Optimising the Use of Spectrum by the Public Sector

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Kingdom of Thailand

Optimising Spectrum Use by the Public Sector

- Introduction: Why seek to improve public sector use?
- Different segments, different needs and opportunities
  - Defence
  - Emergency Services
  - Transport (especially aeronautical and maritime)
- Emerging approaches
  - Technological improvements
  - Improved administrative controls
  - Market mechanisms
- Concluding remarks

Optimising Spectrum Use by the Public Sector

- The material that follows benefits from our ongoing research for the European Commission
- Thanks to my colleagues:
  - Phillipa Marks, Plum
  - John Burns, Aegis
  - Frédéric Pujol, IDATE
  - Prof. Martin Cave
- Materials from April 2008 workshop appear at: http://www.wik.org/content_e/initial%20public%20workshop/public_workshop_main.htm
- See also “Safety First: Reinvesting the Digital Dividend in Safeguarding Citizens”, Ken Carter and Val Jervis, at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1088708

Optimising Spectrum Use by the Public Sector

- Commercial use of spectrum has been progressively modernised and improved in recent years.
  - Increasing emphasis on market-based mechanisms
    - Spectrum auctions
    - Spectrum leasing and trading
  - New technological options
    - Migration to digital
    - New possibilities for spectrum sharing (collective use)
- How much of this could be, or should be, applicable to the public sector?

Optimizing Spectrum Use by the Public Sector

- Public sector spectrum has usually been administratively assigned to date.
- Numerous constraints:
  - Important for the safety of life and property.
  - Harmful interference could be very detrimental.
  - International coordination often required.
  - Militarily sensitive information.
- Spectrum allocations to public agencies are often:
  - Unlimited in duration
  - Costless

Optimizing Spectrum Use by the Public Sector: Concerns that are increasingly raised

- Spectrum assignments may not be adequately tracked or recorded.
  - Public agencies do not always knows what spectrum they are using.
  - Public agencies may not realise the value of the spectrum that they are using (leads to inefficient use).
- Public agencies have little incentive to return spectrum that is no longer (strongly) needed.
- Public agencies will tend to make poor procurement decisions because of misleading economic “signals”.

Optimizing Spectrum Use by the Public Sector

- Public sector use typically represents 30%-50% of all spectrum use, including in the valuable ranges below 6 GHz.
- This is a valuable resource!
- Increasing the efficiency of use could lead to:
  - Better service delivery in the public sector.
  - More spectrum available for private sector use.
- Any changes will require time and great care.
  - Criticality of applications in the public sector.
  - Long procurement cycles for many applications.

Optimizing Spectrum Use by the Public Sector: Radio Spectrum Applications by Sector and Application

	Aeronautical	Maritime	Road / Rail	Defence	Public safety	Meteorology
Voice comms						
Data comms						
Video comms						
Ground Radars						
Airborne Radars						
Ship Radars						
Navigation Aids						
Satellite						
Point–point links						

Extensive spectrum use (>100 MHz below 1 GHz or >200 MHz above 1 GHz)

Some spectrum use

Biggest public sector spectrum users are radars and the military.

