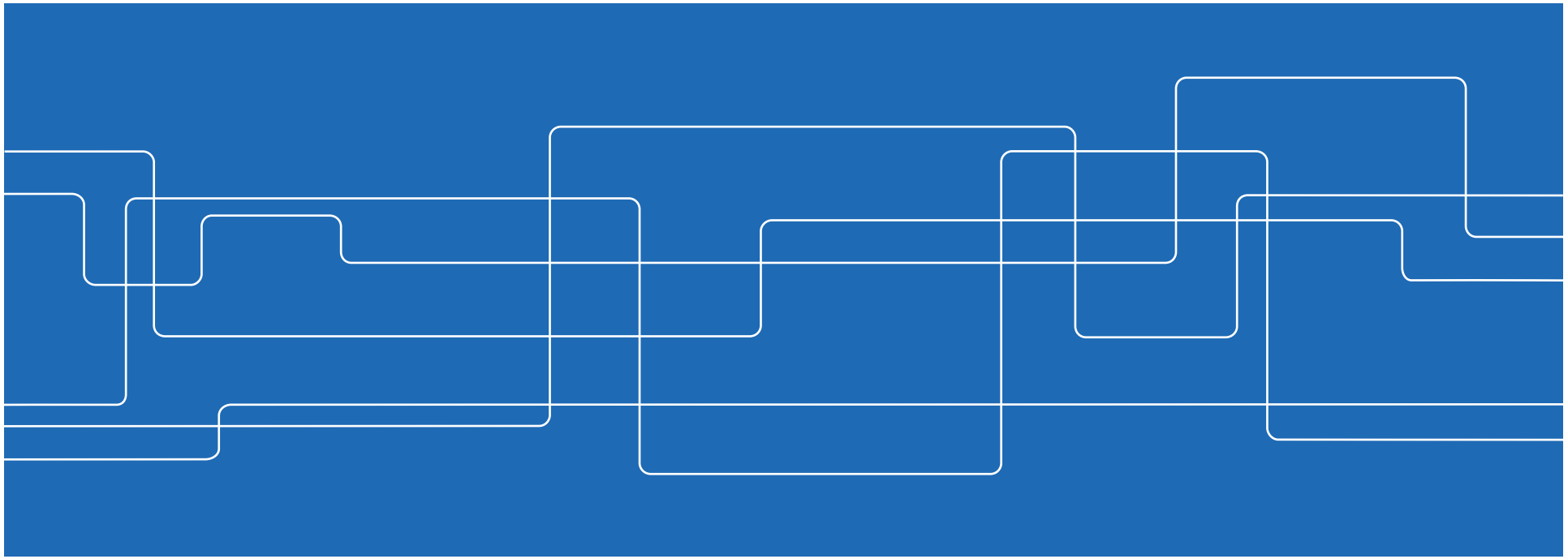
The Incentives and Challenges of Delivering Linear Broadcasting Services over Cellular Network in Developing Countries

Ashraf Awadelkarim Widaa Ahmed, Jan Markendahl and Amirhossein Ghanbari

Wireless@KTH, KTH Royal Institute of Technology, Stockholm, Sweden



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- Research Questions
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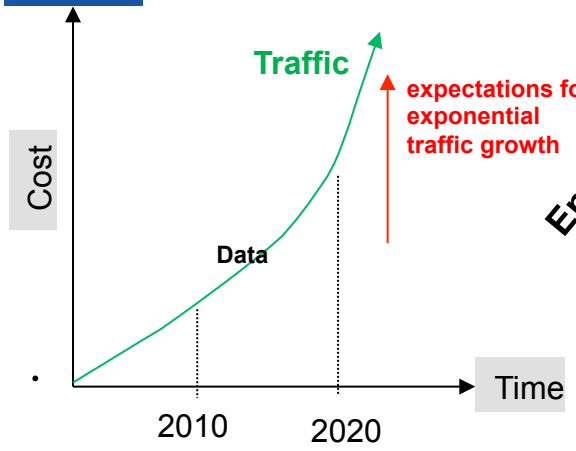
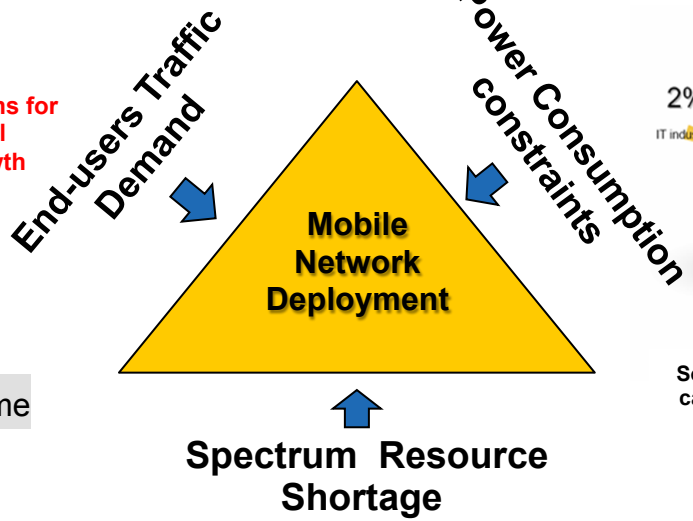
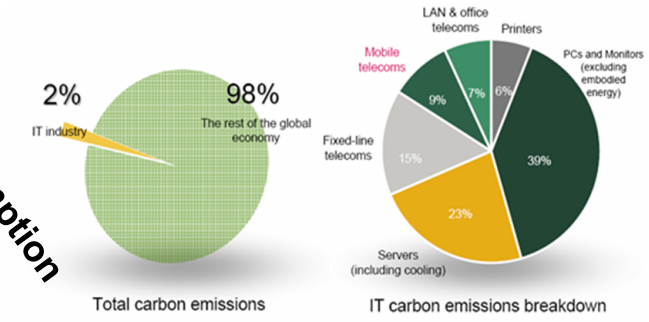
- Conclusion

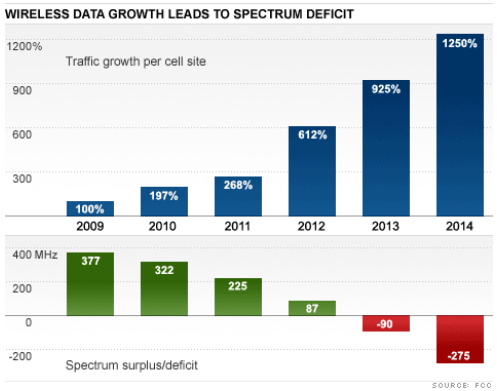
Demand, Cost and Power Consumption



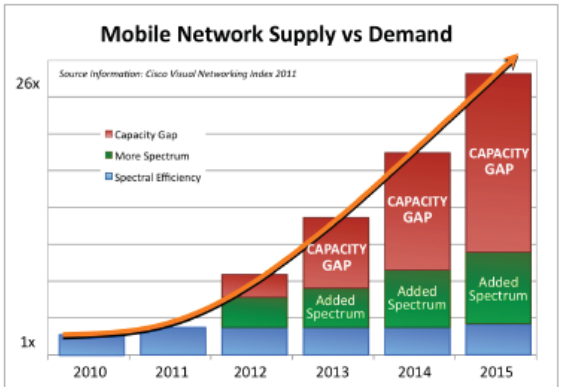




Source Gartner, IT vendors , service providers and users can Lighten IT's environment Footprint, December 2007

