Wireless Technologies and the Broadband Challenge in Brazil

Technologies, Spectrum Decisions and Future directions

Agenda

- The Broadband challenge – new markets
- WiMAX and LTE – two 4G technologies
- Spectrum Planning
- Brazilian Outlook
- Conclusion

The Broadband Challenge

Brazilian Data

Technology	Units	% of Market
Cellular	161M	84% (people)
Wireline Telephony	41M	72% (households)
Broadband (wireline)	9.6M	17% (households)
Broadband (wireless)	2M	1% (people)
PayTV	6M	10% (households)

Cellular and Wireline voice markets are approaching saturation
Broadband (wireless/wireline) and PayTV are just starting

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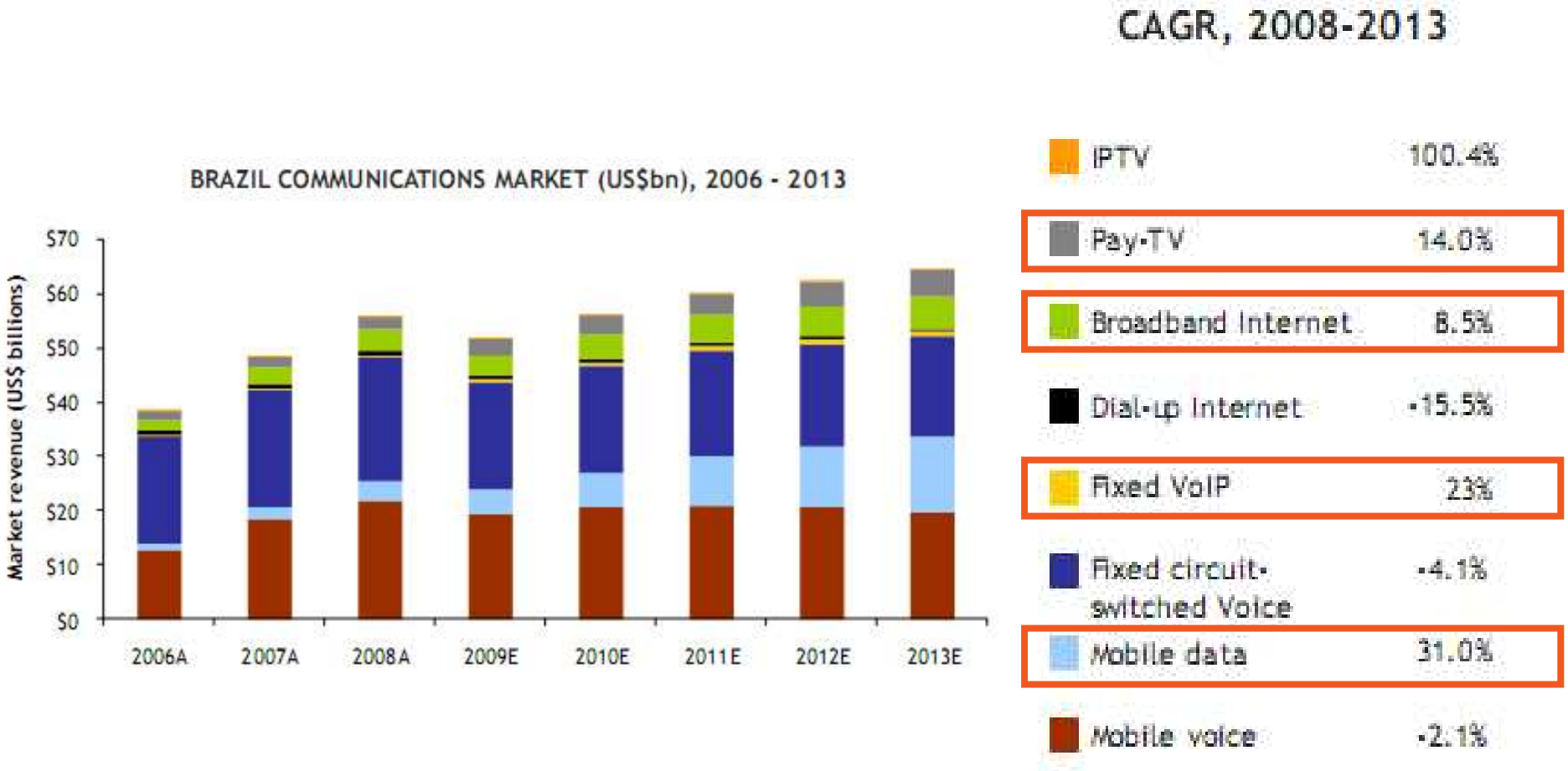
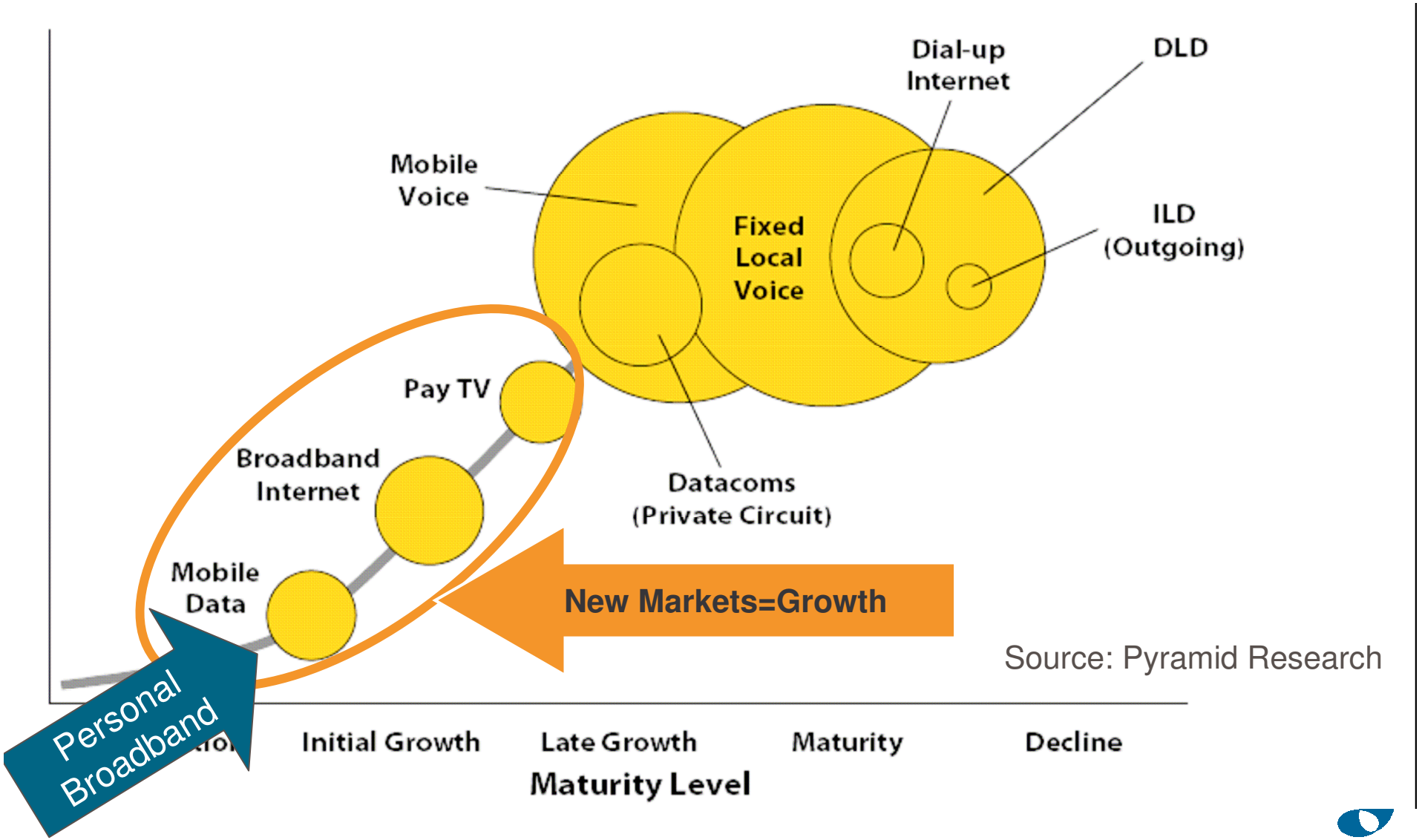
Brazilian Market Forecast



