Friedrich-Alexander-Universität
Erlangen-Nürnberg

# Institute for Electronics Engineering

Prof. Dr.-Ing. Dr.-Ing. habil. Robert Weigel
Prof. Dr.-Ing. Georg Fischer

## ETSI Specialist Task Force STF386
## (PMSE) – Cognitive Radio ERM / TG17 WP3

*Methods, parameters and test procedures for cognitive interference mitigation techniques for use by PMSE devices (Programme Making and Special Events)*

Prof. Dr.-Ing. Georg Fischer, Chairman of STF386

EU Cognitive Radio Workshop
Brussels, 28. January 2010

ETSI World Class Standards

# Agenda

1. What is PMSE?
2. Digital Dividend
3. ETSI STF386 overview
4. Specific PMSE requirements
5. C-PMSE  (Cognitive PMSE)
6. Conclusions

# 1 What is PMSE?

# What is PMSE?
System

**Definitions**

- PMSE = Program Making and special events
- PWMS = Professional wireless Microphone system
- IEM = In Ear Monitor
- SAB = Services Ancillary to Broadcasting
- SAP = Services Ancillary to Programme making
- PMSE not only includes wireless audio, but also wireless video
- PMSE is operating as secondary user in TV spectrum

*Wireless Microphone*

PMSE delivers the content for wireless and wireline networks!

*Camera receiver*

**Applications Broadcast TV/Radio**

- Productions of any kind
- Recordings for CD/DVD/Internet distribution
- Live shows, reportages, Interviews
- ENG – Electronic News Gathering
- OB – Outside Broadcast

*Bodypack for ENG*

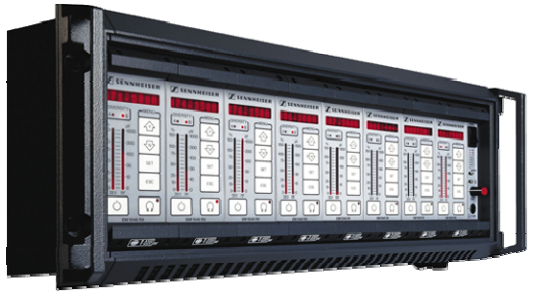
*Wireless mic*

# What is PMSE?
System

## Professional applications – Program production

- Opera
- Theatre
- Musical
- Shows
- Concert hall / event halls
- Congress centers
- Cabaret
- Clubs, bars, casino
- Live events, music, festivals
- Press centers
- Conference centers
- Presentations
- And much more..

