Co-operation and Convergence
Mobile Broadband Perspective

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Capacity Challenges in Cities – Coverage Challenges Rural

Capacity: Dense networks
limited by interference

- Doubling traffic over a decade leads to a 1000x capacity challenge

Addressable by

- substantial performance improvements of the technical solution
- massive amount of additional base stations, primarily small cells near traffic hot spots
- massive amount of additional spectrum, high bands well suited for small cells (c.f. RSPP, WRC-15 agenda item 1.1, etc.)

All driven by additional revenue potential

Coverage: Sparse networks
limited by noise at the cell edge

- Challenges in the physical constraints of the radio channel

Addressable by

- certain costly performance improvements of the technical solution limited by return on invest
- additional base stations strictly limited by return on invest
- additional spectrum at low frequencies needed, e.g. in 700 MHz band (WRC-15 agenda item 1.2)

Additional revenue potential is limited

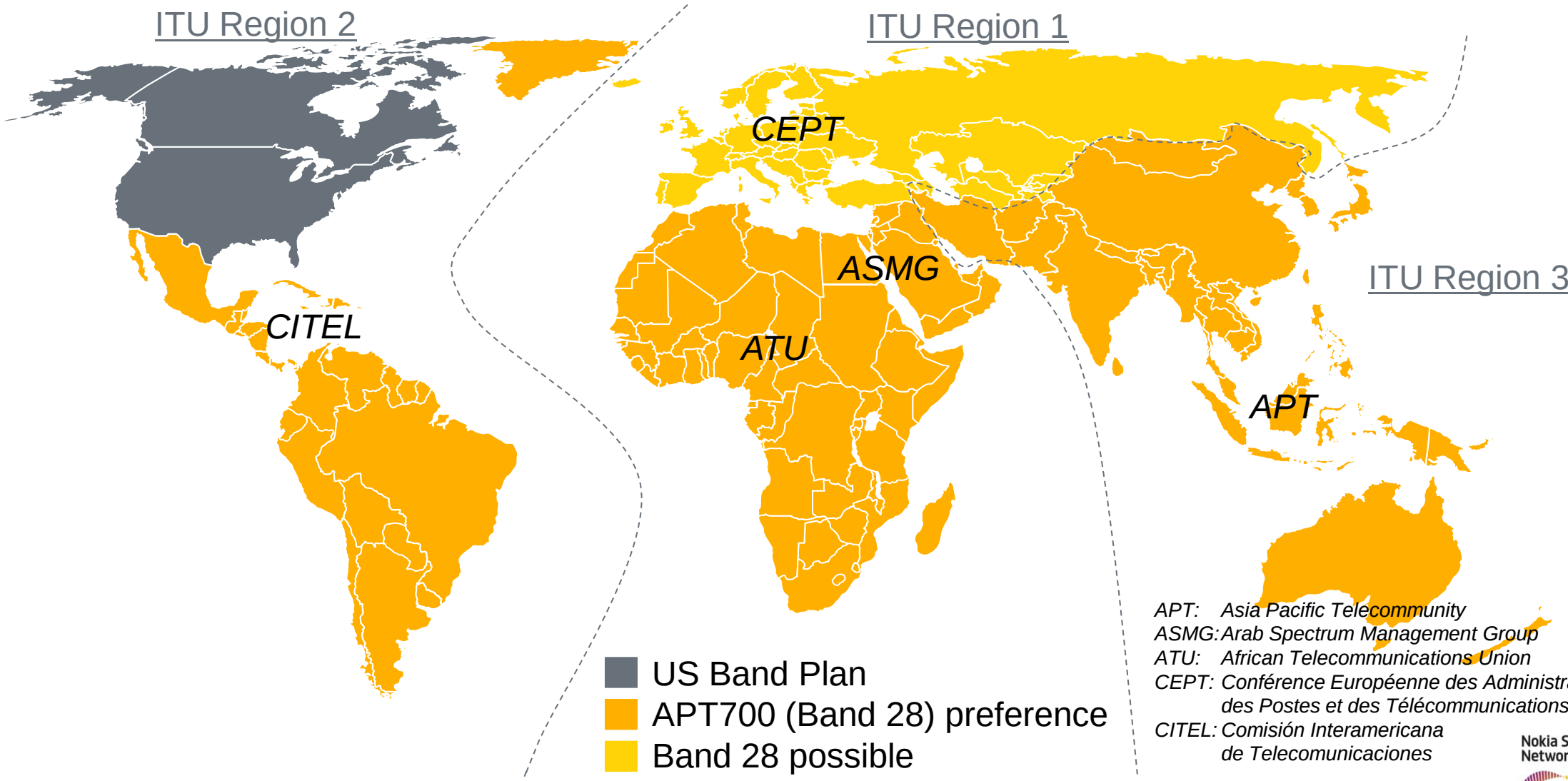
UHF 700 MHz to achieve German broadband targets of 50 Mbps by 2018

