3G & LTE Developments
Spectrum Aspects

Date : February 2015

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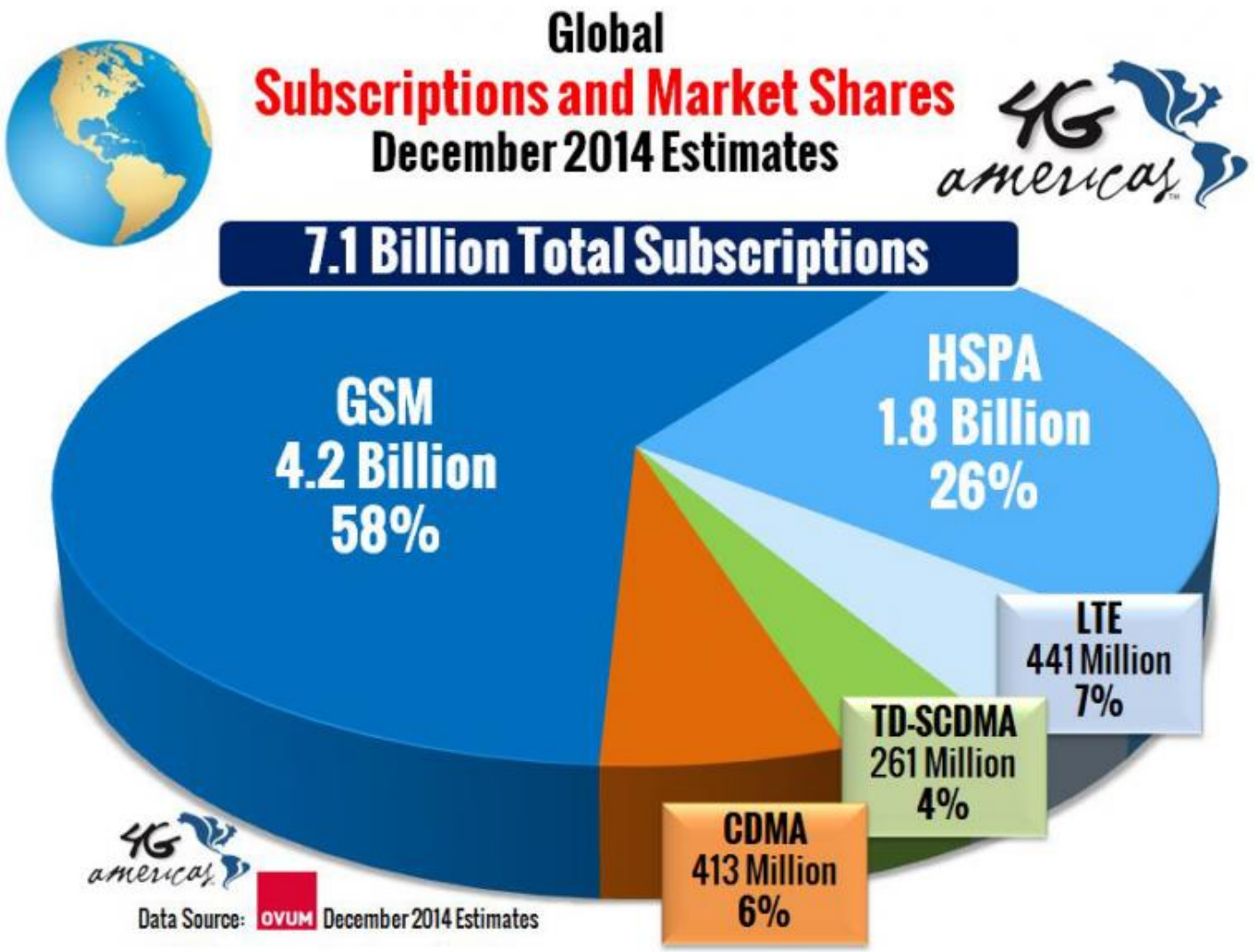
Global trends in Mobile

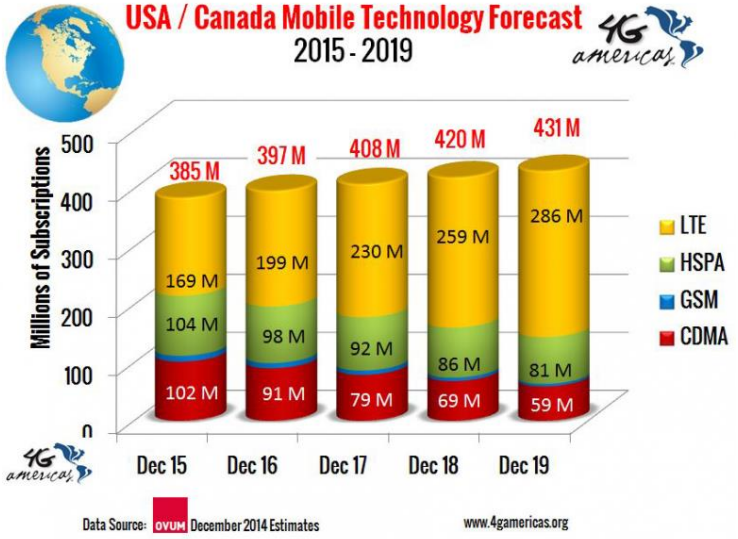
Global Mobile Subscribers

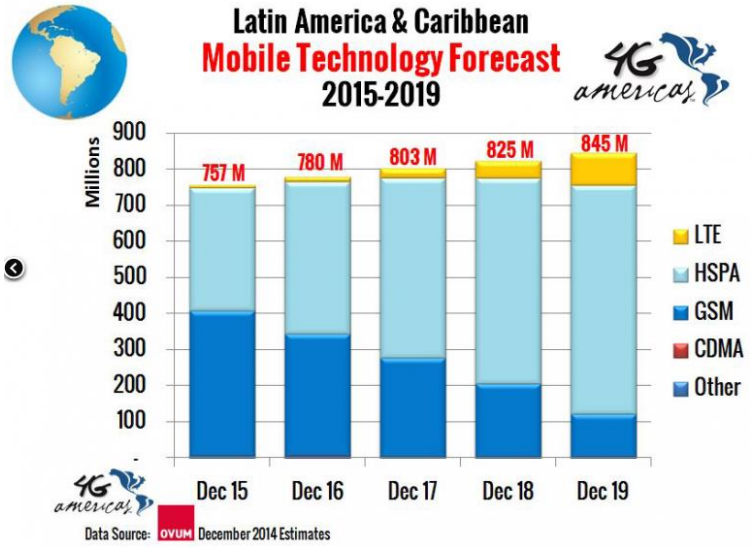


Source: www.4gamericas.org

Regional Mobile Subscribers

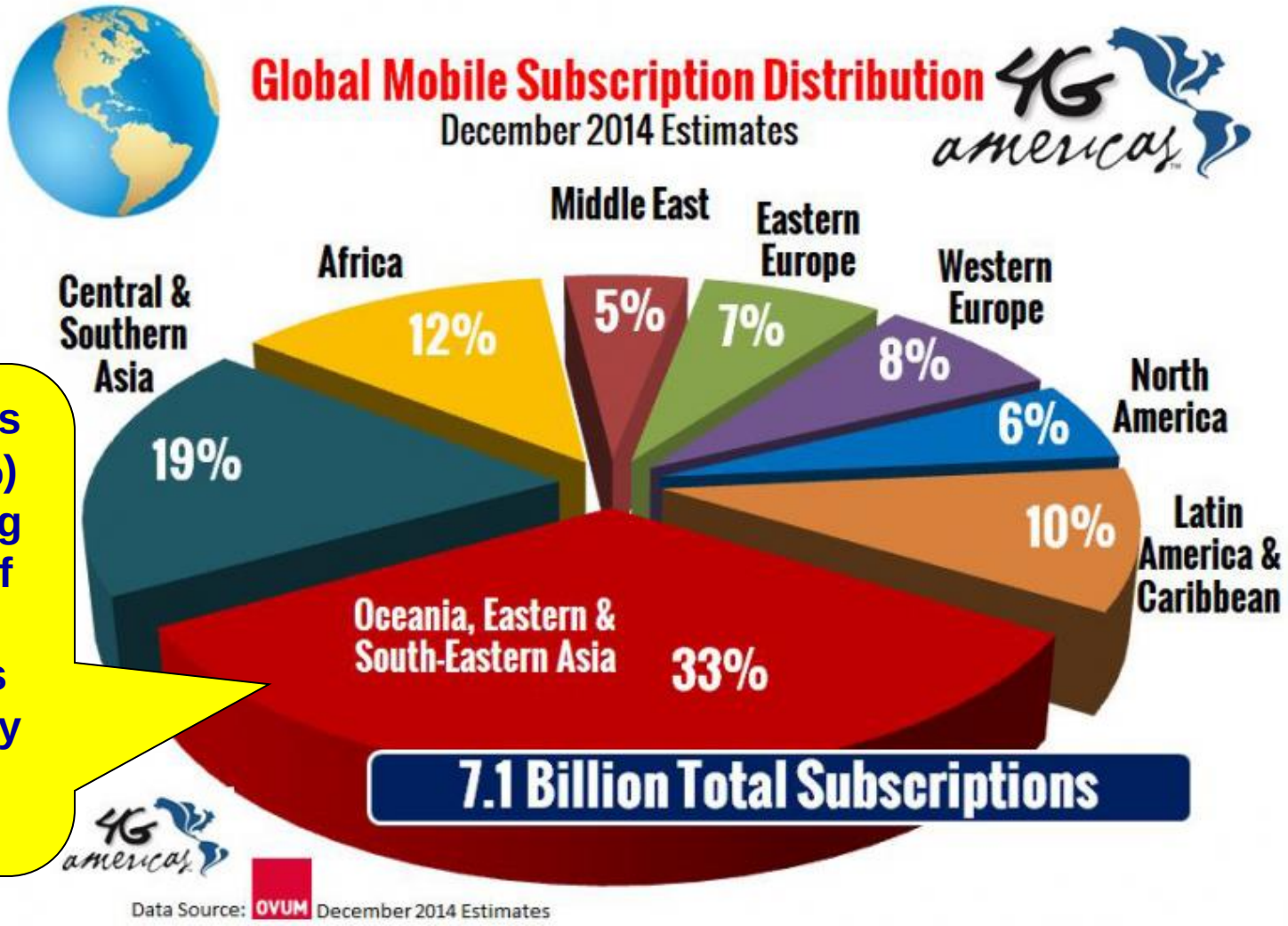
- US market is phasing out GSM (2016) and CDMA. Already 40% of the market is LTE
- Latin America mostly in the migration from GSM to 3G/HSPA. LTE just started





Source: www.4gamericas.org

Global Mobile Subscriber Distribution



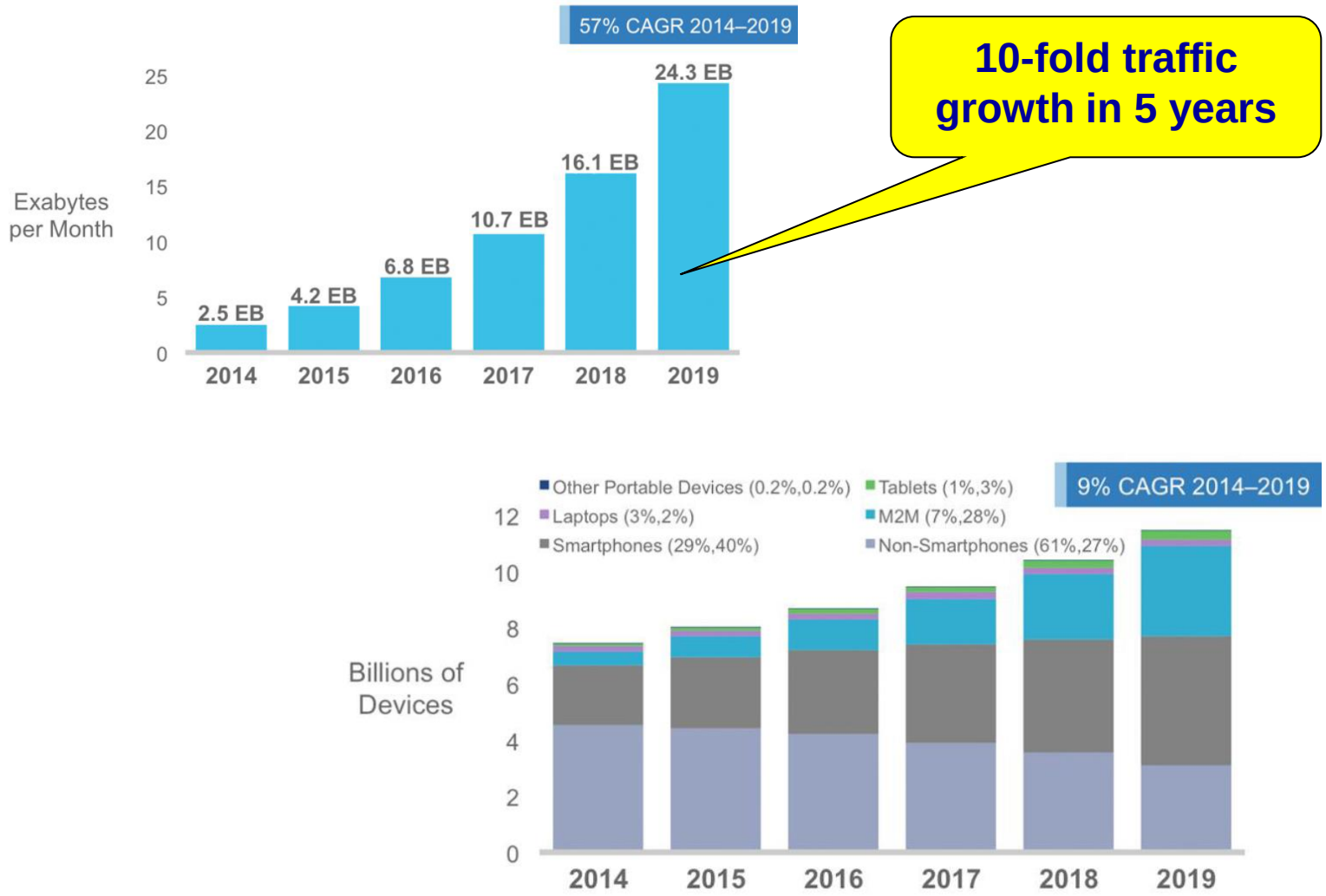
Asian markets are key (52%) in determining economies of scale of technologies and frequency bands supported

