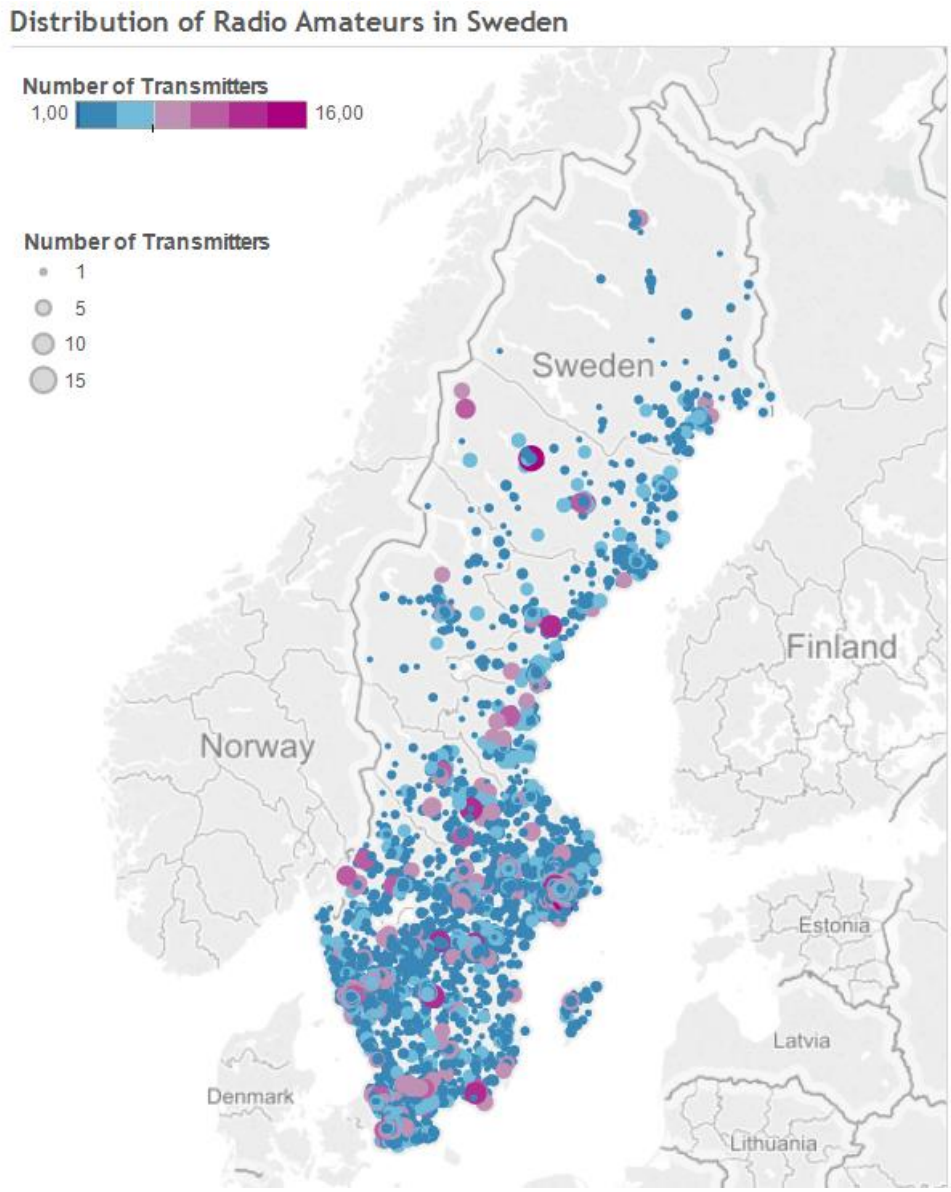
REPORT

Author
Karl-Arne Markström
Phone
+46 10 505 40 62
Mobile
+46 76 107 9671
E-mail
karl-arne.markstrom@afconsult.com

Date
2016-01-27
Project ID
6071921

Study of the distribution and usage profiles of amateur radio stations in Sweden



ÅF Technology AB

Karl-Arne Markström
ÅF Technology AB, Frösundaleden 2 (goods 2E), #delete#, SE-169 99 Stockholm Sweden
Phone +46 10 505 00 00, Registered office in Stockholm, http://www.afconsult.com
Corp. id. [CompCorporateId], VAT [CompVAT]

REPORT

Contents

Report history

Ver.	Issued	Click here to enter Checked status. 15/12/2015	Sign.	Click here to enter Approval. 15/12/2015	Sign.
1	First preliminary release				
2	Second preliminary release				
3	Third preliminary release				
4	Final release				

Executive Summaries

Summary in Swedish (Sammanfattning)

Strålsäkerhetsmyndigheten, SSM har initierat en kartläggning av förekomst och användning av amatörradioutrustning i Sverige. Studien genomfördes av ÅF Technology AB.
Medfinansiärer var Post- och telestyrelsen PTS och Elsäkerhetsverket.

Amatörradiosändare utgör i det stora hela en underordnad källa till exponering för EMF, jämfört med de andra sändare som finns i stora mängder och vilka sänder kontinuerligt.

Den övervägande majoriteten av de amatörradiosändare som är aktiva utnyttjar effektnivåer och antennsystem vilka inte förmår generera fältstyrkor som kan komma i närheten av de referensvärden vilka finns i EU-rekommendation (1999/519/EC) och i svenska författningar (SSM2008:18).

Dessutom är amatörradiotrafik av högst intermittent natur, varför tidsmedelvärdena av fälten blir relativt sett låga.

Amatörradioaktivitet förekommer numera primärt i förorts- och mindre tätortsområden. I stadskärnor och i den rena glesbygden är radioamatörerna relativt sett mindre förekommande.

Radioamatörerna i Sverige som helhet har en medelålder av c:a 63 år
Principen bakom studien är att söka identifiera mönster i aktivitetsprofiler och geografiska profiler så att en skattning av sannolikheten att en aktiv radioamatör uppträder i ett givet område kan göras.

Genom att studera dels den geografiska fördelningen med användningen av postnumret som parameter, samt dels studera vilka former av aktivitet som förekommer hos radioamatörer i olika former av boenden, vilket kan härledas ur publicerade aktivitetsrapporter och ur enkätundersökningar går det att få en fördelning över hur ofta och var olika aktivitetsnivåer förekommer.

Dessutom kan stickprov användas för att genom gatubilder (hitta.se) skaffa sig en uppfattning av t.ex. vilka antenner som förekommer.

Ingångsvärdena i denna studie bygger på material vilket har en jämförelsevis låg kvalitet. Några generella databaser över radioamatörers utrustning och aktivitetsnivåer existerar överhuvudtaget inte, och den databas vilken innehåller deras adresser innehåller i stor utsträckning material som inte är validerat annat än mot folkbokföringen.

Detta beror på att tillståndsplikten för amatörradiosändare är avskaffad, och ingen skyldighet att anmäla t.ex. adressförändringar finns. Dessutom finns det stora

mörkertal vad avser verkliga aktivitetsnivåer och användningsprofiler. Material om aktivitet kan idag primärt återfinnas i listor över diplom och tävlingsresultat, vilket även medför en snedfördelning över aktivitets- och ambitionsnivåer.

Materialet medger följande slutsatser:

- De radioamatörer vilka är påtagligt aktiva samt har en bostadssituation som medför användande av antennsystem vilka är ogynnsamma ur EMF-synpunkt utgör högst några hundratal eller c:a 5% av det totala antalet

- Antalet aktiva radioamatörer vilka bor och använder sina radiostationer inom stadskärnorna är mycket litet

- Majoriteten av antalet märkbart aktiva radioamatörer i landet, som uppgår till högst 2000, använder effektnivåer och antennsystem vilka inte förmår generera EMF-nivåer vilka överstiger referensvärdena

- De radioamatörer vilka använder höga effekter samt genererar stor aktivitet återfinns nästan undantagslöst i områden utanför stadsbebyggelse där uppsättning av adekvata antennsystem är möjligt

- När antennsystem med stor antennvinst eller direktivitet används, t.ex. vid kvalificerade användningar inom VHF och UHF-områdena, blir dessa av prestandaskäl placerade och orienterade så att antennernas huvudstrålningsriktningar inte riktas mot bebodda utrymmen eller platser

- Amatörradiosändningar är högst intermittenta, vilket medför ytterligare marginaler mot referensvärdena.

Endast vid sådana antennarrangemang som kan komma att användas när uppsättning av adekvata yttre antenner inte är möjligt eller tillåtet, alternativt vid oaktsamhet, uppstår det påtagliga potentialer för höga exponeringar.

1 Summary

The Swedish Radiation Safety Authority, SSM has initiated a study of the distribution and usage profiles of amateur radio stations in Sweden. The study was conducted by ÅF Technology AB.

Co-sponsors were the Swedish Post and Telecom Authority (PTS) and the National Electrical Safety Board.

Amateur Radio users contribute a secondary source of EMF exposure.

The overwhelming majority of the active amateur radio stations utilise power levels and antenna systems which are unable to generate field strengths that may come close to the reference levels contained in the EU EMF Council Recommendations and the Swedish regulations.

In addition, amateur radio traffic is of an intermittent nature, why the time-averaged levels of the field-strengths are relatively low.

Amateur Radio activity occurs primarily in suburban and smaller township areas.
In city centers and in rural areas radio amateurs are relatively less frequent.

Radio amateurs as a whole has an average age of about 63.

The principle behind the study is to identify patterns of activity and geographic profiles so that an estimate of the probability that an active radio amateur occur in a given area can be made.

By studying both the geographical distribution of the postal code as a parameter, and by studying what forms of activity that may be generated from radio amateurs in various forms of residences, it is possible to get an overview of how often and where different activity levels occur.

Input data of this study is based on material which has a comparatively low quality. General data-bases of radio amateur equipment and activity levels do not exist at all, and the database containing their addresses largely contain material that is not validated other than by the National Census.

This is primary because the license requirement for amateur radio has been abolished, and there are no obligations to notify e.g. an address change.

In addition, there are large hidden statistics regarding actual activity levels and usage profiles. Evidence of activity can primarily be found in the result listings of awards and competitions, which gives a certain disproportion between activity and levels of ambition.

The conclusions which can be drawn is that the vast majority of amateur radio operations are using power levels and antenna systems which cannot generate exposure values which are at or above the reference levels for general public exposure, and the number that have these potentials do not exceed about 5%, or a few hundreds of the total amount of radio amateurs.

Only when such antenna arrangements that result when more appropriate external antennas are not permitted or feasible, the potentials for higher exposure levels exist.

2 Glossary

ITU	International Telecommunications Union
SSA	Sveriges Sändaramatörer, Swedish national amateur radio society
ARRL	American Radio Relay League, US national amateur radio society
DXCC	DX Century Club, amateur radio operating award, earned by contacting at least 100, or as many different countries as possible
FCC	Federal Communications Commission, US telecommunications regulatory body
PTS	Post & telestyrelsen, Swedish Post & Telecommunications Authority
BNetzA	BundesNetzAgentur, German Post & Telecommunications Agency
QSL	Verification card for radio contacts exchanged between radio amateurs

EMF	Electro-Magnetic Fields
FM	Frequency Modulation, emission using constant envelope
HF	High Frequency, ITU band 7, 3 - 30 MHz
VHF	Very High Frequency, ITU band 8, 30 - 300 MHz
UHF	Ultra High Frequency, ITU band 9, 300 - 3000 MHz
Far-Field	Region around an antenna where electromagnetic waves can be considered as plane. Energy is transported in the far-field.
Near-Field	Region around an antenna where electromagnetic waves propagate in a spherical fashion. Energy is stored in the near-field.
Peak envelope power	The power delivered from a transmitter at the crest of a time-varying power envelope.
Metro Stockholm	The parts of Stockholm that closest surround the city "Stockholm innanför tullarna"
Greater Stockholm	Metro Stockholm with surrounding suburbs (telephone area code 08)
Störningsenkäten	Questionnaire survey of amateur radio local interference conditions made during the late 1980's
Repeater	Automatically operated amateur radio station used to extend the operational range of mobile and portable equipment by retransmitting their signals.
Remote control	The operation of an amateur radio station at a location remote from the location where the operator is present. Remote control today is primarily using the Internet as the transmission medium

3 Introduction

The Swedish Radiation Safety Authority (Strålsäkerhetsmyndigheten, SSM) has contracted a study to determine the possible impacts of EMF (Electro Magnetic Field) exposure emanating from amateur radio transmitters in residential areas.

Co-sponsors of this study are the Post and Telecommunications Agency (Post & telestyrelsen, PTS) and the National Electrical Safety Board (Elsäkerhetsverket, ESV).

The study has been conducted by ÅF Technology AB.

The ÅF group is a large independent international consulting firm with currently about 7500 employees world-wide. The Systems Management Business Area primarily deals with engineering consultancy studies and specifications for a wide range of civilian and defence technical systems.

4 Amateur radio in general

4.1 Justification for the amateur radio frequency allocations

Using the language from the ITU Radio Regulations [1] definition of amateur radio;

"*1.56 amateur service: A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest"*

the aspects of self-training, communication skills and technical investigations as purposes are considered as important. Many prominent inventors, scientists and engineers have had their first exposure to radio science through amateur radio.

In many countries the radio amateurs are also regarded as a reserve of trained radio operators and radio technical personnel, which was expressed in the following quote from a regulator spokesman:

"A reserve corps of trained radio operators and engineers, which without any expenses from public funds maintain their knowledge and competence"

Due to these considerations, amateur radio is regarded as capable of generating a public benefit large enough to justify its frequency allocations both nationally, regionally and globally.

