



Report number
PTS-ER-2014:16

Date
2014-04-15

PTS Swedish Spectrum Strategy



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Report number

PTS-ER-2014:16

Document Number

13-7510

ISSN

1650-9862

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Foreword

The use of wireless technology and the demand for radio spectrum is increasing dramatically. We are also facing a development where everything that profits from being connected to a network will be connected. Many of these things will be connected wirelessly using radio spectrum. Wireless technology will become ever more important to ensure that everybody can participate in our information society, irrespective of where in the country they live. In a society where everybody does not have access to the technology of the future, digital exclusion will be created, which risks turning into real social exclusion in the long term as society's physical services disappear.

The radio spectrum resources are limited and have both economic and societal value. This means there is a need for strategic spectrum management.

In Sweden, we are at the leading edge when it comes to managing spectrum. But it is now time to take the next step. We must plan in a way that facilitates a diversity of spectrum uses and technologies also in the future; even those that are unknown today. With a long-term strategy, we want to ensure that the radio spectrum is sufficient for the needs of society, today and in the future. The vision that guides us is to maximise the long term societal benefit of spectrum in Sweden.

With transparent and predictable spectrum management, we can create good conditions for investment, technological development and innovation, legal stability and the efficient use of spectrum.

The market for electronic communication is key for the development in Sweden as well as in Europe. With strategic spectrum management, we can contribute to strengthening Sweden's competitiveness.

Göran Marby
(Director-General, PTS)

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Abstract

The spectrum strategy of PTS (the Swedish National Post and Telecom Authority) is a tool that the Authority will use in its work with spectrum planning and licensing. The purpose of the strategy is to describe the principles for achieving the Authority's vision for spectrum management. The vision is:

To maximise the long term societal benefit of radio spectrum in Sweden.

A long-term strategy will contribute to ensuring that the radio spectrum is sufficient for the needs of society, today and in the future.

PTS makes decisions on spectrum management in accordance with the goals and rules decided by the EU, the Swedish Parliament and the Swedish Government. With the spectrum strategy, PTS endeavours to clarify the aims of spectrum management and the principles that guide the Authority's priorities.

It is important to regard the spectrum strategy and its main principles as a unified whole, as the different main principles are intended to reinforce and balance each other. Thus, individual principles will not be implemented without taking the other principles in the strategy into consideration.

The main principles of the Strategy are:

Enable the development of radio-based electronic communication services and other services based on radio communication through sufficient availability of spectrum (Chapter 3)

PTS will enable the development of radio-based electronic communication services and other services based on radio communication through the sufficient availability of spectrum suitable for purpose. PTS will increase the availability of useful spectrum by setting the least-restrictive conditions, working for international harmonisation, assigning spectrum at a rate appropriate to meet demands, and promoting secondary trading. PTS will promote more socioeconomically efficient spectrum use through more efficient technical rules, denser radio planning, well-defined receiver characteristics, management of the application process, competition-neutral harmonisation, as well as greater and more efficient spectrum sharing between different users and uses of spectrum.

Promote the sharing of all spectrum between different spectrum uses in the longer term (Chapter 4)

PTS will promote the sharing of all spectrum between different spectrum uses in the long term, for example, in international harmonisation. The basic principle is that all frequency bands will be shared in the long term or be prepared for sharing. Exactly which spectrum uses and sharing criteria that are suitable for co-existence may vary. All licensing should take into account the possibilities for immediate or future sharing. PTS will work towards the harmonisation of wider frequency blocks. It is possible to increase the probability that a secondary service can use available frequency resources at all times and in all places needed by making large amounts of spectrum available on a secondary basis.

Enable a diversity of spectrum uses (Chapter 5)

The measures PTS takes will be future proof and work in different future scenarios. The Authority will therefore enable a large diversity of spectrum uses to facilitate maximum societal benefit given that the Authority cannot know in advance which uses will be most in demand and used. The Authority's tools for creating diversity are, for example, as few restrictive conditions as possible, comprehensive spectrum planning, increased sharing and deliberate choices between different types of usage rights and conditions of use.

All spectrum use will, over the long term, exist in the most suitable frequency bands (Chapter 6)

To maximize the long-term societal benefit of spectrum use, PTS will enable that all spectrum uses are placed in or migrated to the physically and socio-economically most suitable frequency bands over the long term. This will be determined with regard to spectrum planning as a whole, and with a very long time perspective. Long-term thinking and good planning are prerequisites for enabling measures that would otherwise be impossible or inefficient over the short term.

Promote broad international harmonisation with as few restrictive conditions as possible (Chapter 7)

PTS will promote broad international harmonisation with as few restrictive conditions as possible to maximise the opportunities for efficient spectrum use and to minimise negative restrictions. Harmonisation and standardisation

enable economies of scale in manufacturing bringing lower costs for radio equipment and make transnational services possible. A minimum of restrictive conditions (only those required to facilitate efficient spectrum use) enables uses with maximum societal benefits. Broad harmonisation will include as many countries as possible.

Societal cost-benefit analysis will form the basis for PTS spectrum management (Chapter 8)

To determine which measure is socio-economically the most effective and which contributes to the greatest long-term societal benefit possible, societal cost-benefit analysis will form the basis for the choices that PTS makes in spectrum management. This applies to comprehensive spectrum planning, international harmonisation, the choice of usage rights, types of assignments and licence conditions.

Societal cost-benefit analysis and needs assessment will govern the assignment of spectrum where market mechanisms do not work satisfactory (Chapter 9.1)

Societal cost-benefit analysis and needs assessment will guide spectrum allocation in comprehensive spectrum planning, and in the licencing of spectrum for the public goods, in certain cases of transnational services and in order to achieve particular political goals. Public goods refers to spectrum uses needed for public order and safety (such as defence and police), the protection of human life and health (such as emergency services, particular security and emergency signalling systems) and basic scientific research.

Transnational services are spectrum uses that require radio signals or radio transmitters to cross national borders on a regular basis in order to operate as intended, such as maritime radio, aeronautical radio, satellite radio services and short-wave radio. Political goals may, for example, relate to the coverage of publicly available electronic communication networks, or to the importance of freedom of expression and the free formation of opinion in accordance with the Fundamental Law on Freedom of Expression.

PTS has a special responsibility for ensuring that such public goods can be realised. In these cases, PTS can conduct a needs-assessed administrative assignment of spectrum according to a cost-benefit analysis demonstrating that the need is being satisfied in the most cost-effective way possible (for example, through spectrum sharing, by licence conditions in other networks, through cable based solutions or dedicated usage rights).

Demand will govern spectrum assignment for other uses (Chapter 9.2)

For other spectrum uses, demand will as far as possible govern spectrum assignment. In these cases, PTS intends to apply the following principles. If spectrum is sufficient for all who wish to use it, PTS will assign usage rights (for example, via transmitter licences or licence-exempt use). Where there is reason to limit the number of licences, demand and the willingness to pay in a selection procedure will govern who gets licences and for what spectrum can be used. When analysis shows that there is a risk of harm to competition when assigning or using spectrum, competition-promoting measures should be included in decisions about assignment formats and licence conditions.

1 Background

1.1 Spectrum – a valuable natural resource

Radio spectrum is a limited natural resource that belongs to the citizens in Sweden. PTS manages radio spectrum by mandate from the Swedish Parliament and the Swedish Government.

Radio spectrum in Sweden has great economic value as an input for wireless communication and other radio-based services and for scientific research. According to a number of analyses and assessments¹, the radio spectrum is worth at least 2 per cent of GDP, i.e. at least 80 billion SEK per year. There are hardly any empty, i.e. unused or unplanned frequency bands in the Swedish frequency plan today. To an ever greater extent, the existing assignments of radio spectrum will therefore have to change if any new spectrum use is to have access to suitable spectrum.

The use of wireless communication and other radio-based services has increased and greatly changed since mankind discovered the possibilities stemming from using electromagnetic radio waves. At the same time, the allocation and assignment of radio spectrum in Sweden are a result of the priorities and the technologies that existed from around 1910 and later. Because of this, the radio regulations of the International Telecommunications Union (ITU) and PTS's frequency plan are largely a historical legacy rather than a result of current priorities and technologies.

The world about us is changing, and the future is difficult to forecast. But considering how the use of wireless communication and other radio-based services has developed historically, it can be assumed that both the use and the needs will not be the same in ten years' time as compared to now. Use is increasing in several different areas, such as:

- mobile access to the Internet, including networked things, “the Internet of Things”,
- fixed radio links
- short-range radio²,
- Earth exploration satellite services,
- intelligent transportation systems,
- unmanned aircraft and other vehicles,

¹ Analysys (2004): *Study on conditions and options in introducing secondary trading of radio spectrum in the European Community*. Final report for the European Commission. NERA (1998): *Use of Radio and its impact on the Swedish economy*. Final report for Post och telestyrelsen.

² So-called short range devices (SRD).

- the defence sector.

The premise that the use of spectrum will continue to increase and change at the same rate as to date, or even faster is not excluded. PTS can also, to some degree, have an impact on the development of radio use, by facilitating different spectrum uses and types of radio network architectures. If PTS continues to issue licences and to allocate spectrum use in the same way as has been done historically, we will risk stifling development if new and changed spectrum uses are not given sufficient conditions for development. PTS therefore needs a long-term strategy that ensures that the radio spectrum is sufficient for the needs of society, today and in the future.