Source: www.4gamericas.org

Relevant trends in mobile

- **Fast migration from GSM to 3G/HSPA+ and subsequently to LTE/LTE-Advanced**
- **Rapid growth of mobile broadband**
  - **Baseline mobile broadband: 21-42 Mb/s commercially**
  - **Smartphone boom**
- **Continuous technology upgrades**
  - **Increasing datarate and reducing cost/MByte 3G – HSDPA – HSUPA - HSPA+ - LTE – LTE Advanced**
- **Mobile devices, not just mobile phones**
  - **Penetration already > 100%. Further growth is beyond the personal mobile phone**
  - **M2M (Machine to Machine) like a mobile data device in the Tom-Tom, connected cars, E-Call, mobile payment terminals, etc.**

Projections of datatraffic growth (1)



Source: Cisco VNI, 2015

Projections of datatraffic growth (2)

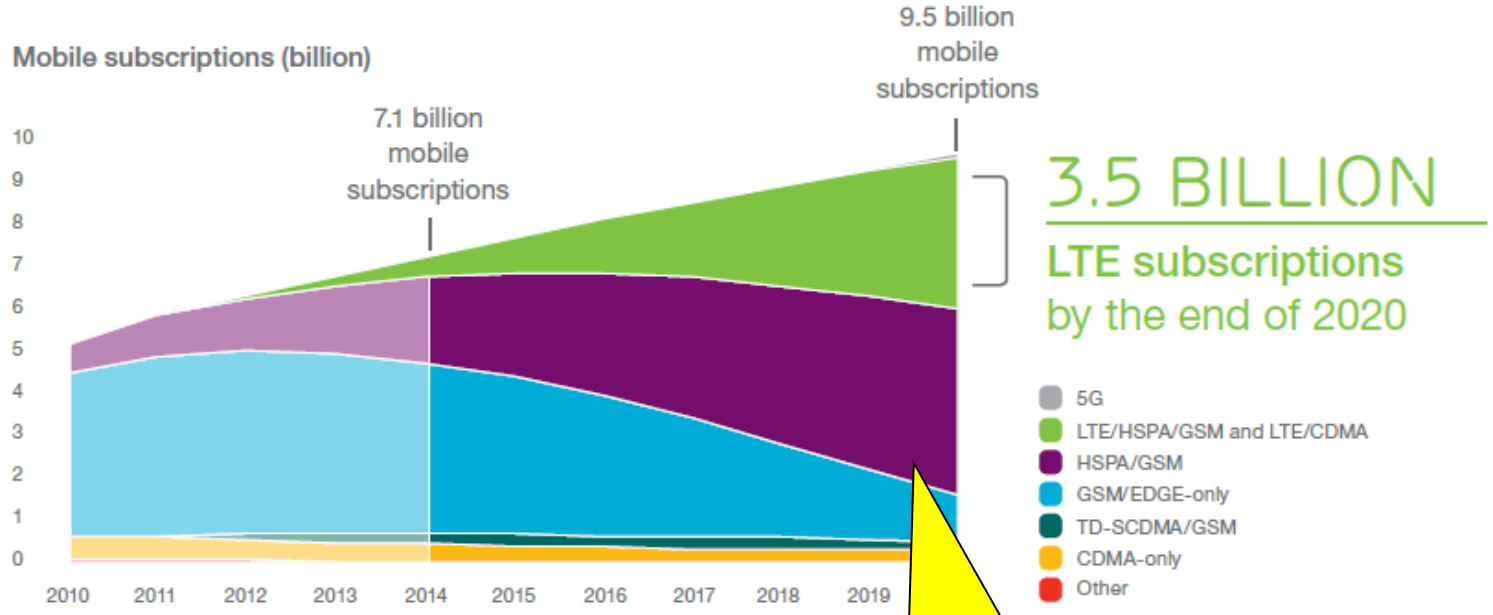
Device Type	2014	2019
Nonsmartphone	22 MB/month	105 MB/month
M2M Module	70 MB/month	366 MB/month
Wearable Device	141 MB/month	479 MB/month
Smartphone	819 MB/month	3,981 MB/month
4G Smartphone	2,000 MB/month	5,458 MB/month
Tablet	2,076 MB/month	10,767 MB/month
4G Tablet	2,913 MB/month	12,314 MB/month
Laptop	2,641 MB/month	5,589 MB/month

Source: Cisco VNI Mobile, 2015

- **Very strong growth both in terms of data traffic/device as well is in the number of devices has to be anticipated.**

Source: Cisco VNI Mobile 2015

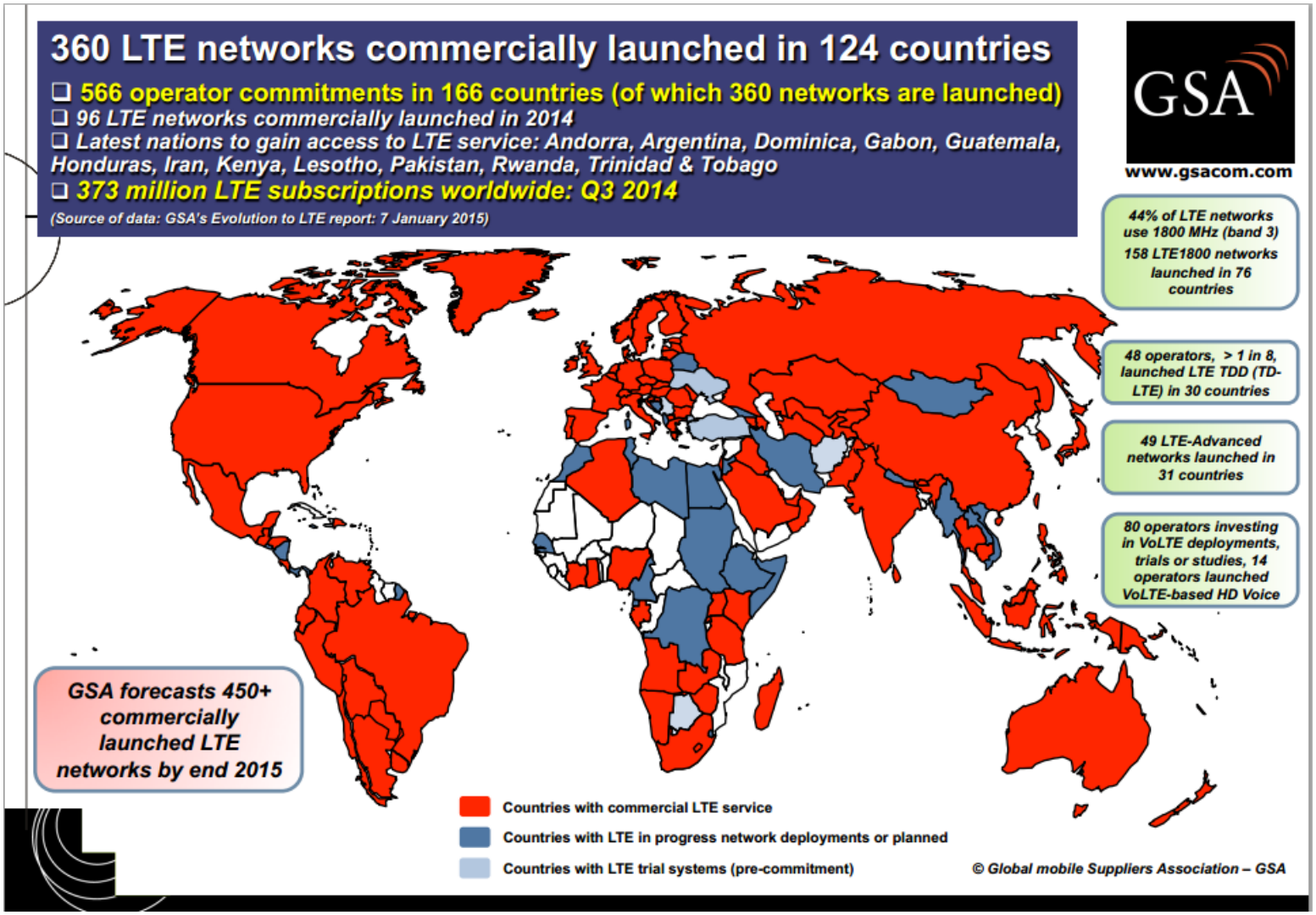
Projections of global mobile broadband growth



Even though LTE shows strong growth, HSPA is expected to dominate the global market for the next 5 years

Source: Ericsson Mobility Report, November 2014

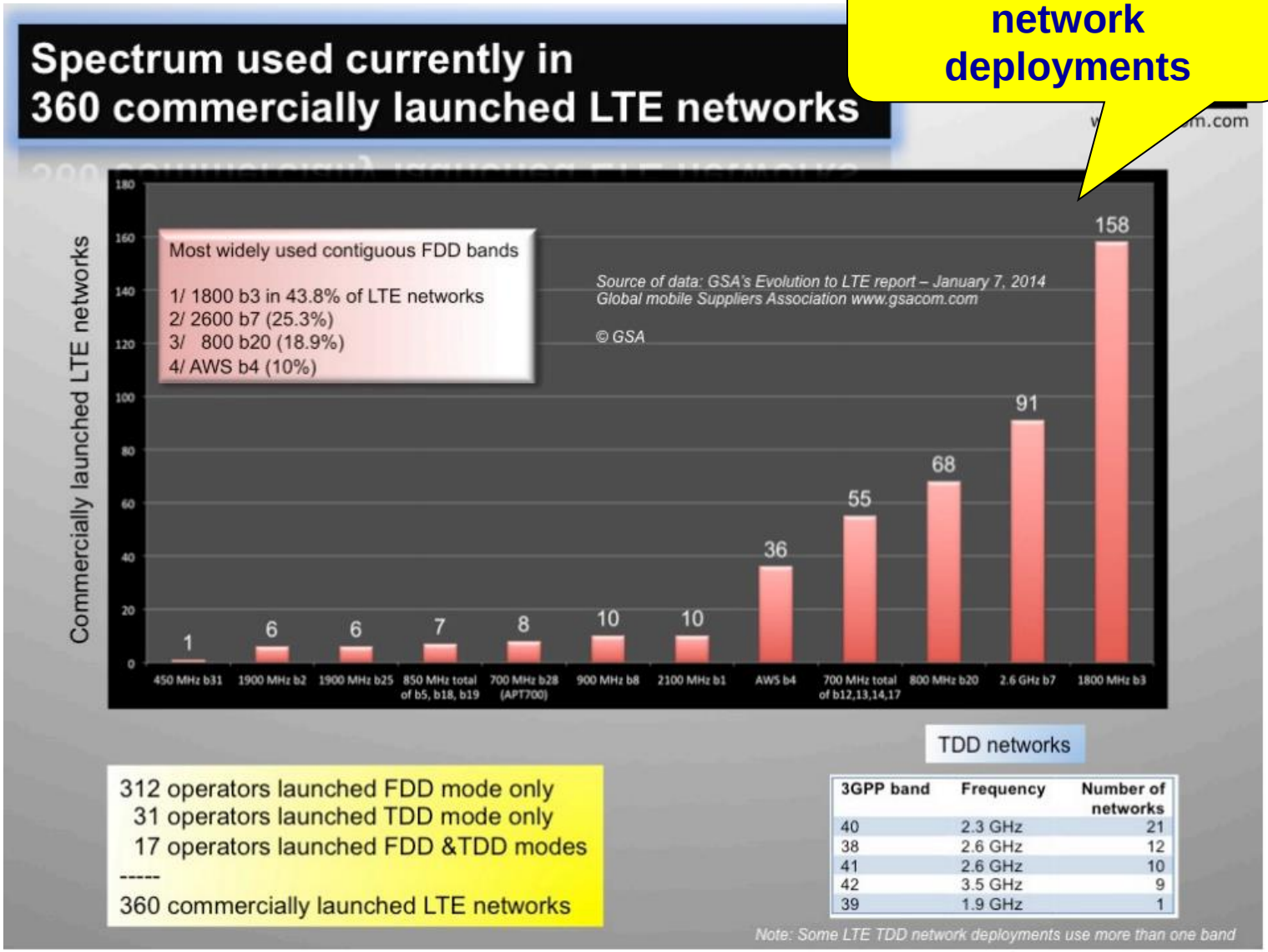
LTE Status Worldwide (1)



