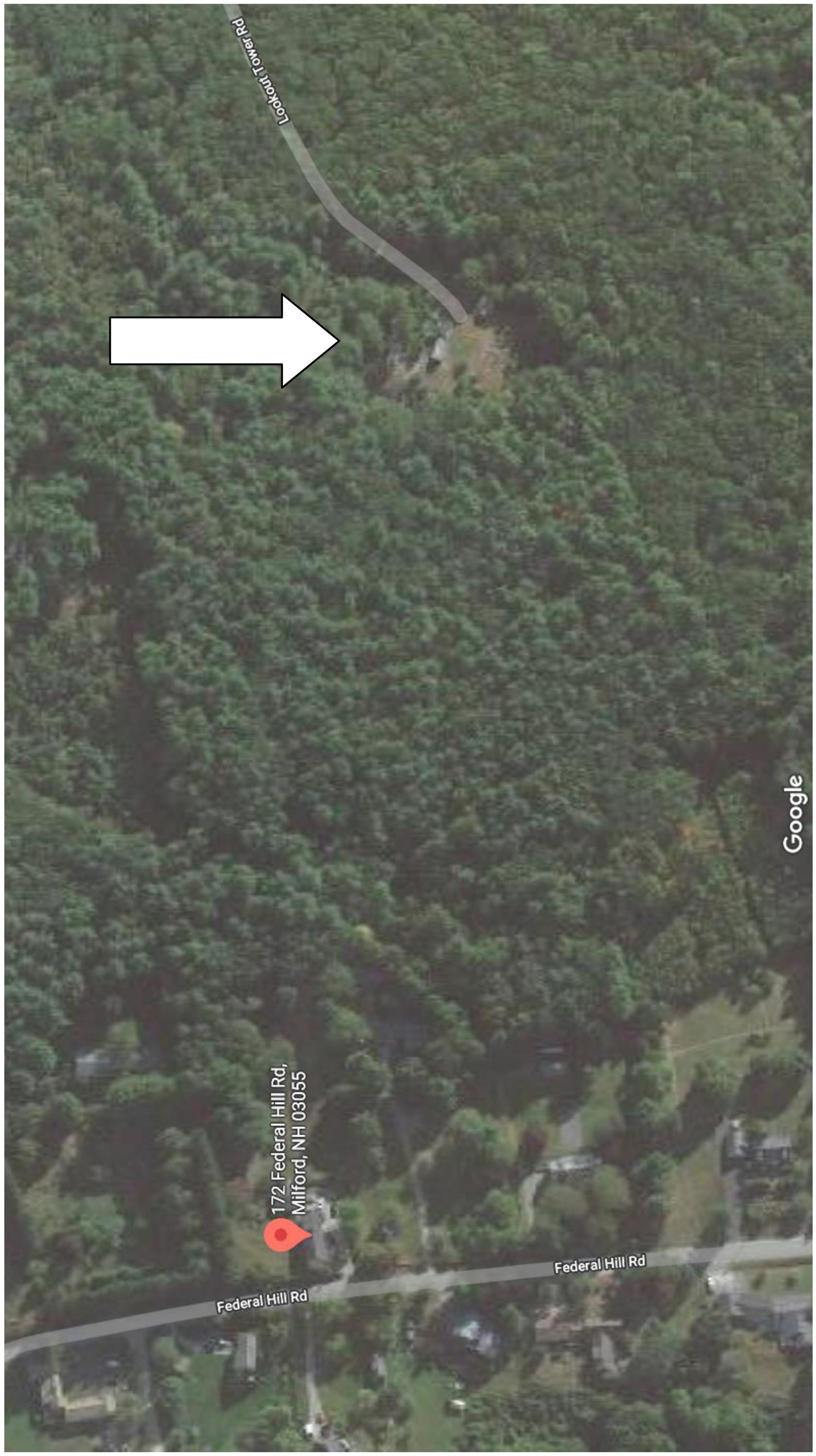
> *Response:* As the New Hampshire Supreme Court has written, "New Hampshire and federal law require municipalities to accommodate amateur communications." *Marchand v. Town of Hudson*, 147 N.H. 380, 386 (2001). And the proposed use is permitted at this address. The proposed use also promotes the purposes of the Zoning Ordinance found at § 1.01.1, which are to promote "the public health, safety, morals, general welfare and civil rights of the inhabitants of the Town of Milford."
>
> The requirement to promote public health and safety is surely met by the federal regulation, 47 CFR § 97.1, which holds that the very basis and purpose of the amateur radio service is to serve "the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications."
>
> The question of whether or not an amateur radio use promotes the general welfare can be satisfied by showing that an FCC license was issued. *T-Mobile Northeast LLC v. Borough of Leonia Zoning Bd. of Adj.*, 942 F. Supp. 2d 474, 486 (USDC D NJ 2013). The Applicant has an FCC license. See **Exhibit A**.

C. The use as developed will not adversely affect the adjacent area.

> *Response:* Located 420' from the public way, and 350' from the rear of the house, the towers will likely not be visible from the public way (Federal Hill Road), although there may be a spot on the street from which one might see an antenna on top of a tower. In addition, an existing fire tower with communications antennas sits on abutting land to the East, atop Federal Hill:



Abutter to the East: Fire tower atop Federal Hill, on Lot 53-21,
off Ponemah Hill Road, on abutting land immediately to the East



Arrow points to the fire tower atop Federal Hill, off Ponemah Hill Road.
Note that the area is heavily forested. Placing the towers to the rear of the property,
in the direction of the fire tower, reduces visibility from the road.
There is effectively no rear neighbor.

D. There will be no nuisance or serious hazard to vehicles or pedestrians.

Response: The proposed use is allowed by the legislature under RSA 674.16.IV and 674.17.III. By state and federal law, this use cannot be a nuisance. Assuming inspection in accordance with the Building Code, it will not present a "serious hazard."

E. Adequate appropriate facilities will be provided for the proper operation of the proposed use.

Response: While the meaning of the phrase "adequate appropriate facilities" is unclear in this context, the proposed station antenna structures will conform to the building code, EIA/TIA-222-F, the National Electrical Code, and good engineering practice. Blockage from 10 to 130 degrees, requires the height proposed – to overcome the hill behind the house. It will be just enough above the trees to make it functional. Furthermore, the accompanying document from Dennis Egan, B.S. Mathematics (Computer Science), discusses the intended purpose (reliable communications over routine paths to Europe and Japan at 7 MHz), and the differences between performance of an antenna system at a lower height, as opposed to a useful height, and discusses the compromise height that the Applicant is willing to accept. As the propagation study shows, at lower heights, the performance does not meet the need. In the amateur radio cases, the need is specific and defined by the individual radio amateur. This concept was confirmed by the Court in *Snook v. Missouri City (TX)*, 2003 U.S. Dist. LEXIS 27256, 2003 WL 25258302 (S.D. Tex. Aug. 26, 2003, Hittner, J.) (the Order, Slip Opinion, 63 pp.), see also the Final Judgment, Slip Opinion, 2 pp. The *Snook* case is most easily found at http://www.arrl.org/files/file/Snook%20KB5F%20Decision%20&%20Order%2034.pdf (USDC, SDTX, 2003, Hittner, J.), wherein the Court stated:

> To conduct effective emergency communications, Snook must be able to achieve at least a 75 to 90 percent successful signal under the changing variables that impact emergency or other amateur radio communications. *Snook* Findings of Fact ¶ 9
>
> Based on his emergency and amateur radio experience, he estimated that an antenna array of 180 to 185 feet would be optimal. *Snook* Findings of Fact ¶ 15. [Note that Snook's requirements were for Texas, where hills – which impact propagation needs -- are rare.]

The key test is: What communications does the amateur desire? That is what must be accommodated by the municipality. Here is the way the test was originally stated by the FCC in 1985.

> [A]mateur station communications are only as effective as the antennas employed, antenna height restrictions directly affect the effectiveness of amateur communications. **Some amateur antenna configurations require more substantial installations than others if they are to provide the amateur operator with the communications that he/she desires to engage in.** For example, an antenna array for International amateur communications will differ from an antenna used to contact other amateur operators at shorter distances. **Federal Preemption of State and Local Regulations Pertaining to Amateur Radio Facilities** (FCC 85-506) (known as "PRB-1"), 9/16/85, ¶ 25. *(Emphasis added.)*

https://www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/prb-1-1985

As some courts and municipalities were to later misread the FCC's rule, the FCC found it necessary to clarify its ruling in 1999, by recognizing that there might be differences between "heavily-populated urban or suburban locales" and the rural situation involved here, wherein the Applicant resides on 2.5 acres of rural, farmed land, stating:

We believe that the effectiveness of these guidelines or standards can be gauged by the fact that a local zoning authority would recognize at the outset, when crafting zoning regulations, the potential impact that high antenna towers in heavily-populated urban or suburban locales could have and, thus, would draft their regulations accordingly. In addition, we believe that PRB-1's guidelines brings to a local zoning board's awareness that **the very least regulation necessary for the welfare of the community must be the aim of its regulations so that such regulations will not impinge on the needs of amateur operators to engage in amateur communications**.

https://www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/prb-1-1999 at ¶ 9. (*Emphasis supplied*).

A. Structures allowed as height limitation exceptions shall not occupy more than twenty (20) percent of the gross roof area of any building upon that they may be located.

Response: Not applicable, as these station antenna structures stand alone, and not upon the roof of any building.

IF § 7.09.0 ("TELECOMMUNICATIONS FACILITIES") DOES NOT APPLY, WHAT DOES?

Response: The proposed station antenna structures are governed by **§ 10.02.0 (Special Exceptions), RSA 674:16 IV** *and* **47 CFR § 97.15(b).**

PROPAGATION MAPS SHOW TECHNICAL JUSTIFICATION FOR HEIGHT

The accompanying document from Dennis Egan, B.S., Mathematics (Concentration in Computer Science) discusses the intended purpose (reliable communications over routine paths to Eastern Europe and Israel), and the differences between performance of an antenna system at a lower height, as well as the compromise height that the Applicant is willing to accept. At lower height, the performance does not meet the need. In the amateur radio cases, the need is specific and defined by the individual radio amateur. This concept has been confirmed by the Court in *Snook v. Missouri City (TX)*, 2003 U.S. Dist. LEXIS 27256, 2003 WL 25258302 (S.D. Tex. Aug. 26, 2003, Hittner, J.) (the Order, Slip Opinion, 63 pp.), see also the Final Judgment, Slip Opinion, 2 pp. This case may be most easily found at http://www.arrl.org/files/file/Snook%20KB5F%20Decision%20&%20Order%2034.pdf (USDC, SDTX, 2003, Hittner, J.), wherein the Court stated:

> To conduct effective emergency communications, Snook must be able to achieve at least a 75 to 90 percent successful signal under the changing variables that impact emergency or other amateur radio communications. *Snook* Findings of Fact ¶ 9
>
> Based on his emergency and amateur radio experience, he estimated that an antenna array of 180 to 185 feet would be optimal. *Snook* Findings of Fact ¶ 15. [Note that Snook's requirements were for Texas, where hills – which impact propagation needs -- are rare.]

The key test is: What communications does the amateur desire? That is what must be accommodated by the municipality. Here is the way the test was originally stated by the FCC in 1985.

> [A]mateur station communications are only as effective as the antennas employed, antenna height restrictions directly affect the effectiveness of amateur communications. **Some amateur antenna configurations require more substantial installations than others if they are to provide the amateur operator with the communications that he/she desires to engage in.** For example, an antenna array for International amateur communications will differ from an antenna used to

> contact other amateur operators at shorter distances. **Federal Preemption of State and Local Regulations Pertaining to Amateur Radio Facilities** (FCC 85-506) (known as "PRB-1"), 9/16/85, ¶ 25. *(Emphasis added.)*

https://www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/prb-1-1985

As some courts and municipalities were to later misread the FCC's rule, the FCC found it necessary to clarify its ruling in 1999, by recognizing that there might be differences between "heavily-populated urban or suburban locales" and the rural situation involved here, wherein the Applicant resides on 2.5 acres of low density single family land.

> We believe that the effectiveness of these guidelines or standards can be gauged by the fact that a local zoning authority would recognize at the outset, when crafting zoning regulations, the potential impact that high antenna towers in heavily-populated urban or suburban locales could have and, thus, would draft their regulations accordingly. In addition, we believe that PRB-1's guidelines brings to a local zoning board's awareness that **the very least regulation necessary for the welfare of the community must be the aim of its regulations so that such regulations will not impinge on the needs of amateur operators to engage in amateur communications**.

https://www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/prb-1-1999 at ¶9 (*Emphasis supplied*).

DESCRIPTION OF THE PROPOSED SYSTEM

The station antenna structures will be erected to the rear of the Applicant's parcel, 400 feet from Federal Hill Road.

THE STATION ANTENNA STRUCTURE

The Applicant proposes to erect two station antenna structures manufactured by Rohn Manufacturing Company, of Peoria, IL, model number 45G, to a height of 90 feet. This is an equilateral, triangle design using 1.25" o.d., 14 gauge special quality steel. The Zig-Zag ® cross-bracing is formed from a continuous 7/16" solid steel rod electrically welded every 15.75" on the side rails. Each 10' sleeve is joined to the other and double bolted for extra strength. A copy of the manufacturer's specification sheet is included in **Exhibit F**. The station antenna structure will be guyed at in accordance with the manufacturer's instructions for the proposed height, see **Exhibit F**.

The system has been designed for Hillsborough County, New Hampshire, where the State Building Code (EIA-222) requirements for such a structure in Zone 3, Exposure B (suburban), and at a height of less than 100 feet, specify a design requirement "Basic Wind Speed" of 80 MPH. The structure will have an abundance of safety margin, as the building code itself has safety margins within it.

NO EFFECT ON MICROCLIMATE

The proposed installation will not emit heat, vapor or fumes. As it is unlighted, there will be no impact on dark skies. It will not impact air or water resources. It will not generate noise, nor change any temperatures. No additional traffic will be associated with this installation. It is not a hazard to air traffic.

EFFECTIVE VISUAL IMPACT IS MINIMAL

A Rohn 45G antenna support structure, with an 18-inch triangular lattice-style face, has an effective visual impact of 0.30 square feet per foot of tower, comparable to a 3.5-inch diameter flagpole (0.292 sq. ft.

per ft.).

The galvanized steel weathers quickly to a non-reflective, dull-gray finish, further diminishing its visibility. The rest is open air. Recall that haze-gray (as in "haze gray and under way") is the color chosen by the U.S. Navy and U.S. Air Force to make things less visible at sea and in the air.

To keep things in perspective, you should note that an ordinary telephone pole is about 12 inches in diameter. It is tar-black in color, which is much more noticeable against blue or gray skies than a dull-gray galvanized steel lattice tower—and few people pay much attention to telephone poles.

See **Exhibits M1** and **M2** for photographs showing the visibility of the proposed structures from several vantage points around the neighborhood. Structures of the same make and manufacture may be seen in the photographs included in **Exhibit L**).

WIND LOADING CONSISTENT WITH STANDARDS

Total wind load of the proposed system will not exceed the manufacturer's specifications, which also include a safety factor. Amateur radio is, by design promoted in Federal law, an experimental service. It is natural and expected that amateurs will change their antenna systems as interests change, and as propagation changes with the season and the 11-year sunspot cycle. In addition, the Applicant wishes to perform experiments in radio signal propagation, communications effectiveness, and antenna design and configuration needed to advance his knowledge and ability in the field of radio communications. Nonetheless, the antenna system shall not exceed the building code requirements of 30 psf. of wind load, well within the manufacturer's specifications for this antenna support structure.[2]

SITE CAREFULLY SELECTED

The Applicant's property is a 2.5 acre site, substantially wooded. Distances from the nearest tower to the boundary line of nearby properties:

Address	Distance (in feet)
152 Federal Hill Road	390
155 Federal Hill Road	530
164 Federal Hill Road	90
165 Federal Hill Road	470
171 Federal Hill Road	460
177 Federal Hill Road	515
178 Federal Hill Road	100
183 Federal Hill Road	600
188 Federal Hill Road	500

Distances from the nearest to nearby houses:

[2] Wind load is the equivalent horizontal force that will act on the structure. It is directly related to the surface area of the antenna. Safety factor describes the ratio between the maximum resistance load and the normal load. For example, if the wind load is 10 square feet, and the structure can hold a wind load equivalent to 20 square feet, the safety factor is 2.

Address	Distance (in feet)
152 Federal Hill Road	530
155 Federal Hill Road	730
164 Federal Hill Road	160
165 Federal Hill Road	620
171 Federal Hill Road	620
177 Federal Hill Road	575
178 Federal Hill Road	180
183 Federal Hill Road	650
188 Federal Hill Road	570

The careful reader of this application will note that the height of the proposed antenna structure is greater than the distance from its base to the nearest property line. But the fall zone requirements for commercial structures do not apply. The setback is six feet. The antennas, when rotated, will not invade the setback.

Accidents involving such structures are rare. They are so rare, in fact, that ARRL Volunteer Counsel Fred Hopengarten, of Lincoln, Massachusetts, reviewing 35 years of literature in amateur radio, was able to discover only a few published photographs, out of thousands of antenna photographs, showing how an antenna structure falls. In conjunction with these several photos, further discussions with mechanical engineers have yielded a better understanding of the failure modes of antenna structures.

A typical failure mode, which may occur when an antenna system is completely out in the open, involves a tower twisting and buckling. In effect, the structure corkscrews onto the ground. Towers do not fall the full length of their height, like a pencil. Instead, a failure occurs at the location of the highest combined stress ratio, as if there is a "mechanical fuse." This phenomenon is well known in physics, and is usually demonstrated in physics textbooks with a photograph of a falling chimney. As an example, see *Fundamentals of Physics*, 2nd Edition, by Halliday and Resnick, page 174, published by John Wiley & Sons:

> When a tall chimney is toppled by means of an explosive charge at its base, it will often break near its middle, the rupture starting at the leading edge. The top part will then reach the ground later than the bottom part.
>
> We note that as the chimney topples, it has at any instant an angular acceleration [A] about an axis through its base. The tangential acceleration [A_t] of its top is given by [$A_t = A_r$].
>
> As the chimney leans more and more, the vertical component of A_t comes to exceed *g* [gravity, or 9.8 m/s^2], so that the bricks at the top are accelerating downward more than they would in free fall. This can happen only as long as the chimney is a rigid body. As the chimney continues to fall, internal tension stresses develop along its leading edge. In nearly all cases rupture occurs, thus relieving those stresses.

Instances of damage caused by a falling antenna system are so rare that the presence of an amateur radio antenna system has no impact on the cost or availability of insurance for the homeowner.

Please note that to the rear of the Applicant's house, Eastward, atop Federal Hill, at a distance of 900 is a fire and lookout tower with multiple communications antennas, approximately 150 tall. By contrast, and as an accommodation to the Town, the Applicant has proposed total heights of less than 95 feet. There will be no need for illumination of the Applicant's towers, nor will there be any FAA-required red paint. See **Exhibit J**.

Just to the South, about 1300 feet away, are 2500 volt high tension lines, all on supports of approximately the same height of the radio pole under discussion here.

An aerial view of the site reveals the heavily forested nature of the entire area, and distances to near neighbors. See **Exhibit O**.

WHY THIS HEIGHT? "EFFECTIVE COMMUNICATIONS"

There are 11 commonly used amateur radio bands between 1.8 MHz and 144 MHz. The choice of which band to use depends on the distance between communicating stations, time of day, time of year, point in the 11-year sunspot cycle, as well as daily propagation conditions. At a given point in time, only one or two of these bands may be useful for communication to a particular location. To have a reasonably high probability of effective communications with a given location, at any given point in time, it is therefore necessary to have high performance antennas on all or most of these bands.

High performance is obtained by using directional antennas. (Recall, before cable TV, the need to aim our television antennas in the correct direction, or in some outlying areas, a rotator was necessary to receive signals from more than one direction.) Directivity not only strengthens received signals, but is also extremely useful to "null out" interfering stations.

High performance antennas can be particularly important under emergency conditions, when operating under auxiliary power sources, when operation may require communications with only low power output or communications with other stations operating under adverse conditions. In addition, doubling the height of the antenna is considered to be approximately equivalent to doubling the power output (permitting lower power, consistent with emergency batteries as power sources). While doubling the power output might be within the capability of the Applicant (up to a maximum of 1500 watts output), doubling the power output on the Applicant's end has no impact on received signals. The height of the antenna is a critical factor in two-way communications.

For communications at frequencies below 30 MHz (High Frequency (HF), or the "shortwave bands"), the height of an antenna above ground is the major controlling factor on the vertical angle at which signals are transmitted ("takeoff"), which in turn directly affects the reliability and dependability of worldwide signal paths. Besides height above ground, the local terrain in the vicinity of the structure can also affect takeoff, as it can reflect and diffract the signal in the near field. If the antenna is not "high enough," signal reliability is compromised; in other words, communications to certain parts of the world can be strictly limited, or nonexistent.

"High enough" is commonly accepted to be, *at a minimum,* ½ wavelength high at the lowest frequency used. A height of 1 to 1½ wavelengths at this lowest frequency is more preferable. The proposed station antenna structure will support antennas for 7 MHz and above. At 7 MHz, ½ wavelength is approximately 70 feet, and 1 wavelength is approximately 140 feet. Thus, the proposed structure represents a significant, but acceptable, compromise by the Applicant.

Communications at frequencies above 30 MHz (known as VHF for Very High Frequencies, or UHF for Ultra High Frequencies -- examples: FM radio, TV, police and fire departments) can be dependent on 'line of sight'. Most *local* emergency communications are conducted above 30 MHz. Here, topography, trees and buildings all cause significant signal loss. Thus, antennas that are above, free and clear of such obstructions permit the amateur to communicate more effectively, over greater distances and using lower power levels. These are the frequencies at which most local emergency communications are conducted. Doubling the height of the antenna is considered to be approximately equivalent to doubling the power output. Considered together, these two factors are strong arguments for higher antennas.

Accompanying this application are two radio propagation studies, one for HF and one for VHF. They show that the heights of the proposed structures represent a significant compromise, but one that is acceptable to the Applicant. Despite additional advantages which might be obtained, the Applicant has no intention of going over 200' in height, as that might then require lighting and painting under FAA regulations. An FAA study of hazards to aircraft is required, speaking generally, only for heights above 200 feet and in very close proximity to an airport. At this height and at this location, no lighting or painting is required. 47 CFR § 17.7. See **Exhibit J**.

The height of the antenna structures satisfies all of these concerns by:

1) Placing the antennas high enough to allow reliable VHF communication, free from obstruction by intervening terrain, and

2) Satisfying the minimum reliability requirements for HF communication at 1.8 MHz and above.

It is a well-recognized phenomenon that communications effectiveness is often a function of height. This was suggested by the American Red Cross when it encouraged the FCC to adopt its limited preemption for amateur radio antenna systems. See **Exhibit I.** The concept is also plainly stated by the FCC in PRB-1, see the discussion above, and has been reiterated by the courts numerous times.

For the purpose of providing emergency communications, a 7 KW Briggs & Stratton generator, has been installed at the residence. See **Exhibit H**.

When complete, the amateur radio station, with its indispensible antenna system, will be a substantial addition to the emergency communications capabilities of the community, and the county, aligning it with the very basis and purpose of the FCC's amateur radio service.

LOCAL TERRAIN REQUIRES ADDITIONAL HEIGHT

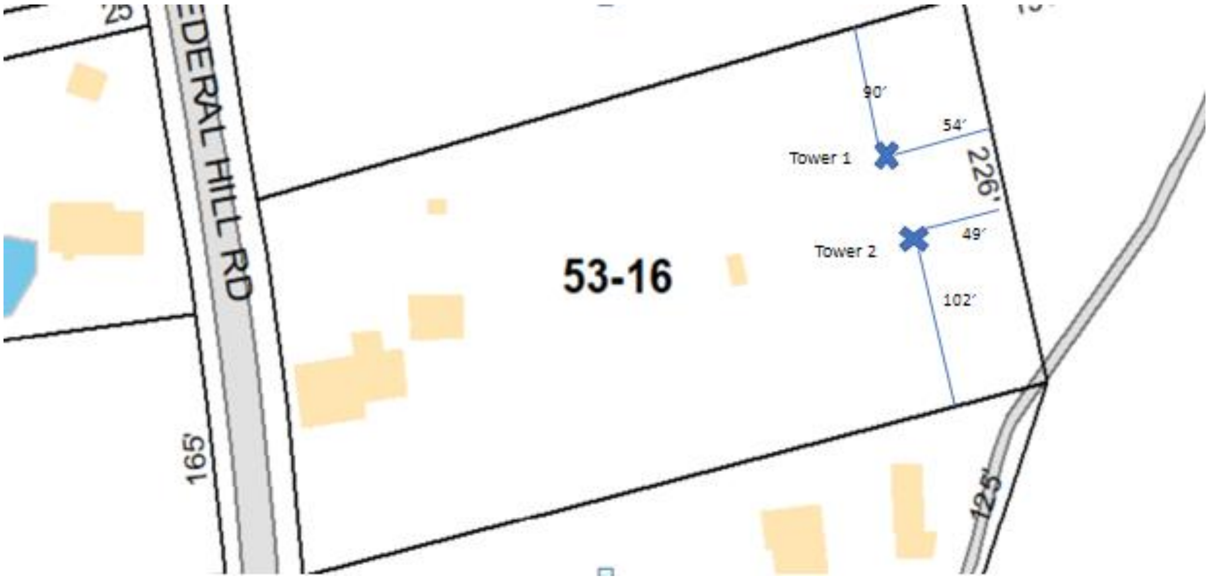
This Applicant's need for the height proposed is greatly influenced by intervening local terrain, especially Federal Hill – to the East and having a substantial impact on propagation from Northeast to Southeast. This topographic map shows that the terrain rises from 550' at the site, to 680' at the Lookout Tower, and in a very desirable direction from communications with Europe. The Applicant's towers, 90 feet tall, will not even "see" over the top of the hill. In fact, the Applicant's towers will be 40 feet shorter than the top of the hill.