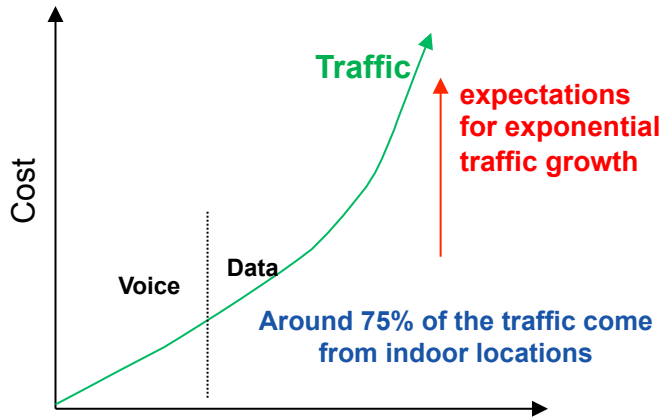


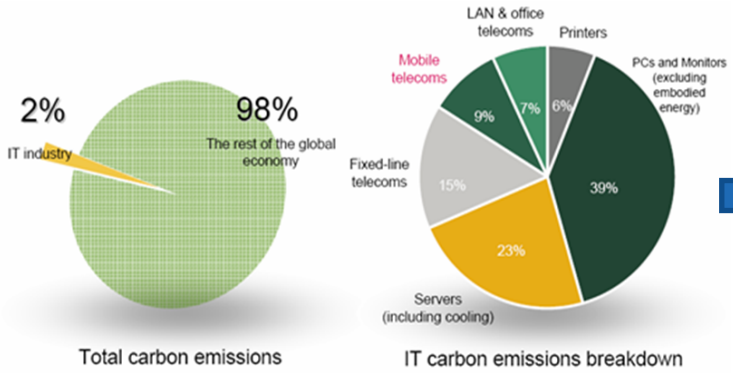
Source: FCC



Source: Cisco

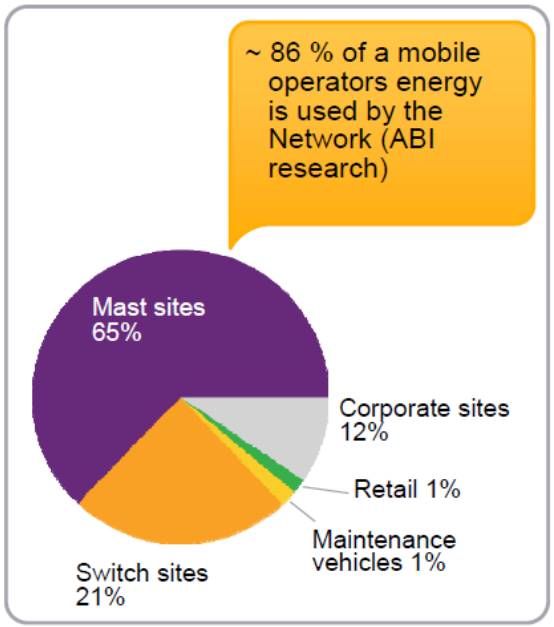
The Power Consumption in Mobile Network



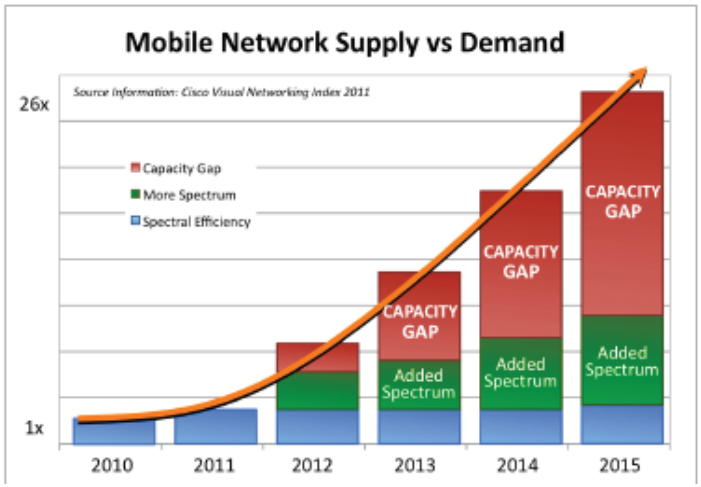


Source Gartner, IT vendors , service providers and users can Lighten IT's environment Footprint, December 2007

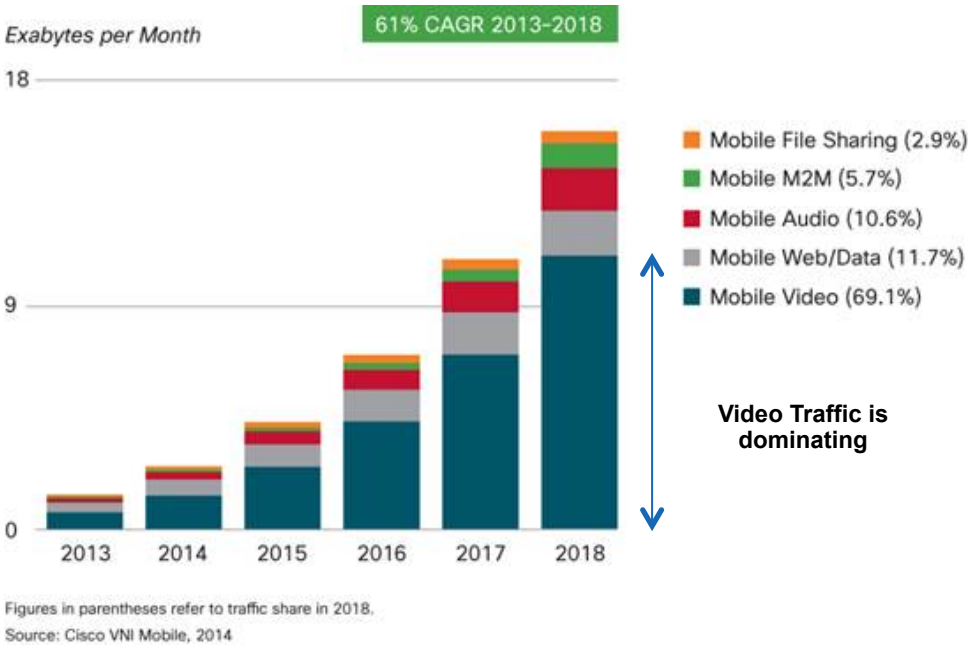
- **Trends:**
  - Exponential growth in data traffic
  - Number of base stations / area is continuously increasing (to meet the higher capacity demand).
- **Needs to Optimize CAPEX and OPEX (ROI)**
- **Environmental issues, Green Network**



Changes in Broadcasting Spectrum Allocation (1/2)



Source: Cisco



- ITU in in year 2007 (WRC-07), has already allocate the upper part of the UHF band (790–862 MHz) is allocated to the mobile service in Region 1 as from 2015, and allowed some countries of this region to use this allocation immediately, under certain conditions.

- Furthermore the WRC-12 concluded with a decision to create a new mobile allocation in the band 694-790 MHz in ITU Region 1, which is proposed to come into force in 2015

Changes in Broadcasting Spectrum Allocation (2/2)

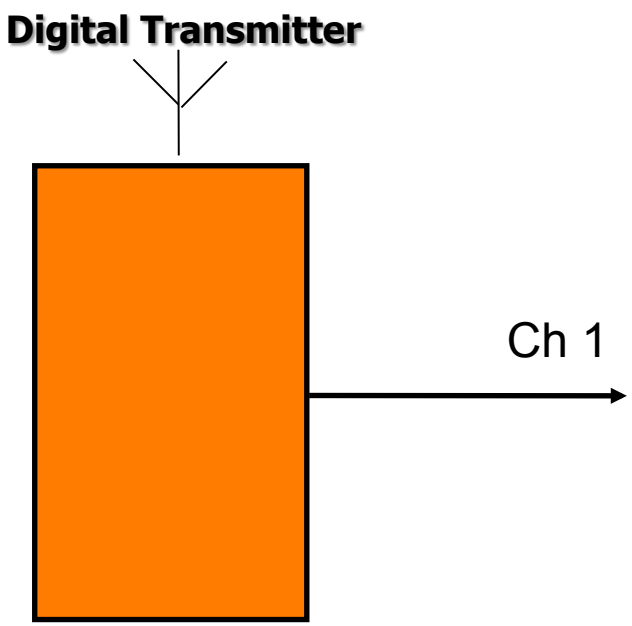
4G mobile Broadband Frequency landscape in UHF band

USA Plan	**698 – 806 MHz (2 x 12 MHz blocks + 2 x 11 MHz blocks)**
Europe	**790 – 862 MH (2 x 30 MHz blocks with 11 MHz center gap)**
Asia Pacific	**698 – 806 MHz (2 x 45 MHz blocks with 10 MHz center gap)**

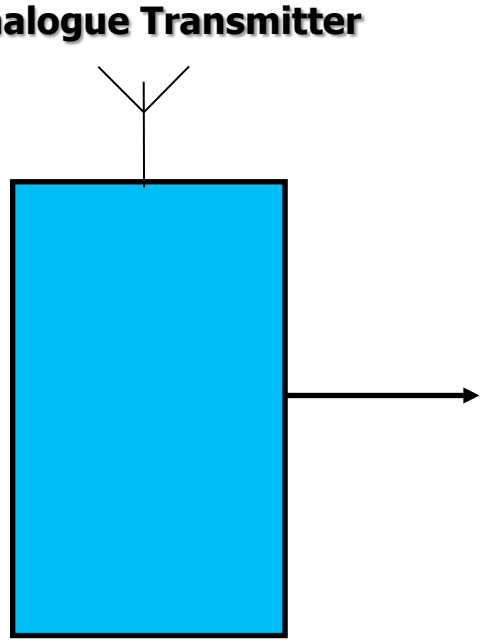
- **Considering a market with three mobile operators in the market (~ 20 MHz)**

Is the time to look into the remaining band 470 – 698 MHz ?

Changes in Broadcasting Standards: Analogue vs. Digital Broadcasting



In one 8 MHz RF-channel; 6 or more services (depending on the required service area coverage, modulation type and quality of reception to be achieved); Same Frequency re-use in SFN (number of sites)