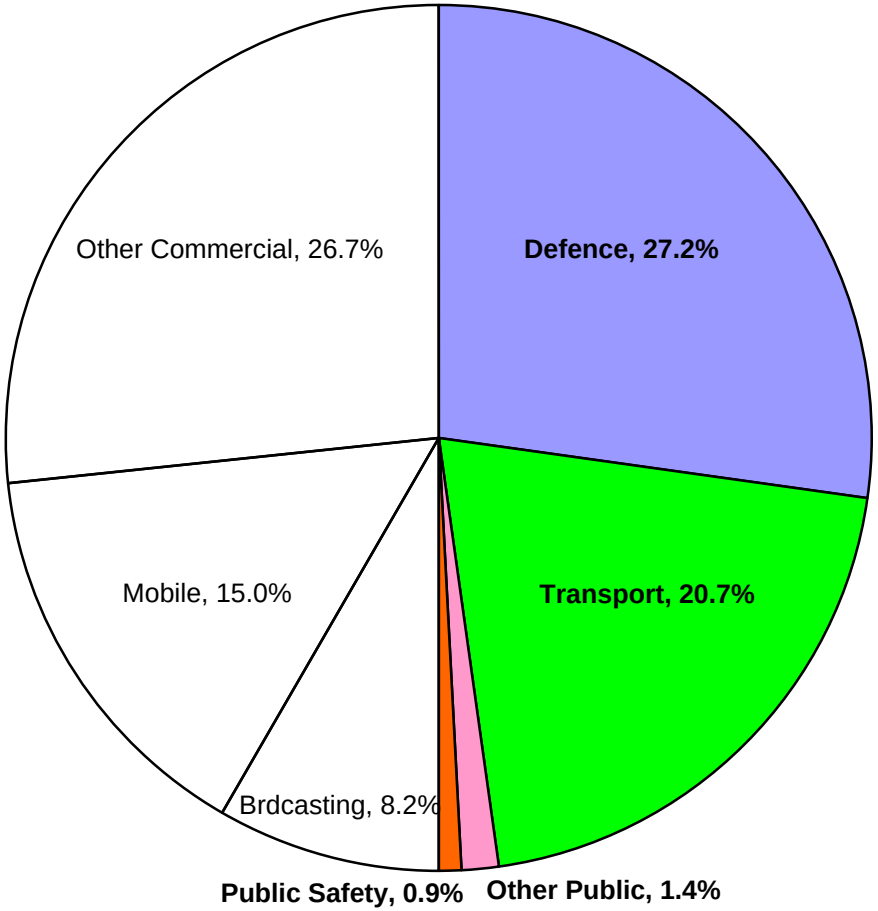
Optimizing Spectrum Use by the Public Sector: Spectrum Use by Sector (typical EU country)

Spectrum Use by Sector

108 MHz – 6 GHz

Notes:

1. To avoid double counting we have assumed that all spectrum used by the civil aviation and maritime sectors is classed under the Transport sector, even where this spectrum is also used by the Defence sector
2. 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.



Optimizing Spectrum Use by the Public Sector: Spectrum Use (typical EU country)

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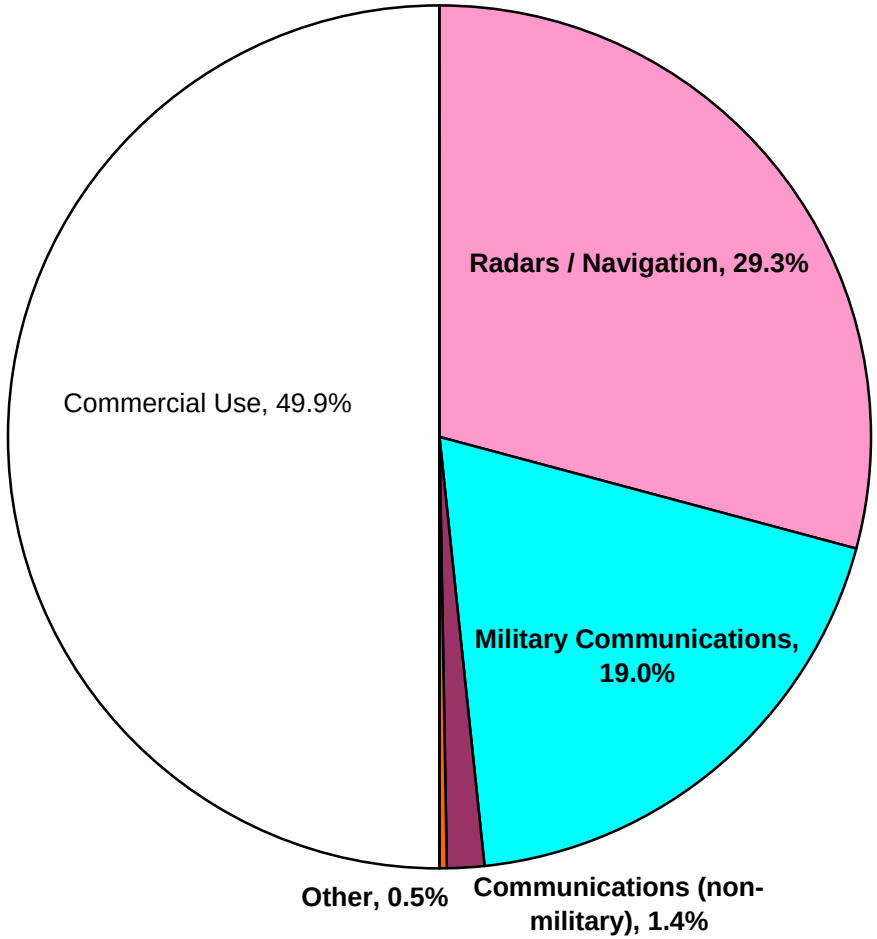


