Flexible Spectrum – Implications for Radio Technology

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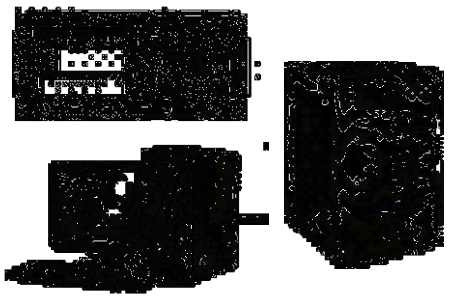
Flexible spectrum

What do we need?

Why does it matter?

How do we know we've got it?



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How do we get it?

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1. What do we need?

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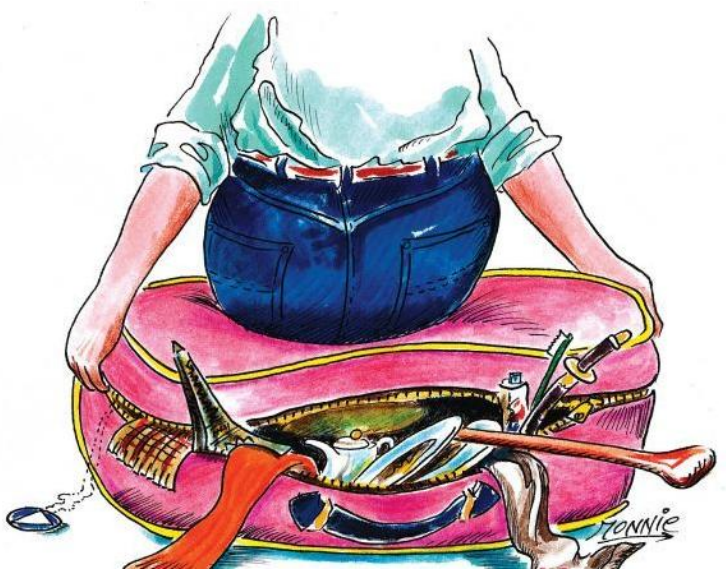
Multi-Band Radio - A Challenge Already

- Today – 5 band / 2 standard devices are common
  - Typically GSM / 3G, 850, 900, 1800, 1900, 21(
- Lots of new bands on the horizon:
  - 700 MHz in US (sub-bands for AT&T and Veriz
  - AWS (2.1/1.7 GHz) in US
  - 790-862 MHz in Europe
  - Other UHF variant elsewhere in the world?
  - 2.6 GHz FDD – mainly in Europe
  - 2.6 GHz TDD – mainly in Europe
  - 2.3 GHz TDD – China, Korea, India
- Plus GPS, WiFi, Bluetooth, FM radio, DAB,….?
- MIMO adds at least a doubling of receive chain and antennas
- Cross-band spectrum aggregation could need more transceivers?
- “SDR” may deliver on multi-standard support, but RF is a big challenge



How do we squeeze it all in – or what do we drop ?

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Why Do We Need So Many Bands In One Terminal?

- We cannot afford to rollout new mobile broadband services quickly to cover entire countries – always concentrate on high traffic areas first
  - Inevitable need to support fallback to legacy technologies with wider existing coverage
- Spectrum varies from country to country – we cannot guarantee to get spectrum in the same band everywhere
- Roaming market still important
- Desirable to get economies of scale with widely saleable terminal

Efficient (low loss) multiband performance is vital for the next generation of mobile devices

Hypothetical Ten-Band "Global" Terminal

Band		Duplex	Technology	Usage	RX paths
13	US 700 (VZW)	✓	LTE	US	2
5	US 850	✓	EVDO	US	2
20	EU 800 ex TV	✓	LTE	Europe	2
8	GSM 900	✗ / ✓	GSM/EDGE (/HSPA)	Europe, China	1/2
3	GSM 1800	✓	GSM/EDGE, LTE	Europe, China	1
2	PCS 1900	✓	EVDO	US	2/1
1	IMT 2100	✓	HSPA/LTE	Europe	2
40	TDD 2300	✗	TD-LTE	China	2
7	IMT ext 2600	✓	LTE	Europe	2
38	IMT ext 2600	✗	TD-LTE	Europe	2

