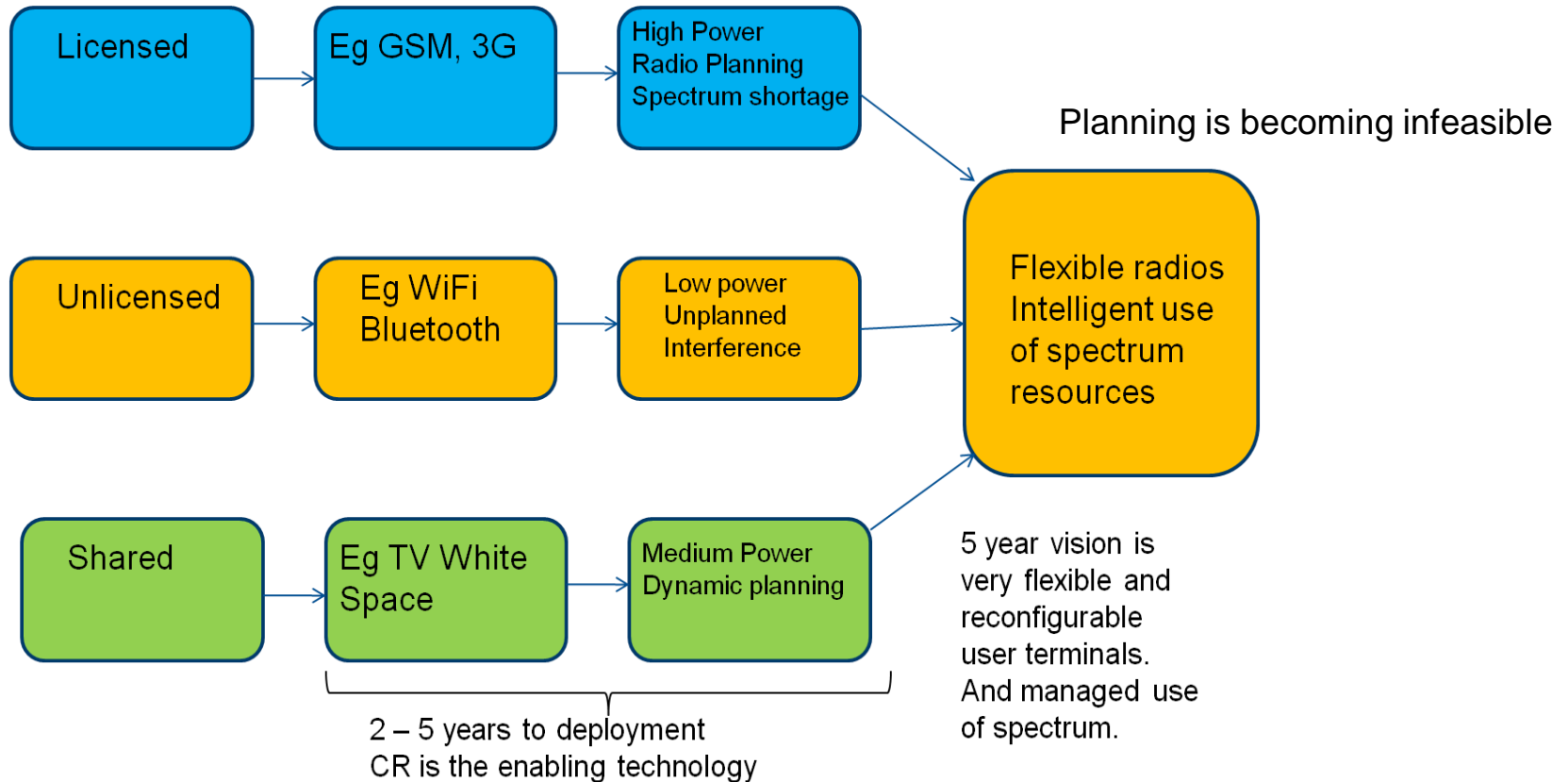


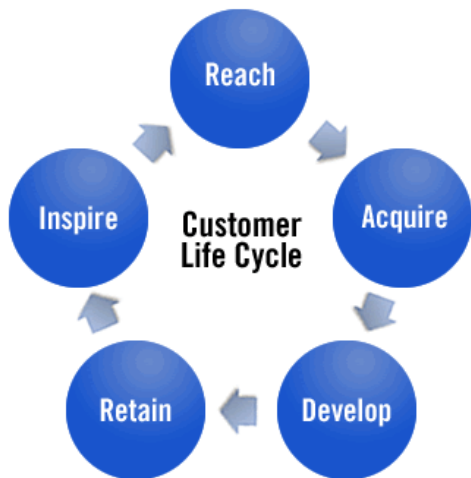
# Lessons from QoSMOS on TVWS

Michael Fitch

# A shift away from binary licensed / unlicensed towards smart sharing



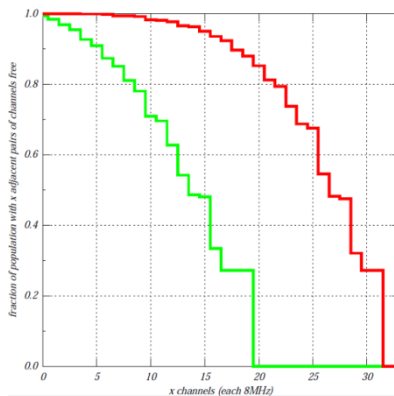
# TVWS ingredients:



**Adequate customer volumes**  
For viable business



