the issue of spectrum

Radio spectrum management in a ubiquitous network society

The Internet of Things

SCF Associates Ltd

simon forge

simon.forge@whsmithnet.co.uk

Our Agenda

1 Where have we been on spectrum allocation?

- Allocation in the past
- Radio communication spectrum

2 Where are we today?

3 Where should we be tomorrow?

4 How do we get there ?

Where have we been with spectrum allocation?

Forms of allocation in the past

- Managed
- Markets and auctions
- Unlicensed IMS

European status – semi -harmonisation

- A mix of policies, stages of advance and national priorities

= Could there be strong barriers to progress?

- NO more spectrum available ?

- Incomplete MS agreement?

Agreed standard frequencies exist for current RFID

•Several bands - exact frequencies set by Radio Regulatory body in each country

•Higher frequency ranges - more regulatory controls, and differ more across countries

•National regulatory authorities follow ETSI/CEPT in EU (FCC in USA) standards as a basis for national regulations for radio communications and may use ISM bands

•Each frequency band has advantages and disadvantages for operation, active or passive RFID may require different bands. For passive tags, the lower frequencies usually have less range, and slower data transfer rate. But lower frequencies (125-134kHz and at 13.56MHz) work much better near water or humans than higher freqs.

•In general the main internationally accepted frequencies for RFID are:-

- 125 - 134 kHz
- 13.56 MHz (HF)
- 400 – 930 MHz (UHF)
- 2.45 GHz
- 5.8 GHz

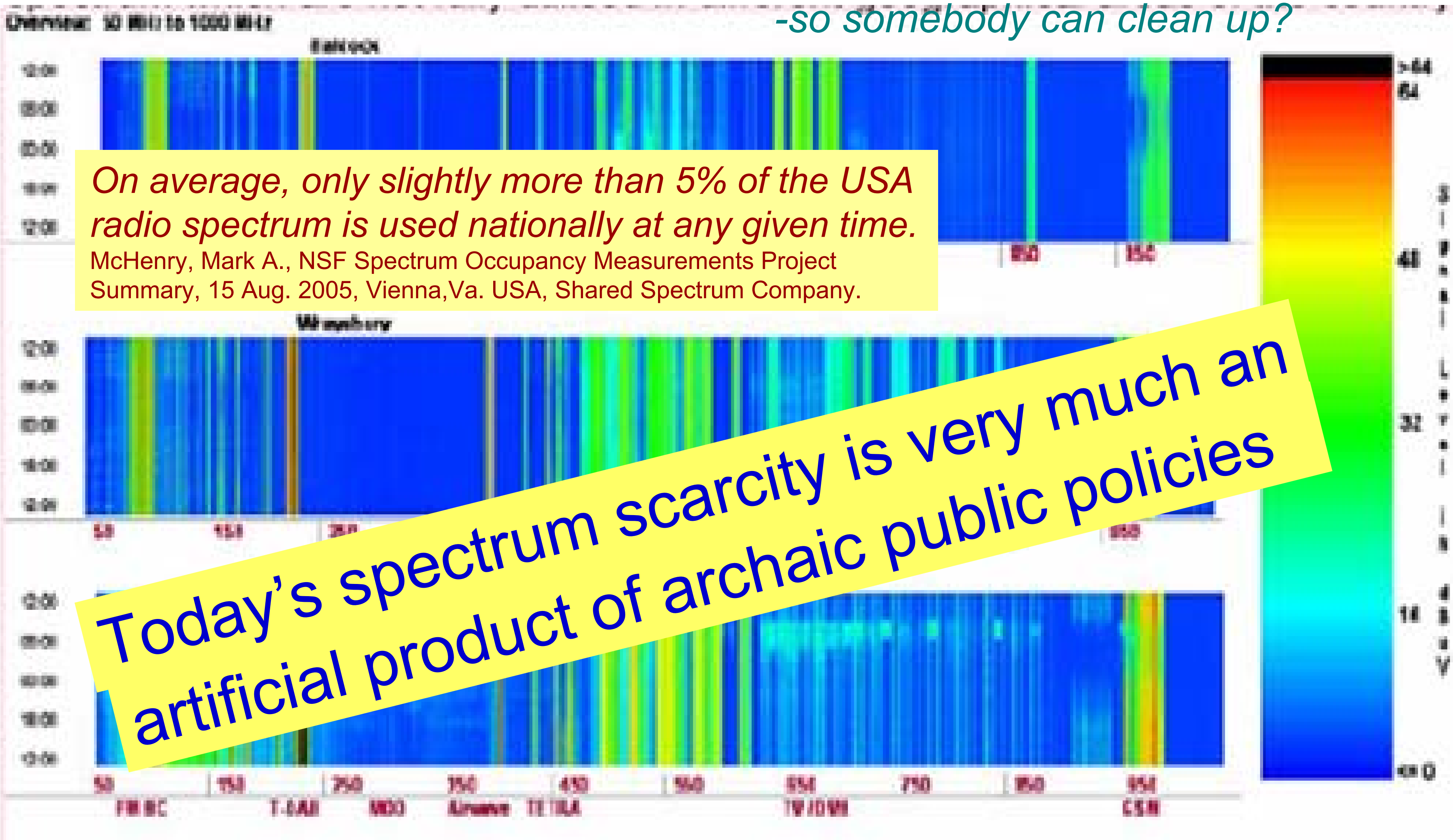
•Others are used but these are the main ones - in the UHF band, 2 main bands of interest – around 400 MHz and 860 – 930 MHz