1.2 The EU's objectives for the spectrum area

The EU has determined how spectrum in the Member States shall be managed and licenced in the EU's Digital Agenda and 2020 Strategy³ and through Directives and Decisions. The EU's Framework Directive⁴ determines that spectrum should be regarded as a limited public resource with considerable value for the general public and for the market.

"It is in the public interest that spectrum is managed as efficiently and effectively as possible from an economic, social and environmental perspective, taking account of the important role of radio spectrum for electronic communications, of the objectives of cultural diversity and media pluralism, and of social and territorial cohesion. Obstacles to its efficient use should therefore be gradually withdrawn."

This means that radio spectrum will be managed and assigned in a way that promotes competition in the supply of electronic communication services. This will ensure, among other things, that users, including users with disabilities, derive maximum benefit in terms of choice, price and quality. It will further ensure that no distortion or restriction of competition arises within the electronic communication sector thereby encouraging efficient investment in infrastructure, the promotion of innovation, the encouragement of efficient use and ensuring the effective management of radio frequencies.⁵

In 2012, The European Parliament and Council, by means of a Decision binding on the member states, created a multi-year programme for radio

³ The Commission's announcement of 3 March 2010 of the Europe 2020 Strategy and the Commission's announcement of 26 August of the Digital Agenda for Europe

⁴ Directive 2002/21/EC of the European Parliament and of the Council of 7 March 2002 on a common regulatory framework for electronic communications networks and services (Framework Directive) as amended by Directive 2009/140/EC of the European Parliament and of the Council of 25 November 2009.

⁵ Article 8.2 of Directive 2002/21/EC of the European Parliament and of the Council of 7 March 2002 on a common regulatory framework for electronic communications networks and services (Framework Directive) as amended by Directive 2009/140/EC of the European Parliament and of the Council of 25 November 2009.

spectrum policy (hereafter called the EU's Spectrum Programme) for strategic planning and harmonisation of spectrum use in the EU. This implies that PTS's decisions, and also any future changes to the law, shall be in line with the EU's Spectrum Programme.⁶ Article 3 a of the Programme states that member states shall:

“encourage efficient management and use of spectrum to best meet the increasing demand for use of frequencies reflecting the important social, cultural and economic value of spectrum”.

In the introduction to the Programme, this is developed in Item 4, among others:

“A renewed economic and social approach with regard to the management, allocation and use of spectrum should be adopted. That approach should have a particular focus directed towards spectrum policy, with the aim to ensure greater spectrum efficiency, better frequency planning and safeguards against anti-competitive behaviour.”

and in Item 5:

“The strategic planning and harmonisation of spectrum use at Union level should enhance the internal market for wireless electronic communications services and equipment as well as other Union policies requiring spectrum use, thus creating new opportunities for innovation and employment creation, and simultaneously contributing to economic recovery and social integration across the Union, while at the same time respecting the important social, cultural and economic value of spectrum.”

The EU's Spectrum Programme may be further defined through Commission Decisions. In accordance with the Programme, the Commission is given implementation authority in order to safeguard uniform conditions for the implementation of the Programme Decision. The Commission may, for example decide:

“to develop a methodology for the analysis of technology trends, future needs and demand for spectrum in Union policy areas covered by this Decision, in particular for those services which could operate in the frequency range from 400 MHz to 6 GHz...”, Article 9, Item 2 b.

If such decisions are made in future, they may take precedence over parts of this Strategy.

The Spectrum Programme shall be implemented no later than as from 1 July

⁶ Decision No 243/2012/EU of the European Parliament and of the Council of 14 March 2012 establishing a multi-annual radio spectrum policy programme (also called Radio Spectrum Policy Programme, RSPP).

2015 in the member states. The PTS Spectrum Strategy is part of this implementation.

In 2013, the Commission issued proposals to the European Parliament and the Council on measures to complete the European internal market for electronic communications, etc.⁷. The work with negotiations concerning the proposal continues during 2014 and may result in binding regulations, which may apply to this Spectrum Strategy in terms of how certain EU-harmonised frequency bands will be used.

1.3 PTS's mandate in the spectrum area

PTS is the public authority that manages radio spectrum in Sweden. Against the background of the EU's objectives, the Government has mandated PTS to manage spectrum through work on spectrum planning and licencing.

PTS receives its mandate from the Swedish Parliament and the Government through appropriations directions, the Electronic Communications Act and Ordinance⁸, the Ordinance with Instruction for PTS, time-limited Government mandates and in the annual appropriations directions⁹. PTS plans its activities so that they comply with the political goals expressed by the Government. The management of spectrum will also be carried out against the background of the mandatory Decisions or Recommendations issued by the European Commission on harmonisation in the area of electronic communications and other international collaboration that takes place within ITU and CEPT, among other bodies. The right to use radio spectrum in Sweden is governed by Chapter 3 of the Electronic Communications Act (ECA) (SFS 2003:389). The portal paragraph of the ECA, Chap. 1, Section 1, underlines that:

⁷ Proposal for a Regulation of the European Parliament and of the Council laying down measures concerning the European single market for electronic communications and to achieve a Connected Continent, and amending Directives 2002/20/EC, 2002/21/EC and 2002/22/EC and Regulations (EC) No 1211/2009 and (EU) No 531/2012

⁸ Electronic Communications Act (ECA) (SFS 2003:389) and Electronic Communications Ordinance (SFS 2003:396)

⁹ The norm hierarchy that governs PTS's mandate is:

Binding regulations:

1. EU rules (directives, regulations, decisions)

2. ECA

3. Electronic Communication Ordinance and Ordinance with Instruction for PTS

4. Appropriations directions

5. ITU-RR. This is binding between states in that a state may not be in breach of the regulation and disrupt the communications of another state (if we breach the regulation within Sweden, that is up to us).

Non-binding regulations:

5. Preparatory work that interprets the binding rules under Items 1–4

6. ITU's resolutions and recommendations

7. CEPT recommendations and decisions as well as reports

8. International standards

“The provisions of this act aims to ensure that individuals and public authorities shall have access to secure and effective electronic communications and the greatest possible return in terms of the choice of electronic communication services and their prices and quality.

The aim shall be achieved primarily by promoting competition and the international harmonisation in the area. Universal services shall, however, always be available to all on equivalent terms throughout the country at reasonable prices.

When implementing the act, special consideration shall be paid to the importance of electronic communications to freedom of expression and freedom of communication.”

In 2014, PTS was mandated to “...be responsible for ensuring that opportunities to use radio waves efficiently are used”¹⁰. PTS has also been tasked to assess licence issues in accordance with the ECA and in accordance with the Ordinance on Electronic Communications. Chapter 3 states that a licence will be granted if an application leads to “efficient use of the frequencies”, among other things, and also that the number of licences may be limited with reference to efficient use, which is defined in the preparatory work as societal benefit¹¹.

In the ECA and the preparatory work in the ECA, the concept of *efficient use of resources* is used as guideline for the state’s overall responsibility for frequency usage.

“The task of the state should be to ensure that the available resources are used in as technically and economically efficient a way as possible.”¹²

It also emerges from the preparatory work to the Act that spectrum management shall take into account socio-economic aspects and the overall societal benefit of a certain use of radio.¹³

¹⁰In 2014, this is shown in Ordinance with Instruction for PTS, Section 4, Item 2

¹¹ ECA Chapter 3, Sections 6 and 7

¹² Govt. Bill 1992/93:200 p. 168 f.

¹³ Govt. Bill 2009/10:193 p. 67

2 Vision: The PTS Spectrum Strategy will maximise the long-term societal benefit of radio spectrum

In line with the Swedish Government's and the EU's objectives and regulations, PTS has produced a comprehensive vision for spectrum management, which will be used as a guideline when allocating and assigning radio frequencies:

The long-term societal benefit of radio spectrum in Sweden shall be maximised

This implies that radio spectrum will be managed and assigned in a way that promotes competition in the supply of electronic communication services and thereby ensures, among other things, that users, including users with disabilities, get maximum returns in terms of choice, price and quality. Furthermore the skewing or limiting of competition within the electronic communications sector will be prevented, thereby promoting effective investments in infrastructure, in innovation and efficient use and safeguarding a proper management of radio frequencies.¹⁴

The vision corresponds to the intent of the law that individuals and public authorities shall have access to secure and effective electronic communications and the greatest return in terms of the choice of electronic communication services as well as prices and quality.

2.1 The purpose of the PTS Spectrum Strategy

The purpose of the PTS Spectrum Strategy is to describe the principles by which PTS can achieve its vision for spectrum management. A long-term strategy will contribute to ensuring that the radio spectrum is sufficient for the needs of society, today and in the future. The strategy has a time perspective of 10 years or more into the future and helps the Authority work with a sufficiently long-term perspective. PTS is also introducing this tool in its work as a step towards compliance with the spectrum programme adopted by the EU. PTS has developed this tool to enable it to make structured and equivalent assessments of what constitutes efficient spectrum use. With clear spectrum management that is transparent and predictable, we wish to create good conditions for investments, technological development and innovation, for

¹⁴ Article 8.2 of Directive 2002/21/EC of the European Parliament and of the Council of 7 March 2002 on a common regulatory framework for electronic communications networks and services (Framework Directive) as amended by Directive 2009/140/EC of the European Parliament and of the Council of 25 November 2009.

legal stability and for the efficient use of spectrum. With this strategy, PTS intends to become even more transparent and predictable for stakeholders and for the world around us.