Topo map showing that terrain rises dramatically in the direction of Europe, a highly desired direction of communications.
Source: http://www.acme.com/mapper

As the Court noted in *Bodony v. Sands Point*, 681 F. Supp. 1009 (E.D. NY 1987), (preempting a 25' height limit, permitting an 86' station antenna structure):

> **One factor in determining the range and effectiveness of radio communication is the height of the antenna. Measurement from the ground tells us little. A 25 foot antenna in a valley surrounded by hills might be useless, while that equipment on a mountain top might give optimum results. An antenna rising above the obstacles that interfere with radio signals obviously gives a greater range and better reception than an antenna of a lesser height.**

To the extent any decision fails to account for local terrain, it would fail to be a reasonable accommodation.



For the purposes of calculating the Applicant's transmitting power to the applicable distance to the nearest boundary line (where access is "uncontrolled," to use an FCC term), calculations were made at a distance of 49 feet from the nearest boundary (the boundary of the water tower land, Lot 53-21).

The maximum legal limit for transmitter output power is 1500 watts. As an amateur radio station, and a hobby of the Applicant, the transmitter will be in intermittent service. Even when an amateur is active, transmissions occupy less than 50% of the time of activity, as amateurs listen more than half the time.

By contrast, typical FM broadcast or AM broadcast stations use from 5,000 to 50,000 watts, continuous duty. Think of it another way—the energy of a ham radio station, at maximum power output, is about the same as a kitchen toaster[3]. Nonetheless, in accordance with 47 CFR § 97.13(c)(1), as the proposed power output exceeds 50 watts at 10 meters (28 MHz), the Applicant has performed the required routine RF environmental evaluation prescribed by 47 CFR § 1.1307(b). Using the output power at the antenna, after feed-line losses, and calculating the energy per square centimeter, the standard units of measurement in these matters are expressed in mW/cm^2, this amateur station, in a worst-case scenario, will produce only 0.019 milliwatts per square centimeter of power, or 8.8% percent of the American National Standards Institute (ANSI) and FCC safety standard at that frequency (the worst case frequency), as measured at 105 feet away from the antenna, at the property line. **Exhibit M** contains the computations for the engineering calculations of power density supporting the statements above. The closest dwelling is 160 feet away from the nearest station antenna structure.

In this case, if the Applicant were to put up the antenna at a lower height, the power required for the same reliability of communications would increase. Thus, a lower antenna would be closer to a neighbor and increase exposure (although exposure would still remain well below the regulatory threshold).

Under the Environmental Policy Act of 1969 (NEPA), 42 USC § 4321 *et seq*. (1976) at § 4332 (2)(c), and as allowed by regulations of the Council on Environmental Quality (CEQ), 40 CFR § 1508.4, the FCC has ordered categorical exclusion of amateur radio stations from the need to do Environmental Assessments.

[3] *See e.g.* Sylvania KWS 1517-01 Electric Oven.

FCC Gen. Docket No. 79-144, adopted February 12, 1987.

Furthermore, a search of the literature fails to find a single example in the history of radio in which an amateur radio station has caused injury or death to a neighbor from exposure to amateur radio signals at any power level.

When amateurs complete FCC Form 605, to obtain or renew a license, they must understand and certify by signature the following statement: "Amateur Applicant certifies that the construction of the station would NOT be an action that is likely to have a significant environmental effect" (see FCC Rules 47 CFR §§ 1.1301-1.1319 and § 97.13(a)). The only amateurs who may be required to file an Environmental Assessment (EA) under the National Environmental Policy Act of 1969 are those whose stations will be located in an officially designated wildlife area; areas that are significant in American history, architecture, archeology, engineering or culture; areas that are listed, or are eligible for listing, in the National Register of Historic Places; where the facility may affect Indian religious sites; facilities located in a flood plain; facilities whose construction will involve significant change in surface features (e.g., wetland fill, deforestation or water diversion), those which require tower lighting; and stations that exceed the maximum permitted RF exposure limits. 47 CFR § 1.1307 (a)-(b).

The Applicant's location for the antenna system does not involve any such concerns. No environmental assessment need be filed.

GOOD ENGINEERING PRACTICES EMPLOYED

The proposed antenna support structure has been manufactured in accordance with the industry standard, EIA/TIA-222-E, by Rohn Products LLC, a leading manufacturer of antenna support structures since 1948 (over 70 years), http://www.rohnnet.com. They used the hot bell die swaging process to manufacturer the pole. The design criteria included the assumption of ½ inch of ice loading on both the pole and all antennas, at a wind velocity of 80 miles per hour. As the Basic Wind Speed for Hillsborough County, NH under the EIA/TIA code is 80 miles per hour (EIA/TIA-222 code, page 44), this antenna support structure is overbuilt.

INSURANCE COVERS LOSSES

If a tree falls in a forest and no one is around to hear it, does it make a sound? This popular philosophical riddle may not have any practical application to the matter at hand, but it does beg the question: What if the station antenna structure falls?

Accidents involving such structures are rare. They are so rare, in fact, that ARRL Volunteer Counsel Fred Hopengarten, of Lincoln, Massachusetts, reviewing 25 years of literature in amateur radio, was able to discover only a few published photographs, out of thousands of antenna photographs, showing how an antenna structure falls. In conjunction with these several photos, further discussions with mechanical engineers have yielded a better understanding of the failure modes of antenna structures.

A typical failure mode, which may occur when an antenna system is completely out in the open, involves a tower twisting and buckling. In effect, the structure corkscrews onto the ground. Towers do not fall the full length of their height, like a pencil. Instead, a failure occurs at the location of highest combined stress ratio, as if there is a mechanical "fuse." Instances of damage caused by a falling antenna system are so rare that the presence of an amateur radio antenna system has no impact on the cost or availability of insurance for the homeowner. The Applicant's standard homeowner's policy provides liability coverage due to failure of an amateur radio antenna structure, without additional premium. From an actuarial point of view, this means that these structures are considerably safer than allowing a teenage boy to drive.

The Applicant's standard New Hampshire homeowner's policy provides coverage for personal liability and medical payments due to failure of an amateur radio antenna structure, without additional premium. From an actuarial point of view, this means that these structures are considerably safer than allowing a teenage boy to drive.

Not an Attractive Nuisance. An opponent to the project might argue that the proposed structure is an attractive nuisance. Certainly the station antenna structure can be seen as "attractive," in the sense that it is majestic. But can such a structure potentially be an *attractive nuisance* in the legal sense? Children have never been seen on this property anywhere near the structure. Nonetheless, the towers will be 400 feet from the public way and anti-climb protection will be installed on both.

RADIO FREQUENCY INTERFERENCE COMPLETELY PREEMPTED

The question of the potential for radio-frequency interference (RFI) has been completely preempted by Federal law on the matter. In amending the Communications Act of 1934 in 1982, the Congress clearly expressed its opinion:

> The Conference Substitute is further intended to clarify the reservation of exclusive jurisdiction to the Federal Communications Commission over matters involving RFI [radio frequency interference]. Such matters shall not be regulated by local or state law, nor shall radio transmitting apparatus be subject to local or state regulation as part of any effort to resolve an RFI complaint. [T]he Conferees intend that regulation of RFI phenomena shall be imposed only by the Commission.

H.R. Report No. 765, 97th Cong., 2d Sess. 33 (1982), reprinted in 1982 U.S. Code Cong. & Ad. News 2277, referring to amendments to Section 302(a) of the Communications Act.

In a private letter opinion to the American Radio Relay League, Inc., dated February 14, 1990, Robert L. Pettit, General Counsel of the Federal Communications Commission (FCC) adopts the position of the Congress as the position of the FCC, writing:

> State laws that require amateurs to cease operations or incur penalties as a consequence of radio interference thus have been entirely preempted by Congress.

These opinions have been confirmed repeatedly by the courts. See, for example, ***Broyde v. Gotham Tower***, 13 F.3d 994 (6th Cir., 1994). For an excellent discussion, and a wealth of cases, see ***Southwestern Bell Wireless, Inc. v. Johnson County Board of County Commissioners,*** 199 F.3d 1185, 1193 (10th Cir. 1999), *cert. denied*, 530 U.S. 1204 (2000).

Another well-written and thorough discussion states plainly: "We conclude that allowing local zoning authorities to condition construction and use permits on any requirement to eliminate or remedy RF interference 'stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress.'" ***Freeman v. Burlington Broadcasters, Inc.,*** 204 F. 3d 311, 326 (2d Cir. 2000), cert. denied, 531 U.S. 917 (2000).

In 2000, the Congress passed, and the President signed, P.L. 106-521 which further clarified, if there was room for doubt, that municipalities have no authority to act with respect to interference. The Communications Act, at 47 USC § 302a, now reads, in relevant part:

47 USC § 302a. Devices which interfere with radio reception

SUBCHAPTER III - SPECIAL PROVISIONS RELATING TO RADIO

. . .

(f) (2) A station that is licensed by the Commission pursuant to section 301 of this title in any radio service for the operation at issue shall not be subject to action by a State or local government under this subsection. A State or local government statute or ordinance enacted for purposes of this subsection shall identify the exemption available under this paragraph.

(3) The Commission shall, to the extent practicable, provide technical guidance to State and local governments regarding the detection and determination of violations of the regulations specified in paragraph (1).

(4) (A) In addition to any other remedy authorized by law, a person affected by the decision of a State or local government agency enforcing a statute or ordinance under paragraph (1) may submit to the Commission an appeal of the decision on the grounds that the State or local government, as the case may be, enacted a statute or ordinance outside the authority provided in this subsection.

(B) A person shall submit an appeal on a decision of a State or local government agency to the Commission under this paragraph, if at all, not later than 30 days after the date on which the decision by the State or local government agency becomes final, but prior to seeking judicial review of such decision.

(C) The Commission shall make a determination on an appeal submitted under subparagraph (B) not later than 180 days after its submittal.

(D) If the Commission determines under subparagraph (C) that a State or local government agency has acted outside its authority in enforcing a statute or ordinance, the Commission shall preempt the decision enforcing the statute or ordinance.

(5) The enforcement of statute or ordinance that prohibits a violation of a regulation by a State or local government under paragraph (1) in a particular case shall not preclude the Commission from enforcing the regulation in that case concurrently.

(6) Nothing in this subsection shall be construed to diminish or otherwise affect the jurisdiction of the Commission under this section over devices capable of interfering with radio communications.

Finally, we call attention to a ruling of the United States District Court for the Northern District of New York in ***Palmer v. City of Saratoga Springs***, 180 F. Supp. 2d 379, 385 (N.D.N.Y. 2001):

> The few Planning Board requests that Palmer refused to agree to were unreasonable on their face. . . . Palmer refused to give the Planning Board any additional information on the issue of interference for the simple reason that the issue of possible interference was beyond the Board's purview.
>
> . . .
>
> Normally, the Court would simply instruct the Planning Board to comply with [the preemption]. However, given that the Planning Board was already fully apprised of its duties under [the preemption] when it reconsidered Palmer's application, such action would likely be futile. The Court thus enjoins the Planning Board from taking further action interfering with Palmer's special use permit application and orders the Planning Board to grant the application with the conditions already agreed to by Palmer.

Nonetheless, amateurs generally, and this Applicant in particular, are prepared to offer aid beyond the requirements of law. Should it be necessary, the Applicant pledges to cooperate with any individual, whether or not an abutter, who owns equipment that might be affected.

At least one study by the FCC Field Operations Bureau has shown that amateurs are responsible for less than 1% of all interference complaints (400 of 42,000 complaints during a fiscal year in the early 1970's) filed with the Commission. (Source: FCC data, as reported in *QST*, July 1974, p. 10). Today, with cable TV, that percentage has declined. Part of the preparation for licensing involves studying how to minimize and correct such problems, if they should ever occur.

Furthermore, many home entertainment electronic devices, including portable telephones, bear the following required label, in accordance with 47 CFR §15.19(a)(3):

> This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Actually, the erection of this antenna system will have a tendency to *decrease*, not increase, the likelihood of television interference, as higher antenna systems (with directional arrays) are farther away from neighboring television sets and transmit *over* nearby homes. Lower antennas, erected in trees, or on a shorter antenna support structure, for example, have a greater likelihood of interference, since they would direct more energy toward a neighboring TV set.

This is exactly the position that was taken by the FCC's Chief of the Private Radio in a letter to the Board of Zoning Appeals of Hempstead, NY (October 25, 1994):

> (A)ntenna height is inversely related to the strength, in the horizontal plane, of the radio signal that serves as a catalyst for interference in susceptible home electronic equipment. It is a matter of technical fact that the higher an amateur antenna, the less likely it is that radio frequency interference will appear in home electronic equipment.

For a review of the field of radio frequency interference (RFI), see *The Ghost in the Computer: Radio Frequency Interference and the Doctrine of Federal Preemption*, Brock, 1999 Computer L. Rev. & Tech. J. 17 (Fall 1998-Spring 1999), available on-line at http://www.arrl.org/files/file/Rfi-art.pdf. Here is the conclusion to that law review article covering the subject and reviewing the case law. It sums up the situation.

> **V. CONCLUSION**
>
> Although home electronic equipment is immersed in a sea of radio frequency energy from myriad sources, most of it functions as intended. The FCC has the authority to virtually eliminate RFI problems by requiring manufacturers to implement design features and filtering that would make all home electronic equipment "bullet proof." Instead, it has chosen to require such equipment to accept any interference it receives, while relying on the marketplace to compel manufacturers to produce serviceable merchandise.
>
> Historically, local authorities have attempted to regulate RFI as a common-law nuisance or trespass. But as courts have consistently concluded, Congress has completely preempted the field of RFI regulation, thus precluding local regulation and state-law claims. Although legislation has been proposed that would yield some limited authority to local governments to regulate illegal CB operations, such legislation has not been enacted.
>
> City, county, and private attorneys who understand how federal preemption applies in RFI matters can prevent potential litigants, beset by RFI problems, from filing ineffective lawsuits. Attorneys should also help their clients to understand that under current law, RFI is properly viewed as the equipment's inability to reject unwanted signals, not as transmitter interference. The focus of eliminating RFI can then properly shift to improving the filtering capabilities of home

> electronic equipment. Unless the law changes, this approach is the only reliable method of exorcizing the ghost in the computer.

PROPERTY VALUES ARE UNAFFECTED

Research by the American Radio Relay League, the National Organization for Amateur Radio, has failed to find any evidence in the appraisal literature, or anywhere else, that home values are harmed by the presence of amateur radio antenna systems. The only study found concluded:

> In the course of this study, I have looked at seven different locations. I have considered thirty three matched pairs. As I indicated in the introduction, this has covered a variety of types, styles locations, time periods, and lot sizes. In no instance have I been able to discover any measurable, uniform decline in value that can be attributed to the presence of a radio antenna. This is verified by my general real estate experience in over 35 years of selling various kinds of residential properties throughout the Denver Metropolitan Area. The presence of a radio antenna has not only failed to make a measurable difference in value, it has not affected the sales time for the properties involved. Therefore, I have concluded that it is not a measurable factor in value.

Russ Wehner, Jr., MAI, SRPA (Appraiser), evidence in *Evans v. Boulder*, 994 F2d 755 (10th Cir., 1993) (decided on other grounds).

Finally, the Applicant assures the Town that should he no longer reside at the property, assuming no other person residing there wishes to continue using the structure, he will remove the station antenna structure. He has every intention of taking everything to his next home.

LEGAL: PREEMPTION & CASE LAW SUPPORT THE APPLICATION

Zoning for amateur radio antenna systems is one of those rare areas of law where an application must be considered against the background of a federal preemption of local zoning law. The Congress of the United States has weighed in on the subject.

SENSE OF CONGRESS

Sec. 10

(a) The Congress finds that —

(1) more than four hundred thirty-five thousand four hundred radio amateurs in the United States are licensed by the Federal Communications Commission upon examination in radio regulations, technical principles, and the international Morse code;

(2) by international treaty and the Federal Communications Commission regulation, the amateur is authorized to operate his or her station in a radio service of intercommunications and technical investigations solely with a personal aim and without pecuniary interest;

(3) **among the basic purposes for the Amateur Radio Service is the provision of voluntary, noncommercial radio service, particularly emergency communications**; and

(4) volunteer amateur radio emergency communications services have consistently and reliably been provided **before, during, and after floods, tornadoes, forest fires, earthquakes, blizzards, train wrecks, chemical spills, and other disasters**.

(b) It is the sense of Congress that —

(1) it strongly encourages and supports the Amateur Radio Service and its emergency communications efforts; and

(2) Government agencies shall take into account the valuable contributions made by amateur radio operators when considering actions affecting the Amateur Radio Service.

(Emphasis added.)

Federal Communications Commission Authorization Act of 1988. Pub. L. No. 100-594, 102 Stat. 3021, 3025 (November 3, 1988); *see also* Joint Explanatory Statement of the Committee of Conference on H.R. Conf. Rep. No. 386. 101st Cong., 1st Sess. 415, 433 (November 21, 1989), *reprinted in 1990* U.S. Code Cong. & Admin. News 3018, 3037 (amateur licensees exempted from new Commission-wide fees program because "[t]he Conferees recognize that amateur licensees do not operate for profit and can play an important public safety role in times of disaster or emergency"). Joint Explanatory Statement of the Committee of Conference on H.R. Conf. Rep. No. 765, 97th Cong., 2d Sess. 18-19 (August 19, 1982), *reprinted in* 1982 U.S. Code Cong. & Admin. News 2261, 2262-63.

PUBLIC LAW 103-408—OCT. 22, 1994

103d Congress
Joint Resolution

To recognize the achievements of radio amateurs, and to establish support for such amateurs as national policy.

Whereas Congress has expressed its determination in section 1 of the Communications Act of 1934 (47 U.S.C. 151) to promote safety of life and property through the use of radio communication;

Whereas Congress, in section 7 of the Communications Act of 1934 (47 U.S.C. 157), established a policy to encourage the provision of new technologies and services;

Whereas Congress, in section 3 of the Communications Act of 1934, defined radio stations to include amateur stations operated by persons interested in radio technique without pecuniary interest;

Whereas the Federal Communications Commission has created an effective regulatory framework through which the amateur radio service has been able to achieve the goals of the service;

Whereas these regulations, set forth in Part 97 of title 47 of the Code of Federal Regulations clarify and extend the purposes of the amateur radio service as a—

(1) voluntary noncommercial communication service, particularly with respect to providing emergency communications;
(2) contributing service to the advancement of the telecommunications infrastructure;
(3) service which encourages improvement of an individual's technical and operating skills;
(4) service providing a national reservoir of trained operators, technicians and electronics experts; and
(5) service enhancing international good will;

Whereas Congress finds that members of the amateur radio service community has provided invaluable emergency communications services following such disasters as Hurricanes Hugo, Andrew, and Iniki, the Mt. St. Helens Eruption, the Loma Prieta earthquake, tornadoes, floods, wild fires, and industrial accidents in great number and variety across the Nation; and

Whereas Congress finds that the amateur radio service has made a contribution to our Nation's communications by its crafting, in 1961, of the first Earth satellite licensed by the Federal Communications Commission, by its proof-of-concept for search rescue satellites, by its continued exploration of the low Earth orbit in particular pointing the way to commercial use thereof in the 1990s, by its pioneering of communications using reflections from meteor trails, a technique now used for certain government and commercial communications, and by its leading role in development of low-cost, practical data transmission by radio which increasingly is being put to extensive use in, for instance, the land mobile service: Now, therefore, be it

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. FINDINGS AND DECLARATIONS OF CONGRESS

Congress finds and declares that—

(1) radio amateurs are hereby commended for their contributions to technical progress in electronics, and for their emergency radio communications in times of disaster;

(2) the Federal Communications Commission is urged to continue and enhance the development of the amateur radio service as a public benefit by adopting rules and regulations which encourage the use of new technologies within the amateur radio service; and

(3) reasonable accommodation should be made for the effective operation of amateur radio from residences, private vehicles and public areas, and that **regulation at all levels of government should facilitate and encourage amateur radio operation as a public benefit**.

Approved October 22, 1994.

(Emphasis added.)

The Applicant wishes to call attention to Federal law that preempts certain elements of regulation by a municipality. Federal Communications Commission Order PRB-1, 101 FCC 2d 952, 50 Fed. Reg. 38813 (September 25, 1985), declares in pertinent part:

> Local regulations which involve placement, screening, or height of antennas based on health, safety or aesthetic considerations must be crafted to accommodate reasonably amateur communications, and to represent the **minimum** practicable regulation to accomplish the local authority's legitimate purpose.

(Emphasis added.)

https://www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/prb-1-1985

The above order has subsequently become part of the Code of Federal Regulations, as 47 C.F.R. § 97.15 (b):

> Except as otherwise provided, a station antenna structure may be erected at heights and dimensions sufficient to accommodate amateur service communications. State and **local regulation of a station antenna structure** must not preclude amateur service communications. Rather, it **must reasonably accommodate** such communications **and must constitute the minimum practicable regulation** to accomplish the state or local authority's legitimate purpose.

(Emphasis added.)

In 1999, the FCC amplified the restrictions on the powers of municipalities and zoning boards when it issued a further Order, holding that:

> **. . . the very least regulation necessary for the welfare of the community must be the aim of its regulations so that such regulations will not impinge on the needs of amateur operators to engage in amateur communications.**

(Emphasis added.)

In the Matter of Modification and Clarification of Policies and Procedures Governing Siting and Maintenance of Amateur Radio Antennas and Support Structures, etc.
https://www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/prb-1-1999, at ¶ 9.

Federal regulations have the same preemptive force as federal statutes. See *Fidelity Savings and Loan Ass'n v. de la Cuesta*, 458 U.S. 141, 153-54 (1983). A local authority that ignores these federal laws violates the supremacy clause of the U.S. Constitution, Article VI, clause 2 which states:

> This Constitution, and the Laws of the United States which shall be made in Pursuance thereof; and all Treaties made, or which shall be made, under the Authority of the United States, shall be the supreme Law of the Land; and the Judges in every State shall be bound thereby, **any Thing in the Constitution or Laws of any state to the Contrary notwithstanding.** *(Emphasis added.)*

FIRM, FIXED, UNVARYING HEIGHT RESTRICTIONS ARE VOID

The Courts have routinely enforced the federal regulation and FCC rulings that favor amateur radio, which have the power of federal law. See:

Bodony v. Sands Point (NY), 681 F. Supp. 1009 (E.D.N.Y. 1987). Ordinance with a firm 25' height limit. Proposed station antenna structure: 86'. Summary judgment for ham; settled with permit granted and $60,000 in legal fees to ham on §1983 claim, because town was seeking ways to deny his rights (soliciting opinion of counsel on how to deny, without regard to merits).

Izzo v. River Edge (NJ), 843 F.2d 765 (3d Cir. 1988). Upholds preemptive effect of PRB-1 on 35' height limitation. "The effectiveness of radio communication depends on the height of antennas." *Id.* at 768. The court need not abstain. Court awarded fees to ham radio operator of $10,000.

Brower v. Indian River County Code Enforcement Board (FL), No. 91-0456 CA-25 (June 23, 1993), 1993 WL 228785 (Fla.Cir.Ct.). Support structure of 68.88 feet, plus antenna to total of 95.6 feet; 72.4 feet from neighbor's property line. By-law had an absolute prohibition on towers over 70'. Ham erected without first attempting to obtain a permit. Court held that any application for a permit would have been futile ("a circular dead-end"). Ordinance facially void as an unvarying maximum height: "We agree with the Evans court's adoption of prior rulings in that case which concluded that flat prohibitions of this nature are not permitted, [Evans v. Commissioners, County of Boulder, Co., 752 F. Supp. 973,] 976 [(D. Colo. 1990)]."

Pentel v. Mendota Heights (MN), 13 F3d 1261 (8th Cir. 1994). Ham applied for 68' antenna (crank-up 30-68' and two Yagis). Absolute 25' height limit in ordinance preempted. Rejects balancing test, as the FCC did the balancing. Accepts 56.5' height as ineffective.

Palmer v. Saratoga Springs (NY), 180 F. Supp. 2d 379 (N.D.N.Y. 2001). Absolute height limit of 20' in ordinance preempted. "(A)n unvarying height restriction on amateur radio antennas would be facially invalid in light of PRB-1." (Citing *Pentel, Evans and Bulchis*.) Commentary on bad faith of town. Request for information on Radio Frequency Interference "unreasonable on (its) face." Grant of permit as applied for, without further proceedings.

Marchand v. Town of Hudson (NH), 788 A.2d 250, 147 N.H. 380 (N.H. 2001). Three, 100' tall antenna systems. Ruling that balancing is not appropriate. "(T)o "reasonably accommodate" amateur radio communications . . . the ZBA may consider whether the particular height and number of towers are necessary to accommodate the particular ham operator's communication objectives. Remand to determine if three towers is a customary accessory use under NH law. [On remand, Hudson, NH Board held that three towers qualifies as a customary use.
http://www.arrl.org/files/file/hudson.pdf
or http://www.antennazoning.com/docs/marchand-decision.pdf]

Snook v. Missouri City (TX), 2003 U.S. Dist. LEXIS 27256, 2003 WL 25258302 (S.D. Tex. Aug. 26, 2003, Hittner, J.) (the Order, Slip Opinion, 63 pp.), see also the Final Judgment, Slip Opinion, 2 pp. May be found at http://www.arrl.org/files/file/Snook%20KB5F%20Decision%20&%20Order%2034.pdf, see also the Final Judgment, Slip Opinion, 2 pp.

Original bylaw permitted only 35', second bylaw permitted more by specific use permit. After grant of building permit under first bylaw (B/I recognized 35' was not legal), Ham built 114'. City cited Ham for repeated violations of second bylaw for failure to have specific use permit, which it declined to grant. City expert recommended 50-60' for 20 meter antenna, and just above tree tops (60-80') for VHF/UHF, but ignored 40 and 80 meter antenna argument. For no special reason, City decided 65' as acceptable. "To conduct effective emergency communications, Snook must be able to achieve at least a 75 to 90 percent successful signal under the changing variables that impact emergency or other amateur radio communications." Findings of Fact ¶ 9. City Ordinance preempted. **Order for City to issue permit (no remand) consistent with existing structure.** Citing *Younger v. Harris*, Court declined to enjoin City, but received assurances City would not further prosecute. "PRB-1 requires a site-specific, antenna-specific, array-specific, operations-specific, ordinance-specific, and city action-specific analysis. PRB-1 at p. 7." [Referring to PRB-1 paragraphs 24 and 25.]