PMSE delivers the content for prof. distribution



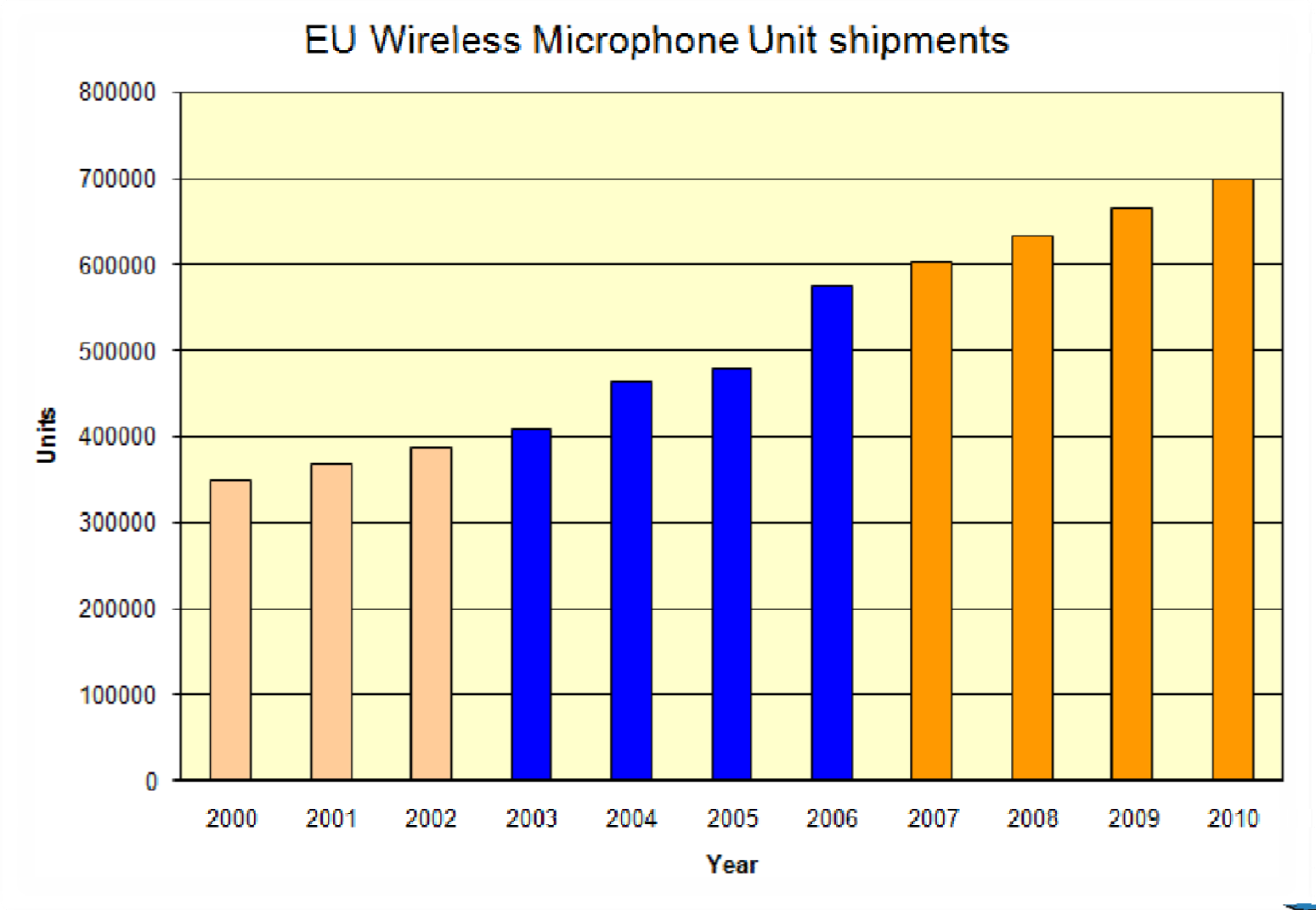
*8 channel receiver*

*wireless instrument transmitter*

*PMSE receiver*

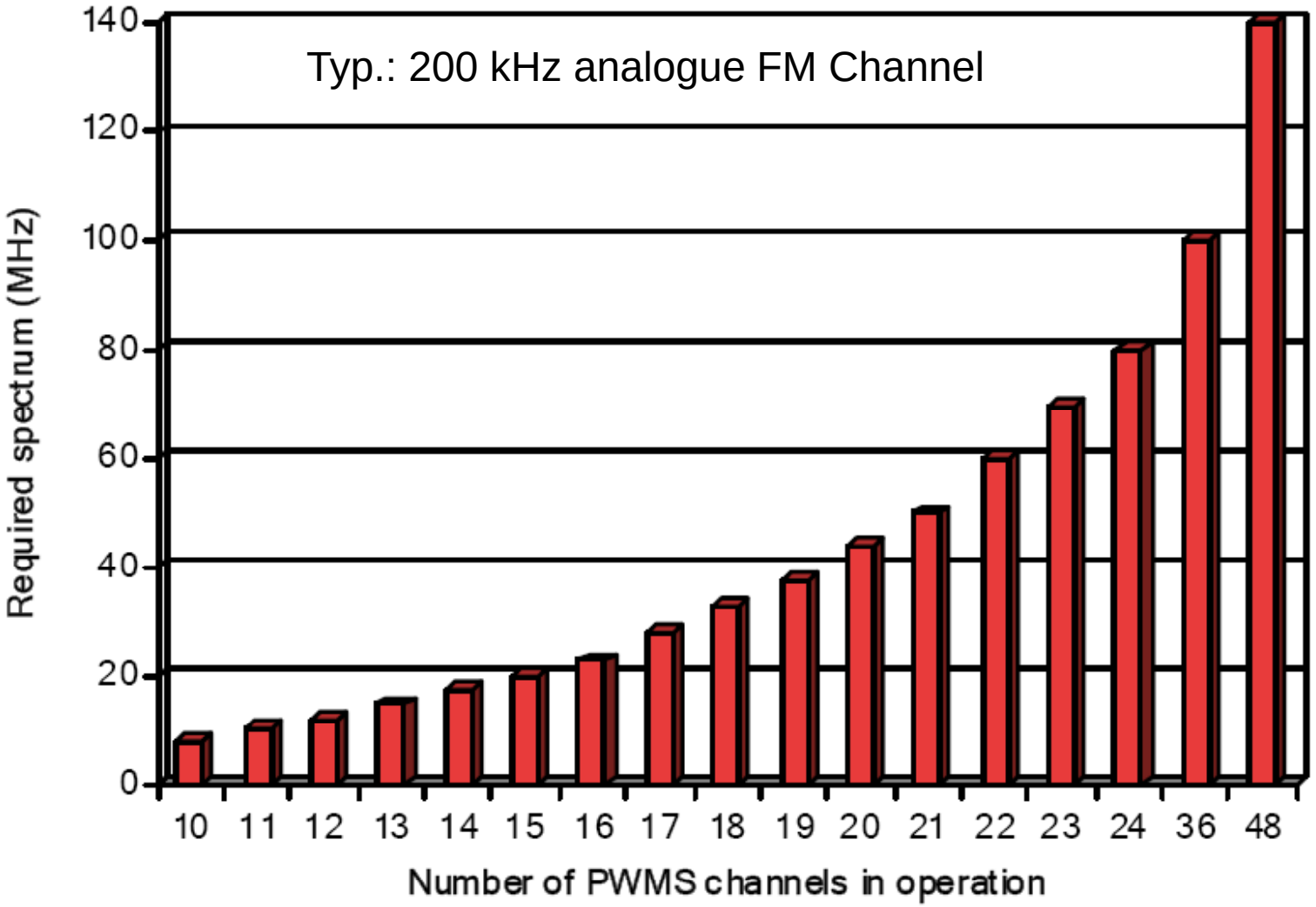
# What is PMSE?

EU Market size (source PAMA study)



# What is PMSE?

Spectrum need



# What is PMSE?
Spectrum need

## Eurovision Song Contest

- 2008 Belgrad, Serbia

## Complexity of PMSE

- 27 handheld transmitters, mics
- 27 transmitters, instruments
- 30 twin receivers
- 12 twin transmitters
- 24 monitoring receivers
- Various antennas, boosters, splitters and combiners
- Additional wireless microphones off-stage and outdoor
- Careful frequency/interference planning
- Man made noise by stage effects
- Collision risk with on tour applications

Photo: Daniel Aragay from Terrassa, Catalunya

## The business

- 43 countries took part at the grand Prix in Serbia
- Up to 250 Million spectators
- Several 100 Million SMS

**66 wireless PMSE links!**

# 2 Digital Dividend

# Digital Dividend

UHF spectrum

## Attractiveness of low frequencies

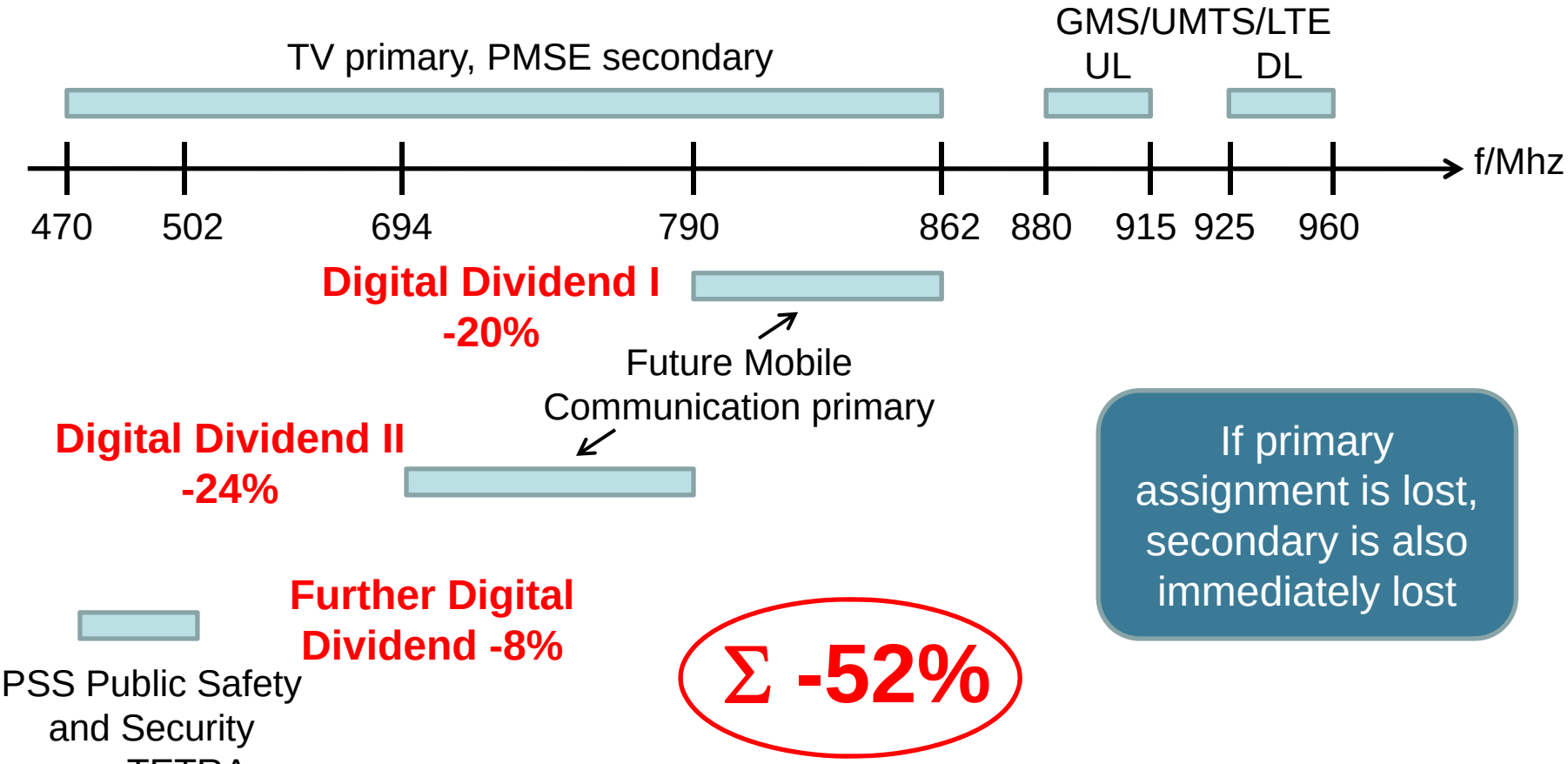
- Strong interest by Mobile Communication Network operators to lower frequency, as network rollout costs are dramatically lower
- Reason
  - Cutting frequency to half: f ½
  - Link Budget improved by: 7...10 dB
  - Cell Radius: x 1.7....2.15
  - Cell Area: x 2.9...4.64 (+193...365%)
  - Saving of cell sites: -66...-78%
  - Investment only 33...21%
- Initial network deployment at a fraction of costs when lowering frequency
- Better penetration into buildings, wall loss lower
- Wireless internet in rural areas
- Better support for high mobility e.g. ICE train *(T-Mobile is operating a 450 MHz Flash-OFDM System to feed WLANs APs in trains)*