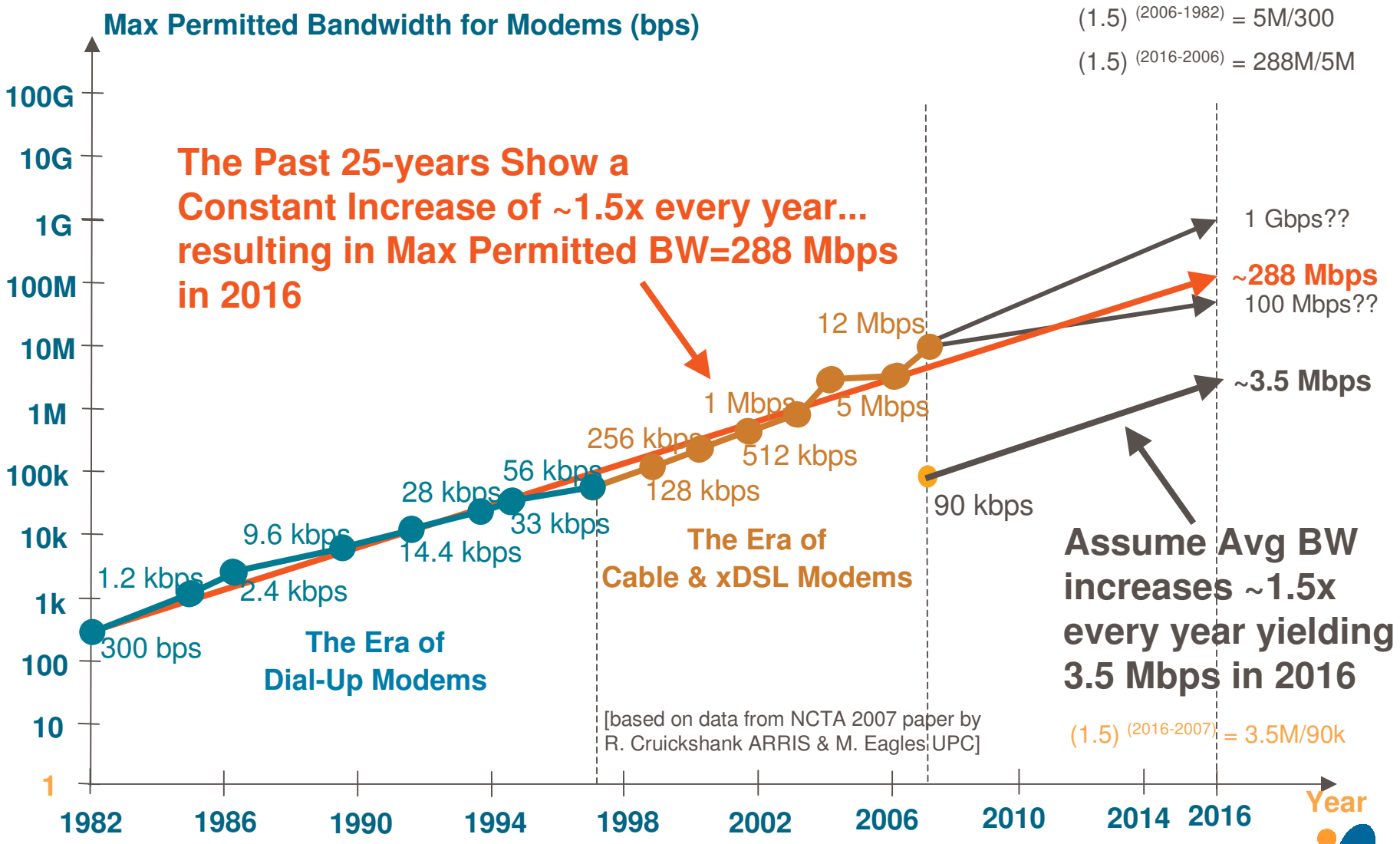
Source: Pyramid Research

The next wave of Telecomm



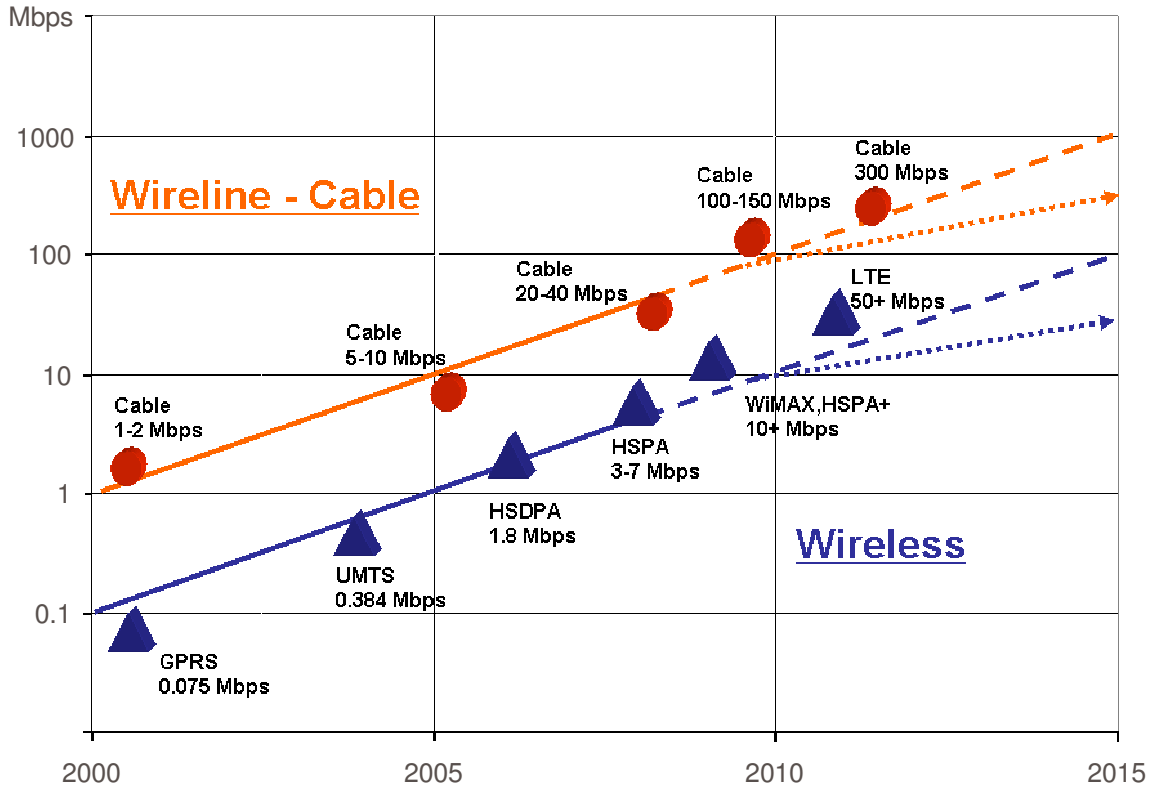
Source: Pyramid Research

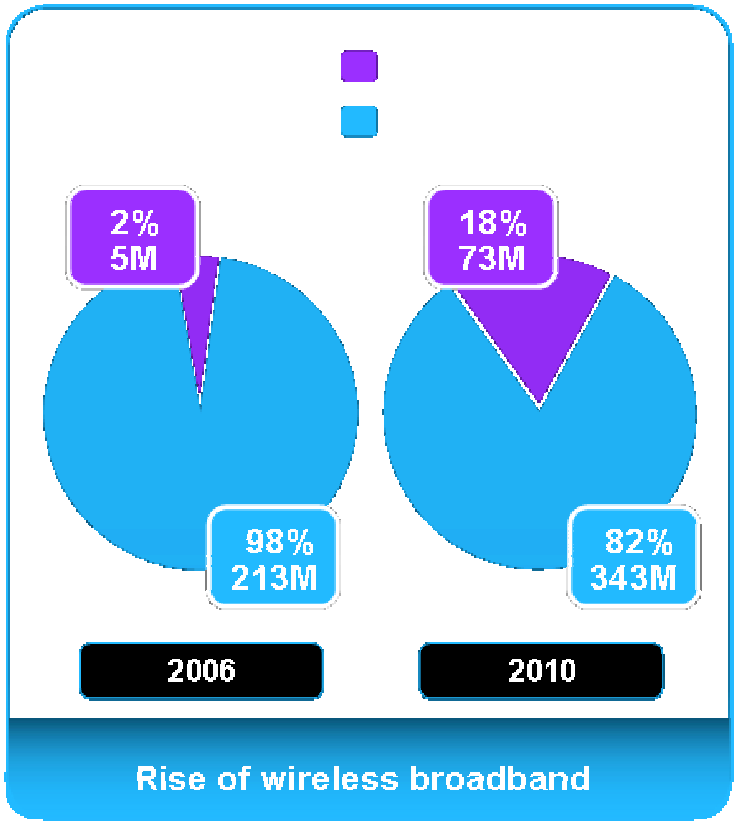
25 Years of Bandwidth Trends



Growth of wireless broadband

Some Projections estimate mobile broadband consumption to exceed fixed broadband by 2015





Wireless Broadband Drivers

Wireless Internet use follows Wired Internet
by 3-5 years

75% of users watch online video*
YouTube = 27% of internet traffic

Short clips - Perfect for mobile use
15min of daily YT = 1.2GB/month

Reasonable Use Profiles - 2011

Road Warrior
Laptop + Mobile

APPS	Days / Mo	KB / Day	Hrs /day	Kbps	KB / Mo
VoIP/Conference on Mobile	20		1	64	576,000
VoIP on Mobile	30		0.1	65	87,750
Netmeeting when Out of Office	4		0.5	500	450,000
Outlook (100 emails + 25 with attachments)	4	55000			220,000
Outlook (100 emails + 25 with attachments but only 5 attachments download)	30	16000			480,000
Communicator	4		8	3	43,200
Linked-In, profile update, video stream up and down	2		1	128	115,200
Competitor sites, News sites, etc... (Bursty traffic)	4		1	100	180,000
Home recorded movie on hard drive set top box / Sling / Com				1000	1,800,000
Youtube, N					576,000
Radio strea					576,000
				h	5.1

5.1GB/month

Urban Professional
Laptop + Mobile

APPS	Days / Mo	KB / Day	Hrs /day	Kbps	KB / Mo