Chedester v. Town of Whately (MA), Superior Court, Franklin ss., Civil Action No. 03-00002, Hillman, J., November 22, 2004, http://www.antennazoning.com/docs/chedester-decision.pdf (2004). Bylaw permitted no more than 35'. Ham granted permit for 140' on 10 acres in agriculture/residential zone when Building Inspector decided bylaw was preempted. Planning Board appeals to ZBA. ZBA revokes permit. Superior Court ruled that town misinterprets both state and federal preemption in holding that while the ordinance may permit antennas over 35', restrictions on antenna support structures are not similarly affected. Height limit of 35' found to be "an absolute and unvarying height restriction" and preempted. "A 35' height restriction would effectively mean that no radio communications would be able to be transmitted." **Building permit reinstated.**

Finally, the Town should be aware of ***Borowski v. City of Burbank (IL),*** 101 F.R.D. 59 (N.D. Ill. 1984), authorizing a class action in Illinois federal court for a claim that a local ordinance illegally regulated the "size, location and height" of amateur radio antennas.

In addition to the above matters of Federal law, New Hampshire law limits municipal action. See RSA § 674:17.III:

> Except as provided in RSA 424:5 or RSA 422-B or in any other provision of Title XXXIX, no city, town, or county in which there are located unincorporated towns or unorganized places shall adopt a zoning ordinance or regulation with respect to antennas used exclusively in the amateur radio service that fails to conform to the limited federal preemption entitled Amateur Radio Preemption, 101 FCC 2nd 952 (1985) issued by the Federal Communications Commission.

Why is it important to know about all of this legal background? Because this Board has an obligation to accommodate the radio amateur in the communications that he or she desires to realize; because the Town may only impose "the minimum practicable regulation," and the Board may *not* balance the amateur's needs with the needs of the Town. The FCC has already done the balancing. As the Commission has ruled: "[I]t is clear that a "balancing of interests" approach is not appropriate in this context." FCC DA 99-2569 at ¶ 7.

http://www.fcc.gov/Bureaus/Wireless/Orders/1999/da992569.txt

AMATEUR RADIO IS AN ORDINARY ACCESSORY USE

Amateur radio antennas are customarily incidental to residential use. *See, e.g., Town of Paradise Valley v. Lindberg*, 551 P.2d 60, 61-62 (Ariz. Ct. App. 1976) (holding that the erection of a ninety-foot amateur radio tower in conjunction with a homeowner's hobby as a ham radio operator is a permissible accessory or incidental use); *Skinner v. Zoning Bd. of Adjustment*, 193 A.2d 861, 864 (N.J. Super Ct. App. Div 1963) (upholding a 100-foot radio antenna tower used as a hobby as an accessory use customarily incidental to the enjoyment of a residential property); *Dettmar v. County Bd. of Zoning Appeals*, 273 N.E. 2d 921, 922 (Ohio Ct. Com. Pl. 1971) (finding that even an unusual customarily incidental use is permissible unless specifically excluded by a zoning restriction). Another common thread in these cases is that neighbors do not determine what is customarily incidental to a particular homeowner's use of his property. *Paradise Valley*, 551 P.2d at 62; *Dettmar*, 273 N.E.2d at 922 (use customarily incidental "does not limit the use to the incidental activity chosen by the neighbors").

THIS BOARD MUST ACCOMMODATE THE INDIVIDUAL RADIO AMATEUR

The New Hampshire Supreme Court has decided:

> In light of the FCC's requirement, a zoning board's fact-finding and analysis should focus, first, on whether the three towers are permitted under local zoning regulations. If, as we have determined here, they are not, the zoning board should then consider what steps must be taken to "reasonably accommodate" amateur radio communications. In making this determination, the ZBA may consider whether the particular height and number of towers are necessary to **accommodate the particular ham operator's communication objectives**.
>
> There was some evidence presented to the ZBA that the tower and antenna operation "was not the typical installation, but rather was something that every ham who was interested in reliable international communication on a regular basis aspired to own." The ZBA, however, did not make any factual findings regarding whether Muller even requires the proposed three radio towers **to facilitate his international ham radio operations**. Therefore, we vacate the superior court's decision and remand with instructions to remand to the ZBA for proceedings consistent with this opinion.

(*Emphasis added.)*

Marchand v. Town of Hudson, 788 A.2d 250 (N.H. 2001). So the question is not whether some other amateur might be satisfied, or some communications would be effective. The question relates to "the particular ham."

As the Federal District Court said in the *Snook* case:

> PRB-1 requires a site-specific, antenna-specific, array-specific, operations-specific, ordinance-specific, and city action-specific analysis. PRB-1 at p. 7.

Snook v. Missouri City, *Id.*

The reference to "PRB-1 at p.7" by the *Snook* Court is to PRB-1 ¶ 25:

> 25. Because amateur station communications are only as effective as the antennas employed, antenna height restrictions directly affect the effectiveness of amateur communications. Some amateur antenna configurations require more substantial installations than others if they are to provide the amateur operator with the communications that he/she desires to engage in.

FCC Order PRB-1, 101 FCC 2d 952, 50 Fed. Reg. 38813, September 25, 1985, ("PRB-1"), https://www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/prb-1-1985.

If another radio amateur were to come along and say: "I'm perfectly happy with a dipole at 18 feet," that would not, in any way, address the PRB-1 requirement "to provide the amateur operator with the communications that he/she desires to engage in."

Note that this not a "Reasonable Man" test, and it is not a "Reasonable Ham" test. Re-read the FCC Preemption (PRB-1), at ¶ 25:

> Some amateur antenna configurations require more substantial installations than others if they are to provide the amateur operator with the **communications that he/she desires to engage in**.

It is very important to understand that this is a subjective test. The amateur determines the communications desired. After the amateur operator has determined the communications desired, regulation "must constitute the **minimum practicable regulation**" 47 CFR Sec. 97.15(b). Furthermore, the law requires that such regulation "will **not impinge on the needs** of amateur operators to engage in amateur communications." FCC DA 99-2569, at ¶ 9. https://www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/prb-1-1999. *(Emphasis supplied.)*

MULTIPLE TOWERS ARE PERMISSIBLE

An opponent to this project might argue that perhaps one amateur radio station antenna structure may be permissible, but multiple antenna systems are not. The response is first that the Applicant is entitled to use all of the amateur frequency bands, which may require wholly separate antennas, at varying heights, for effective communications in accordance with his needs. Second, no limitation on the number of station antenna structures, or antennas, can be found in the Milford Ordinance, nor New Hampshire, nor federal law. Third, there is substantial case law supporting the concept of multiple antennas.

First, as to the radio amateur's need for different antennas at differing heights, this is well addressed elsewhere in the Applicant's submission, including the Needs Analysis.

Second, as to the lack of limit on number, the Town has demonstrated fully that it can draft an ordinance specifically, to deal with single and plural uses. For example: § 5.04.1(c) permits "one single-family manufactured housing unit, per lot," but, by contrast has five other uses are plural (among them -- telecommunications facilities, farm roadside stands, and "accessory uses and structures."

Furthermore, both **47 CFR §97.15(b)** and **RSA 674:16 IV** require that regulation by the Town shall "constitute the minimum level of regulation practicable . . ." Attempting to limit an applicant to one antenna system would be more than "the minimum level of regulation practicable." The Town Code contains no indication whatsoever that multiple amateur radio antenna systems accessory to a single family residence are forbidden.

Third, there are many cases where multiple antenna systems were found allowable, despite opposition to multiple antennas.

> ***Bay v. ZBA of New Canaan (CT),*** 1993 Conn. Super. LEXIS 2345 (Super. Court of Stamford-Norwalk, Sept. 9, 1993). Ham had lawful existing retractable 72-foot structure and proposed to add one antenna to it, as well as to install a new 57-foot vertical. Court finds that an amateur radio antenna is a customary accessory use, and disregards *Presnell v. Leslie.* Good discussion of why Court adopts the majority view. Court finds that additional antenna may be placed 10 feet above present antenna (total 82') due to interaction. **Court finds multiple antennas are customary and accessory.** Court finds that the height is necessary. Ham's appeal sustained.
>
> ***Baskin v. Bath Twp. ZBA (OH),*** 101 F.3d 702 (6th Cir. 1996). **Four towers** plus one antenna without a tower. Bylaw required special approval from BZA for structures >50'. Drop zone imposed

– Cir. Ct. affirmed Dist. Ct. declaratory judgment that the height/location restriction was not a reasonable accommodation, and therefore void and unenforceable.

Marchand v. Town of Hudson (NH), 788 A.2d 250, 147 N.H. 380 (2001), http://www.courts.state.nh.us/supreme/opinions/2001/march221.htm

Bylaw had no regulation on number or height of towers. **Three, 100' tall antenna systems** on 6.04 acres of forest in an R-2 zone. Ruling that balancing not appropriate. "(T)o "reasonably accommodate" amateur radio communications . . . the ZBA may consider whether the particular height and number of towers are necessary to accommodate the particular ham operator's communication objectives." Remand to determine if three towers is a customary accessory use under NH law. [On remand, Hudson, NH Board held that three towers qualifies as a customary use. http://www.arrl.org/files/file/hudson.pdf or
http://www. antennazoning.com/ham/marchand-decision.pdf]

Smith v. Bernalillo County (NM), 110 P. 3d 496, 137 N.M. 280 (2005)
This is not a PRB-1 case. The case involves **two 130-foot towers** with ten-foot masts (a total height of 140 feet each) on five acres in the A-2 (rural residential) in the East Mountain area. But on the subject of customary accessory use, the Court found:

> {25} Our review of cases from other states supports Plaintiff's belief that amateur radio antennas are generally considered customarily incidental to residential use without adding a reasonableness inquiry. See, e.g., Town of Paradise Valley v. Lindberg, 551 P.2d 60, 61-62 (Ariz. Ct. App. 1976) (holding that the erection of a ninety-foot amateur radio tower in conjunction with a homeowner's hobby as a ham radio operator is a permissible accessory or incidental use); Skinner v. Zoning Bd. of Adjustment, 193 A.2d 861, 863-64 (N.J. Super. Ct. App. Div. 1963) (upholding a 100-foot radio antenna tower used as a hobby as an accessory use customarily incidental to the enjoyment of a residential property); Dettmar v. County Bd. of Zoning Appeals, 273 N.E.2d 921, 922 (Ohio Ct. Com. Pl. 1971) (finding that even an unusual customarily incidental use is permissible unless specifically excluded by a zoning restriction).
>
> {37} The results of this case may be unfortunate for the neighbors who understandably regard Plaintiff's radio towers as an eyesore. But Plaintiff fairly relied on the express language of the ordinance and the assurances of the county zoning officials in buying his property. After the County granted Plaintiff a permit, he complied with its terms in the construction of his radio antenna towers. If the County wanted to prevent towers on this scale, the problem could easily have been avoided by doing exactly what has been done since: expressly amending the ordinance with specific height limitations. See Bernalillo County, N.M., Ordinance 2004-1 (adopted Jan. 27, 2004) (amending the zoning ordinance to provide for amateur radio towers as permissive uses up to sixty-five feet or conditional uses up to 100 feet). The County has every right and responsibility to regulate structures such as amateur radio towers, but it did not do so explicitly and in fact exempted such antenna towers from height restrictions. The County cannot after the fact come up with a new legal rationale to block an unpopular activity, which was previously permitted, to the detriment of a property owner who did everything in his power to follow the rules.
>
> {38} . . . We hold that Plaintiff is entitled to a declaratory judgment that the building permit for his antenna towers was properly issued and that the County's stop work notices are invalid.

Evans v. Burruss (MD), 933 A.2d 872, 401 Md. 586 (2007). Ham applied for building permit (not special permit, not variance) for **four 190' towers**, which was granted as a matter of right under the old ordinance. Began construction. Over a year later, new bylaw passes. Court holds his rights have vested. Held, the grant of a building permit is a ministerial act. No notice to neighbors is required.

Note: The neighbors subsequently filed a suit claiming "private nuisance." The ham filed a substantial Motion for Summary Judgment. Plaintiffs withdrew, with prejudice – ending the litigation. The Motion for Summary Judgment is available upon request. The Motion for Summary Judgment is available upon request.

NO ADDITIONAL BALANCING BY THE TOWN PERMITTED

It may be common in other areas of zoning law to balance the needs of the community with the needs of an applicant for a permit. But this is not one of those areas. Balancing local interests against Federal government's interests in promoting amateur communications is not permitted. The FCC has already done the balancing. *Pentel v. Mendota Heights,* 13 F.3d 1261, 1266 at fn 5 (8th Cir. 1994) The municipality must reasonably accommodate the radio amateur.

This "no balancing" approach was affirmed by the FCC in 1999, in an order known as DA 99-2569, which rejects balancing tests, and includes the must "not impinge" language in ¶ 9, last sentence. The FCC ruling may be found at https://www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/prb-1-1999.

.

> 7. . . . PRB-1 decision precisely stated the principle of "reasonable accommodation". In PRB-1, the Commission stated: "Nevertheless, local regulations which involve placement, screening, or height of antennas based on health, safety, or aesthetic considerations must be crafted to accommodate reasonably amateur communications, and to represent the minimum practicable regulation to accomplish the local authority's legitimate purpose." **Given** this **express Commission language, it is clear that a "balancing of interests" approach is not appropriate** in this context.

(*Emphasis added.)*

REMOTE CONTROL IS NOT AN OPTION

Recall that amateur radio is an ordinary accessory use of a residential property. In additional, under 47 CFR § 97.15(b), local regulation must not preclude amateur radio communications. Put those two concepts together and the conclusion is that local regulation cannot preclude antennas on the radio amateur's property. A requirement that a radio amateur's antennas must be located at a remote site would be a requirement that precludes communications from the amateur's home site. A requirement that antennas be located off-site would also frustrate the requirement of the law that regulation must be "the minimum practicable,"[4] and must be regulation that "will not impinge on the needs of amateur operators to engage in amateur communications."[5] Furthermore, a remote-site requirement would frustrate one of the purposes of amateur radio, which is to have stations ready from residences[6] in time of emergency. An amateur radio station designed to be available when telephone and internet communications systems go down would be useless when needed most.

---

[4] 47 C.F.R. § 97.15(b)

[5] FCC DA 99-2569, at ¶ 9. https://transition.fcc.gov/Bureaus/Wireless/Orders/1999/da992569.txt

[6] Public Law 103-408 (J.Res., 103d Congress, 1994) § 1(3)

CONCLUSION

For the reasons set forth above, the Applicant requests that this application for a Special Exception under § 5.04.7.c be granted for the amateur radio station antenna structures as submitted.

Respectfully submitted,

John Webster

by
Fred Hopengarten, Esq.
Six Willarch Road
Lincoln, MA 01773
(781)259-0088
Maine Bar #1660, D.C. Bar # 114124

EXHIBITS

EXHIBIT A: APPLICANT'S FCC AMATEUR RADIO LICENSE

UNITED STATES OF AMERICA
FEDERAL COMMUNICATIONS COMMISSION
AMATEUR RADIO LICENSE
NN1SS

WEBSTER, JOHN S
172 FEDERAL HILL RD
MILFORD, NH 03055

FCC Registration Number (FRN): 0005204466

Special Conditions / Endorsements

NONE

Grant Date	Effective Date	Print Date	Expiration Date
12-07-2013	09-06-2019	09-07-2019	12-07-2023

File Number	Operator Privileges	Station Privileges
0008790167	Amateur Extra	PRIMARY

THIS LICENSE IS NOT TRANSFERABLE

(Licensee's Signature)

FCC 660 - May 2007

The validity of the Applicant's license may be confirmed by checking FCC records by callsign or by licensee name: *http://wireless2.fcc.gov/UlsApp/UlsSearch/searchLicense.jsp*

Note that the license above says" "Reference." For an official copy of your FCC license, a link to the complete FCC's instructions is here: https://www.fcc.gov/how-obtain-official-authorizations-uls. If logging into your account, there is a very obvious link at the top of the page used to download an unlimited number of your official license(s).

EDoc # 6058265 Nov 30, 2016 3:45 PM
Book 8923 Page 1061 Page 1 of 2
Register of Deeds, Hillsborough County

C/H
L-CHIP
HIA380281

Return to:

John S. Webster and Penny S. Webster
172 Federal Hill Road
Milford, NH 03055

STATE OF NEW HAMPSHIRE
DEPARTMENT OF REVENUE ADMINISTRATION
REAL ESTATE TRANSFER TAX
****4 Thousand 5 Hundred 75 Dollars
DATE 11/30/2016 HI083366 AMOUNT $ ****4575.00
VOID IF ALTERED

WARRANTY DEED

KNOW ALL MEN BY THESE PRESENTS: That we, **Vicki L. Blanchard and Christopher M. Rousseau**, both nmarried, of 172 Federal Hill Road, Milford, NH 03055, for consideration paid, grant to **John S. Webster and Penny S. Webster**, of 4 Connors Street, Londonderry, NH 03053, as joint tenants with rights of survivorship, with WARRANTY COVENANTS:

SEE ATTACHED EXHIBIT A.

MEANING and INTENDING to describe and convey the same premises conveyed to the grantors herein by deed of Norman J. Lastovica and Janet K. Lastovica dated 5/24/2004 and recorded at Book 7241, Page 2255 in the Hillsborough County Registry of Deeds.

We, the grantors herein hereby release all rights of homestead in the above-described premises.

Executed this 30 day of November, 2016

Vicki L. Blanchard

Christopher M. Rousseau

State of New Hampshire
County of Hillsborough 11 / 30 /2016.

Then personally appeared before me the said Vicki L. Blanchard and Christopher M. Rousseau and acknowledged the foregoing to be their voluntary act and deed.

MARTHA P. COSSEY
MY COMMISSION EXPIRES MAY 27, 2020
NOTARY PUBLIC
NEW HAMPSHIRE

Notary Public/Justice of the Peace
Commission expiration:

EXHIBIT A

A certain tract or parcel of land, with the buildings thereon, situate in Milford, Hillsborough County, State of New Hampshire, on the easterly side of Federal Hill Road so-called and bounded and described as follows, to wit:

Beginning at the Southwest corner of the property at a drill-hole on the face of a stone wall on the Easterly side of said Federal Hill Road; thence North 6 1/4 degrees East by said Federal Hill Road 232 feet to a drill hole on the face of a stone wall at other land now or formerly of Albert Caron; thence south 87 1/4 degrees East by other land now or formerly of said Caron 423 feet to an iron pipe surrounded by stones at other land now or formerly of said Caron; thence South 2 degrees West by other land of said Caron and partly by a stone wall 226.7 feet to a drill-hole on top of a stone in the stone wall at a corner of walls; thence North 87 1/4 degrees West by other land of the said Caron 444.5 feet to the point of beginning.

0116-00966 Webster legalxA.dot

Penny S. Webster
172 Federal Hill Road
Milford, NH 03055

February 1, 2021

Department of Community Development
Milford NH Town Hall
1 Union Square
Milford, NH 03055

To Whom It May Concern:

As you can see by reviewing the deed to our property, I am a co-owner of the property at 172 Federal Hill Road, and the wife of the applicant in this matter.

We've been married for over 19 years and I really do know what is being proposed here. The application has my full approval.

I enthusiastically encourage the Town to grant all necessary permits for this project.

Sincerely,

Penny S. Webster

Figure B-3.1 Showing Distances to Nearest Property Lines

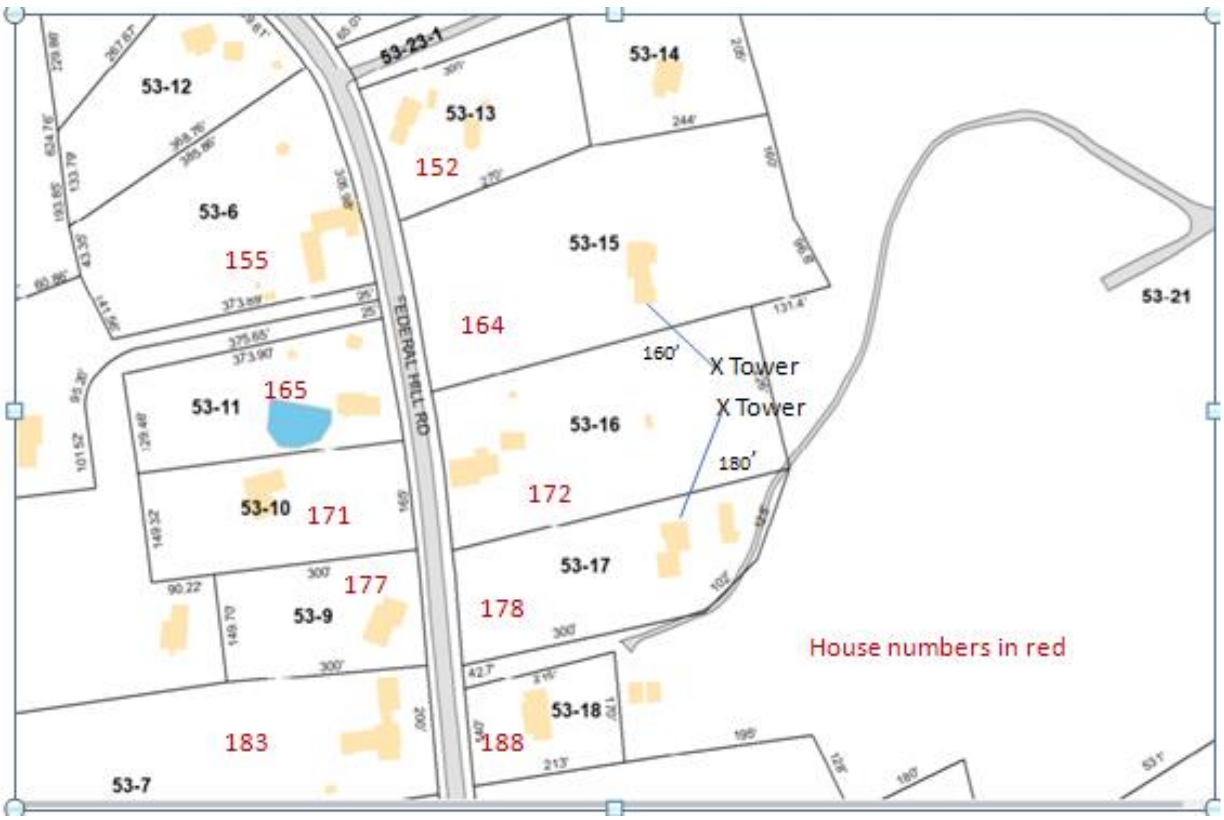


Figure B-3.2 Showing Distances to Nearest Homes

Chart of Distances

From Nearest Station Antenna Structure to	Distance (in feet)
Property line toward home at 164 Federal Hill Road	90
Property line toward home at 178 Federal Hill Road	102
Home at 164 Federal Hill Road	160
Home at 178 Federal Hill Road	178

Figure B-3.3 Chart of Distances

EXHIBIT E: LOCAL ROAD MAP

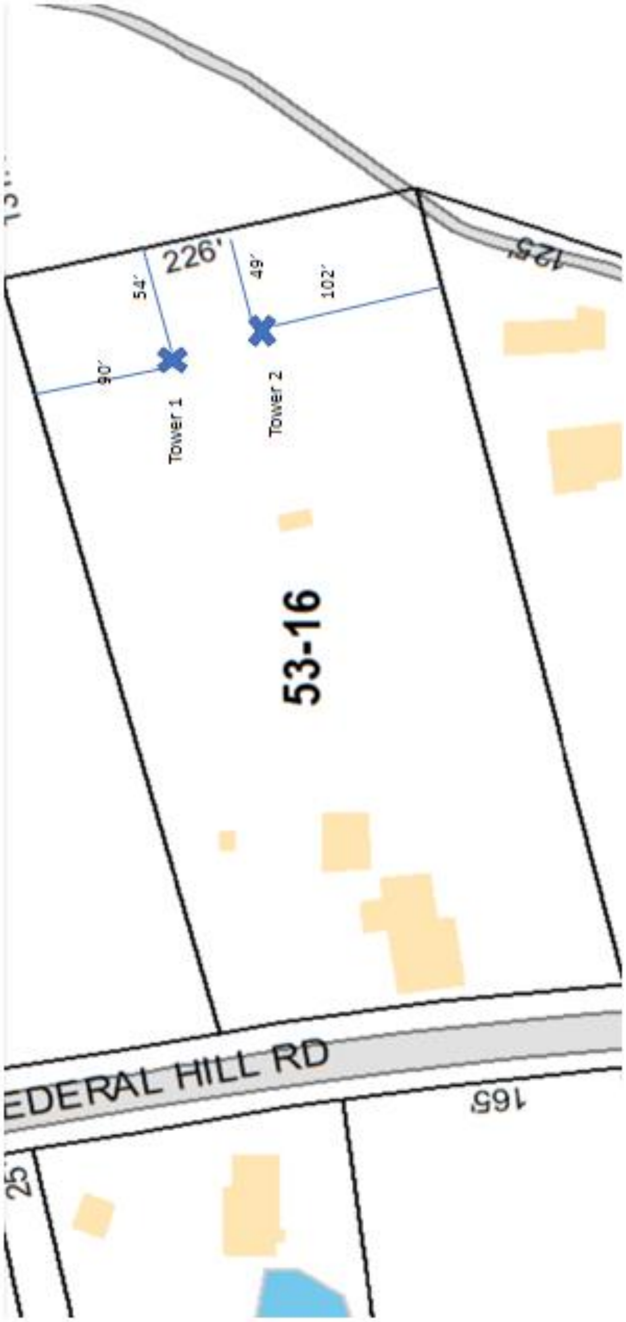


EXHIBIT F: MAP OF ABUTTERS

Figure D-1. The Applicant lives on Plot 53-16, at 172 Federal Hill Road.