**Mature open standards**  
to ensure multi-national market  
and vendor choice



## Effective spectrum management

To mitigate interference and ensure fairness among TVWS users

## Right regulatory conditions

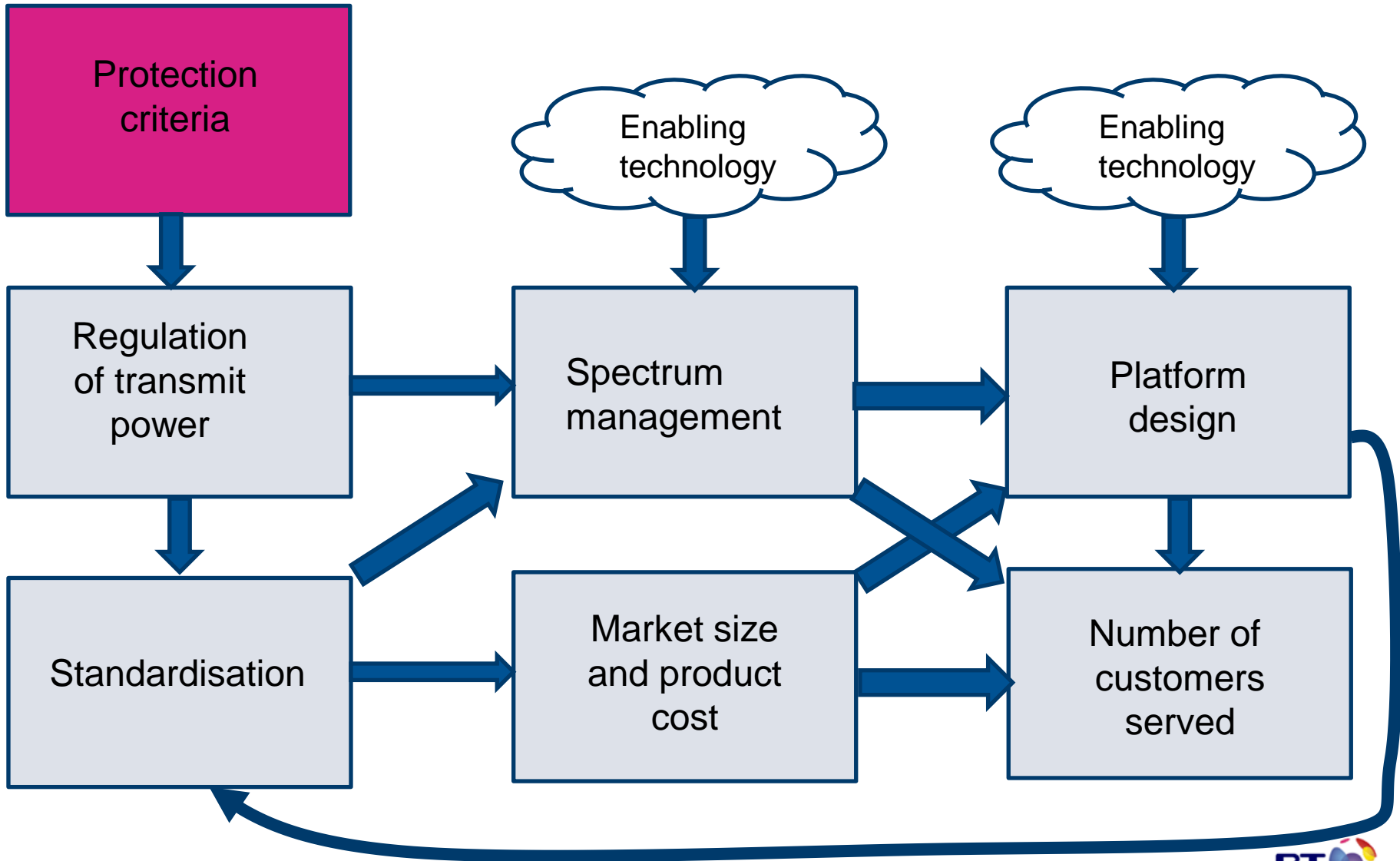
Protection of primary services while allowing suitable signal powers