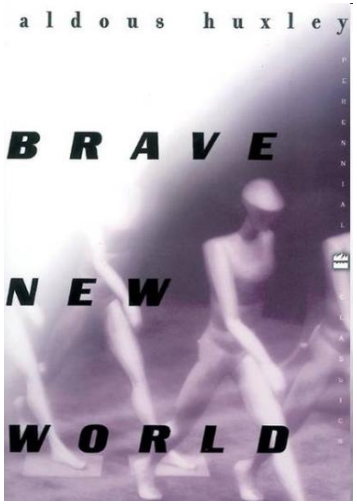
+ GPS, WiFi, Bluetooth, possible extra band/mode combinations

Why 10/11 Bands – Do We Need Even More?

- Our hypothetical terminal would not support all operators even in Europe, US and China. Vodafone + Verizon Wireless + China Mobile is a big market, but it's not the world.
- Chipset vendors are suggesting that we can just about stretch current technology to 10 bands, with performance compromises and added cost

  = multiple SAW filters + multiple PAs + switches + compromise antennas (tuned?)
- New UHF allocations around the world will add even more new bands

Or



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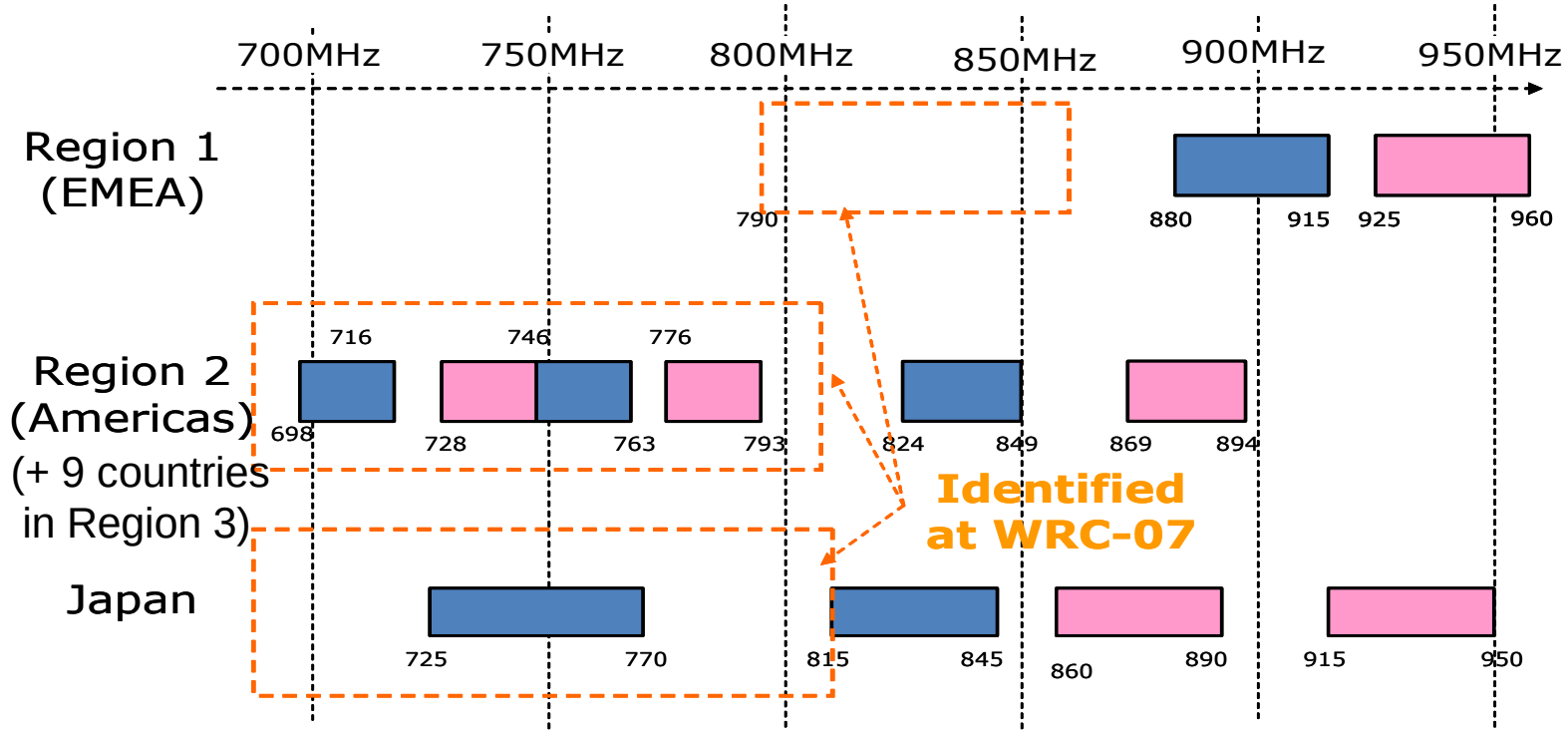
Frequency Ranges Identified For Mobile At WRC-07