Source: GSA global LTE Market Update, January 2015

LTE Status Worldwide (2)

LTE 1800 has most network deployments



Source: GSA status of the global LTE market, January 2015

LTE Mobile Device Status

LTE 1800 has most mobile devices

LTE FDD	
1800 MHz band 3	944 devices
2600 MHz band 7	893 devices
2100 MHz band 1	699 devices
800 MHz band 20	554 devices
AWS band 4	513 devices
800/1800/2600 tri-band	487 devices
700 MHz bands 12 or 17	469 devices
850 MHz band 5	453 devices
900 MHz band 8	425 devices
700 MHz band 13	363 devices
1900 MHz band 2	305 devices
1900 MHz band 25	138 devices
APT700 band 28	55 devices

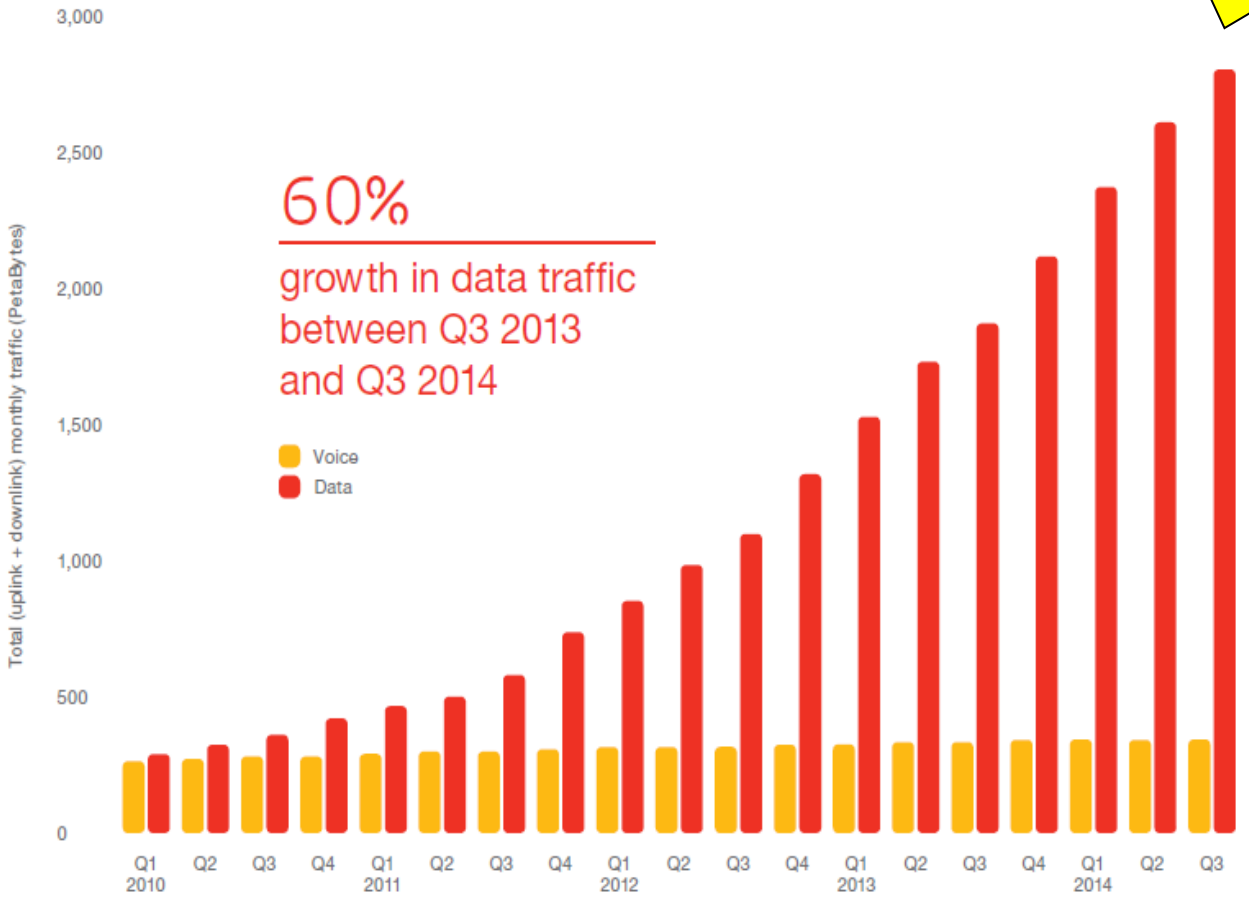
LTE TDD	
2300 MHz band 40	427 devices
2600 MHz band 38	422 devices
2600 MHz band 41	261 devices
1900 MHz band 39	250 devices
3500 MHz band 42,43	26 devices

The APT 700 ecosystem is materialising. Devices become available, networks launch, spectrum widely adopted

Source: GSA global LTE Market Update, January 2015

Growth of data traffic

Data traffic dominates and continues to grow rapidly



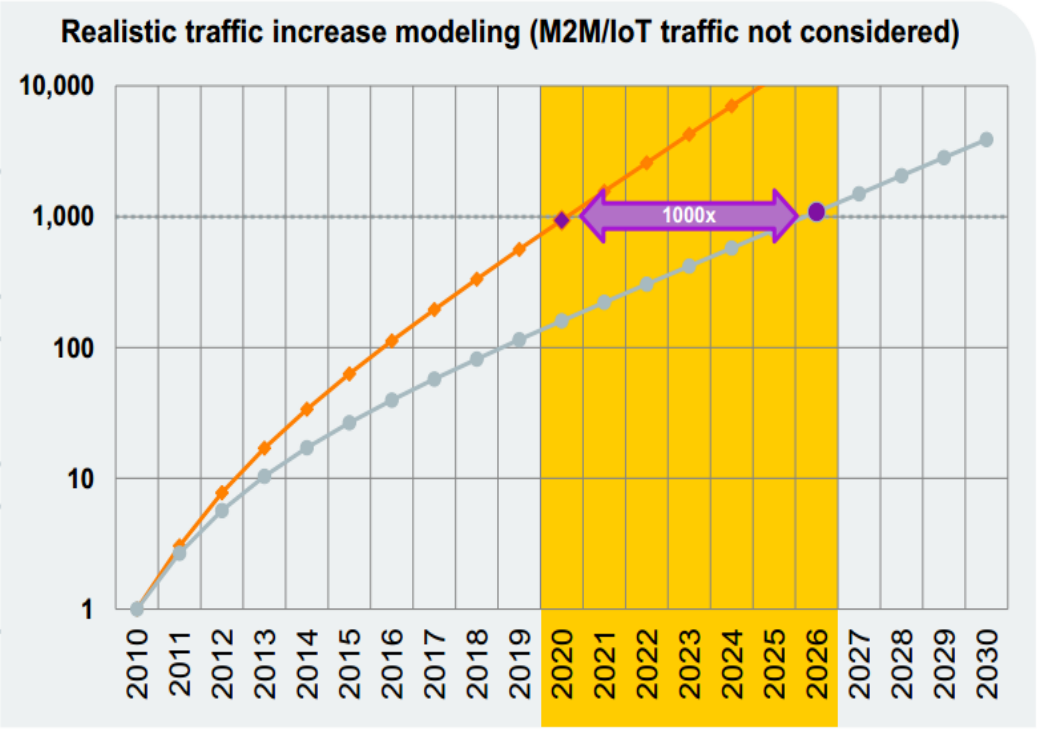
Source : Ericsson Market and Traffic Data Report, November 2014

Growth of data traffic

After 2020 Mobile Networks needs to be ready to cope with the 1000x data challenge

Assumptions

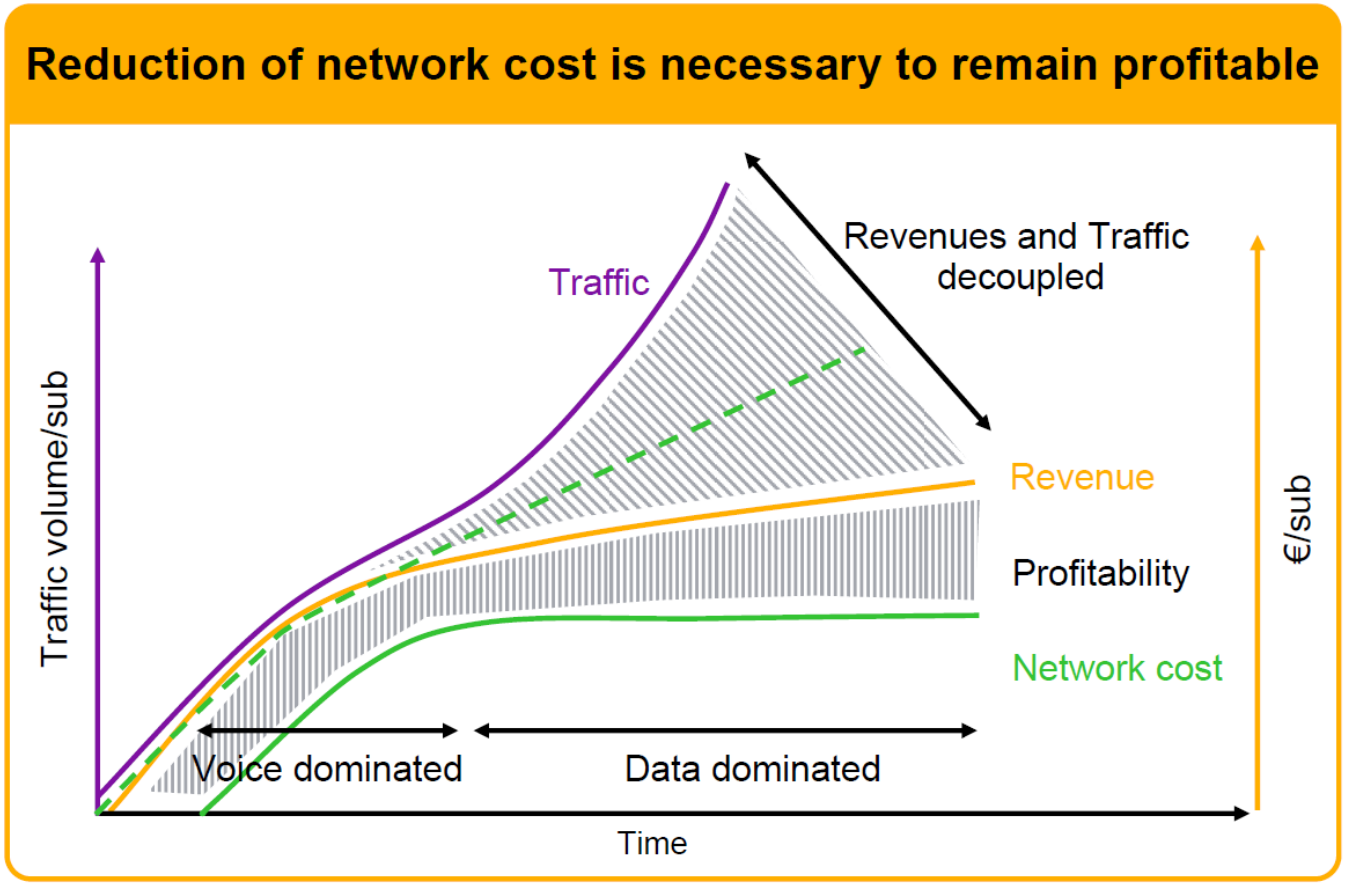
Traffic volume per subscriber	+50% per year +25% per year
Total subscriber base	+10% per year
Mobile broadband penetration	reaching 100% by 2020



Source : NSN presentation, 2013

Industry challenge

Decoupling of revenue and traffic requires lower cost/bit technologies



Source :*Nokia Siemens Network presentation at "Beyond Connectivity 2008" in Dubai, April 2008*