With the spectrum strategy, PTS wishes to clarify the objectives of spectrum management and the principles that form the basis for the Authority's priorities. Chapters 3–8 describe these principles. Chapter 9 describes specific alternative principles in relation to important policy choices.

This strategy replaces the PTS spectrum policy from 2006¹⁵.

¹⁵ PTS spektrumpolicy, PTS-VR-2006:2

3 Principle 1: PTS will enable the development of radio-based electronic communication services and other services based on radio communication through sufficient availability of spectrum

PTS will enable the development of radio-based electronic communication services and other services based on radio communication through the sufficient availability of spectrum suitable for purpose. PTS will increase the availability of useful spectrum by setting the least-restrictive conditions, working for international harmonisation, assigning spectrum at a rate appropriate to meet demands, and promoting secondary trading. PTS will promote more socioeconomically efficient spectrum use through more efficient technical rules, denser radio planning, well-defined receiver characteristics, management of the application process, competition-neutral harmonisation, as well as greater and more efficient spectrum sharing between different users and uses of spectrum.

PTS will counteract spectrum shortage becoming an obstacle to societal development. The sufficient availability of spectrum for new and changed spectrum use enables technical and economic development in Sweden.

In a world of rapid technological development where new opportunities are created, PTS must as far as possible ensure that spectrum resources are available for the radio-based electronic communication services and other services based on radio communication that provide the greatest societal benefit. This has consequences for how PTS manages spectrum.

Shortage of spectrum will be counteracted through two main approaches. Firstly, the availability of usable spectrum must increase as spectrum use increases. PTS will do this by:

- Minimising the number of restrictive conditions in existing licences thereby facilitating more uses of spectrum and increasing the probability that spectrum can be used for what is in demand now and in the future.¹⁶

¹⁶ RSPP Art. 2 Item 1e, Item 2a and Art. 3f

- Working towards further developed or new harmonisation for new and demanded spectrum uses in unused frequency bands or in frequency bands that are currently harmonised but not used or used inefficiently.
- Making spectrum available via use rights¹⁷ with appropriate terms at a rate to meet the demand from all types of spectrum use and users. The conditions (such as harmonisation) should be such that spectrum is sufficiently valuable and usable for societally beneficial spectrum use, which leads to real demand and a willingness to pay for spectrum also ensuring that it is used. This means that demand will not simply be based on spectrum being more or less free or in demand solely on the speculation that it will become more valuable in the future, or to prevent competitors from using it (spectrum hoarding). PTS will not leave spectrum unassigned or unusable for the purpose of creating an “artificial” shortage situation, which could increase value due to the lack of usable spectrum, but decrease the societal benefit of spectrum use.
- Promoting secondary trading (including leasing), so that spectrum resources can be transferred to the spectrum uses that have the greatest demand and in order to facilitate stakeholders to aggregate a sufficient amount of continuous spectrum so as to make new services possible.¹⁸

Secondly, spectrum shortage will be counteracted through more efficient radio planning for existing spectrum use. PTS will also drive the development towards increased sharing of spectrum.

- PTS will introduce more efficient technical conditions to allow denser radio planning with reasonable protection against interference (unnecessarily cautious margins at several stages often produce unreasonably low probability of interference currently). What is reasonable protection against interference varies from case to case, for example, it is reasonable to have better interference protection for uses that are critical for the protection of human life and health. Technical conditions should also be updated as the development of technology provides increased opportunities for more efficient use (for example,

¹⁷ A licence to use radio transmitters refers to the right to use a certain radio transmitter (transmitter licence) or to use radio transmitters within a certain frequency and geographical area (block licence). Use rights may also be issued via regulations of licence-exempt use. PTS may also make decisions about use rights for, for example, the defence forces. Use rights are usually associated with conditions.

¹⁸ Follows from RSPP Art. 4 Item 2 And Art. 6 Item 8

more cost-effective filters), but with an ample lead time to ensure that licence holders have reasonable time for adaptation.

- With a more flexible availability of spectrum (via, for example, leasing, sharing, secondary use, dynamic spectrum access) for temporary needs, dimensioning assigned spectrum for a specific use based on peak capacity needs can be avoided.
- PTS also intends, as far as possible, to specify and communicate the receiver characteristics it has used in radio planning. This may entail licence holders and end users being informed about which receivers are required to avoid interference from other uses. In some specific cases, PTS may set conditions for receiver characteristics in national licencing.¹⁹ Generally, PTS should work internationally for receivers that are less interference sensitive in harmonisation and standardisation activities.²⁰
- Through information, guidance and some direction in the licence application process, PTS can facilitate more efficient choices by licence applicants from a long-term socio-economic point of view (for example, avoiding applying for licences in low-frequency bands when they have no requirements for long-range communication).
- Within international forums (for example in the work with technical sharing studies), PTS will act neutrally and counteract special interests, whose striving to avoid additional costs may create an inefficient use of spectrum. This may mean, for example, that PTS works to ensure that central gaps in duplex bands are use more efficiently, or to safeguard the protection of valuable spectrum use in neighbouring bands.
- Assigned radio spectrum has often a very low rate of utilisation today. PTS will therefore work actively to ensure more sharing of frequency bands. See also Chapter 4.

Radio spectrum must be useful, i.e. sufficiently free from interference to be used as intended. Denser radio planning and increased sharing means that PTS must work more on effective and proactive monitoring to safeguard this.

¹⁹ Chap. 3 Section 6 Item 6 of ECA: “If the licence relates to a certain radio transmitter, this, together with the intended radio receiver, shall be of such a nature in technical respects that it fulfils reasonable demands on efficient frequency use and on the possibility of working in the intended environment.”

²⁰ RSPP Art. 4 Item 3

4 Principle 2: PTS will promote the sharing of all spectrum between different spectrum uses in the longer term

PTS will promote the sharing of all spectrum between different spectrum uses in the long term, for example, in international harmonisation. The basic principle is that all frequency bands will be shared in the long term or be prepared for sharing. Exactly which spectrum uses and sharing criteria that are suitable for co-existence may vary. All licensing should take into account the possibilities for immediate or future sharing. PTS will work towards the harmonisation of wider frequency blocks. It is possible to increase the probability that a secondary service can use available frequency resources at all times and in all places needed by making large amounts of spectrum available on a secondary basis.

Assigned radio spectrum has often a very low rate of utilisation. Even if a frequency band is well used in terms of the number of licences issued, the monitoring of radio signals in many cases indicates that many frequency bands are poorly utilised at particular times and locations. In order to use spectrum more efficiently, PTS will work actively to ensure greater sharing of frequency bands.²¹ In particular, PTS will enable several different spectrum uses sharing the same radio spectrum.

The basic principle is that frequency bands in the long term will be shared or prepared for sharing. Exactly which spectrum uses and sharing criteria that are suitable for co-existence may vary from case to case. For block licences also, the basic principle will be that other users can use spectrum in locations or at times when the licence holder itself does not use it.

In the longer term, PTS will work so that all uses, including existing uses, introduce equipment and plan their use to facilitate more sharing. This means that both primary and secondary use will have terms and conditions that are adapted to sharing. This may be promoted through the development of harmonisation, standardisation and new licence conditions as licences expire and are extended (transmitter licences) or are re-assigned (block licences). Through rules about more sharing and Dynamic Spectrum Access (DSA), PTS can also give incentives for the further development of cognitive radio²².

²¹ RSPP Art. 4 Item 1

²² Radio equipment that uses “sensing” to become “aware” of its surrounding radio environment and can adapt its use to this, for example by avoiding transmitting in “busy” frequencies that are already in use.

Sharing using geolocation databases²³ requires standardised interfaces and that either PTS or the licence holder maintains databases with the transmitter and coverage information that are necessary for sharing.

All new licences should be future-proofed in order to enable the future sharing of the frequency band. PTS should take this into account in its licencing and should use the appropriate licence conditions that allow sharing and take into account possible future technological development. Guaranteed exclusivity should be avoided, in particular, for longer licence periods. The primary user's use is still protected, since a possible secondary user must refrain from transmitting or move its frequency use if and when the licence-holder wishes to use the spectrum. On the other hand, a licence-holder should not be able to limit competition by "hoarding" spectrum not intended for efficient use. This is a requirement for PTS to be able to adapt its future frequency plan and licencing to future technological developments in, for example, cognitive radio and other new technologies that are adapted to spectrum sharing.

In its international work, PTS will work towards the increased sharing of frequencies through decisions that include the harmonisation of technical conditions, primarily at European level. Many potential secondary uses require international harmonisation in order to achieve a sufficiently large market and economies of scale for industry to develop equipment that supports the frequency bands in question, and any technical requirements on which the shared use are based. PTS should actively support European harmonisation based on sharing spectrum.²⁴ It is important for international harmonisation that PTS actively tries to find opportunities for spectrum sharing. Historically, this work has usually been based on inputs from industry interests. Even if this is important information for the work, one should not forget that these industry interests do not have the overall objective of maximising the total societal benefit. The administrations that take active part in the work often have a clear agenda, where they argue unilaterally for or against new uses based on national industry interests. In order to facilitate new sharing, it is important that the work is objective and balanced and not dominated by industry interests who, with the support of administrations, sometimes see it as their main task to protect the existing use, irrespective of the overall societal benefit.