4.2 Amateur radio in the regulatory framework

Amateur radio has its own definitions in the ITU Radio Regulations as the *Amateur Service* (Article 1.56) and *Amateur Satellite Service* (Article 1.57), and is regulated by the relevant provisions in Article 25.

Certain frequency bands from LF to EHF (currently 137 kHz to 245 GHz) are allocated in the frequency table in Article 5 having either primary or secondary status on a world-wide or regional basis.

These allocations are usually carried over in the national regulatory frameworks, with some adaptions due to local conditions. Generally speaking, amateur radio is allowed in the vast majority of the countries of the world.

Radio amateurs are expected to show a relatively high competence, and to be trained and examined after a syllabus, which in Europe is according to the CEPT Recommendation T/R 61-02 [3].

A certificate of competence is issued after a successful examination, which is a general requirement for using amateur radio equipment. Derived from the relatively high competence standards, it is further permitted to home construct or modify amateur radio equipment without being subject to the type acceptance tests and certifications which otherwise are required for equipment used in other radio services.

There are general exemptions from the formal equipment testing and certification procedures in the EMC and R&TTE directives. These exemptions are unique for the Amateur Service.

An in-depth discussion on the historical, legal and regulatory backgrounds for amateur radio can be found in Chapters 3 onwards of reference [11].

5 Previous work

5.1 International studies

In some countries, the EMF exposure of the public by amateur radio question has been addressed by the national Authorities.

The first case was the 1980's study made by the US Federal Communications Commission (FCC) with cooperation by major researchers and the American Radio Relay League, ARRL (Referred in [9]) that evaluated typical exposure cases in residential areas.

In Germany, the EU EMF Council Recommendation [5] has been applied in national regulations by the telecommunications regulatory body BundesNetzAgentur (BNetzA)[7].

The German procedure is to require self-certification, and appropriate notification of the Authorities, of all transmitting systems, regardless of operating frequency, which provide an effective isotropic radiated power (EIRP) exceeding 10W average.
If exposure levels in neighbouring areas are found to exceed certain limits, the Authorities have to be notified using the actual amounts calculated or measured.
This forms one of the conditions for the German amateur radio licence.

For guidance of all concerned, detailed instructions and a special computer software package "WattWächter" [8] has been issued.

Common for the US and German procedures is that they normally do not take near-field effects into consideration [6],[8].

A few European countries, *e.g.* Slovenia, have issued national regulations of permitted field-strengths caused by amateur radio transmitters derived from the EMC radiated immunity standards used for CE mark evaluation of consumer electronics.

These regulations have no formal connection with the EU EMF Council Recommendation.

Currently, reports of interference to consumer electronics due to amateur radio transmitters are comparatively few, which implies that the actual radiated and conducted EMC immunity properties are better than the 3 V/m limit by about an order of magnitude. If EMF exposure levels close to or exceeding the EU limits for the general public should have been common, the EMC immunity incidents would have been much more frequently.

The majority of current EMI cases with radio amateurs involved are encountering severe radio interference from consumer products.

The US regulator body FCC has made rules for self-certification and exposure evaluation for US radio amateurs that operate transmitters above specified power levels [6].

The exposure levels used for deriving these rules correspond to the then current IEEE/ANSI limits, from which current ICNIRP and WHO recommended limits are derived.

Wavelength Band	Evaluation Required if Power* (watts) Exceeds:
MF	
160 m	500
HF	
80 m	500
75 m	500
40 m	500
30 m	425
20 m	225
17 m	125
15 m	100
12 m	75
10 m	50
VHF (all bands)	50
UHF	
70 cm	70
33 cm	150
23 cm	200
13 cm	250
SHF (all bands)	250
EHF (all bands)	250
Repeater stations (all bands)	non-building-mounted antennas: height above ground level to lowest point of antenna < 10 m and power > 500 W ERP building-mounted antennas: power > 500 W ERP

* Transmitter power = PEP input to antenna. For repeater stations *only*, power exclusion based on ERP (effective radiated power).

Figure 1. Table over power limits for self-certification under the FCC rules from OET Bulletin 65 Supplement B. Note that the amateur frequency bands use wavelength designations.

5.2 National studies

No previous studies of amateur radio geographical distribution and potential EMF exposure levels are known to exist in Sweden.

The closest to an EMF exposure study is the initiative in the late 80's to investigate the interference and EMC situation for Swedish radio amateurs related to their activity profiles and residential conditions [13].

5.2.1 Field measurements of EMF exposure

In late 2015, the SSM made field measurements on 6 different cases of amateur radio installations that may be encountered. The results are found in reference [12].

6 Demographics of Swedish amateur radio

6.1 Total number of current valid certificate holders

The total numbers of individual certificates in mid-November 2015 were 12374, distributed as 1862 certificates issued after April 2004, and 10512 issued earlier.

An additional number, 764, of military and civilian radio club stations could be added. Club stations represent a very diverse activity distribution. The activity levels of the club stations fall outside this study, as they nowadays very seldom are located in urban or residential areas, and their activity distribution metrics may be radically different from the individual cases, as they often are activated only on special occasions.

Also, the number of measurably active club stations has decreased considerably.

6.2 Geographical distribution

The graph below shows the distribution of radio amateurs over the postcodes in Sweden.

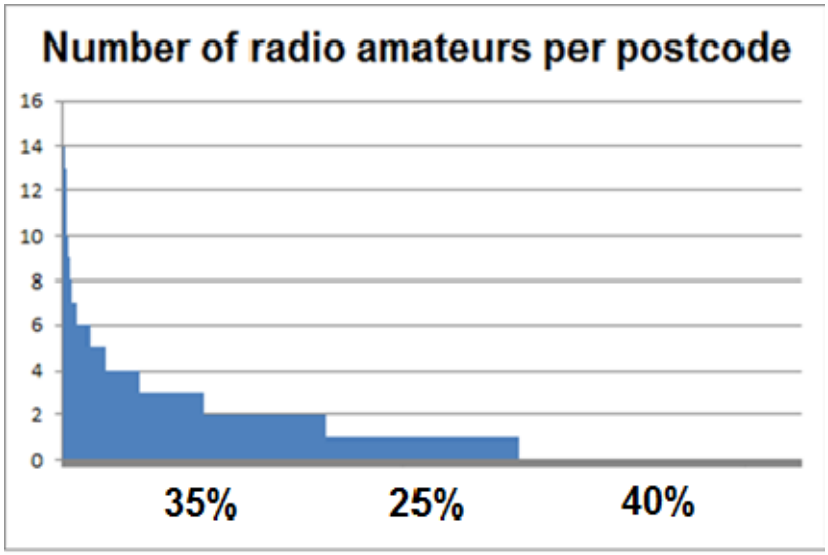


Figure 2 Distribution of radio amateurs with postcodes as parameter

Legend: Y-axis number of radio amateurs per postcode, X-axis proportion of population over postcodes.

It can be noted that almost 40% of the postcodes lack radio amateurs entirely, and an additional about 25% only has one radio amateur. Amateur radio presence is most prevalent in sub-urban, small town or rural areas.

6.3 Population density distribution

Among the top 10 of postcodes with the most resident radio amateurs expressed as a percentage of the total number of residents in the postcode area are:

Postcode area	Number	Percentage of population
546 33 KARLSBORG	13	1,09
370 42 TORHAMN	7	0,91
426 69 VÄSTRA FRÖLUNDA	10	0,40
415 06 GÖTEBORG	10	0,39
141 40 HUDDINGE	10	0,36
640 43 ÄRLA	7	0,35
660 50 VÅLBERG	12	0,33
670 40 ÅMOTFORS	10	0,32
370 24 NÄTTRABY	13	0,27
370 30 RÖDEBY	9	0,13

6.4 Distribution in interest and activity profiles

6.4.1 Frequency bands in use by radio amateurs

There are several frequency ranges allocated to amateur radio traffic. They extend from 137 kHz (LF) to 245 GHz (EHF). Usage of the frequency bands below MF and above UHF is quite infrequent, and the volume usage that would dimension EMF exposure is for all practical purposes confined to the 1,8 – 1296 MHz bands. Higher and lower frequencies are subject to operations that are transient in nature.

Especially is this a property of the frequency bands in the UHF and higher ranges, where purpose-built portable stations has become the norm.

6.4.2 HF (“High Frequency”)

The HF or High Frequency amateur radio bands permit international communications at great distances. Their frequency range are formally between 3 – 30 MHz, but for practical reasons the 1,8 MHz amateur band which formally is in the MF (0,3 - 3 MHz) range is included in the HF bands.

HF permit radio contacts at large distances using low to moderate power, but also requires antennas that are quite physically large for good performance.

HF antennas that are small or are mounted in unfavourable positions such as indoors or very close to buildings provide a very limited performance.

Also, such an antenna mounting may result in higher EMF exposure levels, due to a much closer distance expressed in wavelengths between the antenna structure and the surroundings.

Most older and more established radio amateurs are active on HF.

6.4.3 VHF ("Very High Frequency")

Amateur radio in the VHF and UHF ranges (in this context the 432 MHz band which is formally UHF is grouped together with the 50 and 144 MHz VHF bands) requires smaller antennas for a given directivity factor. The antenna efficiency factors (structural and ground losses) are less influential in this frequency range.

For local or line-of-sight communications very simple antennas such as whips or dipoles are fully sufficient.

Normally, VHF and UHF can provide reliable coverage of town-size areas using simple low-power equipment and small antennas. For larger coverage areas, directional antennas will be required, which also have to be mounted high and free to be effective.

Many repeater stations have been built, usually as club efforts, to improve coverage for amateur stations that have inadequate provisions for VHF/UHF antennas.

A select few of the radio amateurs that are seriously interested in VHF and UHF assemble stations with high enough performance to permit international contacts under average propagation conditions. Many of these stations are club efforts due to the investments necessary.

These erect large antenna systems with highly directive properties and use high power to be able to establish contacts via different forms of scatter propagation or moon reflection. Due to performance reasons, these stations need to use antennas which are adequately separated from surrounding buildings and areas.

The requirements for antenna physical size and transmitter power necessary for moon reflection decrease with increasing frequency, as the sky noise levels decrease and antenna directivity increases [10].

6.5 Age distribution

The complete certified radio amateur population has a quite uneven age distribution. In the following graphs the age relationships of the Swedish radio amateur population are pictured:

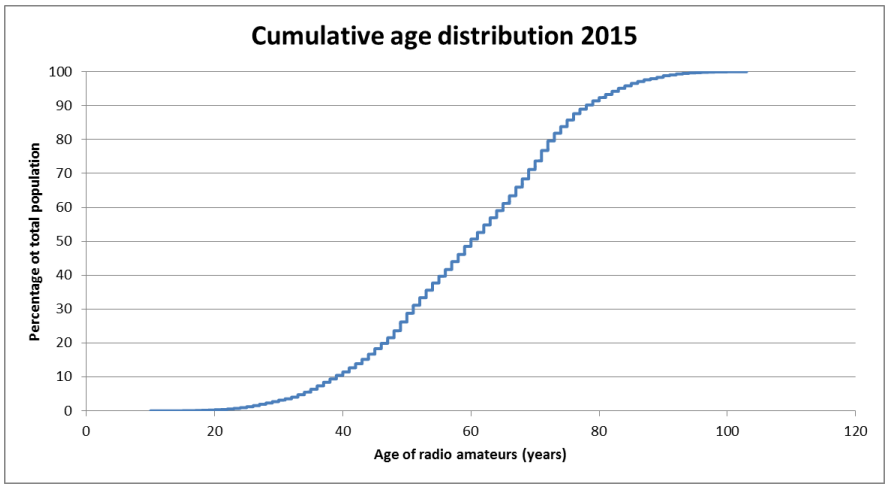


Figure 3 Cumulative age distribution for 2015

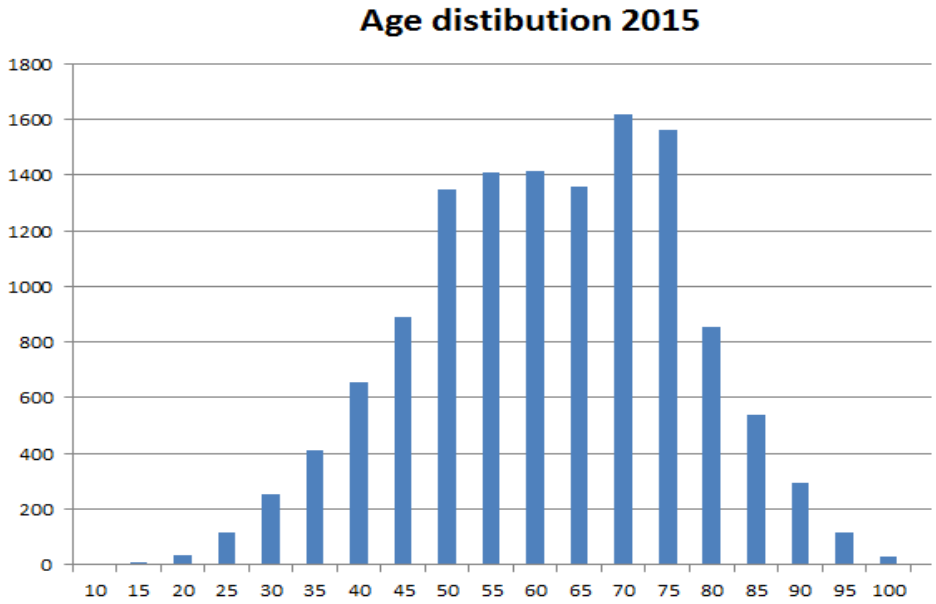


Figure 4 Age distribution for 5 year intervals

Radio amateurs as a whole has an average age of about 63.