Optimizing Spectrum Use by the Public Sector: UK Treasury Study (Cave Report, 2005)

Public sector holdings below 15 GHz:

Defence non-navigation	66%
Defence navigation	9%
Civil aeronautical	12%
Emergency and Safety Services	5%
Science	4%
Maritime	2%

… but the public/private border is porous

Different segments, needs and opportunities

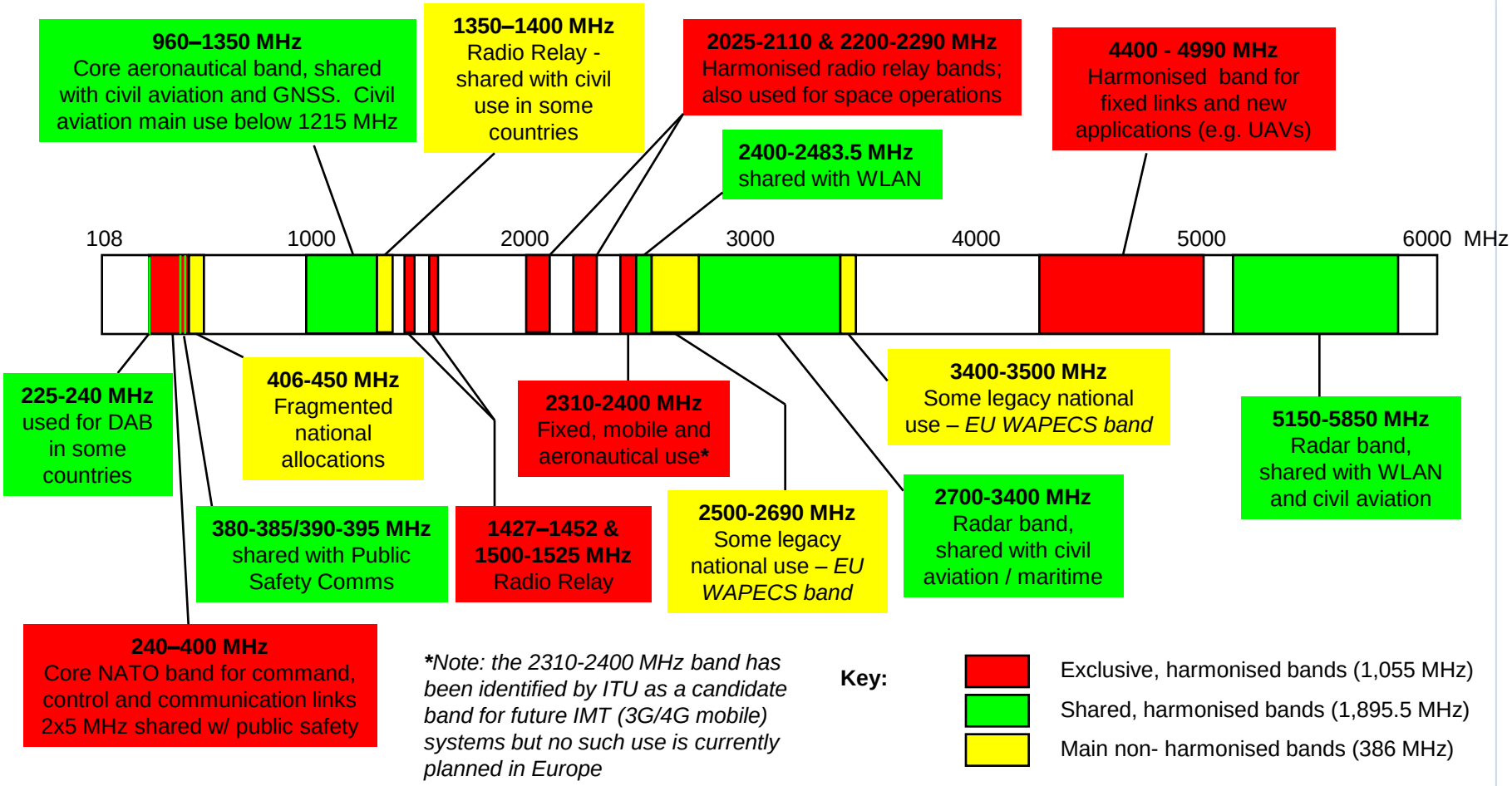
- Defence
  - *Regional* frequency management (e.g. NATO, Warsaw Pact) coexists with *national* frequency management.
  - Reflects possible need to interoperate regionally.
  - Voice and data communications and radars predominate.
- Emergency services
  - Small in spectrum used, large in importance
  - Occasional need for cross-border interoperability
    - Natural disasters such as tsunamis.
    - Terrorist incidents.
- Transport (aeronautical and maritime)
  - Requirements for global interoperability drive global management.
  - Radars, navigation, communication.
  - Spectrum sharing with defence is often workable.