The work of introducing new allocations and identifications for radio uses is usually based on sharing studies. In sharing studies, the opportunity for introducing mitigation methods should be investigated even where these are

²³ Databases that contain information about where and when specific frequencies are used, so that other radio equipment can connect to the database and check which frequencies are free for use.

²⁴ See, for example, *RSPG Opinion on Licensed Shared Access* (2013). RSPG13-538.(LSA)

not currently implemented. It is also important that the studies are based on the actual needs for the protection of existing (rolled out and utilised in a relevant location) services and applications. These should be justified based on actual use and technical development, and should also be justifiable from a socio-economic perspective. Protection criteria based in ITU-R recommendations or technical standards will be reviewed as necessary. PTS should take into account whether there are opportunities for differentiated protection of the existing use, where uses with varying protection requirements can be located in different parts of the spectrum in the long term and the sharing conditions can be adapted to suit.

Even in its simplest form, where PTS limits the geographic use in the licence, sharing conditions in the licences²⁵ offer an opportunity to achieve the harmonisation of frequency bands that otherwise would be difficult to achieve because particular national interests wish to protect the existing use of the frequency band. With more sophisticated sharing in the form of, for example, databases, “sensing” (cognitive radio) or other technical functionality, there is great potential for increased spectrum efficiency in many areas.

PTS will also work for an increased sharing of frequencies at national level, which does not always require European harmonisation. Sharing at national level is, however, currently primarily limited to services that are not based on mass-manufactured consumer equipment, as it is easier to adapt the use and the equipment when this only affects a few radio installations.

PTS will promote the harmonisation of wider frequency blocks. It is possible to increase the probability that a secondary service can find available frequency resources at all times and in all places where this is required by making available large amounts of frequencies on a secondary basis. This in itself increases the number of users and uses that can use the frequencies on a secondary basis and thus makes use of extra resources as needed, instead of dimensioning networks with the constant capacity needed for peak loads. To facilitate such a development, it is advantageous to harmonise broad frequency bands for secondary use. In order to achieve this, it is probable that the new harmonised frequency bands will include several different sub-bands with diverse primary uses. This also implies an overall perspective, which can provide great advantages for making the primary use more efficient, for example, with fewer guard bands.

²⁵ For example according to RSPG LSA Opinion.

5 Principle 3: PTS will enable a diversity of spectrum uses

The measures PTS takes will be future proof and work in different future scenarios. The Authority will therefore enable a large diversity of spectrum uses to facilitate maximum societal benefit given that the Authority cannot know in advance which uses will be most in demand and used. The Authority's tools for creating diversity are, for example, as few restrictive conditions as possible, comprehensive spectrum planning, increased sharing and deliberate choices between different types of usage rights and conditions of use.²⁶

The PTS Spectrum Strategy needs to work irrespective of future developments. Long-term research into strategic planning shows that the future cannot be accurately predicted through forecasts and planning; it is therefore wise to prepare for alternative future scenarios²⁷. Many of the most important changes are also those that cannot be predicted or expected until they occur, as previous experience is lacking²⁸. The experience from when spectrum authorities tried to “pick winners” and harmonise future services also shows that the assumptions about the future have more often proved to be wrong rather than correct, with the result that they have harmonised spectrum for spectrum uses that lacked demand.²⁹ Some frequency ranges are therefore unused. More service-independent, flexible and open platforms or radio network architectures (IP access, for example) are therefore to be preferred, as greater societal benefit can be created by reaching a multitude of networked services (such as multimedia content, websites, social media or storage in “the cloud”).

In order to maximise the societal benefit of radio spectrum, PTS will act to enable as great a diversity of spectrum uses as possible in the future, given that PTS cannot determine with certainty in advance which uses will be most in demand and most used.

PTS has several tools for creating diversity:

- Least restrictive conditions
- Comprehensive spectrum planning

²⁶ RSPP Art. 2 Item 1a “Implement the most suitable and least demanding licence system so that flexibility and efficiency of spectrum use is maximised...” Few limiting conditions are shown in Art. 2 Item 1e and Item 2a and sharing is encouraged in Art. 4 Item 1.

²⁷ See for example van der Heijden (1997): *Scenarios, the Art of Strategic Conversation*. Wiley and Schwartz (1991): *The Art of the Long View*. Doubleday..

²⁸ Nassim Nicholas Taleb (2007): *The Black Swan: The Impact of the Highly Improbable*. Random House.

²⁹ For example Ermes, TFDS, T-DAB in 1452-1492 MHz, MLS, UMTS TDD, MSS 2GHz.

- Sharing
- Timing or time planning

Least restrictive conditions means that PTS will promote use rights with the least restrictive conditions possible i.e. only those needed to enable efficient spectrum use, in order to enable development of both technical solutions and radio-based electronic communication services and other services based on radio communication that users demand. Use rights will normally only have conditions specified that are needed to enable efficient spectrum use and co-existence between different radio users. PTS will promote frequency bands with licence-exempt use and international harmonisation with least restrictive conditions, where several similar spectrum uses can co-exist within a wider framework.³⁰ Licence-exempt use with least restrictive conditions is also an important tool for reducing transaction costs³¹, as this means it is possible to develop and introduce new spectrum uses without the need for comprehensive and time-consuming harmonisation and licencing.

Diversity can also be achieved through *comprehensive spectrum planning*, where different frequency bands are planned with differing conditions. A wide range of bands with different conditions may include differing categories of spectrum uses, differing radio network architectures, bandwidths, use rights, assignment formats and technical terms and conditions.

Greater opportunities for *sharing* frequency bands that are already used open the door to new potential spectrum uses. All licences will, in the long run, include sharing conditions that take into account future technology developments, see also Chapter 4.

The *timing aspect* can also be used to create diversity. Well-developed uses may get licences with longer licence periods, while shorter licence periods may be suitable for new and experimental uses, where development is still uncertain. An evaluation of actual use of spectrum can then form the basis for assessing the extension and possible expansion of the bands for this particular use. Temporary uses can also be given increased space in frequency bands that are under development, such as frequency bands where increased use is predicted some years into the future due to the international harmonisation in progress.

³⁰ According to RSP Art. 3 g, states shall encourage simple access to spectrum, and preferably consider “general authorisation” (licence-exempt use), see also the Authorisation Directive, which encourages states to introduce exemptions where possible.

³¹ See also Chapter 7.

This means that PTS will work actively on analysis of technological development, future trends and the contemporary environment, including demand and usage rates. The better informed PTS is, the greater its opportunities to implement future-proof frequency planning. As lead times in international harmonisation work are very long, PTS intends to work more proactively and future-oriented, in order to facilitate development of new spectrum uses in time.

This also means that PTS will not only react to market demand and lobbying from various types of industry interests, but will proactively create opportunities for new radio network architectures and areas of spectrum use. This may be done through applying least restrictive conditions, new or changed harmonisation, new licence-exempt uses and opportunities for sharing, and also by creating many different types of use rights in terms of, for example, frequency, transmit power, bandwidth, duty cycles and geographic scope³². PTS will strive to enable as many different uses as possible, not in each individual frequency band, but throughout the whole spectrum of radio frequencies. Thereafter, demand and selection mechanisms will govern the actual spectrum use in a specific frequency range to the uses that are the most efficient and have the greatest societal benefit (see Chapters 8–9). PTS will also strive to enable spectrum access for entirely new spectrum uses and radio network architectures, which nobody could have predicted, via licences, sharing and licence-exempt use. It is practically impossible to make a quantitative evaluation and predict the societal benefit of uses that do not yet exist.

As experience indicates that public authorities do not often succeed in predicting which spectrum uses will create the greatest societal benefit and be in greatest demand, PTS will create use rights with the least restrictive conditions possible according to current EU directives.³³ Least restrictive conditions mean that spectrum can be used by the most effective spectrum uses, i.e. those uses that create the greatest societal benefit.

According to Chapter 3 of the ECA, PTS may create rights for spectrum use by awarding a licence for a specific radio transmitter (so-called *transmitter licence*), or for the use of a specific frequency range in a specific geographic area (so-called *block licence*, where several radio transmitters can co-exist and the licence holder carries out its own radio planning), or exempt a specific use in a certain frequency band from the need to have a licence (*licence-exempt use*). PTS

³² For example, nobody predicted WLAN use when the 2.4 GHz band was harmonised globally in the 1950s with very few limiting conditions.