VoIP on Mobile	30		0.1	64	86,400
Outlook (20 emails + 5 with attachments)	4	11000			44,000
Outlook (20 emails + 5 with attachments)	30	11000			330,000
Live Messenger (assuming it replaces SMS)	30		10.0	3	405,000
MySpace/Facebook, profile update, video stream up and down	5		0.5	128	144,000
General Browsing, Music + News sites, etc...	10		0.5	100	225,000
Home recorded movie on hard drive set top box / Sling / Com				1000	3,600,000
Youtube, N					345,600
Radio strea					864,000
				h	6.0

6GB/month

College Student
Laptop + Mobile

APPS	Days / Mo	KB / Day	Hrs /day	Kbps	KB / Mo
VoIP on Mobile	30		0.2	64	172,800
Outlook (10 emails + 5 with attachments)	30	10500			315,000
Outlook (10 emails + 5 with attachments)	30	10500			315,000
Live Messenger (assuming it replaces SMS)	30		10.0	3	405,000
MySpace/Facebook, profile update, video stream up and down	10		0.3	128	172,800
General Browsing, Music + News sites, etc...	20		1.0	100	900,000
Home recorded movie on hard drive set top box / Sling / Co				000	5,400,000
Youtube				56	1,152,000
Radio st					2,304,000
				th	11.1

11.1GB/month

Typical
Mobile only

APPS	Days / Mo	KB / Day	Hrs /day	Kbps	KB / Mo
VoIP on Mobile	30		0.5	64	432,000
Outlook (5 emails + 3 with attachments)	20	6250			125,000
General Browsing, Price check + News sites, etc...	20		1.0	100	900,000
Youtube, N				6	1,152,000
Radio strea				8	115,200
				h	2.7