In one 8 MHz RF-channel; One service; New frequency per site

Efficient Use of Spectrum ➡ **First and Second spectrum Dividend**

Changes in Broadcasting Services

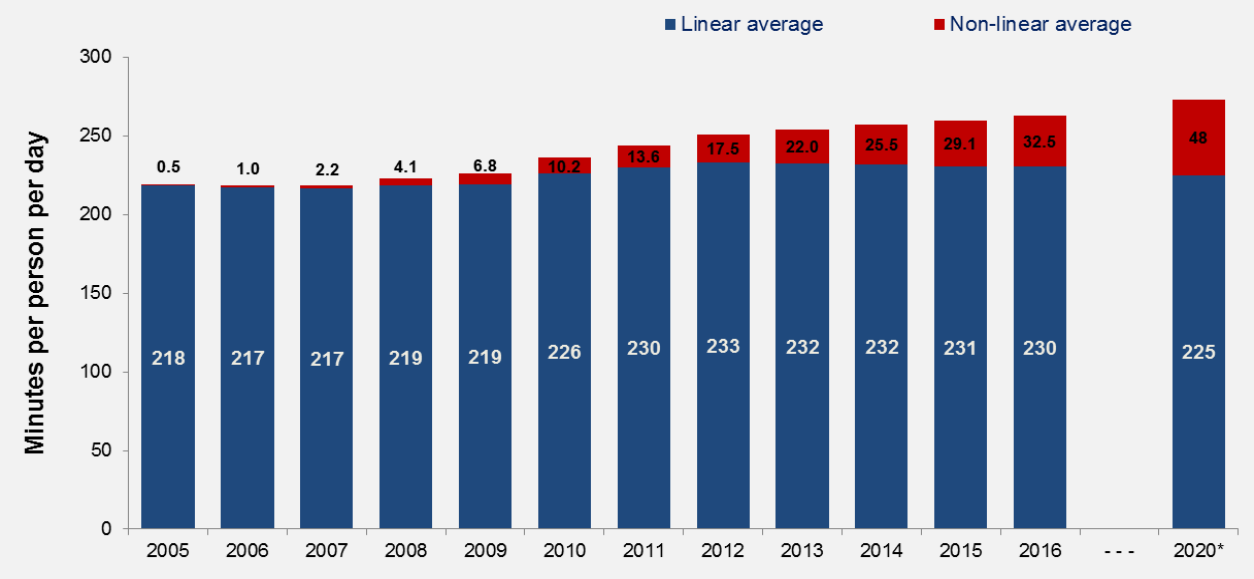
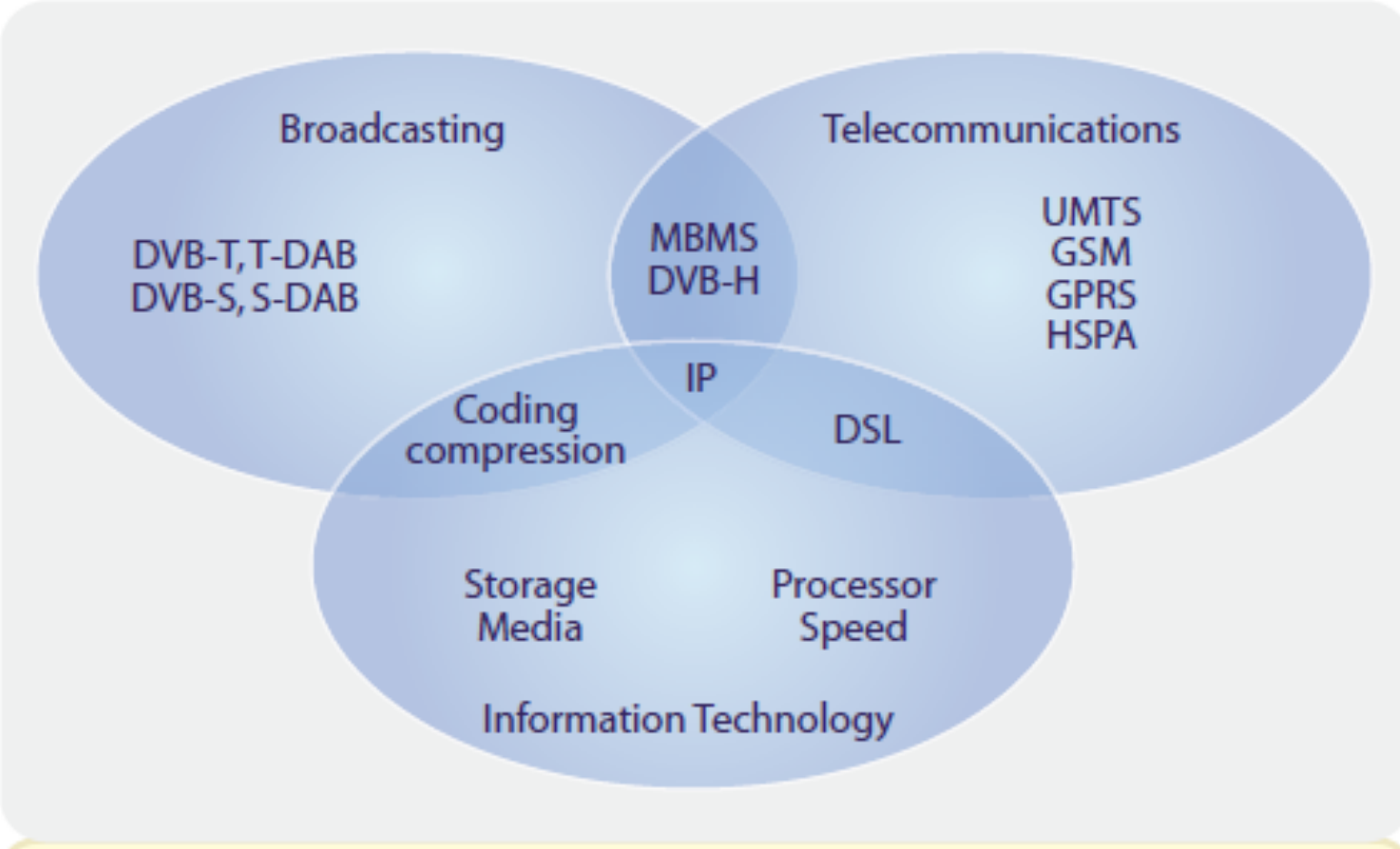


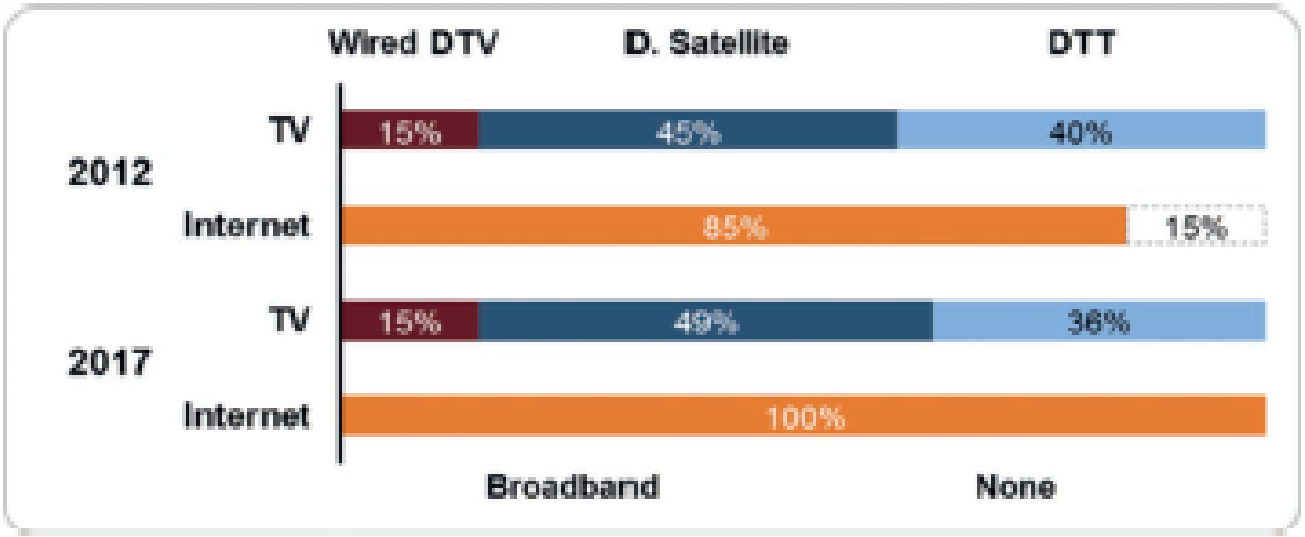
Figure 1: Evolution of TV viewing in Germany, France, Italy, Spain and the UK, Source: IHS - Screen Digest: Cross-platform Television Viewing Time FY 2012 (Forecast for 2020 by EBU)

Broadcasting Service demand trend in Europe

Convergence Between Different Sectors

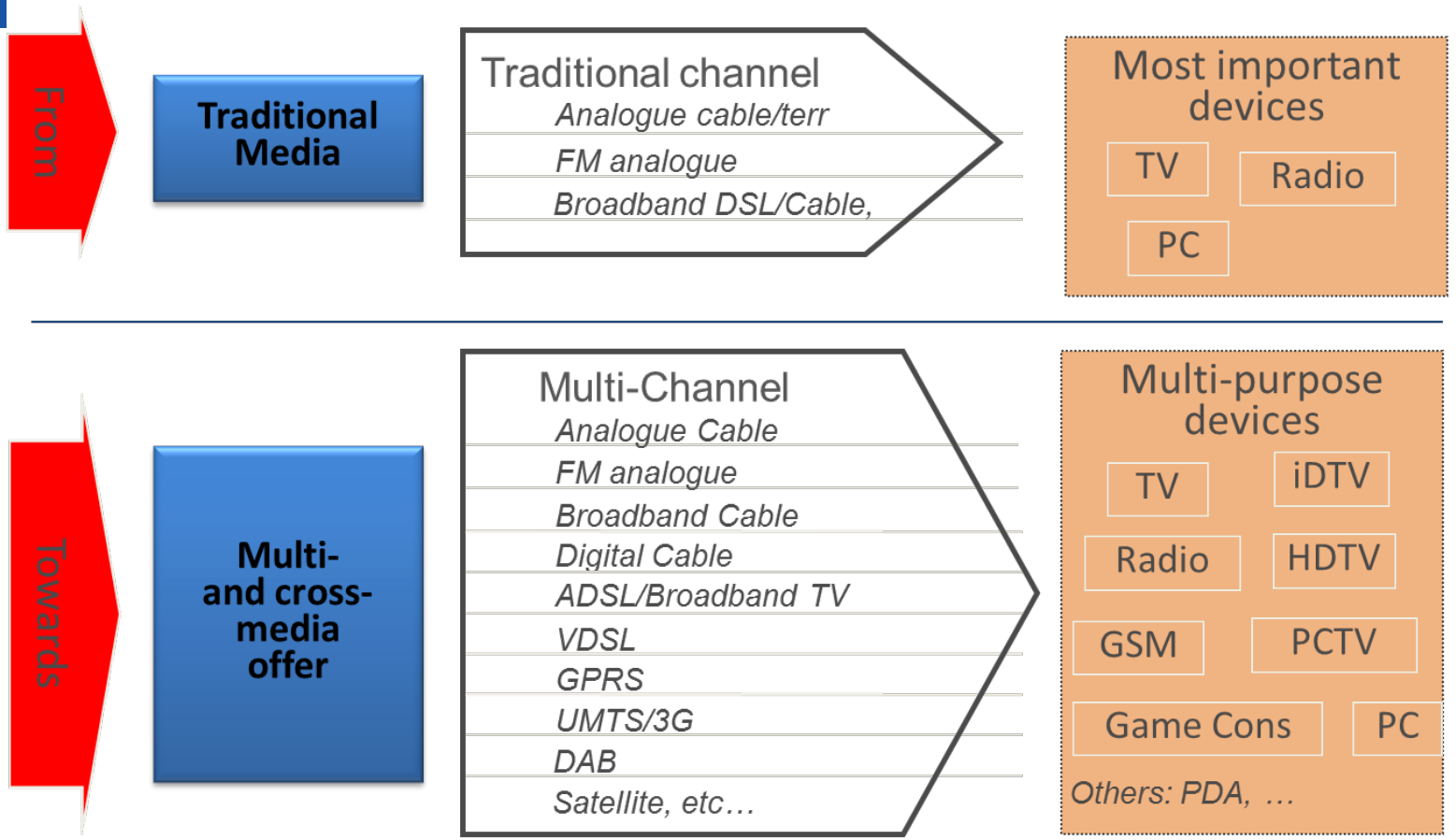


Changes in Broadcasting Services: Delivery Platform



Source: IDATE

Convergence (Multi channel and multi-platform delivery)



Media content will be delivered via different technologies (=channels) to different devices (=platforms). The media users expect that this content (brand) will be accessible continuously and via interoperable devices.