³³ Directive of the European Parliament and of the Council Authorisation Directive, 2002/20/EC.

may also make decisions about use rights for others, for example, the defence forces. Different types of licences and use rights and differing licence conditions are appropriate in different cases. Any decision must be based on an overall assessment, using, for example, cost-benefit analysis. However, it may be generally stated that:

- PTS may limit the number of licences in cases where it is necessary to enable efficient spectrum use, by making a so-called *limitation decision*³⁴ where assignment is then usually carried out through a *selection procedure*³⁵ (for example, in the case of block licences), which may consist of an auction or comparative selection procedure.
- If a limitation decision is not made, and all who wish to have a licence or access to spectrum can get this, PTS's approach will be that those who so wish will get (transmitter) licences in accordance with the positive intent of the law, or that spectrum will be licence-exempt.
- In cases with higher transmit power and the need for protection against interference is greatest, licences (block or transmitter licences) are more suitable. When lower transmit power can be used and where the need for protection is small, licence-exempt use is more suitable.
- For fixed use, transmitter licences are often preferable, but for mobile use, block licences are more appropriate.
- When the same licence holder has many transmitters in the same frequency band, a block licence is usually better as the licence holders themselves can carry out a more efficient radio planning than PTS could do.
- For intensive use, licences where primary users have clear priority are usually better.
- For sporadic use, shared use, short-term licences and licence-exempt use are usually better.
- For large and densely developed geographic coverage areas, national block licences are usually best, whereas for small or fragmented coverage areas transmitter licences, small geographic (regional) block licences or licence-exempt use are usually better.
- Block size and channel plans should facilitate current and potential uses.

³⁴ Chap. 3 Section 7 ECA

³⁵ Chap. 3 Section 8 ECA

- Broad continuous frequency bands with similar use rights and technical conditions can enable greater flexibility for future use and spectrum sharing.

Having many differing spectrum uses, services and networks has also extra value in creating efficient competition together with an increased redundancy and robustness in society's communications.

The concept of decreasing marginal returns means that the first unit added by a resource theoretically creates greater value than any additional resources that are added. This speaks in favour of diversity also in the context of spectrum in that there is reason to investigate the uses that have relatively large amounts of spectrum at their disposal, in order to see whether all spectrum is actually needed and used efficiently. However, it must be taken into account that there are threshold effects that mean that there may have to be a certain minimum amount of spectrum in order for the use to be competitive and cost-effective. For example, a supply of 1 MHz spectrum is most likely too small to justify the construction of a mobile network with national coverage. The development of demand for a certain use does however have a continuous impact on the marginal benefit, i.e. a use seeing strong growth may, for example, need additional spectrum resources at an early stage.

PTS should facilitate experiments with *new* spectrum uses. For example, several different new spectrum uses with similar conditions may be tested for a given time in smaller subsidiary bands. The most successful use can then extend into expansion bands which have already been prepared. Such experimental use can, for example, be secondary use or exist in frequency bands with very low demand.

6 Principle 4: All spectrum uses will, over the long term, exist in the most suitable frequency bands

To maximize the long-term societal benefit of spectrum use, PTS will enable that all spectrum uses are placed in or migrated to the physically and socio-economically most suitable frequency bands over the long term. This will be determined with regard to spectrum planning as a whole, and with a very long time perspective. Long-term thinking and good planning are prerequisites for enabling measures that would otherwise be impossible or inefficient over the short term.

In the long term (changes may need to be prepared over decades, 10-30 years), all spectrum use must be placed in or moved to those frequency bands that are physically and socio-economically most suitable for long-term societal benefit of spectrum to be maximised. Over the shorter term, (< 10 years), many changes are not possible or are not cost-effective, however, over the long term all equipment must be replaced and all harmonisation decisions reviewed. The objective is that the aggregate of spectrum use will create the greatest societal benefit possible.

PTS will base comprehensive spectrum planning on technical suitability and a socio-economic cost-benefit analysis which includes the assessment of demand over time. Technical suitability can, for example, mean that certain uses must use certain frequencies due to the laws of physics (for example, the absorption lines of specific elements and molecules in radio astronomy). Communication without the need for long range should normally be placed in higher-frequency bands; using low-frequency bands for this is unsuitable given that uses requiring long range need space in the low-frequency bands. Socio-economic cost-benefit analysis deals with calculating the benefits and costs of a specific measure for all individuals in Sweden, see Chapter 8. It may, for example, be a question of the benefits and costs of a specific spectrum use compared to alternative uses, including technical efficiency, for example, bits per Hz or energy costs. Normally, one strives to maximise benefits compared to costs.

PTS will also take into account situations where there is access to a cable-based infrastructure (for example, fibre). Cable-based communication may then be used instead of occupying spectrum resources which could then be made available for another use requiring a wireless infrastructure.

Predictability and long-term thinking are extremely important. Changes in the use of a frequency band, “re-farming”, may require that work be started ten years or more before the licence period expires. New international harmonisation or re-harmonisation entails very long lead times. To reduce costs during re-farming, finding an optimal point in time for the migration of an existing use to another frequency band is desirable. This is optimal when the equipment would need to be replaced in any case or when the licence would expire.

Proper forward planning and clear information to licence holders can substantially reduce migration costs and increase regulatory certainty. In certain cases, secondary trading can facilitate the migration of existing uses through the existing user being thus able to finance new investments in equipment so as to be able to use other frequency ranges. In cases where the demand for a certain use ceases or where the frequency band is not used at all, the conditions are of course even better for facilitating re-farming.

There are frequency bands that are harmonised and used in other countries, but which lack service coverage in Sweden, for example, certain satellite services. In such cases PTS will facilitate other use in Sweden, for example, by working internationally to bring about alternative co-allocation or harmonisation, or by preparing the assignment of licences in Sweden. This is to prevent the frequency in question not being usable in Sweden.

7 Principle 5: PTS will promote broad international harmonisation with as few restrictive conditions as possible

PTS will promote broad international harmonisation with as few restrictive conditions as possible to maximise the opportunities for efficient spectrum use and to minimise negative restrictions. Harmonisation and standardisation enable economies of scale in manufacturing bringing lower costs for radio equipment and make transnational services possible. A minimum of restrictive conditions (only those required to facilitate efficient spectrum use) enables uses with maximum societal benefits. Broad harmonisation will include as many countries as possible.

International harmonisation of spectrum is a very important tool for the socioeconomic efficient use of spectrum, as it facilitates the necessary economies of scale in manufacturing thereby providing cheaper radio equipment as well as transnational radio services.

Future needs for new spectrum uses will be solved with broad harmonisations and a minimum of restrictive conditions. It is not possible to dedicate frequencies for every new technical standard, as there will not be enough spectrum available for this. It is also difficult to predict with certainty how technology and demand will develop. Harmonisation also takes a long time, and has difficulty to adapt to the technology or market developments in time.

Harmonisation is necessary in order to create the greatest possible benefit because of transaction costs³⁶. Goods and services are bought and sold on markets, but in each transaction there arise costs³⁷ in the form, for example, of work on finding the right quantity of the right products with the right quality, price negotiations, legal questions around contracts and similar things. High transaction costs also lead to the need for coordinated behaviour in the form of large gains, if many market entities coordinate their actions and do roughly the same thing, for example, by standardising products and product interfaces. As regards radio spectrum, international harmonisation and standardisation take place in order to create larger markets for equipment and for economies of scale in manufacturing.

³⁶ Coase, Ronald (1937). "The Nature of the Firm". *Economica* (Blackwell Publishing) 4 (16): 386–405.

³⁷ These transaction costs are the reason that not all transactions take place on the open market; instead, many long-term economic relations in the form of organisations, companies, permanent employment, long-term contracts, etc. are created, which are used to reduce insecurity for individual entities and because the process of searching for suppliers and negotiating prices becomes too costly if it is used too often for exchanges that are too small.

PTS activities can contribute to reducing transaction costs through coordinated actions with other countries in international organisations such as the EU, CEPT, ETSI and the ITU. In certain cases detailed harmonisation is needed, for example in security-critical and global services such as satellite navigation systems or certain aeronautical or maritime radio communications. The transaction costs for operating international aviation activities, for example, would be extremely high if different rules applied and different equipment was required in all the countries a flight passed through. In other cases, great success has been achieved with very general harmonisation, such as the licence-exempt radio use in the 2.4 GHz band where transmit power restrictions were globally agreed.

PTS will promote broad international harmonisation with as few restrictive conditions as possible:

- Only those restrictive conditions that are necessary for the intended spectrum uses will be imposed. The restrictions should take societal benefit into consideration so that they do not raise costs unnecessarily. A diversity of spectrum uses is facilitated by as few restrictive conditions as possible.
- Harmonise for shared spectrum use through alternative harmonisations and through facilitating several uses with similar needs or characteristics in the same harmonised frequency band. All harmonised uses do not necessarily need to be able to co-exist with each other in the same geographical place at the same time; co-primary allocations in the Radio Regulations can enable national choices between different alternatives.
- Harmonised use will normally be possible in Sweden (if there are no compelling reasons against it) however licence conditions may be more permissive as long as any need for bilateral coordination can be provided for. The goal of harmonisation is not to create mass markets by prohibiting all other uses besides those that are harmonised, but to enable as many of them as possible. Mass markets are created through the most competitive spectrum use “winning” in competition with others.
- Broad harmonisation with as few restrictive conditions as possible as regards the countries covered. The greatest joint market possible is most often desirable, not only in Europe but preferably in several

regions, and ideally global harmonisation. Individual countries should also have the flexibility to adapt and select a specific domestic spectrum use in accordance with specific national needs and circumstances. Sometimes it may also be in Sweden's interest to choose a national use that is harmonised within ITU Region 2³⁸ or 3³⁹ instead of Region 1 (CEPT) if this leads to greater societal benefit in Sweden.

