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Locating Wireless Devices Where GPS May Not Be Available

Final Conclusions Summary

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Agenda

- Introduction
- A contemporary application example
- Technologies covered
- How hard is a 100m accuracy target?
- Matching technologies to applications
  - Infrastructure as a key differentiator
  - Some technologies were not well suited
- Conclusions and Issues

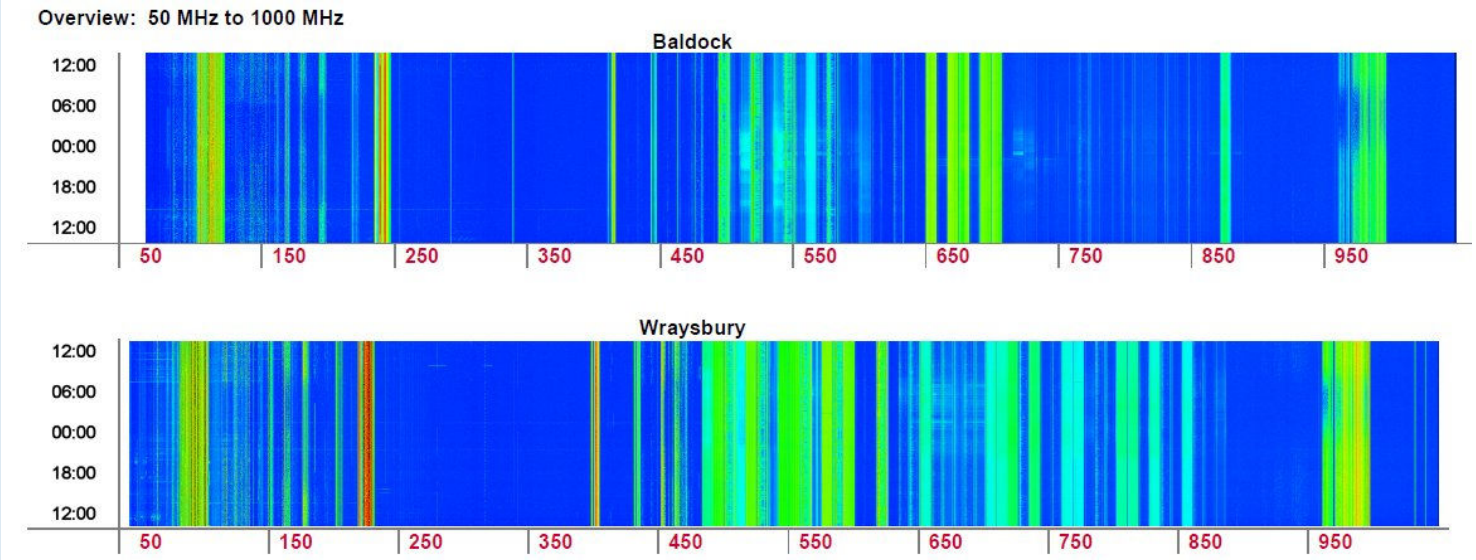
Introduction

- **Who?** Ofcom – research, regulatory interest
- **What?** Wireless devices where GPS is not an option
  - e.g. in urban canyons or indoors
  - we are not looking for a GPS substitute
- **Why?** Location is needed for
  - permission to communicate, e.g. cognitive devices (see later)
  - to report the position of a person or an asset
  - to enable a service , e.g. Location Based Services
- **Where?** UK focus, global interest
- **When?** Now and 10 years into the future
- **How?** ....?

Wireless devices which need location

- Cognitive devices will use spectrum opportunistically

  Lots of potential – 'Wi-Fi on steroids'?