Digital Terrestrial Broadcasting services Status in Africa

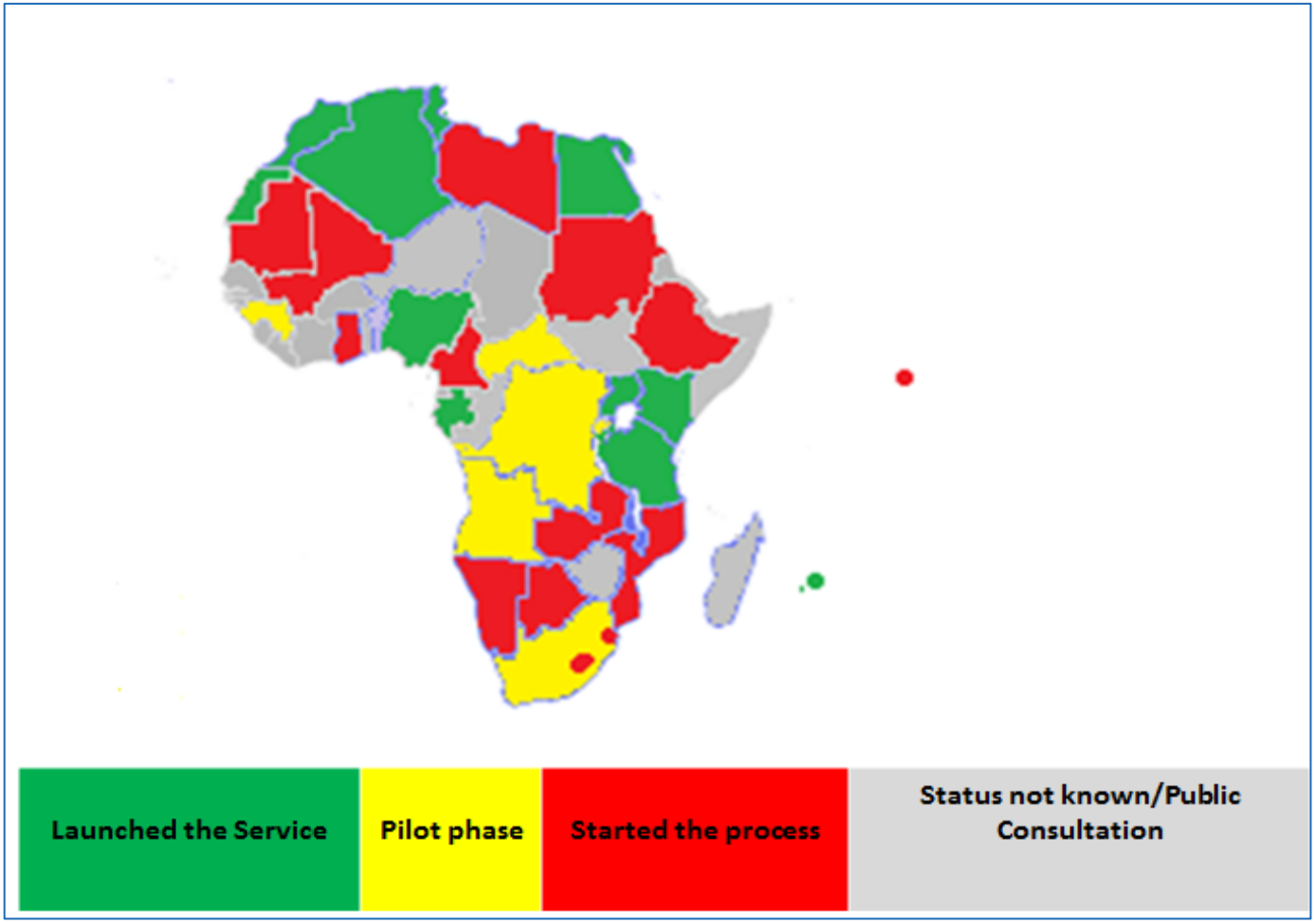


FIGURE 3: STATUS OF AFRICAN UNION MEMBER STATES (MS) (AUC, 2012)

Research Questions

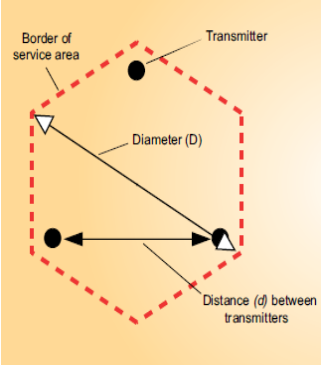
RQ1: What are the incentives and challenges of delivering the broadcasting Services over cellular network?

RQ2: Could all the parties benefit from such approach or not? How the regulations and market conditions in the developing countries work for or against such approach?

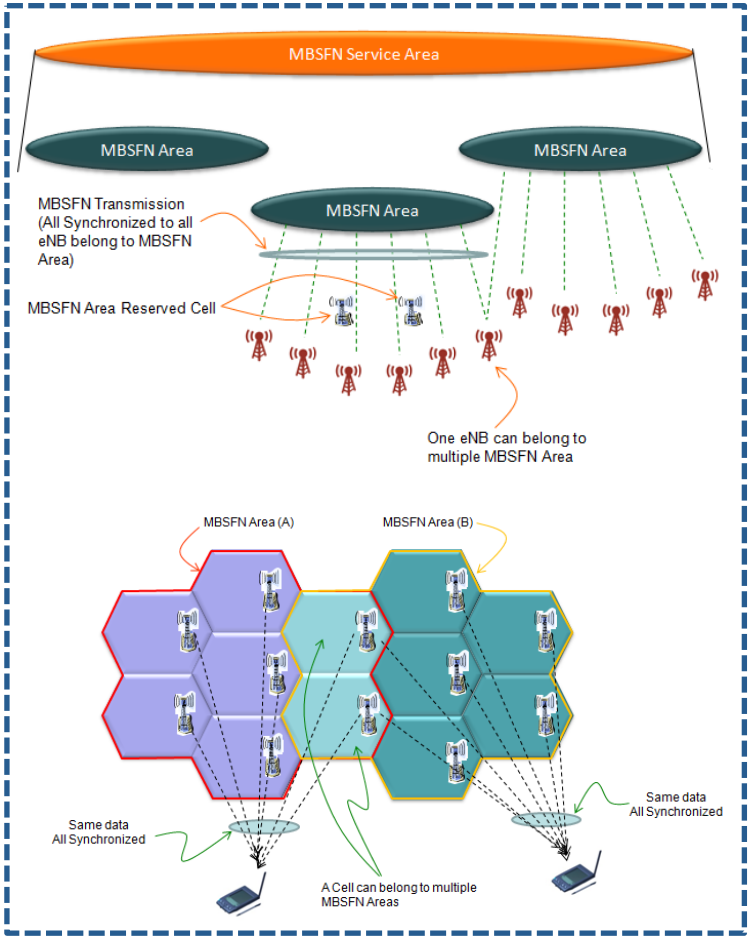
Separate Solution Vs. Common Platform

DVB-T small-area SFN (RN2)

RPC and reception type		RPC1 Fixed antenna	RPC2 Portable outdoor and mobile	RPC3 Portable indoor
Type of network		Open	Open	Open
Geometry of service area		Hexagon	Hexagon	Hexagon
Number of transmitters		3	3	3
Geometry of transmitter lattice		Triangle	Triangle	Triangle
Distance between transmitters *d* (km)		40	25	25
Service area diameter *D* (km)		53	33	33
Tx antenna height (m)		150	150	150
Tx antenna pattern		Non-directional	Non-directional	Non-directional
ERP (dBW)	Band III	21.1 + Δ	23.6 + Δ	31.1 + Δ
	Band IV/V	28.8 + Δ	36.0 + Δ	43.3 + Δ
The power margin Δ is 3 dB				

