Spectrum sharing: something old, something new

Phillipa Marks, Tony Lavender, Paul Hansell, Tim Miller

This paper discusses a new approach to spectrum sharing being developed in Europe and the USA. To date sharing of bands has been undertaken on a hierarchical basis with the incumbent use having priority over new uses. This does not provide some potential new users, and in particular wireless broadband operators, with the quality of service and certainty of availability they require. A new approach is required to sharing that treats the incumbent and the newcomer in a symmetrical way – so they both have quality of service guarantee and legal certainty over access rights.

Sharing should allow spectrum to be used more efficiently. The challenge implementing this approach is creating regulatory arrangements that offer incumbents incentives to share whilst providing suitable access rights to newcomers.

Spectrum sharing between different applications is nothing new. The ITU Radio Regulations make provision for sharing through the designation of services as primary, co-primary and/or secondary each of which indicates different levels of protection from interference. In addition a "first in time" rule is applied to determine the priority between users with the same designation i.e.co-primary services or co-secondary services. Regulators have applied this framework to facilitate sharing between different applications in many frequency bands (for example between fixed link and fixed satellite services). These arrangements are generally relatively rigid with a defined hierarchy of rights and obligations. More flexible sharing is possible in countries where rights are tradable and the incumbent can choose whether to share with new users and possibly new services.

Why is a new sharing framework needed?

The pressure for change is coming from rapidly growing demand for spectrum from wireless broadband services. These services require:

- An assured quality of service given through specified protection from interference;
- Spectrum access rights of relatively long duration to justify network investment; and
- Access to bands that are internationally harmonised to keep equipment costs down[1].

[1] It may not possible to move incumbent services from these bands (for economic, social or political reasons), and so sharing may be the only feasible way forward.

A new sharing approach that meets these requirements is called Licensed Shared Access (LSA)[2] in Europe and Priority Access (PA) in the USA[3]. These approaches are more flexible than the current sharing framework. The nature and extent of sharing permitted does not depend on pre-set rules but rather is based on enhancing the effectiveness of spectrum use – depending on the balance of economic and social costs and associated benefits.

Current approach	LSA approach
Hierarchy of access based on whether primary or secondary in National Frequency Allocation Table	Effective use of the band – economic and social value enhanced
First in time rule gives priority to incumbent users	Compensation may be paid to incumbents[4].

In the table below we use LSA to illustrate the key features of a new approach to sharing:

Features of LSA
Incumbent Rights – the incumbent's access to spectrum is licensed or otherwise formalised (including interference protection) as part of the sharing process. The arrangements would be entered into on a voluntary basis. By entering into the sharing arrangement the incumbent agrees that it will adhere to the terms and conditions of its new licence and access rights.

[2] ECC Report 205, Licensed Shared Access, February 2014. http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP205.PDF

[3] Priority access is similar to LSA although at present the US framework envisages opportunistic licence exempt access and control of spectrum access by new users will be dynamic and governed by a spectrum database.

[4] For example, to offset any costs imposed by sharing.

Features of LSA
New user rights – the new user is granted an exclusive licence that is likely to be long term. With this will come the condition that the new user will adhere to the licence conditions and any other processes that go with the sharing arrangement.
Role of the regulator – to facilitate engagement between incumbent and new user, issue new licenses and provide or control a spectrum database if one is required.
Compensation arrangements – the incumbent may receive compensation for costs incurred implementing sharing[5]. The new user is likely to pay a licence fee, or payment may be determined by auction.

LSA is expected to be applied in bands where incumbent users are often not commercial entities including:

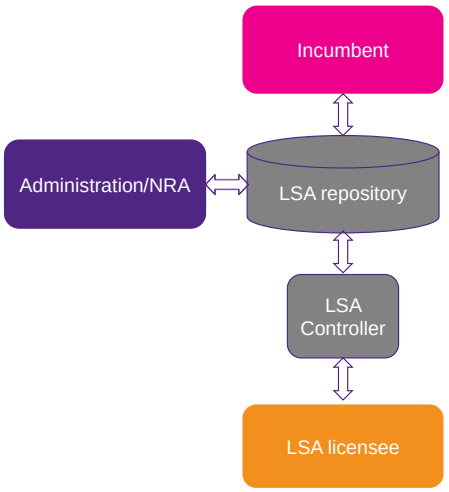
- Bands allocated to defence and other government uses. These bands may not be managed by the regulator and incumbents' spectrum access may not be governed through explicit rights.
- Bands allocated to receive only services (e.g. satellite receivers). These services are usually not explicitly authorised or licensed.
- Bands where incumbents have overlapping, non-exclusive rights (such as PMSE in Finland) or where rights are not tradable.