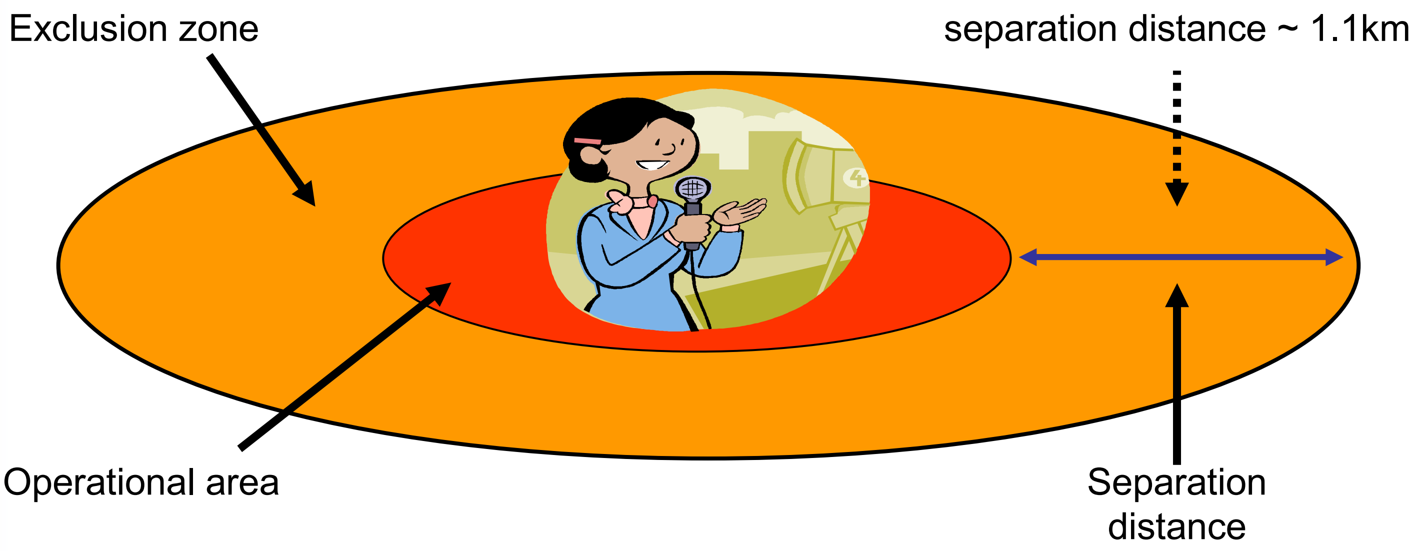
- Potential spectrum availability depends on where you are

  TV bands could be shared with 'white space devices'

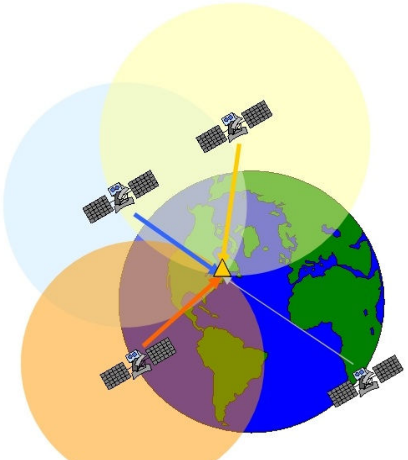
Figure: Ofcom

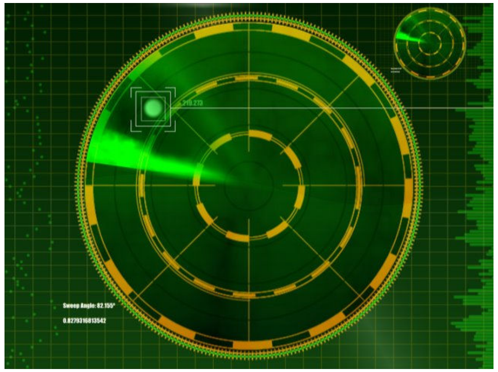
White space devices

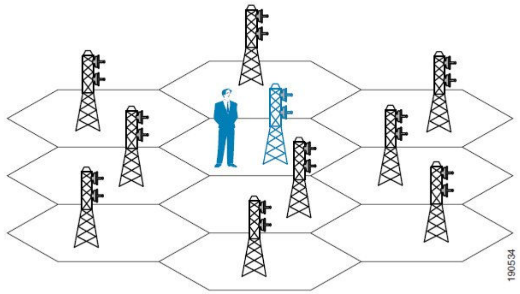
- Protecting PMSE users – is high accuracy important?
  - Reduce accuracy to 100m instead of 40m
    - Increases size of exclusion area from 1 sq.km to 1.2 sq.km
    - Applies at most to ~3000 PMSE locations & only when GPS not available
    - Reduction in availability of white space spectrum likely very small



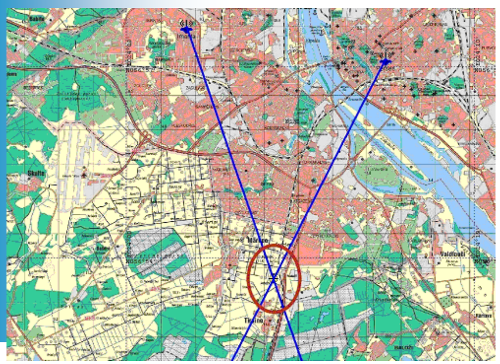
Introduction to general positioning methods