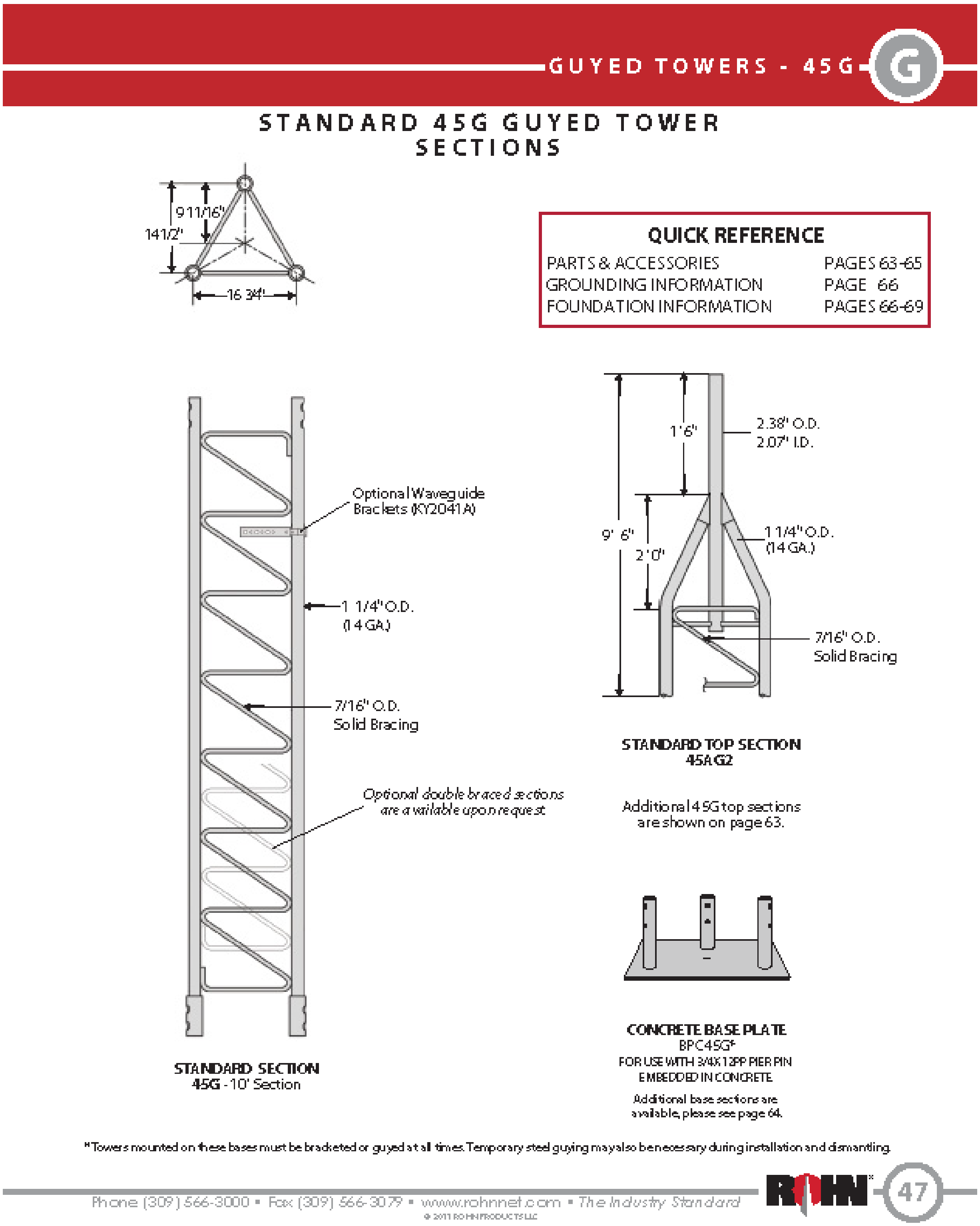
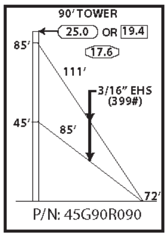


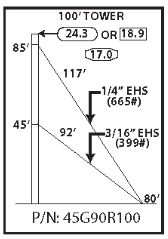
Figure G1. Catalog Sheet of Structure.
Source: http://www.rohnnet.com/files/2015_Rohn_Full_Catalog.pdf

STANDARD DESIGN - 45G
90MPH REV. G, 70MPH REV. F



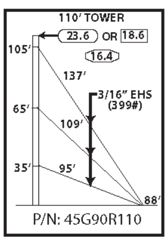
TOWER PARTS INCLUDED	45G	45AG2	BPC45G	GA45GD	FDNS BASE	FDNS ANCHOR
	8	1	1	2	CB1G	AB2
GUYS & CONNECTIONS INCLUDED	3/16EHS	BG2142	5/16THH	1/2TBE&J	TBSAFETY	
	625’	12	12	6	3	
ANCHORS & GROUNDING INCLUDED	GAC3455TOP	AGK1GGX	BGK3GGX	CPC.5/.75	3/4x12PP	
	3	1	3	3	1	

90’ ROHN 45G
All parts shown in table are included when ordering Part No: 45G90R090



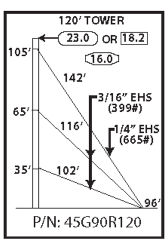
TOWER PARTS INCLUDED	45G	45AG2	BPC45G	GA45GD	FDNS BASE	FDNS ANCHOR	
	9	1	1	2	CB1G	AB2	
GUYS & CONNECTIONS INCLUDED	3/16EHS	1/4EHS	BG2142	BG2144	5/16THH	3/8THH	1/2TBE&J
	300’	375’	6	6	6	6	6
ANCHORS & GROUNDING INCLUDED	GAC3455TOP	AGK1GGX	BGK3GGX	CPC.5/.75	3/4x12PP	TBSAFETY	
	3	1	3	3	1	3	

100’ ROHN 45G
All parts shown in table are included when ordering Part No: 45G90R100



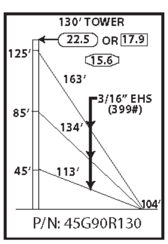
TOWER PARTS INCLUDED	45G	45AG2	BPC45G	GA45GD	FDNS BASE	FDNS ANCHOR
	10	1	1	3	CB1G	AB2
GUYS & CONNECTIONS INCLUDED	3/16EHS	BG2142	5/16THH	1/2TBE&J	TBSAFETY	
	1100’	18	18	9	3	
ANCHORS & GROUNDING INCLUDED	GAC3455TOP	AGK1GGX	BGK3GGX	CPC.5/.75	3/4x12PP	
	3	1	3	3	1	

110’ ROHN 45G
All parts shown in table are included when ordering Part No: 45G90R110



TOWER PARTS INCLUDED	45G	45AG2	BPC45G	GA45GD	FDNS BASE	FDNS ANCHOR	
	11	1	1	3	CB1G	AB2	
GUYS & CONNECTIONS INCLUDED	3/16EHS	1/4EHS	BG2142	BG2144	5/16THH	3/8THH	1/2TBE&J
	700’	475’	12	6	12	6	9
ANCHORS & GROUNDING INCLUDED	GAC3455TOP	AGK1GGX	BGK3GGX	CPC.5/.75	3/4x12PP	TBSAFETY	
	3	1	3	3	1	3	

120’ ROHN 45G
All parts shown in table are included when ordering Part No: 45G90R120

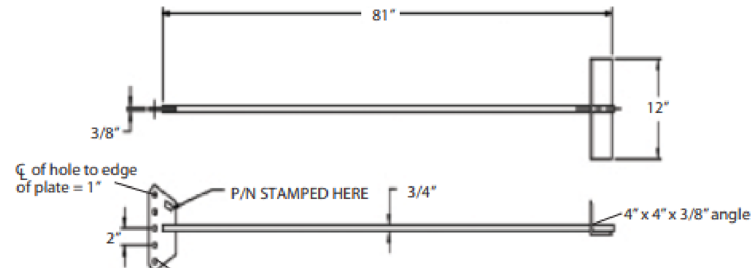


TOWER PARTS INCLUDED	45G	45AG2	BPC45G	GA45GD	FDNS BASE	FDNS ANCHOR
	12	1	1	3	CB1G	AB2
GUYS & CONNECTIONS INCLUDED	3/16EHS	BG2142	5/16THH	1/2TBE&J	TBSAFETY	
	1325’	18	18	9	3	
ANCHORS & GROUNDING INCLUDED	GAC3455TOP	AGK1GGX	BGK3GGX	CPC.5/.75	3/4x12PP	
	3	1	3	3	1	

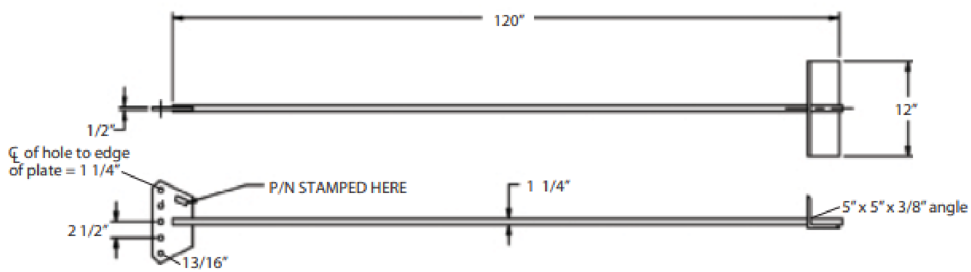
130’ ROHN 45G
All parts shown in table are included when ordering Part No: 45G90R130

Figure G2. Guying Details at TIA/EIA-222-F (Industry Standard) Wind Speed Required for Hillsborough County.

ANCHOR INFORMATION

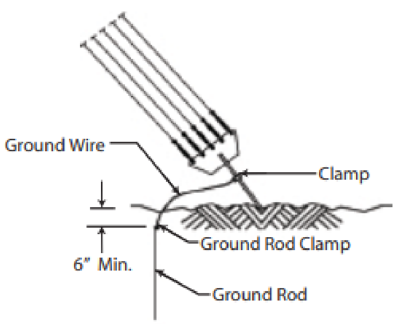


GAC3455TOP



GAC5655TOP

REV G
ANCHOR GROUNDING
AGK1GGX



REV G
BASE GROUNDING
BGK3GGX

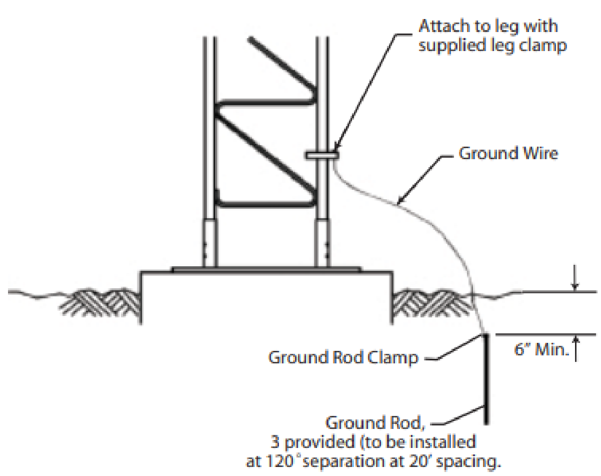
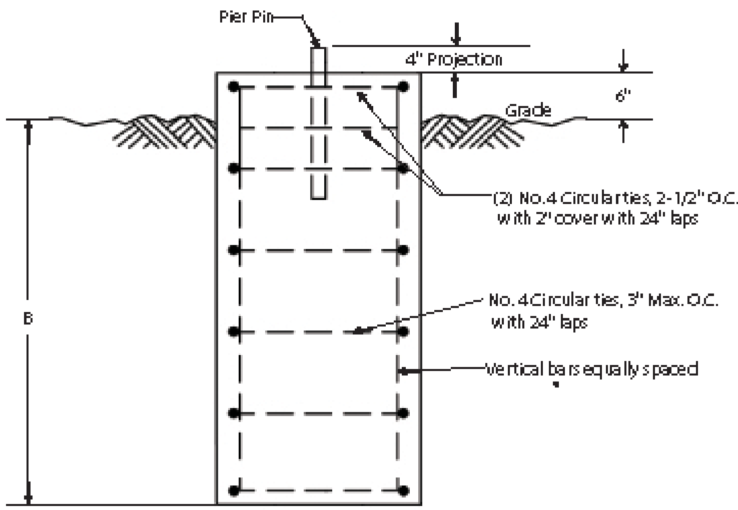


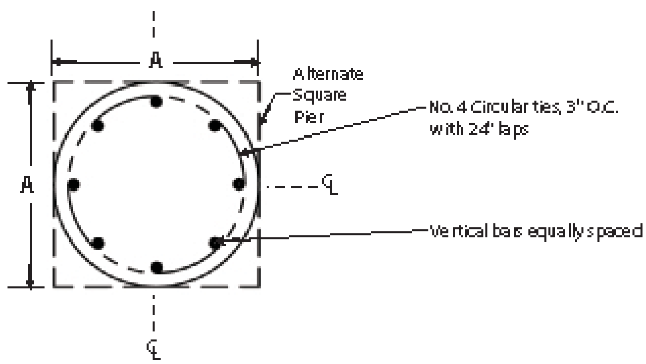
Figure G3. Anchor and Grounding Detail

GUYED TOWERS - 45G

STANDARD BASE PIERS



ELEVATION VIEW



PLAN VIEW

Base	A	B	Concrete Vol. (Cu. Yds) Round Pier	Vertical Bars (No. & Size)
CB1G*	2'-6"	4'-0"	1.0	(8) #7
CB2G	3'-0"	4'-0"	1.2	(10) #7
CB3G	3'-6"	4'-0"	1.6	(12) #7

*Square pier option must be used for CB1G.

Figure G4. Detail of reinforced concrete foundation.

Briggs & Stratton Generator

BRIGGS & STRATTON

Portable Generator

Product Specifications

Model 030470

Starting Wattage ....8,750 Watts
Wattage* ....7,000 Watts
AC Voltage ....120/240 Volts
at 240 Volts ....29.1 Amps
at 120 Volts ....58.3 Amps
Frequency ....60 Hz at 3600 rpm
Phase ....Single Phase
Displacement ....25.63 cu. in. (420 cc)
Spark Plug Gap ....0.030 in. (0.76 mm)
Fuel Capacity ....7 U.S. Gallons (26.5 Liters)
Oil Capacity ....36 Ounces (1.0 Liters)

Model 030471

Starting Wattage ....10,000 Watts
Wattage* ....8,000 Watts
AC Voltage ....120/240 Volts
at 240 Volts ....33.3 Amps
at 120 Volts ....66.6 Amps
Frequency ....60 Hz at 3600 rpm
Phase ....Single Phase
Displacement ....25.63 cu. in. (420 cc)
Spark Plug Gap ....0.030 in. (0.76 mm)
Fuel Capacity ....7 U.S. Gallons (26.5 Liters)
Oil Capacity ....36 Ounces (1.0 Liters)

Common Service Parts

Air Cleaner ....491588 or 5043
Engine Oil Bottle ....100005 or 100028
Synthetic Oil Bottle 100074
Fuel Stabilizer ....100002 or 5041
Spark Arrester 83083GS

Power Ratings: The gross power rating for individual gas engine models is labeled in accordance with SAE (Society of Automotive Engineers) code J1940 (Small Engine Power & Torque Rating Procedure), and rating performance has been obtained and corrected in accordance with SAE J1995 (Revision 2002-05). Torque values are derived at 3060 RPM; horsepower values are derived at 3600 RPM. Net power values are taken with exhaust and air cleaner installed whereas gross power values are collected without these attachments. Actual gross engine power will be higher than net engine power and is affected by, among other things, ambient operating conditions and engine-to-engine variability. Given the wide array of products on which engines are placed, the gas engine may not develop the rated gross power when used in a given piece of power equipment. This difference is due to a variety of factors including, but not limited to, the variety of engine components (air cleaner, exhaust, charging, cooling, carburetor, fuel pump, etc.), application limitations, ambient operating conditions (temperature, humidity, altitude), and engine-to-engine variability. Due to manufacturing and capacity limitations, Briggs & Stratton may substitute an engine of higher rated power for this Series engine.

* This generator is rated and certified to be compliant with CSA (Canadian Standards Association) standard C22.2 No. 100-04 (motors and generators).

Briggs & Stratton Power Products Group, LLC
P.O. Box 702
Milwaukee, Wisconsin, 53201-0702 U.S.A.

(800) 743-4115

BRIGGSandSTRATTON.COM

American Red Cross

National Headquarters
8111 Gatehouse Road
Falls Church, VA 22042

September 11, 2002

President Jim Haynie
The American Radio Relay League
225 Main Street
Newington, CT 06111-1494

Dear President Jim Haynie:

Each year, on average, the American Red Cross provides services in over 62,000 emergencies in various places around the United States. Whether flood, fires, earthquakes, hurricanes, or man made disasters, the American Red Cross is there to respond. As our corporate slogan states "Together, we can save a life". When the Red Cross asks for help from America's radio hams we get it. Every time we ask, radio hams volunteer the use of their stations, including antennas, and they volunteer their time. For this, and for the results they achieve for victims of tragedies, we are grateful. Your membership helps us at the disaster scene or from their home running emergency communications.

Even in an era of cell phones and satellite communications, amateur radio continues to provide crucial links in disaster stricken areas. When the emergency arises, it is too late to build or transport communications systems equivalent to those available in the existing stock of amateur radio stations.

We understand the in emergency communications the one of the key issues is to have trained emergency communicators who have equipment and antennas set up for fast response. For this reason, we supported the American Radio Relay League when it sought preemption of zoning and other local regulations that, either as written or as applied, act to inhibit effective communications. We applauded when the Federal Communications Commission recognized an obvious fact of physics – that effective communications is often a function of height.

For these reasons, the American Red Cross strongly supports amateur radio, and the construction of station antenna systems to provide effective local and long distance communications. We have done so through Memoranda of Understanding with the American Radio Relay League dating back before World War II, and still current today. We encourage municipalities and Home Owner Associations to employ their regulations so they will not impinge on the needs of amateur radio operators. In emergencies, the American Red Cross, and the people we serve in your area, need what radio amateurs provide – effective communications through existing equipment and antenna systems.

Sincerely,

Jayson T. Fenton
Disaster Telecommunications Partner
Disaster Services

Together, we can save a life

Antenna Structure Registration - TOWAIR Determination Results

*** NOTICE ***

TOWAIR's findings are not definitive or binding, and we cannot guarantee that the data in TOWAIR are fully current and accurate. In some instances, TOWAIR may yield results that differ from application of the criteria set out in 47 C.F.R. Section 17.7 and 14 C.F.R. Section 77.13. A positive finding by TOWAIR recommending notification should be given considerable weight. On the other hand, a finding by TOWAIR recommending either for or against notification is not conclusive. It is the responsibility of each ASR participant to exercise due diligence to determine if it must coordinate its structure with the FAA. TOWAIR is only one tool designed to assist ASR participants in exercising this due diligence, and further investigation may be necessary to determine if FAA coordination is appropriate.

DETERMINATION Results	
Structure does not require registration. There are no airports within 8 kilometers (5 miles) of the coordinates you provided.	
Your Specifications	
NAD83 Coordinates	
Latitude	42-48-19.1 north
Longitude	071-38-01.2 west
Measurements (Meters)	
Overall Structure Height (AGL)	30.5
Support Structure Height (AGL)	27.4
Site Elevation (AMSL)	170.7
Structure Type	
LTOWER - Lattice Tower	

Federal Communications Commission
445 12th Street SW
Washington, DC 20554

Source: http://wireless2.fcc.gov/UlsApp/AsrSearch/towairResult.jsp
To convert decimal locations to degrees, minutes and seconds: https://www.fcc.gov/media/radio/dms-decimal

When Hurricane Harvey hit the coast of Texas in late August, it brought with it "catastrophic rain" and flooding that caused billions of dollars in damage, especially in and around the Houston area. Fortune reports the storm knocked out 70 percent of the cell towers in affected counties.

According to a report from MySanAntonio.com, Hurricane Harvey knocked out internet and telephones service to almost 200,000 homes, more than 360 cell towers and 16,911 call centers. A study from the Federal Communications Commission shows that about 1,000 cell towers were knocked out during Hurricane Katrina.

Source: https://www.sunherald.com/news/weather/article213083739.html (updated June 19, 2018)

CNN

Ham radio operators are saving Puerto Rico one transmission at a time

By Paul P. Murphy and Michelle Krupa, CNN

Updated 4:18 PM ET, Wed September 27, 2017

(CNN) The phone call from the Red Cross came in late Friday night, just as the full scale of Hurricane Maria's calamity began taking shape.

"We need 50 of your best radio operators to go down to Puerto Rico."

In the days after the worst storm in three generations hit the American island -- and for many more to come -- public electrical, land-line and cellular communication systems showed few signs of life. And radio networks used routinely by police officers, power company workers and other first responder still were down.

No gas. No food. No power. Puerto Ricans fear their future

Yet, a key mode of communication -- one not reliant on infrastructure vulnerable to strong winds and flooding -- still crackled: the "ham" radio.

Answering the phone that night in Connecticut was the emergency manager for the American Radio Relay League, the group's CEO said. For more than a century, this group has served as a hub for amateurs licensed to operate the dependable, if archaic, medium known as ham radio and eager to pitch in when disaster strikes.

When the Red Cross made its latest appeal for heroes, these were the people it had in mind.

Jumping to respond to disaster

Already gearing up on his own that night to go to work, turning knobs and flipping switches, was Oscar Resto.

As one of dozens of ham -- shorthand for "amateur" -- operators across Puerto Rico, Resto had been authorized by the Federal Communications Commission to use radios, computers, satellites or the Internet to assist and support public safety during emergencies.

Often untethered from wires and cables, operators share information by voice, Morse code and other methods on a wide range of frequencies above the AM broadcast band. Such communications were critical during rescue operations after the 9/11 attacks and Hurricane Katrina.

Oscar Resto works with another volunteer to pass along information at the Red Cross headquarters in San Juan, Puerto Rico.

For three days after Maria hit, Resto sawed through the downed trees that separated his home from the road, he told CNN. Then he packed his car with radio gear, left his family and made the 25-mile journey to a makeshift Red Cross headquarters, where generators and batteries could power his equipment.

"I have the responsibility to establish the required emergency communications that the American Red Cross needed for understanding the needs of the citizens impacted by the hurricane," said Resto, a section manager for the American Radio Relay League, which boasts 160,000 members.

Survivors needed food, water, shelter and fuel to power generators after Maria knocked out the entire electrical grid. They also needed to communicate, to share critical information about diabetics nearing the end of their insulin reserves, babies threatened by dehydration, families rationing crackers.

Transmitting radio signals to other ham operators in the Caribbean, Resto and his shortwave brethren traded National Hurricane Center reports on Maria's position. He also contacted a ham operator in Florida, and asked "just to tell my daughter, Astrid, that we were fine," he recalled.

Before long, Resto and his compatriots realized their messages were the only ones getting off the island.

In an instant, their mission expanded: Anyone with the requisite skills and equipment was conscripted.

Shoulder to shoulder with first responders

Two ham volunteers, Raul Gonzalez and Jose Santiago, set up a radio control hub run by generator power in Monacillo, near San Juan, and other centers quickly followed suit. There, ham operators work shoulder to shoulder with public safety and utility officials to transmit information to other ham operators working with teams in the field.

Puerto Rico governor: Power could be out for months

A full week after Maria battered their homes, Resto and two dozen other Puerto Rican ham operators were still running radio operations for the police and the local power company, whose own wireless communications systems rely in part on computers and power sources knocked out by the storm.

For instance, ham operators riding with police use radios tuned to the special broadcast frequencies to transmit calls to other ham operators hunkered down at the command centers with officers, who in turn respond with orders.

A power company generator low on fuel? A ham operator from Resto's team deployed with the power company calls his counterpart at the command center and coordinates a fuel delivery.

Raul Gonzalez and Jose Santiago work to maintain the communication infrastructure they set up between ham radio operators in the Monacillo Control Center.

For his part, Resto learned Tuesday via a ham radio at the command center that an unsanitary hospital in western Puerto Rico was transferring patients to another hospital. It was just one of countless threads of information squawked across the operational frequencies in a massive effort to deliver relief and supplies.

"I am very proud of them," Resto said of his crew of amateurs. "They are the real heroes."

More help on the way

Less than 48 hours after the American Radio Relay League's emergency manager fielded the Red Cross' call, 350 ham operators had offered to help, said Tom Gallagher, the group's CEO.

Fifty of them prepared this week to embark upon a three-week deployment to Puerto Rico. They include retired executives and public safety officers, and hail from places from Washington to Texas to New Hampshire, he said.

"It's an incredibly personal sacrifice from individuals who are dedicated to serving communities," Gallagher said. "They have the skills and the motivation and the sense of responsibility."

Volunteers will deploy to the island with equipment kits so they can be agile and provide for themselves.

Volunteers will be outfitted with self-sustaining kits provided by radio manufacturers and dealer partners so they can be agile and won't burden those they're trying to help, he said.

Southwest Airlines was due to transport the equipment for free Wednesday from the group's New York headquarters to Atlanta, where volunteers planned to convene Thursday to board a chartered JetBlue flight for San Juan, Gallagher said.

There, they plan to connect with the Red Cross and likely spread out across Puerto Rico to continue the life-saving work of radio operators already well underway, Gallagher said.

"It's the first time they've asked us to do this on this scale," he said. "This is why we're here."

Source: https://www.cnn.com/2017/09/27/us/puerto-rico-maria-ham-radio-operators-tmd/index.html

EXHIBIT K-2: PRESIDENTIAL RECOGNITION

THE WHITE HOUSE

WASHINGTON

January 8, 2007

I send greetings to all those celebrating 100 years of voices over the airwaves.

Radio plays an important role in informing, entertaining, and protecting people everywhere. At the turn of the last century, Reginald Fessenden pioneered wireless communications and opened the door for technological advances that have improved the lives of Americans and individuals around the world. This occasion is an opportunity to remember Fessenden's broadcast of voice and music over the air a century ago and a chance to celebrate the many ways radio has enriched our lives and our Nation.

I appreciate all who work in radio, and I am grateful to the amateur radio operators who provide emergency communications that help make our country safer and more secure. Your good work strengthens our society and represents the American spirit.

Laura and I send our best wishes. May God bless you.

Source: http://www.arrl.org/news/stories/2007/01/17/102/PresBush-VoiceOverRadio-large.jpg

EXHIBIT K-3: ARRL-FEMA AFFILIATION

STATEMENT OF AFFILIATION BETWEEN THE FEDERAL EMERGENCY MANAGEMENT AGENCY AND THE AMERICAN RADIO RELAY LEAGUE

The ***Department of Homeland Security (DHS)*** and the ***American Radio Relay League (ARRL)*** view community disaster preparedness and response as top priorities for their respective organizations and for the American people. As such, our organizations have come together to provide mutual support for ***Citizen Corps.***

Under the direction of ***DHS, Citizen Corps*** is a community-based initiative to engage all citizens in homeland security and community and family preparedness through public education and outreach, training opportunities, and volunteer programs. Programs under the Citizen Corps umbrella include federally sponsored programs and other activities that share the goal of helping communities prevent, prepare for, and respond to terrorism, public health issues, and disasters of all kinds. It encourages all Americans to take an active role in building safer, stronger, and better-prepared communities.