# Digital Dividend

Frequency assignments

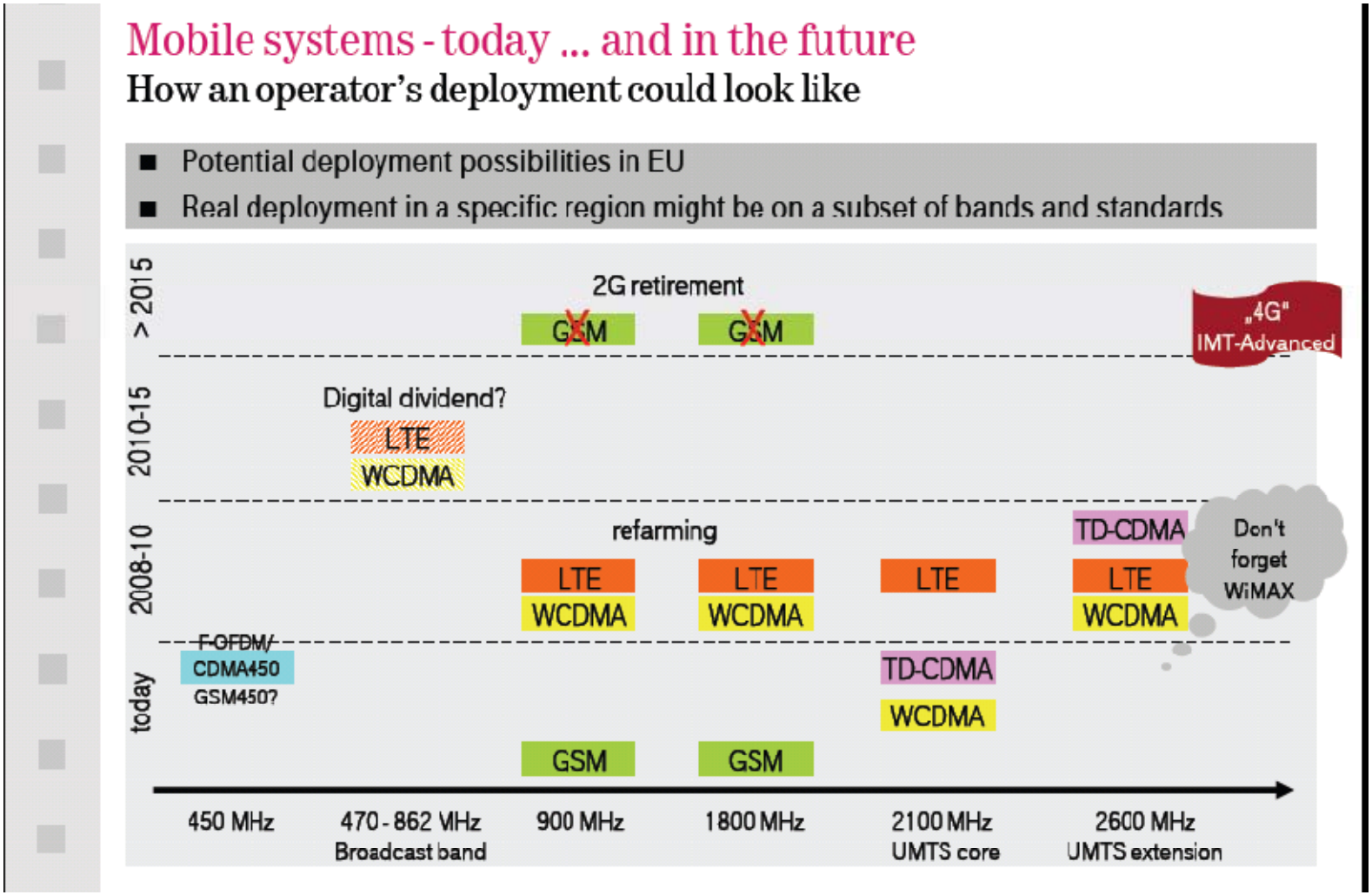
## Prerequisite

- Terrestrial TV transition from analogue to digital (DVB-T) will clear part of TV spectrum