	"Today" 10MHz@800	"Plus 700 MHz Band" 10MHz@800+10MHz@700	"Spectrum Pooling" 30MHz@800+30MHz@700
	LTE 2x2 MIMO	LTE-Advanced 4x4 MIMO	LTE-Advanced 4x4 MIMO
Contracted bandwidth	"up to 7.2 Mbps"	"up to 15 Mbps"	"up to 50 Mbps"
Theoretical peak	75 Mbps	300 Mbps	(900 Mbps)
Expected average *)	5 to 20 Mbps	10 to 60 Mbps	30 to 180 Mbps
Cell edge *)	3 to 5 Mbps	6 to 15 Mbps	18 to 45 Mbps

*) not quantifying load impact by change in usage patterns e.g. towards HD streaming
not considering all possible but costly technology measures

- Opening the 700 MHz band for mobile broadband is a valuable step forward
- Together with spectrum pooling, 30 Mbps and 50 Mbps targets can be reached
- LTE-Advanced can meet targets for initial coverage
- Heavy utilization may trigger need for more UHF spectrum

Close-to-global harmonization potential in 700 MHz based on APT-700 band plan / 3GPP Band 28



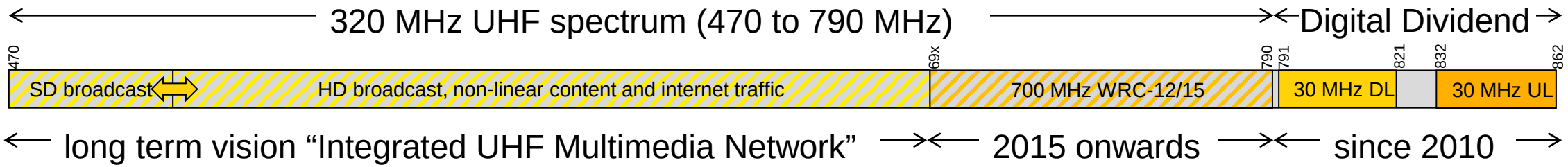
APT: Asia Pacific Telecommunity
ASMG: Arab Spectrum Management Group
ATU: African Telecommunications Union
CEPT: Conférence Européenne des Administrations des Postes et des Télécommunications
CITEL: Comisión Interamericana de Telecomunicaciones

Convergence Potential of Terrestrial TV and Mobile Broadband

An **Integrated UHF Multimedia Network** based on LTE-Advanced and eMBMS SFN *) may resolve the competition for UHF spectrum between broadcast and MBB

Rewards and challenges:

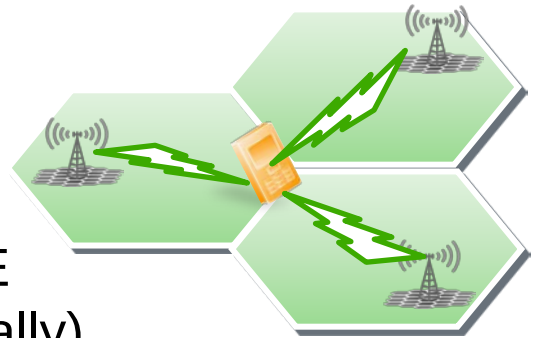
- Massively improved UHF spectrum utilization can free the bandwidth required for digital inclusion with massive video capacity also for non-linear broadcast content
- Terrestrial broadcast reach extends to smart phones and tablets, to indoors and mobile
- HD capability for terrestrial broadcast based on a global standard
- Interactive TV capability for broadcast including bandwidth required for non-linear content
- Flexibility regarding linear vs. non-linear content
- Shared infrastructure investment into existing base station sites
- Innovation potential in technical, regulatory and business model domains



*) eMBMS SFN: evolved Multimedia Broadcast Multicast System in Single Frequency Network, efficient technology to broadcast multimedia content in LTE and LTE-Advanced networks

Technology: eMBMS

- Cellular networks are primarily designed for Unicast or point to point services, i.e. individual content for each user.
- Multimedia Broadcast / Multicast Services (MBMS) for UMTS and evolved MBMS (eMBMS) for LTE are a fully compatible expansions in the 3GPP standards to allow for efficient transmission of linear content where required.
- Single frequency network (SFN) is applicable where linear content is shared over multiple base stations