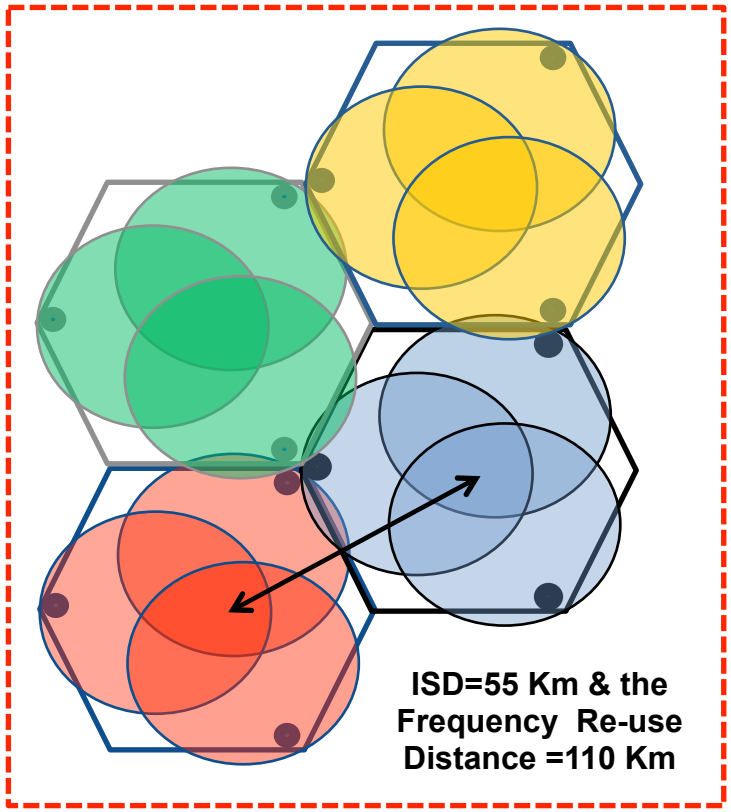


GE06 Agreement

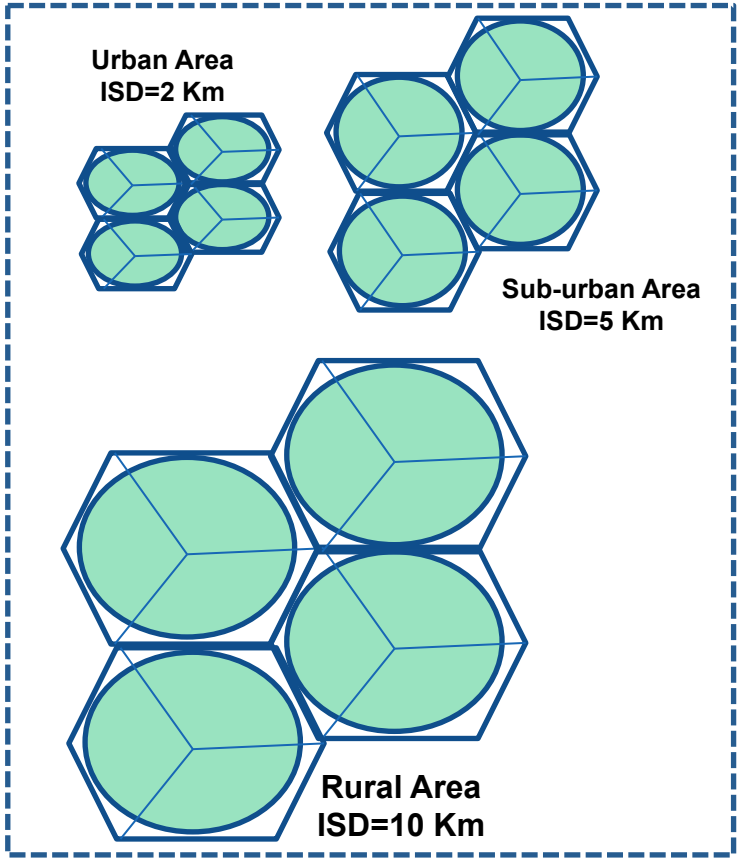


Multicast Broadcast Single Frequency Network

Deployment Options



Small SFN Areas
Based on The ITU's RN2



e.g. LTE MBSFN

Demand Assumptions: Mobile Broadband

Mobile Broadband Services

- The mobile broadband user consumption is estimated to be between 0.5 GB/month
- Considering an annual average growth of 70% (as per the forecast reports issued by Cisco); the mobile broadband usage is expected to grow to around 50 GB/month and user near to year 2025..
- Nowadays, the Mobile Broadband Penetration rate remain under 10%, considering objective to double the mobile broadband by each year (up to year 2025).

Area Type	Total Inhabited Area in km.²	Average Population Density per km.²	Existing Mobile Coverage (%)
Urban	95,697	250	100%
Sub-Urban	413,431	100	100%
Rural	468,944	50	73 %

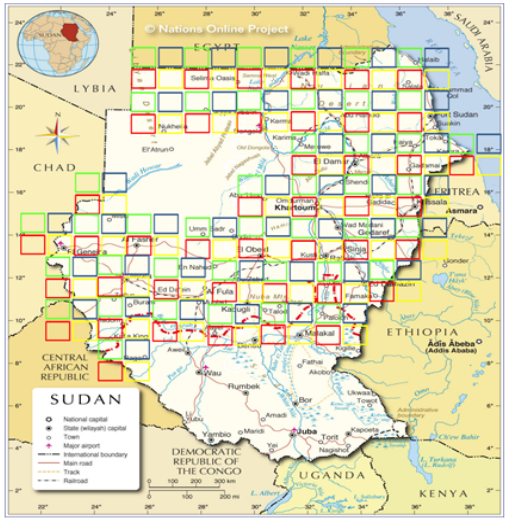
Demand Assumptions: Digital Broadcasting Services (1/2)

- **Sudan is a party to Geneva agreement of 2006 (GE 06) which resulted from the Regional Radio Communication Conference of 2006 (RRC 06) for countries in Region 1 (Europe, Africa and the Middle East and Region 3 (Islamic Republic of Iran).**
- **GE06 agreements Adopted Digital Terrestrial Broadcasting Plan in the frequency bands III (174-230 MHz) and bands IV/V (470-862 MHz)**
  - **T-DAB (Band III), Terrestrial digital sound broadcasting, for radio with two reception modes of mobile and portable**
  - **DVB-T (Bands III, IV, V), Digital video broadcasting – terrestrial, for television with four reception modes of fixed, mobile, portable indoor and outdoor.**
- **International Switch-over date is June 2015 (However, analog TV broadcasting will be protect up to 2020 upon the request of a number of African and Middle East countries in VHF (Band III)).**

- According to GE06, 7 National Multiplexers is guaranteed
- Recent coordination lead by ATU in order to reduce guarantee 4 national Multiplexers (free the band 690 to 790 MHz)

Demand Assumptions: Digital Broadcasting Services (2/2)

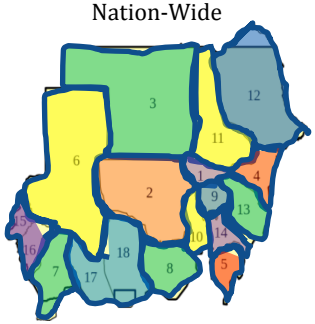
Format	Screen	Compression	Average bit rate	Remark
SDTV	CRT	MPEG2	≥ 3 Mbit/s	
SDTV	Flat screen	MPEG2	≥ 6 Mbit/s	
SDTV	Flat screen	MPEG4	≥ 4 Mbit/s	
HDTV 720p	Flat screen	MPEG4	≥ 10 Mbit/s	When MPEG4 technology is mature ≥ 8 Mbit/s is expected to be sufficient
HDTV 1080i	Flat screen	MPEG4	≥ 12 Mbit/s	Depending on content and application of horizontal sub sampling



Sudan Digital Broadcasting Plan compose of 7 multiplexer layers for fixed and mobile reception. The frequency plan is conducted with a re-use distance of 110 Km.

(a) City-Wide

(C)
Nation-Wide



(b) State-Wide

- **Digital Terrestrial Broadcasting Services Plans include City-Wide, State-Wide and Nation-Wide coverage.**
- **4 to 8 multiplexers will be required at short – term .**

Dimensioning (1/3)

The required number radio base stations to satisfy the mobile subscribers demand is subject to the coverage and capacity constraints of the type of radio base station used (and of course the demand level).

$$N_{BS} = ((Pent * N_{user} * R_{user} * A_{service})) / N_{TRX} * ((B) * SE - D_{DTTB}) * A_{RBS}$$

Linear Broadcasting

$$N_{BS} = ((Pent * N_{user} * R_{user} * A_{service})) / ((B) * SE * N_{TRX}) * A_{RBS}$$

Non-Linear Broadcasting

Option	Inter-Sites Distance (ISD) in [km]	REUSE Distance in [km]	Spectral Efficiency bit/s/Hz		References
			Optimistic	Conservative	
LTE MBSFN (Urban Area)	2 Km	4	3	1.1	(ECC, 2013)
LTE MBSFN (Sub-urban Area)	5 Km	10	2	0.5	(ECC, 2013)
LTE MBSFN (Rural Area)	10 Km	20	1	0.1	(ECC, 2013)
DVB-T2 (Small Service Area SFN)	55 km	110	3.3	1.6	(ECC, 2013)

Dimensioning (2/3)

A) The required number radio base stations to satisfy the mobile subscribers demand is subject to the coverage and capacity constraints of the type of radio base station used (and of course the demand level)

$$N_{BS} = \left(\left(Pent * N_{user} * R_{user} * A_{service} \right) / N_{TRX} * \left((B * SE) - D_{DTTB} \right) * A_{RBS} \right)$$

Linear Broadcasting

Viable if better SE can be achieved

$$N_{BS} = \left(\left(Pent * N_{user} * R_{user} * A_{service} \right) / \left((B) * SE * N_{TRX} \right) * A_{RBS} \right)$$

Non-Linear Broadcasting

Option	Inter-Sites Distance (ISD) in [km]	Re-use Distance in [Km]	Spectral Efficiency bit/s/Hz		References
			Optimistic	Conservative	
LTE MBSFN	2 Km	4	3	1.1	(ECC, 2013)
LTE MBSFN	5 Km	10	1.5	0.5	(ECC, 2013)
LTE MBSFN	10 Km	20	0.7	0.1	(ECC, 2013)
DVB-T2 (Small SFN)	55 km	110	3.3		(ECC, 2013)

Dimensioning (3/3)

B) Dimensioning of the Backhauling Part

- **Number of backhaul links**

$$N_{BHL} = (\quad /C_{BH})^* \; N_{BS}$$

- **Number of Aggregation Nodes**

$$N_{Agg} = (\quad)$$

- **Number of leased lines**

$$N_{BHL} = (\quad /C_{leasedline})^* \; N_{BHL}$$

Power Consumption (1/2)