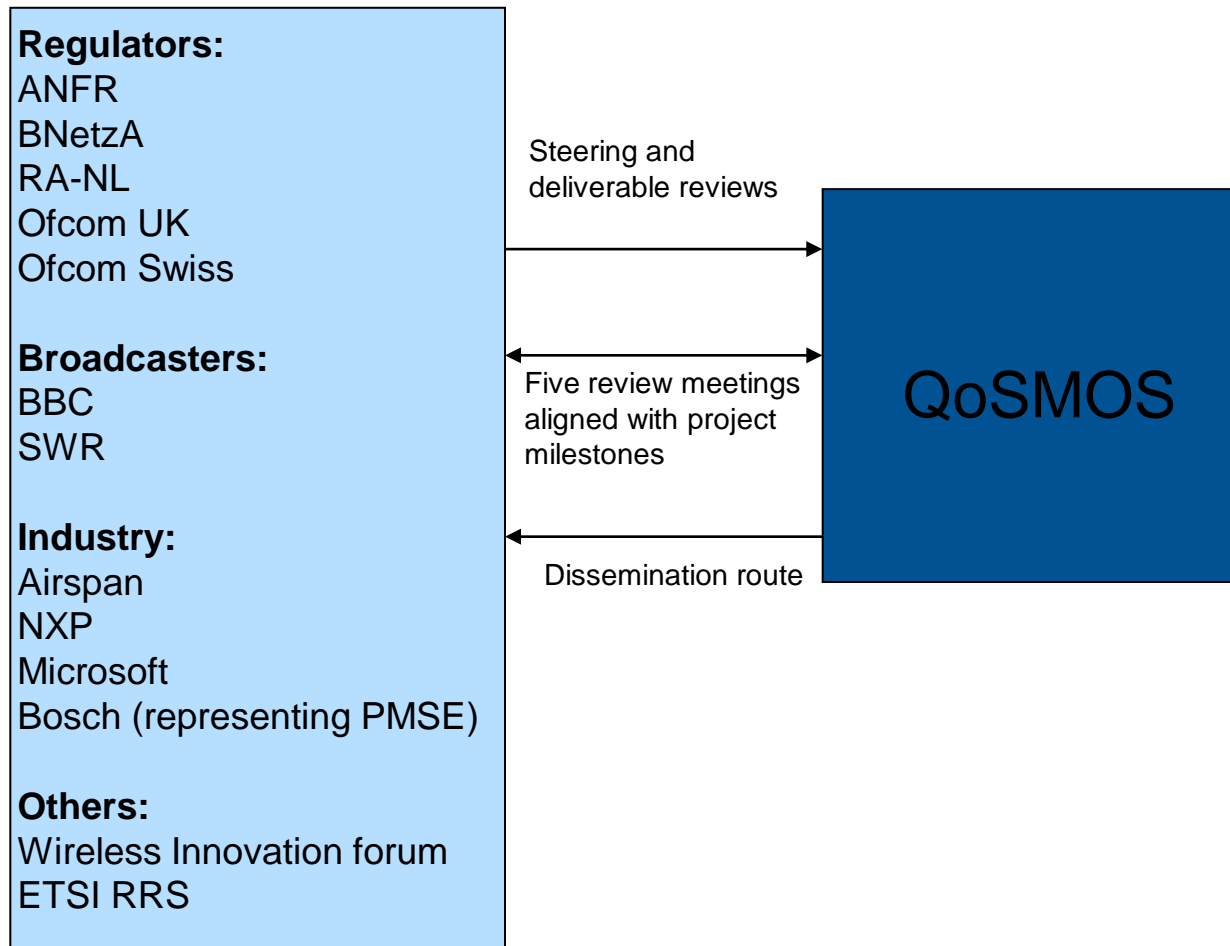
**Large vendors interested**  
for workable costs and choice