RFID Frequency bands in detail for Europe and USA

RFID Frequency (range)	Description of contact form	Permitted field strength / transmission power
< 135 kHz	Low frequency, inductive coupling	72 dBµA/m
6.765 to 6.795 MHz	Medium frequency (ISM), inductive coupling	42 dBµA/m
7.400 to 8.800 MHz	Medium frequency, used for electronic article surveillance (EAS) only	9 dBµA/m
13.553 to 13.567 MHz	Medium frequency (13.56 MHz, ISM), inductive coupling, wide spread usage for contactless smartcards (ISO 14443, MIFARE, LEGIC, ...), smart labels (ISO 15693, Tag-It, I-Code, ...) item management (ISO 18000-3).	42 dBµA/m
26.957 to 27.283 MHz	Medium frequency (ISM), inductive coupling, specific applications	42 dBµA/m
433 MHz	UHF (ISM), backscatter coupling, rarely used for RFID	10 to 100 mW
868 to 870 MHz	UHF - backscatter coupling – systems in development	500 mW, Europe only
902 to 928 MHz	UHF - backscatter coupling, several systems	4 W - spread spectrum USA/ Canada only
2.400 to 2.483 GHz	SHF / ISM - backscatter coupling, several systems (eg vehicle identification: 2.446 to 2.454 GHz)	500 mW, Europe 4 W - spread spectrum USA/ Canada only
5.725 to 5.875 GHz	SHF (ISM), backscatter coupling, rarely used for RFID	500 mW Europe 4 W USA/Canada

BUT is this crowded spectrum all a myth?

-so somebody can clean up?



On average, only slightly more than 5% of the USA radio spectrum is used nationally at any given time.
McHenry, Mark A., NSF Spectrum Occupancy Measurements Project Summary, 15 Aug. 2005, Vienna,Va. USA, Shared Spectrum Company.