Defence

- In western Europe, NATO allocations play a huge role.
- In former Warsaw Pact countries, allocations are being transitioned rapidly in an ongoing process.
- Many bands are shared.
  - Sharing with aeronautical and maritime is probably effective.
  - Difficult to judge the effectiveness of sharing with other private sector applications.
- Most spectrum harmonised to varying extent, but still significant variation in some bands.
- Small, fragmented allocations at national level can constrain re-farming options.

NATO Members

Defence


960–1350 MHz
Core aeronautical band, shared with civil aviation and GNSS. Civil aviation main use below 1215 MHz
1350–1400 MHz
Radio Relay - shared with civil use in some countries
2025-2110 & 2200-2290 MHz
Harmonised radio relay bands; also used for space operations
2400-2483.5 MHz
shared with WLAN
4400 - 4990 MHz
Harmonised band for fixed links and new applications (e.g. UAVs)
108
1000
2000
3000
4000
5000
6000 MHz
225-240 MHz
used for DAB in some countries
406-450 MHz
Fragmented national allocations
2310-2400 MHz
Fixed, mobile and aeronautical use*
3400-3500 MHz
Some legacy national use – EU WAPECS band
5150-5850 MHz
Radar band, shared with WLAN and civil aviation
380-385/390-395 MHz
shared with Public Safety Comms
1427–1452 & 1500-1525 MHz
Radio Relay
2500-2690 MHz
Some legacy national use – EU WAPECS band
2700-3400 MHz
Radar band, shared with civil aviation / maritime
240–400 MHz
Core NATO band for command, control and communication links 2x5 MHz shared w/ public safety
*Note: the 2310-2400 MHz band has been identified by ITU as a candidate band for future IMT (3G/4G mobile) systems but no such use is currently planned in Europe
Key:
Exclusive, harmonised bands (1,055 MHz)
Shared, harmonised bands (1,895.5 MHz)
Main non- harmonised bands (386 MHz)