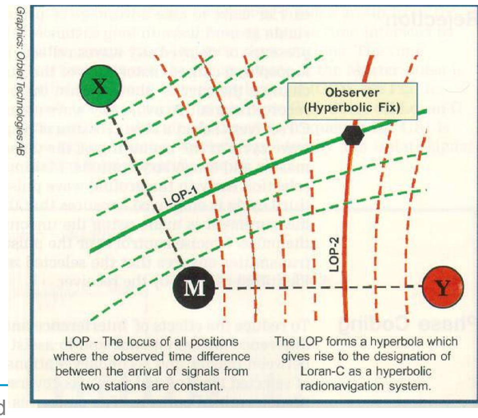


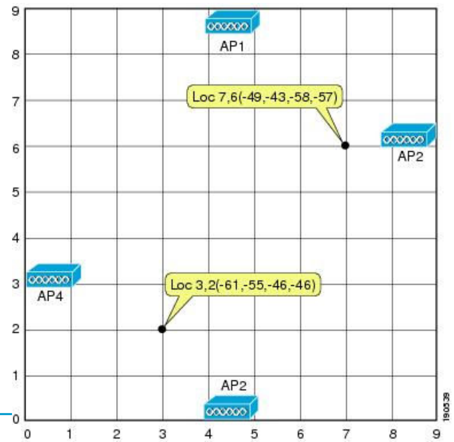




Angles, distances (times), proximity and pattern matching







Technologies covered

1. Global Navigation Satellite Systems (GNSS), for example GPS
2. Navigation infrastructure based solutions, for example Loran
3. Communications infrastructure based solutions, for example cellular
4. Broadcast infrastructure based solutions, for example TV
5. Local area and short range solutions, for example Wi-Fi
6. Non-wireless navigation solutions, for example inertial navigation (INS)
7. Solutions which deliver height information, for example baros
8. Integrated solutions, for example GPS with INS
9. Integrity monitoring solutions, for example RAIM
10. Upcoming and potential solutions, including more blue-sky approaches

Various proprietary solutions fall within the above

Plus users can self-declare their location, e.g. via social networking on the Internet, or be tracked indirectly via various databases

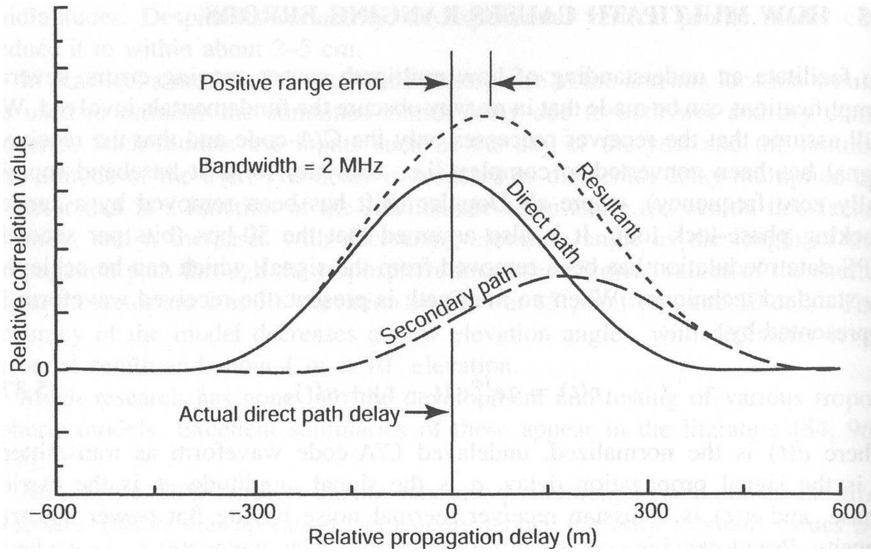
How hard is a 100m accuracy target?