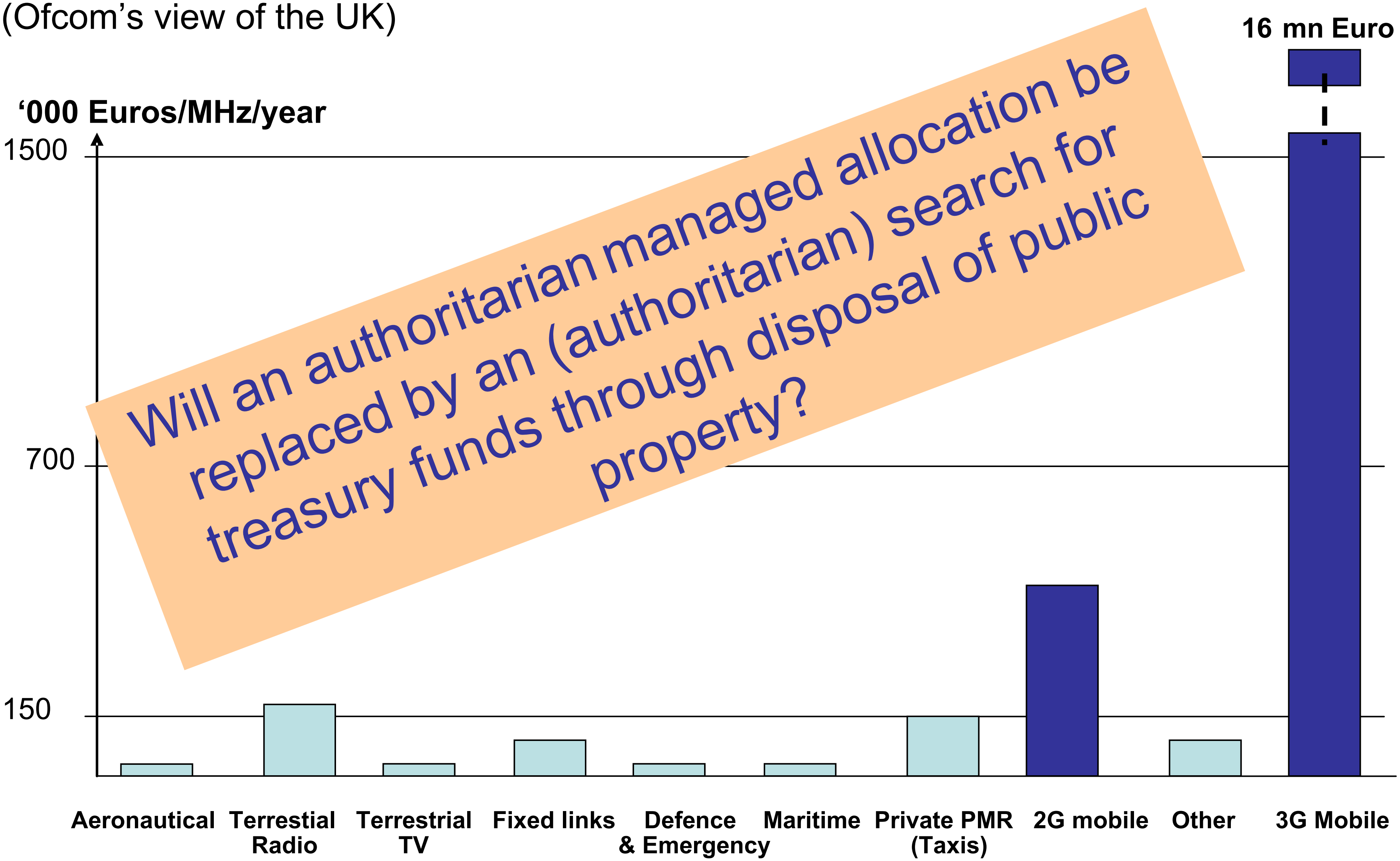
Today's spectrum scarcity is very much an artificial product of archaic public policies

Spectrum utilisation studies undertaken in the USA and by UK's Ofcom have investigated the degree of usage of the radio spectrum, indicating many areas of the radio spectrum are not fully utilised.