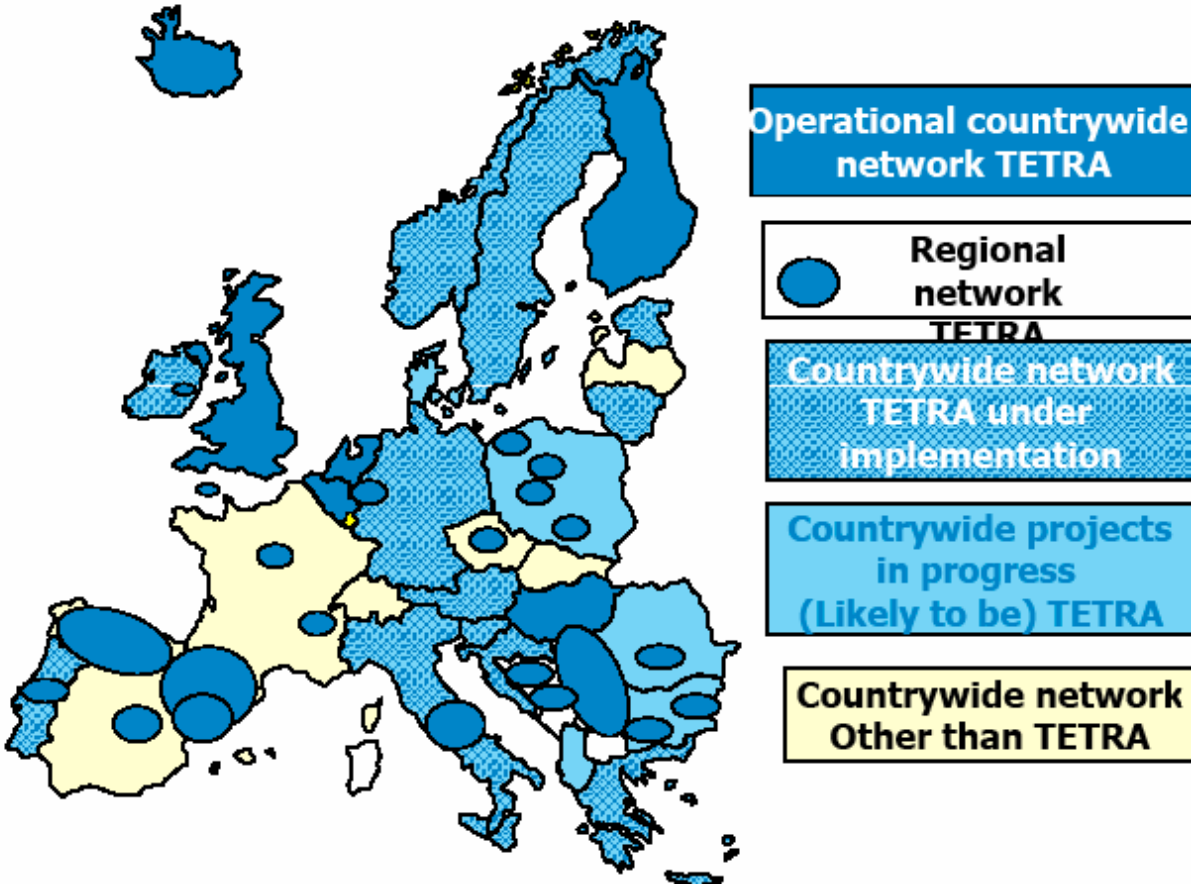
Defence: Spectrum Demand Trends

- Demand growing for wideband data links and airborne telemetry systems.
- Future combat systems increasingly reliant on mobile broadband tactical communications with resilient wide area coverage – implies large, contiguous RF bandwidth.
- Increased deployment of unmanned vehicles (ground and airborne) driving demand for wireless telemetry.
- Demand growth can be offset to some extent by deployment of new technologies.
  - Software Defined Radio (SDR) allows systems to operate across wide range of existing bands and air interfaces, adapting to local availability.
  - Efficiency enhancements to radar.

Emergency Services

- A relatively small spectrum user, but vital.
  - Mainly voice and narrowband data but growing interest in broadband (e.g. video links).
  - Legacy analogue services migrating to harmonised digital trunked radio band (380 – 400 MHz).
- Increasing recognition of the need for harmonised spectrum for emergency services use.
- US: 700 MHz auction.
  - Sought to balance preemptible private use and as-needed emergency use.
  - Bids did not reach the US FCC's minimum expectation.
- Europe: Growing interest in allocation of a small harmonised band for broadband data out of the Digital Dividend.

Emergency Services

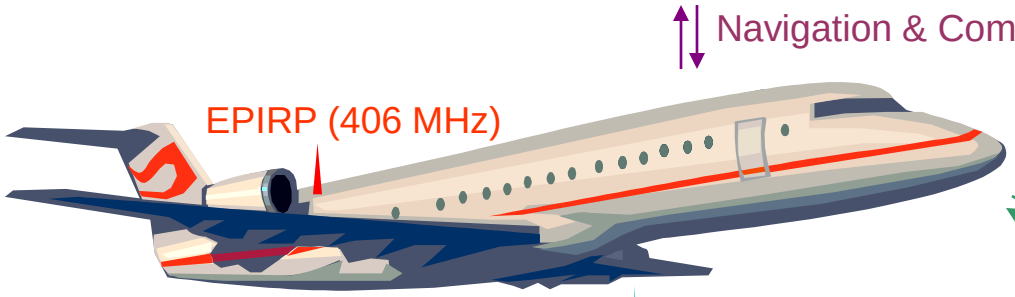


Narrowband interoperability?