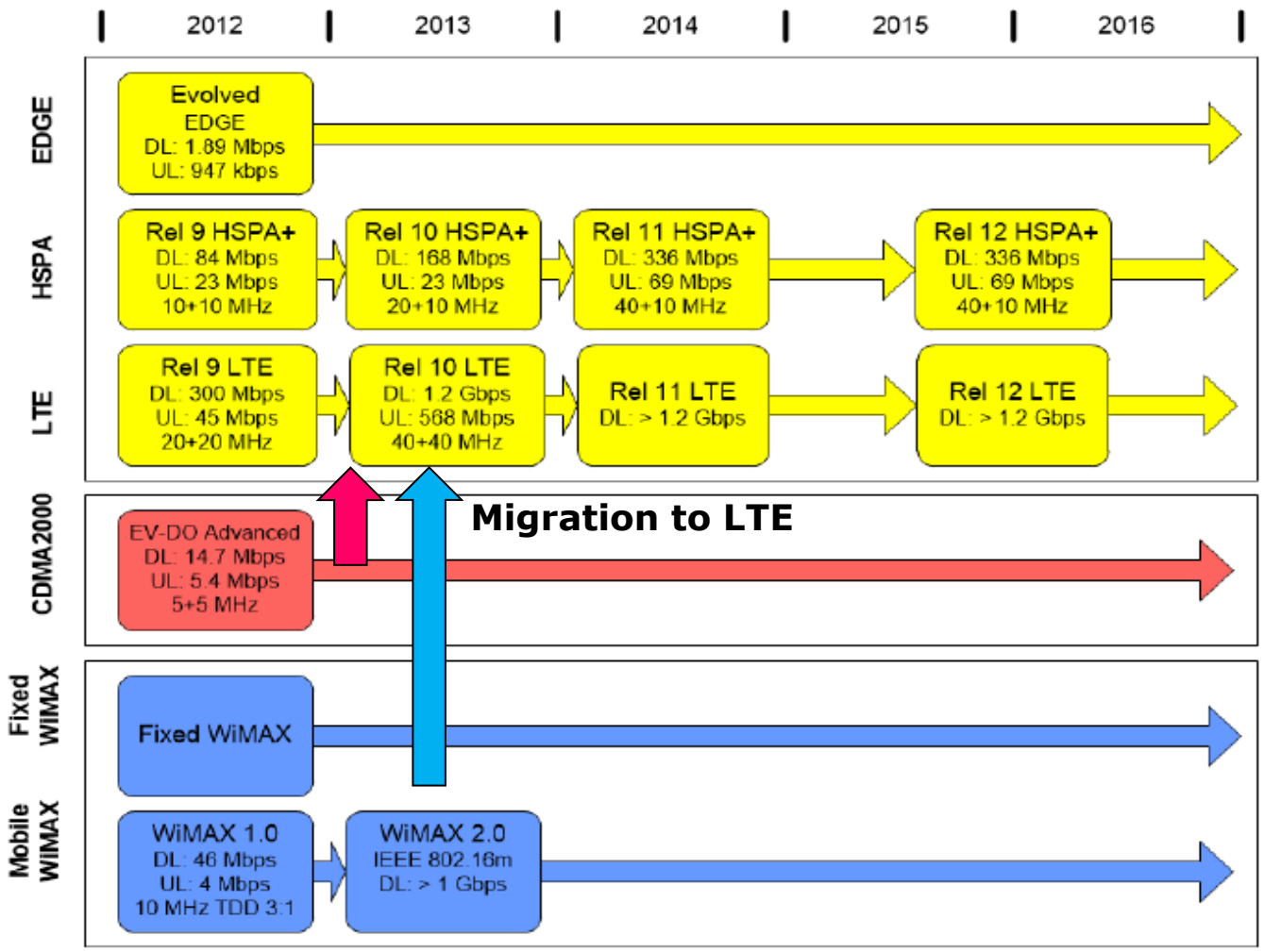
Mobile technology roadmap

How to increase RAN capacity?

- **Modulation: from QPSK to 64 QAM (and beyond)**
- **Coding: variable coding to maximise throughput under different conditions**
- **Spectrum: more bandwidth, more throughput**
- **More cells: like more basestations, 6 instead of 3 sectors, small cells, etc.**
- **MIMO and other smart antenna solutions: by using multiple, decorrelated, flows within the same spectrum more throughput can be achieved with signal processing. Or similarly, using multiple beams within a cell to serve different customers**
- **Carrier aggregation, combining multiple frequencies**
- **CoMP, Coordinated Multi Point, being connected to multiple cells at the same time (, 2 macro cells or macro and small cell)**

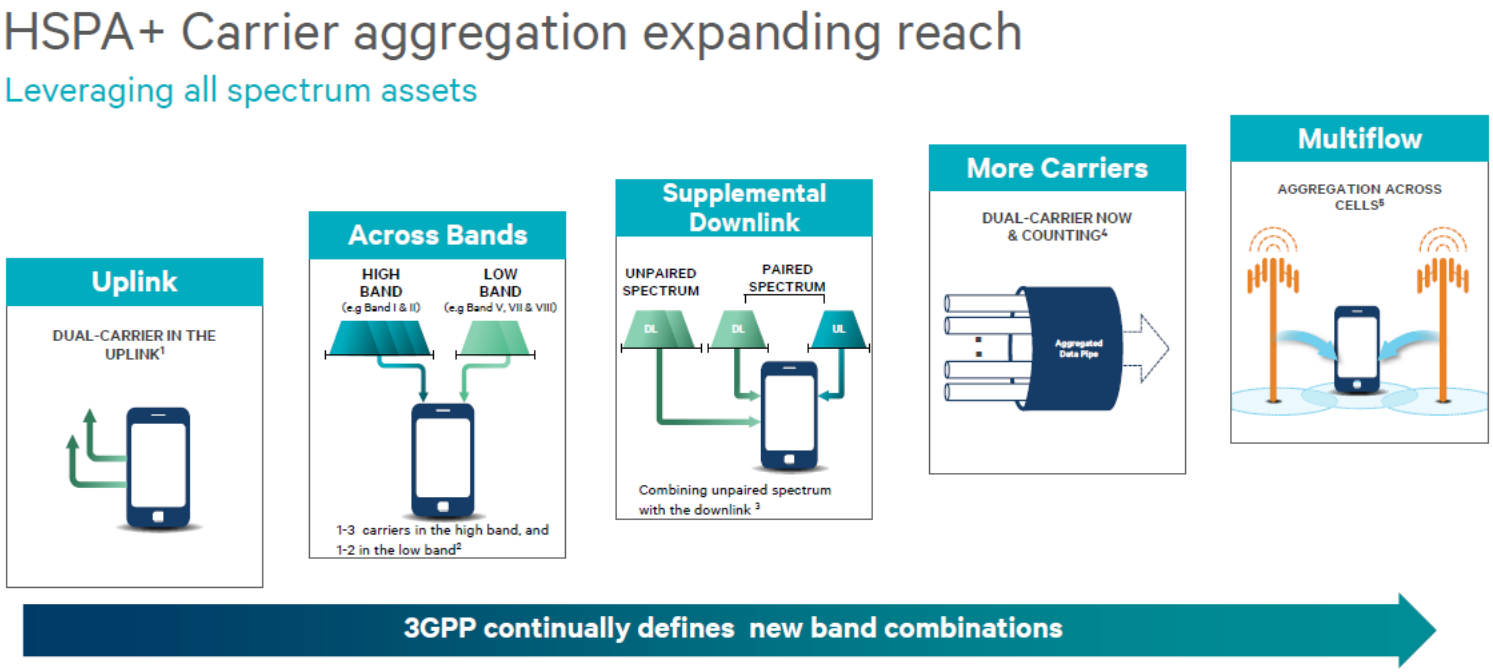
The same concepts do apply to both HSPA and LTE but implementation can be different

Overall technology roadmap



Source: Rysavy Mobile Broadband Explosion, August 2013

General trend in carrier aggregation (HSPA+ and LTE)



Source: Evolution of HSPA+ Carrier Aggregation, August 2014

Drivers for 4G deployment

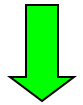
- Further reduction of cost/Gbyte
- Higher spectrum efficiency

Cost-efficiency

- Lower latency
- Higher peak throughput

Improved QoS

- Remaining Issue: premium price of phone



Roaming

Roaming issue

- Roaming is a major source of revenues
- Tourists from both the US, Europe and South America
- Roaming does not necessarily require the visited network to use the same band as in the home country. This is a common misunderstanding. What is essential is that the mobile device brought along by the visitor supports the frequency band used locally
- Current US LTE Roaming potential is fragmented due to use of multiple incompatible band plans in the US
- Anticipate most roamers to use 3G/HSPA for the coming years. Typical US roamer has a 3G capable device. Most higher-end devices are quad-band GSM and quad/penta-band 3G/HSPA and can roam on 3G 850/900/1900/2100 MHz
- Existing data roaming is too expensive so benefits of LTE will not be used unless LTE roaming data tariffs drop very significantly

Mobile phone LTE roaming capability (iPhones)

Main Model	Version	Band 17	Band 13	APT 700	800 MHz	850 MHz	900 MHz	1800 MHz	2600 MHz
iPhone 5 model (Q3 2012)	AT&T	Yes	No	No	No	No	No	No	No
	Verizon	No	Yes	No	No	Yes	No	Yes	No
	Global	No	No	No	No	Yes	No	Yes	No
iPhone 5C/5S model (Q3 2013)	AT&T/Verizon	Yes	Yes	No	Yes	Yes	Yes	Yes	No
	Sprint	Yes	Yes	No	Yes	Yes	Yes	Yes	No
	Global	No	No	No	Yes	Yes	Yes	Yes	Yes
	Asia	No	No	No	Yes	Yes	Yes	Yes	Yes
	China	No	No	No	Yes	Yes	Yes	Yes	Yes
iPhone 6/6 Plus model (Q3 2014)	AT&T/Verizon	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Global	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

- **Using 1800 MHz provides roaming to most iPhone models so a better capture of roamers than FCC 700**

Key: use one of the main global mobile bands for maximum roaming revenues. 1800 MHz most popular

Source: www.apple.com/iphone/LTE

Frequency bands

Standardised bands for 3G/UMTS/HSPA FDD

Operating Band	UL Frequencies UE transmit, Node B receive	DL frequencies UE receive, Node B transmit
I	1920 - 1980 MHz	2110 -2170 MHz
II	1850 -1910 MHz	1930 -1990 MHz
III	1710-1785 MHz	1805-1880 MHz
IV	1710-1755 MHz	2110-2155 MHz
V	824 - 849MHz	869-894MHz
VI	830-840 MHz	875-885 MHz
VII	2500 - 2570 MHz	2620 - 2690 MHz
VIII	880 - 915 MHz	925 - 960 MHz
IX	1749.9 - 1784.9 MHz	1844.9 - 1879.9 MHz
X	1710-1770 MHz	2110-2170 MHz
XI	1427.9 - 1447.9 MHz	1475.9 - 1495.9 MHz
XII	699 - 716 MHz	729 - 746 MHz
XIII	777 - 787 MHz	746 - 756 MHz
XIV	788 - 798 MHz	758 - 768 MHz
XV	Reserved	Reserved
XVI	Reserved	Reserved
XVII	Reserved	Reserved
XVIII	Reserved	Reserved
XIX	830 – 845 MHz	875 -890 MHz
XX	832 - 862 MHz	791 - 821 MHz
XXI	1447.9 - 1462.9 MHz	1495.9 - 1510.9 MHz
XXII	3410 – 3490 MHz	3510 – 3590 MHz
XXV	1850 -1915 MHz	1930 -1995 MHz
XXVI	814-849 MHz	859-894 MHz
XXXII (NOTE 1)	N/A	1452 – 1496 MHz

UMTS Core Band

UMTS 850

UMTS 900

Source: 3GPP TS 25.104 v12.3.0 (2014-6)

LTE Spectrum options

- LTE is available in FDD and TDD
- Main new bands for LTE FDD:
  - Digital dividend (700 MHz Americas, 700 and 800 MHz Europe/Africa/Middle East/parts of Asia)
  - 2600 MHz band
- Main band for LTE TDD:
  - 2300 MHz band, some in 2600 MHz band
- Main in-band migration option with global acceptance:
  - LTE 1800, LTE 900 also starts to gain momentum
- Many other potential bands have been identified and are possible according to 3GPP but terminal developments are likely to focus initially on the main bands with the largest economies of scale
- Low band required for coverage
- Higher band and a lot of spectrum required for capacity (2x20 MHz initially, more for LTE-Advanced)

LTE Frequency bands (FDD)