# Digital Dividend

T-Mobile view

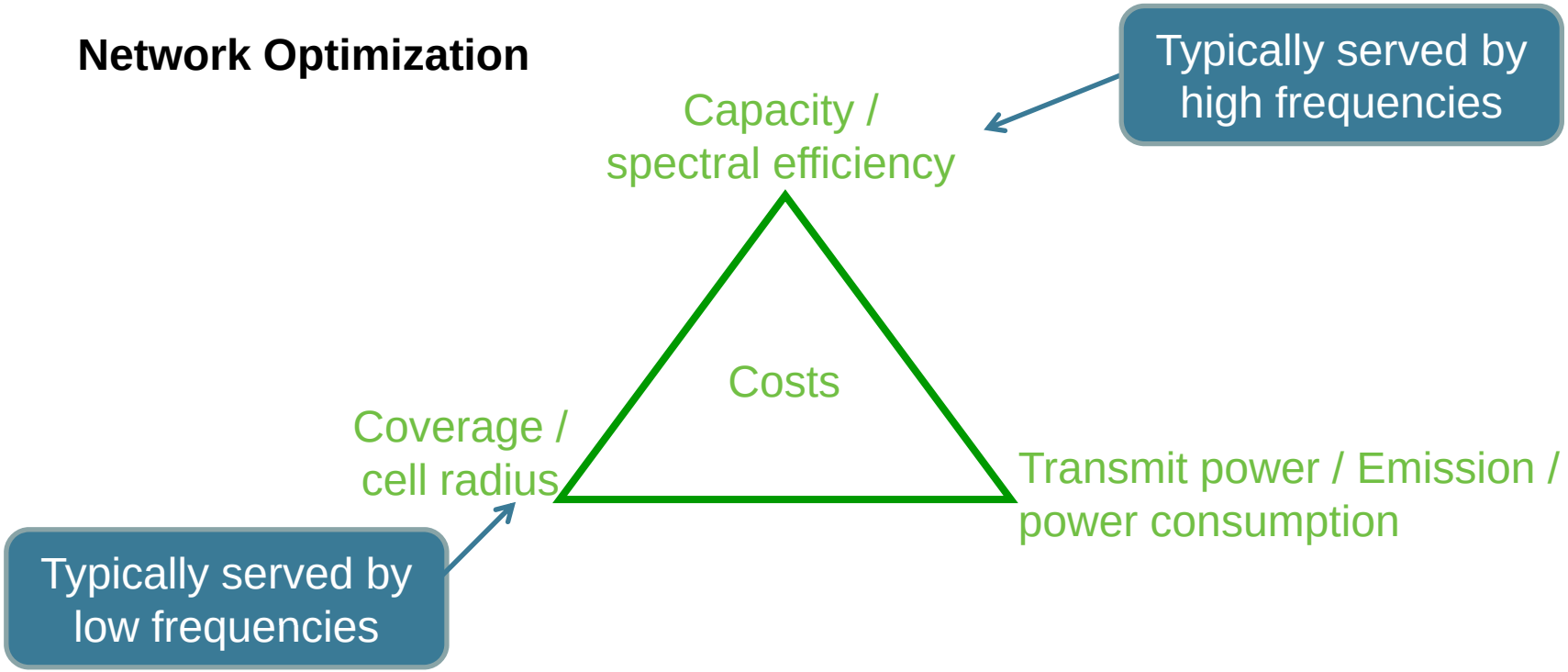



*Source: T-Mobile Multiband-Multistandards symposium, Bonn 11th May 2006*
*Future challenges and requirements from an operator's perspective, Dr. Raimund Walsdorf, RAN Strategy*

# Digital Dividend

Degrees of freedom in a reconfigurable multiband network

## Network Optimization




**See also:**

## Increased Flexibility

- Multiband networks [450 MHz…4 GHz]
- Scalable air interface, channel width1.25…20 MHz (LTE/WIMAX)
- TDD and FDD operation, e.g. operation in duplex gap

# 3 ETSI STF386 overview

# ETSI STF386 overview

Set-up

## Instrument STF

- ETSI Specialist Task Force
- Expert team working for a limited period of time
- Funding by ETSI, 150 working days
- Focus on a specific technical question

## Scope

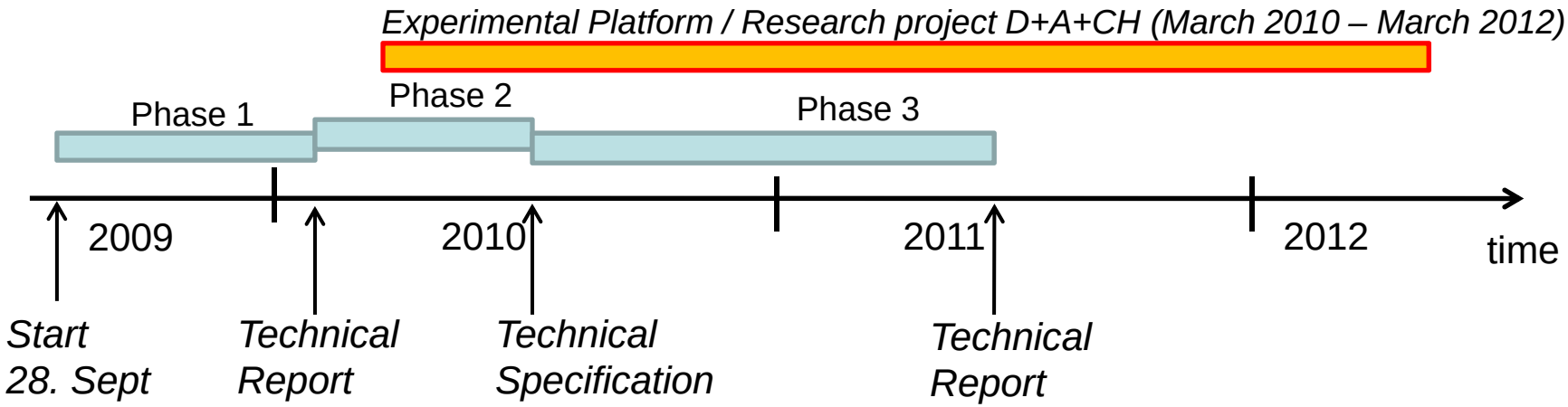
- Set by ToR (Terms of reference): "*Methods, parameters and test procedures for cognitive interference mitigation techniques for use by PMSE devices (Programme Making and Special Events)*"
- Purpose: *Achieve co-existence of high audio quality PMSE devices using often a 100% transmitter duty cycle emission profile with victim radio services such as Services in L-Band or Broadcast Services and future Land Mobile Services and applications in the UHF frequency range that is currently under investigation under the "Digital Dividend" discussions in EC, ECC and ETSI fora.*

# ETSI STF386 overview

Schedule

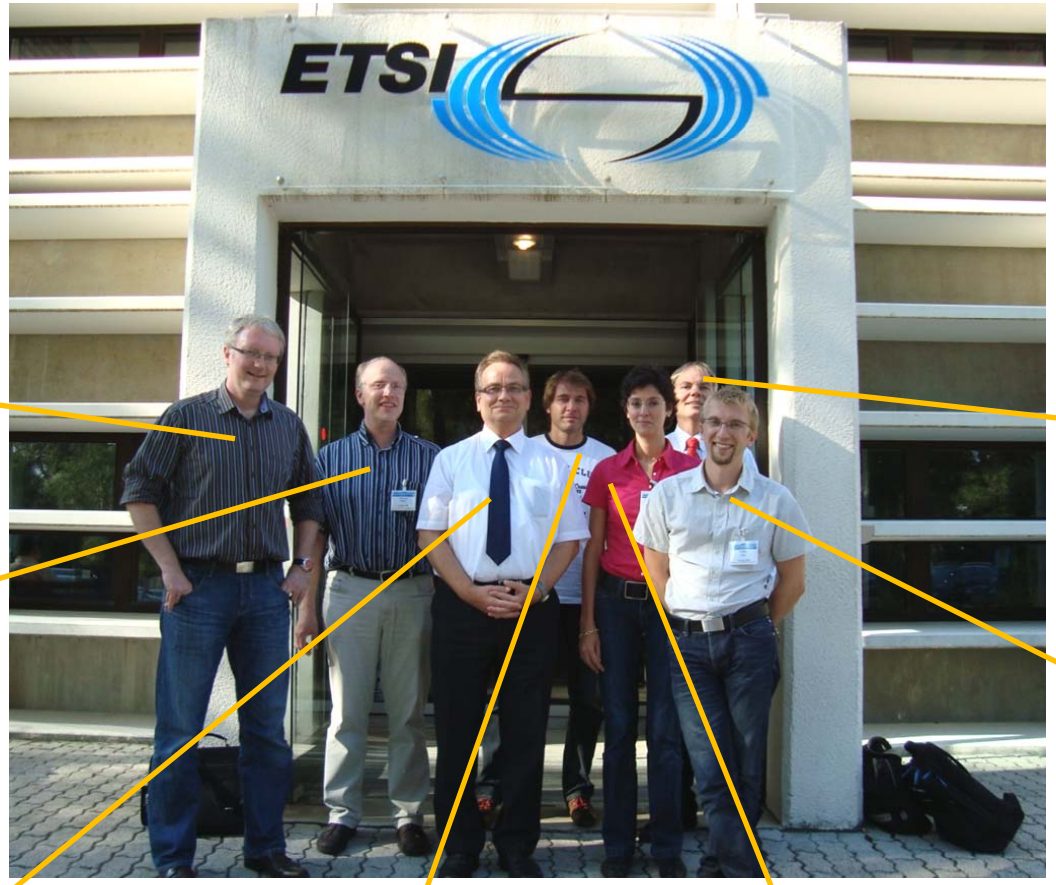
## Phases

- Phase 1: ETSI Technical Report on “Operation methods and principles for spectrum access systems and quality control of used spectrum for PMSE technologies utilising cognitive interference mitigation techniques”: TB approval November 2009 (delayed to January 2010).
- Phase 2: ETSI Technical Specification on the recommended spectrum access technique: TB approval June 2010.
- Phase 3: ETSI Technical Report of the different RF compliance tests for the selected spectrum access mechanism: TB approval June 2011