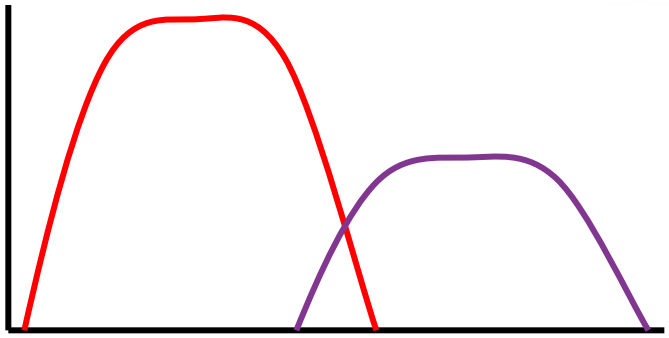
- Little prospect of a globally harmonised bandplan
  - The US bandplan was already finalised
  - The Japanese bandplan cannot be followed by any other country
  - Neither are consistent with the spectrum identified in Europe
  - In USA and other countries the 800MHz band is already used for mobile

But what about TRULY flexible spectrum?

Ofcom plans "white space" networks by 2013

1 September 2011

Ofcom has published plans to use licence-free wireless frequencies to promote a wide range of new services and potentially push broadband further into rural areas.



Frequency

- "White Space" technology in UHF TV band suggested as a solution to spectrum shortage

BUT

- Little work to address the challenges of RF design
- **Adjacent channel rejection /suppression in receivers and transmitters is a real challenge**
- FCC rules in US confirmed in September 2010 require TX adjacent channel suppression of 72.8dB – much tighter than today's mobile phones
- TV receivers need to be improved too!

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Summary - We need radios that :

Can tune anywhere

Have clean transmitters

Have efficient antennas

Reject adjacent interference

Have sensitive receivers

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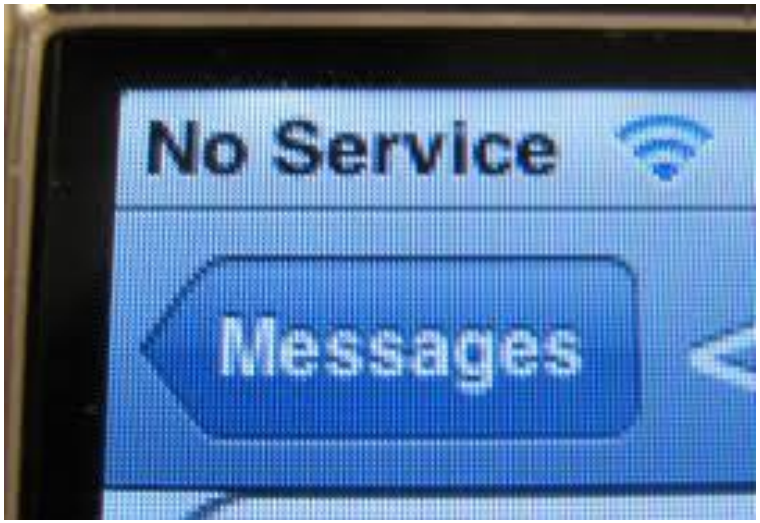
2. Why does it matter?