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit	Downlink (DL) operating band BS transmit UE receive	Duplex Mode
	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	FDD
2	1850 MHz – 1910 MHz	1930 MHz – 1990 MHz	FDD
3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	FDD
4	1710 MHz – 1755 MHz	2110 MHz – 2155 MHz	FDD
5	824 MHz – 849 MHz	869 MHz – 894MHz	FDD
6 (NOTE 1)	830 MHz – 840 MHz	875 MHz – 885 MHz	FDD
7	2500 MHz – 2570 MHz	2620 MHz – 2690 MHz	FDD
8	880 MHz – 915 MHz	925 MHz – 960 MHz	FDD
9	1749.9 MHz – 1784.9 MHz	1844.9 MHz – 1879.9 MHz	FDD
10	1710 MHz – 1770 MHz	2110 MHz – 2170 MHz	FDD
11	1427.9 MHz – 1447.9 MHz	1475.9 MHz – 1495.9 MHz	FDD
12	699 MHz – 716 MHz	729 MHz – 746 MHz	FDD
13	777 MHz – 787 MHz	746 MHz – 756 MHz	FDD
14	788 MHz – 798 MHz	758 MHz – 768 MHz	FDD
15	Reserved	Reserved	FDD
16	Reserved	Reserved	FDD
17	704 MHz – 716 MHz	734 MHz – 746 MHz	FDD
18	815 MHz – 830 MHz	860 MHz – 875 MHz	FDD
19	830 MHz – 845 MHz	875 MHz – 890 MHz	FDD
20	832 MHz – 862 MHz	791 MHz – 821 MHz	
21	1447.9 MHz – 1462.9 MHz	1495.9 MHz – 1510.9 MHz	FDD
22	3410 MHz – 3490 MHz	3510 MHz – 3590 MHz	FDD
23	2000 MHz – 2020 MHz	2180 MHz – 2200 MHz	FDD
24	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD
25	1850 MHz – 1915 MHz	1930 MHz – 1995 MHz	FDD
26	814 MHz – 849 MHz	859 MHz – 894 MHz	FDD
27	807 MHz – 824 MHz	852 MHz – 869 MHz	FDD
28	703 MHz – 748 MHz	758 MHz – 803 MHz	FDD
29	N/A	717 MHz – 728 MHz	FDD (NOTE 2)
30	2305 MHz – 2315 MHz	2350 MHz – 2360 MHz	FDD
31	452.5 MHz – 457.5 MHz	462.5 MHz – 467.5 MHz	FDD
32	N/A	1452 MHz – 1496 MHz	FDD (NOTE 2)

LTE in 2100

LTE 1800

LTE 850

LTE 2600

LTE 900

FCC 700 Lower A, B & C

FCC 700 Upper C “Verizon”

FCC 700 Upper D, band 14

FCC 700 Lower B & C “AT&T”

LTE 800

E-SMR-800, “Sprint”

APT-700

Source: 3GPP TS 36.104 - V12.4.0 (2014-06)

LTE Frequency bands (TDD)

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit F_{UL_low} – F_{UL_high}	Downlink (DL) operating band BS transmit UE receive F_{DL_low} – F_{DL_high}	Duplex Mode
33	1900 MHz – 1920 MHz	1900 MHz – 1920 MHz	TDD
34	2010 MHz – 2025 MHz	2010 MHz – 2025 MHz	TDD
35	1850 MHz – 1910 MHz	1850 MHz – 1910 MHz	TDD
36	1930 MHz – 1990 MHz	1930 MHz – 1990 MHz	TDD
37	1910 MHz – 1930 MHz	1910 MHz – 1930 MHz	TDD
38	2570 MHz – 2620 MHz	2570 MHz – 2620 MHz	TDD
39	1880 MHz – 1920 MHz	1880 MHz – 1920 MHz	TDD
40	2300 MHz – 2400 MHz	2300 MHz – 2400 MHz	TDD
41	2496 MHz – 2690 MHz	2496 MHz – 2690 MHz	TDD
42	3400 MHz – 3600 MHz	3400 MHz – 3600 MHz	TDD
43	3600 MHz – 3800 MHz	3600 MHz – 3800 MHz	TDD
44	703 MHz – 803 MHz	703 MHz – 803 MHz	TDD

LTE-2600

LTE-2300

LTE-2600 “Clearwire”

Source: 3GPP TS 36.104 - V12.4.0 (2014-06)

LTE 1800 dominates

1800 MHz: most popular LTE band

1800 MHz continues to be the most popular spectrum for LTE deployments, which is used in the majority of commercially launched networks globally. ***GSA expects that 1800 MHz (3GPP band 3) will continue as the prominent band for LTE network deployments for the foreseeable future.***

322 LTE1800 user devices are announced, i.e. more than 3 times the number confirmed by GSA a year ago. LTE1800 user devices are entering the mainstream and come in all form factors. The most popular smartphones and brands support LTE1800.

Source: GSA Status of the LTE ecosystem, 25 August 2013

Example of LTE 1800 considerations: Starhub (1)

Why LTE1800?

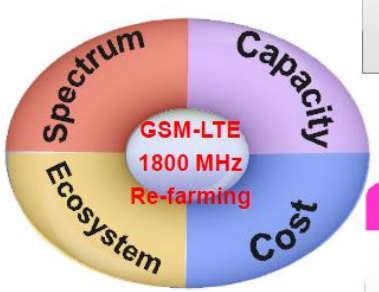
StarHub

Spectrum Availability

- 351 operators in 148 countries.
- No need for new spectrum for LTE1800.

Capacity Requirement

- Data traffic volume doubles every year (or more).
- LTE1800 complements LTE2600 and existing HSPA networks.



Eco-system Ready

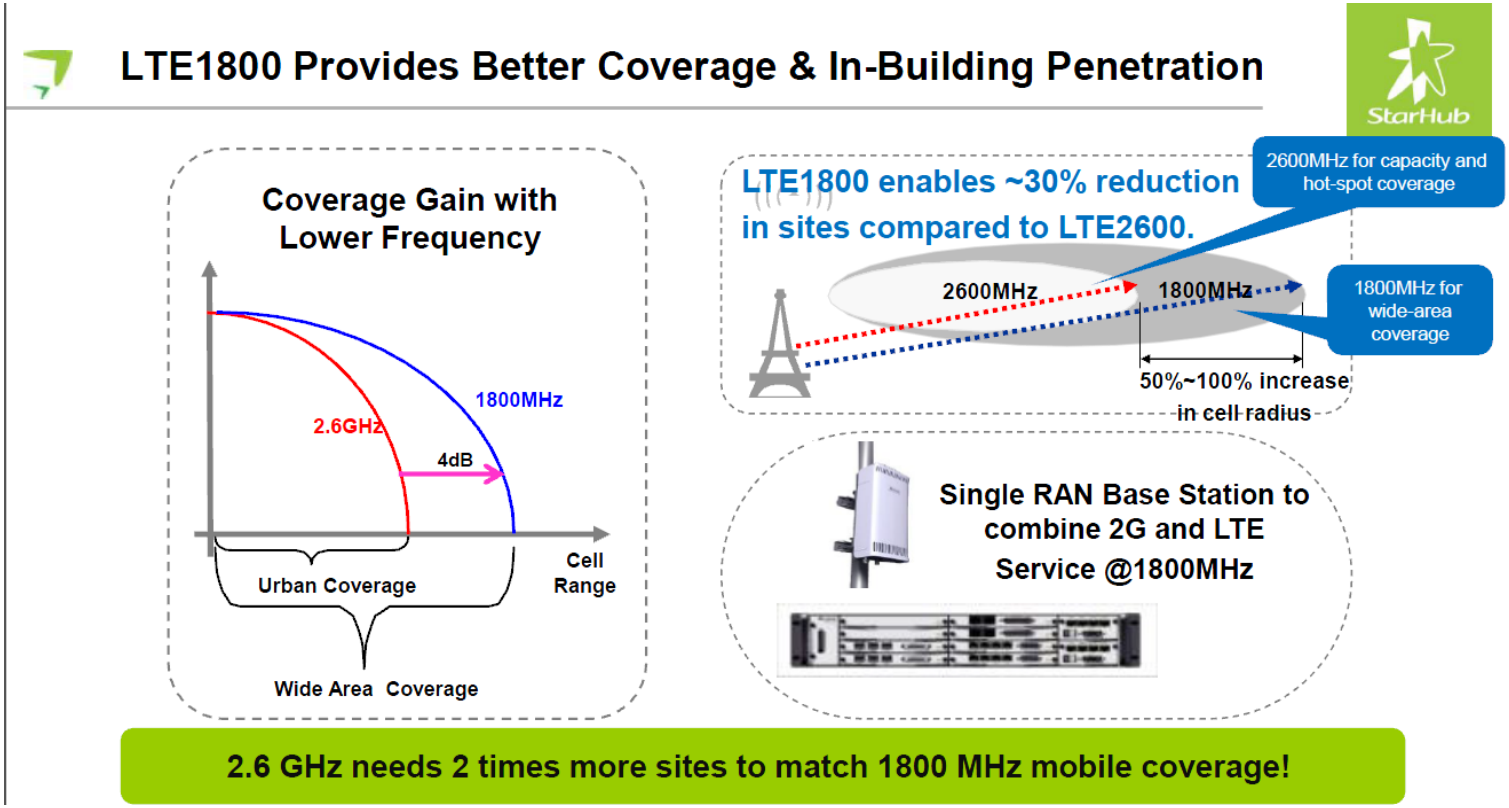
- LTE1800 commercial terminals are ready.
- LTE1800 networks being rolled out, with more to come.

Cost Effective

- Significant cost savings without need for new spectrum.
- Up to 50% reduction in site count compared with LTE2600.
- ~50% in-site TCO saving with SDR solution.

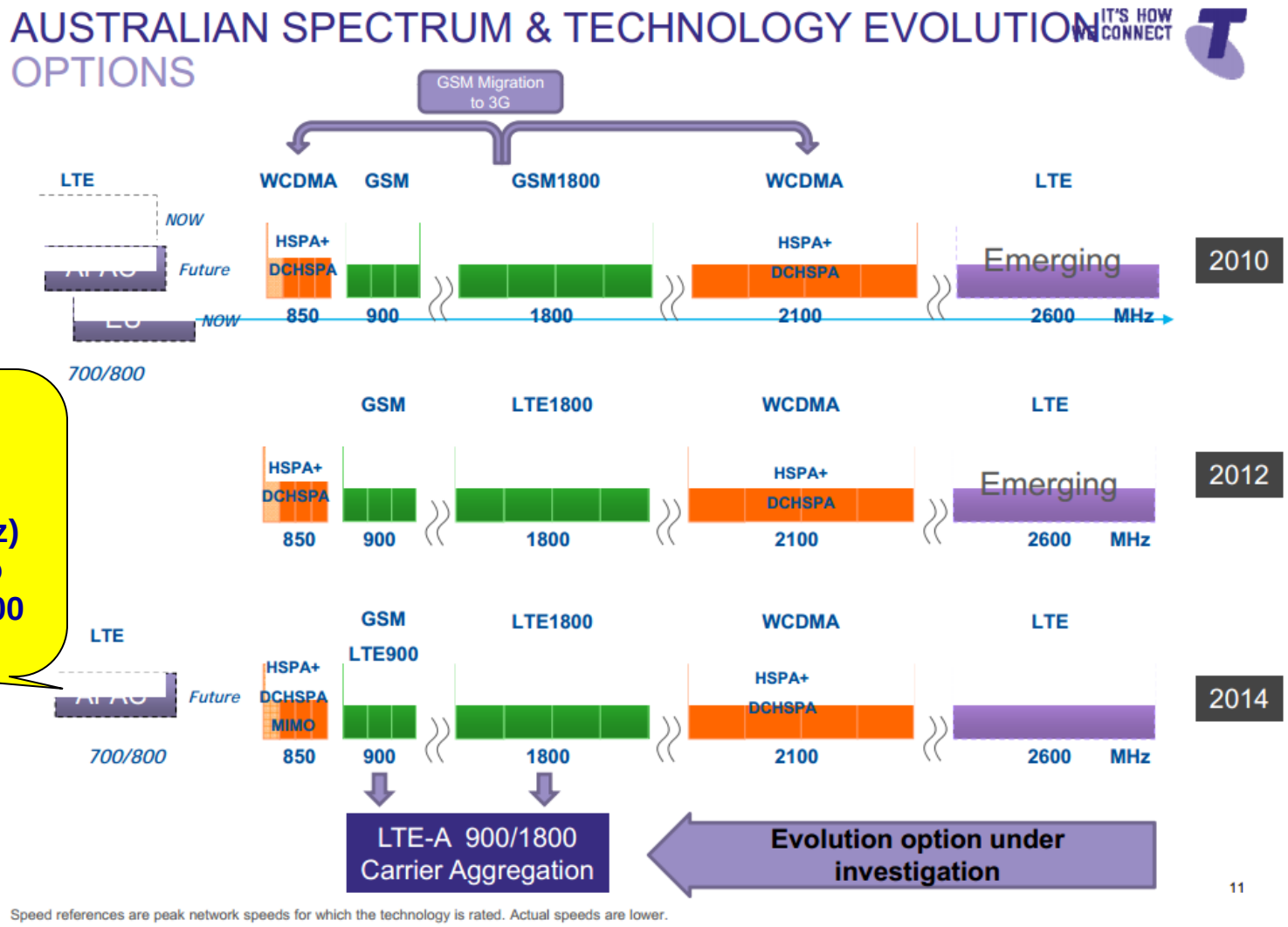
Source: LTE 1800 Review in Asia-Pacific, Starhub, Sept 2011

Example of LTE 1800 considerations: Starhub (2)