ARRL is a non-commercial membership association of radio amateurs organized for the promotion of interest in Amateur Radio communication and experimentation, for the establishment of networks to provide communications in the event of disasters or other emergencies, for the advancement of the public welfare, and for the representation of the Radio Amateur in legislative and regulatory matters. ***ARRL*** is the principal organization representing the interests of the more than 650,000 U.S. Radio Amateurs. Because of its organized emergency communications capability, ***ARRL's Amateur Radio Emergency Service (ARES)*** can be of valuable assistance in providing critical and essential communications during emergencies and disasters when normal lines of communication are disrupted. ***ARRL*** conducts emergency communications training and certifies proficiency in emergency communications skills.

Together ***DHS*** and the ***ARRL*** agree to work collaboratively to:

- Raise public awareness about the use of Amateur Radio as a public safety resource;
- Provide training and accreditation for Amateur Radio Emergency Communications;
- Promote the formation of local ***Citizen Corps Councils*** and assist these Councils with providing public education, training and volunteer service opportunities that support first responders, disaster relief organizations, and community safety efforts;
- Publicly acknowledge the affiliation of ***Citizen Corps*** and the ***ARRL,*** which may include website links, co-logos on publications, and references in printed materials, including articles and news releases;
- Coordinate their respective activities to further their shared mission; and
- Keep each other informed of activities conducted in support of ***Citizen Corps*** and to provide an annual report summarizing those activities.

On this 21st day of June 2003, both parties enter into this agreement in good faith and agree to pursue the shared mission as stated.

citizen corps

MICHAEL D. BROWN
UNDER SECRETARY
DEPARTMENT OF HOMELAND SECURITY
EMERGENCY PREPAREDNESS AND RESPONSE

JIM HAYNIE
PRESIDENT
AMERICAN RADIO RELAY LEAGUE, INCORPORATED

Source: http://www.arrl.org/files/file/Public%2520Service/FEMA-ARRL-SOA1.pdf

Figure L1. K1TSV, 245 Colburn Road, Milford, NH (100' in height)

Figure L2. KJ1I, 60 Brookview Drive, Milford, NH (80' in height)

Figure L3. WB1CMG, 19 Harwood Road, Mont Vernon, NH (180' in height)
Note: House in foreground is not the home of the radio amateur.
The view from the road in front of his house is obscured by trees.

Figure M1. From Northern Tower Location Toward 164 Federal Hill Road (winter, leaves off the trees)

Figure M2. From Southern Tower Location Toward 178 Federal Hill Road (winter, leaves off the trees)

Figure M3. From Federal Hill Road, Looking East, Toward Southern Tower

Figure M4. From Southern Tower, Looking West, Toward Federal Hill Road

EXHIBIT N: POWER DENSITY CALCULATION

```
                    Far Field Power Density Calculation
           From PWR_DENS V3.7 by E. S. Parsons, BSEE, MSEE, K1TR
                 -----------------------------------------
SITE: NN1SS - Milford, NH

INPUTS:
   Output Power from transmitter is 1500 Watts.
   Antenna Gain over a dipole is 8.0 dBd.
   Frequency of operation is 28.5 MHz. [Worst case.]
   Total feedline and system losses are 2.2 dB.
   Distance from antenna to uncontrolled boundary is 105 feet.

OUTPUTS:
   Average Power at antenna feedpoint is 241.4 Watts.
   Average Effective Radiated Power (ERP) is 2497 Watts.
   FCC OET-65 maximum limit is 0.22 mW/sq cm.
   Computed Power Density is 0.019 mW/sq cm (0.194 W/sq meter).
   (Power density calculated along antenna boresight; no assumptions made about
   antenna pattern.)

   Hence: 1.   The Computed Power Density is 8.8% of the FCC OET-65 Maximum
               Permissible Exposure (MPE).
          2.   The Computed Power Density is -10.57 dB from the FCC OET-65 MPE.
          3.   Transmitter output power must be increased by at least a factor
               of 11 to exceed the FCC OET-65 MPE.
```

Note: All calculations conform to FCC OET Bulletin 65 Supplement B, to OET Bulletin 65, http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65b.pdf

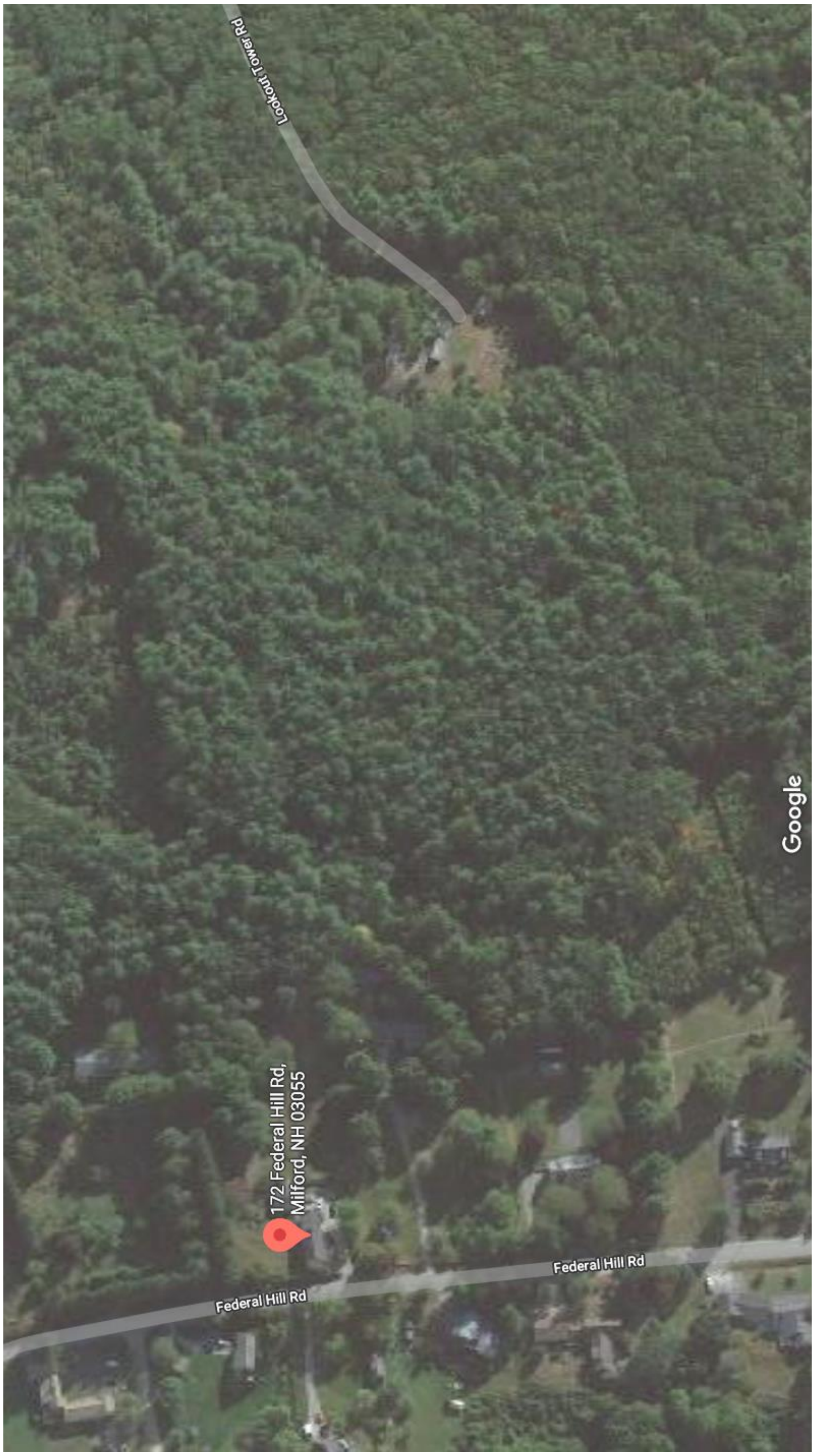
Power density is a measure, in units of milliwatts per square centimeter (mW/cm2), of the intensity of radio frequency fields a person is exposed. To put this in context and add meaning, the power density at the point specified (usually the home closest to the amateur's antenna, but in this case the property line closest to the antenna) is compared to the Maximum Permissible Exposure (MPE) for uncontrolled environments set forth by the FCC in the Commission's Rules. 47 CFR § 1.1310 Radiofrequency radiation exposure limits, https://www.ecfr.gov/cgi-bin/text-idx?node=pt47.1.1&rgn=div5#se47.1.1_11310

An uncontrolled environment is an area where people would not normally be aware of potential RF exposure. Area beyond the property boundary is an example of an uncontrolled RF environment. The FCC rules adopted the description set forth in IEEE C95.1-1992 for uncontrolled RF environments.

This analysis assumes that the antenna is pointed at the nearest dwelling. For rotary antenna systems, the antenna is often pointed in other directions, over time, this results in much lower power densities at the nearest dwelling.

Supplement B to FCC OET Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields" states duty factors in Table 2. SSB and CW are less than 50% duty cycle, whereas FM and RTTY are somewhat more than 50%. To calculate power density, the FCC method assumes a 30 minute averaging time (transmit 10 minutes, receive 10 minutes, transmit 10 minutes). This is then compared to the FCC Maximum Permissible Exposure limits for the general population.

EXHIBIT O: AERIAL VIEW



Note that the area is heavily forested. Placing the towers to the rear of the property reduces visibility from the road, and there is effectively no rear neighbor.

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788 A.2d 250 (N.H. 2001)
147 N.H. 380
Suzanne MARCHAND and another,
v.
TOWN OF HUDSON.
No. 2000-131.
Supreme Court of New Hampshire.
December 31, 2001.

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[147 N.H. 381] Prunier & Leonard, P.A., of Nashua (Andrew A. Prolman on the brief and orally), for the plaintiffs.

Donahue, Tucker & Ciandella, of Exeter (John J. Ratigan and Susan W. Chamberlin on the brief, and Mr. Ratigan orally), for the defendant.

Bolton Law Offices, P.A., of Nashua (Steven A. Bolton on the brief), and Michael N. Raisbeck, of Chelmsford, Massachusetts, on the brief and orally, for the intervenor, Jeremy L. Muller.

Booth, Freret, Imlay & Tepper, of Washington, D.C. (Christopher D. Imlay on the brief), for The American Radio Relay League, Inc., as amicus curiae.

[147 N.H. 382] BROCK, C.J.

The defendant, the Town of Hudson (town), appeals from a Superior Court (*Brennan*, J.) order rescinding a building permit granted to the intervenor, Jeremy L. Muller. The town argues that the court misapplied the law on accessory uses and ordered relief that conflicted with federal objectives to allow and promote amateur ham radio facilities. We affirm in part, reverse in part, vacate and remand.

Muller resides in a section of Hudson zoned Residential-Two (R-2), and is an amateur or "ham" radio operator. In December 1998, when Muller applied for a building permit, the town had no regulations restricting the number or height of amateur radio towers. The town zoning administrator granted Muller a building permit to erect three ninety-foot amateur radio towers with antennae to be added at a later date that would bring the total height of each tower to one hundred feet.

Shortly thereafter the plaintiffs, Suzanne Marchand, Joanne Radziewicz and Peter Radziewicz, Muller's neighbors, appealed the grant of the building permit to Hudson's zoning board of adjustment (ZBA), arguing that radio communications towers were not permitted in the R-2 zone. Following a hearing on the merits, the ZBA upheld the grant of the building permit. In support of its decision, the ZBA made the following findings:

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> 1. The Hudson Zoning Ordinance, in listing accessory uses, does not use the word "only" for items permitted; since it is a permitted accessory use, site plan is not required.
>
> 2. RSA 674:16; 17; III: we do not get to prohibit Hamm [*sic*] radio.
>
> 3. Historically, Hamm [*sic*] radio has been an accessory use, with no quantification of type; simply an accessory to residential property-as a hobby;
>
> 4. This is a permitted accessory use.

Following a rehearing at the plaintiffs' request, the ZBA upheld its decision. The plaintiffs appealed to the superior court.

The superior court did not hold a hearing, but relied on the ZBA's certified record to evaluate the ZBA's decision. The court ruled that while the ZBA heard sufficient evidence to establish ham radio as an accessory use in residential districts in the town, "there was no evidence of ham radio operations in residential neighborhoods which included anything reasonably close to the scale of the three antennae proposed in this case." The court also addressed whether the federal government had preempted local regulation in this area, *see Amateur Radio Preemption*, 101 F.C.C.2d 952, 1985 WL 544557 (1985), and concluded that the size and height of the towers "would upset the balance between the federal interest in promoting amateur operations and the legitimate interest of local governments in regulating local zoning matters." The court therefore reversed the ZBA decision, rescinded the building permit and ordered the towers removed.

The trial court's review of the ZBA decision is governed by RSA 677:6 (1996). Pursuant to this statute, to the extent that the ZBA made findings upon questions of fact, these findings are deemed *prima facie* lawful and reasonable, and the superior court shall not set aside or vacate the ZBA's decision "except for errors of law, unless the court is persuaded by the balance of probabilities, on the evidence before it, that said order or decision is unreasonable." RSA 677:6. On appeal, the superior court's decision will be upheld unless it is not supported by the evidence or is legally erroneous. *Peabody v. Town of Windham*, 142 N.H. 488, 492, 703 A.2d 886 (1997).

We first address the town's argument that the superior court erred when it failed to uphold the ZBA's conclusion that the building permit was properly issued as an accessory use under the town zoning ordinance.

The interpretation of a zoning ordinance and the determination of whether a particular use is an accessory use are ultimately questions of law for this court to decide. *KSC Realty Trust v. Town of Freedom*, 146 N.H. 271, ----, 772 A.2d 321, 322-23 (2001) (quotations omitted). The town's zoning ordinance expressly permits, as an accessory use, "[t]raditional secondary accessory uses and structures, including garages, toolsheds, parking areas, recreational facilities, outdoor in-ground swimming pools and other customary uses and structures." *Town of Hudson Zoning Ordinance* Table of Permitted Accessory Uses (1996). The ordinance defines accessory use as "[a]ny use which is customary, incidental, and subordinate to the principal use of a structure or lot." *Town of Hudson Zoning Ordinance* § 334-6 (1996).

We have generally held that the language "customary, incidental and subordinate" requires that the accessory use be minor in relation to the permitted use, bear a reasonable relationship to the primary use, and have been habitually established

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as reasonably associated with the primary use. *See Becker v. Town of Hampton Falls*, 117 N.H. 437, 440, 374 A.2d 653 (1977); *see also Hannigan v. City of Concord*, 144 N.H. 68, 71, 738 A.2d 1262 (1999); *Nestor v. Town of Meredith*, 138 N.H. 632, 634, 644 A.2d 548 (1994); *Narbonne v. Town of Rye*, 130 N.H. 70, 73, 534 A.2d 388 (1987). An aggregation of incidental uses, however, may result in the loss of "accessory" status. *See Perron v. Concord*, 102 N.H. 32, 35-36, 150 A.2d 403 (1959). If the scope and significance of the proposed use is at least equal to the permitted residential use, the proposed use may no longer be subordinate or incidental and thus not permitted as an accessory use. *See id.*; *Gratton v. Pellegrino*, 115 N.H. 619, 621, 348 A.2d 349 (1975).

[147 N.H. 384] The plaintiffs have not challenged the ZBA's finding that historically, ham radio antennae have been permitted as an accessory use in the town. Rather, they argued to the superior court, and now argue on appeal, that there was no evidence presented to the ZBA to support the position that three 100-foot towers are a customary, accessory use in the R-2 zone. The superior court found that, given the scale of the proposed towers, they no longer qualified as accessory uses under the Hudson Zoning Ordinance. We agree.

The ZBA minutes reflect that a number of town residents stated that they had amateur radio towers. One resident stated that he had a seventy-foot tower attached to his house, and another stated that her neighbors had a 100-foot tower at their house. There was no evidence presented, however, that there exist in Hudson three, or even two 100-foot radio towers which are accessory to a residence. Indeed, as the superior court noted, "[T]here was no evidence of ham radio operations in [any] residential neighborhoods which included anything reasonably close to the scale of the three antennae proposed in this case." We therefore agree with the superior court that, to the extent the ZBA decision rested upon the conclusion that the construction of three 100-foot amateur radio towers qualified as an "accessory use" under the ordinance, it is unreasonable. *Cf. City of Knoxville v. Brown*, 195 Tenn. 501, 260 S.W.2d 264, 269 (Tenn.1953).

We turn now to the town's argument that the superior court erred as a matter of law when it ordered relief that conflicted with federal objectives to allow and promote amateur ham radio facilities. According to the town, the superior court's order to remove all three radio towers, thereby preventing all ham radio operation by Muller, fails to preserve the FCC's legitimate interest in promoting amateur radio operations. We agree.

Because a municipality's power to zone property to promote the health, safety and general welfare of the community is delegated to it by the State, the municipality must exercise this power in conformance with the enabling legislation. *See Britton v. Town of Chester*, 134 N.H. 434, 441, 595 A.2d 492 (1991). RSA 674:16 grants municipalities the power to enact zoning ordinances, but expressly prohibits any such ordinance that fails to conform "to the limited federal preemption entitled *Amateur Radio Preemption*, 101 FCC 2nd 952, 1985 WL 544557 (1985) issued by the Federal Communications Commission." RSA 674:16, IV (Supp.2000). The limited preemption to which the statute refers is a limited preemption of state and local regulations governing amateur radio station facilities, including antennae and support structures designed to protect the "strong federal interest in promoting amateur communications." *Amateur Radio Preemption*, 101 F.C.C.2d 952, 959-60, 1985 WL 544557 (1985). The FCC codified the

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[147 N.H. 385] central holding of *Amateur Radio Preemption*, the FCC Memorandum Opinion referred to in RSA 674:16, IV, when it revised its amateur radio rules to provide as follows:

Except as otherwise provided [by the regulations], a station antenna structure may be erected at heights and dimensions sufficient to accommodate amateur service communications (State and local regulation of a station antenna structure must not preclude amateur service communications. Rather, it must reasonably accommodate such communications and must constitute the minimum practicable regulation to accomplish the state or local authority's legitimate purpose).
47 C.F.R. § 97.15(b) (2000).

In light of the FCC's clear directive that "[s]tate and local regulations that operate to preclude amateur communications in their communities are in direct conflict with federal objectives and must be preempted," *Amateur Radio Preemption*, 101 F.C.C.2d at 960, we agree with the town that the superior court erred when it ordered the towers removed. Regarding the federal preemption issue, the superior court held that the size and height of the towers "would upset the balance between the federal interest in promoting amateur operations and the legitimate interest of local governments in regulating local zoning matters." While some courts have focused on whether the municipality properly balanced its interest against the federal government's interests in promoting amateur communications, *see, e.g.*, *Howard v. City of Burlingame*, 937 F.2d 1376, 1380 (9th Cir. 1991); *Williams v. City of Columbia*, 906 F.2d 994, 998 (4th Cir. 1990), we agree with the United States Court of Appeals for the Eighth Circuit that the federal directive requires municipalities to do more:

PRB-1 specifically requires the city to accommodate reasonably amateur communications. This distinction is important, because a standard that requires a city to accommodate amateur communications in a reasonable fashion is certainly more rigorous than one that simply requires a city to balance local and federal interests when deciding whether to permit a radio antenna.

Pentel v. City of Mendota Heights, 13 F.3d 1261, 1264 (8th Cir. 1994) (citation omitted); *In the Matter of Modification and Clarification of Policies and Procedures Governing Siting and Maintenance of Amateur Radio Antennas and Support Structures*, 14 F.C.C.R. 19413, 19416, 1999 WL 1567541 (1999) [147 N.H. 386] (reconsideration pending) ("Given th[e] express Commission language [of PRB-1], it is clear that a 'balancing of interests' approach is not appropriate...."). Thus, we conclude that the manner in which the superior court applied the zoning ordinance violates PRB-1.

We note, however, that while New Hampshire and federal law require municipalities to accommodate amateur communications, they do not require the town to allow an amateur operator to erect any antenna he or she desires. *See Pentel*, 13 F.3d at 1264. Instead, they require only that the town "consider the application, make factual findings, and attempt to negotiate a satisfactory compromise with the applicant." *Id.* (quotations, citation and brackets omitted).

In light of the FCC's requirement, a zoning board's fact-finding and analysis should focus, first, on whether the three towers are permitted under local zoning regulations. If, as we have determined here, they are not, the zoning board should then consider what steps must be taken to "reasonably accommodate" amateur radio communications. In making this determination, the ZBA may consider whether the

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particular height and number of towers are necessary to accommodate the particular ham operator's communication objectives.

There was some evidence presented to the ZBA that the tower and antenna operation "was not the typical installation, but rather was something that every ham who was interested in reliable international communication on a regular basis aspired to own." The ZBA, however, did not make any factual findings regarding whether Muller even requires the proposed three radio towers to facilitate his international ham radio operations. Therefore, we vacate the superior court's decision and remand with instructions to remand to the ZBA for proceedings consistent with this opinion.

Affirmed in part; reversed in part; vacated and remanded.

BRODERICK, NADEAU and DUGGAN, JJ., concurred.

EXHIBIT Q: PROPAGATION STUDY WITH MAPS (EGAN REPORT)

Showing of Need for Height

of an Amateur Radio Antenna Support Structure

with Propagation Maps

Submitted on Behalf of

John Webster
NN1SS
152 Federal Hill Rd
Milford NH 03055

Prepared by

Dennis G. Egan, B.S. Mathematics (Computer Science)
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Table of Contents

Executive Summary

The purpose of this report is to show the need for an antenna system of sufficient height and dimension to provide reliable High Frequency (HF), or ‘shortwave’, communications, under the changing variables that impact Amateur Radio communications, for John Webster, amateur radio call sign NN1SS, located in Milford NH.

As described to me by Mr. Webster, he desires to construct an antenna support structure of sufficient height and size to place horizontal antennas at a height of 90 feet. This study has been completed to see if that antenna height satisfies Mr. Webster's communications needs.

Target Areas: Japan (337 degree heading), Israel (57 degree heading), and South Africa 111 degree heading). Mr Webster wishes to converse with amateur radio operators in all 3 locations.

Target Frequency: 14 MHz
Antennas: 3 element Yagi antenna for 14 MHz

It is the conclusion of this report that the station antenna structure desired by the amateur – with a 90-foot structure - which ideally should be taller – is an acceptable compromise, adequate only for the modest needs of the Amateur Radio operator applicant, when measured against commonly used engineering metrics.

Outline

This report is organized as follows:

1. Background of the author.
2. A brief discussion of communications reliability as it pertains to Amateur Radio.
3. An HF communications reliability study of the installation, using industry standard tools.
4. A reprint of a publication from the American Radio Relay League, "Antenna Height and Communications Effectiveness," that provides the basic technical background as to why, for certain needs, higher antennas perform more reliably.

Background of the Author

Dennis G. Egan is a graduate of California State University at San Jose. His degree was in mathematics, with a concentration in computer science. For many years he served in a variety of management positions for the United States Postal Service, retiring in 2007. While working for the Postal Service, he worked on major computer programs including Delivery Systems Information System and Carrier Optimal Routing.

An active radio amateur since 1969, he holds the FCC's Amateur Extra Class license – the highest class of license available. Egan's principal activity since 1980 has been radio contesting. He has been a member of teams holding several North American and Caribbean records. He was been the top scoring USA Single Operator in the CQ WW RTTY contest for three years running, and did hold the USA and North American score records for that contest at one time.

He has done simulations of antenna systems and propagation maps for the purpose of optimizing antenna system designs at major multi-tower amateur radio installations W1KM and K1TTT. He is the manager of several major "home-brew" construction projects for one of the largest contest clubs in the world, the Yankee Clipper Contest Club, and is currently immediate past- President. He has created Propagation Maps for amateur radio stations AG1LE, AK1MD, N2QV, KF0KR, KL7EZ, N2IS, WB6RMY, N5VR, N9GB, N7TY, W3KL, W9XS and many others.

Mr. Egan has no affiliation with Mr. Webster -- other than his request for this report. For this report, Mr. Webster provided latitude, longitude, and height above sea level. The databases and programs used in generating this report are all in the public domain and, while some basic tests are used to verify the data from the databases, the information from the databases is assumed to be correct. Mr. Egan is available to testify if needed. This independent report is being produced using readily available software, standard methodology, and reasonable assumptions as to propagation conditions.

High Frequency (HF) Communications Reliability

For the reader to meaningfully interpret the reliability study presented herein, a brief discussion of the major concepts and terms involved is relevant. The reader is also urged to review the document prepared by technical staff at the American Radio Relay League, "Antenna Height and Communications Effectiveness," which provides the physical explanation as to why radio communications reliability and effectiveness is strongly affected by antenna height, a foundational concept routinely recognized by the courts.

For communications to be acceptable, Amateur Radio operators expect the signal to be above the noise level so that they may understand what is being communicated. The ratio of Signal to Noise (SNR) is measured in decibels (dB), and a minimum acceptable level is approximately 40 dB SNR.[1]

Reliability (REL) in a radio communications context, answers the question "How often, on average, can this communication take place at the specified 'minimum acceptable level'?" Reliability is normally expressed as a percentage, and arriving at a specific value depends on the definition of "Minimum Acceptable Level" (MAL) in use. Several different MALs are commonly accepted in the engineering community. Take, for example, a distant TV station received over-the-air. If we define our MAL to be "we can tolerate an occasional pixelation," then the measured REL might be as low as 20-30%. If we define our MAL as "a completely clear picture without any pixelation ever," then the measured REL may jump to 80-90%. For another example, many areas of the communications industry (broadcasting and networking) routinely use a REL of 99.99% (commonly called "the four nines") which means they are "down" no more than 52 minutes each year. Radio amateurs do not, generally speaking, require such a high level of REL; a REL of 50-60% is usually sufficient. This would mean that the communications path at a given time and frequency would be available 5 to 6 days out of 10.