- Native limitations of the technologies
  and / or
- Externally induced limitations (in addition to lower SNR)

1. Multipath

For all time of flight methods.

e.g. GPS accuracy can degrade to 50-200m



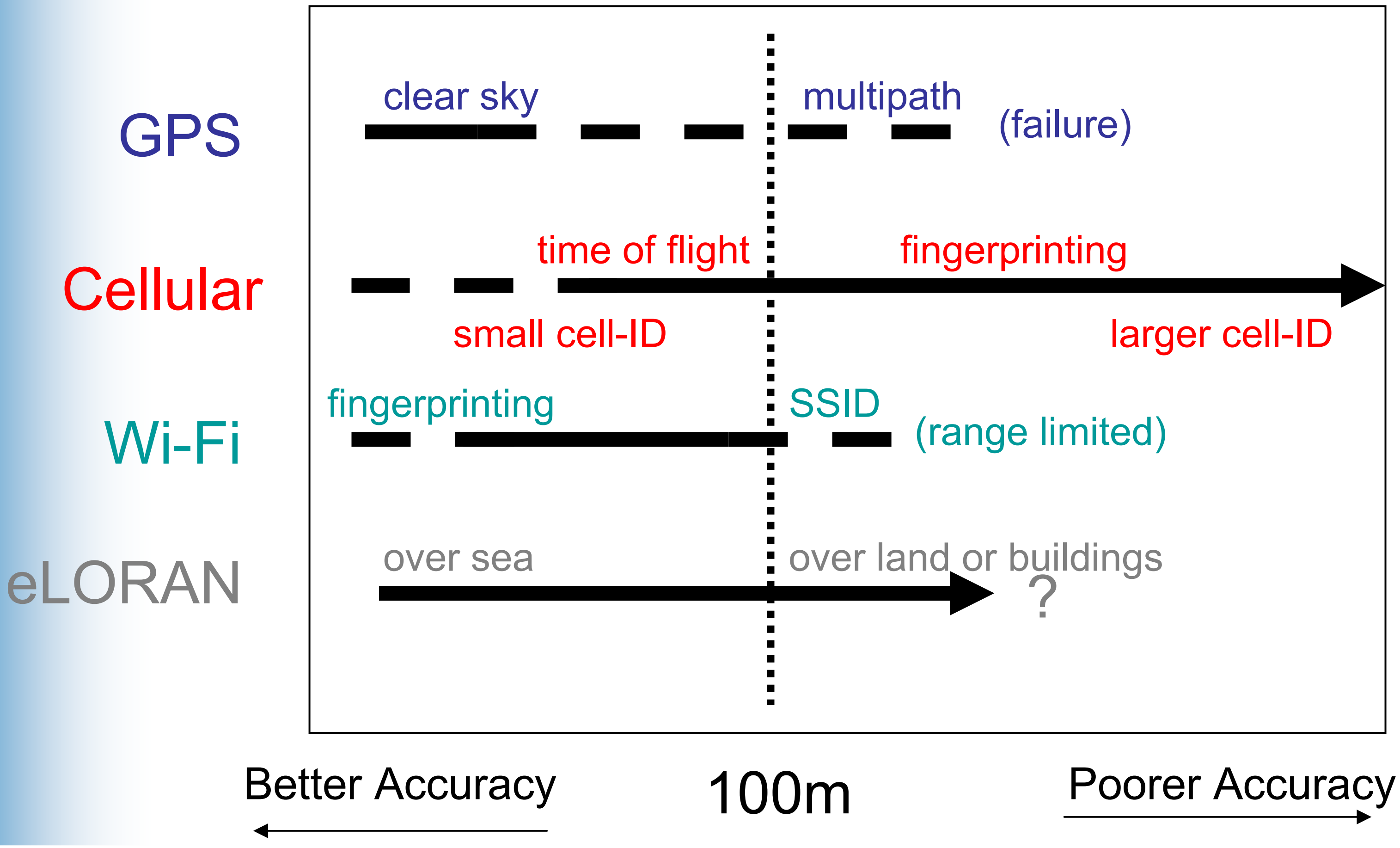
2. Near-far problem for Spread Spectrum (e.g. GPS)

A code cross correlation problem; GPS has only 23dB margin

May result in no position report

Figure: Grewal et al.

How hard is 100m? - examples



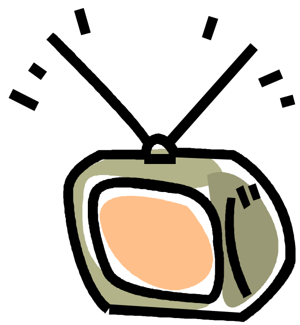
Matches 1 – no new infrastructure

- A1 - E911/112, LBS, LE sharing, and A2 – Femtocells

  Matched by T2 - GSM or Broadcast
  - **If** height requirement is removed
  - Little penalty seems to result

- A3 - Light licensing fixed links

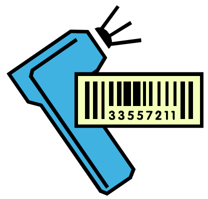
  Matched by T2 - GSM or Broadcast
  - **If** barometric altimetry is also used
  - Baros are practical in this fixed application