Source: LTE 1800 Review in Asia-Pacific, Starhub, Sept 2011

Example: Spectrum/technology roadmap Telstra Australia

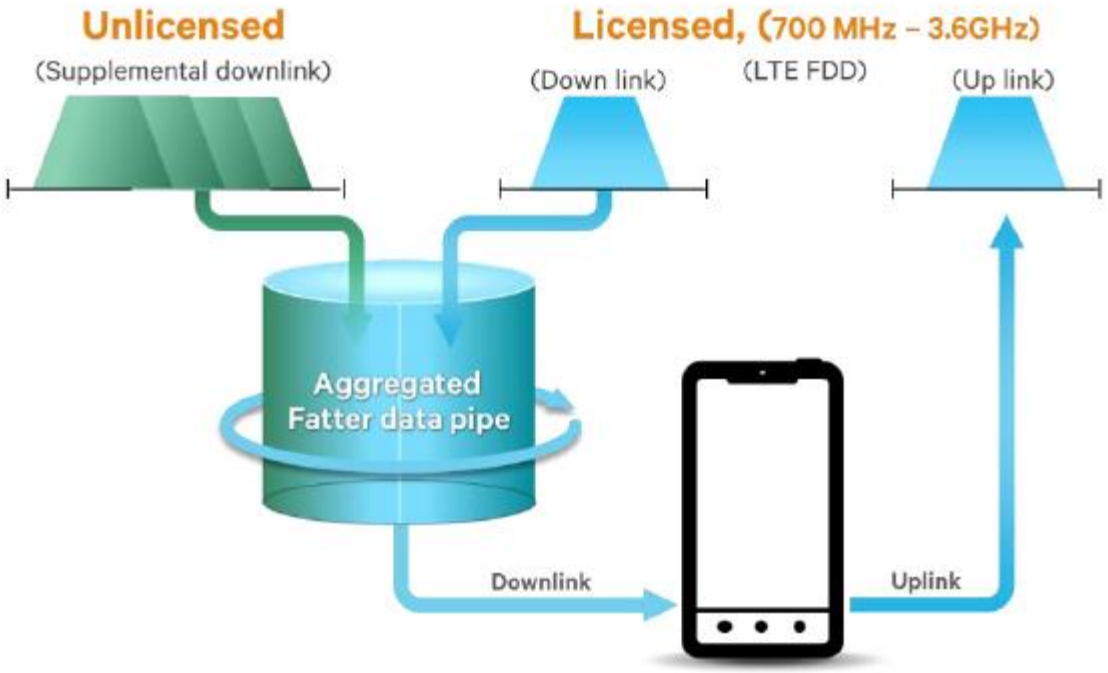


Early-2015: LTE-Advanced APT 700 – LTE 1800 (2 x 40 MHz) called 4GX. Also LTE-A 1800 - 2600

Source: Telstra MWC 2012 presentation "Spectrum: Using what we have got"

LTE-Unlicensed

- **Several key players in the LTE market (like Qualcomm, NSN, Huawei and Ericsson) are promoting the concept of LTE unlicensed, in particular using the large bandwidth available between 5250 – 5825 MHz (5 GHz band), as either supplementary downlink or TDD**



Source: Extending LTE Advanced to unlicensed spectrum, Qualcomm, December 2013

International Frequency Coordination

Basic principles in frequency coordination

- **Around country borders the available spectrum capacity has to be shared between the countries:**
  - **GSM is typically using the mechanism of preferential ⇔ non-preferential frequencies**

    (at different signal level at the border)
  - **3G/HSPA+ is typically using the mechanism of preferential ⇔ non-preferential scambling codes**

    (at equal signal level at the border)
  - **LTE is typically using the mechanism of preferential ⇔ non-preferential PCI's**

    (at equal signal level at the border)

Reference documents

- **Well-known reference documents:**
  - **ECC RECOMMENDATION (05)08,**
    - **FREQUENCY PLANNING AND FREQUENCY COORDINATION FOR THE GSM 900, GSM 1800, E-GSM and GSM-R LAND MOBILE SYSTEMS**
  - **ERC Recommendation 01-01 (revised Dublin 2003, Helsinki 2007)**
    - **BORDER COORDINATION OF UMTS**
  - **ECC Recommendation (08)02 (updated in 2012),**
    - **Frequency planning and frequency coordination for GSM / UMTS / LTE / WiMAX Land Mobile systems operating within the 900 and 1800 MHz bands**
  - **ECC RECOMMENDATION (11)04:**
    - **FREQUENCY PLANNING AND FREQUENCY COORDINATION FOR TERRESTRIAL SYSTEMS FOR MOBILE/FIXED COMMUNICATION NETWORKS (MFCN) CAPABLE OF PROVIDING ELECTRONIC COMMUNICATIONS SERVICES IN THE FREQUENCY BAND 790-862 MHZ**

Scrambling Code Sharing (1)

■	Preferential code
	non-preferential code

1. FDD case:

For the FDD mode; 3GPP TS 25.213 defines 64 « scrambling code groups » in §5.2.3, numbered {0…63}, hereafter called « code groups ».

	Set A	Set B	Set C	Set D	Set E	Set F
Country 1	0..10	11..20	21..31	32..42	43..52	53..63
Border 1-2	■	■				■
Zone 1-2-3	■	■				
Border 1-3	■	■	■			
Zone 1-2-4	■					■
Border 1-4	■		■			■
Zone 1-3-4	■		■			

	Set A	Set B	Set C	Set D	Set E	Set F
Country 2	0..10	11..20	21..31	32..42	43..52	53..63
Border 2-1			■	■	■	
Zone 2-3-1			■	■		
Border 2-3		■	■	■		
Zone 2-1-4			■	■		
Border 2-4			■	■		■
Zone 2-3-4			■	■		

	Set A	Set B	Set C	Set D	Set E	Set F
Country 3	0..10	11..20	21..31	32..42	43..52	53..63
Border 3-2	■				■	■
Zone 3-1-2					■	■
Border 3-1				■	■	■
Zone 3-1-4					■	■
Border 3-4			■		■	■
Zone 3-2-4					■	■

	Set A	Set B	Set C	Set D	Set E	Set F
Country 4	0..10	11..20	21..31	32..42	43..52	53..63
Border 4-1		■		■	■	
Zone 4-1-2		■			■	
Border 4-2	■	■			■	
Zone 4-2-3	■	■				
Border 4-3	■	■		■		
Zone 4-3-1		■		■		

Source: Rec (01)01, UMTS Border Coordination

Scrambling Code Sharing (2)

	Field strength level at 3 m height	
	900 MHz	1800 MHz
GSM vs. GSM	GSM systems can continue operating according to ECC Recommendation (05)08 and the existing agreements.	
UMTS vs. UMTS using non preferential codes and with centre frequencies aligned	35 dBµV/m/5MHz @0 km	41 dBµV/m/5MHz @0 km
All other cases*	59 dBµV/m/5MHz @0 km & 35 dBµV/m/5MHz @9 km	65 dBµV/m/5MHz @ 0km & 41 dBµV/m/5MHz @ 9km

Table 1: Summary of field strength levels for the coordination between systems at 900 MHz and 1800 MHz

Source: Rec (08)02, Frequency planning and frequency coordination for GSM / UMTS / LTE / WiMAX Land Mobile systems operating within the 900 and 1800 MHz bands

PCI sharing

■	Preferential PCI
	non-preferential PCI

PCI	Set A	Set B	Set C	Set D	Set E	Set F
Country 1	0..83	84..167	168..251	252..335	336..419	420..503
Border 1-2	■	■				■
Zone 1-2-3	■	■				
Border 1-3	■	■	■			
Zone 1-2-4	■					■
Border 1-4	■		■			■
Zone 1-3-4	■		■			

PCI	Set A	Set B	Set C	Set D	Set E	Set F
Country 2	0..83	84..167	168..251	252..335	336..419	420..503
Border 2-1			■	■	■	
Zone 2-3-1			■	■		
Border 2-3		■	■	■		
Zone 2-1-4			■	■		
Border 2-4			■	■		■
Zone 2-3-4			■	■		

PCI	Set A	Set B	Set C	Set D	Set E	Set F
Country 3	0..83	84..167	168..251	252..335	336..419	420..503
Border 3-2	■				■	■
Zone 3-1-2					■	■
Border 3-1				■	■	■
Zone 3-1-4					■	■
Border 3-4			■		■	■
Zone 3-2-4					■	■

PCI	Set A	Set B	Set C	Set D	Set E	Set F
Country 4	0..83	84..167	168..251	252..335	336..419	420..503
Border 4-1		■		■	■	
Zone 4-1-2		■			■	
Border 4-2	■	■			■	
Zone 4-2-3	■	■				
Border 4-3	■	■		■		
Zone 4-3-1		■		■		

Further options:

- **Demodulation Reference Signal (DM RS) coordination**
- **Physical Random Access Channel (PRACH) coordination**

Source: Rec (08)02, Frequency planning and frequency coordination for GSM / UMTS / LTE / WiMAX Land Mobile systems operating within the 900 and 1800 MHz bands

Existing Frequency Coordination Agreement (1)

4.3.2 Code sharing for UMTS system in the frequency ranges 1805-1880 MHz, 1900-1920 MHz, 1930-1990 MHz, 2010-2025 MHz and 2110-2170 MHz

In order to ensure the optimum network performance for UMTS system, the administrations shall encourage operators to coordinate the use of scrambling code groups for UMTS and other radio parameters given in **Annex 3**.

UMTS system

For the FDD mode; 3GPP TS 25.213 defines 64 "scrambling code groups" in § 5.2.2, numbered {0 to 63}

SCRAMBLING CODE GROUPS	[0-20]	[21-42]	[43-63]
AIA	PREFERENTIAL	NON PREFERENTIAL	PREFERENTIAL
SXM or BES	NON PREFERENTIAL	PREFERENTIAL	NON PREFERENTIAL
F	NON PREFERENTIAL	NON PREFERENTIAL	PREFERENTIAL

Existing Frequency Coordination Agreement (2)

4.3.3 Allocation of physical-layer cell-identity groups for LTE system in the frequency ranges 1805-1880 MHz and 1930-1990 MHz

In order to ensure the optimum network performance for LTE system, the administrations shall encourage operators to coordinate the use of physical-layer cell-identity groups for LTE and other radio parameters given in **Annex 3**.

LTE system

3GPP TS 36.211 defines 168 "unique physical-layer cell-identity groups" in § 6.11, numbered 0…167, hereafter called "PCI groups". Within each PCI group there are three separate PCIs giving 504 PCIs in total. Each country can use all PCI groups away from the border areas.

PCI GROUPS	[0-167]	[168-335]	[336-503]
AIA	PREFERENTIAL	NON PREFERENTIAL	NON PREFERENTIAL
SXM or BES	NON PREFERENTIAL	PREFERENTIAL	NON PREFERENTIAL
F	NON PREFERENTIAL	NON PREFERENTIAL	PREFERENTIAL

Existing Frequency Coordination Agreement (3)

6 ARRANGEMENT FOR PLANNING AT AN OPERATIONAL LEVEL

Further cooperation between the operators sharing overlapping frequency assignments should be encouraged to promote local solutions and coordination efforts. Given the size of St Maarten/St. Martin and the social structure resulting in a lot of interaction between the two sides of the island also further integration and cooperation between the operators on each side is encouraged as long as it stays with the legal framework of French, Dutch St. Martin/ St. Maarten and Anguilla laws.

Administrations should encourage and facilitate the establishment of arrangements between operators of different countries with the aim to enhance the efficient use of the spectrum and the national coverage in the border areas. Those arrangements will be subject to approval by the Administrations concerned.