PTS will promote that binding harmonisation decisions (EC Directives, for example) include a "sunset clause"; a date that requires active renewal in order to continue to apply, and which otherwise would be automatically revoked. This should drastically facilitate the process of revoking harmonisation decisions that are preventing efficient spectrum use. PTS will also work for other ways to make the processes in international harmonisation work more efficiently, especially within the ITU and CEPT. Sometimes PTS must question why and how international harmonisation processes work, since otherwise they may become ends in themselves. PTS plans the international harmonisation work to spend resources in those international forums where PTS's impact is greatest.

In its international work, PTS will work in accordance with the other principles indicated by this strategy, for example, that all spectrum be shared.

³⁸America and Greenland

³⁹Asia and Oceania, excluding Russia and parts of the Middle East

8 Principle 6: Societal cost-benefit analysis will form the basis for PTS spectrum management

To determine which measure is socio-economically the most effective and which contributes to the greatest long-term societal benefit possible, societal cost-benefit analysis will form the basis for the choices that PTS makes in spectrum management. This applies to comprehensive spectrum planning, international harmonisation, the choice of usage rights, types of assignments and licence conditions.

Radio spectrum is a limited common resource of significant value for the public and the market. It is in the interests of the public that the radio spectrum is managed as efficiently as possible from a socio-economic perspective.⁴⁰ In radio spectrum management, PTS must continuously make choices and prioritise how the spectrum resources should best be used, even when the alternatives have many uncertain effects and no clear price tags. All spectrum use has an opportunity cost, as alternative spectrum uses that also have a value are unrealised. To determine which action is socio-economically the most efficient and contributes to the greatest long-term societal benefit possible in Sweden, PTS needs a basis for making decisions. The choices are seldom easy; however a structured cost-benefit analysis produces a better supported decision, thereby increasing the likelihood that the common but limited spectrum resource is used efficiently for the benefit of the whole of society.

Socioeconomic cost-benefit analysis and assessment of how future demand and needs develop should serve as guidance in general spectrum planning given that PTS makes decisions on what types of spectrum uses should be facilitated or restricted in any specific frequency band, through for example ITU allocations, harmonisation decisions, the choice of usage rights and licence conditions. The resources PTS commits to analyses must be proportionate to the benefit of the analyses; see Chapter 10.

The cost-benefit analysis, which primarily builds on socio-economic welfare theory,⁴¹ aims at answering the question of what is a socio-economically efficient use of society's resources. Cost-benefit analyses cover methods for systematically comparing the possible effects of various potential actions with

⁴⁰ 2009/140/EG, point 24.

⁴¹ Welfare economics is an established branch of economics that deals with the efficient use of society's resources for the purpose of maximising the aggregate welfare in society. For a summary, see for example Pindyck, Robert S. & Rubinfeld, Daniel L., *Microeconomics*

each other in advance, and with alternatives where these measures are not carried out. A cost-benefit analysis covers all citizens and organisations in a society and shows what effects an action has for society as a whole.

There are many different methods for evaluating efficiency, for example, business efficiency, household economic efficiency, and technical efficiency. It should be noted however that the different forms are included in an evaluation of socio-economic efficiency. In addition, the evaluation of social, environmental and other external consequences is included.

PTS's overall objective is to prioritise those actions that maximise long-term consumer benefit. A societal cost-benefit analysis values benefits and costs for everyone in society; consumers/citizens, producers/business corporations, government agencies etc. In the short term consumer benefits are prioritised but over the long term and where efficient competition exists, producer surpluses also tend to benefit consumers through lower prices and better products, for example. In practice, the societal cost-benefit analyses are a way to ensure that consumer interests influence spectrum management more.

A quantitative cost-benefit analysis is a form of cost-benefit analysis that quantifies the positive and negative effects of an action in terms of money. Although certain effects are difficult to assess, they may be estimated in a quantitative analysis. Normally, the goal is to maximise benefit compared to the costs⁴² and choose the alternative that yields the greatest surplus. The effects can sometimes be difficult to evaluate and quantitative cost-benefit analyses should therefore be primarily used to show orders of magnitudes or probable outcomes. In many cases, they should be used together with supplementary (qualitative) decision support. Even if a quantitative cost-benefit analysis does not provide the absolute truth, or cannot be used to compare alternatives that involve only marginal differences, the method is still preferable to not having any kind of decision support at all. The main value of quantitative cost-benefit analysis is that different effects are systematically identified and evaluated. A structured methodology increases transparency and reduces the risk of inefficient demands from special interests (lobbying) having an impact on PTS decisions.

⁴² Net benefit – that is, gross benefit minus the costs.

9 The choice between societal cost-benefit analysis and needs assessment versus demand and market mechanisms in assignment

The EU framework Directive states that “with a market focused on competition, users gain access to broad content and a large selection of applications and services.”⁴³ The demand from end users and other entities can affect the supply of goods and services. The degree of competition varies between different markets. PTS will work to promote competition⁴⁴. When assuming a particular type of competition in the market and a particular interchangeability between production factors, it can be expected that well-informed, rational market stakeholders buy and sell the input goods (for example, spectrum) needed to satisfy the demand from their customers. In these cases, it is reasonable that the demand (that is, preferences and willingness to pay) and market mechanisms be allowed govern the assignment of the spectrum, but with different degrees of governance (through, for example, designing competitive selection procedures, licence conditions, etc.) in order to handle aspects of competition and transaction costs, see Chapter 9.2.

There are, however, conditions that make normal assignment processes through market mechanisms unsuitable or insufficient. The clearest example of such cases is spectrum assignment for public goods with high societal benefits, transnational services or in order to reach specific political goals.

- Public goods⁴⁵. Public goods are defined as goods or service that are characterised by two fundamental properties: that one person’s consumption of the good does not impact the quantity or quality of the same good when another person wants to consume it (*non-rivalrous*) and that it is impossible to exclude someone from the consumption of a good (*non-excludable*, the “free rider” problem). A free market tends to produce too little of public goods even where they create great societal benefit, primarily because it is difficult to charge for them. Most often, such public goods are publicly funded, for example, through the State taking responsibility for goods that are important for society to be able to function in accordance with principles that are democratically

⁴³ 2002/21/EC

⁴⁴ Chap. 1, § 1 ECA.

⁴⁵ “Public goods”, see for example Varian, H.R. (1992). *Microeconomic Analysis*, 3rd ed. Norton, p. 414.

decided. Examples of such services are fire prevention, emergency services, and national defence. Since the producer of a public good, such as defence, cannot be paid for the services by customers in a market, the social value of the service risks not having an influence on the willingness to pay for, for example, spectrum (see Chapter 9.1). PTS has a special responsibility to ensure that public goods can be realised.

- Transnational services. PTS will work to reduce transaction costs, primarily through work in international harmonisation and standardisation in order to create larger markets for equipment and economies of scale in manufacturing. PTS activities can contribute to reducing transaction costs through collaboration with other countries in international organisations such as the EU, CEPT, ETSI and the ITU. In certain cases detailed harmonisation is necessary, for example, in security-critical and global services such as satellite navigation systems or some aeronautical or maritime radio communications. The transaction costs for operating international aviation activities, for example, would be extremely high if different rules applied and different equipment was required in all the countries a flight passed through. As regards important transnational services where spectrum uses that require radio signals or radio transmitters to cross national borders on a regular basis in order to work as intended (maritime radio, aeronautical radio, satellite or short-wave radio, etc.) the transaction costs would be disproportionately large without international harmonisation.
- Political goals for the area. For example, if there is a political goal that all citizens have access to specific electronic communications services, regardless of where they live.

In the above cases, societal cost-benefit analyses and needs assessments will form the basis of PTS decisions on the assignment of spectrum, see Figure 1 below. These cases are described in more detail in Chapter 9.1.

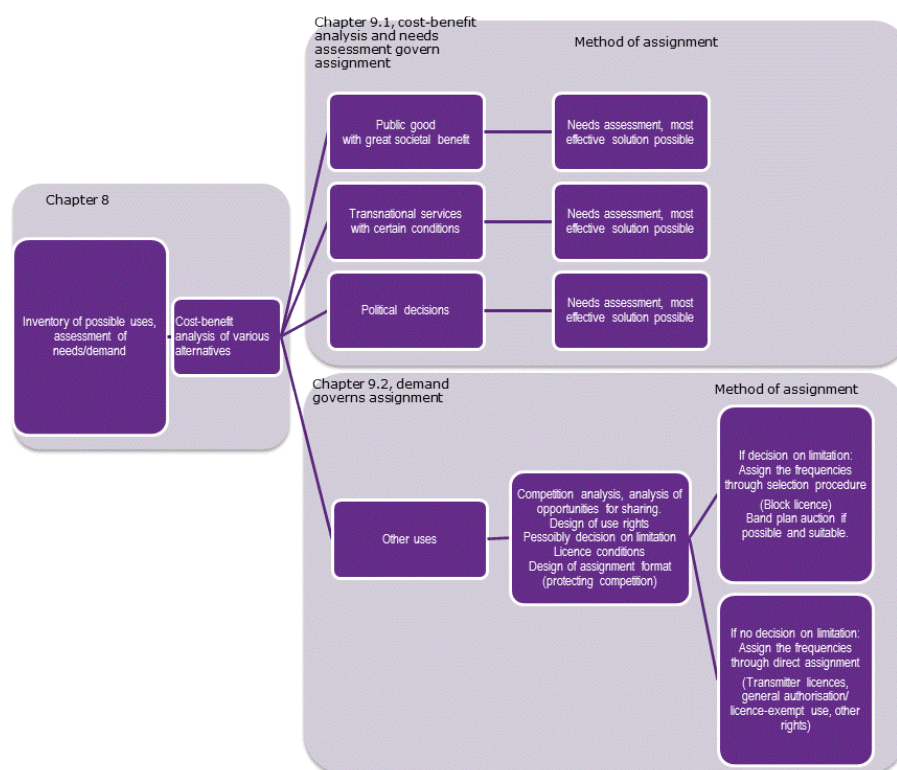


Figure 1: The choice between needs assessment and demand as guidance for spectrum assignment.