1. Power consumption in Radio Base Station

$$P{\downarrow}c\,[\text{Watts}]=(N{\downarrow}TRX*[P{\downarrow}max*(\%Fixed+\%\ load)/ANT*\eta{\downarrow}PA*\eta{\downarrow}feed\ ]+([P{\downarrow}Tx-unit+P{\downarrow}processing-unit\,]*BW*ANT/BW{\downarrow}TRX\ ))/\eta{\downarrow}DC-DC*\eta{\downarrow}AC-DC*\eta{\downarrow}cooling$$

The % load represents the users' traffic load in the downlink as proportional to the possible maximum data rate

2. Power consumption in backhauling Network

Power consumption per Backhaul connection= P_F + P_{tx_BH} * (%load)

Power Models (2/2)

3. Power consumption in DTT Transmitter

$$P\downarrow c\,[Watts]=N\downarrow TRX*([P\downarrow max\,/ANT*\eta\downarrow PA*\eta\downarrow feed\,]+([P\downarrow RF+P\downarrow BB\,]*BW*ANT/BW\downarrow TRX\,MHz))/\eta\downarrow DC-DC*\eta\downarrow AC-DC*\eta\downarrow cooling$$

Source : Hauke Andreas Holtkamp, 'Enhancing the Energy Efficiency of Radio Base Stations, PhD thesis, 2013

Where

- $P\downarrow c$ represents the total consumed power per DVB-T2 transmitter,
- $N\downarrow TRX$ represents the number of transmitters (TRXs),
- $P\downarrow max$ represents the equivalent the maximum amount of power emitted by the antenna
- $P\downarrow BB$ represents the power consumed in the based band module as result of the digital signal processing and computation
- The $P\downarrow RF$ represents the power consumed RF module as results of the data transmission,
- BW represents the utilize spectrum bandwidth per transmitter.
- BW_{TRX} represents the maximum possible spectrum bandwidth per TRX (reference model Earth project).
- and ANT represents the number antennas per the TRX

Power Consumption Assumption

	DTTB	Mobile Network	References
P_{max} in Watt	1.2	0.02	(google, 2014) (ECC, 2013) (Anon., Dec. 2010)
Tx antenna height / m (Urban)	150	30	(google, 2014) (ECC, 2013) (Anon., Dec. 2010)
Power Amplifier Efficiency ($\eta\downarrow PA$)	0.4	0.4	(Holtkamp, 2013)
Cooling System Efficiency ($\eta\downarrow cooling$)	0.9	0.9	(Holtkamp, 2013)
Feeder and connection Efficiency ($\eta\downarrow feed$)	0.5	0.5	(Holtkamp, 2013)
Main Power Supply Efficiency- AC to DC ($\eta\downarrow AC\_DC$)	0.91	0.91	(Holtkamp, 2013)
p			
$\eta\downarrow DC\_DC$)			
$P\downarrow BB$ [k Watt]	1.2	0.029	(Holtkamp, 2013)
$P\downarrow RF$ in [k Watt]	0.484	0.0129	(Holtkamp, 2013)

Backhaul Link Type	P_F [W]	P_{tx_Bh} [W]	Maximum Capacity	Source
FIBER OPTIC LINK	5	2.5	10 GBPS	(GROBE, ET AL., 2011) (SKUBIC, ET AL., JANUARY 2012)

Cost Models

- The annualized total cost of ownership (TCO_t) of a radio access network (in terms of CapEx and OpEx) can be broken down into two parts: radio access part and backhaul network part.

$$C\downarrow CapEx = C\downarrow BS * N\downarrow BS + C\downarrow BHL * N\downarrow BHL + N\downarrow inst$$

$$C_{OpEx} \approx P_{BSs} + P_{BHLs} + C_{O\&M} + CR_{site} + C_{ls}$$

- The total cost of ownership of ownership (TCO) considering the annual investments and operations costs for 10 years (from year 2010 to year 2020) is calculated. For this purpose, the net present value (NPV) method is used considering discount rate of 10%.

Where TCO_t represents the annualized total cost of ownership in term of the annualized CapEx and annualized OpEx at year t, while r represents the discount rate and T represents the network operation period in year.

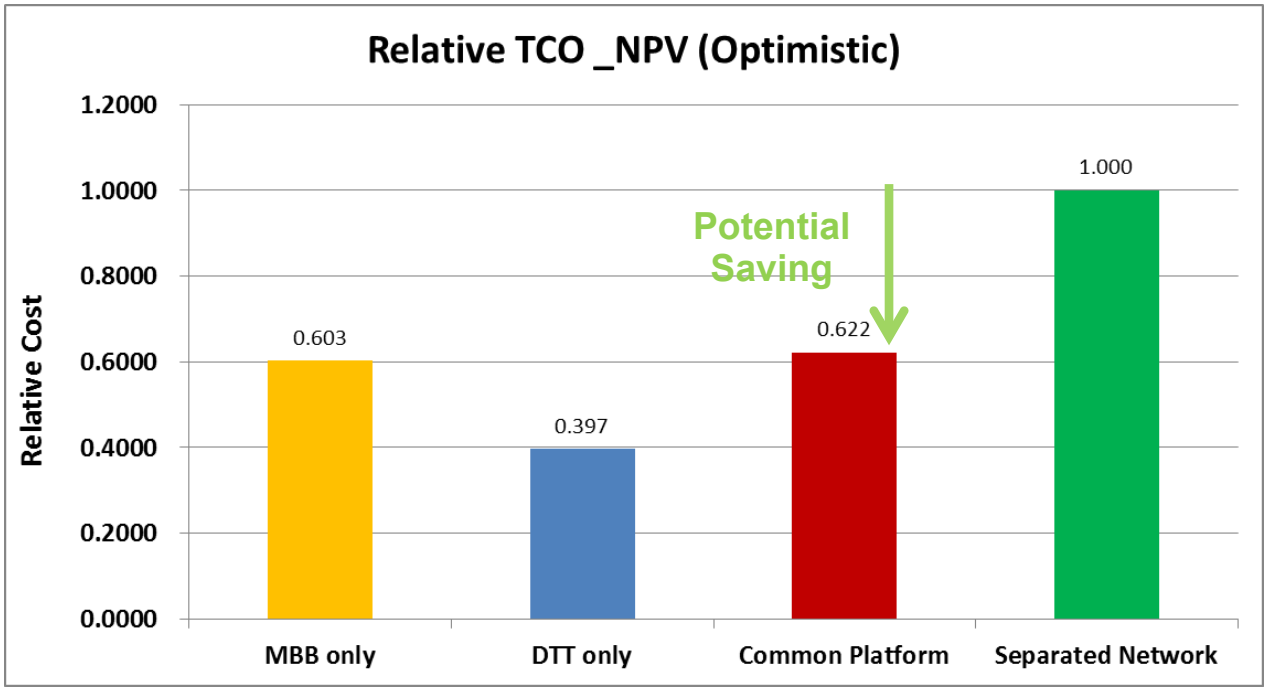
Cost Assumptions

ITEM	Cost (k€)	Reference
LTE Radio Base Station (with 3 TRX, 20 MHz per TRX)	25	(Ahmed, et al., 2013)
Cost of additional TRX in LTE	5	(Ahmed, et al., 2013)
Site Construction (LTE Macrocell)	50	(Ahmed, et al., 2013)
DVB-T2 Transmitter	225	(alibaba, 2014) (ROHDE&SCHWARZE, 2013)
Cost of Combiner in DTTB site (2 MUX per Transmitter)	15	(ROHDE&SCHWARZE, 2013)
DTTB Site Construction	400	(ROHDE&SCHWARZE, 2013)
Fiber Optic Link (ONU+ modem)	0.5	(Ahmed, et al., 2013)
Fiber Optic rollout cost per Km	1.5	(Ahmed, et al., 2013)
Annual Fiber Optic leased line fee (STM1= 155 Mbps)	1.2	(Ahmed, et al., 2013)
Annual Site rent	3	(Ahmed, et al., 2013)
Price of Electricity (KWH)	0.00007764	
O&M represent 10%(of CapEx) and installation 5%(of CapEx)		

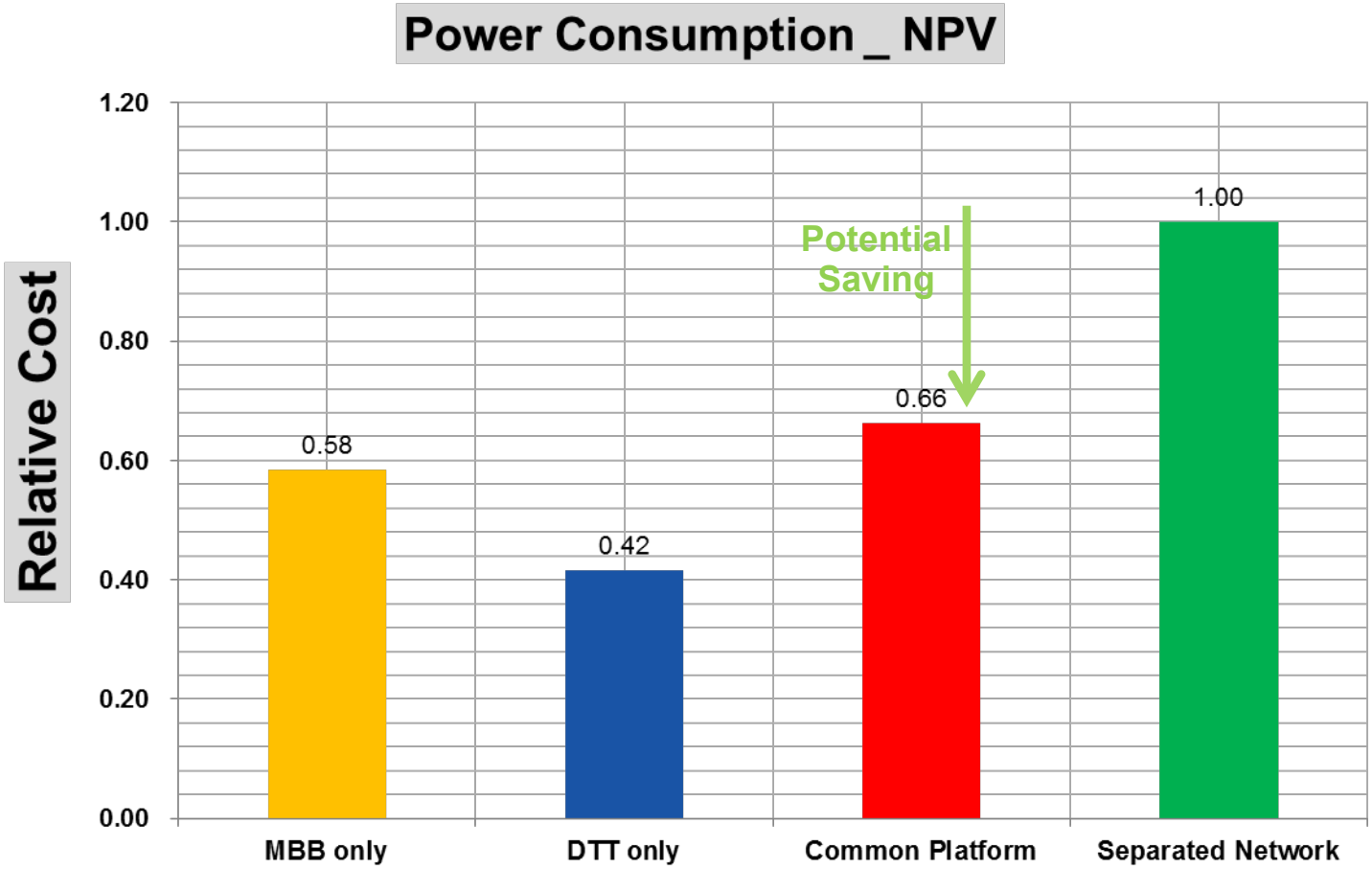
Results (1/5)