LSA may also be employed in bands where there is low utilisation by the incumbent services. A good example of this is 3.4-3.8 GHz in Europe where incumbent use includes fixed satellite, fixed links and broadband wireless access.

In its simplest form the sharing envisaged under LSA is static and on a long term basis – for example geographic sharing. More complex forms envisage dynamic frequency and geographic sharing through access to a spectrum use database – the LSA repository. The repository may be managed by the incumbent, the regulator or be delegated to an independent trusted third party.

[5] These costs could include costs associated with administration, changing equipment, modifying spectrum software and databases. These may be paid directly by new users or come from government revenues.

Functional implementation of LSA



To be in a position to share, the incumbent first needs to know the extent of its current use and likely expected future use of the band. While this may not seem an onerous requirement, it is only in recent years that many countries have undertaken audits of government spectrum use and government users have started to develop strategies for their future spectrum use[6]. Even if incumbents know their current and likely future spectrum requirements, sharing could be perceived as reducing options for future development.

Making LSA a reality in Europe

The initial application of LSA in Europe is likely to be in the 2.3 GHz band (and possibly also the 3.5 GHz band)[7]. The 2.3 GHz band is harmonised for mobile use but has existing defence, aeronautical, satellite and in some cases PMSE use. However there seem likely to be significant amounts of spectrum in the band that are unused often in urban areas.

In principle the simplest use case is of static sharing. Ideally, the frequencies and locations are in large blocks to facilitate wideband communications and minimise the frequencies/areas sterilised by interference between incumbent and new user systems. This approach has been considered in France in the case of sharing with military systems in the 2.3 GHz band[8].

[6] "Optimising public sector's use of the radio spectrum", WIK, Aegis, Plum IDATE for the European Commission, April 2010. http://www.plumconsulting.co.uk/pdfs/Plum_Optimising_public_sector_spectrum_use_April_2010.pdf

[7] LSA may also be required in bands identified in future for 5G mobile given the large amounts of contiguous spectrum (up to 1 GHz) may be required.

[8] P30, http://www.fub.it/sites/default/files/attachments/2014/02/Faussurier.pdf

Dynamic sharing through the use of database control of spectrum access by the new user could also be envisaged – for example sharing with use of the 2.3 GHz band where the incumbent use is PMSE video links.

CEPT is developing guidance for a sharing framework between PMSE and mobile broadband services[9] for the 2.3 GHz band. This involves the definition of protection from the mobile service and exclusion zones for different PMSE deployment cases. The details have still to be developed but it is expected that the mobile network would be required to reduce the traffic or to shut down completely at the needed locations. This would need to be done automatically and so means the new user network will need to operate interfaces accepting information from the incumbents. Such an approach has been trialled in Finland for PMSE operating in the band[10].

Even when these regulatory arrangements are in place further work is required to make LSA a reality. Specifically, there are challenges in devising the right incentives for incumbents to share and developing the details of the sharing framework, in particular devising appropriate technical conditions and enforcement procedures to avoid harmful interference.

In the case of 3.4-3.8 GHz in Europe a static approach through the provision of exclusion zones could be taken to the protection of licensed or registered satellite ground earth stations and fixed link services.

Incentives on incumbents to share?

Incumbents may only be willing to share if they see some benefit from the arrangements. These benefits might include:

- Direct payments from the new user or the regulator (assuming no state aid issues in the European context).
- Payments to upgrade equipment or take other costly actions than would facilitate sharing[11].
- Savings on fees paid to the regulator for underused spectrum.
- The security of tenure and greater certainty about the interference environment that comes through formalisation of its access rights (and their enforcement) or access to services provided by the new user.

Taking the case of the 2.3 GHz band, a Plum study[12] found that sharing is required to create a critical mass of countries in Europe where the band will be used. Under these conditions LSA at 2.3 GHz could offer net economic benefits in Europe of at least €12bn. The scale of the economic benefits suggests that there would be opportunities to incentivise incumbents to share the band. Clearly the introduction of LSA should not be associated with higher fees for incumbents as this could destroy incentives to share – such fees that might be set if an auction of mobile access rights makes it clear the spectrum is worth more than current fee levels.

Developing the details of the sharing arrangements

Assuming the incumbent is willing to share and there is demand from new users, how might dialogue concerning the sharing arrangements be achieved? This is where the regulator comes in.

The regulator may be the only channel through which dialogue between the new users and the incumbents can occur. For example, commercial users often cannot act collectively on spectrum access issues because of competition concerns. Furthermore there may not be any obvious point of contact in the incumbent organisation. The regulator will be a trusted party for the sharing of confidential technical information and will need to ensure terms and conditions are consistent with legal requirements (and any international obligations) and undertake any enforcement activities.

