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Study for the European Commission

Final Report:

Optimising the Public Sector's Use of the Radio Spectrum in the European Union

– Executive Summary –

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Executive Summary

This is the *Executive Summary* of a study carried out on behalf of the European Commission: *Optimising the Public Sector's Use of the Radio Spectrum in the European Union*. The objective of the study was to develop a better understanding of the use of spectrum by the public sector and to explore ideas for improving the efficiency of spectrum allocation, assignment and use to and by public sector organisations. The study focused on three principal segments of the public sector (for which not all participants are necessarily public agencies):

- Defence
- Emergency services
- Transport (aeronautical, maritime and land)

In recent years, enormous emphasis has been placed on optimising the use of spectrum in the *private* sector; however, in most countries[1] relatively little has been done in the public sector. More efficient and effective use of radio spectrum by the public sector could produce multiple benefits, including:

- More effective delivery of services by the public sector;
- Improved economic performance of the private sector to the extent that spectrum currently used exclusively by the public sector might be either freed or else made available for sharing;
- Increased speed and administrative efficiency in responding to spectrum needs that change over time.

The public sector is a very substantial user of European spectrum (representing 40-50% of the valuable frequencies below 15 GHz); consequently, obtaining greater operational performance and economic/societal value per unit of spectrum employed could potentially improve public service delivery, in addition to having a positive impact on the overall European economy. Inasmuch as the public sector users in question play an important role in the European economy, any improvement in their socio-economic efficiency can play a significant direct role, and can generate substantial economic spill-overs. For example, the defence sector in Europe spends more than € 200 billion per year, representing some 1.78% of European GDP, and employs just under two million military personnel and half a million civilians.[2] Maritime transport (including both sea

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1 Later in the *Executive Summary*, we explain the initiatives that a few forward-looking countries in Europe and elsewhere have undertaken.

2 European Defence Agency, "European Defence Expenditure in 2006", Brussels, 19 November 2007. These figures correspond to the 26 Member States that participate in the EDA.

and inland waterways) employs 223,000 in the EU27, and represents 89 billion euro of annual turnover; air transport employs 392,000 in the EU27, and represents 111 billion euro of annual turnover.[3]

More socio-economically efficient use of spectrum by the public sector can contribute in important ways to the achievement of the Lisbon Strategy that was promulgated in 2000. The Lisbon Strategy is a development plan that seeks to make the EU the most dynamic and competitive knowledge-based economy in the world by 2010, and in doing so to generate sustainable economic growth, more and better jobs, and greater social cohesion.[4] Better use of spectrum by the public sector can contribute to the achievement of these goals not only by making the public sector more efficient, but potentially also by making unneeded spectrum available to stimulate the growth of the non-public sector.

In this *Executive Summary*, we proceed to discuss (1) the challenges to socio-economically efficient use of spectrum by the public sector, (2) the use of spectrum by the public sector today, (3) the implications of changing technology, (4) ongoing initiatives in various countries to improve the effectiveness and socio-economic efficiency of spectrum use by the public sector, (5) different approaches to improving socio-economic efficiency, and (6) our recommendations.

Challenges to socio-economically efficient use in the public sector

Spectrum allocation for the public sector faces particular challenges in terms of maintaining efficiency of use. There are two aspects of efficiency that are relevant here: 1) whether the amount of spectrum allocated to the public sector is optimal from a social perspective in the sense that it maximises the economic and social benefits from spectrum use and 2) whether the public sector user is deploying technologies that make economically efficient use of the spectrum taking due account of equipment costs and the value of the spectrum occupied.

Concretely, public sector frequency management typically differs from that of the private sector in four key respects:

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3 European Commission (DG TRAN), *Energy And Transport In Figures 2007*. These are estimates of 2005 activity based on Eurostat data (economic activity according to NACE Rev.1 classification). See also http://ec.europa.eu/research/transport/transport_modes/water_en.cfm#, which claims that more than three million people work directly in the European maritime sector and generate a turnover that is also about € 200 billion per year.