# ETSI STF386 overview

Team




Wolfgang Bilz
(Shure EU)
***Chairman***

Prof. Georg Fischer
(UNI Erlangen)
***Chairman***

Matthias Fehr
(APWPT)

Dr. Axel Schmidt
(Sennheiser)

Dr. Maria Dolores
Perez-Guario
(UNI Hannover)

Edgar Reihl
(Shure US)

Dr. Radu Circa
(Bosch conference
systems)

*IRT will join*

# ETSI STF386 overview

Background info

## Objection by PMSE community

- Production companies fear that there is not enough spectrum to support a full featured production
- Constant growth in spectrum need for production
- Production companies and equipment manufacturers (e.g. AKG, Audio-Technica, Beyer dynamic, Bosch, Sennheiser, Shure...) cannot agree that their spectrum grant is reduced
- Association APWPT “Association of Professionals in Wireless Production Technologies” Slogan: “Save our Spectrum” http://www.apwpt.org/

## Questions

- Is the spectrum need by PMSE justified?
- Why is PMSE so spectrum hungry?
- Are the PMSE wasters of spectrum?
- What technical methods could be implemented to boost PMSE spectral efficiency?

APWPT
ASSOCIATION OF PROFESSIONAL WIRELESS PRODUCTION TECHNOLOGY

# 4 PMSE requirements

# PMSE requirements
Specialities

**Highest Audio Quality demands**

- Serve studio/CD quality 44 kSa/s,16 bit (Current state. Develops!)
- Lowest latency < 3ms roundtrip (drummer: mic-mixing console-monitor)
- No interruptions, availability 100% of time
- Calculation:
  - Mic Audio SNR: 100 dB (*orchestra even does 140 dB*)
  - Compander gain: 40 dB *(analogue, no significant delay!)*
  - FM process gain 10 dB *(20 kHz Audio on 200 kHz channel)*
  - Results in 50 dB C/I on RF channel

**Actual Technology**

- Analogue transmission, digital source coding would cause too much delay
- FM modulation
- Constant Envelope provides long operation time for wireless microphones and body pack instrument transmitters
- Proprietary digital systems just enter the market.

# PMSE requirements

Comparison PMSE versus cellular

| | PMSE | Cellular |
|---|---|---|
| Audio Quality | Highest for content production | Only speech |
| Audio rate | CD: 44 kSa/s, 16 bit<br>704 kbit/s | 8 kSa/s, 13 bit<br>104 kbit/s |
| Compression | Analogue compander | Digital source coding |
| Comp Audio rate | 352 kbit/s | 12 kbit/s |
| Channel arrangements | 15 channels in 20 MHz | 75 channels in 5 MHz |
| Raw Audio related spectral efficiency | 0.5 bit/s/Hz | 1.56 bit/s/Hz |
| Compressed Audio related spectral efficiency | 0.25 bit/s/Hz | 0.18 bit/s/Hz |

## Conclusions

- PMSE is not a waster of spectrum (in light of audio quality to be delivered)!
- PMSE Analogue compander very effective
- Cellular suffers from a lot of signalling overhead

# PMSE requirements

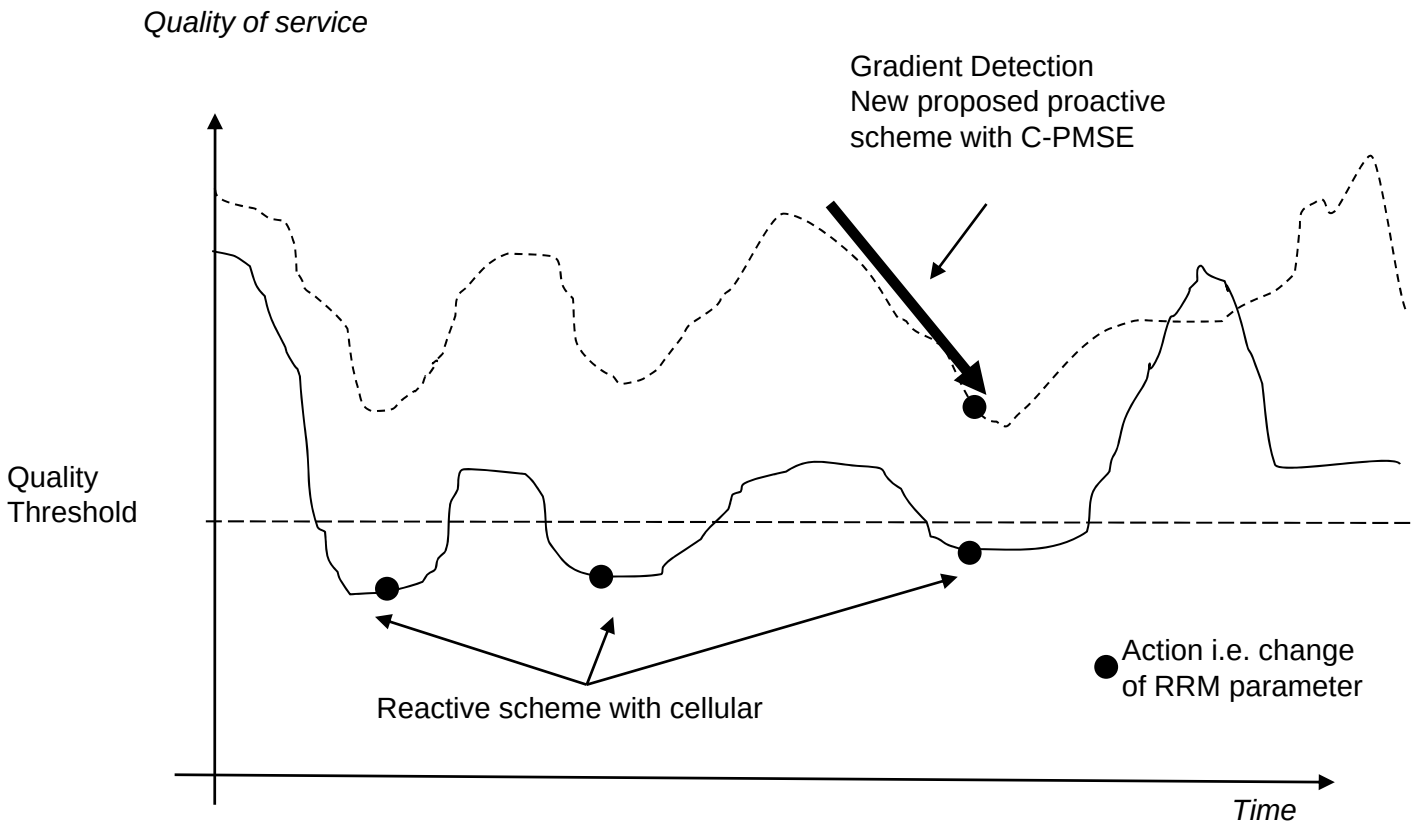
## Comparison PMSE versus cellular

| | PMSE | Cellular |
|---|---|---|
| Transmission | Analogue FM | Digital GMSK...128QAM |
| Crest | 0 dB | ≈14 dB with OFDM |
| Interruptions | None | Short e.g. 20 ms |
| RRM | Fixed power, fixed frequency, fixed modulation | Resource allocation<br>Power control, Handover, adaptive modulation and coding |
| Mobility | 54 km/s<br>e.g. Starlight Express | 250 km/h<br>e.g. GSM, UMTS |