7 Mobile and portable operations

7.1 Mobile operations

The use of amateur radio transmitters in cars and other vehicles was once wide-spread, but has decreased due to the proliferation of mobile telephones, which enable much easier day-to-day communications. The hobby communications aspects dominate today for the quite small group that still use mobile installations.

Typical installations for mobile use in the HF range use a transmitter power of less than 100W and a simple coil-loaded whip antenna, and in the VHF/UHF ranges less than 50W and a self-resonant whip antenna mounted on the roof or back of the car.

The most common VHF/UHF equipment categories provide about 10 - 25 W output power in practice.

Due to the fact that mobile operations are of a transient and non-stationary nature they are not subject to further consideration in this study.

7.2 Portable operations

Amateur radio transmitters may also be used for portable purposes. Generally, portable transmitters use low power, in the region of 5-10 W or less. The antennas used often have low radiation efficiencies which in turn results in lower EMF exposure levels.

Due to the fact that portable operations also are of a transient and non-stationary nature they are not subject to further consideration in this study.

8 VHF/UHF spectrum utilisation in Metro Stockholm area

8.1 General

The recorded spectrum utilisation is one useful measure for potential and actual EMF exposure levels.

If a certain transmitter is using a frequency at a 100 % level, the EMF exposure level at its site will be at the maximum possible.

As can be seen from spectrum graphs below, individual transmitters within the radio coverage range (about 15 km radius) of the PTS monitoring station in southern Stockholm each generate in the order of a few percent actual transmission time.

8.2 144 – 146 MHz amateur band utilisation

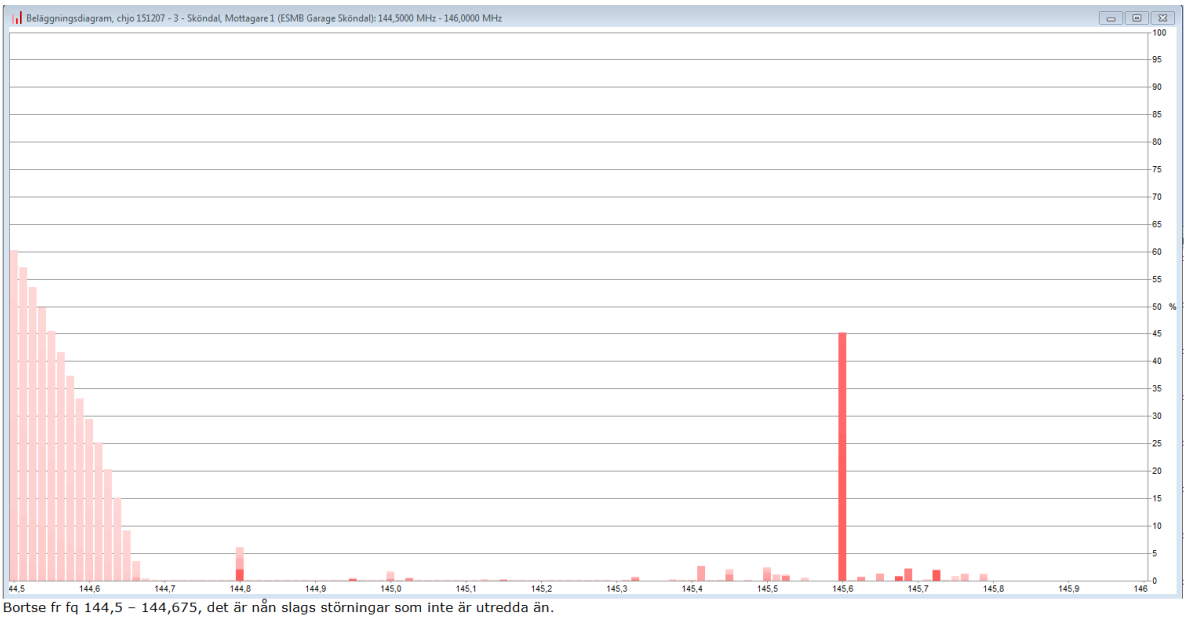


Figure 5 Spectrum utilisation in the 144 - 146 MHz range provided by the radiomonitoring service of the Post & Telecommunications Authority PTS

(The shaded areas to the left represent transient local interference at the monitoring station and should be disregarded)

As an illustration of the amateur radio activity averaged over a 72 hour period in December 2015, the above graph shows that the major user in the 144 MHz VHF band is one single repeater station located in western Greater Stockholm area (in a tower without neighbours), whose downlink transmitter generates a 45 % use of one frequency.

All other frequency users generate an averaged utilisation figure of below 5 %.

8.3 432 – 435 MHz amateur band utilisation

This system is linked to another repeater station using the 432 MHz UHF band, where the same usage distribution can be observed in the graph below.

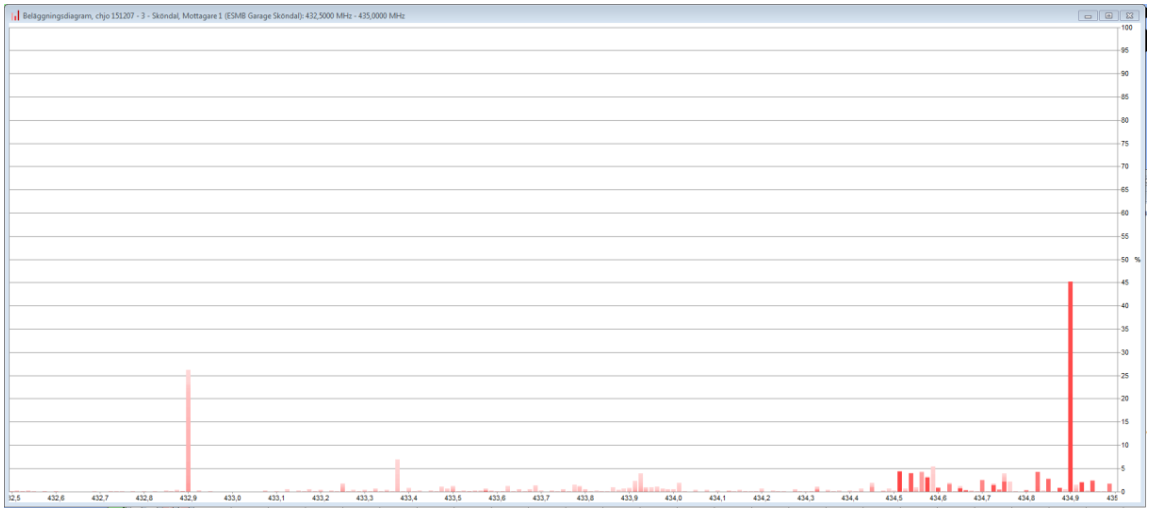


Figure 6 Spectrum utilisation in the 432 - 435 MHz range provided by the radiomonitoring service of the Post & Telecommunications Authority PTS

9 Methodology of the study

9.1 Methods of selection

9.1.1 Assumptions used in this study

It is assumed that the general activity levels and patterns are constant within the various groups that have been created.

It is further assumed that activity periods are reasonably uniformly distributed over time.

9.1.2 Activity

9.1.2.1 "The 80/20 rule"

In many aspects of modern life, distributions in larger populations can be described with the "80/20 rule" or "Pareto distribution" [4] which means that 80% (or more) of the influence on a parameter can be attributed to 20% (or less) of the population. This also holds for amateur radio activity.

Several on-line club newsletters have been accessed, and the activity reports (such as received verification cards of a completed amateur radio contact, "QSL:s" or participation in radiosport competitions or in club events) of individual members have been compared to the club roster. In all cases, the average distributions of inactive to active members were in the order of 80/20 %.

9.1.3 Parameter selection

9.1.3.1 Post codes

Sweden is divided into a number of postal code areas, roughly distributed according to geography and population density. In more densely populated areas, the postcode area corresponds to an average total population of about 2800.

An analysis of the database of radio amateurs together with a list of postcodes with associated population data reveals that the highest radio amateur densities may be

found in small town or sub-urban areas, where up to 10 – 14 amateurs may reside in one postcode area.

In central urban and in rural areas, the density falls off considerably. City centres and rural areas only have an average of 2-3 radio amateurs per populated postcode.

As can be seen in the graph under 6.2, almost 40% of the total number of postcode areas lack radio amateurs entirely, with another about 25% with only one per area.

9.1.3.2 Activity profiles

Amateur radio can broadly be described [11] with the "3 T's", "Technical, Traffic and Tests" which generate very different forms of activity.

"Technical" use their transmitters quite infrequently, but may be using higher-powered systems with larger antenna systems for purposes related to e.g. propagation research and investigations into more exotic forms of propagation, with moon reflection (EME) representing an extreme case.

"Traffic" use transmitters more regularly, often on a daily basis, for general national or international contacts among other like-minded radio amateurs. Most "traffic amateurs" use equipment and antenna systems which represent "average" performance.

Finally, "Test" or "Radiosport". These activities are most often concentrated to major competitions that occur during a few week-ends per year. These radio amateurs often use high-powered transmitters and large antenna systems, and for performance and interference reasons, the stations involved are nowadays very often located outside cities and in rural areas.

It is therefore very uncommon to find high-performance stations intended for radiosport in densely populated areas.

A special case of the "Traffic" category can be considered to be co-incident with the "Test" category, where the purpose of the amateur radio activity is to get into contact with new or exotic "countries" or entities.

The levels of ambition and general activity profiles of these categories are quite similar.

9.1.3.3 Traceable activity

As there exist no general database data over regular transmitter usage activity, the activity levels have to be deduced from sources that may vary wildly in accuracy.

In this study, compilations from lists of awards or diplomas together with result listings of "Contest" or "Radiosport" activities have been used to deduce the number of active radio amateurs with higher levels of ambition, together with data from local clubs outlining the activity levels and distribution of their membership.

9.1.4 Classifications

These categories are based on observations made of amateur radio activities reflected in frequency usage monitoring, signs of activity on web-sites and in journals and other printed sources during the past about 5 years. These have also been compared to experience contributed by local club officers in the larger metropolitan areas.

9.1.4.1 Not active

A very large proportion of the current Swedish radio amateur population generate no traceable or measurable activity. It is estimated from observations made during the last five years that more than 50% are completely inactive or very sporadically active.

If they possess any transmitters or not would be unclear, a large number of transmitters are believed to be in storage by otherwise inactive amateurs.

Major reasons for inactivity are the local man-made interference situation, inability to get permission to put up workable antenna systems, increasing age or lack of interest.

9.1.4.2 Urban area dweller

A smaller proportion of the active radio amateurs are resident in densely populated urban areas.

About 10 % of the total population live in or near city centres where the majority of buildings are of the apartment type. How many of these that actually generate measurable activity from their home addresses is open to discussion, very few can be found in more current result listings.

An increasing trend for urban dwellers is to remote control transmitting or receiving stations located in sub-urban or rural areas, where the antenna and interference situations are much easier to handle.

9.1.4.3 Sub-urban and municipality area dweller

The largest proportions of the radio amateur population, about 50%, reside in sub-urban districts or in comparable surroundings.

They usually have been able to put up adequate outdoor antennas in some form on their detached or semi-detached houses with surrounding lots.

The increasing difficulties of getting permissions for adequate outdoor antennas have however more recently made operation from apartments or some semi-detached houses in sub-urban environments just as difficult as operation from urban areas.

A large proportion of the verifiable and measurable activity comes from this category.

9.1.4.4 Rural area dweller

The remaining parts of the amateur radio population reside in rural areas. Often are their surroundings and general provisions for erecting antennas and to be more active considerably better than for the two preceding categories. Amateur radio stations that generate a high or very high measurable and traceable activity are most often found in these areas.

Several purpose-built stations with high performance that are activated for special occasions may be found in the rural surroundings.

9.1.4.5 Low or sporadic activity (1-10 usage events per month or 0,2-2 transmitting hours accumulated monthly)

It is difficult to draw a line between the “low-activity” and “inactive” radio amateur. A quite large proportion of amateurs are only very sporadically active during the week-ends or from portable or mobile locations.

9.1.4.6 Medium activity (10-100 usage events per month or 2-20 transmitting hours accumulated monthly)

This category represents the vast majority of the active population.

9.1.4.7 High activity (>100 usage events per month or more than 20 transmitting hours accumulated monthly)

Only in quite isolated cases are these levels of activity approached or exceeded. The large "Contest" or "Radiosport" stations usually generate these levels during their peak usage periods, and a quite small number of "ordinary" radio amateurs may also present these activity levels.

The numbers above have been derived from the activity statements made in "Störningsenkäten"[13], and from observations of radio amateur activity in general. They serve as the starting points for the classifications used in paragraphs 11.

9.1.5 Amateur Radio Certificates issued before 2004

When the current demographics of the amateur radio population are taken into account, the vast majority of the activity is generated by radio amateurs that received their certificates (formerly "licences") before 2004. They can be differentiated by a different prefix (SM instead of SA).

About 10000 of the total number of 12374 certificate holders are in this category, which in general contributes more to the activity numbers in relative proportions.

9.1.6 Amateur Radio Certificates issued after 2004

After a licence restructuring process in 2004, all new certificate holders have callsigns using the prefix SA. About 1900 SA callsigns have been issued to date.

From data collected from local club officers responsible for training and certification of new radio amateurs, it is estimated that a maximum of 10%, or about 200, of the new certificate holders are generating any measurable activity 2 years after receiving their certificates. A majority of the new recruited radio amateurs only become active on VHF or UHF with local operations, and never make any impressions in activity listings.

They also are comparatively infrequently encountered in radiosport result listings and in award listings.