Application to HF Analysis

Turning closer to our domain, High Frequency (HF) shortwave broadcasters, like the Voice of America or the BBC World Service, look for Reliability numbers in the 80-90% range when planning their time and frequency schedules, to achieve an area coverage goal. In their cases, the MAL parameter (yardstick) is the Signal-to-Noise ratio, or SNR. This is basically the ratio of how loud the broadcast is in relation to background radio 'hiss' and static levels. Commonly used SNR numbers are anywhere from 40-70 dB (a higher number means better quality reception).

In the analysis presented below, the Reliability threshold is set at 60%, using an SNR of 40 dB for Single Sideband (SSB) voice communication. This is a *very* conservative (low) value for measuring acceptable communications quality.

HF radio communication is made possible by reflecting signals off an ionized portion of the earth's atmosphere known as the ionosphere. The very nature of this communication is variable (*i.e.*, not constant) and depends on many factors, including the time of year, time of

[1] A signal to noise ratio (SNR) of 40 dB for radio communications is defined as yielding copy "with annoying noise, readable by trained, persistent operators."

day, solar (sunspot) activity, local noise sources and other geomagnetic and atmospheric conditions. The test cases presented consistently used very conservative models and accepted a low Reliability (REL) factor (60%).

• **A Reliability threshold of 60% is equivalent to 6 days out of 10.** Imagine if your cell phone or cable TV service worked only six days out of ten – that would be a Reliability of 60%. If your cell phone or cable TV service worked seven days out of ten, that would be a Reliability of 70%. In the figures that follow, the Reliability contours are under 20, 20-29, 30-39, 40-49, 50-59, and over 60%, to correspond to easily understood levels of less than 2, 2, 3, 4, 5, and 6 or more days out of ten.

• The MAL (Minimum Acceptable Level) is expressed as a Signal-to-Noise Ratio (SNR). This value (40 dB) is commonly used in Amateur Radio; it is the **minimum required SNR** for a Single Sideband (voice) transmission. Single sideband transmissions sometimes require an SNR up to 50 dB or more, which would further lower the results presented here (*i.e.*, require a larger/taller antenna system). In other words, in presenting the results here, the assumptions about required REL are *very* modest.

Some generalizations:

- The higher an HF antenna, the lower the angle of radiation
- The lower the angle of radiation, the further the signal travels before reflecting against the ionosphere
- The farther a signal travels, the more loss in signal level
- The more times a signal is reflected, the more loss in signal level
- Solar activity, as measured by the Sun Spot Number (SSN), varies over an 11-year cycle
- Solar activity changes the reflection properties of the ionosphere
- The time of year or position of the sun changes the ionosphere's properties
- The more power used in generating a signal, the stronger the signal. The maximum power allowed in generating an amateur radio signal is 1500 watts.

High Frequency (HF) Analysis of the Installation

Antenna support structures have been requested by Mr. Webster to support antennas at the 90- foot level. I was requested to provide an analysis of how well Mr. Webster could communicate to his target areas using that antenna height.

Design parameters:

- Communications to Israel, South Africa, and Japan
- SNR 40 dB
- REL 60%
- Smoothed Sunspot Average 100 (11 year average figure)
- December is the month used for all analysis
- Peak times to communicate
- Low geomagnetic Activity
- Low noise levels

- Transmission power 1400 watts (to account for feed line and switching losses)
- Frequency bands at 14 MHz (20 meter amateur band)
- Antenna height: 90-feet proposed, 35-feet permitted
- Receiving antenna: a standard half-wave dipole at 60 feet above ground and oriented for maximum received signal strength at the target location
- Transmit Antenna: 3 element Yagi antenna for 20m
- Scale and color coding on all maps is the same
- REL colors: Orange is >60%, Grey is 50-59%, Yellow is 40-49%, Pink is 30-39%, Lightt Blue is 20-29%, and White is <20%
- Communication mode: Single Sideband (SSB), 2.4 kHz bandwidth (SNR 40dB)

The process starts with terrain data entered for the Milford location in the direction of the desired geographic locations (target areas), fed as input to the HFTA (High Frequency Terrain Assessment) program from the ARRL – the national association for Amateur Radio. This program uses the terrain of the residence, elevation, and antenna parameters as input, and provides antenna gain and take-off (elevation) angle data as output.

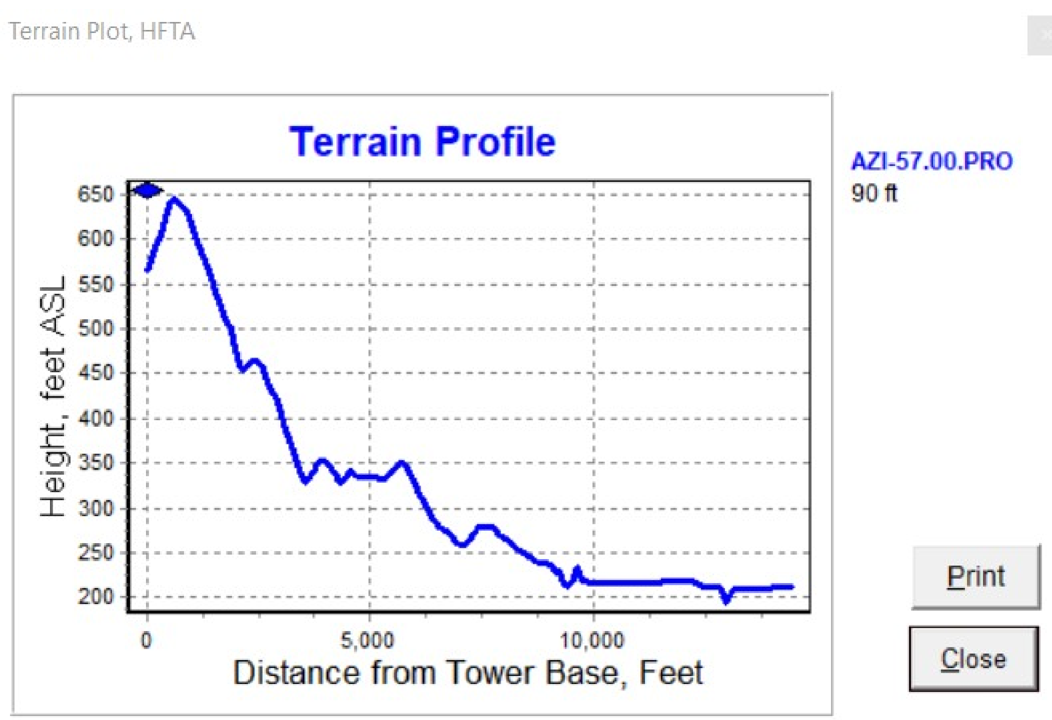

Figure 1 (Terrain Profile Toward Israel)

Figure 1 above is the terrain from the Milford location at a 57 degree heading toward Israel. After a 90-foot hill about 500 feet in the direction of Israel, the terrain after that is pretty much all downhill..

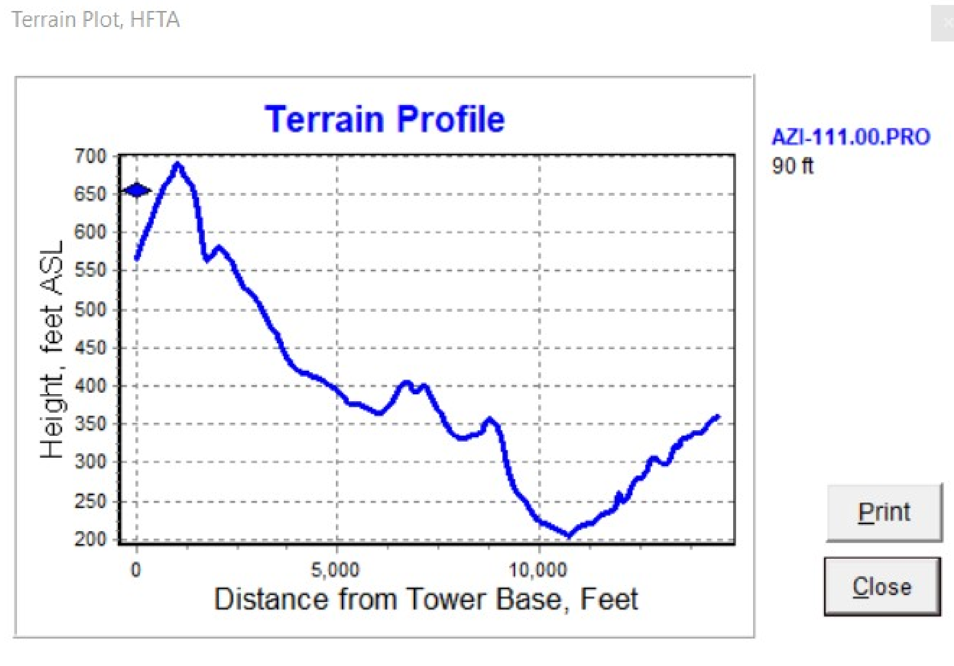

Figure 2 (Terrain Profile Towards South Africa)

Figure 2 above is the terrain from the Milford location toward South Africa. After a 130-foot rise in that direction, the next 2 miles its pretty much all downhill. The close in hill has definite impacts on signals to South Africa.

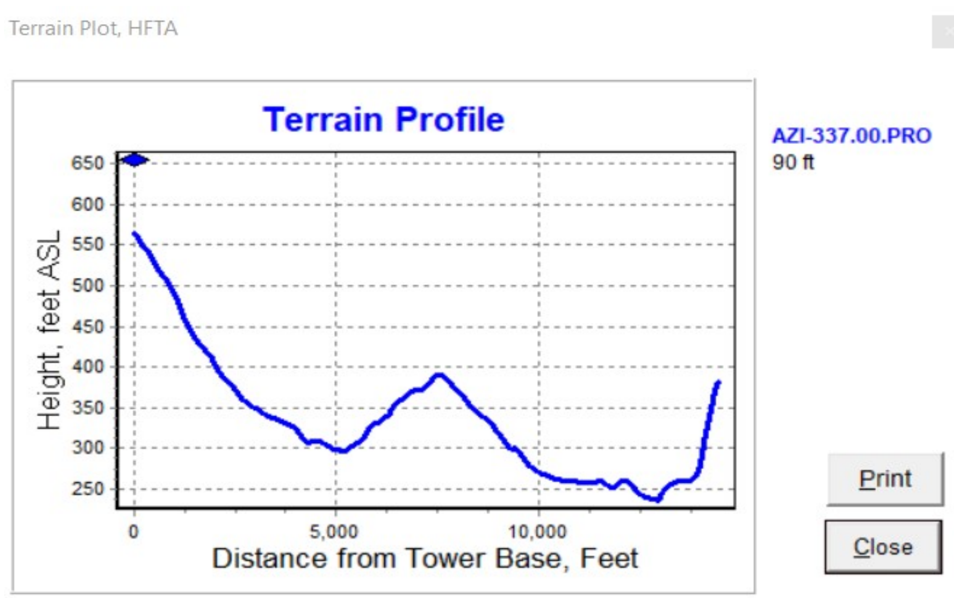

Figure 3, (Terrain Profile towards Japan)

Figure 3 above is the terrain from the Milford location toward Japan; It is all downhill out to a mile, then a slight rise (100 feet) before another drop.

The terrain characteristics are then combined with the antenna characteristics to produce an output file from HFTA that is used for input to VOAAREA. VOAAREA is an HF Propagation Analysis software tool developed by the U.S. Department of Commerce / Institute for Telecommunication Sciences, public domain software made possible by funding from the Voice of America (VOA), the U.S. Army, and the U.S. Air Force. In other words, the software was not designed to favor amateur radio, or a particular radio amateur. Area Coverage is one of many calculations that VOAAREA can perform. It displays a number of calculated quantities (including REL) for a specified transmission system to a specified reception area for a specified month, time of day, frequency, and sunspot level. The results appear as contours plotted on a world map background.

In the discussion that follows, 60% is used as the minimum acceptable reliability (REL) value, *i.e.*, successful communications is defined as a path reliability of 60% or greater – six or more days out of ten -- of otherwise available time (blackout times are not included) under the changing variables that impact amateur radio communications. This is a very conservative service goal, as *Snook v. City of Missouri City* (Texas), an amateur radio case tried in the U.S. District Court, Southern District of Texas (2003)[2], accepted a service reliability standard of 75-90%.

[2] *Snook v. City of Missouri City,* 2003 U.S. Dist. LEXIS 27256, 2003 WL 25258302 (S.D. Tex. Aug. 27, 2003, Hittner, J.) (the Order). Available on the internet at http://www.arrl.org/files/file/Snook%2520KB5F%2520Decision%2520%26%2520Order%252034.pdf (retrieved May 2, 2015). See also the Final Judgment, Slip Opinion, 2 pp. available at:

(PACER citation) https://ecf.txsd.uscourts.gov/cgi-bin/login.pl?387442335892775-L_238_0-14:03-cv-00243_Snook v._City_of_Missouri, (S.D. Tex. 2003) or (Internet) http://www.arrl.org/files/file/Snook%2520KB5F%2520Final%2520Judgment%252035.pdf retrieved May 2, 2015)

Propagation Map Study #1 - 14 MHz to Israel

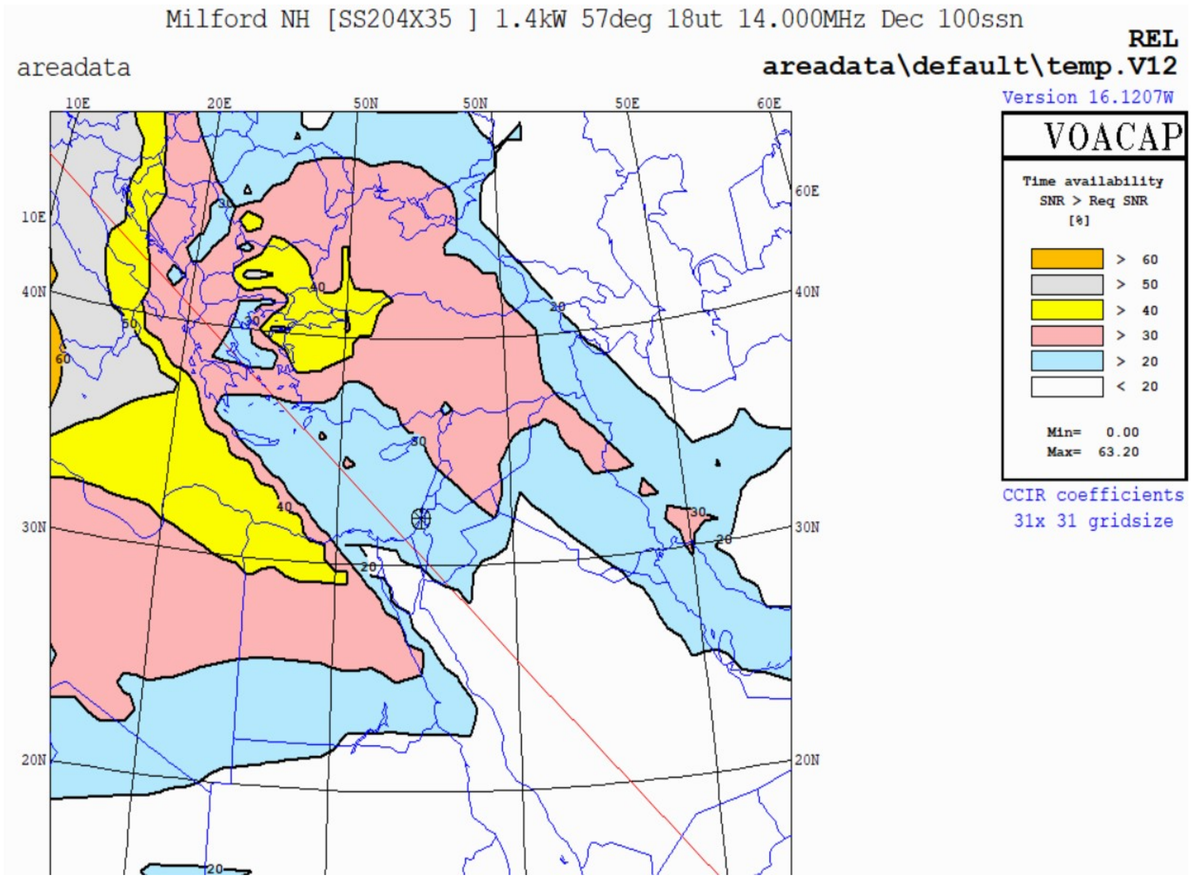

Figure 4 (35-foot antenna height, 14 MHz, to Israel)

Figure 3 communications to Israel would have a REL between 20 and 30%. Communications should be possible less than 2-3 days out of 10. This is far short of minimum REL of 60%..

Propagation Map Study #2 - 14 MHz to Israel

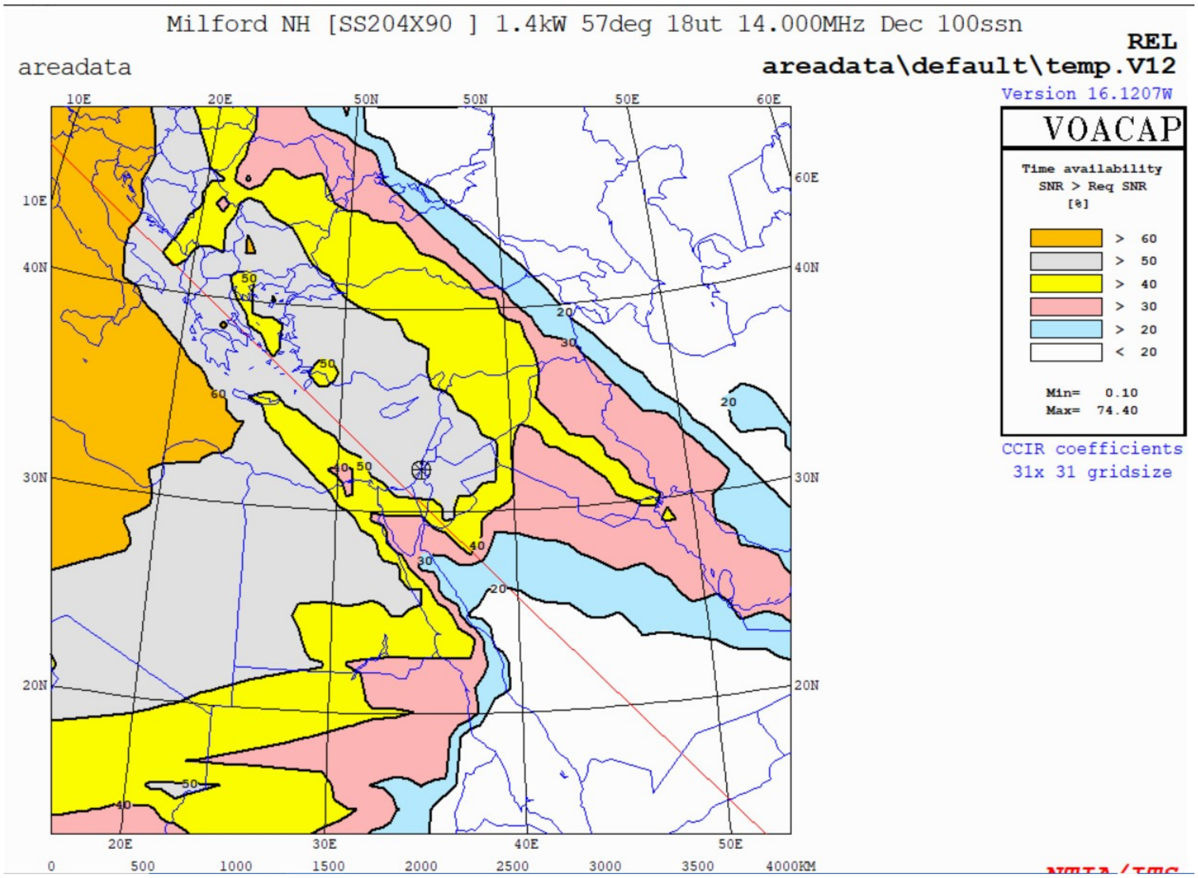

Figure 5 (90 foot antenna height, 14 MHz, to Israel)

Figure 5 to Israel shows a REL over 50%; communications to Israel should be possible over 50% of the days. The additional height makes a major difference in clearing the nearby hill. While this does not meet the required REL of 60%, Mr. Webster is apparently willing to live with it.

While it is true that increasing the power output could generate an increased signal into Israel with a shorter antenna height, there are problems with that strategy:

- It is illegal to exceed the FCC's maximum permitted output, which was already modeled into this analysis, and
- Increasing transmitter output has no impact on received signals, which would still be unreadable.

Propagation Map Study #3 – 14 MHz to South Africa

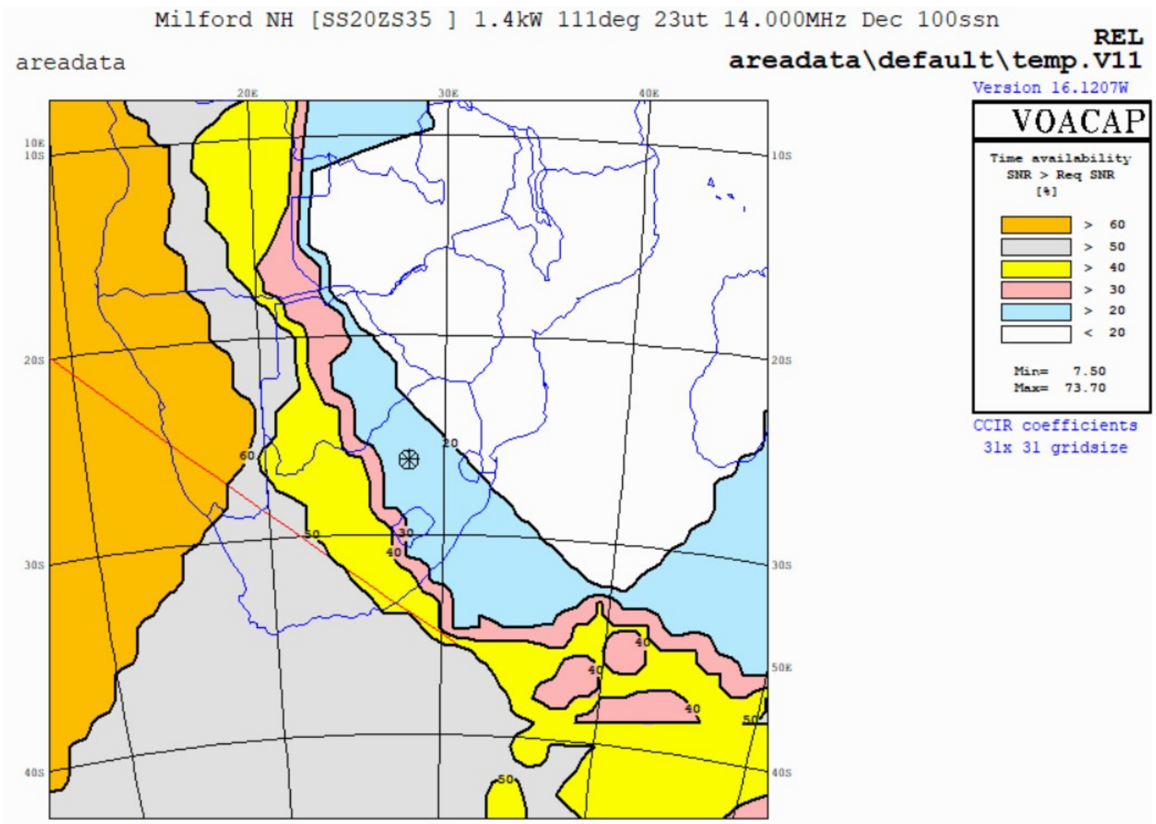

Figure 6 (35-foot antenna height, 14 MHz, to South Africa)

Figure 6 is a picture of the REL to South Africa on 14 MHz. The REL to Johannesburg is in the 20-30% range, indicating that communications at this time and frequency would be possible 2 to 3 days out of 10.

Propagation Map Study #4 - 14 MHz to South Africa

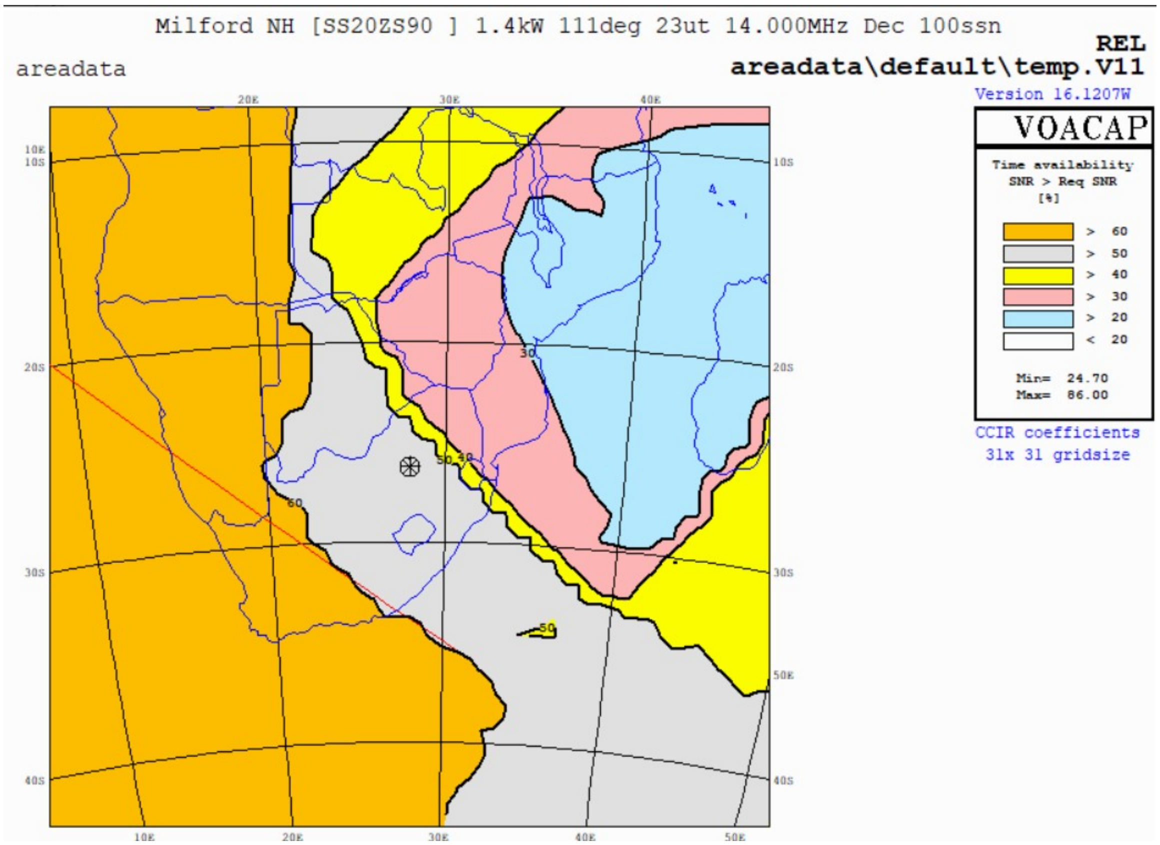

Figure 7 (90-foot antenna height, 14MHz to South Africa)

Figure 7 is a picture of the REL for South Africa on 14MHz. The REL is over 50%; communications should be possible over 5 days out of 10. While this does not meet the REL requirement of 60%, Mr. Webster is apparently willing to live with it.