# 5 C-PMSE (Cognitive PMSE)

# C-PMSE

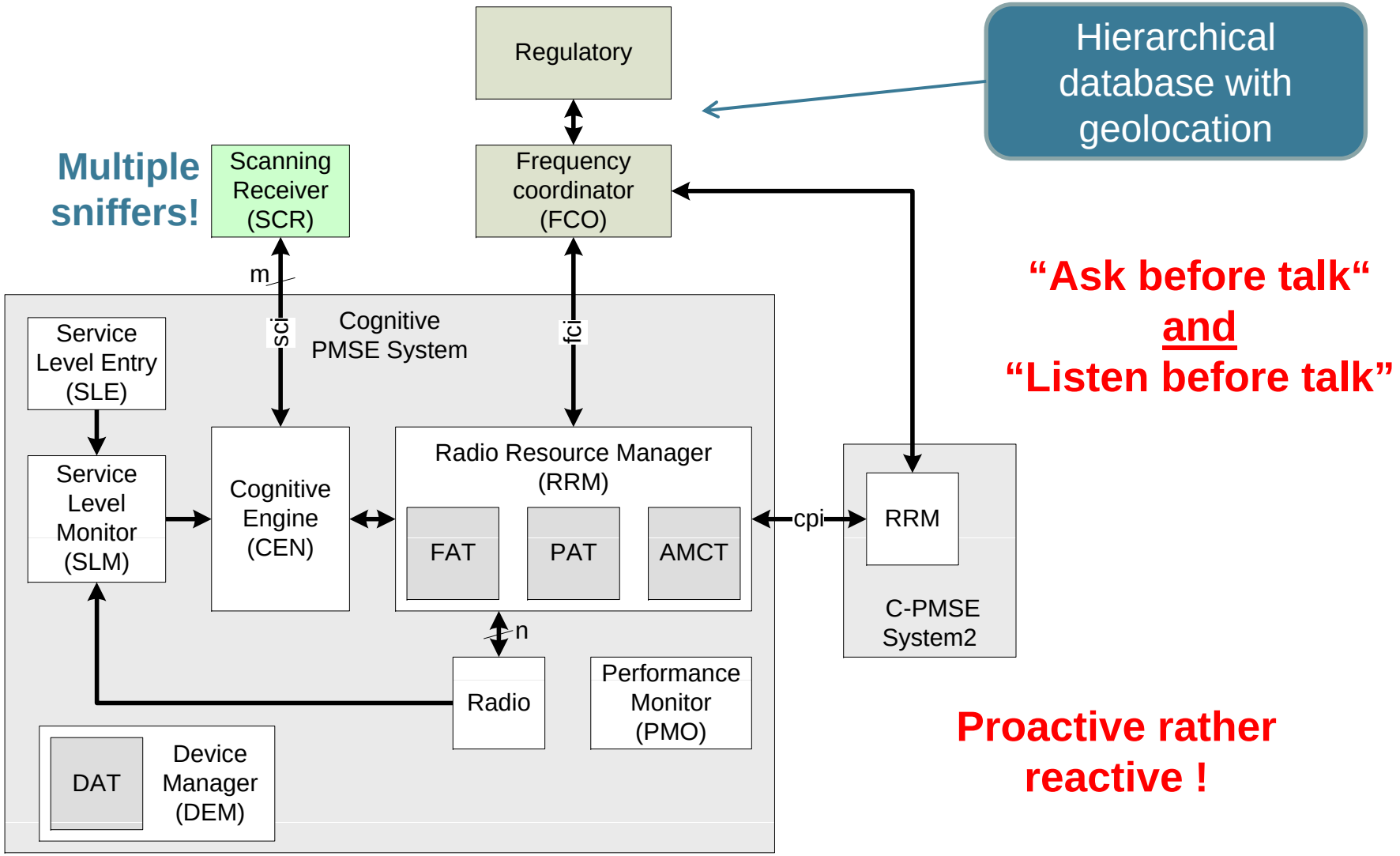
## Link quality supervision




### RRM scheme

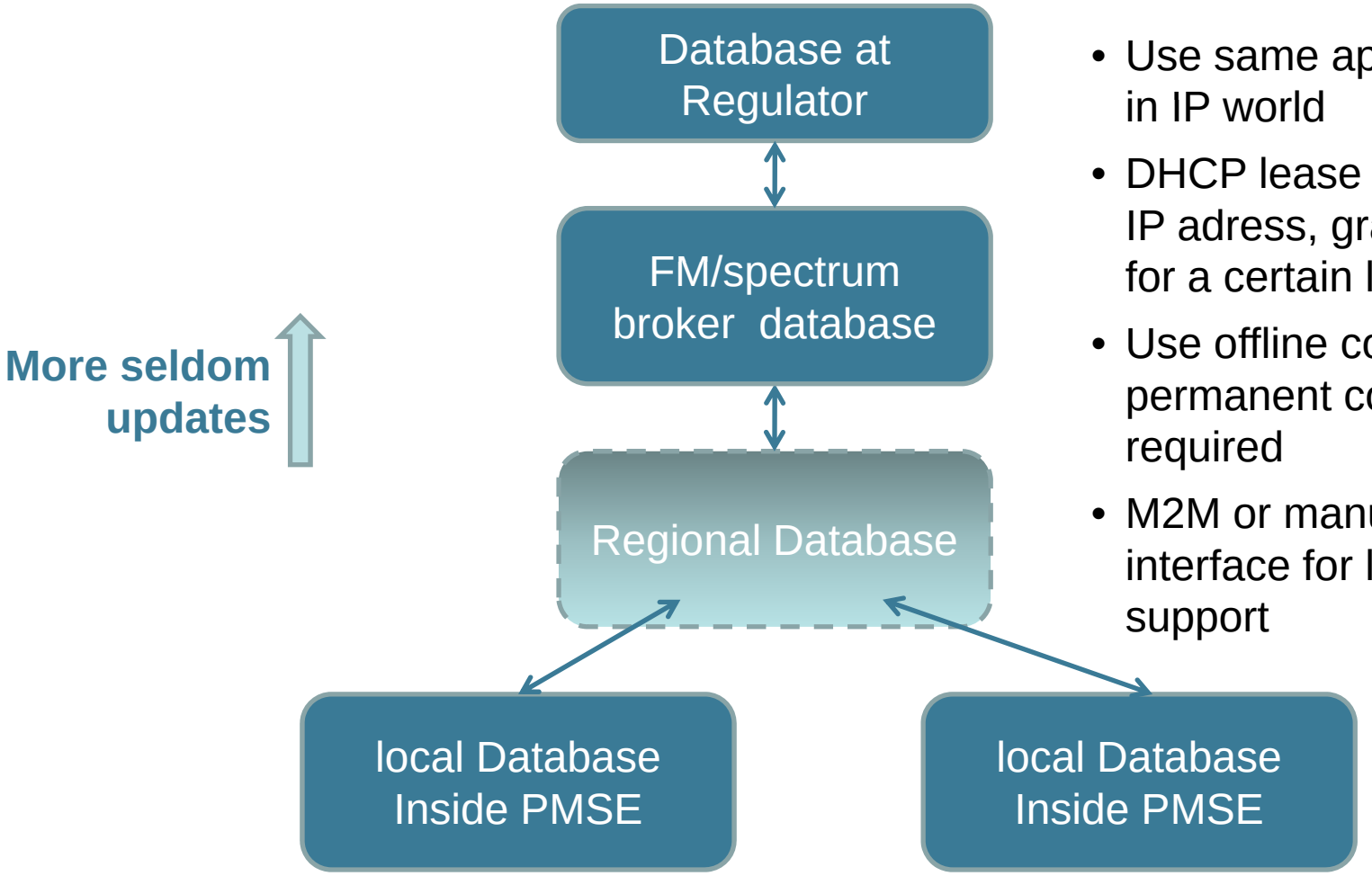
- Cellular - reactive scheme
- PMSE - Detect quality below threshold in advance
- PMSE - needs proactive scheme! *(Ensure production quality 100% of time)*