Practical LTE Options

General recommendations

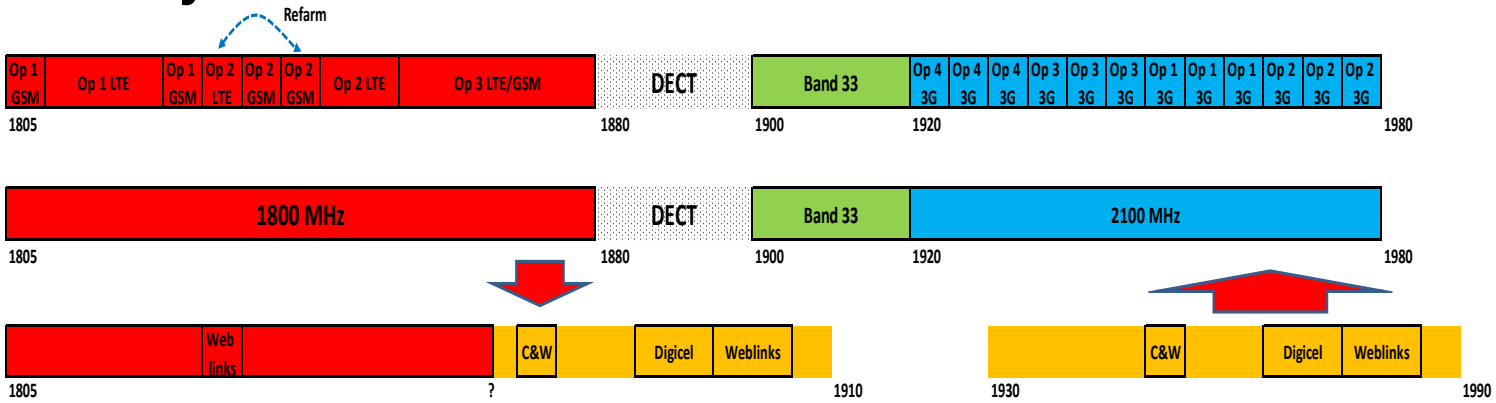
- **Sufficient low-band spectrum (700/800/900) available to allow for cost-effective coverage by mobile operators**
- **Large block(s) of high-band spectrum available (1800/2100/2300/2600) to enable mobile operators to provide cost-efficient capacity**
- **Management of terminal market is a concern to make sure mobile devices with the desired 3G and LTE capabilities are widely available**
- **Consider mid-term approach to GSM. Low capacity remaining GSM network just for a few roamers and legacy devices? Security risks are a major concern**
- **Primary allignment with St Martin. Remaining issues of "conflicting" band plans with St Kitts and Anguilla to be handled through further coordination. Avoidance possible as well by use of "low" sites**

Main LTE Options

- 1800 MHz offers wide channels (2x20 MHz), globally most popular band and compatible with existing 1800 GSM (sharing antennas, RRH, etc.)
- 800 MHz, new band fully available.
- 900 MHz, limited spectrum available but compatible with GSM/UMTS (sharing antennas, RRH, etc.)
- APT 700, new band fully available, globally becoming very popular, operational in Asia, recently auctioned in Chili, Brazil, etc. and scheduled for first auctions in Europe as well
- Higher bands for additional capacity (2.1 GHz, 2.3 GHz and 2.6 GHz)

1800 MHz

- **Ready to use:**

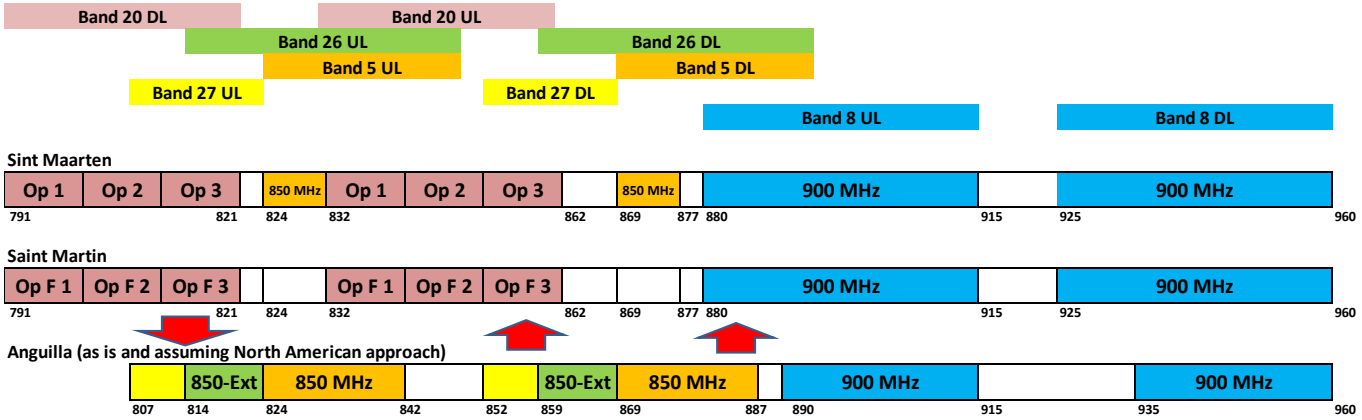


- **Migration options from GSM to LTE:**

	20 MHz			20 MHz			15 MHz			20 MHz		
Step 1	LTE	GSM	GSM	GSM	GSM	LTE	LTE	GSM	GSM	GSM	LTE	
Step 2	LTE		GSM	GSM	LTE		LTE	GSM	GSM	LTE		
Final	LTE											

	20 MHz			20 MHz			15 MHz			20 MHz		
Step 1'	GSM	LTE	GSM	GSM	GSM	LTE	LTE	GSM	GSM	LTE	GSM	
Step 2	LTE		GSM	GSM	LTE		LTE	GSM	GSM	LTE		
Final	LTE											

900 MHz



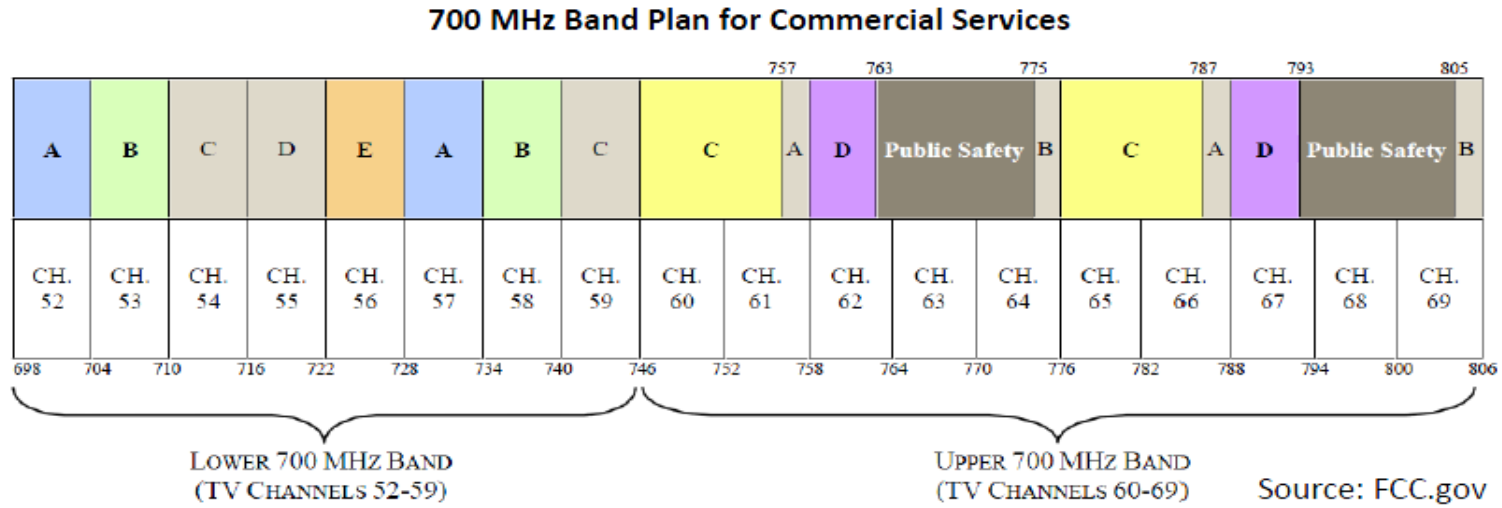
- Requires refarming on French side to align with 5 MHz blocks before enabling operators on both sides of the border to change from preferential frequencies to preferential codes or PCI's
- Extended 900 MHz can be used as well but potential BTS TX ⇔ BTS RX from Anguilla and St Kitts. Requires "low" sites to avoid interference issues

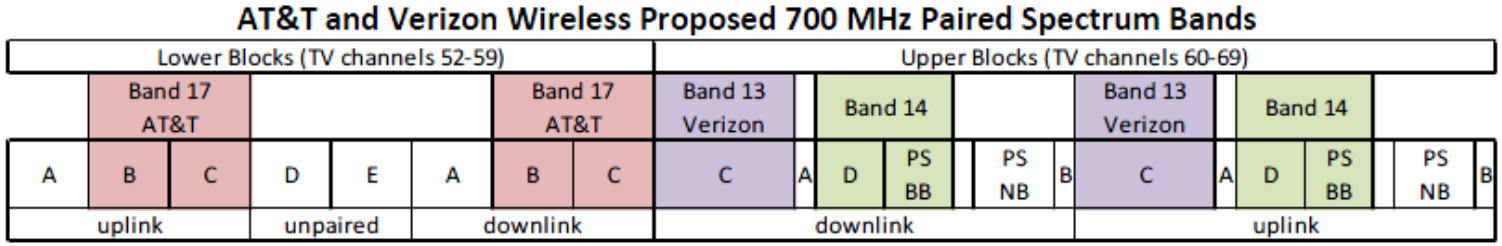
Conclusions

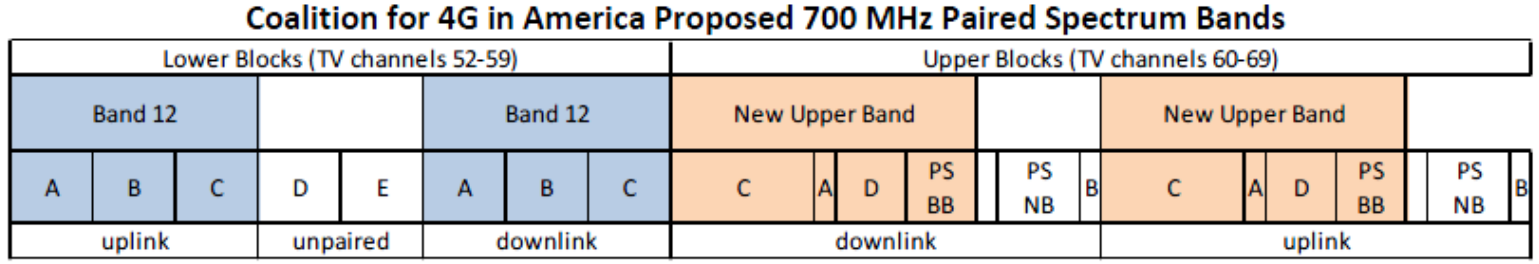
- **Range of LTE spectrum options:**
  - **LTE 1800 is an obvious choice and ready to go**
  - **LTE 800 spectrum would be available**
  - **LTE 900 spectrum is in the process of being coordinated**
  - **APT 700 spectrum would be available**
- **On St Maarten far reaching coordination to align spectrum use. However incompatible band plans still prevail in the region requiring further coordination. Avoiding hill top locations helps to avoid interference issues and supports high capacity mobile broadband networks.**
- **Coordination 3G/HSPA+ and LTE on St Maarten will be based on preferential Codes (3G/HSPA+) and preferential PCI's (LTE)**

Annex FCC 700 ⇔ APT 700

700 MHz: US band plan (1)





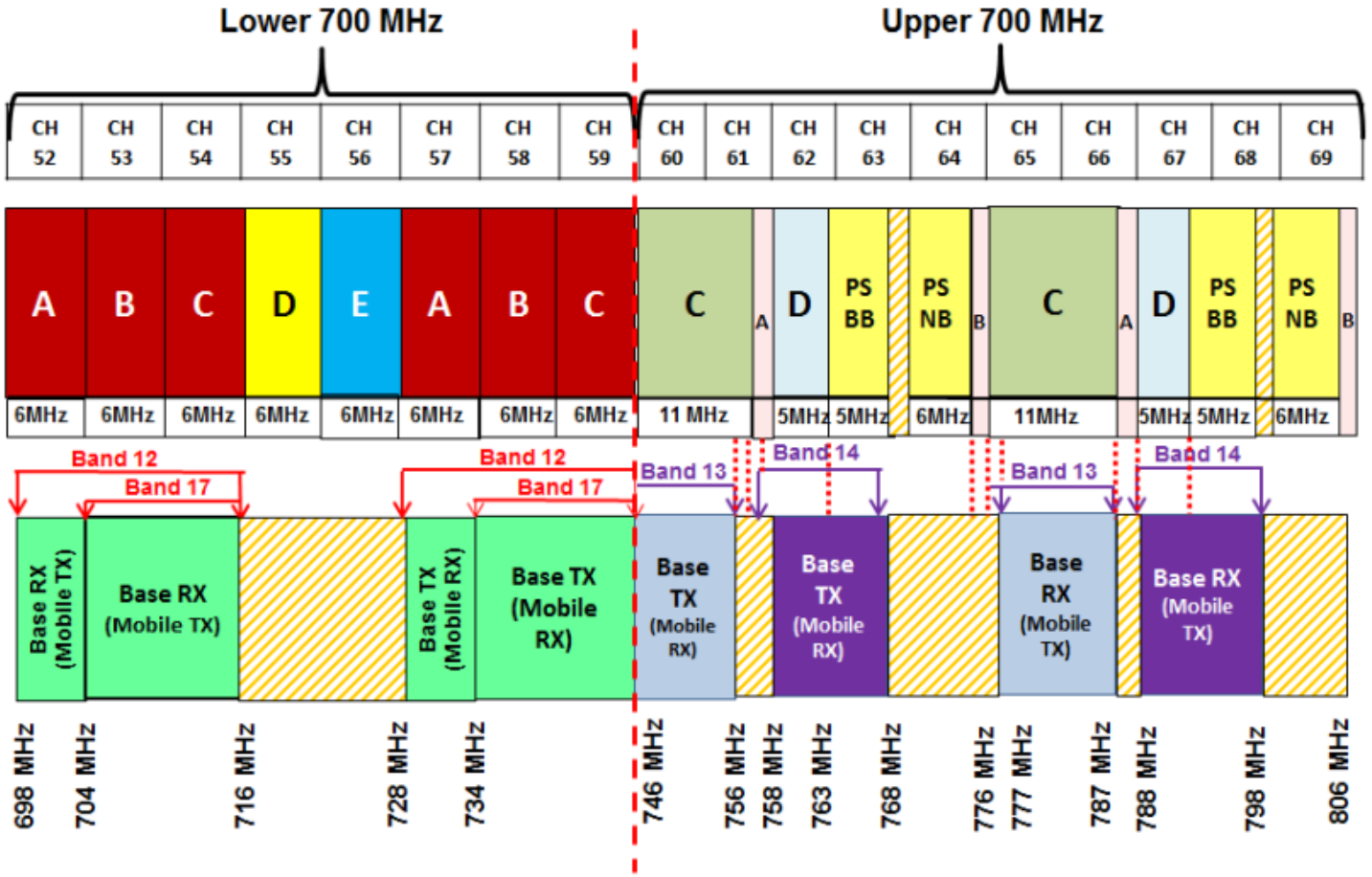


- **Reality: 4 different band plans in 700 MHz band with 2 different duplex arrangements (12, 13, 14 and 17)**