While it is true that increasing the power output could generate an increased signal into South Africa, there are two problems with that strategy:

- It is illegal to exceed the FCC's maximum permitted output, which was already modeled into this analysis, and
- Increasing transmitter output has no impact on received signals, which would still be unreadable.

Propagation Map Study #5 - 14 MHz to Japan

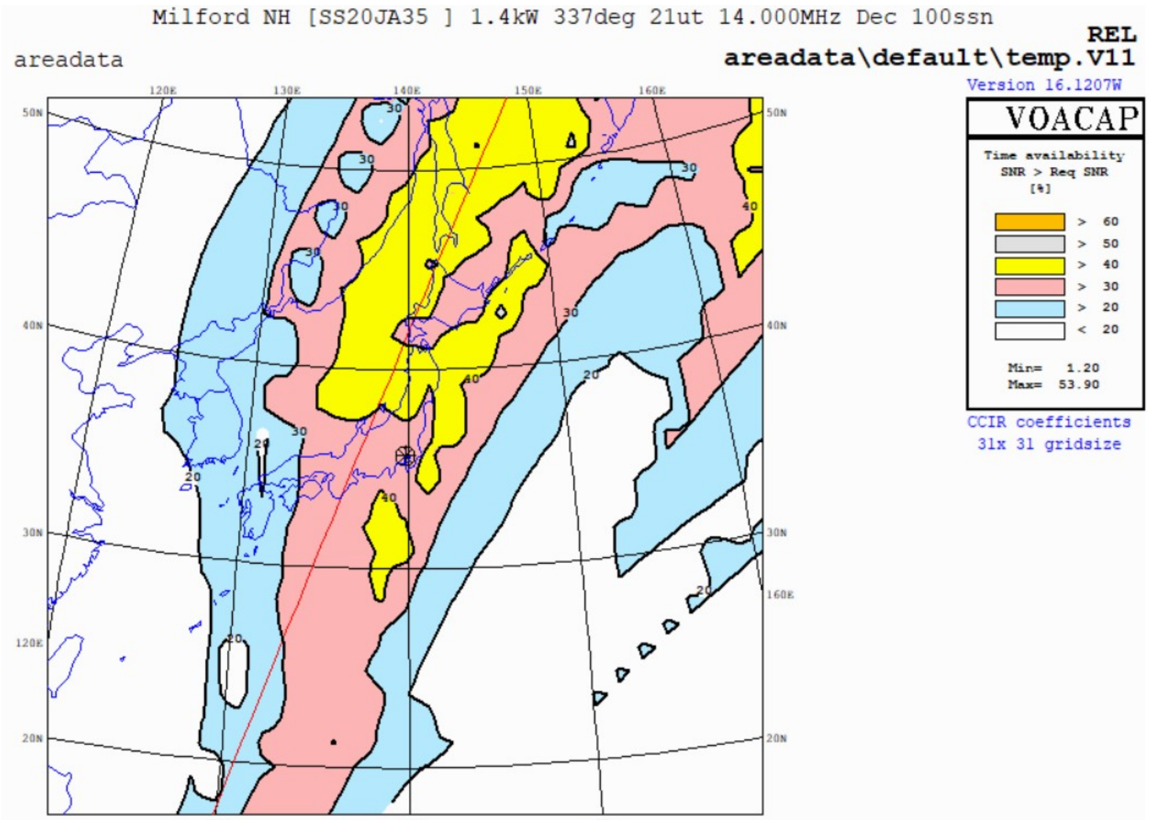

Figure 8 (35-foot antenna height, 14MHz to Japan

Figure 8 is a picture of the REL for Japan on 14MHz. The REL for Japan varies from 20% to 40%; for Tokyo (map center) its in the 30-40% range. Communications should be possible on 3-4 days out of 10.

Propagation Map Study #6 - 14 MHz to Japan

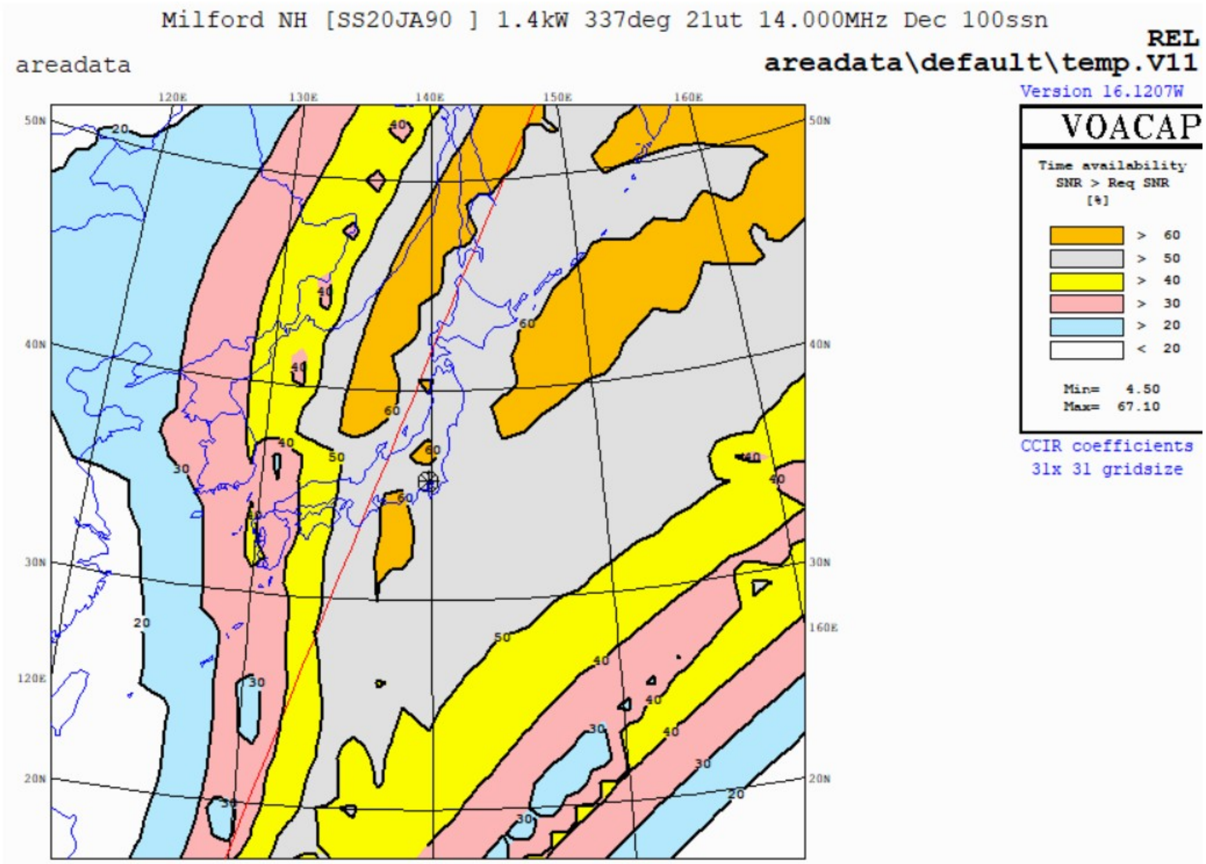

Figure 8 (90 foot antenna height, 14MHz to Japan

Figure 8 is a picture of the REL for Japan on 14MHz using the 90-foot tower. The REL for Japan is solidly in the 50% range; communications should be possible on 5 days out of 10. While this does not meet the REL requirement of 60%, Mr. Webster is apparently willing to live with it.

While it is true that increasing the power output could generate an increased signal into Japan with a lower antenna height, there are two problems with that strategy:

- It is illegal to exceed the FCC's maximum permitted output, which was already modeled into this analysis, and
- Increasing transmitter output has no impact on received signals, which would still be unreadable.

High Frequency (HF) Communications Analysis Conclusion

The height of the proposed antenna support structure and antennas were analyzed for the purpose of determining whether they would meet the need for effective communications of the amateur radio operator. Commonly used engineering metrics were employed to determine the effectiveness of communications.

The antenna, when installed at the 90-foot height as indicated, will result in greatly improved REL for Amateur Radio communications with Israel, South Africa, and Japan. While the 90-foot height, in the three propagation studies, does not produce a REL that meets our requirement of 60%, Mr. Webster is apparently willing to live with this antenna height, despite the limitations it presents, as an acceptable compromise.

Respectfully submitted,

Dennis G. Egan, B.S.

Affidavit of Dennis G. Egan, B.S. Mathematics (Concentration in Computer Science)

The facts or denial of facts set forth in the foregoing document are based upon either my personal knowledge, or information and belief. I prepared the document myself, including all of the terrain data and propagation maps, based on information about frequencies, desired directions, and power output provided by the applicants and, based on my experience and history using the software employed, I believe the reported results to be reliable. I did not modify the software used to prepare the document so as to achieve a particular outcome, and I used standard assumptions, stated in the report, about propagation.

I acknowledge that this document is being submitted to the Town of Milford NH Zoning Board, in support of the application of Mr. John Webster NN1SS, and will be considered in those proceedings.

I certify under penalty of perjury that the foregoing submission is true and correct to the best of my knowledge and belief.

Dennis G. Egan, B.S.

A reprint of "Antenna Height and Communications Effectiveness" follows. It is an engineering study by the technical staff of the American Radio Relay League (ARRL), and provides the basic technical background as to why, for certain amateur radio applications, higher antennas perform more reliably.

Antenna Height
and
Communications Effectiveness

Second Edition

A Guide for City Planners and Amateur Radio Operators

By R. Dean Straw, N6BV, and Gerald L. Hall, K1TD
Senior Assistant Technical Editor and Retired Associate Technical Editor

The American Radio Relay League, Inc.
225 Main Street
Newington, CT 06111

Executive Summary

Amateur radio operators, or “hams” as they are called, communicate with stations located all over the world. Some contacts may be local in nature, while others may be literally halfway around the world. Hams use a variety of internationally allocated frequencies to accomplish their communications.

Except for local contacts, which are primarily made on Very High and Ultra High Frequencies (VHF and UHF), communicating between any two points on the earth rely primarily on high-frequency (HF) signals propagating through the ionosphere. The earth’s ionosphere acts much like a mirror at heights of about 150 miles. The vertical angle of radiation of a signal launched from an antenna is one of the key factors determining effective communication distances. The ability to communicate over long distances generally requires a low radiation angle, meaning that an antenna must be placed high above the ground in terms of the wavelength of the radio wave being transmitted.

A beam type of antenna at a height of 70 feet or more will provide greatly superior performance over the same antenna at 35 feet, all other factors being equal. A height of 120 feet or even higher will provide even more advantages for long-distance communications. To a distant receiving station, a transmitting antenna at 120 feet will provide the effect of approximately 8 to 10 times more transmitting power than the same antenna at 35 feet. Depending on the level of noise and interference, this performance disparity is often enough to mean the difference between making distant radio contact with fairly reliable signals, and being unable to make distant contact at all.

Radio Amateurs have a well-deserved reputation for providing vital communications in emergency situations, such as in the aftermath of a severe icestorm, a hurricane or an earthquake. Short-range communications at VHF or UHF frequencies also require sufficient antenna heights above the local terrain to ensure that the antenna has a clear horizon.

In terms of safety and aesthetic considerations, it might seem intuitively reasonable for a planning board to want to restrict antenna installations to low heights. However, such height restrictions often prove very counterproductive and frustrating to all parties involved. If an amateur is restricted to low antenna heights, say 35 feet, he will suffer from poor transmission of his own signals as well as poor reception of distant signals. In an attempt to compensate on the transmitting side (he can’t do anything about the poor reception problem), he might boost his transmitted power, say from 150 watts to 1,500 watts, the maximum legal limit. This ten-fold increase in power will very significantly increase the *potential* for interference to telephones, televisions, VCRs and audio equipment in his neighborhood.

Instead, if the antenna can be moved farther away from neighboring electronic devices—putting it higher, in other words—this will greatly reduce the likelihood of interference, which decreases at the inverse square of the distance. For example, doubling the distance reduces the potential for interference by 75%. As a further benefit, a large antenna doesn’t look anywhere near as large at 120 feet as it does close-up at 35 feet.

As a not-so-inconsequential side benefit, moving an antenna higher will also greatly reduce the potential of exposure to electromagnetic fields for neighboring human and animals. Interference and RF exposure standards have been thoroughly covered in recently enacted Federal Regulations.

Antenna Height and Communications Effectiveness

By R. Dean Straw, N6BV, and Gerald L. Hall, K1TD
Senior Assistant Technical Editor and Retired Associate Technical Editor

The purpose of this paper is to provide general information about communications effectiveness as related to the physical height of antennas. The intended audience is amateur radio operators and the city and town Planning Boards before which a radio amateur must sometimes appear to obtain building permits for radio towers and antennas.

The performance of horizontally polarized antennas at heights of 35, 70 and 120 feet is examined in detail. Vertically polarized arrays are not considered here because at short-wave frequencies, over average terrain and at low radiation angles, they are usually less effective than horizontal antennas.

Ionospheric Propagation

Frequencies between 3 and 30 megahertz (abbreviated MHz) are often called the "short-wave" bands. In engineering terms this range of frequencies is defined as the *high-frequency* or *HF* portion of the radio spectrum. HF radio communications between two points that are separated by more than about 15 to 25 miles depend almost solely on propagation of radio signals through the *ionosphere*. The ionosphere is a region of the Earth's upper atmosphere that is ionized primarily by ultraviolet rays from the Sun.

The Earth's ionosphere has the property that it will refract or bend radio waves passing through it. The ionosphere is not a single "blanket" of ionization. Instead, for a number of complex reasons, a few discrete layers are formed at different heights above the earth. From the standpoint of radio propagation, each ionized layer has distinctive characteristics, related primarily to different amounts of ionization in the various layers. The ionized layer that is most useful for HF radio communication is called the *F layer*.

The F layer exists at heights varying from approximately 130 to 260 miles above the earth's surface. Both the layer height and the amount of ionization depend on the latitude from the equator, the time of day, the season of the year, and on the level of sunspot activity. Sunspot activity varies generally in cycles that are approximately 11 years in duration, although short-term bursts of activity may create changes in propagation conditions that last anywhere from a few minutes to several days. The ionosphere is not homogeneous, and is undergoing continual change. In fact, the exact state of the ionosphere at any one time is so variable that is best described in statistical terms.

The F layer disappears at night in periods of low and medium solar activity, as the ultraviolet energy required to sustain ionization is no longer received from the Sun. The amount that a passing radio wave will bend in an ionospheric layer is directly related to the intensity of ionization in that layer, and to the frequency of the radio wave.

A triangle may be used to portray the cross-sectional path of ionospheric radio-wave travel, as shown in **Fig 1**, a highly simplified picture of what happens in propagation of radio waves. The base of the triangle is the surface of the Earth between two distant points, and the apex of the triangle is the point representing refraction in the ionosphere. If all the necessary conditions are met, the radio wave will travel from the first point on the Earth's surface to the ionosphere, where it will be bent (*refracted*) sufficiently to travel to the second point on the earth, many hundreds of miles away.

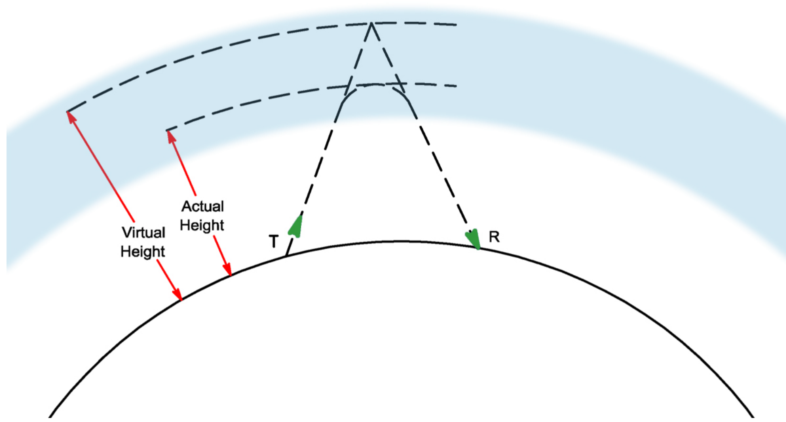

Fig 1—A simplified cross-sectional representation of ionospheric propagation. The simple triangle goes from the Transmitter T up to the virtual height and then back down to the Receiver R. Typically the F layer exists at a height of 150 miles above the Earth at mid-latitudes. The distance between T and R may range from a few miles to 2500 miles under normal propagation conditions.

Of course the Earth's surface is not a flat plane, but instead is curved. High-frequency radio waves behave in essentially the same manner as light waves—they tend to travel in straight lines, but with a slight amount of downward bending caused by refraction in the air. For this reason it is not possible to communicate by a direct path over distances greater than about 15 to 25 miles in this frequency range, slightly farther than the optical horizon. The curvature of the earth causes the surface to "fall away" from the path of the radio wave with greater distances. Therefore, it is the ionosphere that permits HF radio communications to be made between points separated by hundreds or even thousands of miles. The range of frequencies from 3 to 30 MHz is unique in this respect, as ionospheric propagation is not consistently supported for any frequencies outside this range.

One of the necessary conditions for ionospheric communications is that the radio wave must encounter the ionosphere at the correct angle. This is illustrated in **Fig 2**, another very simplified drawing of the geometry involved. Radio waves leaving the earth at high elevation angles above the horizon may receive only very slight bending due to refraction, and are then lost to outer space. For the same fixed frequency of operation, as the elevation angle is lowered toward the horizon, a point is reached where the bending of the wave is sufficient to return the wave to the Earth. At successively lower angles, the wave returns to the Earth at increasing distances.

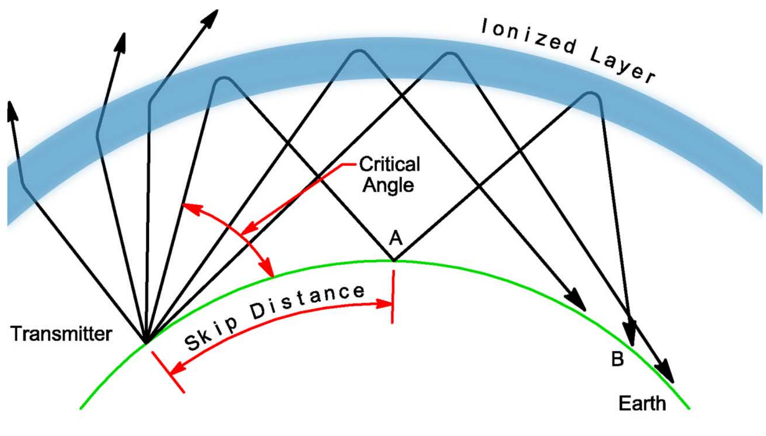

Fig 2—Behavior of radio waves encountering the ionosphere. Rays entering the ionized region at angles above the critical angle are not bent enough to return to Earth and are lost to space. Waves entering at angles below the critical angle reach the Earth at increasingly greater distances as the angle approaches the horizontal. The maximum distance that may normally be covered in a single hop is 2500 miles. Greater distances may be covered with multiple hops.

If the radio wave leaves the earth at an *elevation angle* of zero degrees, just toward the horizon (or just tangent to the earth's surface), the maximum distance that may be reached under usual ionospheric conditions is approximately 2,500 miles (4,000 kilometers). However, the Earth itself also acts as a reflector of radio waves coming down from the ionosphere. Quite often a radio signal will be reflected from the reception point on the Earth back into the ionosphere again, reaching the Earth a second time at a still more distant point.

As in the case of light waves, the angle of reflection is the same as the angle of incidence, so a wave striking the surface of the Earth at an angle of, say, 15° is reflected upward from the surface at the same angle. Thus, the distance to the second point of reception will be approximately twice the distance of the first. This effect is also illustrated in Fig 2, where the signal travels from the transmitter at the left of the drawing via the ionosphere to Point A, in the center of the drawing. From Point A the signal travels via the ionosphere again to Point B, at the right. A signal traveling from the Earth through the ionosphere and back to the Earth is called a *hop*. Under some conditions it is possible for as many as four or five signal hops to occur over a radio path, but no more than two or three hops is the norm. In this way, HF communications can be conducted over thousands of miles.

With regard to signal hopping, two important points should be recognized. First, a significant loss of signal occurs with each hop. Lower layers of the ionosphere absorb energy from the signals as they pass through, and the ionosphere tends to scatter the radio energy in various directions, rather than confining it to a tight bundle. The earth also scatters the energy at a reflection point. Thus, only a small fraction of the transmitted energy actually reaches a distant receiving point.

Again refer to Fig 2. Two radio paths are shown from the transmitter to Point B, a one-hop path and a two-hop path. Measurements indicate that although there can be great variation in the ratio of the two signal strengths in a situation such as this, the signal power received at Point B will generally be from five to ten times greater for the one-hop wave than for the two-hop wave. (The terrain at the mid-path reflection point for the two-hop wave, the angle at which the wave is reflected from the earth, and the condition of the ionosphere in the vicinity of all the refraction points are the primary factors in determining the signal-strength ratio.) Signal levels are generally compared in decibels, abbreviated dB. The decibel is a logarithmic unit. Three decibels difference in signal strengths is equivalent to a power ratio of 2:1; a difference of 10 dB equates to a power ratio of 10:1. Thus the signal loss for an additional hop is about 7 to 10 dB.

The additional loss per hop becomes significant at greater distances. For a simplified example, a distance of 4,000 miles can be covered in two hops of 2,000 miles each or in four hops of 1,000 miles each. For illustration, assume the loss for additional hops is 10 dB, or a 1/10 power ratio. Under such conditions, the four-hop signal will be received with only 1/100 the power or 20 dB below that received in two hops. The reason for this is that only 1/10 of the two-hop signal is received for the first additional (3^{rd}) hop, and only 1/10 of that 1/10 for the second additional (4^{th}) hop. It is for this reason that no more than four or five propagation hops are useful; the received signal eventually becomes too weak to be heard.

The second important point to be recognized in multihop propagation is that the geometry of the first hop establishes the geometry for all succeeding hops. And it is the elevation angle at the transmitter that sets up the geometry for the first hop.

It should be obvious from the preceding discussion that one needs a detailed knowledge of the range of elevation angles for effective communication in order to do a scientific evaluation of a possible communications circuit. The range of angles should be statistically valid over the full 11-year solar sunspot cycle, since the behavior of the Sun determines the changes in the nature of the Earth's ionosphere. ARRL did a very detailed computer study in the early 1990s to determine the angles needed for propagation throughout the world. The results of this study will be examined later, after we introduce the relationship between antenna height and the elevation pattern for an antenna.

Horizontal Antennas Over Flat Ground

A simple antenna that is commonly used for HF communications is the horizontal half-wave *dipole*. The dipole is a straight length of wire (or tubing) into which radio-frequency energy is fed at the center. Because of its simplicity, the dipole may be easily subjected to theoretical performance analyses. Further, the results of proper analyses are well borne out in practice. For these reasons, the half-wave dipole is a convenient performance standard against which other antenna systems can be compared.

Because the earth acts as a reflector for HF radio waves, the directive properties of any antenna are modified considerably by the ground underneath it. If a dipole antenna is placed horizontally above the ground, most of the energy radiated downward from the dipole is reflected upward. The reflected waves combine with the direct waves (those radiated at angles above the horizontal) in various ways, depending on the height of the antenna, the frequency, and the electrical characteristics of the ground under and around the antenna.

At some vertical angles above the horizon, the direct and reflected waves may be exactly in phase—that is, the maximum signal or field strengths of both waves are reached at the same instant at some distant point. In this case the resultant field strength is equal to the sum of the two components. At other vertical angles the two waves may be completely out of phase at some distant point—that is, the fields are maximum at the same instant but the phase directions are opposite. The resultant field strength in this case is the difference between the two. At still other angles the resultant field will have intermediate values. Thus, the effect of the ground is to increase the intensity of radiation at some vertical angles and to decrease it at others. The elevation angles at which the maxima and minima occur depend primarily on the antenna height above ground. (The electrical characteristics of the ground have some slight effect too.)

For simplicity here, we consider the ground to be a perfectly conducting, perfectly flat reflector, so that straightforward trigonometric calculations can be made to determine the relative amount of radiation intensity at any vertical angle for any dipole height. Graphs from such calculations are often plotted on rectangular axes to show best resolution over particularly useful ranges of elevation angles, although they are also shown on polar plots so that both the front and back of the response can be examined easily. **Fig 3** shows an overlay of the polar elevation-pattern responses of two dipoles at different heights over perfectly conducting flat ground. The lower dipole is located a half wavelength above ground, while the higher dipole is located one wavelength above ground. The pattern of the lower antenna peaks at an elevation angle of about 30º, while the higher antenna has two main lobes, one peaking at 15º and the other at about 50º elevation angle.

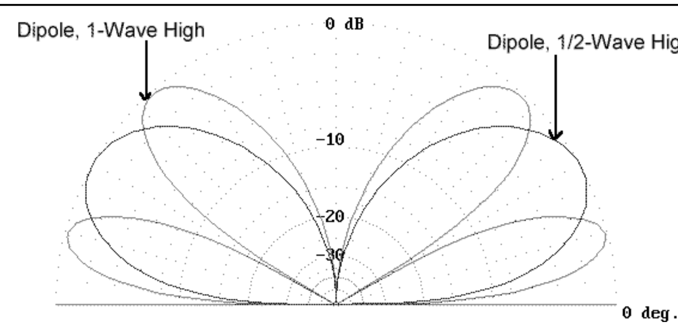

Fig 3–Comparison of elevation responses for two dipoles: one ½-wavelength high, and the other 1-wavelength high.