2.7GB/month

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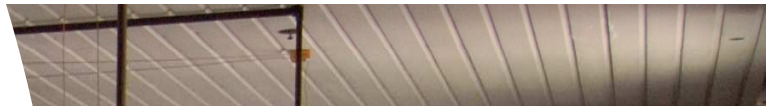
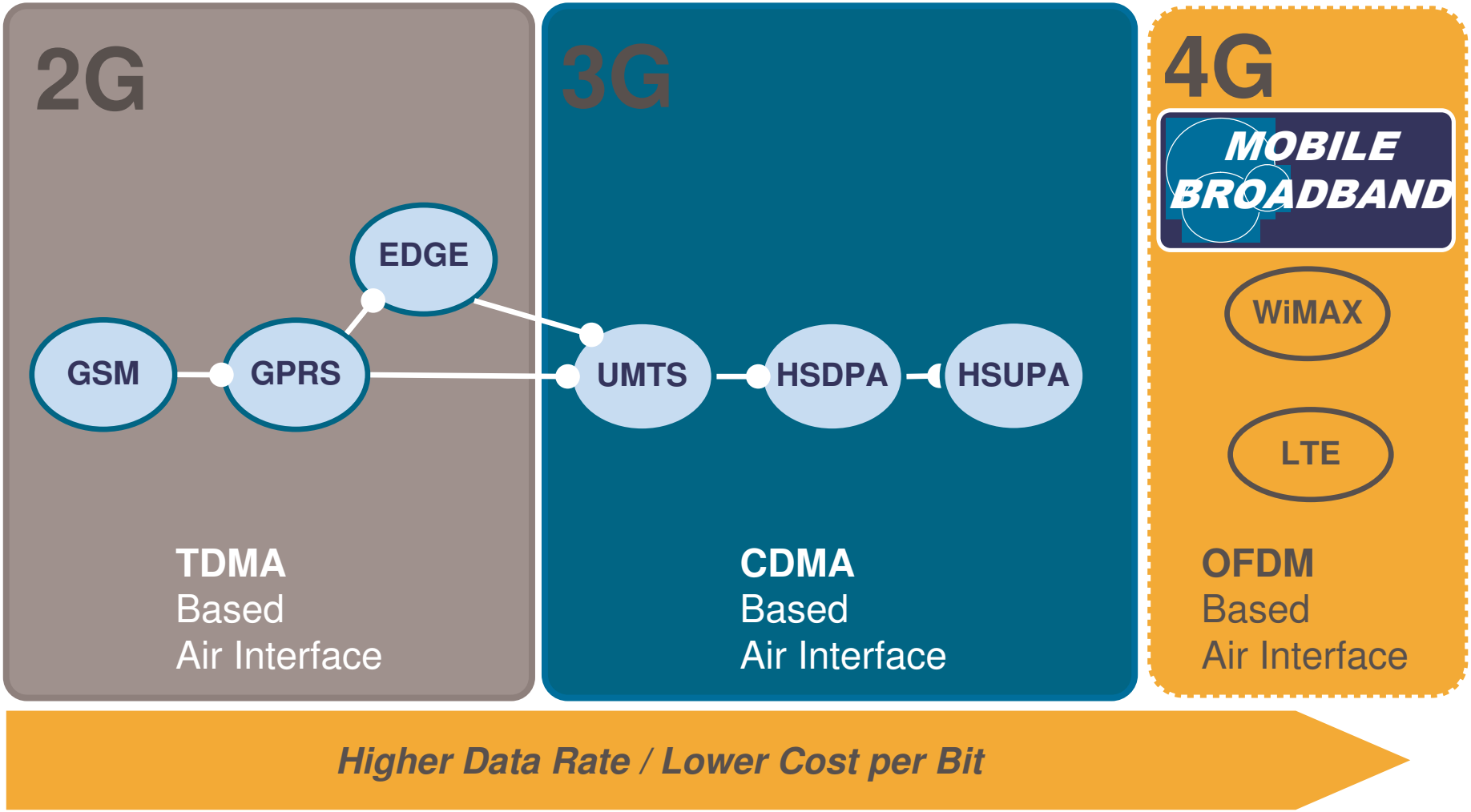


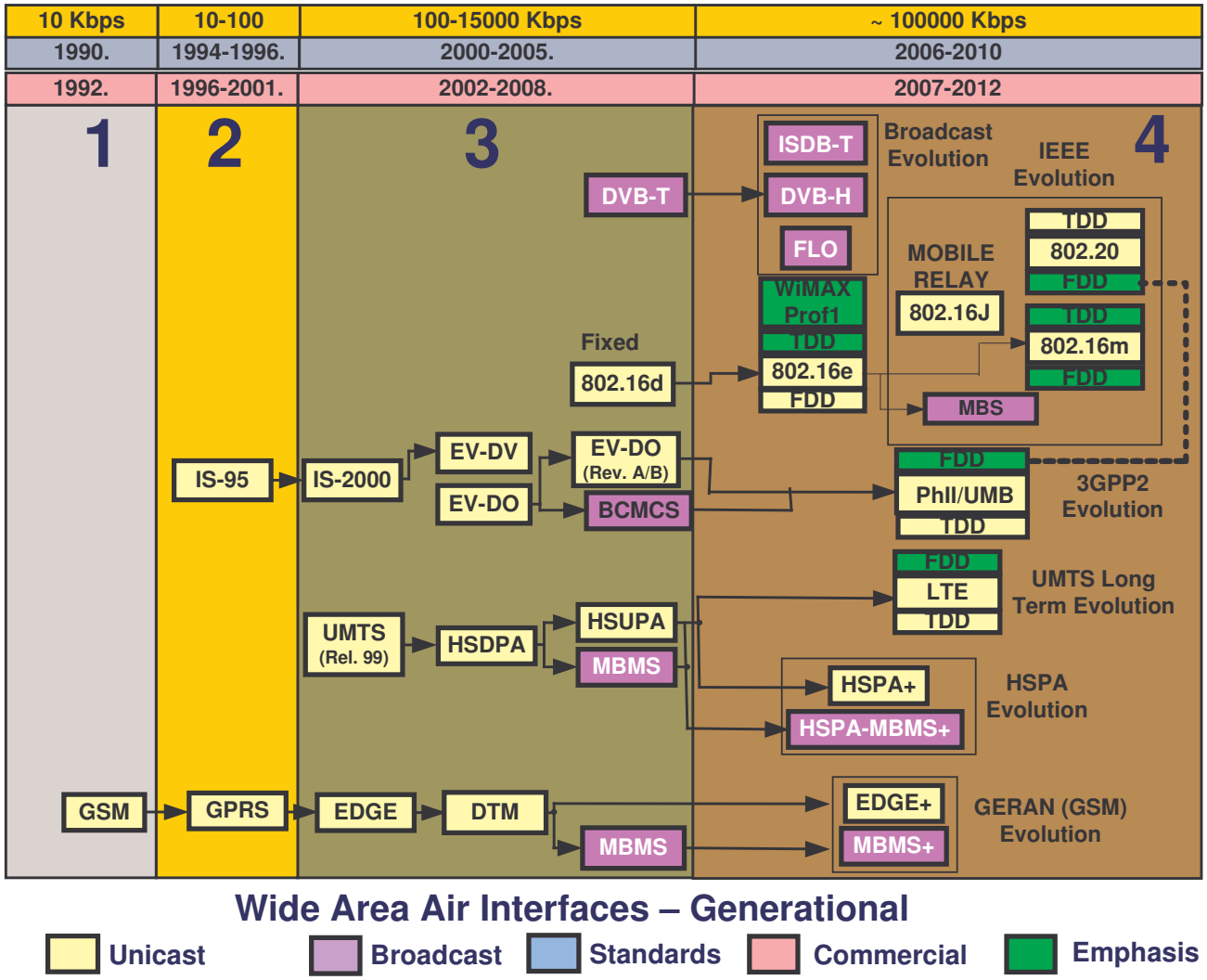
Broadband is the Electricity of the 21st Century