Source : Peter Cramton paper August 2010

700 MHz: US band plan (2)

- **Not one but 4 different bandplans, “Balkanised” and until recently devices typically only support one out 4 bandplans. Latests devices support 2 out of 4.**



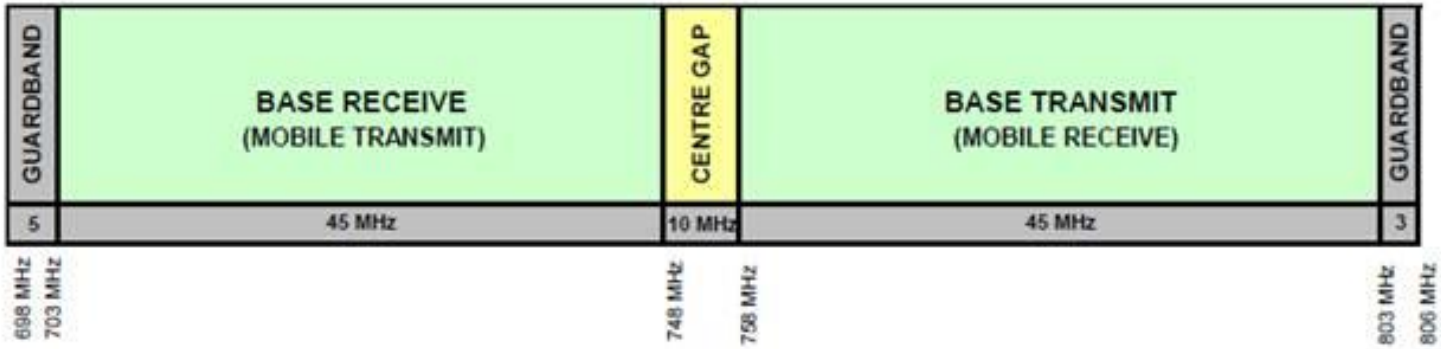
Source : Benefits of LTE in Digital Dividend, November 2011

US 700 MHz terminal market

- The fragmentation in the US in 4 different band plans has resulted in 700 MHz terminals specific for the AT&T or the Verizon 700 MHz band plan (often also having different combinations of 3G/2G capabilities)
- Other operators, in particular the Lower 700 MHz A band operators, have complained to the FCC to mandate terminals covering more complete bands to avoid a fragmented terminal market. Consultation started in March 2012 and only recently some compromis has been reached
- The two leading operators in the US don't have an incentive to solve the issue. Terminal suppliers do have an incentive to solve the fragmentation
- Apple iPad 4 and iPhone 5 support both Verizon and AT&T 700 MHz band plans but with different devices (not compatible). iPhone 5C/S and 6 support both
- Qualcomm announced RF360 chipset to solve LTE spectrum fragmentation in one chipset (since late 2013)

700 MHz: Asian (APT) band plan (1)

Figure 5.6: APT band plan for FDD operations in the 698-806 MHz range

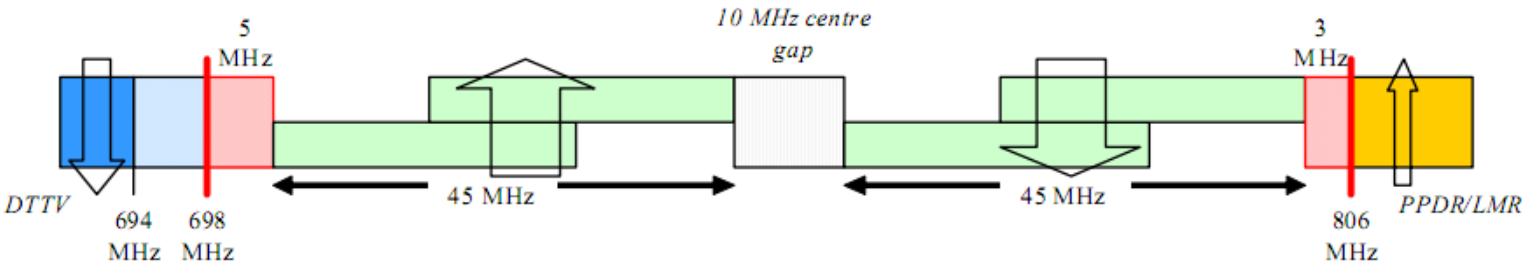


- **One duplex distance and allowing larger and more efficient spectrum allocations**

Source: Canadian 700 MHz consultation

700 MHz: Asian (APT) band plan (2)

- **“Regular” 2 x 45 MHz bandplan. Some considerations with respect to the duplex filter (one version with good specification ⇔ 2 versions with more relaxed specification)**



Source : Benefits of LTE in Digital Dividend, November 2011

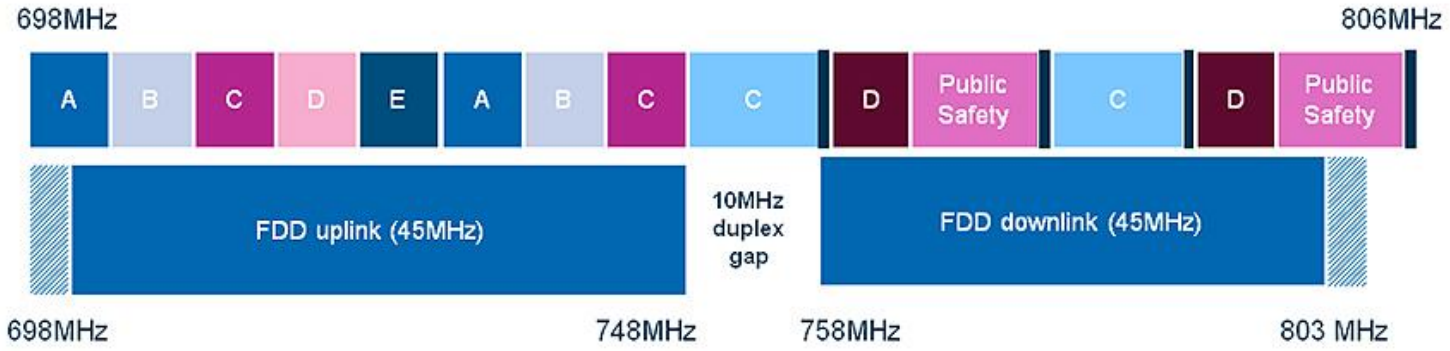
800 MHz: European band plan

- **“Regular” 2 x 30 MHz bandplan. Similar to Asian bandplan but in the 800 MHz.**

791–796	796–801	801–806	806–811	811–816	816–821	821–832	832–837	837–842	842–847	847–852	852–857	857–862
Downlink						Duplex Gap	Uplink					
30 MHz (6 blocks of 5 MHz)						11 MHz	30 MHz (6 blocks of 5 MHz)					

Source : Benefits of LTE in Digital Dividend, November 2011

Comparison bandplan Asia ⇔ USA



New developments:

- **WRC-12 allocates 698 – 790 MHz also as second digital dividend in Europe – Middle East and Africa.**
- **Band plan for Europe for the second Digital Dividend targets lower 2x30 MHz of APT 700 bandplan.**
- **Middle-East country, UEA, has been first in adopting both APT 700 and 800 MHz bands**
- **Both combi's APT700/800/900 and APT 700/850/900 are happening. Extended 850 MHz also possible.**

Source of figure: www.analysysmason.com/About-Us/News/Insight/Implementing-the-second-digital-dividend--harmonisation-is-key/

GSMA Recommendations for Latin America 700 MHz

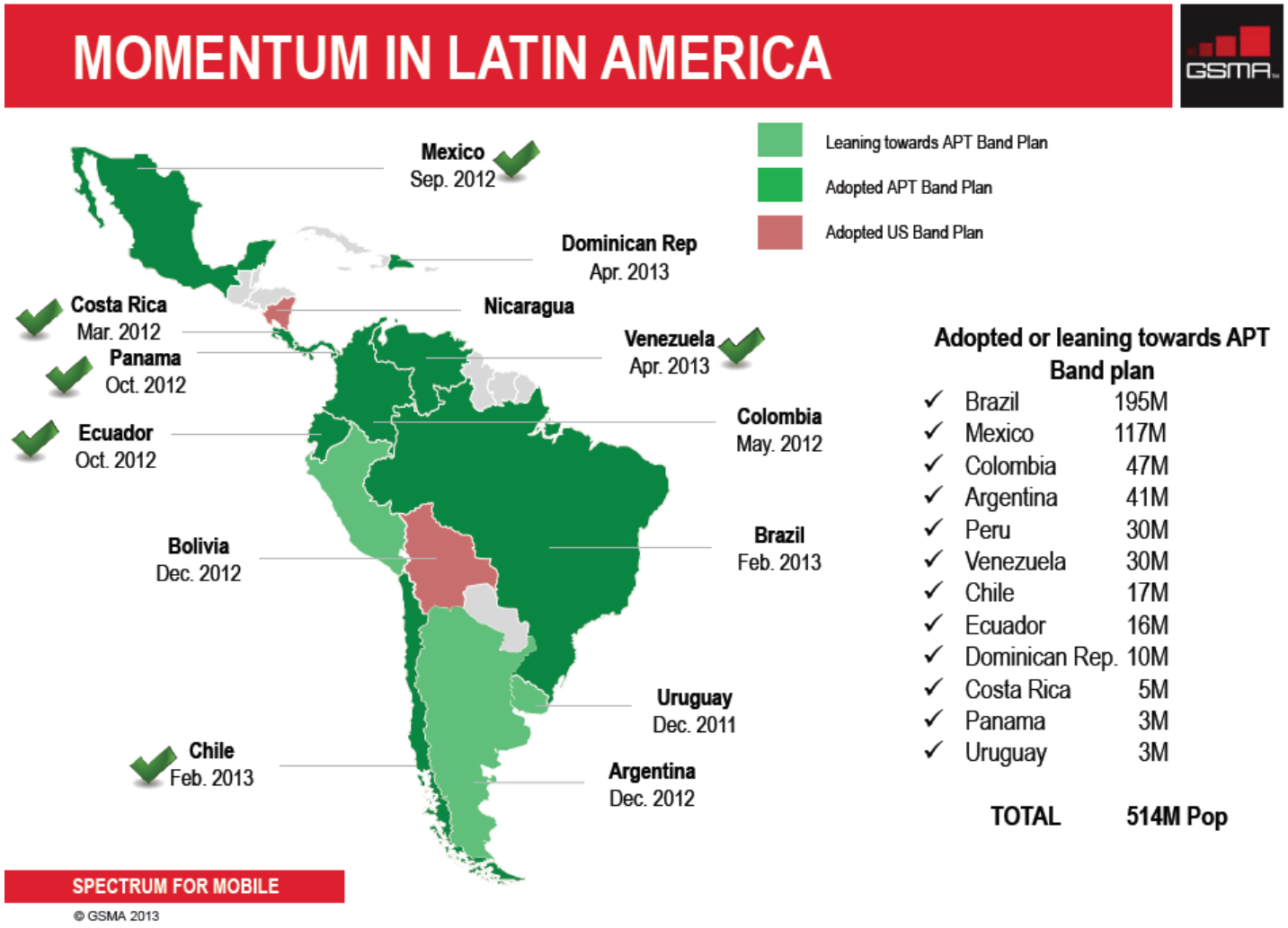
Conclusion:

Both options 2 and 3 should be considered in Latin America:

- **Option 2 (Asian band plan) is likely to be better for those administrations that can wait until more countries adopt the Asian band plan.**
- **Option 3 (US band plan) is likely to be better for those Administrations that can move more quickly and want to make spectrum awards in the shorter term.**

Source : GSMA, Draft Position paper for Latin America on Digital Dividend/UHF band plans, March 2011

700 MHz band plan status Latin America



Source : GSMA presentation