Why it matters: Frustrated customers

Apple Responds to iPhone 4 Antenna Problem

PC World 25th June 2010

Apple's iPhone 4 signal problems have been the source of a barrage of complaints by customers complaining of a faulty antenna …



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Why it matters: Network costs

Terminal Cost

Network Cost

1dB loss in RF performance = **14% more sites for same coverage**

GSM RF performance of early 3G phones was 2dB worse than GSM only

Today's worst smartphone would need TWICE the base stations to get the coverage achieved by today's best!

Adding a second antenna to every terminal could increase network capacity by 20-40%, cell area by 30% and cell edge throughput by 40-75%

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Why does it matter? – Limits spectrum exploitation

FCC halts LightSquared rollout pending "targeted" GPS interference tests
Air Transport Intelligence news 13th September 2011

Nascent broadband provider LightSquared's plans to roll out a satellite-terrestrial network adjacent to the GPS band next year have been halted by the US Federal Communications Commission (FCC).

The problem:

Coping With Noisy Neighbours

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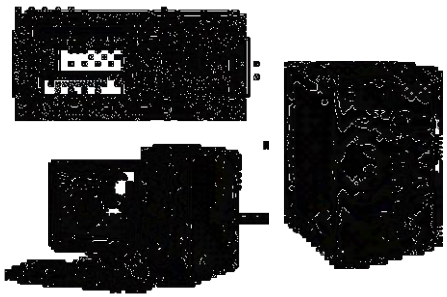
3. How do we know we've got it?



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How do we know it works – MIMO testing

- Network CAPACITY depends on the performance of MIMO or RX diversity
- MIMO adds cost to base stations and terminals
- If we can't test terminals, we can't tell whether our investment in MIMO will pay back
- How can we tell a gem from a dud?

OR

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How do we define a suitable test method?

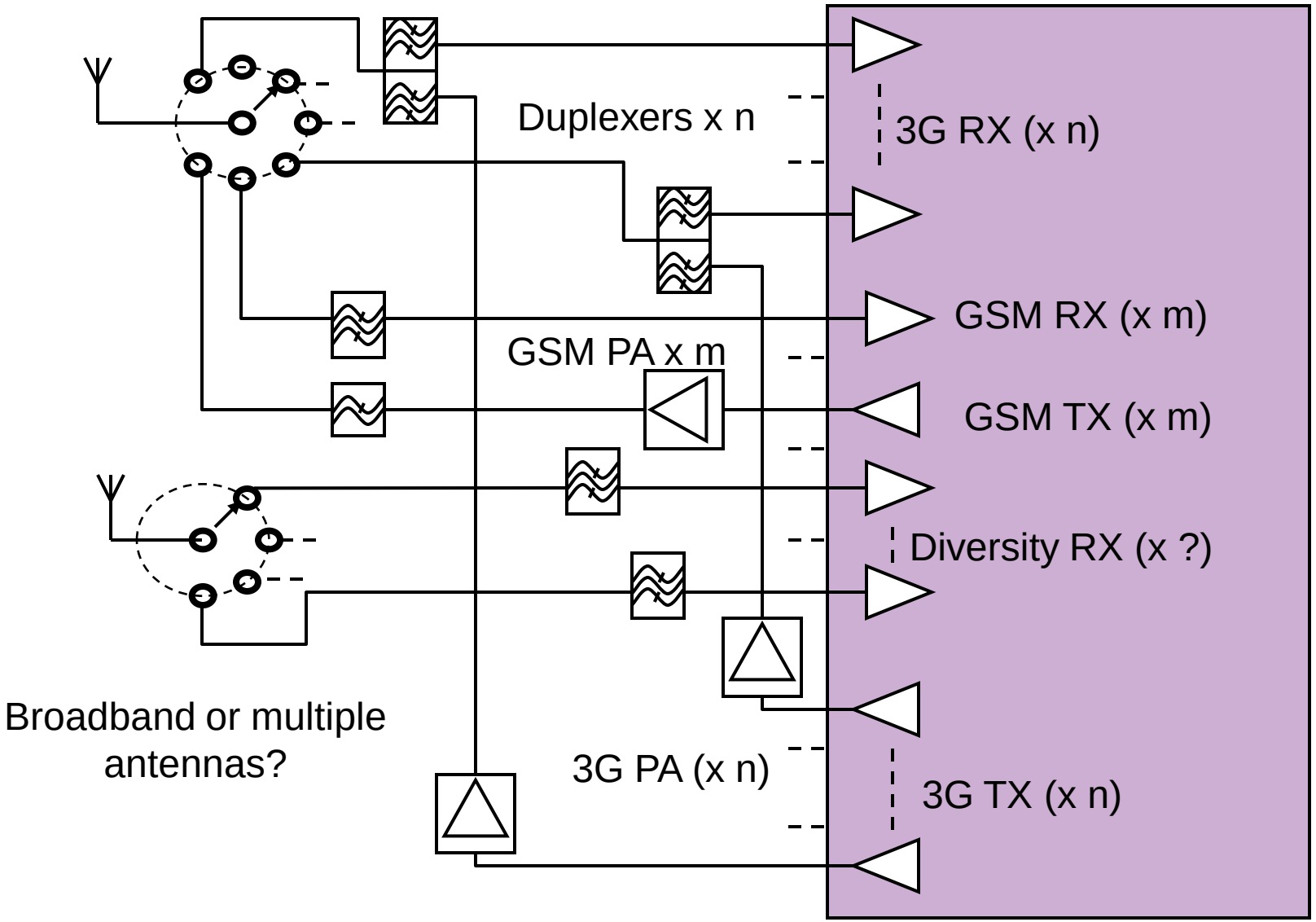
How do we interpret the results?