WiMAX and LTE – two 4G technologies

Cellular Evolution

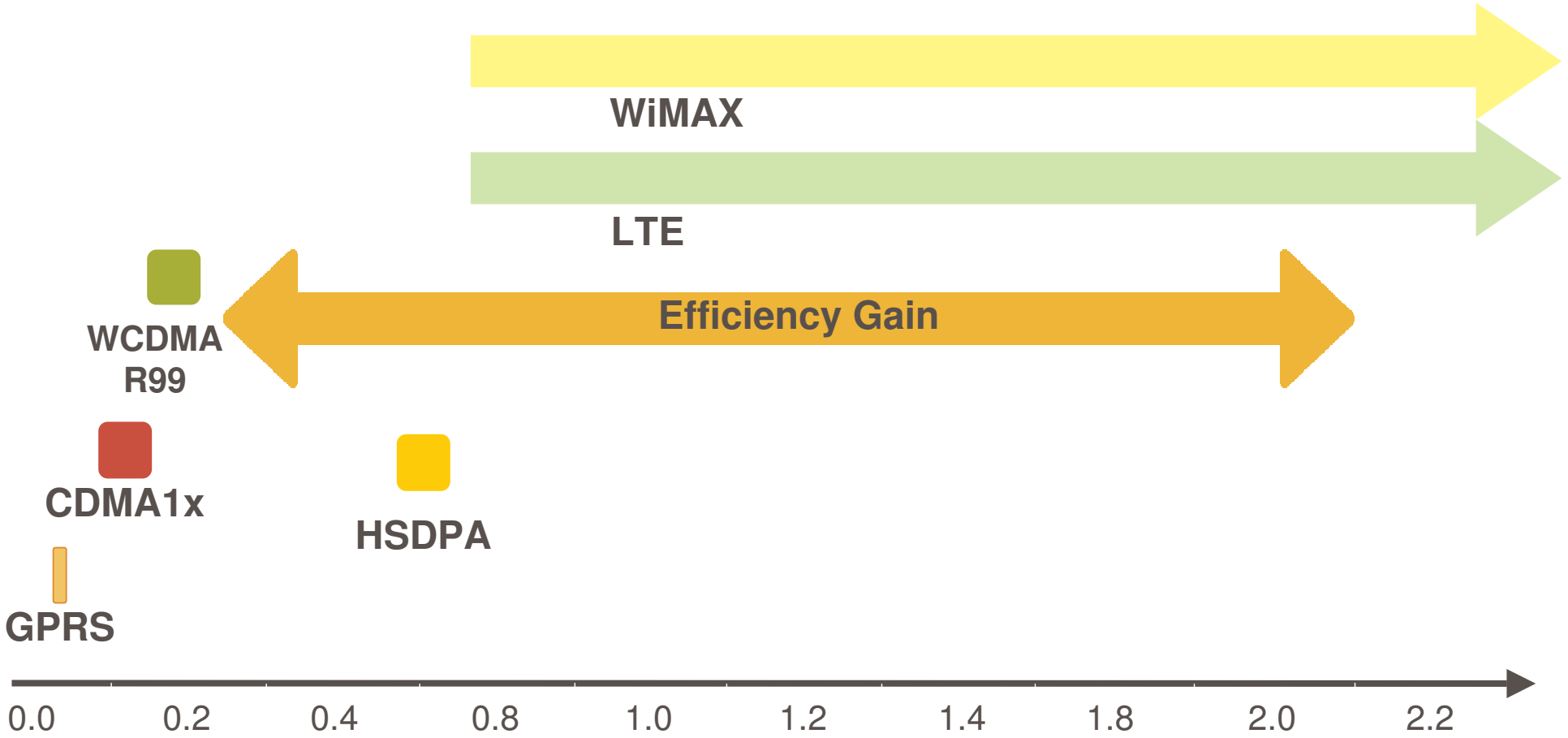


A real view….



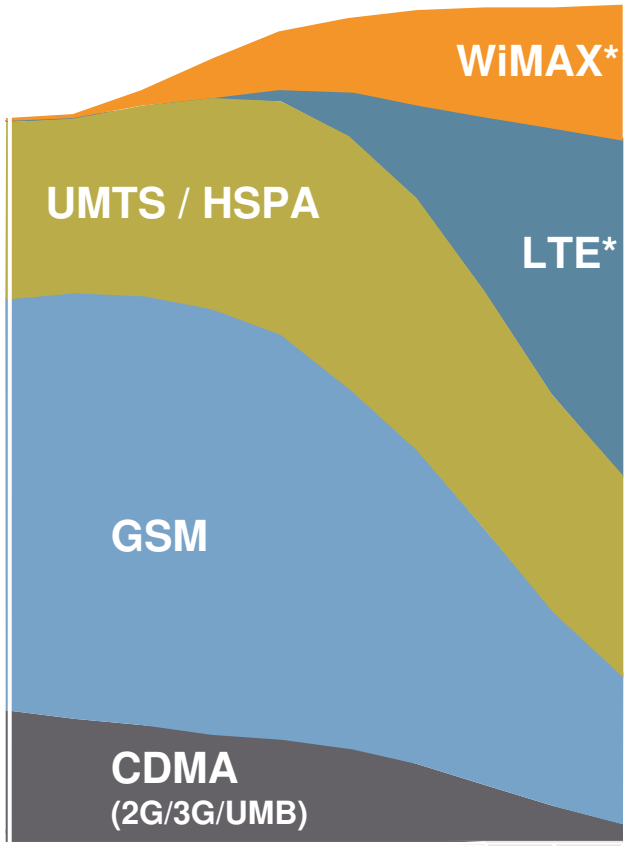
- 4 waves of technology change:
  - Analogue
  - TDMA
  - CDMA
  - OFD
- Every wave required:
  - New BTSs
  - New Handsets

Spectrum Efficiency



WiMAX & LTE

Two principal wireless broadband platforms for the next decade…

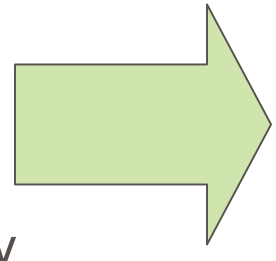


- All IP Networking
- OFDM Air Interface
- Light Infrastructure Design
- Advanced Antennas and SA Technology
- Supported in Many Spectrum Bands

WiMAX and LTE

WiMAX and LTE share a common set of technologies:

- Radio Access
  - OFDM
  - HARQ
  - Turbo Codes etc
- New Antenna Technology
  - MIMO
  - Smart Antennas
- Flat all IP Architecture