The additions to the ranks of "active" radio amateurs are therefore fewer than the number of radio amateurs that leave the ranks due to age or other reasons.

9.2 Uncertainty factors

9.2.1 Considerable amounts of hidden statistics

9.2.1.1 Lack of database maintenance

The current database is an amalgamation of data from several different sources, and the most reliable sources are the membership records of the national amateur radio society SSA.

This is regularly maintained as required for issuing membership fee invoices and for postal distribution of the membership magazine. About 35% of the total database is composed of current SSA members.

All historical data before 2004 come from the records of the previous licence administrative authority PTS, and the mandatory updating of this database ceased in 2004 when amateur radio became licence-exempt.

After 2004, all new certificates are recorded in the database, but there has been no obligation to enter a change of address or ceasing/resuming of amateur radio activity. There is no expiration date on the current certificates, which in effect are issued for life.

Also, there are no mandatory procedures for deleting deceased radio amateurs from the records. This is most often taken care of by relatives or by club members that knew the deceased, but may sometimes be overlooked.

Taken together, there exist large uncertainties about the real number of living radio amateurs and their current addresses.

9.2.1.2 Lack of database entries of activity and equipment

Not in modern times have equipment or activity profiles been recorded in files or databases.

The only records that may serve as more reliable guidance are the "Radiosport" result listings and awards listings. Other activity indicators are entries in amateur radio journals and on web-sites.

A list of Swedish callsigns that have contributed in any way to the total recorded activity has been compiled from available online sources which currently contains 1302 callsigns.

9.2.2 Small number of respondents in previous questionnaire studies

In the late 1980's a questionnaire study of the interference situation of Swedish radio amateurs was undertaken, "Störningsenkäten" [13]. This study also contained questions about the general activity, antenna and equipment usage profiles.

However, only 876 of the potential about 6000 respondents (then current members of SSA) returned completed questionnaires.

9.2.3 Bias due to activity levels and age profiles of respondents in previous studies

It can be questioned if the material in the previous study represents an entirely statistically valid sample of the radio amateur population.

It can also be reasonably assumed that only somewhat active radio amateurs have completed and sent in the questionnaire form, which only makes them a small sample of the whole community.

The age distribution of current active radio amateurs however shows that only a quite small relative fraction of new amateurs have joined the ranks and an even smaller number have become measurably active since the previous study was made.

Most of those that generate activity today are the same persons as those 20 years ago.

Due to lack of more recent studies, the assumption that the activity and equipment usage profiles are similar today as compared to the time of this study has been made.

Obvious factors such as known deceased amateurs have been deleted from the study material.

10 Graphical presentations

10.1 General

A total of 8 overview presentations of the relative densities of active and inactive radio amateurs in selected geographical areas have been compiled. The GIS-based tool *"Tableau"* has been used for visualising the distributions.

The general assessment is that an actual average relative activity level of maximum 10-20% of all potential cases can be reasonably assumed derived from recent and historical activity indications, and including the hidden statistics.

These are roughly divided among the six typical cases described in the SSM report, and also correspond to total numbers in the 1200-2000 range.

10.2 Contents and organisation of the maps

10.2.1 Radio amateurs in Sweden and radio amateurs in Greater Stockholm, Appendix 1 and 2

These maps are divided into 2 separate parts, one which shows the geographical distribution of existing radio amateurs over the whole country, and one that shows radio amateurs having shown known activity.

10.2.2 Radio amateurs in Stockholm Metro Area, Appendix 3

Due to the lesser number of amateurs, both types of maps are combined into one, the top map showing existing amateurs and the bottom showing amateurs showing known activity.

10.2.3 Radio amateurs in Lund Area, Radio amateurs in Örebro Area, Radio amateurs in Gotland except Visby Area, Appendices 4-6

Due to the lesser number of amateurs, both types of maps are combined into one, the top map showing existing amateurs and the bottom showing amateurs showing known activity.

10.3 Potential for further refinement

The "Tableau" GIS tool may be used for dynamic studies of the population down to individual level on an interactive basis, if it is connected to the appropriate census and licencing databases.

11 Analysis

11.1 Probability distribution of active radio amateurs having potential of approaching the EMF reference levels

11.1.1 General

As it is generally not possible to find comprehensive activity levels on an individual scale, a statistical approach is used to estimate the density of potential EMF emitters as a percentage or fraction normalised as a fraction to 100 amateurs in each area.

11.1.2 General about the activity distribution

The distributions used in the following discussions are derived from the material in reference [13], and from the distribution of radio amateur population densities as function of geography derived from the callsign database.

11.1.3 Activity parameter

Using an activity parameter (0-4) that has been derived from the answers in the "Störningsenkäten" questionnaire in reference [13], five quite arbitrary activity levels have been deduced:

1= Not active or very sporadically active

2= Not more than once per month activity

3= Weekly

4= Several times weekly

5= Daily

It is assumed here that the inactive and very low activity (1 and 2) fractions do not contribute to any long-term EMF exposure, leaving the remainder (3 weekly, 4 several times weekly and 5 daily) as the contributing factors.

Adding these percentages, a total of 13+29+14 = 56 % of the active population in the urban HF case is able to contribute to any HF EMF exposure in urban apartment living areas, and a total of 14+16+14 = 44 % of the active population in the urban VHF case is able to contribute to any VHF EMF exposure.

Taking as an example one of the most densely radio amateur populated postcode areas in Sweden (141 40 Huddinge with 10 resident amateurs and 2777 inhabitants) and assuming that 50% of amateurs living in apartments in the area, a total of 4, also are active there is a probability that an average of 2 amateurs may contribute to EMF exposure of their neighbours, with levels depending on the particulars of their equipment and antennas.

If the sample size is extended to the 321 listed radio amateurs residing in the 181 postcode areas with a total population of 314099 inhabitants within the Metro area of Stockholm, and assuming

(1) all live in apartments and

(2) a more realistic activity level of maximum 25%,

the result is a probability that an maximum average of 40 radio amateurs in this area may contribute to EMF exposure.

Current operational experience however shows that the actual amateur radio activity level generated from Metro built up areas is very low, in the order of 10%, which would reduce the numbers correspondingly.

The same calculation exercises can be carried out for the other population areas.

A detailed investigation, made from the current DXCC top listings for Sweden using a sample size of 50 selected from the most active and ambitious radio amateurs known showed that none of those currently operate from urban areas, so for all practical purposes all regular operations using higher power levels are from sub-urban or rural areas.

11.1.3.1 Special case Post Code 546 33 KARLSBORG

It may be of interest to study the geographical distribution of individual radio amateurs in one of the most radio amateur dense postcode areas. This postcode belongs to a small town in Western Sweden.

By closer inspection, using www.hitta.se, only one radio amateur out of 13 lives in an apartment, and the rest in detached or semi-detached houses.

11.1.4 Urban areas

The amount of active radio amateurs residing in urban area apartments can be estimated from operational experience to be less than 10% of the total active population.

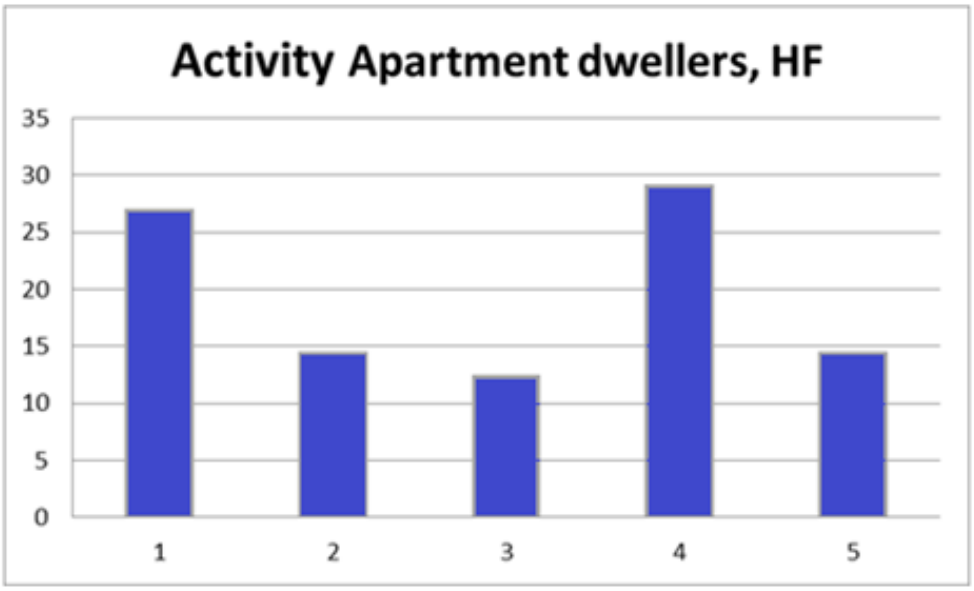


Figure 1 Percentage activity levels on HF by apartment dwellers, 1=Not active 2= Monthly activity 3=Weekly 4= Several times weekly 5= Daily

A total of 13+29+14 = 56 % of the active population in the urban HF case may then be able to contribute to any HF EMF exposure at any level.

In numbers, 56 out of 100 active amateurs may generate HF EMF exposure, and a reasonable estimate of a proportion of urban radio amateurs to the grand total is 10%.

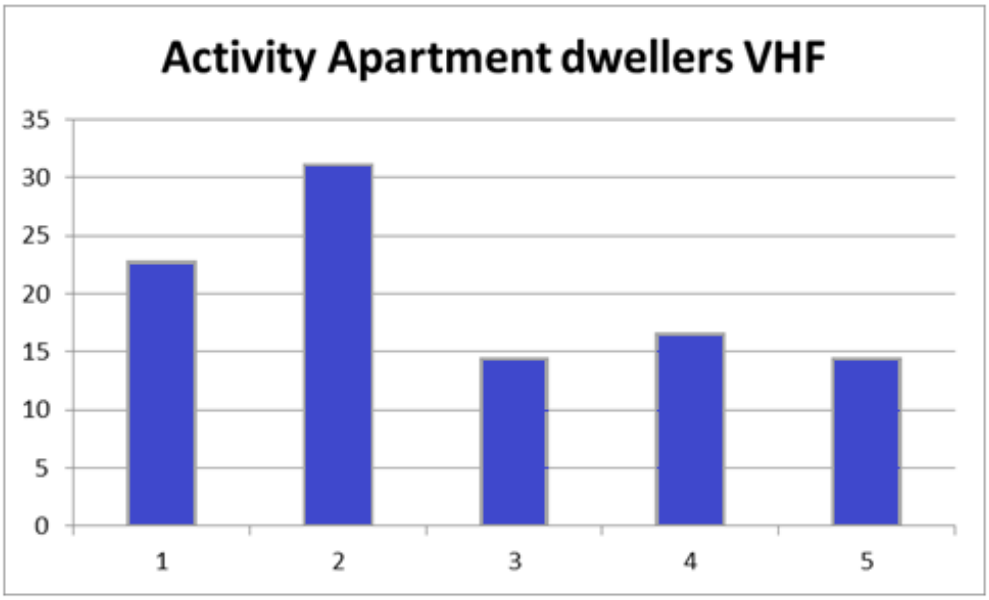


Figure 2 Percentage activity levels on VHF by apartment dwellers, 1=Not active 2= Monthly activity 3=Weekly 4= Several times weekly 5= Daily

Correspondingly, in urban apartment living areas, a total of 14+16+14 = 44 % of the active population in the urban VHF case may be able to contribute to any VHF EMF exposure.

There is a practically negligible activity with high levels of ambition in urban areas which uses large antennas or high power levels.

11.1.5 Sub-urban, small town and municipality areas

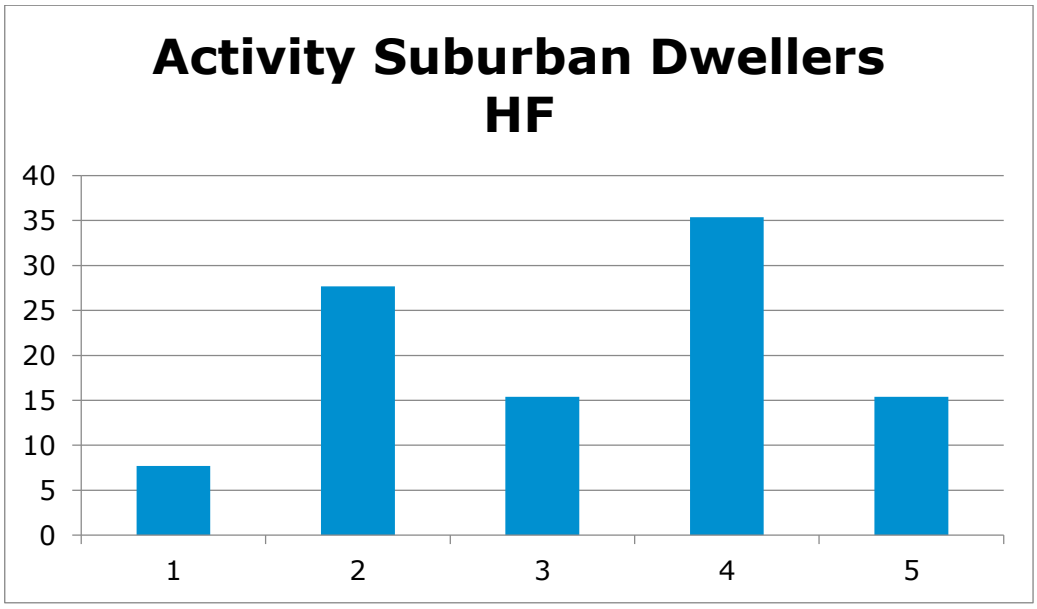


Figure 3 Percentage activity levels on HF by suburban dwellers, 1=Not active 2= Monthly activity 3=Weekly 4= Several times weekly 5= Daily

A total of 15+35+16 = 66 % of the active population in the sub-urban HF case may be able to contribute to any HF EMF exposure at any level.