MIMO Testing - status

- "Over The Air" testing essential
- Work progressing slowly to standardise tests
- Now multiple candidate methods, but no clear single solution which is:
  - Cheap
  - Simple
  - Truly representative of the "real world"
- Important to start with something SOON but continue work on better solutions

3. How do we get it?

Typical Current Transceiver Design



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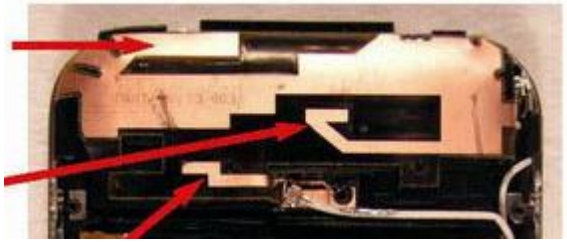
Todays Technology

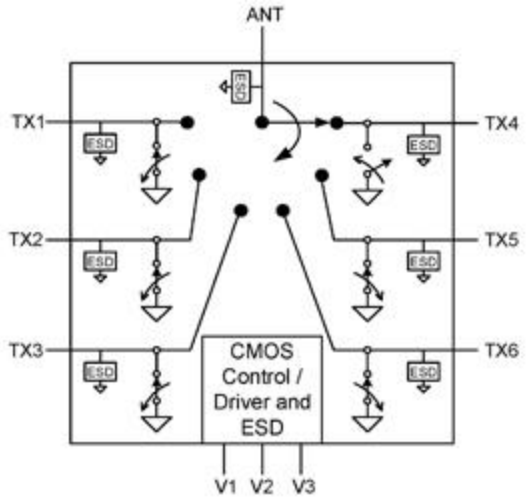
850 / 900 Antenna

1800 / 1900 Antenna



Wifi Antenna

SAW or FBAR provide high performance filtering in small, low cost package. Typically 2mm x 3mm x 1mm



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Areas for Research

- Some areas to consider:
  - Low loss **switching** with high isolation
  - Continued incremental improvement in **filter** performance at low cost
  - Broadband **PAs** shared between adjacent bands
  - Broadband **antennas** with adaptive tuning / matching
  - (Long term) **Technologies for tunable RF filtering** ?

A major investment in RF R&D is needed to enable the next generation of flexible radios to fully exploit the available spectrum