4 See "The Lisbon strategy for growth and employment: Report from the High Level Group chaired by Wim Kok", November 2004, available at: http://ec.europa.eu/growthandjobs/pdf/kok_report_en.pdf.

- Spectrum allocated and assigned to commercial and private users is usually managed by the spectrum management authority, but spectrum allocated and assigned to public sector users is often allocated to governmental bodies (e.g. Ministries) that in some cases manage their own assignments.

- Private sector users typically have licences of fixed duration, which do not have an automatic presumption of renewal; public sector users by contrast often have long term exclusive spectrum reservations, often with no end date.

- Commercial and private use is licensed while public sector use often is not.

- Commercial and private use is usually publicly documented. By contrast, there has been little public transparency concerning decisions over public sector allocations, and even the spectrum management authority in some countries has little information on actual spectrum use (partly for security reasons).

These differences have important implications. Assignees tend to view spectrum assignments as permanent and, in most cases, costless. This tends to mean that the efficiency of current use is rarely challenged. It may also create a perverse incentive for public sector organizations to seek spectrum resources beyond their needs for current use, holding spectrum for the possibilities of future use. More generally, public sector agencies may not face sufficient incentives to make the most economically efficient use of their spectrum assignments (e.g. through sharing with other compatible uses), or to give spectrum back to the spectrum management authority if they no longer need it.

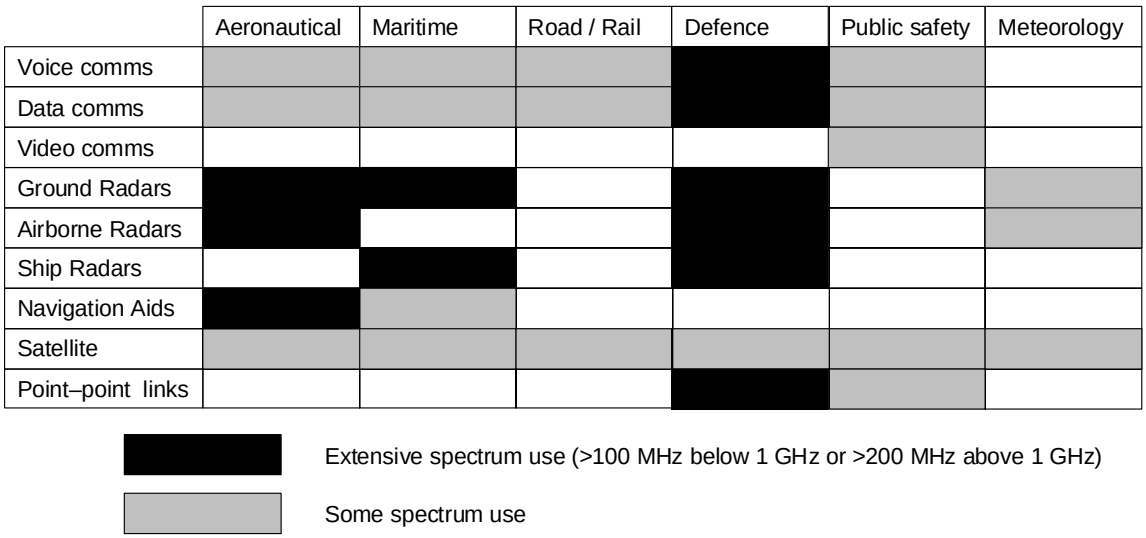
Spectrum licensed for commercial use in Europe, by contrast, is generally assigned through the use of competitive mechanisms such as auctions, and the Commission has recommended that they be increasingly subject to trading in a secondary market after initial assignment. These market-based mechanisms tend to promote economically efficient use, not only by getting radio spectrum into the hands of those who value it most, but also by motivating commercial entities to make efficient use of a resource for which they have paid substantial sums. In addition, technically efficient use is often imposed through administrative policies applied to the commercial sector (e.g. through requirements for particular channelisation, modulation and link lengths). For collective and/or licence-exempt use, technological mechanisms help to maintain efficiency, as witnessed by the rapid improvement in performance and capacity of wireless local area networks since their introduction.