In numbers, 66 out of 100 active amateurs may generate HF EMF exposure, and a reasonable estimate, derived from population statistics, of the proportion of sub-urban radio amateurs to the grand total is 50%.

Active operators in sub-urban areas usually have had space and permission to put up better antennas in both the performance, EMC and EMF aspects.

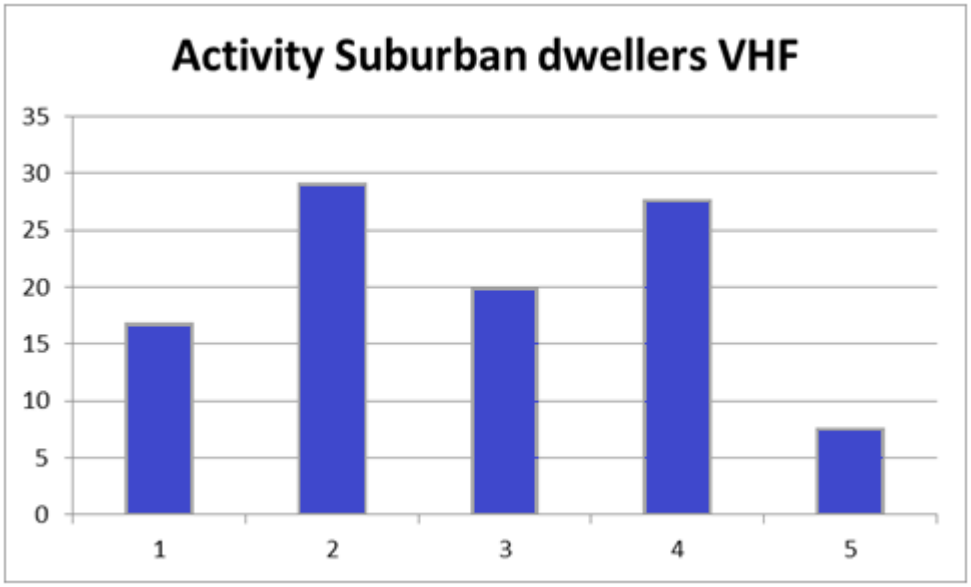


Figure 4 Percentage activity levels on VHF by suburban dwellers, 1=Not active 2= Monthly activity 3=Weekly 4= Several times weekly 5= Daily

A total of 20+27+8 = 55 % of the active population in the sub-urban VHF case may be able to contribute to any VHF EMF exposure at any level.

In numbers, 55 out of 100 active amateurs may generate VHF EMF exposure.

As in the HF case, active operators in sub-urban areas usually have space and permission to put up better antennas in both the performance and EMF aspects.

11.1.6 Rural areas

Rural areas have the largest proportion of high-powered stations using large antenna systems, and a reasonable estimate, derived from population statistics, of the proportion of rural radio amateurs to the grand total is 40%.

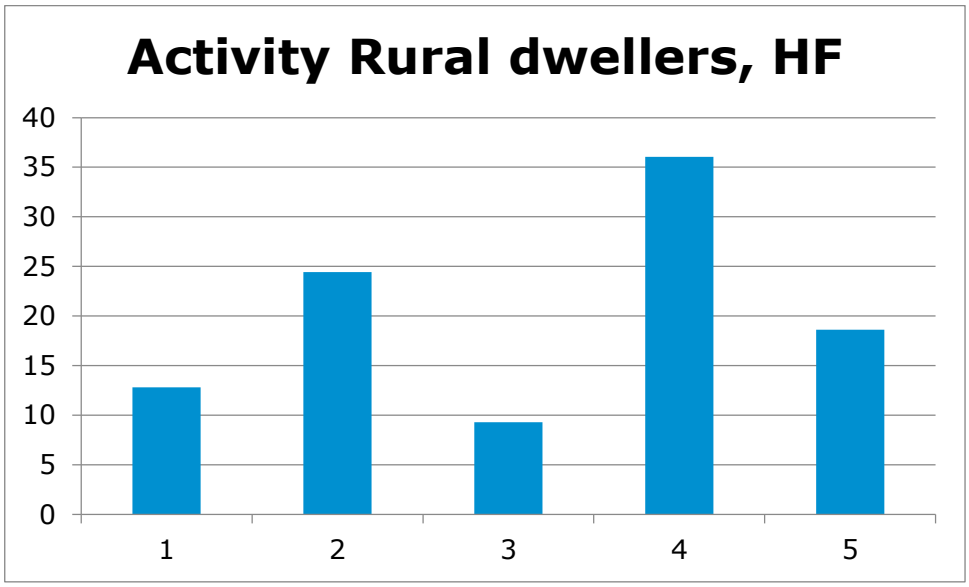


Figure 5 Percentage activity levels on HF by rural dwellers, 1=Not active 2= Monthly activity 3=Weekly 4= Several times weekly 5= Daily

Also, the rural area radio amateur tends to be more active than the two other categories.

A total of 9+36+19 = 64 % of the active population in the rural HF case may be able to contribute to any HF EMF exposure at any level.

In numbers, 64 out of 100 active amateurs may potentially generate HF EMF exposure, but as the antenna conditions are good, and the general sizes of the lots are larger, the risks for approaching or exceeding the EMF limits will be remote.

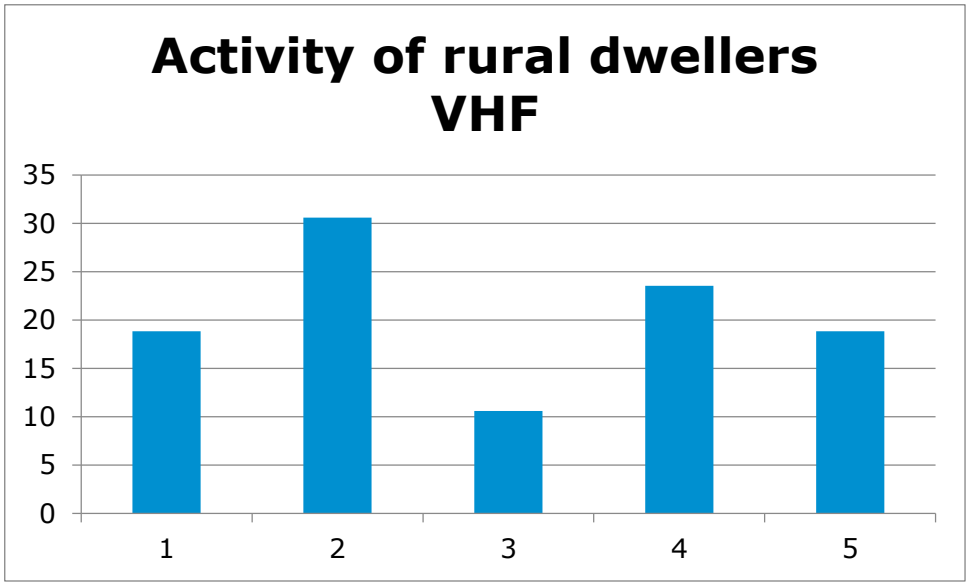


Figure 6 Percentage activity levels on VHF by rural dwellers, 1=Not active 2= Monthly activity 3=Weekly 4= Several times weekly 5= Daily

A total of 11+24+19 = 54 % of the active population in the rural VHF case may be able to contribute to any VHF EMF exposure at any level.

In numbers, 54 out of 100 active amateurs may generate VHF EMF exposure.

As in the HF case, operators in rural areas usually have space and permission to put up better antennas in both the performance and EMF aspects.

11.1.7 The remote control operation case

A complicating factor is that many radio amateurs that reside in urban or apartment conditions cannot put up antennas of any sort, or that the man-made interference situation is such that operation would be impractical.

Radio amateurs in this category having high levels of ambition therefore in an increasing amount are using remote controlled radio stations with high performance located in rural areas. This may skew the future geographical distribution considerably, as there are no records whatsoever in the databases regarding these conditions.

Remote control of amateur radio stations is today primarily made through the Internet. There exist a variety of hardware and software products for this purpose.

11.2 Trends in amateur radio transmitter usage

11.2.1 Trends in general activity

Compared to 20 years ago, the general activity level has decreased considerably. The number of measurably active stations is estimated from operational experience to be around 1/2 less than previously, and the activity periods tend to be more and more concentrated to specific events.

The current average activity between these events remains on an historical low level.

11.2.2 Trends in power, emission and antenna conditions

For a very long time, the most common power levels of amateur radio transmitters have been in the 50-200 W peak envelope power output range. This appears not to have been changed in a time period of 20 – 30 years.

Single-sideband radiotelephony and Morse telegraphy remain the most popular waveforms or emissions in the HF range, and their long term peak-to-average power ratios, excluding listening pauses, are in the order of 30% or less.

For VHF operations FM is the most popular emission, with a long term peak to average ratios of 50 to 60%. FM operations are mostly using low to medium power levels, 10-50 W.

In recent years, some digital emissions with less peak-to-average ratios, around 60%, have become popular. They permit workable amateur radio contacts with significantly smaller signal-to-noise ratios and correspondingly lower required transmitter output power levels.

They have become popular by those that cannot put up efficient transmitting antennas for the HF range.

The more common antenna conditions, especially among new amateurs, have however shifted from larger, higher performance and more freely located antennas towards smaller and less conspicuous antennas. Such antennas are worse performers in several aspects;

- Lower radiation efficiency due to increased heat losses
- Increased outward coupling to the surroundings, leading to worse EMF and EMC situations
- Increased inward coupling from the surroundings, leading to higher electrical noise levels in the amateur receiver

11.2.2.1 Impact of duty cycle and peak-to-average ratios on the relation between observed and limits for EMF exposure

The limits for EMF exposure are defined as averages during a 6 minute time period [2].

When dealing with the time-varying and intermittent emissions from amateur radio transmitters, the indicated or calculated field-strengths in amplitude units such as V/m or A/m will have to be divided by the square root of the long term peak to average power ratio.

As an example, the field-strength of an HF single-sideband transmitter and antenna installation may be measured or calculated as 20 V/m normalised to a transmitter peak envelope output power of 100 W. Both the regulatory power limits and equipment power ratings are currently expressed in peak envelope power or PEP.

This field strength that is calculated or measured using continuous or CW emissions represents the both the average and the highest value at the peak of the envelope of the emission. If the transmissions also were to be continuous during the whole 6 minute period this would correspond to the total exposure level.

In practice, the emissions have a time-varying power, and are not continuous, as practical two-way communications require listening pauses.

Radio telephone conversations seldom provide more than two minute transmissions at a time interspersed by at least four minute reception pauses during a given 6 minute interval, which gives a transmission to reception to ratio of 30%. Further, the long-term ratio of peak power to average power for the most common emissions or waveforms seldom is more than 30%.

Multiplied together, the total averaged peak-to-average power ratio becomes about 10-12% for the most commonly used waveforms.

This means that the 20 V/m value has to be divided by 3 to arrive at a more valid long term EMF exposure level.

An expanded discussion and further derivations may be found in FCC OET Bulletin 65 Supplement B [6].

It can be noted that in EMC evaluations, the channel occupancy or transmitter duty cycle is of much less importance, as EMC immunity deficiencies will be observed at instantaneous field strength levels.

11.2.3 Trends in location and utilisation of transmitter and antenna equipment

Many radio amateurs have found the antenna permission situation or the man-made interference levels in the cities unworkable, and therefore operate from an auxiliary location such as a summer-house or using remote control of a rural station.

12 Sensitivity analysis

12.1 General

The most influential parameter would be the general activity level. If the average activity should double, the number of radio amateurs that may generate EMF exposure also will double.

Activity is further closely related to age and types of residential arrangements. Amateurs in the 40-75 year group living in detached houses or in rural areas are the most active, judging from general activity reports.

13 Geographical analysis

This material has generally been derived from the "SM Callbook" callsign database and from the activity and equipment parameters derived from the "Störningsenkäten" data.

The tables contain from left to right:

Total number of issued amateur radio permits in the geographical category. This forms an upper bound for the number of possible installations;

The fraction of this number that may generate transmitting activity;

The fraction of the active number that reside in apartments or in very small lots where distances to neighbours are short;

These multiplied with each other and with the total number gives an upper bound of the number that may contribute EMF exposure approaching the limits;

The fraction that use higher power levels on HF;

The fraction that use higher power levels on VHF/UHF;

The HF fraction multiplied with the number of active amateurs in the geographical category;

The VHF/UHF fraction multiplied with the number of active amateurs in the geographical category

13.1 National average

Total number of listed individual potential amateur radio installations	Fraction Active	Fraction of active residing in apartments or in small lots	Total potential EMF exposure number	Fraction using HF with 100W power or more	Fraction using VHF with 50W power or more	Potential HF EMF exposure number	Potential VHF EMF exposure number
12374	20%	40%	989	25%	50%	250	495

Table 1 Distribution of radio amateurs nationally

The national average numbers should be viewed and used with great care, as they represent an amalgamation of material dealing with diametrically differing conditions.