# Ingredients are inter-dependent

Protection criteria are cautious and progressive



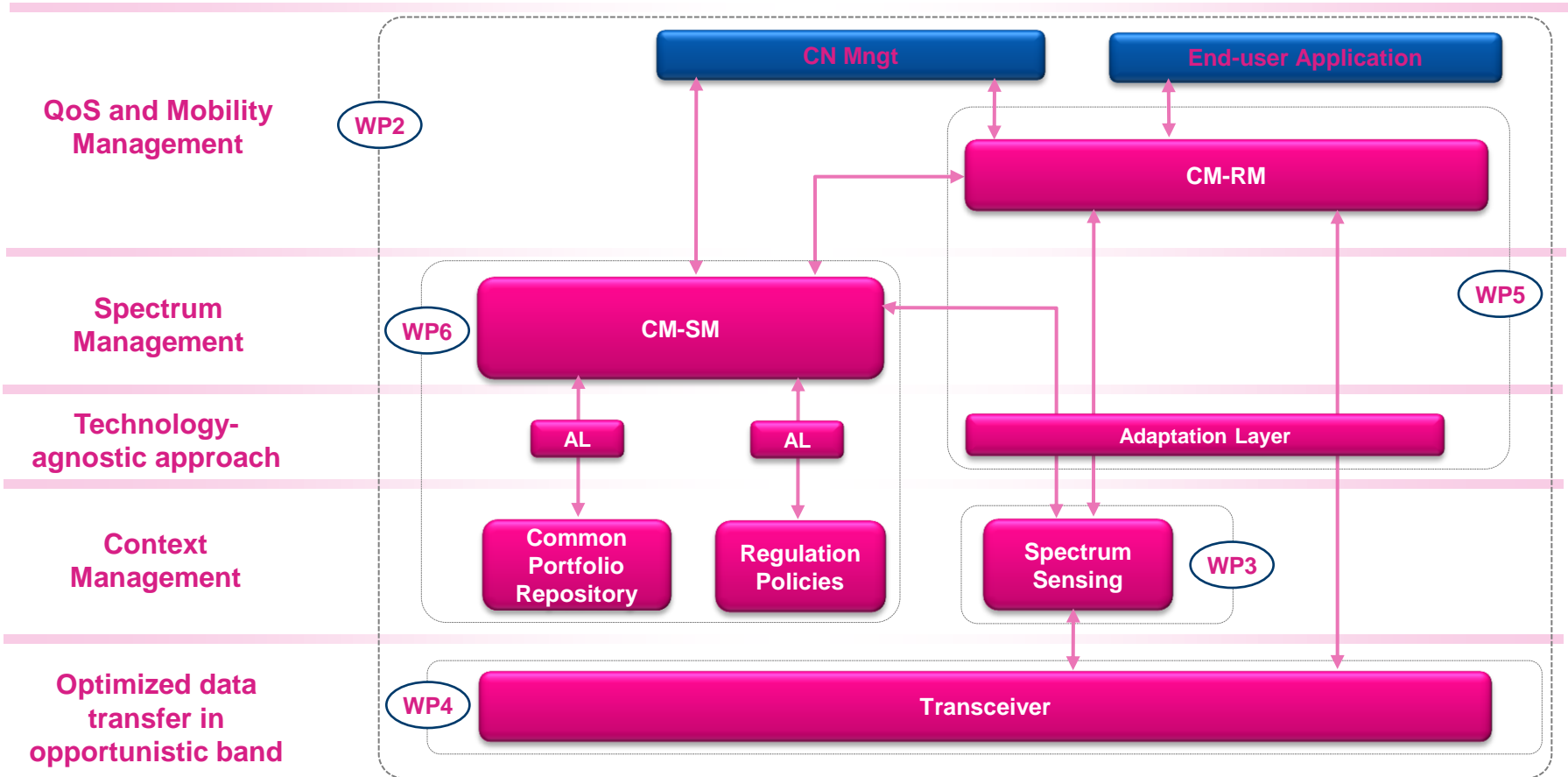
# Involve stakeholders that will be affected