Matches 2 –new infrastructure

- A4 - ITS monitoring, personnel and asset tracking, emergency service personnel tracking
  - Matched by T3 - Short range - Wi-Fi, RFID, UWB, GPS beacons

- A5 - Indoor location, automated logistics
  - Matched by a subset of T3, with high height accuracy -
    - UWB – continuous tracking
    - RFID – discontinuous tracking



Matching – unmatched technologies

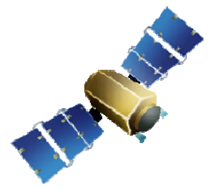
- T5 - eLoran
- T1 - A-GPS, GPS/INS

Agenda

- Conclusions – All Applications
- Conclusions – WSDs and Femtocells
- Conclusions – Future Applications

Conclusions – All Applications (1 of 2)

- No one location technology solution fits all applications;
- Future GNSS developments over the next ten years will not solve the indoor positioning problem, although a greater satellite density will help today's marginal cases, plus the deployment of GPS beacons would create location hotspots indoors;



- If we had 'position roaming' amongst the UK cellular networks, then the potential for cellular location not-spots would be reduced. If all cellular location devices monitored all networks then Cell-ID alone could be made more accurate from a fingerprint of which Cell-IDs were visible at any given location;

- Combination solutions will be increasingly important, such as with GPS, Wi-Fi, RFID, sensor networks, UWB etc. Higher accuracy 'location hotspots' could thus be created;

Conclusions – All Applications (2 of 2)

- A combination of positioning technologies will enable location in many more environments, but the differing levels of trustworthiness of the location reports from different sources may be harder to establish;

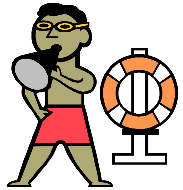
- Information on accuracy at high confidence levels is lacking for consumer positioning systems;

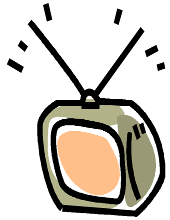
- Information on accuracy for consumer positioning system is often given for a standard operating environment. More information is needed on the performance of positioning systems in more challenging, real world environments;

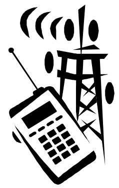
- Consumer devices are unable to report accuracy in real time, as they move between different operating environments. To increase the trustworthiness of these reports, user level integrity monitoring schemes are needed. Such schemes may check consistency across multiple positioning technologies and/or inertial sensors.

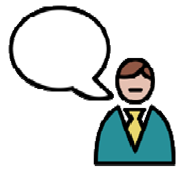
Conclusions – WSDs and femtocells

- A WSD should not cause interference to licensed users, thus where a WSD position fix is unreliable it should fail safe;
- WSD location accuracy can be traded against the size of the exclusion zone around a licensed user;
- Height information would benefit WSDs and femtocells, although its omission results in only a small penalty. However, it is only via the omission of the height requirement that a good match with any location technology is possible;
- GSM and broadcast based location technologies were best matched to WSDs and femtocells;
- Cell-ID is widely deployed in the UK today, but other cellular and broadcast location techniques are not yet deployed. This means that Cell-ID is presently the best matched location technology for WSD and femtocell applications, although its accuracy is lower than required for best efficiency in some scenarios.
- For femtocells, the simple option of the end user self declaring the installation location should not be discounted and is already in use today in the UK. Femtocells are always connected to the broadband infrastructure so the physical connection identifier could be used to confirm location.







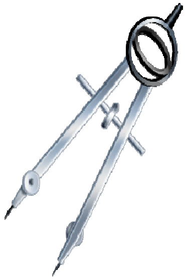


Conclusions – Future Applications

- We expect the EU may instigate E112 location in manner similar to E911 in the USA. It is possible that even greater accuracy will be required, based on EU research into the location requirements of the emergency service professionals who attend incidents. This could become a driver for far stricter femtocell location accuracy and would be very challenging to meet. The accuracy required may need to be re-evaluated against what is achievable in practice;

- Multipath distortion means accuracy better than 100m (95%) is unlikely to be available in all environments, all of the time, for technologies with nationwide coverage. This includes present and future cellular or broadcast based location systems;

- Accuracy very much better than 100m (95%) can be provided by short range solutions. These rely on local infrastructure and are less economically attractive for nationwide deployment. However Wi-Fi is already quite widely deployed to provide a communications service, although it is not nationwide.



Thank you

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