# C-PMSE
Architecture



# C-PMSE

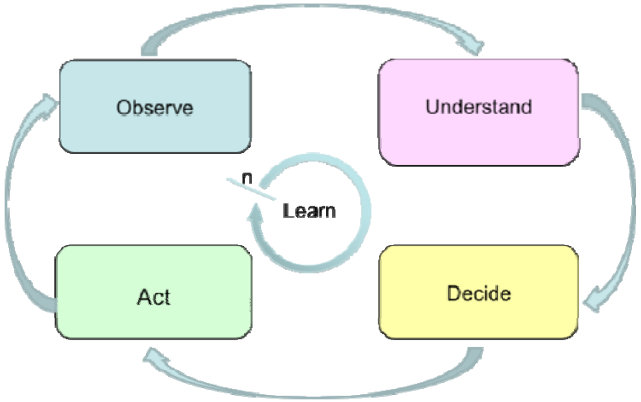
## Hierarchical database approach



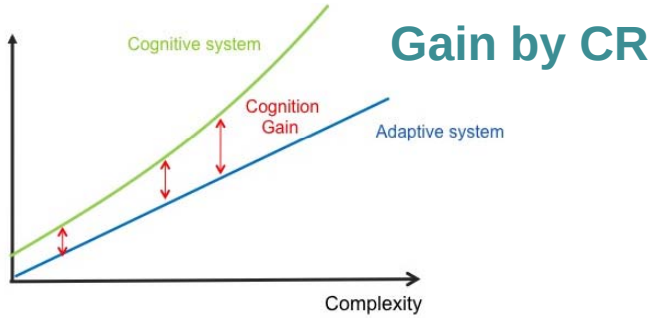

- Use same approach as in IP world
- DHCP lease for IP adress, grant valid for a certain lease time
- Use offline copy, no permanent connectivity required
- M2M or manual Web interface for legacy support

# C-PMSE

The cognitive engine



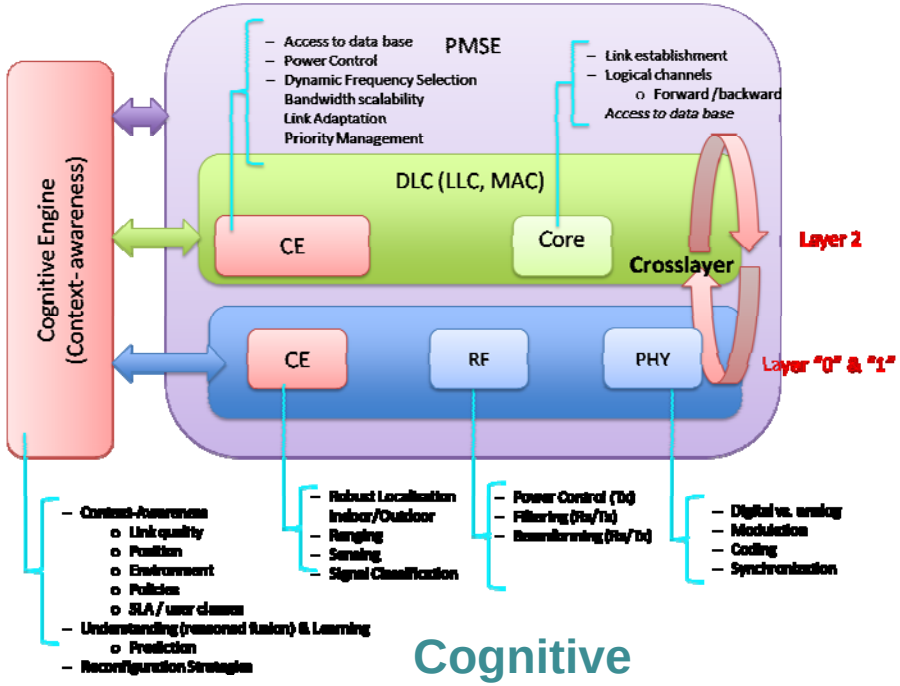

**"The cognitive cycle"**




**Gain by CR**

## CR Techniques

- Observations: Spectrum sensing, Feature detection
- Radio Environment maps
- Localization
- Cognitive pilot channel
- Actions: RRM, DFS, Bandwidth scaling, PC, AMC, Preemption
- Decision making: Cognitive Engine