A key question for this study is the degree to which the differences between private sector and public sector spectrum management are justified, and if they are not how the specific challenges posed by public sector spectrum use could best be addressed. In particular, should public sector users face stronger incentives for more economically efficient spectrum use?

Use of spectrum by the public sector today

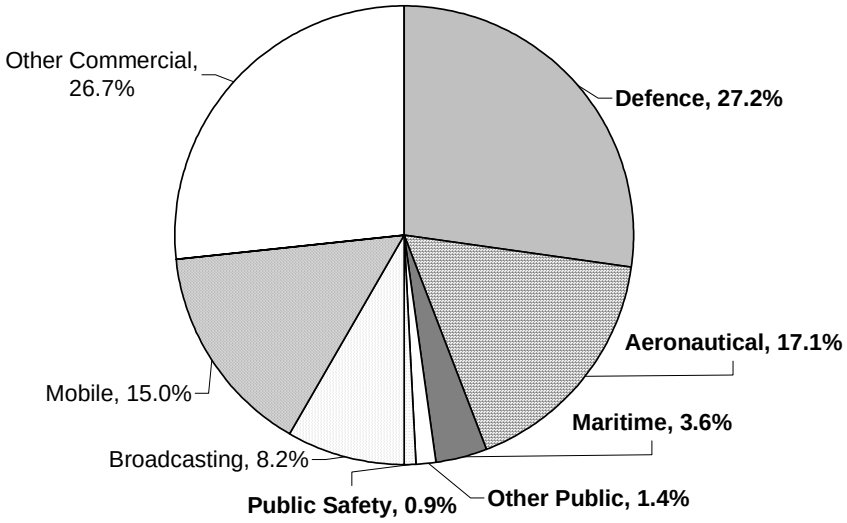
The public sector uses spectrum in many ways, from straightforward voice or data communication to specialised applications like weather radars and radio altimeters. Spectrum can be categorised either by user sector or by application, as illustrated by the matrix in Figure 1.

Figure 1: Public sector spectrum use by application and sector



About half of the allocated spectrum between 108 MHz and 6 GHz (the spectrum that is most sought after for commercial applications) has the public sector as primary user. The three largest public sector users in bandwidth terms are the defence, aeronautical and maritime transport sectors, as illustrated in Figure 2.

Figure 2: Spectrum allocations by sector (108 MHz – 6 GHz) in a typical EU country[5]



The characteristics of defence, emergency services, and transport are distinct:

- **Defence** poses many challenges to improvements in the economic efficiency of spectrum allocation and usage. Defence spectrum is partly managed at the national level but is largely coordinated internationally. NATO and the European Defence Agency (EDA) play particularly prominent roles in international coordination. International interoperability in terms of defence is vital for European Member States. NATO imposes harmonisation at international level (membership includes most but not all EU Member States as well as several non-European countries), while EDA operates at European Union level.

- **Emergency services** do not use large volumes of spectrum, but their usage is of vital importance to society. Emergency services networks can be national or regional, and address the needs of the many different users, including police, fire, ambulance, public safety, and prisons. The emergency services sector tends to be highly fragmented. Many small organisations operate at the local level, often with limited funding. This has implications for the speed with which enhancements could be introduced, inasmuch as there may at present be no

5 The figures include the main harmonised allocations plus national assignments applicable to the UK. Harmonised allocations account for over 90% of public sector spectrum allocations (in bandwidth terms). Note that to avoid double counting we have assumed that all spectrum used by the civil aviation and maritime sectors is classed under those sectors, even where this spectrum is also used by the Defence sector. Where spectrum is widely used for commercial applications but is also used by the Defence sector (e.g. the 5 GHz WLAN bands), this has been classified as commercial.

good funding vehicle for equipment upgrades. This fragmentation also potentially complicates a coordinated response when a natural disaster or terrorist incident crosses national borders.