# Use a two-stage spectrum manager augmented with sensing

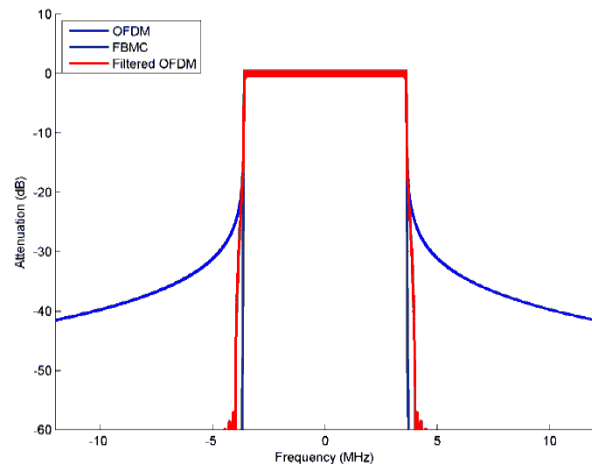
## Challenges

## Architecture

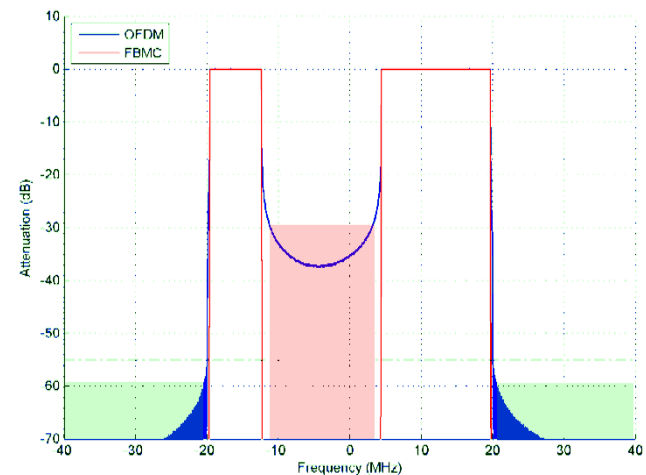


# Have a PHY layer that enables sharing

- Filter Bank Multiple-Carrier (FBMC) emerged as a strong contender and has as been developed and prototyped in the context of the TVWS
- FBMC is here benchmarked against OFDM (incl. 3GPP LTE PHY)



**FBMC vs OFDM with 480 active carriers of LTE**



**Fragmented spectrum usage with FBMC**

# One-slide summary of what we have achieved...

- Use-cases defined and business modelling tools developed
  - We have looked at the most viable markets and sensitivities
  - Allows more efficient spectrum sharing, through protocols and less wastage
- Radio environment modelling and awareness
  - Performance limits are now known for a wide range of sensing methods
- Spectrum management architecture
  - System solution for QoS and mobility, including a prototype database -> ETSI RRS, IETF PAWS
- Physical layer
  - Allows more efficient spectrum sharing, through reduction in interference -> IEEE P.1900-7