13.2 Urban dwellers (Metro Stockholm)

Total number of listed individual potential amateur radio installations	Fraction Active	Fraction of active residing in apartments or in small lots	Total potential EMF exposure number	Fraction using HF with 100W power or more	Fraction using VHF with 50W power or more	Potential HF EMF exposure number	Potential VHF EMF exposure number
321	10%	95%	31	25%	50%	8	16

Table 2 Distribution of radio amateurs in Metro Stockholm

13.3 Sub-urban dwellers (Greater Stockholm)

Total number of listed individual potential amateur radio installations	Fraction Active	Fraction of active residing in apartments or in small lots	Total potential EMF exposure number	Fraction using HF with 100W power or more	Fraction using VHF with 50W power or more	Potential HF EMF exposure number	Potential VHF EMF exposure number
2405	20%	20%	97	25%	50%	24	49

Table 3 Distribution of radio amateurs in Greater Stockholm area

13.4 Sub-urban or small town dwellers (Örebro)

Total number of listed individual potential amateur radio installations	Fraction Active	Fraction of active residing in apartments or in small lots	Total potential EMF exposure number	Fraction using HF with 100W power or more	Fraction using VHF with 50W power or more	Potential HF EMF exposure number	Potential VHF EMF exposure number
173	30%	20%	11	25%	50%	3	6

Table 4 Distribution of radio amateurs in Örebro area

13.5 Rural area dwellers (Gotland except Visby)

Visby is excepted, as it represents a small township.

Total number of listed individual potential amateur radio installations	Fraction Active	Fraction of active residing in apartments or in small lots	Total potential EMF exposure number	Fraction using HF with 100W power or more	Fraction using VHF with 50W power or more	Potential HF EMF exposure number	Potential VHF EMF exposure number
131	40%	10%	6	25%	50%	2	3

Table 5 Distribution of radio amateurs in rural Gotland

13.6 Visualisation of the distributions

In the Appendices, the spatial distributions of known or verified active radio amateurs versus those with unknown activity status are presented in maps.

These maps permit a quick overview of the relative and absolute numbers of populations that fulfil certain criteria.

14 Sources

14.1 List of current amateur radio certificates in Sweden, "SM Callbook"

An updated listing of current certificates was received as an Excel document from SSA at 2015-11-30.

14.2 List of all issued amateur radio callsigns in Sweden since 1924 "New Calls in Sweden"

Online resource compiled by a third party, which contains an accumulation of issued callsigns from 1924 onwards. www.rigpix.com/ncis/ncis.htm. The compilation has been transformed into an Excel file.

14.3 List of all postcodes with associated population data accessible from Statistics Sweden

An Excel file has been downloaded from the Statistics Sweden web-site www.scb.se

14.4 Compilation of questionnaire "Störningsenkäten"

In the late 80's a questionnaire was distributed among the then current SSA membership (about 6000), requesting them to answer a 4-page form about their residential, operating, equipment and interference situations. A total of 876 answered the query.

Out of these answers, 250 have been randomly selected, and their residential conditions together with equipment and operating status profiles have been extracted.

This data is the latest available, but since the majority of the active radio amateurs today also were active at the time when the questionnaire was issued the profiles in general may be considered valid also today.

During the compilation process, obvious sources of errors such as deceased and known entirely inactive amateurs have been deleted from the material.

14.5 Compilation of amateur radio activities from web-sources and amateur radio journals

A list of total 1302 individual amateur radio callsigns have been compiled from online sources and amateur radio journals accessible on the Internet. The callsigns represent those radio amateurs that have presented a sufficient level of ambition for generating enough activity to be reflected in listings of different forms.

In these figures, a substantial hidden statistic must be observed. There are radio amateurs that may be quite active without ever appearing in any written or on-line sources or result listings.

A conservative estimate for the hidden statistics is that the number of "active in any form" radio amateurs must be weighted with 50 % or to about 2000 for use in statistical calculations.

14.5.1 Radiosport result listings

Radiosport or "contest" result listing for both national and international HF and VHF competition events reaching back 10 years have been used to compile the list.

14.5.2 Awards listings

Another metric of activity and level of ambition are the current standings in the DXCC "DX Century Club" lists, which are accumulated during the past 5 decades which show the status of individual radio amateurs active in collecting radio contacts with different "countries".

To rank high in these listings represents a substantial investment and effort in both equipment and operating time.

14.5.3 Highly active radio amateurs

A sampling of 50 of the highest ranked Swedish amateurs in radiosport and awards compiled from results listings was used to determine residential conditions and antenna installation profiles among this group, which can be considered dimensioning for EMF exposure from stations with a high activity and level of ambition.

None of these stations were found in apartment buildings.

14.6 Web-services "hitta.se" and Google Maps

The web-services www.hitta.se and Google Maps which permit viewing actual addresses with maps and street views together with population data has been used to verify the data contained in the databases on a sample basis.

15 References and literature

[1] ITU Radio Regulations Edition of 2012

[2] Strålsäkerhetsmyndighetens Författningssamling SSMFS 2008:18

[3] CEPT Recommendation T/R 61-02 "Harmonised Amateur Radio Certificate"

[4] Pareto, Vilfredo; "Manuale di economia politica" (1906) translation "Manual of Political Economy" by A.M. Kelley (1971). Also Eric W. Weisstein; "Pareto Distribution" in the MathWorld user manual

[5] Council Recommendation 1999/519/EC - On the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)

[6] FCC 1997 "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, Supplement B to OET Bulletin 65 (Edition 97-01)"

[7] "Sechsundzwanzigste Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung über elektromagnetische Felder - 26. BImSchV) § 2 Hochfrequenzanlagen"

http://www.gesetze-im-internet.de/bimschv_26/__2.html

[8] "Programmbeschreibung des Softwarepakets Watt-Wächter Mai 2014"

http://emf3.bundesnetzagentur.de/pdf/Programmbeschreibung_WW_2014_05_06.pdf

[9] Ivan A. Shulman "Is Amateur Radio Hazardous to Our Health?" QST October 1989 pp 31-38

[10] Roger Blackwell, Ian White "RF Hazards Revisited" Earth-Moon-Earth Newsletter April 1984

[11] ESR PM om amatörradio Release 3, Juli 2015 http://www.esr.se/phocadownload/ESR_PM_om_amatorradio_utg_3_2015-07-03.pdf

[12] "Fältmätningar av amatörradioanläggningar" SSM Report Dnr SSM2015-4097

[13] "Störningsenkäten" Compiled and published in SSA QTC 1988-1989

16 Acknowledgements

The contributions from SSA, by deputy chairman Jonas Hultin, and "Störningsenkäten" from Rune Wande are hereby acknowledged.

The material about spectrum usage from PTS is also acknowledged.

In compiling this report, colleagues Johan Endrell and Stellan Wersén have contributed valuable assistance, Johan Tenstam has proof-read.

17 Declaration of Interest

The author of this report is or has been affiliated to the following:

Member of the Swedish National Committee for Scientific Radio SNRV, chairman of Section C "Signals and Systems";

Board member of the Nordic Radio Society NRS;

Member of the Swedish Radio Navigation Board RNN;

Radio engineering and spectrum management advisor for Föreningen Experimenterande Svenska Radioamatörer ESR;

Former technical advisor for Föreningen Sveriges Sändaramatörer SSA;

Former Swedish Government delegate to the CCIR and ITU-R Study Groups 8 and 5

18 Appendices

The distributions in all appendices are shown as total numbers of radio amateurs, compared to the numbers of radio amateurs having shown known or measurable activity.

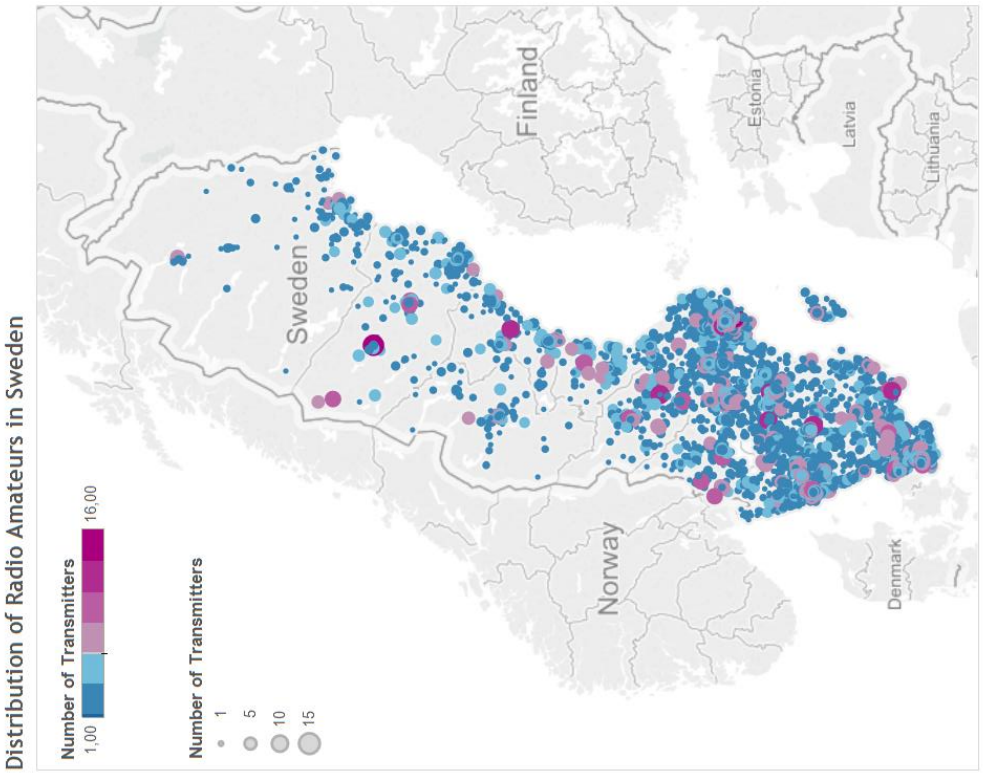
In these graphs, any radio amateur is considered a "potential transmitter", and a radio amateur having shown verified activity is shown as a "verified transmitter". At each address in a given postcode area, there may be several physical transmitters, but only one transmitter is assumed to be operating at a time.

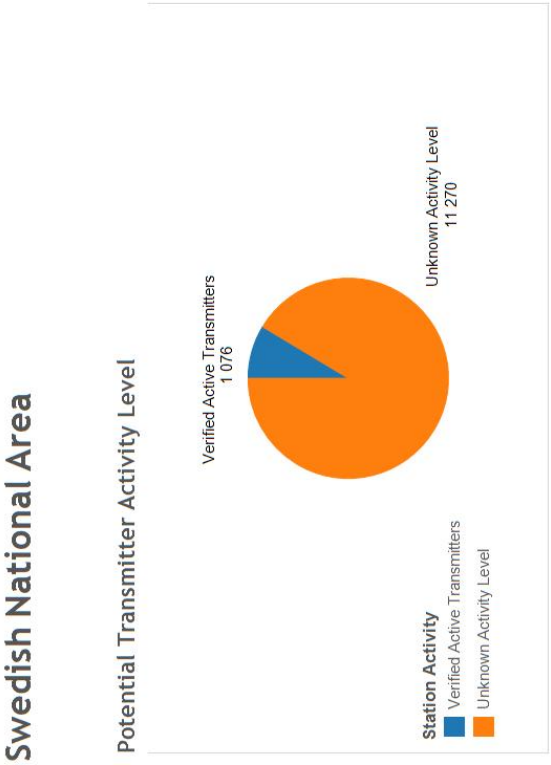
All distributions use the postal code area as parameter.

The colour coding and size of the dots are proportional to the numbers in each postal code area.

18.1 Appendix 1

Distribution of radio amateurs in the whole of Sweden (the National Area)



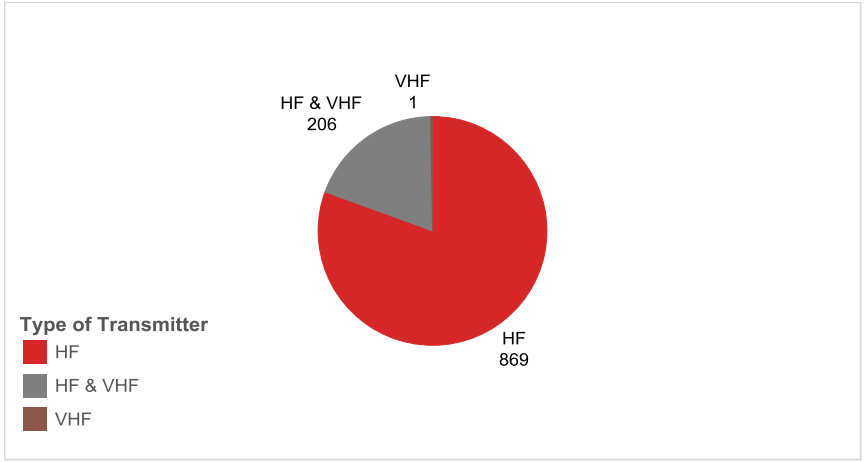


Distribution of Transmitters

Geographical area	Private Transmitters				Grand Total
	Unknown Activity Level	Verified Active Transmitters			
	-	HF	HF & VHF	VHF	
Gotland (Visby excluded)	59	5	3		67
Lund	102	7			109
Stockholm Metro	303	18			321
Greater Stockholm (excl. Metro)	2 153	147	23	1	2 324
Örebro	156	11	1		168
Sweden Other Areas	8 420	672	179		9 271
Grand Total	11 193	860	206	1	12 260