9.1 Principle 7: Societal cost-benefit analysis and needs assessment shall govern the assignment of spectrum where market mechanisms do not work satisfactory

Societal cost-benefit analysis and needs assessment will guide spectrum allocation in comprehensive spectrum planning, and in the licencing of spectrum for the public goods, in certain cases of transnational services and in order to achieve particular political goals. Public goods refers to spectrum uses needed for public order and safety (such as defence and police), the protection of human life and health (such as emergency services, particular security and emergency signalling systems) and basic scientific research.

Transnational services are spectrum uses that require radio signals or radio transmitters to cross national borders on a regular basis in order to operate as intended, such as maritime radio, aeronautical radio, satellite radio services and short-wave radio. Political goals may, for example, relate to the coverage of

publicly available electronic communication networks, or to the importance of freedom of expression and the free formation of opinion in accordance with the Fundamental Law on Freedom of Expression.

PTS has a special responsibility for ensuring that such public goods can be realised. In these cases, PTS can conduct a needs-assessed administrative assignment of spectrum according to a cost-benefit analysis demonstrating that the need is being satisfied in the most cost-effective way possible (for example, through spectrum sharing, by licence conditions in other networks, through cable based solutions or dedicated usage rights).

There are cases where normal application and assignment processes, market mechanisms, and licence-exempt use are neither suitable nor sufficient for spectrum assignment. The clearest examples when this is the case regard spectrum for public goods, some transnational services and where political objectives exist for the area.

A public good is a good or service that is characterised by two fundamental properties: *non-rivalrous* and *non-excludable*; see above. A free market tends to produce too little of public goods, primarily because it is difficult to charge for them. Since the producer of a public good cannot be paid for the services by customers in a market, there is a risk that the societal value of the service does not translate into a willingness to pay for spectrum.

The following uses of radio comprise public goods with great societal benefits and which, additionally, have a special status in the ECA:

- Radio usage needed for activities conducted for the purpose of providing for public order and safety, that is, radio usage required for defence and police operations.
- Radio usage needed for activities conducted for the purpose of providing for the protection of human life and health, that is, radio usage required for emergency service activities and certain security and emergency signalling systems.

The following uses of radio are not specifically mentioned in the ECA, but are public goods that can have great societal benefits:

- Radio usage for basic scientific research, for example radio astronomy, Earth exploration, or meteorology.

PTS has special responsibility for ensuring that public goods can be realised. In such cases, PTS can make a means-tested administrative assignment of spectrum following a cost-benefit analysis that shows that the needs are satisfied in the most cost-effective way possible. Proprietary spectrum or exclusive licences will be used as a last resort if the use cannot be realised more efficiently through other alternatives such as licence conditions in commercial networks or licences, public procurement, shared spectrum with other uses, visible spectrum⁴⁶, cable-based solutions, local storage of data, etc.

It should be emphasized that needs assessment includes questioning needs, realising the benefit of the use as efficiently as possible, and defining and expressing needs explicitly, for example bits/s, maximum tolerated delay, etc. A needs assessment should also define when or where a need exists. There is a great difference in the need for public goods such as defence and emergency services in peacetime or during a war or crisis. In specific situations such as war or the threat of war, there are particular regulations⁴⁷. If the need is limited in time, there are great benefits to sharing the spectrum with other uses in order to maintain a high degree of utilisation over time.

Historically, spectrum management in Sweden has followed the international mainstream and assessed which services should be regarded as socially critical without a consistent and communicated method and in some cases with an inadequate needs assessment. This was not needed to as significant a degree when there was plenty of unused spectrum available to assign. The strategy entails a more systematic approach together with quality assurance throughout the assessments, leading to an increased probability of efficient spectrum use.

Transnational services are spectrum uses that require radio signals or radio transmitters to cross national borders on a regular basis in order to work as intended and thereby with a greater need of international harmonisation and coordination, such as maritime radio, aeronautical radio, satellite or short-wave radio. Transnational services are not necessarily public goods, but often have a major focus on protecting human life and health (for example, aeronautical radio, maritime radio, navigational services). These are also services where usage in Sweden is restricted by international agreements, and where PTS needs to conduct spectrum planning primarily through international harmonisation. In cases that do not concern public goods, and where market mechanisms can be applied, this will be the primary approach. When market mechanisms do not function satisfactory, PTS will apply a cost-benefit analysis and needs assessment during spectrum planning.

⁴⁶ Optical communication through infrared, visible, ultraviolet light, and so on.

⁴⁷ See for example Chap. 1, §§ 8-9 ECA.

As regards other political goals or decisions that PTS is tasked with, the method used is the same. The aim will be achieved in as cost-effective a way as possible. The tools of PTS are thus efficient competition, promotional activities, coverage requirements and in certain cases procurement.

Free-to-air television and sound broadcasting are public goods, in contrast to paid services. But the licencing of radio use related chiefly to broadcasting programmes to the public via radio or other methods indicated in Chap. 1, §1, third paragraph of the Fundamental Law on Freedom of Expression (SFS 1991:1469) is primarily governed by other legislation. The spectrum used for such broadcasts is decided upon by the Government. The issuance of licences in the spectrum takes place via both the Swedish Broadcasting Authority (broadcast licence) and PTS (frequency licence), which means PTS does not have the final authority over how these frequencies will be allocated and assigned.

There is good reason that the spectrum uses indicated above, which are given access to the spectrum via needs assessment, cost-benefit analysis and administrative decisions have more restrictive conditions than other uses. A requirement to use assigned frequencies for the purposes indicated is reasonable, as the rights to use the spectrum were granted to satisfy a defined societal need. It is unfair competition if an entity that has been granted spectrum through an administrative decision for a specific purpose is allowed to use the spectrum freely in order to compete in other markets. The main principle is that spectrum fees should be based on the frequency range that other spectrum uses are prevented from using.

9.2 Principle 8: Demand will govern spectrum assignment for other uses

For other spectrum uses, demand will as far as possible govern spectrum assignment. In these cases, PTS intends to apply the following principles. If spectrum is sufficient for all who wish to use it, PTS will assign usage rights (for example, via transmitter licences or licence-exempt use). Where there is reason to limit the number of licences, demand and the willingness to pay in a selection procedure will govern who gets licences and for what spectrum can be used. When analysis shows that there is a risk of harm to competition when assigning or using spectrum, competition-promoting measures should be included in decisions about assignment formats and licence conditions.

In cases where spectrum use does not relate to public goods with great societal benefit, to particular cases of transnational services and spectrum use to attain political goals, or to other spectrum use governed by other legislation, demand

will govern spectrum assignment to the greatest extent possible, through pricing and market mechanisms. As described in Chapter 8, cost-benefit analysis is a tool for determining which spectrum uses will be facilitated when PTS makes decisions on fundamental band planning (for example frequency block sizes, channel plans, duplex arrangements) and licence conditions prior to assignment of spectrum. Market mechanisms entail that spectrum is priced based on supply and demand (preferences and willingness to pay) via, for example, spectrum auctions or comparative selection procedures and secondary trading. This provides incentive to reduce the inefficient use of spectrum resources, since possession of spectrum comes at a cost and the willingness to pay is the chief means of assigning the spectrum.

Transaction costs for changing spectrum use is reduced through PTS promoting secondary trading and leasing of spectrum while competition is promoted through lower barriers to entry. More competing and supplementary radio network infrastructures result in increased redundancy and in incentive for technological development, better coverage, affordability, etc., which means that PTS will also promote competition between the various radio networks. In the case of cellular networks it is positive for consumers that there are several networks and operators to choose among.

If there is uncertainty about which of multiple possible and mutually exclusive (i.e. they cannot co-exist) spectrum uses that are most socio-economically efficient, “*band plan auctions*”⁴⁸ can be used for assignment to the spectrum use that entails the highest willingness to pay. The consequences of this are that spectrum uses that create less societal benefit than those with the highest willingness to pay use a smaller frequency range or are forced to migrate to less valuable frequency ranges.

Least restrictive conditions for use give the licence holder or user of a licence-exempt frequency band great freedom, and facilitate the spectrum being used for what provides the greatest benefit.

For more large-scale geographically extensive commercial use (cellular networks, for example), block licences and market mechanisms such as auction assignments may well be used. Willingness to pay must not be expressed solely as money, but can in certain cases consist wholly or in part of commitments the applicant makes in a comparative or combined selection procedure, for example, a commitment on coverage and network roll-out. This favours societal benefit, and it appears “fair” that willingness to pay governs. The

⁴⁸ That is, the frequency band is auctioned off with several mutually exclusive alternative band plans, block divisions, and licence conditions, and is then assigned with the type of licence that received the highest total bid.

purpose of the selection procedure is to make spectrum available so that individuals, companies and government agencies have access to secure, efficient, and affordable electronic communications services and other radio-based services.