Aeronautical and Maritime

- Largely managed by ICAO / Eurocontrol and IMO.
- ICAO / Eurocontrol specify performance requirements and in some cases technical standards for aeronautical communications and navigation (for example, mandating of narrower bandwidth (8.33 kHz) communications channels above 24,000 ft).
- Frequency Bands are generally harmonised globally.
- Safety of Life at Sea (SOLAS) regulations specify distress frequencies and carriage requirements for communications and radar equipment (for example, all merchant ships above 3,000 tonnes must carry S-band and X-band radar)

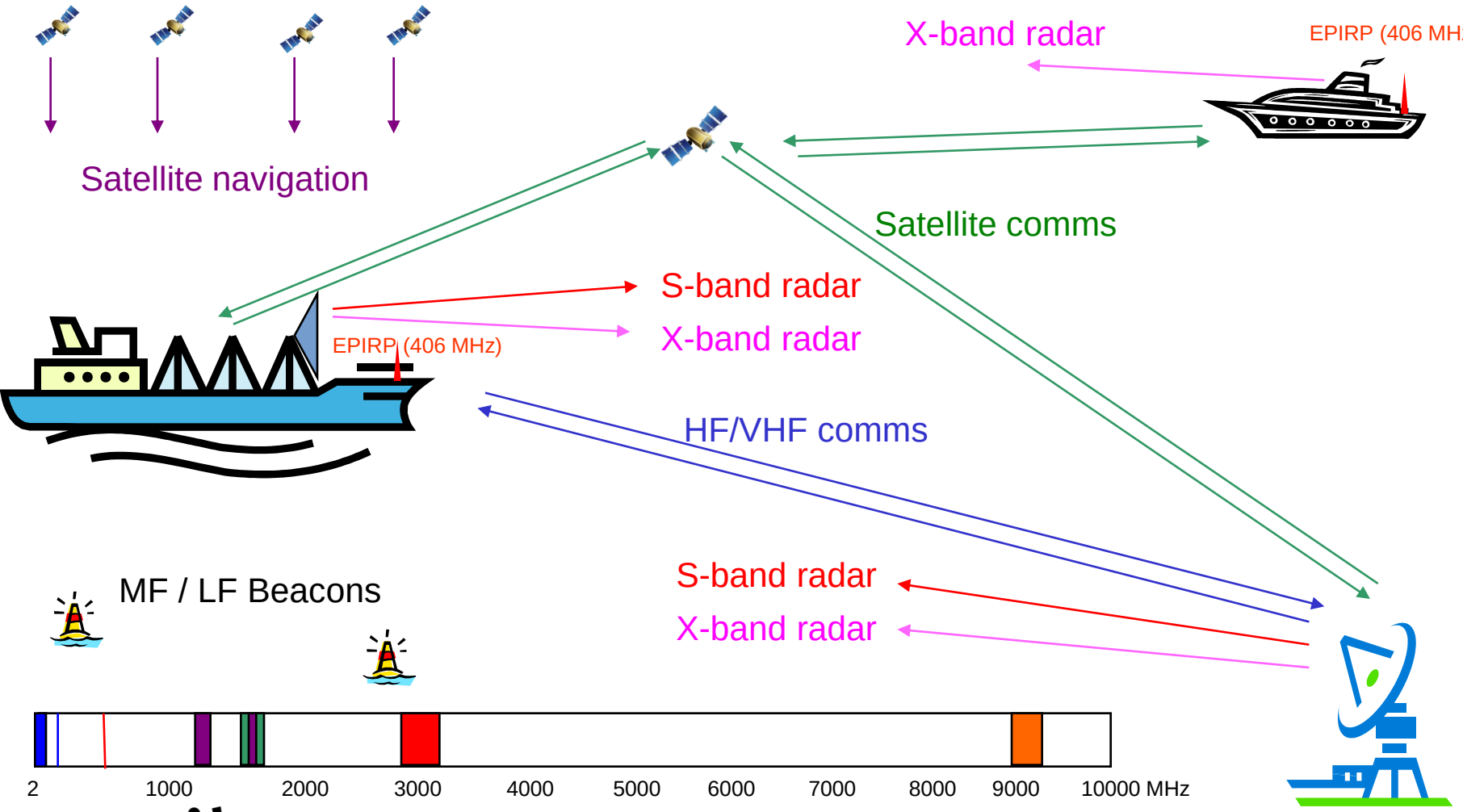
Aeronautical



Note:

This diagram illustrates the diversity of aeronautical spectrum use but is not intended to cover all applications. Various additional frequencies above 6 GHz are also deployed, e.g. for short range airport surveillance, surface monitoring and airborne navigation aids.

Maritime


X-band radar
EPIRP (406 MHz)
Satellite navigation
Satellite comms
S-band radar
X-band radar
EPIRP (406 MHz)
HF/VHF comms
MF / LF Beacons
S-band radar
X-band radar
2
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000 MHz

Optimising Spectrum Use

- Technological opportunities
  - Migration to digital technology (Digital Dividend).
  - Improved radar efficiency.
  - Spectrum sharing
    - Automated and/or dynamic “assignment” of spectrum
    - Cognitive radio, software-defined radio (SDR)
    - Coordinated LAN use for emergency services
- Improved management and coordination
  - Spectrum audits (e.g. the UK, Netherlands, US)
  - Administrative justification (Netherlands)
  - Market-based mechanisms (UK)

Radar: Principal Radar Frequency Bands

- Different Bands used for Different Applications:
  - L-band (960 – 1215 MHz): Secondary radar systems 
  - L-band (1215 – 1365 MHz): Long range surveillance (to 450 km) 
  - S-band (2700 – 3400 MHz): Mid-range Surveillance (to 80 km) 
  - C-band: (4200 – 4400 MHz): Altimeters 
  - C-band (5350 – 5470 MHz): Wind Shear Detection 
  - X-band (9000 – 9500 MHz): Surveillance 
  - X-band (9345 – 9375 MHz): Storm Cloud Detection 
  - X-band (9300 – 9500 MHz): Ground Movement Radar 
  - Ka-band: (13.25 – 13.4 GHz): Airborne Doppler Radar 
  - Ka-band (15.3 – 15.7 GHz): Ground Movement Radar 

 Ground / Shore based

 Airborne

 Ship borne

Radar: Controlling Radar Emissions

- Radar emissions are largely defined by range / resolution requirements.
- Out-of-band emissions can extend well beyond the limits established for the corresponding bands.
  - Emissions can spill over into adjacent bands.
  - Substantial frequency separation is required for other radars (due to highly sensitive receivers).
  - New tighter out-of-band limits have been developed by CEPT.
  - Recent solid state radars significantly improve out-of-band performance.
  - Many existing radars still use older valve technology.

Radar: Benefit of reduced out of band emissions

- Work undertaken for Ofcom in the UK suggests up to **63% reduction** in required frequency separation between two S-band radars at 45 km distance if latest solid state technology were used to replace existing TWTA based radars.*
- Average reduction anticipated to be about half this (**32%**).
- Suggests ability to pack more radars into existing frequency bands without compromising performance.
- Longer term possibility to re-plan the bands and maybe reduce overall bandwidth, but this would require all existing TWTA / magnetron radars to be upgraded.

* 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

Netherlands

- Ministry of Economic Affairs published their Radio Spectrum Policy Memorandum in 2005.
  - The frequencies should not be more than is needed for the exercise of the tasks.
  - The assignments to public interest tasks should be based on a needs justification plan (as public interest use often denies use to others).
  - Where spectrum reserved for public interest tasks is not in use all the time, third party access should be permitted where practically possible.
- Agencies submit justifications to the Ministry every three years.
- Assessed on the basis of the “effectiveness and efficiency of frequency use”.

The Netherlands

- First audit is complete.
  - Detailed information from the Ministry of Defence.
  - High level information from other agencies.
- Perceived benefits:
  - Government agencies are now aware that they use spectrum, and that spectrum is a scarce resource.
  - Agencies see benefit in developing plans for their future use, so that they can secure future spectrum access.
  - Benefits the national Radiocommunications Agency in international discussions.
  - Some frequencies (PMR) have been given back by the MoD.
  - Some sharing opportunities have been identified.