The desirable move away from dedicated spectrum for a single use or user to shared spectrum on a more widespread basis demands robust mechanisms regarding technical compatibility to prevent harmful interference. Current institutional mechanisms are often based on a conservative interference “trigger level” that prompts more detailed coordination between two systems thereby enabling sharing to take place. Coordination more often than not is a “closed door activity” and until that activity takes place the potential new entrant has no idea as to the possibilities for sharing the spectrum except under conservative conditions.

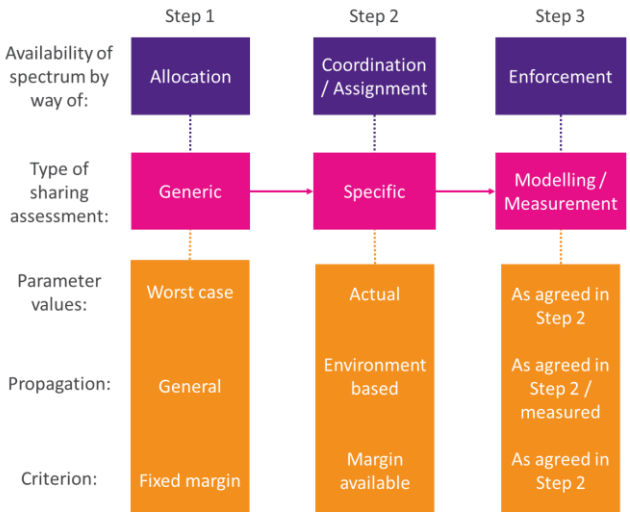
Making spectrum available to a new use (and so users) on a shared basis has generally followed a three stage process as shown in the diagram below. All three stages may apply when LSA is implemented. What makes LSA particularly challenging is the nature of the incumbent use – often a government user with no transparency over the nature of their actual use of spectrum.

[9] http://www.cept.org/ecc/groups/ecc/wg-fm/fm-52/page/results-of-the-tenth-meeting-of-pt-fm52

[10] M, Palola, M. Matinmikko, J. Prokkola, M. Mustonen,M. Heikkilä, T. Kippola, S. Yrjölä, V. Hartikainen, L.Tudose, A. Kivinen, J. Paavola, K. Heiska. (2014, Apr.). Live field trial of Licensed Shared Access (LSA) concept using LTE network in 2.3 GHz band. Presented at the 2014 IEEE International Symposium on DYSPAN, McLean, VA, US, Apr. 1-4, pp. 38-47. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6817778

[11] these payments might be made by the new user or possibly even central government in the case of a government user

[12] The economic benefits of LSA in 2.3 GHz in Europe, Plum for Ericsson, NSN and Qualcomm, December 2013 http://www.plumconsulting.co.uk/pdfs/Plum_Dec2013_Economic_benefits_of_LSA_2.3_GHz_in_Europe.pdf



It can be seen that the approach used to assess the sharing situation for each of the three stages differs. This is mainly down to the level of technical detail that applies. However there are different issues at each stage of the process as follows.

Step 1

Allocation decisions on sharing are by their nature generic. There is potential to assume worst case parameters but for sharing to work efficiently there should be consideration of more realistic scenarios. This is the sort of work that the ECC has been undertaking in a European context through its working group on spectrum engineering (WG SE).

In a European context the output would be an ECC Decision. Moving from here to sharing using LSA for example requires the parties to negotiate as they would for coordination (the next step).

Step 2

The allocation of spectrum, as discussed above, and which results in a sharing situation, will lead to scenarios where:

- The sharing systems have to coordinate use between themselves, or
- The regulator assigns spectrum and determines usage conditions.

Given the conservative nature of the assumptions often used in the previous step, more detailed technical assessment is required to establish whether sharing is feasible or not in practice. For this to happen in practice transparency of data from both the incumbent and new use or user is essential

Step 3

Although operating parameter values will have been agreed as part of the coordination and assignment stage, there is still the question of how to arbitrate in cases where interference is experienced. This would be addressed on a case by case basis but both incumbent and new user need to understand in advance the process the regulatory authority would propose to use in these circumstances.

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The way forward

Sharing provides a promising way forward to achieve more effective use of spectrum and in the near term allow use of harmonised bands for wireless broadband services in most countries. So far licensed shared access or priority access has not been fully implemented though there is a great deal of regulatory activity in both the US and Europe aimed at achieving robust sharing frameworks.

Further work is required to provide incentives on incumbents to share, where these incentives could be financial and/or in terms of providing greater legal certainty over spectrum access rights, and to define the technical details of the sharing framework. In particular more effective overall use of the spectrum could be achieved through greater concentration of resources in three areas:

- Harmonisation measures based on a clear framework of baseline technical operating conditions;
- Transparent availability of all system technical parameter values to potential new users of the spectrum; and
- More comprehensive propagation models addressing a wider range of physical situations and environments.