Source: OFCOM /Dettmer R, 'Up the revolution', *IEE Review*, May 2005, p. 44

The value of spectrum in one EU country which follows a market policy for auctions and secondary market resale

(Ofcom's view of the UK)



Source: Dettmer R, 'Up the revolution', *IEE Review*, May 2005, p. 44

There is a growing demand for radio technologies through and beyond RFID –AWTs (Alternative Wireless Technologies)

- RFID is the start point for :-
    - Identification and tracking and other applications - security (access controls) etc
- Machine to machine communications via Internet likely to grow

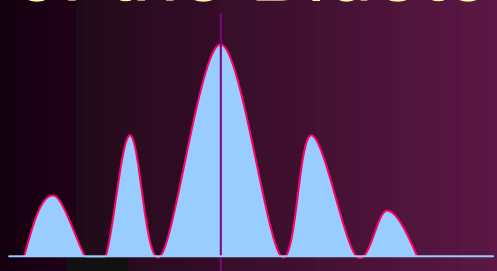
- Growing demand for radio usage means either:

- The spread of unlicensed bands in breadth and number

- And /or the spread of new technology which:-
    - Allows transparent overlap of multiple signals (direct spread spectrum)
    - Adapts and compensates for already occupied spectrum with cognitive radio/ SDR

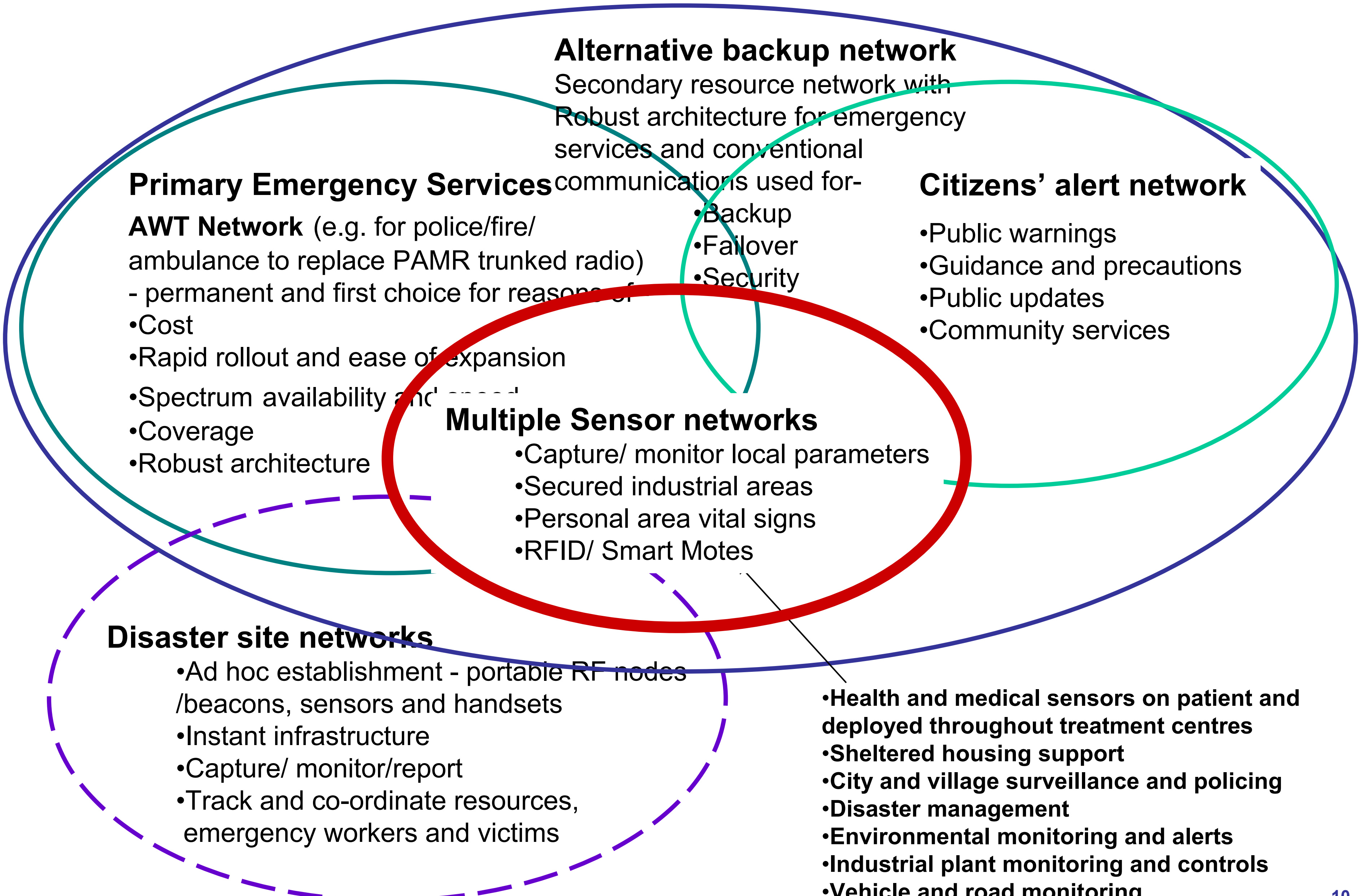
However – are we at a turning point?