- The **aeronautical transport** sector is by its very nature global; consequently, sectoral arrangements often play a more significant role than national arrangements. International arrangements play a huge role in consequence. Adoption of new radio technology in the aeronautical sector has primarily been driven by the need to increase capacity in response to the massive growth in commercial air traffic, and secondarily by the desire to reduce cost (e.g. by reducing the size and weight of equipment carried on board aircraft and hence reducing fuel consumption).

- Communications are essential in the **maritime transport** sector, both for routine operations and for safety purposes. They serve professional seafarers and leisure craft. The maritime sector, like the aeronautical sector, is by its nature global; again, sectoral arrangements play a significant role, although there is also substantial scope for national arrangements.

Changing technology

Radio technology has advanced enormously since the first wireless services appeared, providing both performance improvements and a massive increase in the capacity of the available spectrum. The public sector has taken advantage of many of these developments, but the pace of change has by necessity been slower than in some parts of the commercial sector. This reflects the very demanding operational parameters that apply to many public sector applications, particularly in the aeronautical and defence sectors, and the global nature of many users. For example, deployment of a new wireless system relating to flight safety can require several years of development and testing to prove its capability, and its deployment may require costly and time-consuming upgrades to the in-flight equipment on hundreds of thousands of planes. On the other hand, the benefits in terms of operational efficiency, safety and long term running costs can also be significant, and in some cases technology evolution is essential to accommodate growth in the sector; thus, ongoing evolution is often warranted and cost-effective, even if the process is sometimes slower and more costly than in the commercial sector.

Enhancements are already in progress to reduce bandwidth demand (for example for aeronautical communications), and generally to migrate to digital transmission. Beyond these changes, improvements in technology that could profitably be deployed include:

- Enhanced techniques for spectrum sharing;

- More efficient primary radars.

Sharing of radio spectrum (i.e. the use of the same frequencies by more than one entity) is one way of addressing growing spectrum demand. Sharing is already practised to some extent by public sector users, e.g. many aeronautical bands are used by both civil and military aviation. Historically, *static* sharing of spectrum between different users has relied on prior arrangements where the sharers would use the spectrum at different times, or would apply a fixed geographic or frequency separation to avoid interference. Because radio propagation conditions vary with time, and given that the required separation is typically based on near-worst case scenarios, this static sharing can result in a significant proportion of spectrum being unusable at any given location.

The nature of certain public sector agencies' operations means that the "average" or long-term spectrum requirement can be very different from the peak requirement that is likely to arise during major incidents (for public safety) or training exercises (for defence). Hence, there is likely to be benefit in a combination of dedicated and shared use spectrum, where the shared use spectrum is utilised *dynamically* rather than statically to address peaks as and when they arise. Shared use could be on a pre-emptive basis, where the spectrum is cleared for public sector use during emergency situations (sometimes referred to as callable or interruptible spectrum).

Technologies exist and are evolving further to support continuous access to spectrum on a shared, dynamic. These dynamic spectrum usage techniques could also simplify technological evolution over time, inasmuch as it might no longer be necessary (in some cases, at least) to deploy new equipment as requirements change over time. Dynamic techniques could potentially simplify the coexistence of old equipment with new, and might also be useful for band-clearing where a band has been refarmed.

Probably the most significant development in this area is *Cognitive Radio*, which combines existing techniques such as *Dynamic Frequency Selection (DFS)* with newer concepts such as *Incumbent Profile Detection (IPD)* to provide a more adaptive and intelligence-based approach to spectrum sharing. IPD refers to the ability of a radio system to identify the nature of an incumbent's signal by analysing its key technical characteristics, and adjusting its own transmissions to ensure that interference is avoided. In effect, this adds a degree of "intelligence" to the DFS function, which essentially only detects that a signal is present above a certain threshold.