WiMAX and LTE have very similar performance when adjusted by their implementation characteristics:

- TDD vsus FDD
- Bandwidth used
- MIMO Level

LTE has to pay a high mobility (350Km/h) performance price

VERY DIFFERENT MODELS / ECOSYSTEMS

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LTE: Not a Simple 3G Upgrade

- LTE Represents a Major change from HSPA
  - Not a “simple” SW upgrade:
    - CDMA to OFDMA, represent different technologies
    - Circuit switched to IP e2e network
  - Also requires new spectrum to take full advantage of wider channel BWs and …
  - Requires dual-mode (or three mode) user devices for internetwork connectivity

LTE Projections & Mobile WiMAX

FDD 2 x 20 MHz Channel BW

Parameter	Reported LTE Results				WiMAX Rel 1.5	
	Motorola[1]		T-Mobile[2]	Qual-comm[3]		
BS Antenna	2x2	4x4	2x4	4x2	2x2	4x4
Channel BW	2 x 20 MHz				2 x 20 MHz	
Mod-Code Rate	64QAM-5/6		64QAM-5/6	64QAM-?	64QAM-5/6	
DL Peak User Rate	117 Mbps	226 Mbps	144 Mbps	277 Mbps	144.6 Mbps	289 Mbps
MS Antenna			1x2	1x2	1x2	
Mod-Code Rate			64QAM[4]-?	16QAM[4]-?	64QAM-5/6	
UL Peak User Rate	?	?	50.4 Mbps	75 Mbps	69.1 Mbps	

1. Motorola website, "LTE In Depth" , Reference does not show UL peak rate projections
2. "Trials–Ensuring Success for Innovation", Joachim Horn, T-Mobile, NGMN Conference presentation, June 25-27,2008
3. "3GPP Long-Term Evolution (LTE)", Qualcomm, January 2008
4. 64QAM is optional for UL in LTE specification, 16QAM is mandatory

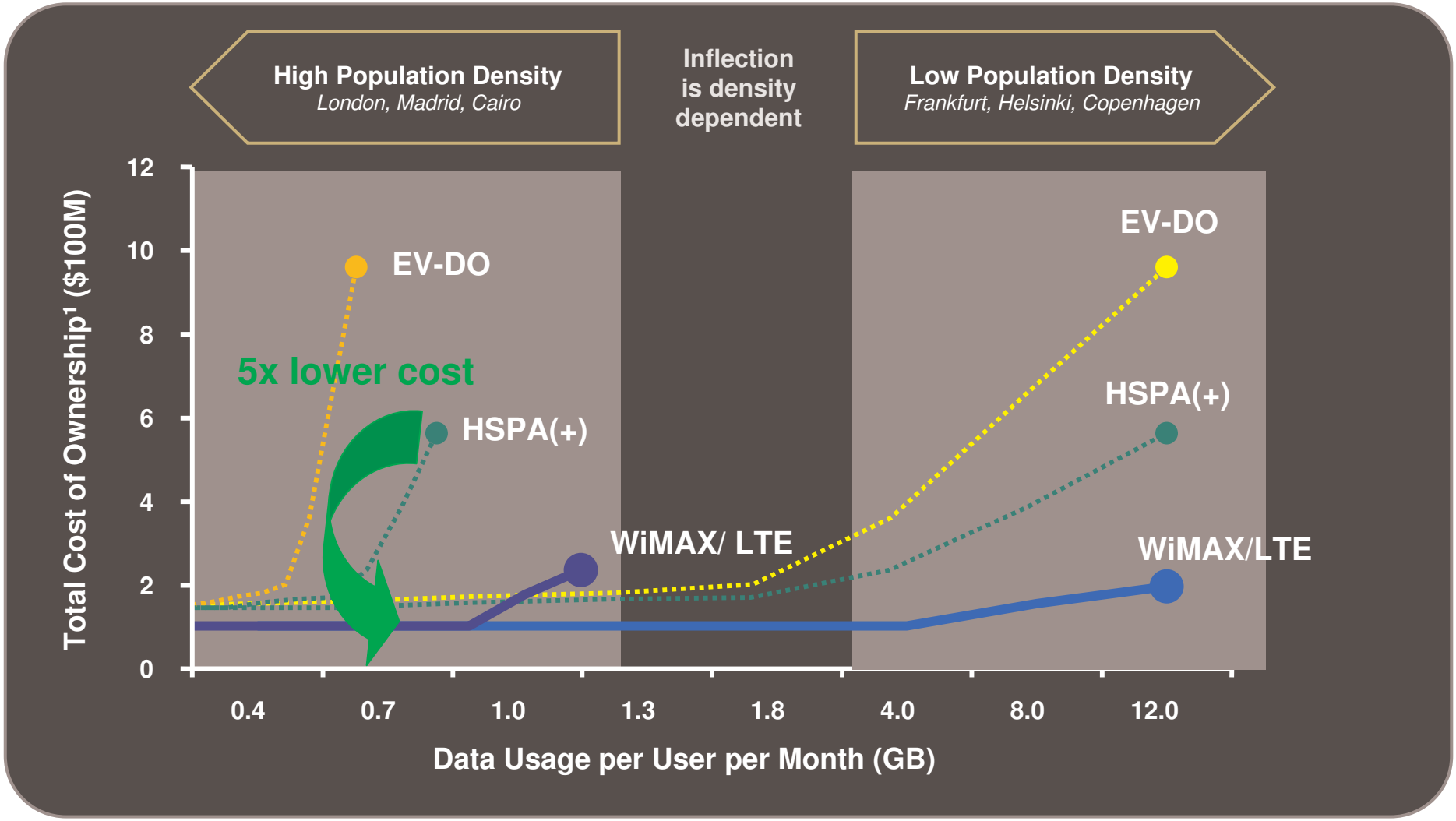
Other Key Parameter Comparisons

Parameter	LTE	Mobile WiMAX Rel 1.5
Duplex	FDD and TDD	FDD and TDD
Frequency Band for Performance Analysis	2000 MHz	2500 MHz
Channel BW	Up to 20 MHz	Up to 20 MHz
Downlink	OFDMA	OFDMA
Uplink	SC-FDMA	OFDMA
DL Spectral Efficiency[1]	1.57 bps/Hz/Sector (2x2) MIMO[2]	1.59 bps/Hz/Sector (2x2) MIMO
UL Spectral Efficiency[1]	0.64 bps/Hz/Sector (1x2) SIMO[2]	0.99 bps/Hz/Sector (1x2) SIMO
Mobility Support	Target: Up to 350 km/hr	Up to 120 km/hr
Frame Size	1 millisec	5 millisec
HARQ	Incremental Redundancy	Chase Combining
Link Budget	Typically limited by Mobile Device	Typically limited by Mobile Device
Advanced Antenna Support	DL: 2x2, 2x4, 4x2, 4x4 UL: 1x2, 1x4, 2x2, 2x4	DL: 2x2, 2x4, 4x2, 4x4 UL: 1x2, 1x4, 2x2, 2x4