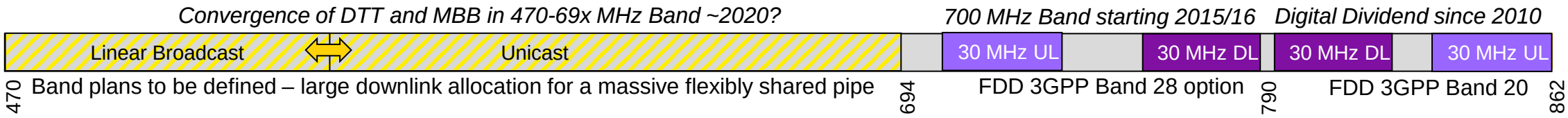
- eMBMS with SFN allows to broadcast linear content within mobile LTE and LTE-Advanced networks. Reception of the linear content (technically) not necessarily requires a SIM card or a subscription

- eMBMS with SFN can be implemented on the full variety of devices without large impact on the device bill-of-material
- eMBMS is announced to become commercially available in advanced LTE markets like US and Korea in the 2014 timeframe e.g. for capacity relief during sports events

Band Plan Considerations:
Symmetric FDD in 700 MHz, wide DL only in 470 – 694 MHz

Symmetric FDD allocation in 700 MHz:

- Option for synergies with global ecosystem of Band 28
- UL bandwidth required to meet requirements of small and medium enterprise in rural areas



In 470-694 MHz UHF spectrum, arbitrary large parts of the band can be designed for DL only to meet broadcast and streaming bandwidth requirements

Bandwidth can be flexibly shared between linear and non-linear content

Required UL bandwidth can be allocated in 700/800 MHz and/or 470-694 MHz

Competing Network Topologies

High Power – High Tower Economic Efficiency

- Few, costly transmitters required for very large areas,
  yet economically efficient
- Broadcast technology can be optimized for high efficiency within a carrier frequency relying on excellent SINR due to very large frequency re-use distances
- A whole set of frequencies (“allotment”) is required to build a coverage layer over a large geography in Multiple Frequency Network (MFN)
- Single Frequency Network (SFN) has re-use issues at its borders with 100+ km co-ordination areas

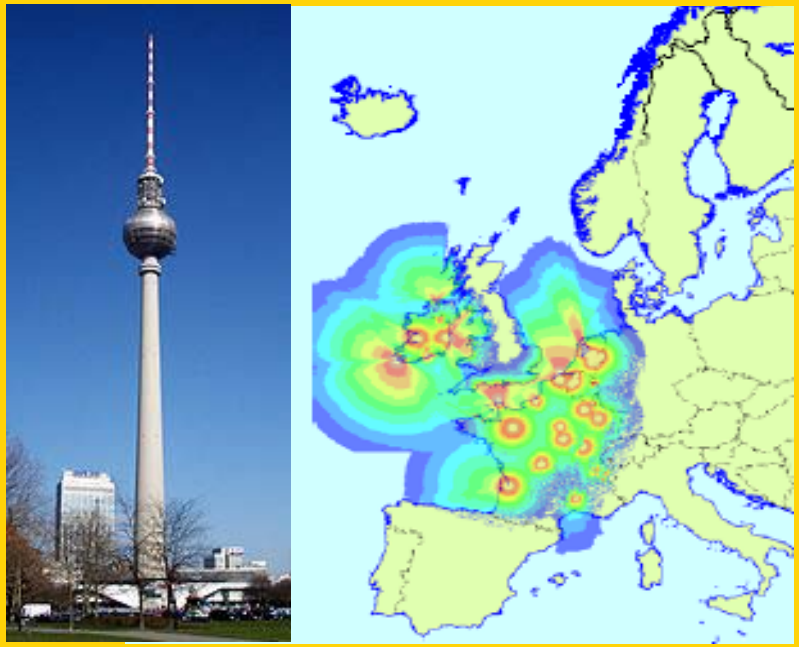
v.s.

Cellular Network Spectrum Efficiency

- Many more, less costly transmitters required for very large areas, can be based on existing sites
- Mobile technology sacrifices some efficiency within a carrier frequency to be robust against interference in 100% frequency re-use and adverse channel conditions from mobility etc.
- The entire frequency resource can be used even multiple times within one base station site, i.e. once per sector
- Single Frequency Network border issues can be limited to very small parts of the total area due to lower TX powers and small cell sizes

LTE Tower Overlay would not deliver spectrum efficiency gain
Macro-cellular approach can create value from spectrum

Example
- Sparsely used within any given country
- Substantial impact on neighbour countries