Another technology that can also assist sharing and that is often combined with Cognitive Radio is *Software Defined Radio (SDR)*. With SDR, parameters such as frequency range, modulation type, or output power can be set or altered by software, with the changes either implemented locally (possibly manually), or else downloaded automatically over the air interface. For the military, SDR is seen as a way to provide greater flexibility to respond to local operating conditions and to provide greater interoperability with other systems, including civil communication networks. SDR

potentially simplifies the evolution of public spectrum-based services over time, inasmuch as equipment could be dynamically reprogrammed as needed.

Radars and navigation systems represent the greatest use of spectrum (in volume terms) by the public sector. There are many different types of radar system, from simple handheld radars used by the Police to detect speeding motorists to large complex systems designed to detect airborne targets at distances of hundreds of km. Aeronautical and maritime surveillance radars play an important role in maintaining safe operation of these sectors by providing accurate information on the location and velocity of aircraft, ships and potential hazards. To perform this function effectively, the radars must operate over a sufficient range and must provide sufficient resolution between two nearby objects so as to minimise the risk of collision.

There is scope to benefit from technological improvements that would reduce radar out-of-band emissions, and also to make further improvements to pulsed radar designs in the future. This could reduce the frequency separation required between primary radars and could enable a reduction in the total bandwidth required (up to 30% in a typical practical scenario), potentially releasing spectrum for other uses[6].

Initiatives to improve the effectiveness and socio-economic efficiency of spectrum use by the public sector

In recent years, a number of countries have conducted significant national policy reviews concerning public sector spectrum management and use: Australia (2008), the Netherlands (2005), Sweden (2007), the UK (2005), and the US (2008). Further details on these initiatives are available in the Annex to this report. In all cases, the purpose of the review was to identify ways of improving the efficiency and effectiveness of public sector spectrum use. As the reviews are very recent implementation of the review recommendations has only just started in the Netherlands and the UK.

In most cases, the reviews have examined the use of public sector bands. This provides the information base for any assessment of efficiency and helps the public sector user to identify opportunities for sharing or otherwise releasing spectrum where exclusive use is no longer required. Next, specific bands where spectrum might be released or shared are evaluated in greater detail, which often requires additional studies to be undertaken to ensure that any changes do not result in harmful interference or otherwise reduce safety or security requirements. In all cases, opportunities for spectrum release or additional sharing have been found.

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6 See "Study into Spectrally Efficient Radar Systems in the L and S Bands - Short Report for Ofcom Spectral Efficiency Scheme 2004 – 2005, by BAe Systems, July 2006.

The reviews have examined the extent to which administrative arrangements for managing public sector spectrum could be improved variously through (1) the application of more formal licensing arrangements, (2) collecting and disseminating more information on use, (3) the application of IT in licensing and co-ordination activities, and (4) better integration with the management of non-public sector spectrum. Finally, in some cases the potential for use of market-inspired[7] approaches to spectrum management such as pricing, trading and auctions has been considered.

Table 1 contains a summary of the main recommendations from the reviews. Follow-up actions are also noted.

Table 1: Summary of Recommendations and Actions from National Initiatives

Type of recommendation	Country details	Actions
Spectrum audits	Netherlands - Conduct three yearly audits of public sector spectrum use – Netherlands UK - Detailed audit of Ministry of Defence bands required Australia - Increase transparency in use of spectrum by the public sector (use regular audits) esp. Defence	Netherlands: First audit completed. Second audit to start in 2008. Some spectrum returned and sharing opportunities found UK: Audit of Ministry of Defence bands on-going. Bands for sharing/release identified. US: NTIA has just completed a comprehensive audit of usage by Federal agencies.
Forecast future spectrum requirements	UK - Public sector to produce a forecast of requirements every two years – the "Forward Look" Australia – Form a committee to advise on future government priorities Netherlands – produce forecasts as part of 3 yearly audits US - Do further work to quantify future spectrum requirements	UK - First "Forward Look" published
Improve technical efficiency	Sweden - Defence to adopt new digital equipment to facilitate sharing/spectrum release US - Investigate sharing using dynamic frequency systems	UK - Study to rationalise aero navigation aids started

7 In this report, we generally refer to these mechanisms as *market-inspired* rather than *market-based*. The use of Administrative Incentive Pricing (AIP) is market-inspired, but it is not market-based (because the price has not been set by the market); spectrum trading, however, could be said to be both market-inspired and market-based.