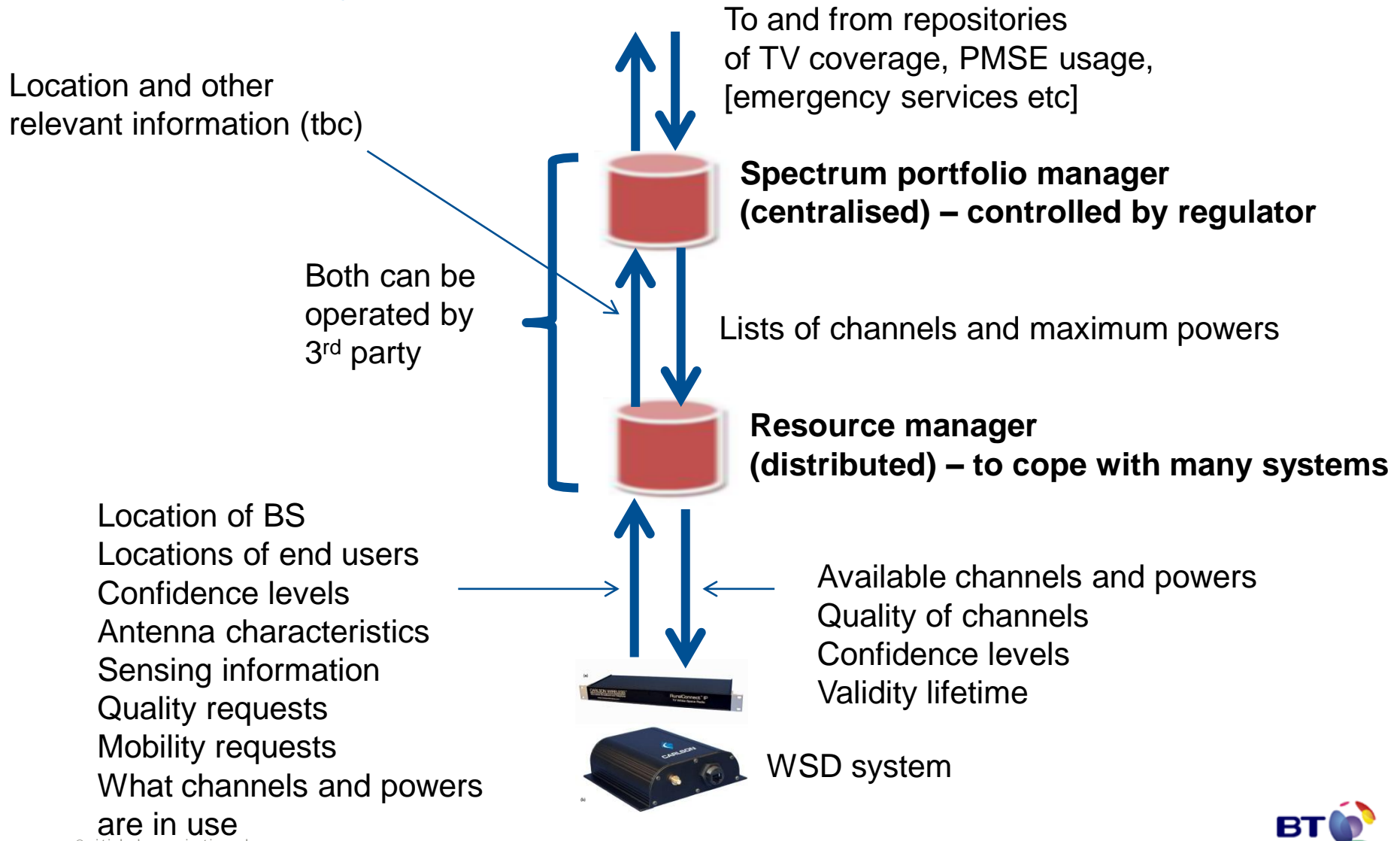
# Further work needed (what would we like to do?)