Low MBB demand Assumption (1 GB/month and user)

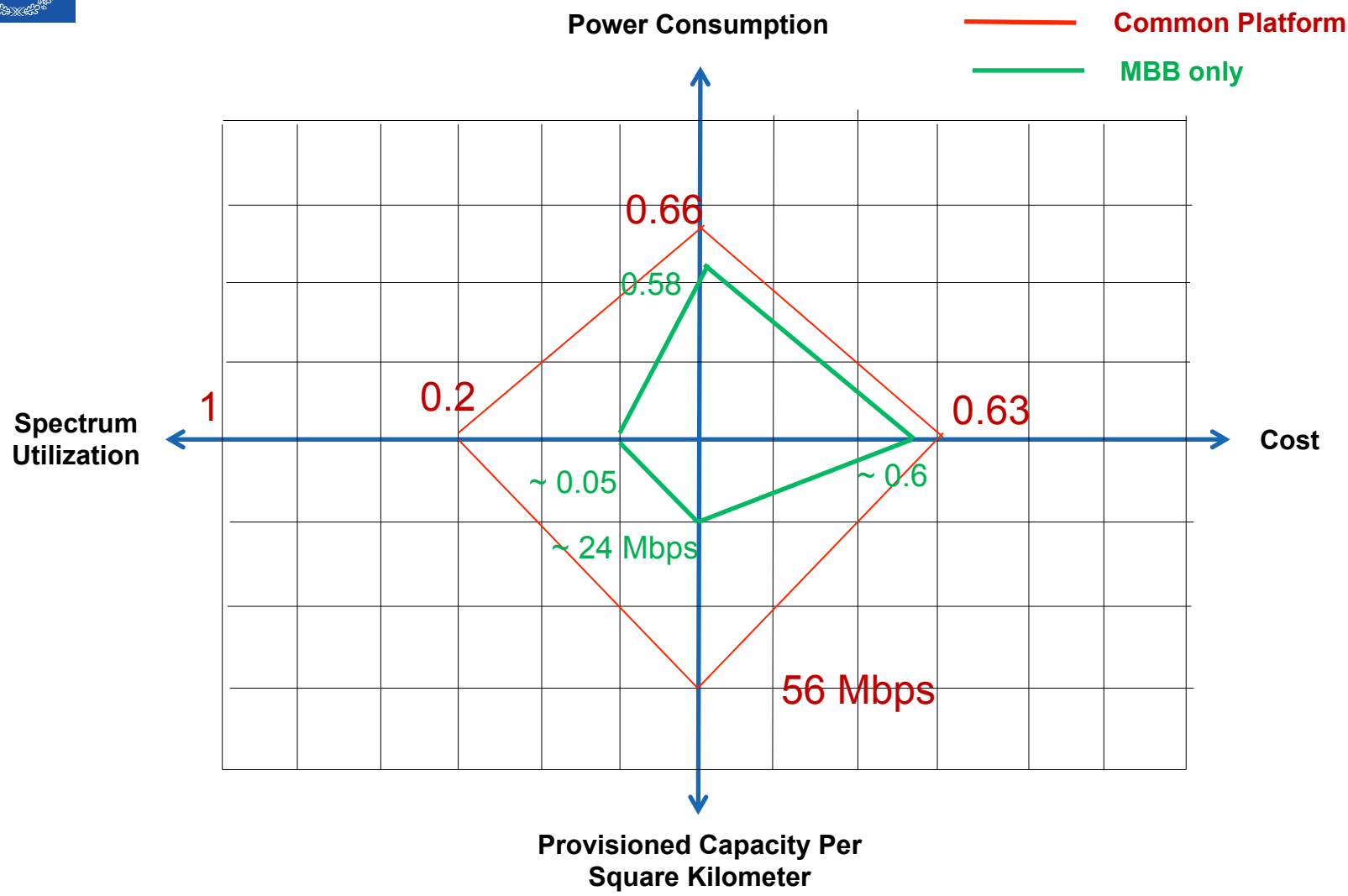
Inter site Distance (ISD in KM)	2	5	10
Spectral Efficiency SE	3	1.5	1
Cell Area	3.14	19.63	78.539
Cell Capacity (MBB)_20 MHz	180	270	180
Cell Capacity (Common)_80 MHz	86.4	-183.6	-333.6
DTTB	211.2	211.2	211.2



Results (2/5)

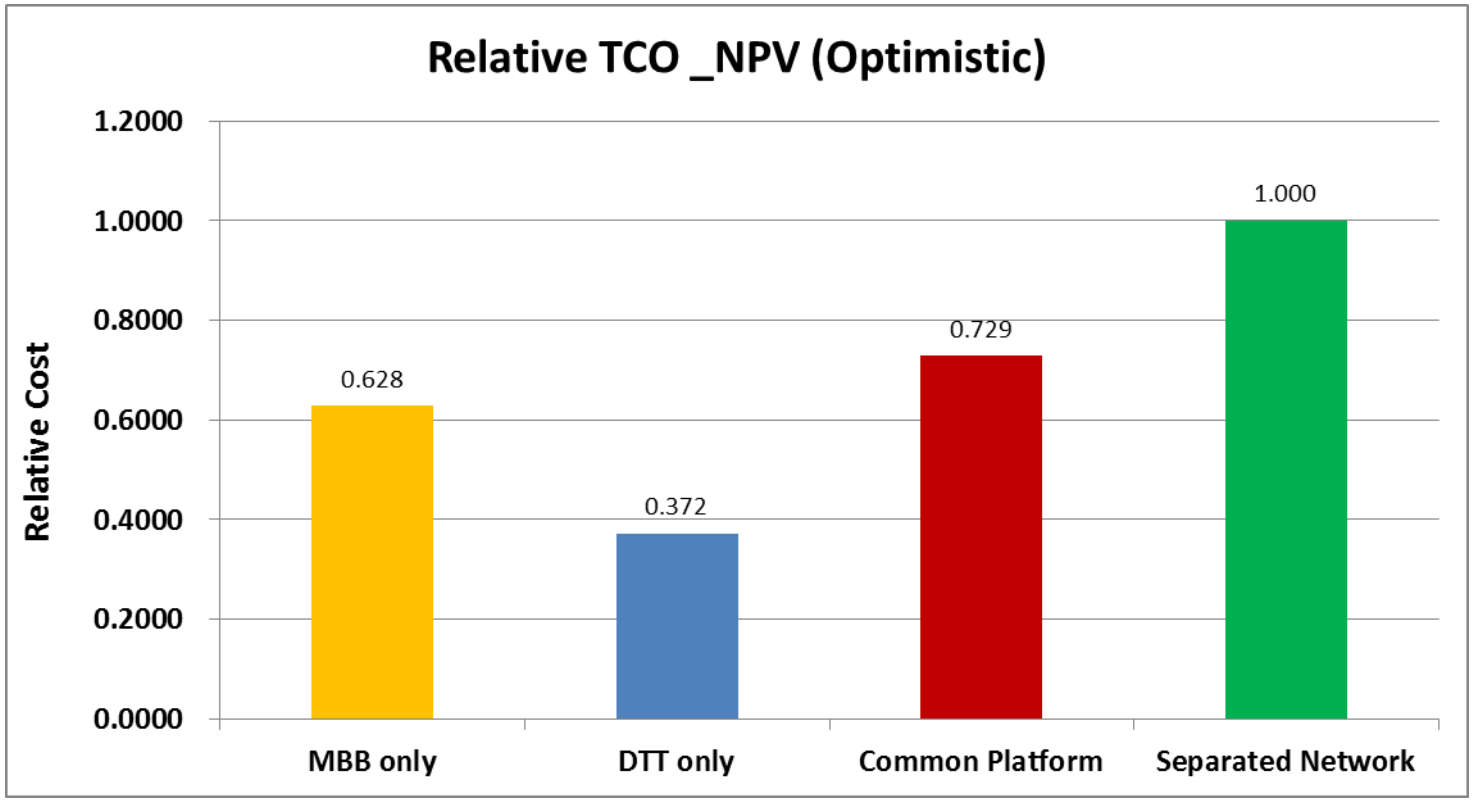

Power Consumption _ NPV
Relative Cost
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.58
0.42
0.66
1.00
Potential Saving
MBB only
DTT only
Common Platform
Separated Network