Type of recommendation	Country details	Actions
Release spectrum for other users – sharing or release of bands for others	UK - Seek to release spectrum in particular bands Australia – increase sharing in public sector bands. Incentivise through licence fee relief Sweden - Re-plan and increase sharing in Defence bands US – Use more dynamic spectrum technologies to share public sector spectrum allocations.	UK - Radar sharing trials commence; A Ministry of Defence consultation document published setting out plans for spectrum release[8]
Automated coordination between sectors	US - Automate spectrum co-ordination and sharing among federal users and between the NTIA and FCC by means of IT	
Licensing	UK - Formalise public sector spectrum access through a legal instrument termed Recognised Spectrum Access[9] Australia – put public sector licensing on same basis as for commercial use; develop criteria for renewal of public sector licences	Policy statement on imple-menting a tradable Recognised Spectrum Access (RSA), subject to Administered Incentive Pricing (AIP)
Procurement	Australia – early identification of spectrum requirements for major public sector projects US - Integrate spectrum value in capital budgeting for new spectrum-dependent systems	
Market approaches	UK - Adopt market mechanisms (pricing, trading and auctions) US – Interest, but no specific actions Australia – continue to apply market approaches where practicable; allow public sector users to make financial gains from improved spectrum use Netherlands – rejected use of spectrum pricing Sweden - Consider application of pricing	UK - Extension of AIP to more bands (esp. MoD) Study on applying AIP to aero/maritime bands US - Refarming of public sector spectrum using auction proceeds

8 406.1-430 MHz and 3400-3600 MHz are to be released in 2008-2009 and eight possible bands between 4.4 GHz and 15.2 GHz in 2009/10 have been identified.

9 In the UK many public sector organisations do not need to be authorised (by law) to use spectrum.

Different approaches to improving socio-economic efficiency

A key driver of our recommendations is the belief that spectrum assignments that are perceived as unbounded in time (and without cost) do not provide incentives to ensure that public sector users pay sufficient attention to using their spectrum assignments in ways that optimise socio-economic efficiency.

As we have seen, different countries (in Europe and elsewhere) have tried to address these concerns in different ways. The two approaches that hold greatest promise in our view are (1) an administrative approach, based on periodic surveys of audits of spectrum use and a requirement that public sector users periodically plan and justify their requirements for spectrum, and (2) a market-inspired approach, typically based on the simulation of market prices through *Administrative Incentive Pricing (AIP)*, ideally accompanied by policies that allow public sector entities to participate in spectrum secondary market activities. In Europe, the former approach is exemplified by the Netherlands; the latter, by the United Kingdom. Each approach has much to recommend it – the Netherlands and the UK are to be commended for their leadership and initiative.

We conclude that the administrative approach is a best practice, and its adoption should be encouraged throughout Europe. Given the significant amounts of spectrum (some of which is potentially of high value) used by the public sector, we think that evolving to this form of spectrum management for the public sector is likely to generate net benefits in all Member States. *This is perhaps the most sweeping recommendation in this report.*

We also feel that market-inspired approaches like those used in the UK approach hold great promise, and are likely to lead to greater socio-economic efficiency than administrative means alone. We see merit in expanding the cautious, selective implementation of these market-inspired mechanisms. We have stopped short of a blanket recommendation for three key reasons:

- First, experience to date is limited, so costs and benefits are still uncertain. It is not clear that the incremental gains would exceed costs in all Member States.
- Second, smaller Member States, or those with a less robustly staffed spectrum management authority, might find the complexity of market-inspired mechanisms for the public sector to be daunting, at least initially.
- Third, the effectiveness of these arrangements is heavily dependent on the specific characteristics and circumstances of the Member State, including (1) institutional arrangements, (2) budget processes, and (3) the financial flexibility available to the public sector.