- Fairness between WSD spectrum allocations
  - Co-operation between databases
  - IETF PAWs working on protocols but not this issue
- Development of better tools for WSD transmit power calculations
  - Tools to aid installation
  - Aggregate interference
- Towards M2M with TVWS
  - Business case evaluation
  - Coping with increase of scale of connections
    - Increasing distributed nature of spectrum manager
    - Integration with fixed network and taking advantage of virtualisation
    - OSS development for scale of connections and lowering barriers to entry for operators

Thanks for listening

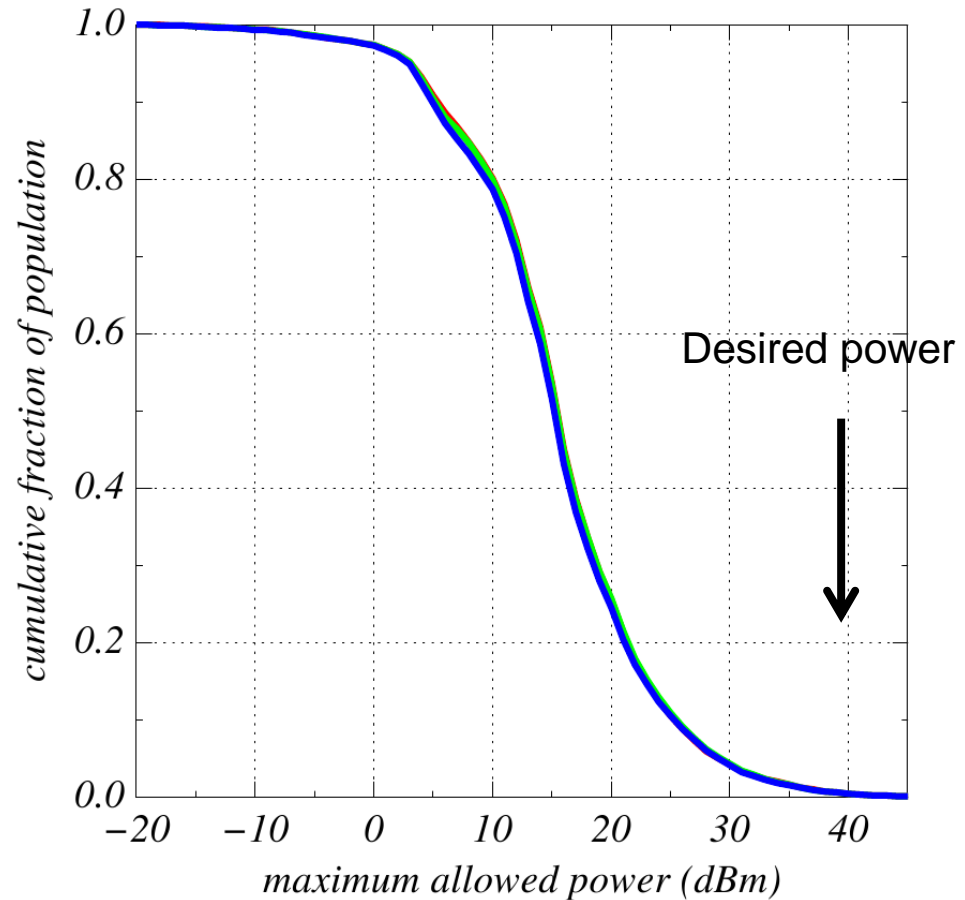
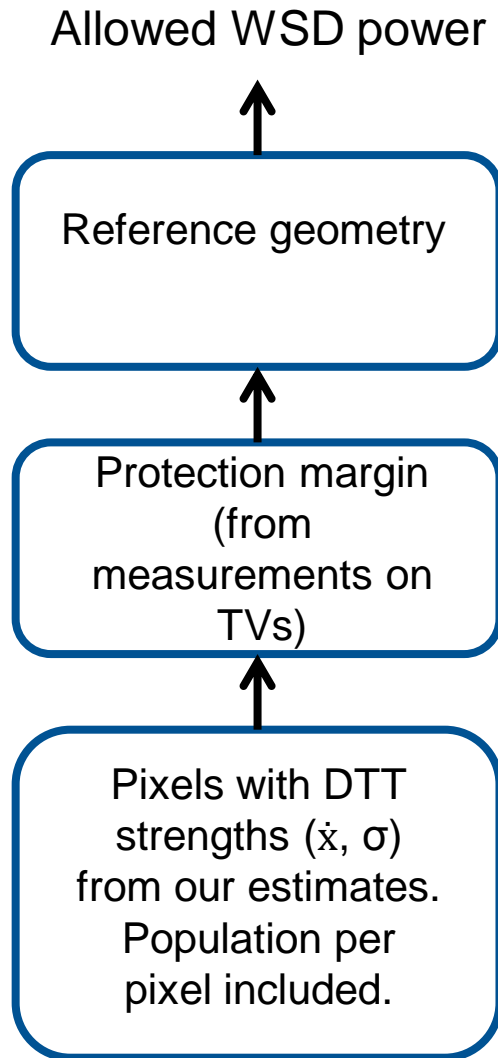
<http://www.ict-qosmos.eu>