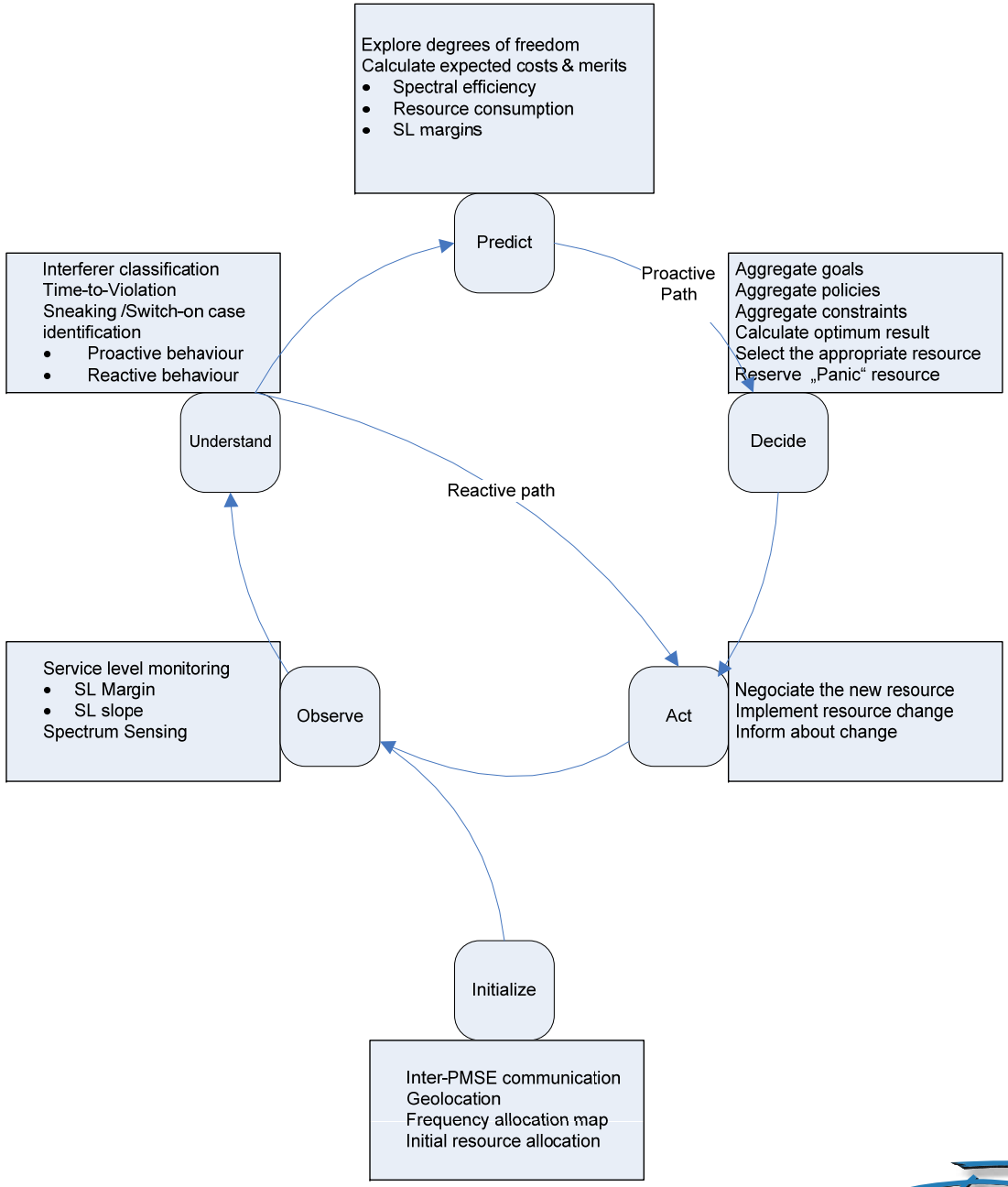



**Cognitive System**

# C-PMSE
The cognitive engine

## Rationales

- Ultimate goal: Avoid drop of audio quality
- Predict upcoming risks for a hit of audio quality
- Try to stay on predictive path
- Only in seldom(?) cases act reactive



# C-PMSE

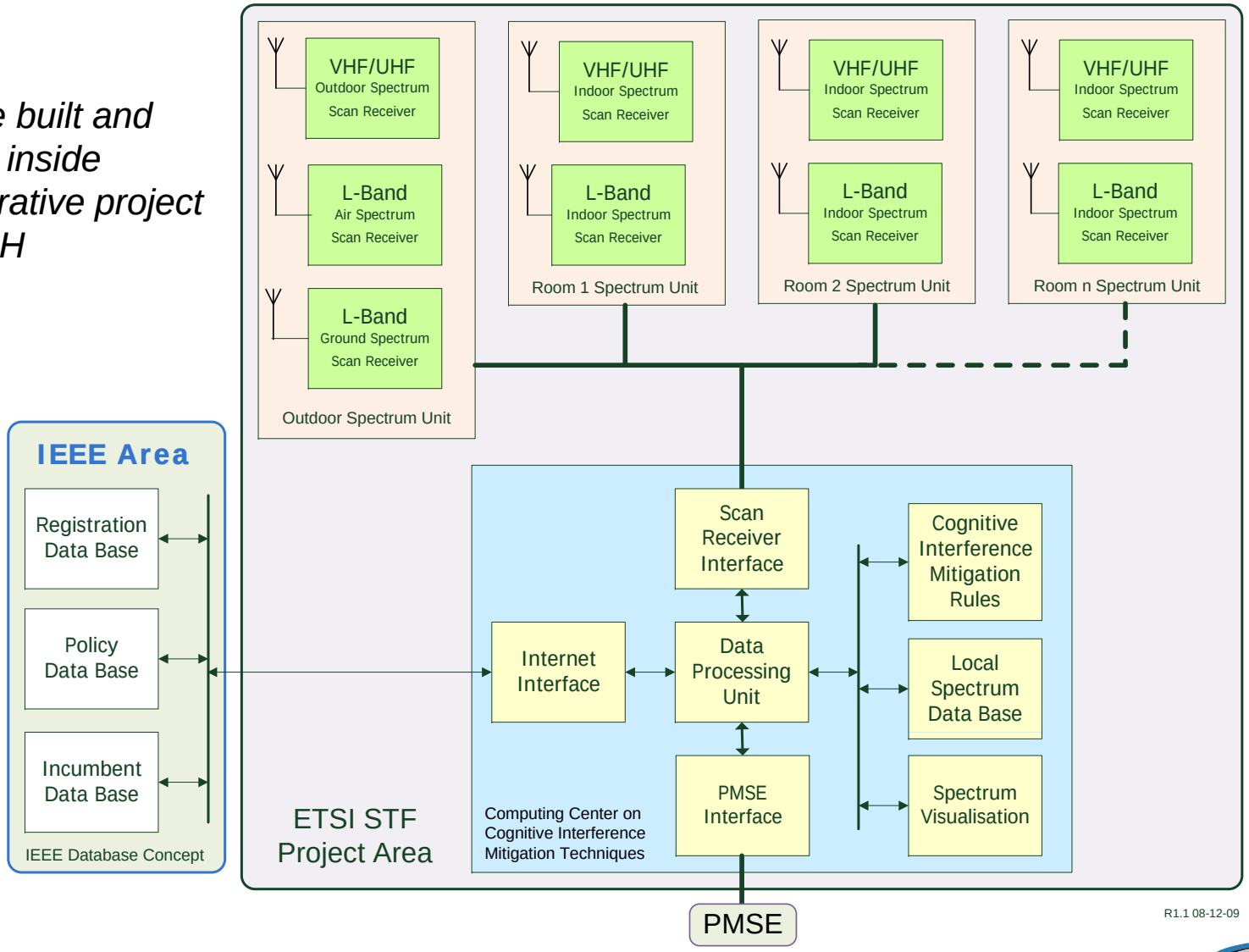
Technical advances proposed

**Techniques**

- Adaptive Antenna Arrays
  - Spatial separation
- Higher Receiver Intermodulation Robustness
  - Use e.g. GaN LNA
- Higher receiver selectivity
  - Increase robustness against inband blockers
- Advanced Receiver
  - Interference Cancellation techniques
  - Highest gain with diversity RX (typically present)
- Reduction of Transmitter Intermodulation
  - Also called reverse Intermod
  - Use of Switch mode PAs

# C-PMSE
## Experimental Platform

*Will be built and tested inside cooperative project D-A-CH*



# 6 Conclusions

# Conclusions
by STF386 expert team

**After Phase 1**

- Hidden Node Problem → “Ask Before Talk” – ABT *(Spectrum sniffing not sufficient)*
- Serious TX and RX intermodulation – frequency resources not orthogonal
- Using UHF for home multimedia (WSD) misuse of spectrum, better use 60 GHz
- Max tolerable interference power cannot be specified independent of bandwidth
- WSD *(White space devices)* also have to follow regime “ABT”
- Directing to new bands e.g. L and 1.8 GHz, propagation studies needed
- QoS Metric derivation (C/I, not RSSI) with analogue FM transmission needed
- PMSE is not spectrally inefficient in light of high audio quality that has to be delivered
- PMSE analogue companders very effective
- Cellular suffers a lot from signalling overhead
- RRM was found to be a valuable tool to boost spectral efficiency
  *(power, frequency, adaptive Modulation and coding)*
- Geolocation accuracy tightly linked with gain in spectral efficiency
- Database security questions have to be solved