Active Transmitters in Swedish National Area

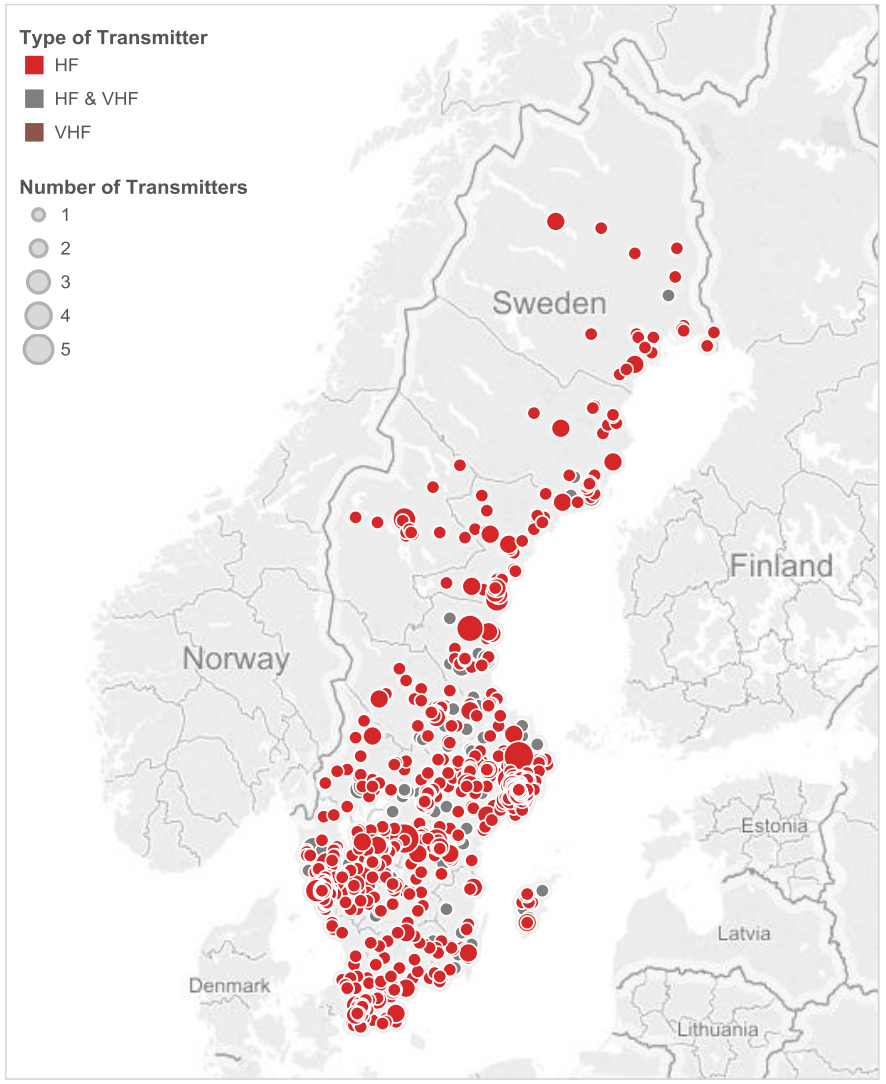
Active Transmitter Type



Distribution of Transmitters

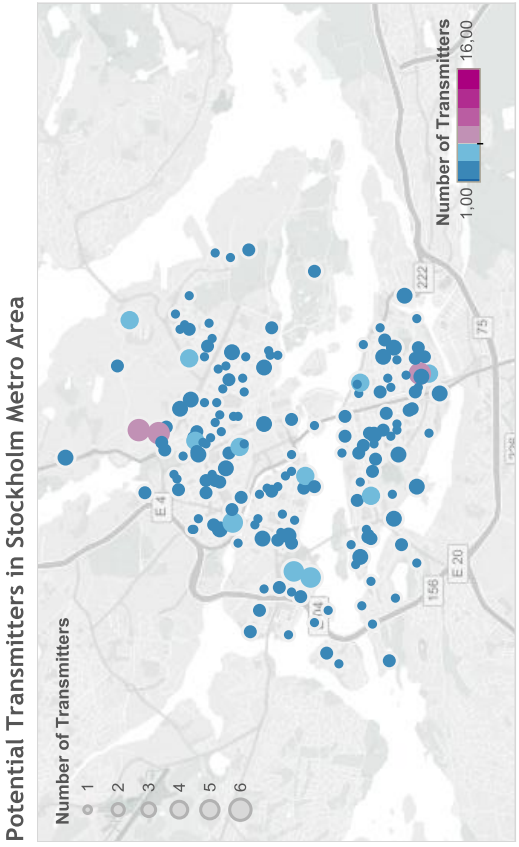
	Private Transmitters				
	Unknown Activity Level	Verified Active Transmitters			Grand Total
Geographical area	-	HF	HF & VHF	VHF	
Gotland (Visby excluded)	59	5	3		67
Lund	102	7			109
Stockholm Metro	303	18			321
Greater Stockholm (excl. Metro)	2 153	147	23	1	2 324
Örebro	156	11	1		168
Sweden Other Areas	8 420	672	179		9 271
Grand Total	11 193	860	206	1	12 260

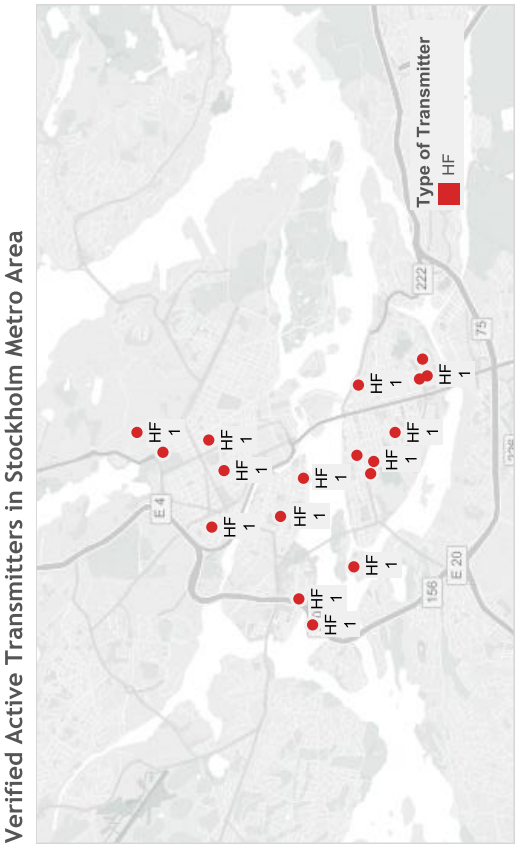
Verified Active Transmitters in Sweden National Area

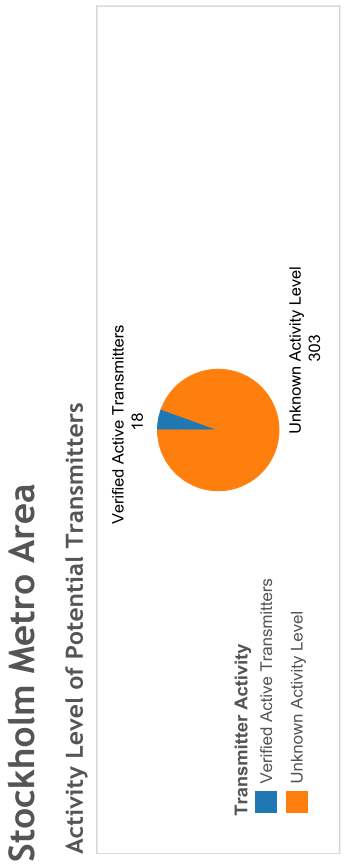


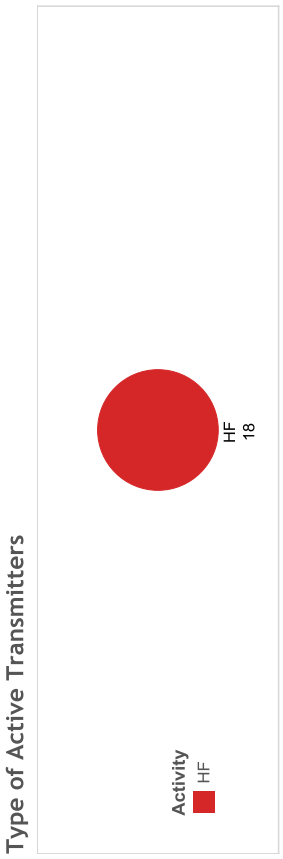
18.2 Appendix 2

Distribution of radio amateurs in Greater Stockholm Area (Stor-Stockholm, telephone area code 08)







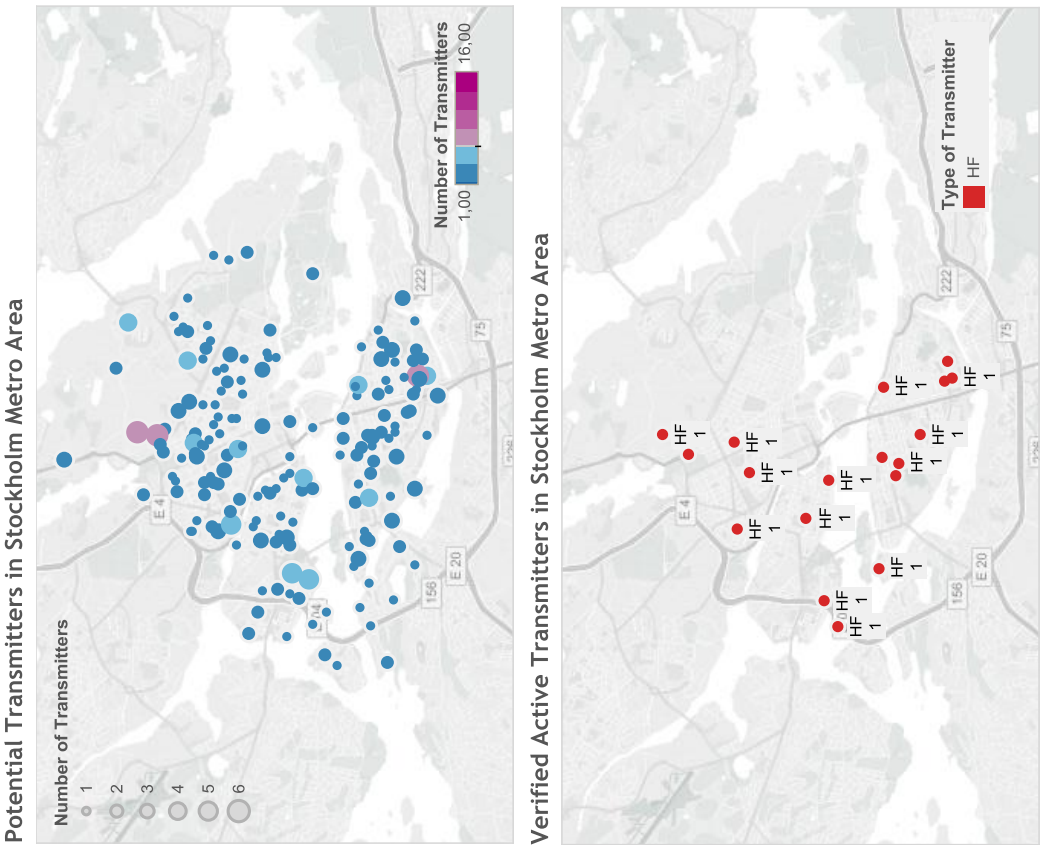


Distribution of Transmitters in Stockholm Metro Area

Geographical area	Private Transmitters		Grand Total
	Unknown Activity Level	Verified Active Transmitters	
	-	HF	
Stockholm Metro	303	18	321
Grand Total	303	18	321

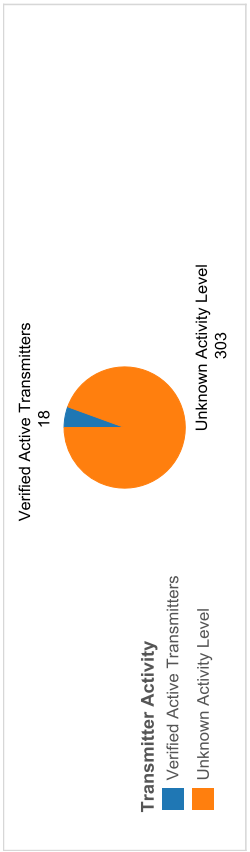
18.3 Appendix 3

Distribution of radio amateurs in Metro Stockholm Area (Stockholm innanför tullarna)