# Spectrum management – a possible approach from FP7 QoS MOS project [www.ict-qosmos.eu](http://www.ict-qosmos.eu)



Fairness between WSD devices is an ongoing research problem

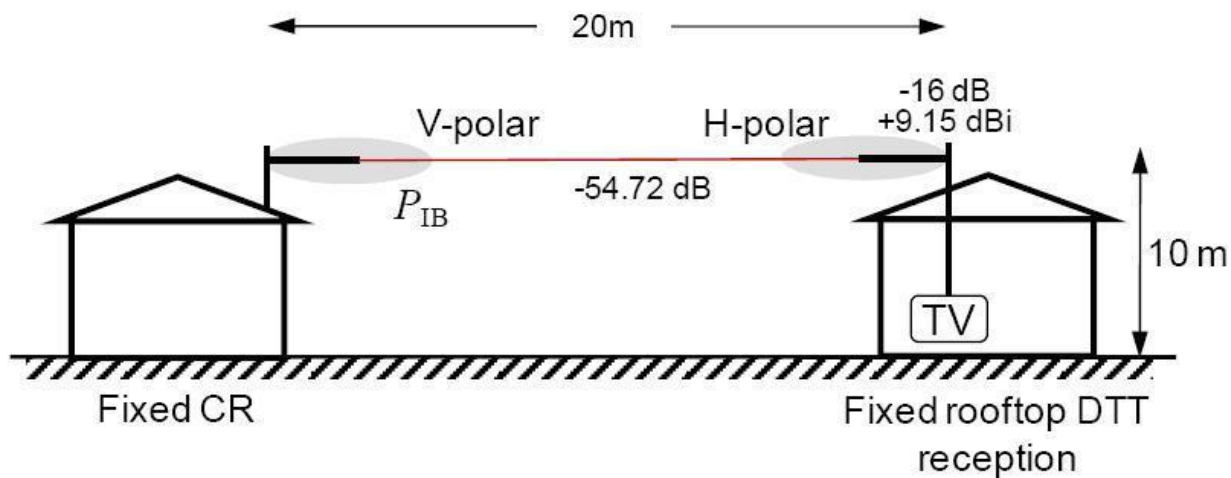
# TVWS availability modelling



Output from BT implementation of model (all TV channels protected -80dBm)

Of the three steps, it is the Reference Geometry that has the most potential for improving the maximum allowable power

# Reference geometry



This geometry is applied as default in absence of planning, which is valid in only a tiny minority of cases. It is the approach used when spectrum is totally unplanned.

Trials run by BT have shown the reference geometry case to be overly conservative – and are running today at 10W transmit powers with no interference caused

There is a need for expert tools to assist deployment of WSD, especially base-stations, which will lead to the transmit powers we need in most situations