Currently, we think that individual Member States should evaluate the potential costs and benefits of market-inspired mechanisms for spectrum used by the public sector based on their respective circumstances. Member States that wish to go forward with such an approach should be encouraged. While we have stopped short of recommending overall adoption of market-inspired mechanisms for public sector spectrum today, widespread adoption might nonetheless be appropriate at some future date.

The two approaches are by no means mutually exclusive. Even in Member States that make heavy use of market-inspired mechanisms, it is unlikely that they will be applied all at once, and even in the long run they are unlikely to apply to all bands. Also, while the use of market-inspired mechanisms certainly reduces the need for periodic justification, it is not clear that it entirely eliminates it. Thus, we feel that administrative requirements for periodic rejustification are appropriate and should be encouraged in all Member States.

Both approaches imply (1) a move away from the notion that spectrum assignments are made to the public sector for an unlimited duration, (2) the implementation of periodic surveys or audits, and (3) the need to plan for future spectrum use. We think that all three of these should be viewed as best practices for all Member States, quite independent of the Member States' choices as regards the use or non-use of market-inspired mechanisms.

Finally, we would like to note that there are subtle linkages among the recommendations. The migration away from assignments without time limits, for example, is a key theme. The implementation of licence-like instruments for the public sector is a natural outgrowth of this development. In the case of administrative mechanisms, the licence-like instrument ensures that both the spectrum user and the spectrum management authority are fully cognizant of the assignment; the licence-like instrument also has an expiry date which can help to ensure that the spectrum user must return to the spectrum management authority periodically to reconfirm the assignment. In the case of tradable or leaseable rights, the licence-like instrument defines the rights that can potentially be conveyed.

To re-cap: We think that all Member States should be encouraged to evolve to time-limited assignments to the public sector (where applicable); to periodically survey or audit assignments to the public sector, and to prepare forward-looking plans; and to require periodic justification in bands where it is appropriate to do so. For market-inspired mechanisms for public sector spectrum, we think that Member States that wish to implement them should be encouraged, but we think it would be premature to say that they are appropriate for all Member States.

Recommendations

The optimisation of spectrum use by the public sector has received relatively little systematic attention to date. We see many opportunities to do better, in the sense of achieving greater socio-economic efficiency and also of enhancing the effectiveness with which public services are delivered; however, we do not see a single "silver bullet". We think that a number of mutually complementary initiatives must be launched, reflecting a mix of improved public availability of information, better institutional arrangements, better management tools and planning, better technology, better incentive arrangements, and better support from related policies that are not themselves part of the spectrum management process. Schematically, this can be visualised as depicted in Table 2.

Table 2: A range of initiatives to achieve more efficient and effective outcomes in regard to the use of spectrum in the public sector

Better Information	• Periodic surveys • Improve EFIS data - more complete, more on sharing
Better Institutional Arrangements	• Impose time limits on spectrum grants • Ensure independence of spectrum management authority • Create Member State strategic plans • Create strategic plan for European harmonised spectrum • Plan for hamonised band for broadband emergency services • Assess effectiveness of sharing
Better Management Tools	• Ensure public sector spectrum users know what they are assigned • Explore tools to improve static and dynamic assignment and sharing
Better Technology	• Explore technological options to improve efficiency • Plan to deploy better primary radars
Better Incentive Arrangements	• Require periodic rejustification of assignments • Make allocations as flexible as possible • Find ways to fund refarming of bands • Member States consider, according to their circumstances, whether to implement market-inspired mechanisms (such as AIP, trading)
Better support from related policies	• Procurements should consider the opportunity cost of spectrum • If market-inspired mechanisms are chosen, re-work budget mechanisms accordingly

Table 3 lists our recommendations based on these categories.