Is the danger from interference such that ‘**mono’ frequency concentration** is too hazardous to our existence due to EMC problems – the case of the Bluetooth disabled car?



Is our dependence ***economically*** on new forms of radio technology likely to be too great to allow a restricted misuse and effective squandering of its usage to continue, in the way we have done over the last century?

We can formulate compound networks – e.g. for security - Integration of multiple AWT networks into a single European security resource



Our Agenda

1 Where have we been on spectrum allocation?

- Forms of allocation in the past
- European status – non-harmonisation

2 Where are we today on spectrum allocation?

- How much is really used
- Current RFID Allocation bands and mechanisms

3 Where should we be tomorrow?

- What are the demand trends – the socio-economics
- How can we reply in terms of spectrum allocation and new technology

4 How do we get there ?

- Forms of radio spectrum allocation for a ubiquitous network society

Forms of spectrum allocation

Governments and regulators have essentially four choices before them:-

•***Managed*** – command and control

•***Markets*** – and secondary markets – the property model

•***The commons*** – unlicensed spectrum and use of open source software concepts. Technological developments now coming to fruition promise to revolutionise sharing of spectrum and whether spectrum can even be considered as a resource, let alone a scarce resource.

New studies* are pointing in this direction

•***A mixed collective approach*** – multiple forms of the above, by function and economic purpose, with overlap and 'hole filling' (dynamically), again relying on technological developments to make the property attribute disappear

But which choice will catalyse maximum economic growth?

**** The Economic Impacts of Spectrum Allocation, SCF 2006***

Nevertheless, THE BIG ISSUE is more than collision contention and adaptation mechanisms for co-existence

-it is the secure transmission of many signals over the same frequency range = sharing the same spectrum

These signals are not identified by their power around a single frequency but by their pattern of power over many bands – direct spread spectrum [1] . In this situation, other devices are oblivious to the transmission – it is transparent. But this needs computing capability for decoding since the power per unit bandwidth descends to allow more sharing.

Computer power substitutes for simple transmission power around one frequency :

- Signal identification from apparent noise
- Cognitive radio front-end for intelligent adaptation

which requires

- advances in processing capacity and power dissipation for handset
- complex signal processing algorithms

[1] there are many forms of this signal processing – one is Orthogonal Frequency Division Multiplexing, OFDM

commons model - *spectrum could be better used to promote competition rather than monopoly - in contrast to the property model -*

Exploit spectrum sharing - devices may cooperate or merely coexist - 2 different operational modes