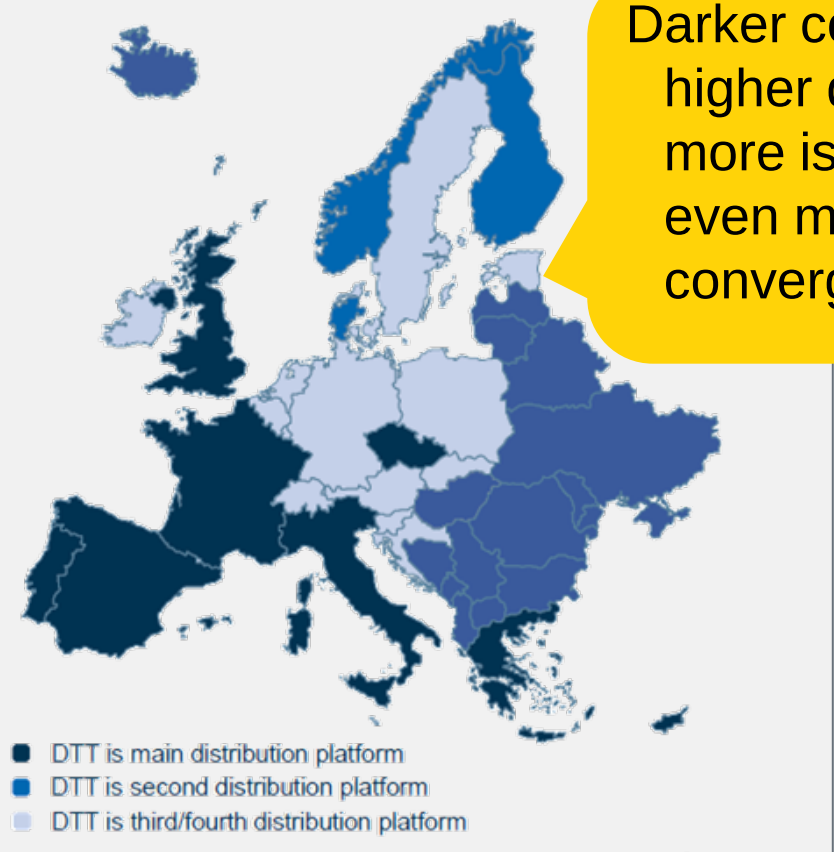


- DVB-T provides 3 to 8 multiplexes of 8 MHz each (depending on location)
  - 24 to 64 MHz out of 312 MHz available are used
  - between 92% and 79% of the spectrum remain unused
  - co-ordination between countries up to hundreds of km
- Parts of the unused spectrum are “polluted” by power of neighbouring TV transmitters, parts remain useable as TV White Spaces by e.g. PMSE etc.
- LTE High Power Tower Overlay would have similar issues with very large coordination areas along country borders
- In a cellular topology, in the vast majority of locations up to 100% of the spectrum can be actively used, border co-ordination can be reduced to narrow corridors

Dependency on DTT varies within EU
Likely different pace at 700 MHz and in UHF Convergence

- DTT is an important platform in many parts of Europe – even though cable, satellite, and online and IP-based platforms also distribute broadcast content to many homes.
- Furthermore, in many cases, regulators have long-term licensing arrangements in place with broadcasters operating the 470–790MHz band, and specific obligations are in place, for example, in relation to coverage targets for public service broadcasting.
- Spectrum availability for DTT is particularly constrained within European border areas, where complex multi-country co-ordination arrangements are in place to avoid interference.

Figure 8: Status of the DTT platform in European countries, July 2012 [Source: Analysys Mason, 2012]



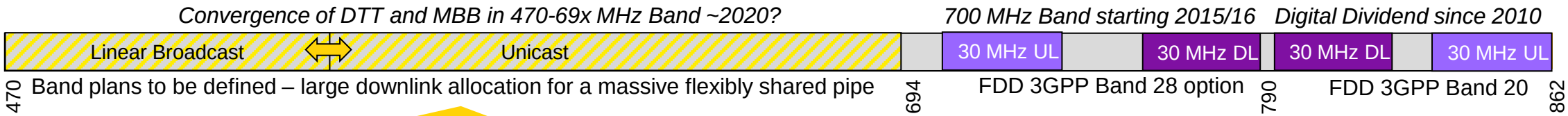
Darker color:
higher dependency on DTT
more issues to clear 700 MHz
even more need for convergence solutions?

Source: Analysys Mason

Summary

- **700 MHz LTE: near term opportunity for broadband targets**
- **470-694 MHz convergence: longer term vision**

- 700 MHz can substantially contribute to broadband targets and EU Digital Agenda (50 Mbps 100% population in 2018 in D, 30 Mbps 100% population in 2020 in EU)
- 700 MHz quickly evolves to a close-to-global ecosystem around 3GPP band 28
- Finland: UHF strategy to open 700 MHz for MBB in 2017
  Germany: BMWi investigation “Mobile Media 2020” option 2
  High on Nelly Kroes’ and EU DG Connect agenda, CEPT starts working on band plan



- In 470-694 MHz UHF spectrum, convergence is a compelling longer term option, requires further research on technology, regulatory and business models
- Discussion is most advanced in Germany, e.g. “Mobile Media 2020” option 3, new Bund-Länder working group involves state level, could evolve to driving role (c.f. 800 MHz)
- Monitored with interest in EU DG Connect

Thank you for your attention

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