In selection procedures, PTS strives for a high degree of transparency and competition neutrality, applying “objective, transparent, non-discriminatory and proportionate criteria”⁴⁹ and counteracting unfair collusion. Furthermore, PTS prioritizes preserving or improving competition and coverage. In addition, the assignment(s) will ensure that the common resource of spectrum realizes a corresponding value for the public (for example in the form of coverage of socially beneficial services or auction revenue that goes into State coffers) in order to counteract a disproportionate transfer of wealth from public to private interests.

In each selection procedure, PTS can make adjustments so as to preserve or improve competition and coverage. From this perspective, it is an advantage if the licensing periods for block licences in the frequency bands that are of immediate interest for assignment expire at yearly intervals, as both PTS and market entities can then adapt their actions according to what has happened during previous assignments.⁵⁰ High auction proceeds are an effect of major competition for valuable spectrum, and possibly of spectrum shortage for a given use. PTS also counteracts spectrum shortage in accordance with what is described in Chapter 3. The primary reason for restrictions, such as spectrum caps in an auction (a limitation rule for how much spectrum or how many block licences a given applicant may be assigned in a selection procedure) is to promote competition in the various markets within the field of electronic communications, as well as other markets using radiocommunication. The EU Framework Directive states that “with a market focused on competition, users gain access to broad content and a large selection of applications and services.”⁵¹ At the same time, suppliers have thereby strong incentives to develop better or more affordable services. Without competition, however, there are only weak incentives for the development of better, more efficient, and more affordable offerings. Even though there may be few suppliers on the market, competition can be strengthened if entry barriers to the market are low since the existing suppliers must then pay attention to competition from potential entrants and substitutes⁵². Efficient competition that leads to benefits for society also benefits consumers; it does not only increase profitability for suppliers.

⁴⁹ Authorisation Directive, Article 7, 2002/20/EC.

⁵⁰ Licences in the same band, however, should preferably expire at the same time.

⁵¹ 2002/21/EG

⁵² Porter, M. (1980). *Competitive Strategy*. Free Press.

In order to protect vulnerable competition, or improve inefficient competition in the markets for radio-based electronic communications services and other services based on radio communication, tools such as spectrum caps, (for example, differentiated spectrum caps based on how much spectrum an actor already possess, exclusion of dominant market stakeholders, reserved licences for new entrants) may be of interest in the assignment of licences. Low entry barriers in the market are in the interests of society and consumers by favouring innovation, quality, and affordable services, even in the absence of efficient competition. It is also important to prevent market entities hoarding spectrum they do not intend to use efficiently themselves for the purpose of preventing competitors from using it thereby weakening competitive pressure (spectrum hoarding). Opportunities may also arise for “ex post-opportunism”, for “racketeering”, on an open market if individual entities are allowed to act to prevent the activities of other stakeholders for the purpose of being paid⁵³. In such cases it appears more practical and with lower transaction costs to let licences expire and for PTS to re-assign new licences, perhaps with amended conditions. It is in the interests of society and consumers that usage rights to spectrum are actually used to deliver beneficial services, and not to prevent beneficial services from being produced. Open platforms and standardised interfaces promote competition, as a diversity of entities can compete at different levels in the value chain.

For more small-scale use, where each user has only individual or a small number of transmitters, transmitter licences or licence-exempt use is more suitable. In these cases, the basic principle is that everyone who needs spectrum can and will have access to it in accordance with the positive intent of the law, rather than having pricing mechanisms and the willingness to pay governing use. Licence-exempt use also implies very low barriers to entry. Even if selection procedures are not relevant owing to the fact that all those who demand spectrum access receive it, PTS can, as needed, create incentives for the efficient use of frequencies with the help of pricing mechanisms, for example, annual fees for licences.

⁵³ “Spectrum trolls” – compare with “patent trolls”, who create or procure patents not to deliver new products to customers, but with the main purpose and business idea of suing others for patent infringements and getting royalties; see also Weiser and Hatfield (2008). Spectrum Policy Reform and the Next Frontier of Property Rights. *George Mason Law Review* Vol. 15:3.

10 PTS implementation of the spectrum strategy

As mentioned above, PTS makes decisions regarding spectrum management in accordance with the applicable laws and other regulations for the purpose of fulfilling the objectives for this area. This strategy will make the principles according to which PTS primarily intends to work in the application of the current system of rules transparent for those cases where PTS can assess how the objectives can best be attained. The principles in the strategy aim at maximising the long-term societal benefit of radio spectrum.

It is important to regard the spectrum strategy and its main principles as a unified whole, as the various main principles are intended to reinforce and balance each other. Thus, individual principles will not be implemented without consideration of the other principles in the strategy.

Even though the principles of the spectrum strategy are in line with previous PTS approaches to spectrum management, they involve a partially new working method for PTS. The Authority works now in a more structured way with the inventory of spectrum usage and the demands for spectrum. It applies socio-economic analysis in a cyclical process. PTS will also review the conditions for use of the radio spectrum and which planning criteria the Authority uses, for the purpose of using the spectrum more efficiently and increasing spectrum sharing.

PTS intends to review the use of the radio spectrum and the long-term conditions for use in a structured fashion, based on the principles in this spectrum strategy. In implementing this strategy, PTS will work on changing and streamlining how the radio spectrum is used, based on a process described in the figure below.

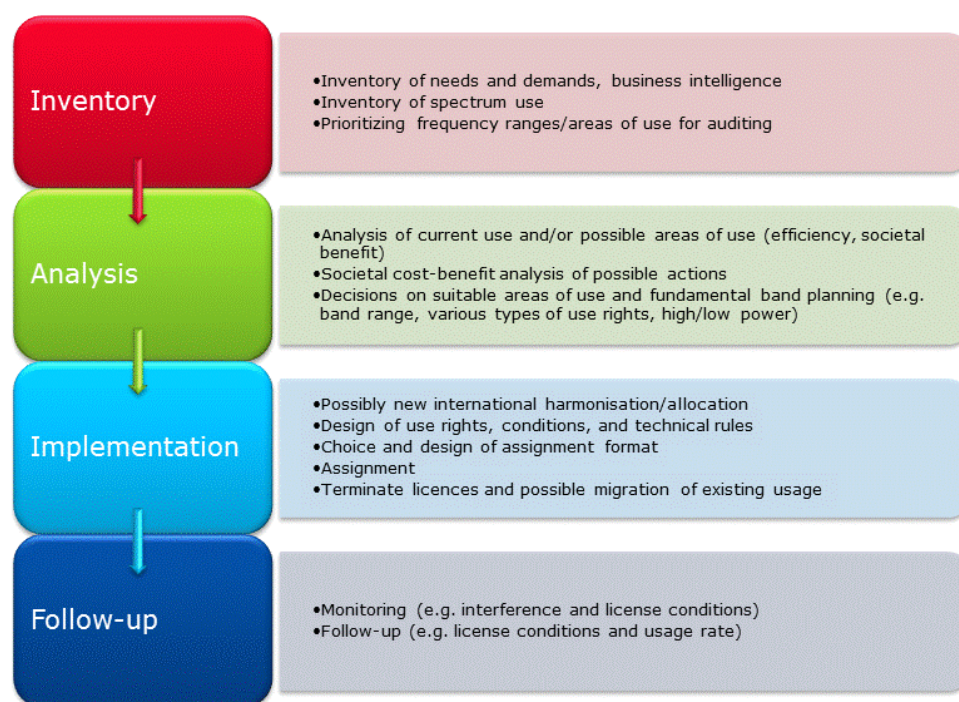


Figure 2: The spectrum management process.

PTS will prioritise the areas being reviewed based on needs and demand. This entails that the Authority communicates proposals for changes in frequency use and the conditions for use gradually over the coming years. Over time PTS intends to prioritise an overhaul of the frequency ranges that have high demand, and the uses where either demand is increasing or where there is reason to investigate whether the efficiency of spectrum use can be increased, for example, to find room for more use through sharing. Planned changes in frequency use will be primarily communicated through the PTS spectrum orientation plan.⁵⁴

As regards the proposed changes, PTS intends, where possible, to work with proper advance planning and to pay attention to investment cycles, equipment service life and licence periods with the purpose of minimising unnecessary transaction costs during changes and providing market entities with sufficient time for adjustments. Changes will be carried out in concert with licences being issued or renewed.

In the work on societal cost-benefit analyses and analysis of demand, PTS will need support and information in some cases from the entities concerned. A

⁵⁴ PTS Spectrum Orientation Plan.

clear methodology will provide transparency in connection with PTS decisions as well as opportunities for entities to contribute information and their own analyses. At the same time, it is important to emphasize that even though cost-benefit analysis will form the basis for the work of PTS, it is not the only foundation for PTS proposals and decisions. The quality of the analysis as decision support is influenced by which assumptions are made and what information has been made available. Forward-looking analyses are complex, and there are often great uncertainties. PTS also needs to adjust its ambition level based on priorities, primarily using the quantitative cost-benefit analysis tool as it deals with relatively large values that justify a more thorough analysis.

It is important to emphasize that implementing the strategy in many cases is dependent upon international support to achieve great success. Nevertheless, it is important that Sweden has a clear orientation on the issues that are brought up through the international work which this strategy contributes to.