Co-operation - subject of much research ambient conditions are detected and compensated for by some form of intelligent radio front-end, usually under software control – the software defined radio (SDR)[1] /CR

so completely different types of systems may co-operate

Contention - the coexistence model is not new and exists today

spawning successful products such as WiFi and cordless phones. The original ideas of Norm Abramson's University of Hawaii radio packet network of 1972 all on a single frequency, ALOHANET, were taken by Robert Metcalfe, Butler Lampson and others to form the (wired) LAN Ethernet packet collision/contention algorithm, at Xerox PARC in the early 1970s. Ethernet contention mechanisms runs at Gbps speeds over cable- Also can have scheme of delays in transmission to avoid collision - network etiquette - rules to improve efficiency could even be set by the regulator. But they need to be designed appropriately for the applications in the band (Peha, 1998; Peha 2000; FCC, 2004).

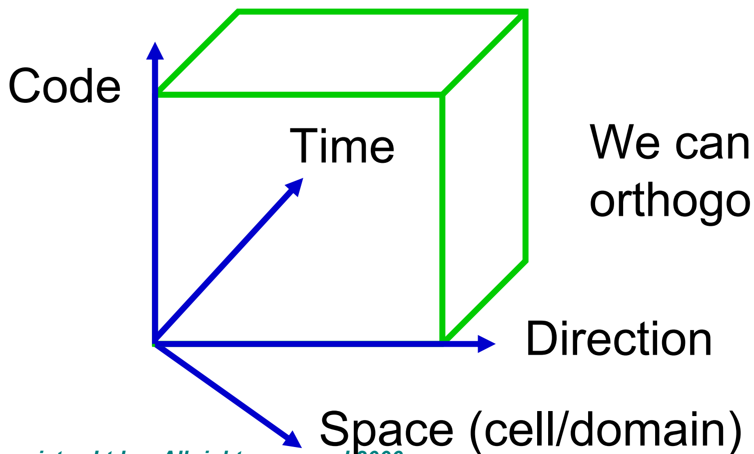
Overlaps, underlays and tolerance – '*Interference temperature*' (FCC) – although disputed concepts/interpretations –- a measure of the pollution of the spectrum by all devices operating in that band, beyond by raising the apparent noise floor to other users and so limit range &/or quality, and increasing costs due to interference for licensed users

or exploiting holes & gaps [2] ?

[1] See for example, Software Defined radio Forum, for an overview and the participants in the technology standardisation: http://www.sdrforum.org
[2] See, for example, Shared Spectrum Company Comment to FCC, 01 June 2004, FCC ET Docket No. 03-108

RF measures to meet demand for spectrum

- Cognitive Radio – dynamic adaptive co-working ('time')
- Highly spread signals such as UWB (code)
- Smart Antennae – directionally muxed MIMO channels
- Mesh Networking – self organising ('space')



We can multiplex in (at least) four orthogonal dimensions

CR EXAMPLE :

PC transmitting HDTV to a TV receiver in the same room using a wireless broadband protocol (eg USB WiMedia) would detect someone walking past, wearing a broadband media headset linked to a remote MP3 player in the person's pocket.

The four radios involved would co-operate to share the spectrum and the space, so as not to interfere, using short-range wireless ports with cooperative mechanisms driving adaptive front-ends (cognitive radio). Each device would be independent and adapt dynamically to its radio environment. To do this, it would maintain a map of all the devices it could see and that its immediate neighbours could see.

SO –

•making more unlicensed spectrum available encourages innovation

•now is the time for a new approach to the allocation of spectrum - with more unlicensed bands for sharing through a 'commons' in spectrum

In summary

The Internet of Things — AWTs such as RFID can fill the areas of life that today's cellular mobile cannot reach - in the 21st century, productivity will be inextricably tied to the ubiquitous availability of wireless services

The Internet of Things — RFID and companion AWTs will only open the door to the world of the Internet of Things if we permit appropriate usage of spectrum in line with our new lifestyle demands

The Internet of Things — The challenge is to turn the opportunities offered by AWTs into reality through appropriate spectrum policy with suitable rethinking of regulation – right across the board.

simon.forge@whsmithnet.co.uk