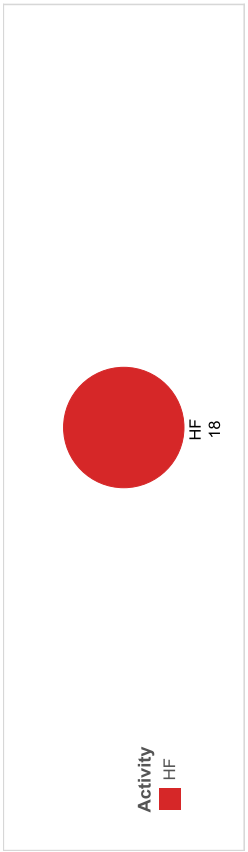


Stockholm Metro Area

Activity Level of Potential Transmitters



Type of Active Transmitters

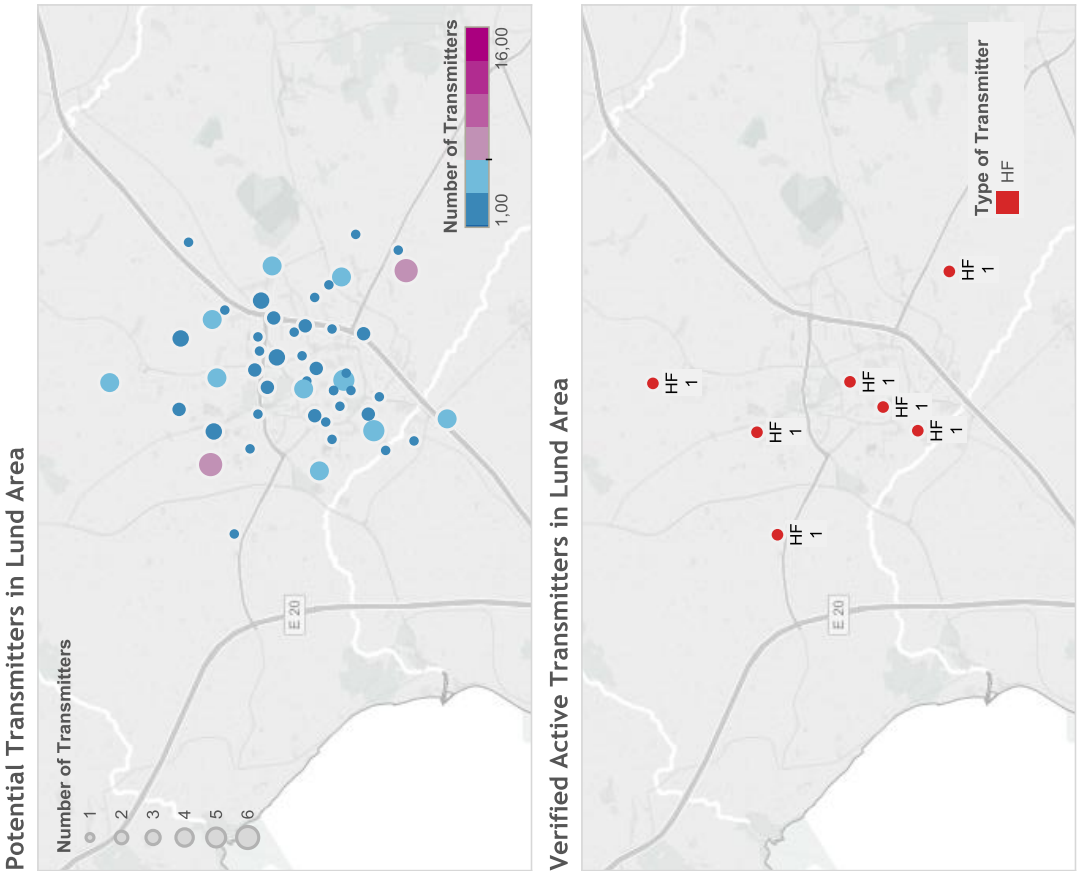


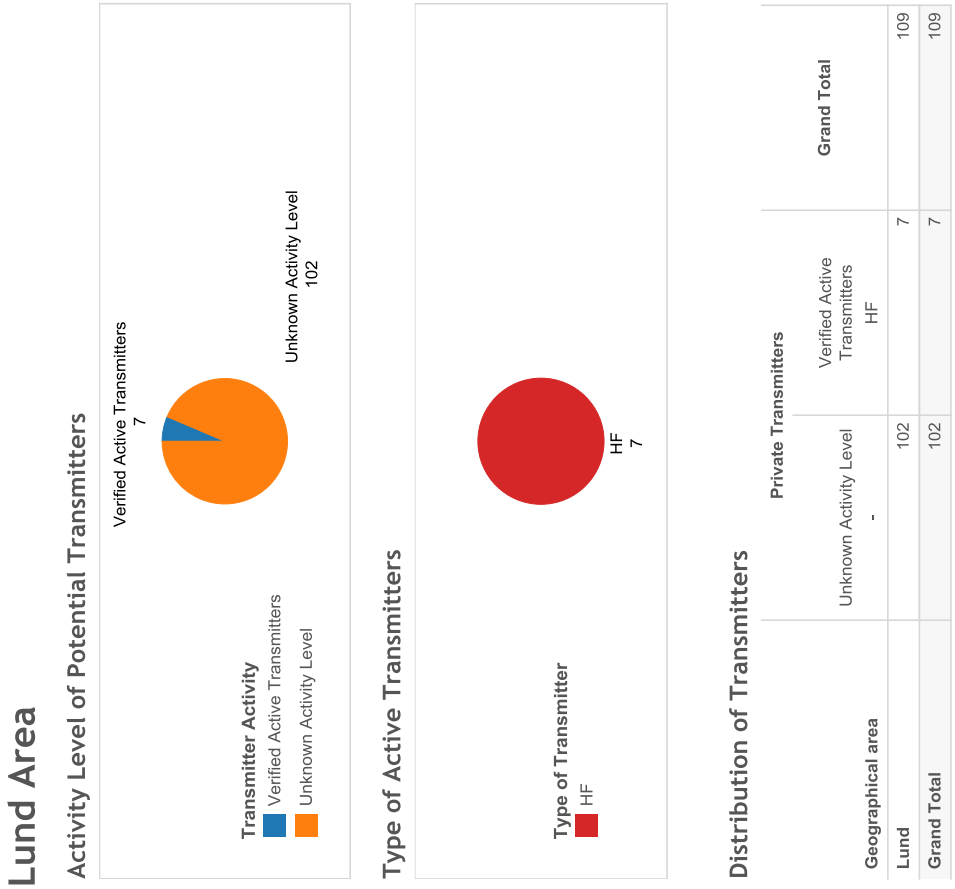
Distribution of Transmitters in Stockholm Metro Area

Geographical area	Private Transmitters		Grand Total
	Unknown Activity Level	Verified Active Transmitters	
	-	HF	
Stockholm Metro	303	18	321
Grand Total	303	18	321

18.4 Appendix 4

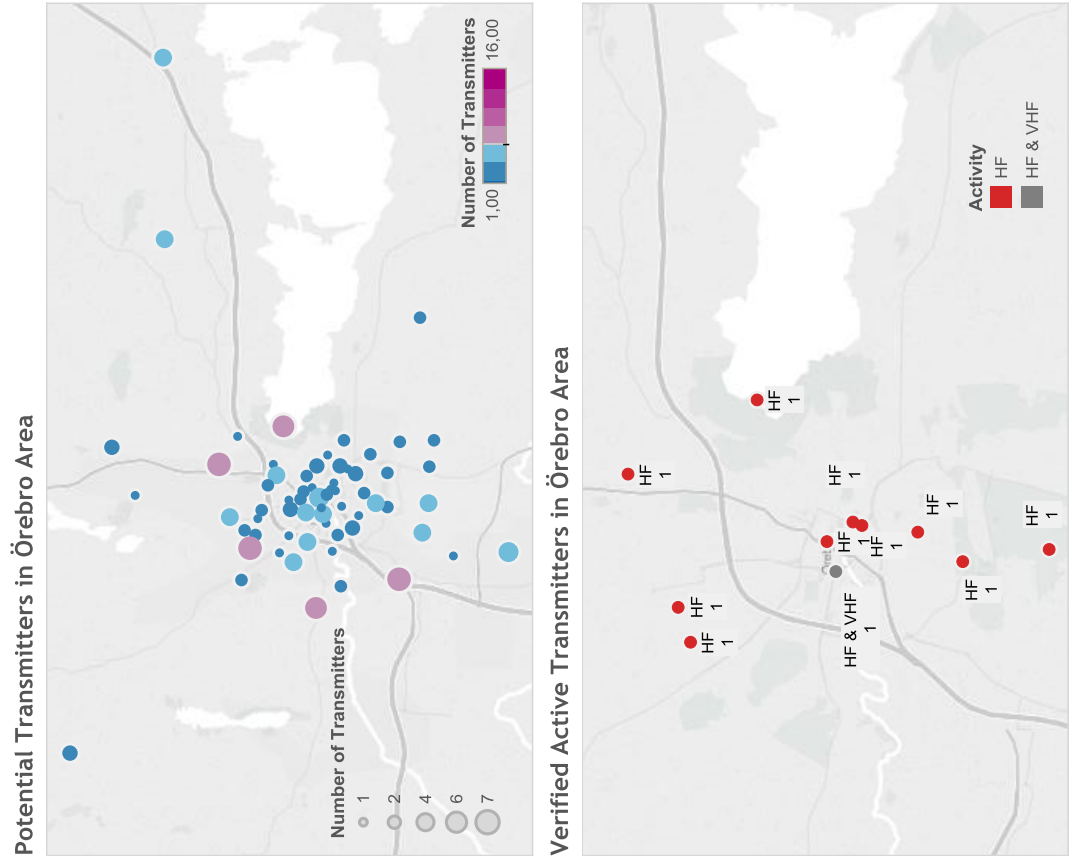
Distribution of radio amateurs in Lund Area





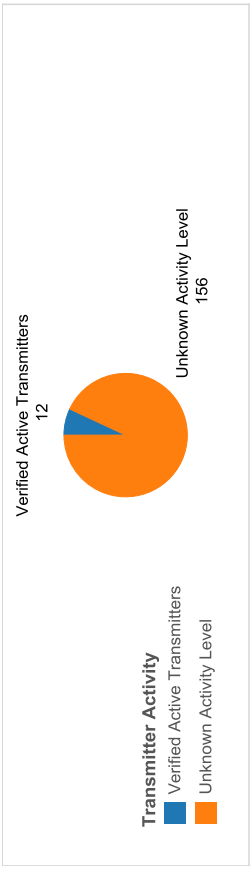
18.5 Appendix 5

Distribution of radio amateurs in Örebro Area

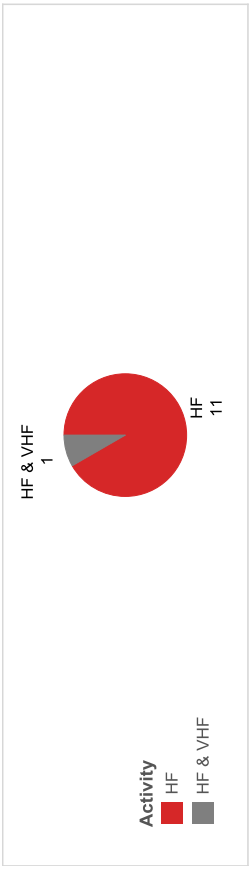


Örebro Area

Transmitter Activity Level



Type of Active Transmitters

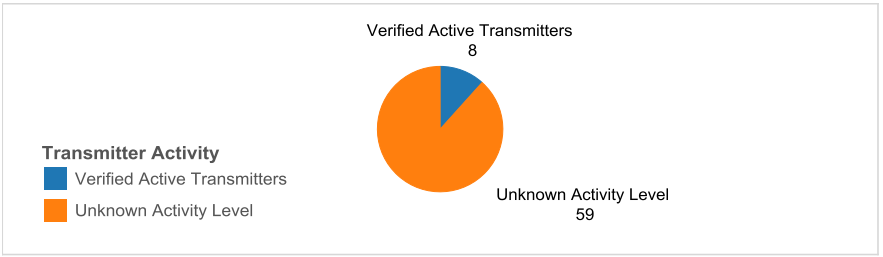


Distribution of Transmitters

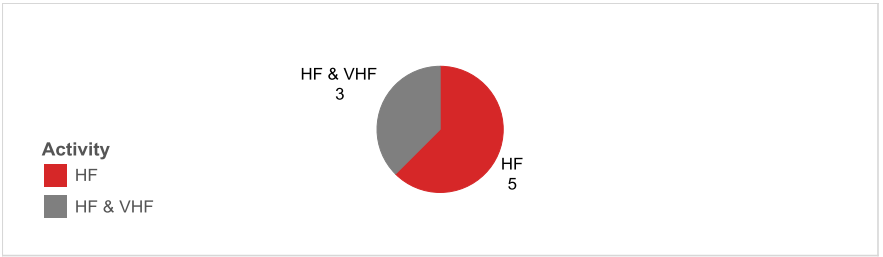
Geographical area	Private Transmitters			Grand Total
	Unknown Activity Level	Verified Active Transmitters		
	-	HF	HF & VHF	
Örebro	156	11	1	168
Grand Total	156	11	1	168

Gotland Area (Visby excluded)

Transmitter Activity Level



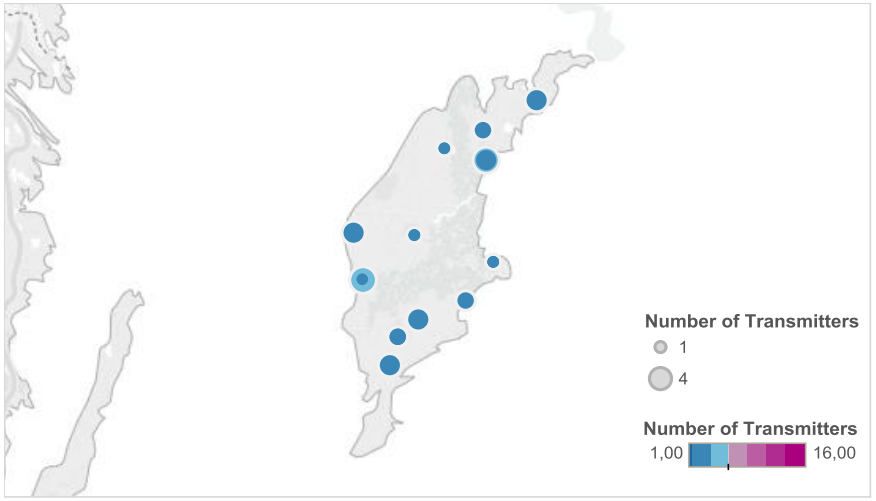
Type of Active Transmitters



Distribution of Transmitters

	Private Transmitters			
	Unknown Activity Level	Verified Active Transmitters		Grand Total
Geographical area	-	HF	HF & VHF	
Gotland (Visby excluded)	59	5	3	67
Grand Total	59	5	3	67

Potential Transmitters in Gotland Area



Verified Active Transmitters in Gotland Area