In the plots shown in Fig 3, the elevation angle above the horizon is represented in the same fashion that angles are measured on a protractor. The concentric circles are calibrated to represent ratios of field strengths, referenced to the strength represented by the outer circle. The circles are calibrated in decibels. Diminishing strengths are plotted toward the center.

You may have noted that antenna heights are often discussed in terms of *wavelengths*. The reason for this is that the length of a radio wave is inversely proportional to its frequency. Therefore a fixed physical height will represent different electrical heights at different radio frequencies. For example, a height of 70 feet represents one wavelength at a frequency of 14 MHz. But the same 70-foot height represents a half wavelength for a frequency of 7 MHz and only a quarter wavelength at 3.5 MHz. On the other hand, 70 feet is 2 wavelengths high at 28 MHz.

The lobes and nulls of the patterns shown in Fig 3 illustrate what was described earlier, that the effect of the ground beneath an antenna is to increase the intensity of radiation at some vertical elevation angles and to decrease it at others. At a height of a half wavelength, the radiated energy is strongest at a rather high elevation angle of 30º. This would represent the situation for a 14-MHz dipole 35 feet off the ground.

As the horizontal antenna is raised to greater heights, additional lobes are formed, and the lower ones move closer to the horizon. The maximum amplitude of each of the lobes is roughly equal. As may be seen in Fig 3, for an antenna height of one wavelength, the energy in the lowest lobe is strongest at 15º. This would represent the situation for a 14-MHz dipole 70 feet high.

The elevation angle of the lowest lobe for a horizontal antenna above perfectly conducting ground may be determined mathematically:

$$\theta = \sin^{-1}\left(\frac{0.25}{h}\right)$$

Where

θ = the wave or elevation angle
h = the antenna height above ground in wavelengths

In short, the higher the horizontal antenna, the lower is the lowest lobe of the pattern. As a very general rule of thumb, the higher an HF antenna can be placed above ground, the farther it will provide effective communications because of the resulting lower radiation angle. This is true for any horizontal antenna over real as well as theoretically perfect ground.

You should note that the *nulls* in the elevation pattern can play an important role in communications—or lack of communication. If a signal arrives at an angle where the antenna system exhibits a deep null, communication effectiveness will be greatly reduced. It is thus quite possible that an antenna can be *too high* for good communications efficiency on a particular frequency. Although this rarely arises as a significant problem on the amateur bands below 14 MHz, we'll discuss the subject of optimal height in more detail later.

Actual earth does not reflect all the radio-frequency energy striking it; some absorption takes place. Over real earth, therefore, the patterns will be slightly different than those shown in Fig 3, however the differences between theoretical and perfect earth ground are not significant for the range of elevation angles necessary for good HF communication. Modern computer programs can do accurate evaluations, taking all the significant ground-related factors into account.

Beam Antennas

For point-to-point communications, it is beneficial to concentrate the radiated energy into a beam that can be aimed toward a distant point. An analogy can be made by comparing the light from a bare electric bulb to that from an automobile headlight, which incorporates a built-in focusing lens. For illuminating a distant point, the headlight is far more effective.

Antennas designed to concentrate the radiated energy into a beam are called, naturally enough, *beam antennas*. For a fixed amount of transmitter power fed to the transmitting antenna, beam antennas provide increased signal strength at a distant receiver. In radio communications, the use of a beam antenna is also beneficial during reception, because the antenna pattern for transmission is the same for reception. A beam antenna helps to reject signals from unwanted directions, and in effect boosts the strength of signals received from the desired direction.

The increase in signal or field strength a beam antenna offers is frequently referenced to a dipole antenna in free space (or to another theoretical antenna in free space called an *isotropic antenna*) by a term called *gain*. Gain is commonly expressed in decibels. The isotropic antenna is defined as being one that radiates equally well in all directions, much like the way a bare lightbulb radiates essentially equally in all directions.

One particularly well known type of beam antenna is called a *Yagi*, named after one of its Japanese inventors. Different varieties of Yagi antennas exist, each having somewhat different characteristics. Many television antennas are forms of multi-element Yagi beam antennas. In the next section of this paper, we will refer to a four-element Yagi, with a gain of 8.5 dBi in free space, exclusive of any influence due to ground.

This antenna has 8.5 dB more gain than an isotropic antenna in free space and it achieves that gain by squeezing the pattern in certain desired directions. Think of a normally round balloon and imagine squeezing that balloon to elongate it in one direction. The increased length in one direction comes at the expense of length in other directions. This is analogous to how an antenna achieves more signal strength in one direction, at the expense of signal strength in other directions.

The elevation pattern for a Yagi over flat ground will vary with the electrical height over ground in exactly the same manner as for a simpler dipole antenna. The Yagi is one of the most common antennas employed by radio amateurs, second in popularity only to the dipole.

Putting the Pieces Together

In **Fig 4**, the elevation angles necessary for communication from a particular transmitting site, in Boston, Massachusetts, to the continent of Europe using the 14-MHz amateur band are shown in the form of a bargraph. For each elevation angle from 1º to 30º, Fig 4 shows the percentage of time when the 14-MHz band is open at each elevation angle. For example, 5º is the elevation angle that occurs just over 12% of the time when the band is available for communication, while 11º occurs about 10% of the time when the band is open. The useful range of elevation angles that must accommodated by an amateur station wishing to talk to Europe from Boston is from 1º to 28º.

In addition to the bar-graph elevation-angle statistics shown in Fig 4, the elevation pattern responses for three Yagi antennas, located at three different heights above flat ground, are overlaid on the same graph. You can easily see that the 120-foot antenna is the best antenna to cover the most likely angles for this particular frequency, although it suffers at the higher elevation angles on this particular propagation path, beyond about 12°. If, however, you can accept somewhat lower gain at the lowest angles, the 70-foot antenna would arguably be the best overall choice to cover all the elevation angles.

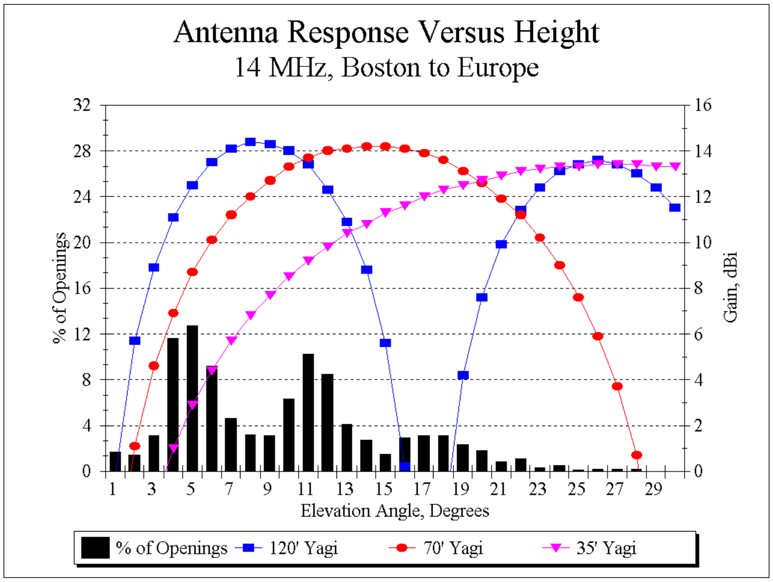

Fig 4—Elevation response patterns of three Yagis at 120, 70 and 35 feet, at 14 MHz over flat ground. The patterns are overlaid with the statistical elevation-angles for the path from Boston to continental Europe over the entire 11-year solar sunspot cycle. Clearly, the 120-foot antenna is the best choice to cover the low angles needed, but it suffers some at higher angles.

Other graphs are needed to show other target receiving areas around the world. For comparison, **Fig 5** is also for the 14-MHz band, but this time from Boston to Sydney, Australia. The peak angle for this very long path is about 2º, occurring 19% of the time when the band is actually open for communication. Here, even the 120-foot high antenna is not ideal. Nonetheless, at a moderate 5° elevation angle, the 120-foot antenna is still 10 dB better than the one at 35 feet.

Fig 4 and Fig 5 have portrayed the situation for the 14-MHz amateur band, the most popular and heavily utilized HF band used by radio amateurs. During medium to high levels of solar sunspot activity, the 21 and 28-MHz amateur bands are open during the daytime for long-distance communication. **Fig 6** illustrates the 28-MHz elevation-angle statistics, compared to the elevation patterns for the same three antenna heights shown in Fig 5. Clearly, the elevation response for the 120-foot antenna has a severe (and undesirable) null at 8°. The 120-foot antenna is almost 3.4 wavelengths high on 28 MHz (whereas it is 1.7 wavelengths high on 14 MHz.) For many launch angles, the 120-foot high Yagi on 28 MHz would simply be too high.

The radio amateur who must operate on a variety of frequencies might require two or more towers at different heights to maintain essential elevation coverage on all the authorized bands. Antennas can sometimes be mounted at different heights on a single supporting tower, although it is more difficult to rotate antennas that are "vertically stacked" around the tower to point in all the needed directions. Further, closely spaced antennas tuned to different frequencies usually interact electrically with each other, often causing severe performance degradation.

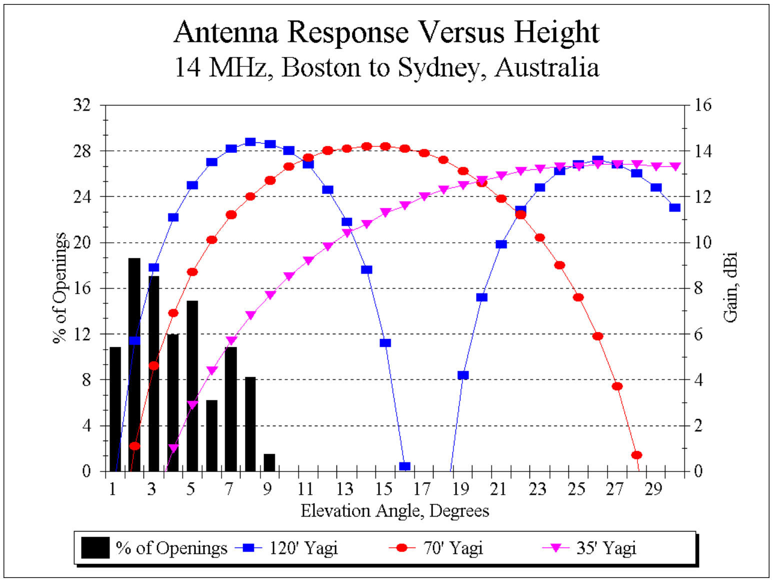

Fig 5—Elevation responses for same antennas as Fig 4, but for a longer-range path from Boston to Sydney, Australia. Note that the prevailing elevation angles are very low.

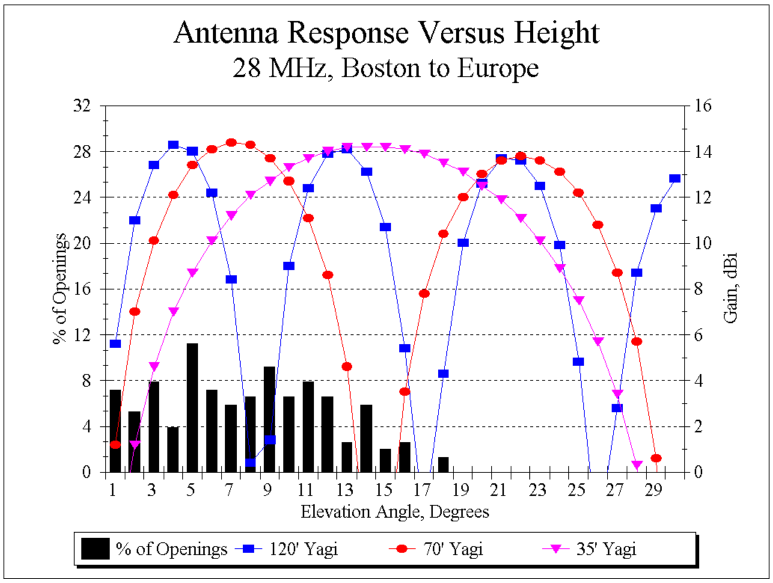

Fig 6—Elevation angles compared to antenna responses for 28-MHz path from Boston to Europe. The 70-foot antenna is probably the best overall choice on this path.

During periods of low to moderate sunspot activity (about 50% of the 11-year solar cycle), the 14-MHz band closes down for propagation in the early evening. A radio amateur wishing to continue communication must shift to a lower frequency band. The next most highly used band below the 14-MHz band is the 7-MHz amateur band. **Fig 7** portrays a 7-MHz case for another transmitting site, this time from San Francisco, California, to the European continent. Now, the range of necessary elevation angles is from about 1° to 16°, with a peak statistical likelihood of about 16% occurring at an elevation of 3°. At this low elevation angle, a 7-MHz antenna must be *very* high in the air to be effective. Even the 120-foot antenna is hardly optimal for the peak angle of 3°. The 200-foot antenna shown would be far better than a 120-foot antenna. Further, the 35-foot high antenna is *greatly* inferior to the other antennas on this path and would provide far less capabilities, on both receiving and transmitting.

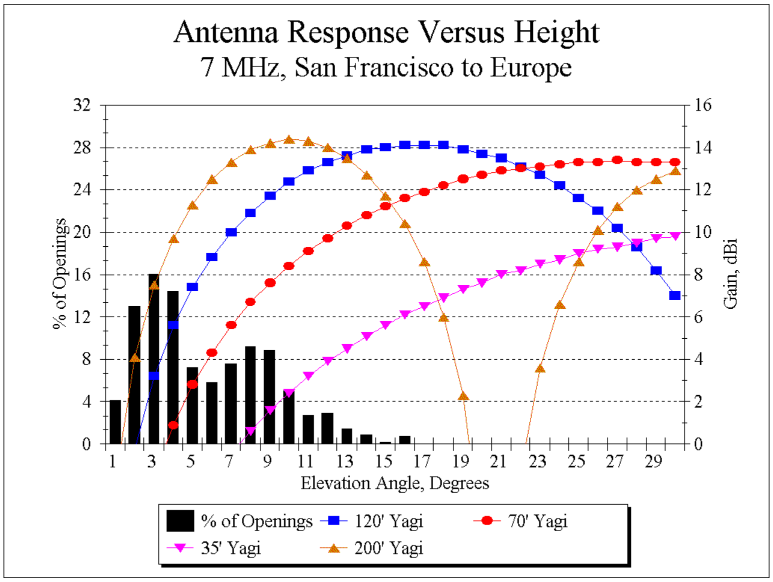

Fig 7—Comparison of antenna responses for another propagation path: from San Francisco to Europe on 7 MHz. Here, even a 120-foot high antenna is hardly optimal for the very low elevation angles required on this very long path. In fact, the 200-foot high antenna is far better suited for this path.

What If the Ground Isn't Flat?

In the preceding discussion, antenna radiation patterns were computed for antennas located over *flat ground*. Things get much more complicated when the exact local terrain surrounding a tower and antenna are taken into account. In the last few years, sophisticated ray-tracing computer models have become available that can calculate the effect that local terrain has on the elevation patterns for real-world HF installations—and *each* real-world situation is indeed different.

For simplicity, first consider an antenna on the top of a hill with a constant slope downward. The general effect is to lower the effective elevation angle by an amount equal to the downslope of the hill. For example, if the downslope is –3° for a long distance away from the tower and the flat-ground peak elevation angle is 10° (due to the height of the antenna), then the net result will be 10° – 3° = 7° peak angle. However, if the local terrain is rough, with many bumps and valleys in the desired direction, the response can be modified considerably. **Fig 8** shows the fairly complicated terrain profile for Jan Carman, K5MA, in the direction of Japan. Jan is located on one of the tallest hills in West Falmouth, Massachusetts. Within 500 feet of his tower is a small hill with a water tower on the top, and then the ground quickly falls away, so that at a distance of about 3000 feet from the tower base, the elevation has fallen to sea level, at 0 feet.

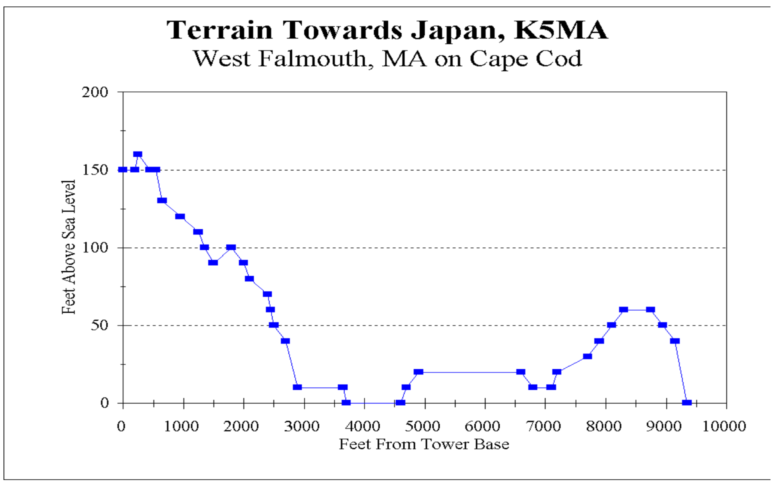

Fig 8—Terrain profile from location of K5MA, Jan Carman, in West Falmouth, MA, towards Japan. This is a moderately complicated real-world terrain on one of the highest hills on Cape Cod.

The computed responses toward Japan from this location, using a 120- and a 70-foot high Yagi, are shown in **Fig 9**, overlaid for comparison with the response for a 120-foot Yagi over flat ground. Over this particular terrain, the elevation pattern for the 70-foot antenna is actually better than that of the 120-foot antenna for angles below about 3°, but not for medium angles! The responses for each height oscillate around the pattern for flat ground — all due to the complex reflections and diffractions occurring off the terrain.

At an elevation angle of 5°, the situation reverses itself and the gain is now higher for the 120-foot-high antenna than for the 70-foot antenna. A pair of antennas on one tower would be required to cover all the angles properly. To avoid any electrical interactions between similar antennas on one tower, two towers would be much better. Compared to the flat-ground situation, the responses of real-world antenna can be very complicated due to the interactions with the local terrain.

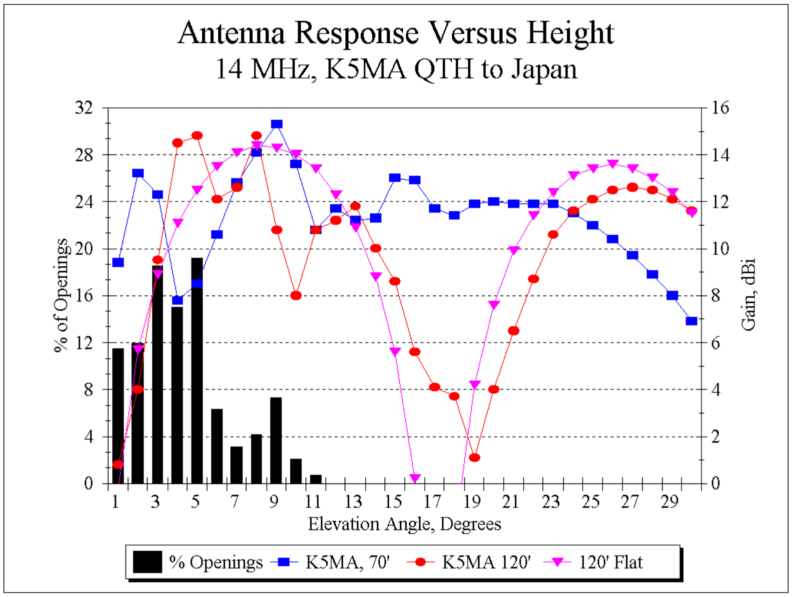

Fig 9—Computed elevation responses of 120- and 70-foot high Yagis, at the K5MA location on Cape Cod, in the direction of Japan and over flat ground, for comparison. The elevation response of the real-world antenna has been significantly modified by the local terrain.

Fig 10 shows the situation for the same Cape Cod location, but now for 7 MHz. Again, it is clear that the 120-foot high Yagi is superior by at least 3 dB (equivalent to twice the power) to the 70-foot high antenna at the statistical elevation angle of 6°. However, the response of the real-world 120-foot high antenna is still up some 2 dB from the response for an identical antenna over flat ground at this angle. On this frequency, the local terrain has helped boost the gain at the medium angles more than a similar antenna 120 feet over flat ground. The gain is even greater at lower angles, say at 1° elevation, where most signals take off, statistically speaking. Putting the antenna up higher, say 150 feet, will help the situation at this location, as would adding an additional Yagi at the 70-foot level and feeding both antennas in phase as a vertical stack.

Although the preceding discussion has been in terms of the transmitting antenna, the same principles apply when the antenna is used for reception. A high antenna will receive low-angle signals more effectively than will a low antenna. Indeed, amateur operators know very well that "If you can't hear them, you can't talk to them." Stations with tall towers can usually hear far better than their counterparts with low installations.

The situation becomes even more difficult for the next lowest amateur band at 3.5 MHz, where optimal antenna heights for effective long-range communication become truly heroic! Towers that exceed 120 feet are commonplace among amateurs wishing to do serious 3.5-MHz long-distance work.

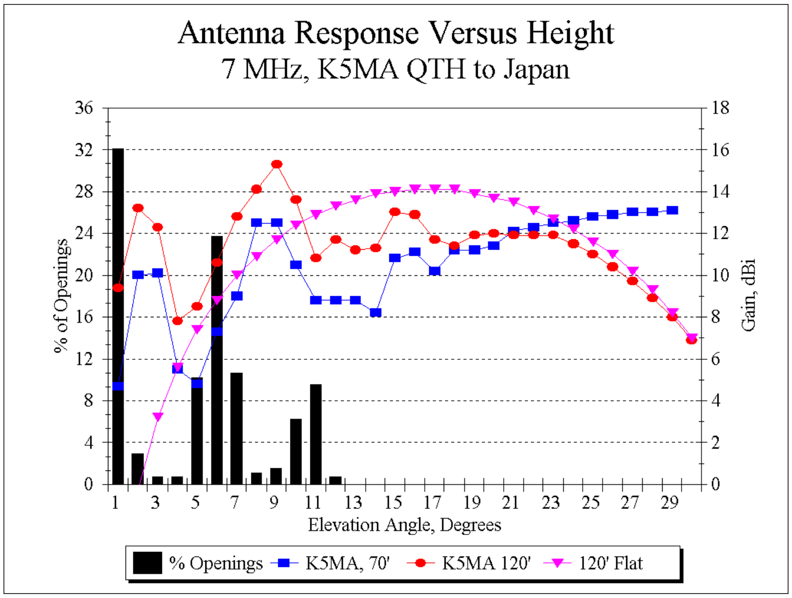

Fig 10—Elevation response on 7 MHz from K5MA location towards Japan on 7 MHz. The 120-foot high Yagi is definitely superior to the one only 70-feet high.

The 3.5 and 7-MHz amateur bands are, however, not always used strictly for long-range work. Both bands are crucial for providing communications throughout a local area, such as might be necessary in times of a local emergency. For example, earthquakes, tornadoes and hurricanes have often disrupted local communications—because telephone and power lines are down and because local police and fire-department VHF/UHF repeaters are thus knocked out of action. Radio amateurs often will use the 3.5 and 7-MHz bands to provide communications out beyond the local area affected by the disaster, perhaps into the next county or the next metropolitan area. For example, an earthquake in San Francisco might see amateurs using emergency power providing communications through amateurs in Oakland across the San Francisco Bay, or even as far away as Los Angeles or Sacramento. These places are where commercial power and telephone lines are still intact, while most power and telephones might be down in San Francisco itself. Similarly, a hurricane that selectively destroys certain towns on Cape Cod might find amateurs in these towns using 3.5 or 7.0 MHz to contact their counterparts in Boston or New York.

However, in order to get the emergency messages through, amateurs must have effective antennas. Most such relatively local emergency situations require towers of moderate height, less than about 100 feet tall typically.

Antenna Height and Interference

Extensive Federal Regulations cover the subject of interference to home electronic devices. It is an unfortunate fact of life, however, that many home electronic devices (such as stereos, TVs, telephones and VCRs) do not meet the Federal standards. They are simply inadequately designed to be resistant to RF energy in their vicinity. Thus, a perfectly legal amateur-radio transmitter may cause interference to a neighbor's VCR or TV because cost-saving shortcuts were taken in the design and manufacture of these home entertainment devices. Unfortunately, it is difficult to explain to an irate neighbor why his brand-new $1000 stereo is receiving the perfectly legitimate transmissions by a nearby radio operator.

The potential for interference to any receiving device is a function of the transmitter power, transmitter frequency, receiver frequency, and most important of all, the proximity of the transmitter to the potential receiver. The transmitted field intensity decreases as the inverse square of the distance. This means that doubling the height of an antenna from 35 to 70 feet will reduce the potential for interference by 75%. Doubling the height again to 140 feet high would reduce the potential another 75%. Higher is better to prevent interference in the first place!

Recently enacted Federal Regulations address the potential for harm to humans because of exposure to electromagnetic fields. Amateur-radio stations rarely have problems in this area, because they use relatively low transmitting power levels and intermittent duty cycles compared to commercial operations, such as TV or FM broadcast stations. Nevertheless, the potential for RF exposure is again directly related to the distance separating the transmitting antenna and the human beings around it. Again, doubling the height will reduce potential exposure by 75%. The higher the antenna, the less there will any potential for significant RF exposure.

THE WORLD IS A VERY COMPLICATED PLACE

It should be pretty clear by now that designing scientifically valid communication systems is an enormously complex subject. The main complications come from the vagaries of the medium itself, the Earth's ionosphere. However, local terrain can considerably complicate the analysis also.

The main points of this paper may be summarized briefly:

> **The radiation elevation angle is the key factor determining effective communication distances beyond line-of-sight. Antenna height is the primary variable under control of the station builder, since antenna height affects the angle of radiation.**
>
> **In general, placing an amateur antenna system higher in the air enhances communication capabilities and also reduces chances for electromagnetic interference with neighbors.**