Results (3/5)


Power Consumption
Common Platform
MBB only
0.66
0.58
1
0.2
0.63
Spectrum Utilization
Cost
~ 0.05
~ 0.6
~ 24 Mbps
56 Mbps
Provisioned Capacity Per Square Kilometer

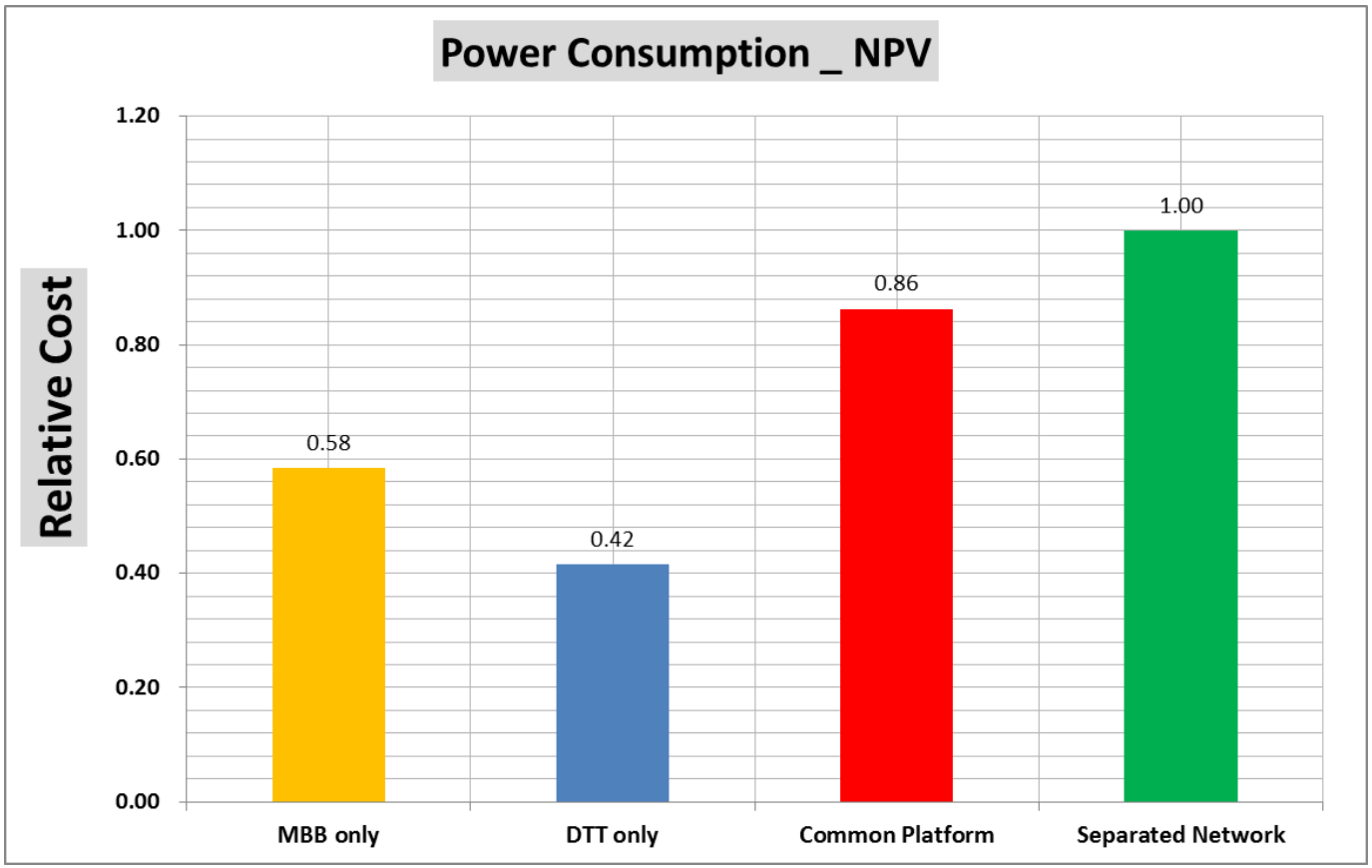
Results (4/5)

High MBB demand Assumption (5 GB/month and user)

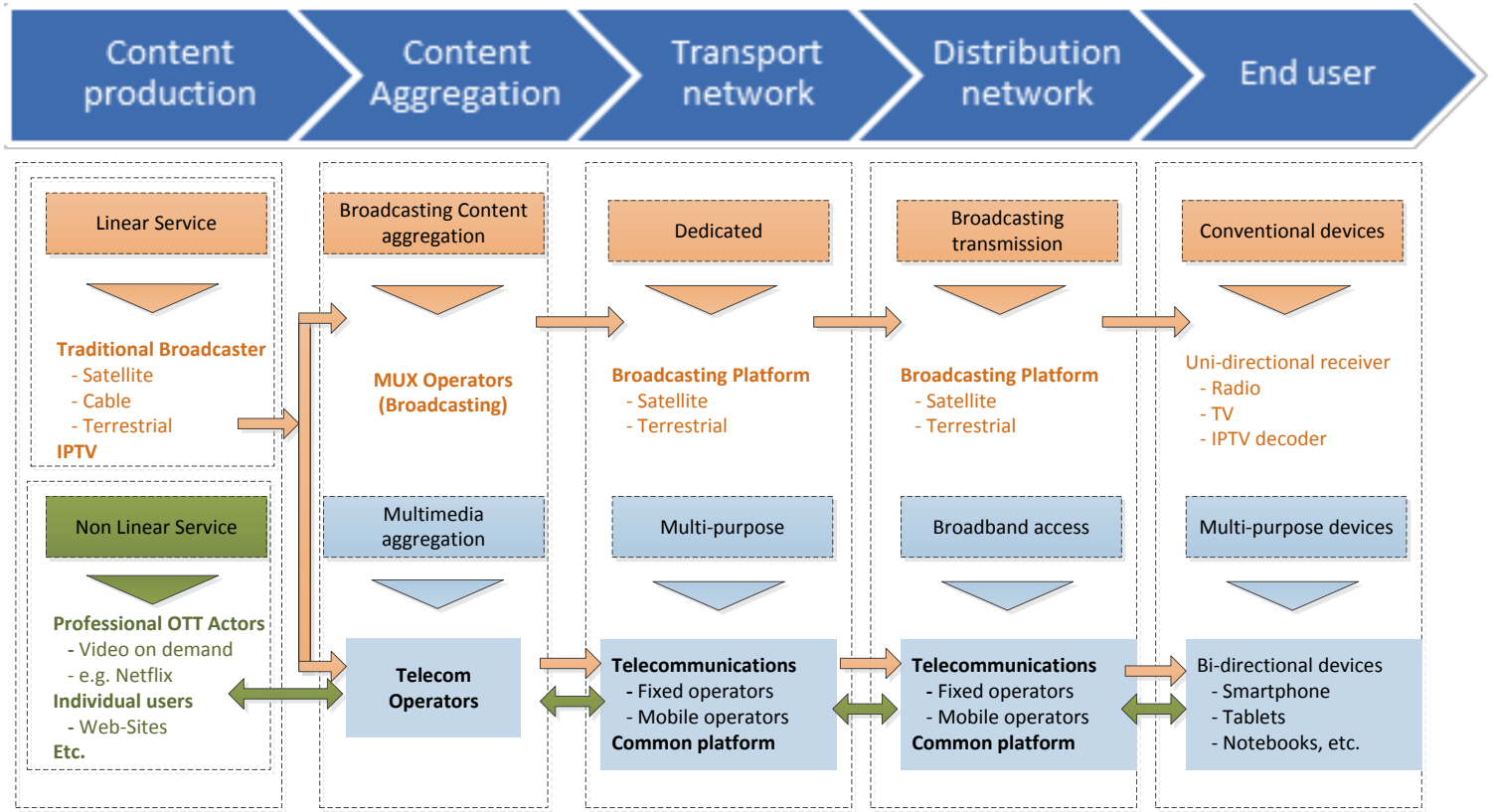


Results (5/5)

High MBB demand Assumption (5 GB/month and user)



Move From Analogue to Digital value Chain (1/2)



- Sudan National TV Broadcasting (SNTBC) and Sudan National Radio Broadcasting Corporation (SNRBC) which are government-owned entities that supervise and monitor all radio and TV programming.
- The state-owned Sudan Radio and Television Corporation (SRTC), is the only broadcaster with transmission facilities within Sudan.

Move From Analogue to Digital value Chain (2/2)

There are three key Function in a digital broadcasting :-

- ***Content Providers:*** produce the programmes but may not have any control over the multiplexer and transmitters.
- ***Multiplex Operators and content aggregators :*** are responsible for packaging different broadcasting content into bouquets.
- ***Signal Distributors:*** distribute the aggregated content from multiplexers to the transmitter networks and operate transmitters that broadcast the content.

A new regulations frameworks need to be developed to separate the three key function in digital terrestrial broadcasting value

Conclusions

- There is potential economic incentives for delivering broadcasting services over mobile network; yet this incentive can be realized only when an efficient mobile systems is deployed.
  - In order to reduce the cost of Digital Broadcasting network deployments, coordination and infrastructure sharing agreements can be encouraged as appropriate between Digital Terrestrial TV broadcasting (DTTB) networks owners and mobile TV (MTV) networks operators.
  - Efficiency and synergy gains can be achieved in network planning, by sharing resource planning and site. Also the DTTB and MTV networks will be operated and maintained together by using the same monitoring system and by the same team of experts (reducing the operational costs).
- A new regulation framework may need to be developed to separate the three key function in digital terrestrial broadcasting value chain (namely the content production and distribution).
- *Further on, the necessary interconnection regulations need to put on place in order to pave the way for rollout of common platform that are necessary for interactive and nonlinear services (Revenue Sharing challenges)*

Thanks ..