Sweden

- One process for armed forces.
  - Armed forces and the regulator develop a plan showing all the frequencies available to the armed forces on an exclusive or on a shared basis.
  - The regulator could “loan” frequencies to the private sector, on a short term or long term basis, subject to consultation with the armed forces.
- A different process for most other public agencies. Most public agencies pay licence fees based on the number of transmitters in use, just like private sector users.
- In an October 2007 report, the National Post and Telecom Agency (PTS) evaluated usage by the armed forces and found that in many cases it was not efficient. They intend to study ways to try to improve efficiency, including market mechanisms.

United States

- The NTIA manages spectrum used by the US government; the FCC manages all other spectrum use.
- NTIA just completed a comprehensive audit of spectrum use.
  - Extensive information about current spectrum use.
  - Only limited, high level information about future needs.
- The report expresses interest in automated planning tools, technological improvements, dynamic sharing, and the possible use in the longer term of market mechanisms.
- The report does not establish a clear strategic direction for improved spectrum efficiency on the part of the US government.

The UK

- The Cave Report (2005), an audit for the UK Treasury, established key economic and management principles:
  - New spectrum requirements of the public sector should be realised through the market.
  - Spectrum pricing should be introduced for (almost) all existing holdings.
  - Surplus public sector spectrum should be available for sale, lease or sharing.
  - The Government's UKSSC (Spectrum Strategy Committee) should produce a 'forward look' of public sector spectrum use every two years.
  - A demand forecast for all spectrum should be undertaken regularly.
  - More resources should be devoted to collecting information and managing public sector spectrum holdings.

The UK

- UK government has accepted the recommendations of the Cave Report.
- The first “forward look” was published in 2007.
- Extended pricing to most existing holdings.
- Established a legal instrument to trade public sector spectrum (recognised spectrum access – RSA).
- Committed to publishing more information on public sector spectrum to facilitate trade.
- Ofcom published an overall plan in 2008.
- The UK Ministry of Defence has just published a comprehensive consultation on their spectrum use.

Administrative Incentive Pricing (AIP)

- Has been applied in varying degrees in the United Kingdom (UK), Canada and elsewhere.
- Basic concept: Government should pay for spectrum, as do private sector users. Just as in the private sector, if government users have to constantly confront their opportunity costs, they will be motivated to make better decisions about spectrum use.
- The approach is eminently sensible, but faces significant implementation challenges.

Administrative Incentive Pricing (AIP): Rationale

- Public agencies typically operate as a normal market player when they need to purchase:
  - Office supplies
  - Buildings
  - Civilian employees
- They should pay a market competitive price –neither more nor less.
- Why should spectrum be any different?

Administrative Incentive Pricing (AIP): Challenges

- Incentives to public agencies
  - Does the agency benefit from the money saved?
  - Can the budget be reapplied elsewhere?
  - Will savings result in reduced future budgets?
- Pricing: How should the opportunity cost of public sector spectrum be determined without an auction?
- Can public sector agencies trade or lease spectrum?
- How reliable is preemption?

Administrative Incentive Pricing (AIP): Emerging Solutions

- Reapplication of budget is difficult.
  - Ability to choose to shift funds between spectrum and equipment is logical.
  - Budget has to be stable for long enough to make return of unneeded spectrum attractive.
- Pricing is usually an approximation based on values (e.g. through auction) of “similar” spectrum.
- Considerable resistance to leasing or trading.
- Preemption:
  - Implemented as DFS.
  - Attempted in the US 700 MHz auction.

Concluding Remarks

- A rigorous audit of spectrum use by the public sector is a key prerequisite to any improvements.
- Periodic re-justification seems to be appropriate for all bands that are not subject to market mechanisms.
- We do not see a fundamental conflict between the administrative (Netherlands) and market (UK) approaches.
  - Countries that seek to implement market mechanisms will need to improve administrative controls first anyway.
  - Market mechanisms are unlikely to apply to all countries, nor to all bands.
- For now, a one size fits all approach would appear to be premature. There is no “silver bullet”.

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