For each Recommendation, Table 3 identifies the *actionee*, the party or parties who should consider the recommendation and implement it if appropriate. We have taken the liberty of attempting to identify an appropriate actionee even in cases where the European Commission does not have explicit authority to act. In some cases, it is clear that the appropriate actionee is a Member State spectrum management authority; in

other cases, however, we have simply indicated that the Member State should address the matter, because the choice of agency within the Member State will depend on specific arrangements in each Member State (which vary greatly among the Member States).

Table 3: Summary of Recommendations

Recommendation	**Actionee**
Better information	
R1. Conduct periodic surveys of current spectrum use and evaluate future needs of the public sector.	Member States
R2. Develop guidelines to enhance the consistency of data in the European Frequency Information System (EFIS), and to express shared use more meaningfully in EFIS.	European Commission
Better institutional arrangements	
R3. Where feasible, phase out spectrum "grants" that do not have time limits.	Member States, Spectrum Management Authorities
R4. Ensure appropriate institutional design to enable integrated planning of public and non-public sector use, and impartial and objective decisions between public versus non-public use of specific spectrum bands.	Member States
R5. Develop long term integrated strategic plans for public sector and non-public sector spectrum allocations.	Member States
R6. Develop long term strategic plans for harmonised public sector allocations at European level. Justify with a rigorous impact assessment.	European Commission, supported as appropriate by RSPG, RSC, and/or CEPT
R7. Determine where and how to implement a harmonised band or set of bands for mobile broadband use by emergency services.	European Commission, supported as appropriate by RSC and/or CEPT
R8. Assess the effectiveness of existing arrangements for sharing public sector allocations (with public and non-public sector users). Consider preemptible use.	Member States, including Spectrum Management Authorities
Better management tools	
R9. Ensure that public sector agencies know what spectrum they are using, and ensure that assignments are recorded in centralised databases. Consider developing mechanisms (if they do not already exist) for "licensing" public sector use.	Member States
R10. Undertake ongoing exploration (entailing both technical and policy aspects) and use of automated and/or dynamic tools to improve spectrum assignment and to enhance spectrum sharing for spectrum assigned to the public sector.	Commission and Member States

Recommendation	Actionee
Better technology	
R11. Ongoing exploration of technological options to improve overall efficiency.	Commission and Member States
R12. Begin coordinated planning for deployment of more spectrum efficient primary radar systems.	Commission, Member States, and other public sector entities (e.g. in the transport sector)
Better incentive arrangements	
R13. Ensure that public sector users are subject to a requirement for periodic rejustification of their allocations every few years (with the recognition that this may not be necessary for assignments where the public sector user faces the opportunity cost of spectrum e.g. through participation in an effective secondary market arrangement).	Member States
R14. Evaluate allocations to the public sector to permit as much flexibility of use as is possible.	Spectrum Management Authorities
R15. Consider funding mechanisms for accelerating re-farming of bands allocated to the public sector when appropriate.	Member States
R16. Consider, according to the Member State's circumstances, the potential additional benefits of the use of market-inspired mechanisms in selected bands (as a complement to periodic administrative justification in other bands) to enhance the prospects for socio-economically efficient use of spectrum. If market-inspired mechanisms are implemented in selected bands, ensure that the necessary prerequisites are in place, including: (1) establishing suitable means for determining prices (AIP) where appropriate; (2) putting in place arrangements that enable the public sector agencies to benefit from the economies achieved; (3) giving public agencies ability to participate in a secondary market for spectrum; and (4) providing enough flexibility in assignments to the public sector to make the market arrangements effective.	Member States
Better support from related policies	
R17. Ensure that procurements in the public sector appropriately reflect the opportunity cost associated with spectrum. In particular, ensure that trade-offs between equipment or service quality and spectrum utilisation reflect the realistic opportunity cost of spectrum in evaluating life cycle cost.	Member States
R18. If market mechanisms are applied, revise budgeting processes to enable the public sector agency to benefit from the savings that it achieves.	Member States