1. Spectral efficiency is based on NGMN Alliance recommended evaluation methodology

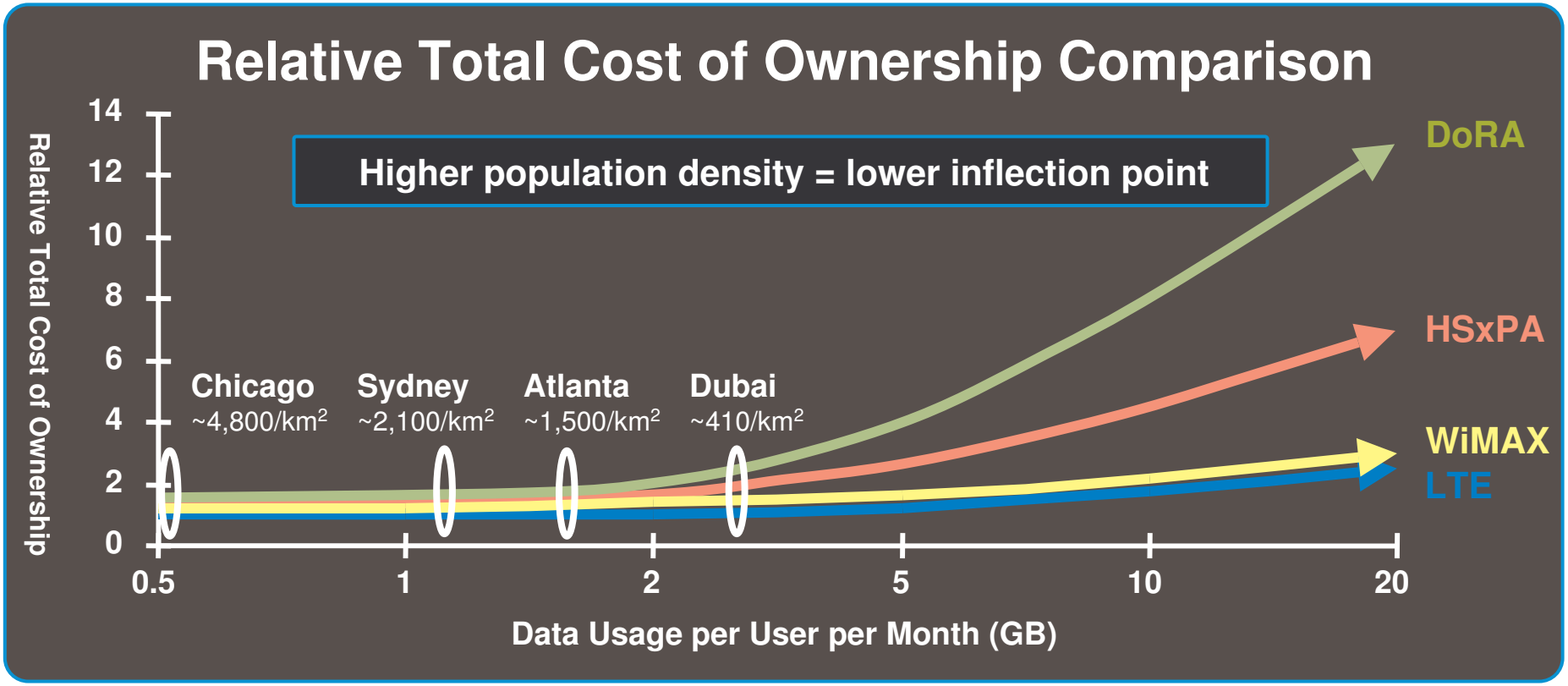
2. Reference for LTE Spectral Efficiency: Motorola website, "LTE in Depth".

Why is it all important?



[1] Motorola network models, March 2009, [2] Signals Research Group, November 2008

Why is it all important?



Assumptions:

* Population density of 1,000 pop/km^2,15% subscriber penetration
* Per subscriber data usage (1 busy hour, 7 non-busy hours per day) based on 15k subscribers in 100 km^2
* Spectrum usage normalized across technologies; cell edge data rates DL 1 Mbps, UL 256 Kbps
* Backhaul costs assume operator uses lowest cost solution (owned wireless)
* **Note:** Data Usage/Sub/Month will vary with the population density of the city for a given subscriber penetration assumption

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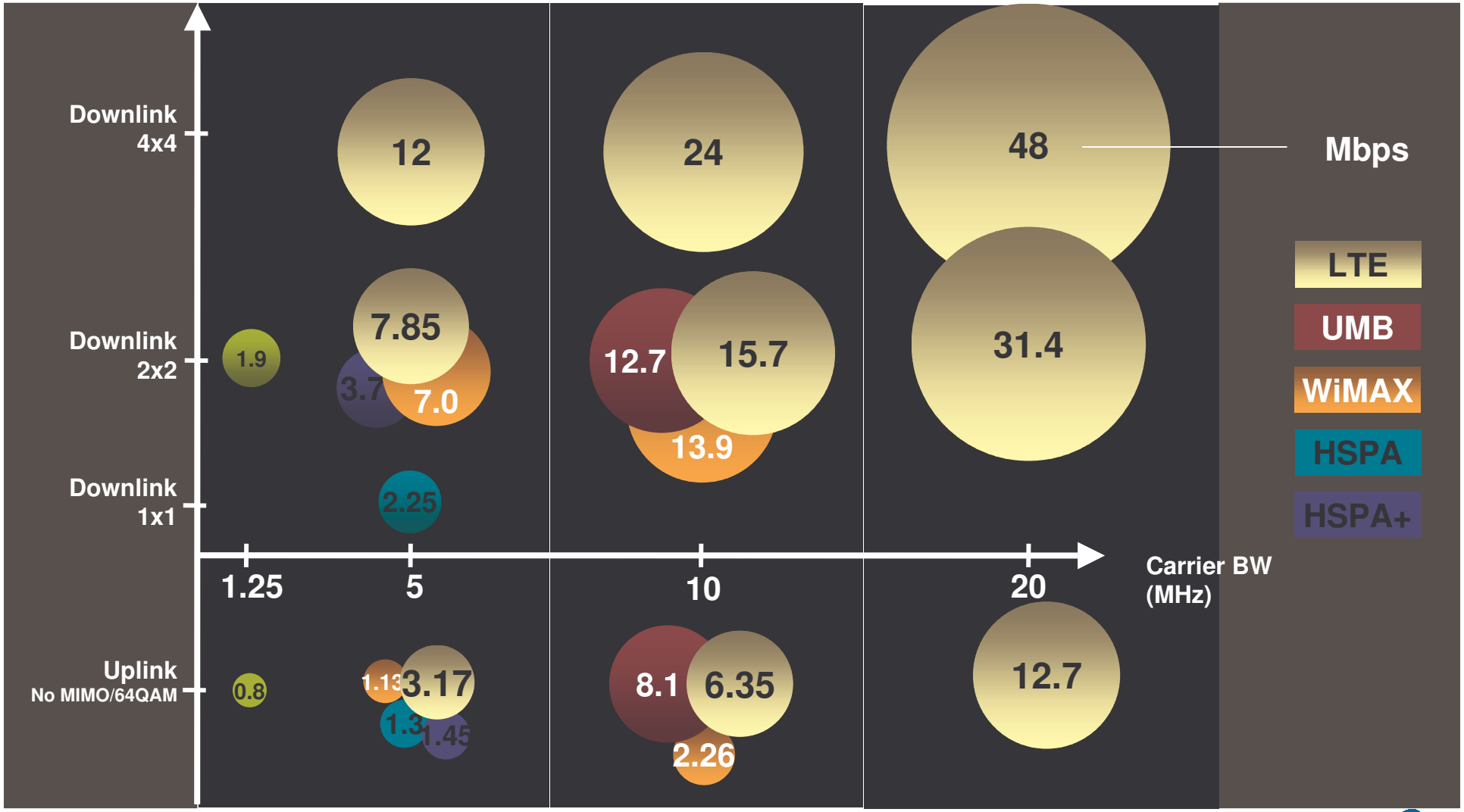
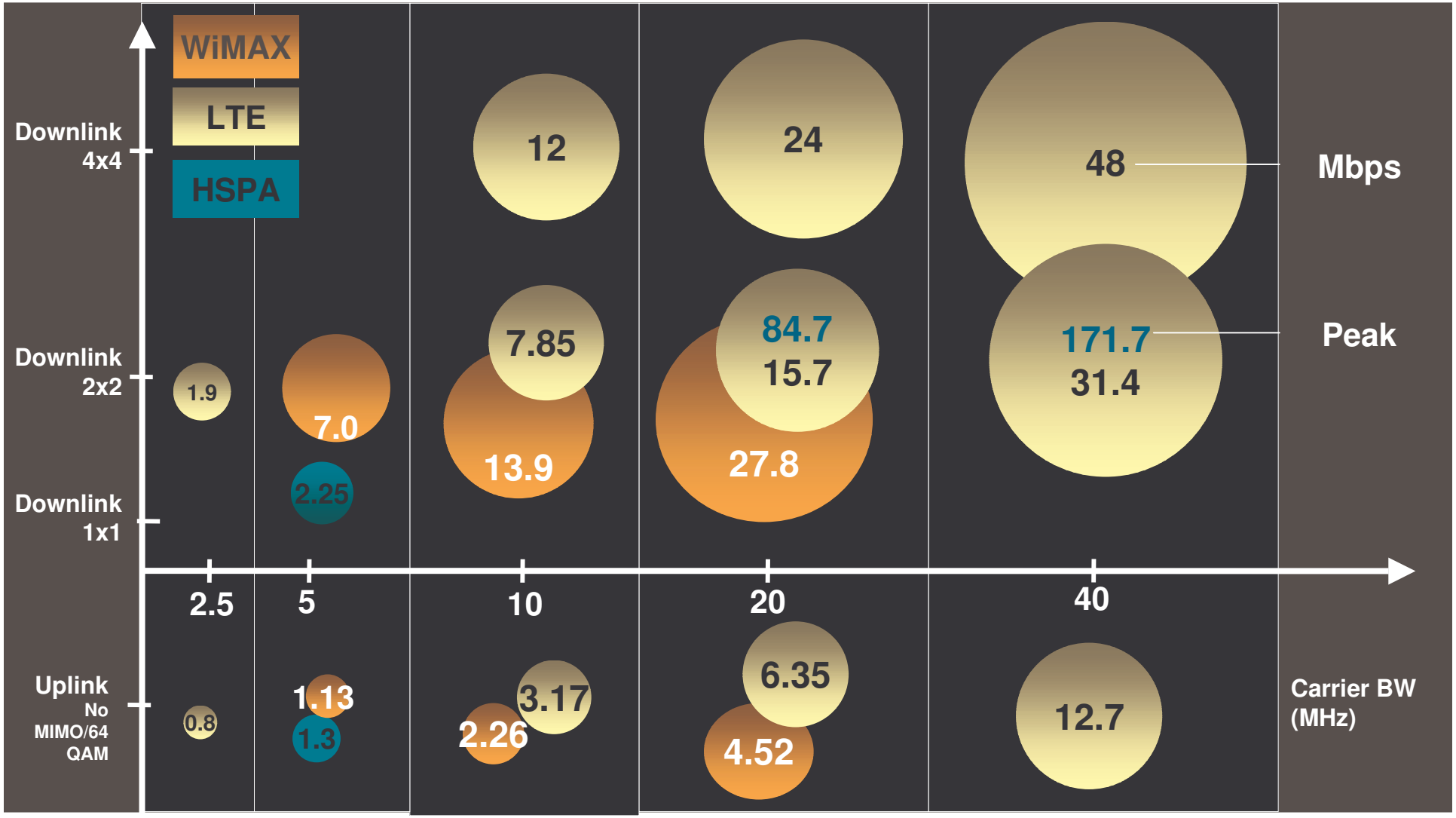
Real World Performance



A More Realistic View

Taking FDD into account, WiMAX Rel 1.5



Source: Motorola NAT, Rysavy Research,CDG-QCOM, WiMAX Forum

What drives the Choice?

For WiMAX

- Time to Market
- No Cellular Legacy
- New Business Model – Focus on Broadband

- New Operators
- New Business Models

For LTE

- Cellular Model continuity / Compatibility
- Access to Spectrum
- “Natural” extension from voice to Broadband

- Cellular Operators

Spectrum Planning

Spectrum Availability for WiMAX and LTE

LTE spectrum focused on traditional cellular bands

Appeal for many cellular operators

May require re-mining spectrum to allow build out

WiMAX spectrum is new, underutilized, and less costly

Offers access to new wireless players…

& existing operators looking for time to market

- Both require significant spectrum
- Both can be FDD or TDD

WiMAX	2300 MHz	TDD
	2500 MHz	TDD
	3500 MHz	TDD
LTE	800 MHz	FDD
	850 MHz	FDD
	900 MHz	FDD
	1500 MHz	FDD
	1700 MHz	FDD
	1800 MHz	FDD
	1900 MHz	FDD
	2100 MHz	FDD
	2500 MHz	FDD

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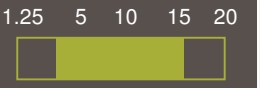
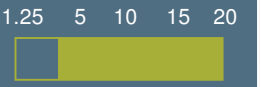
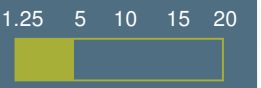
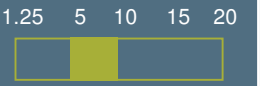
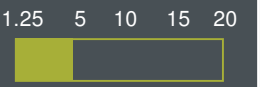
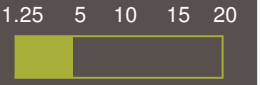
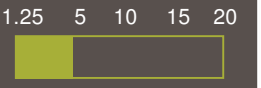
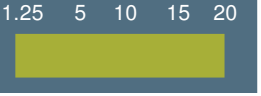
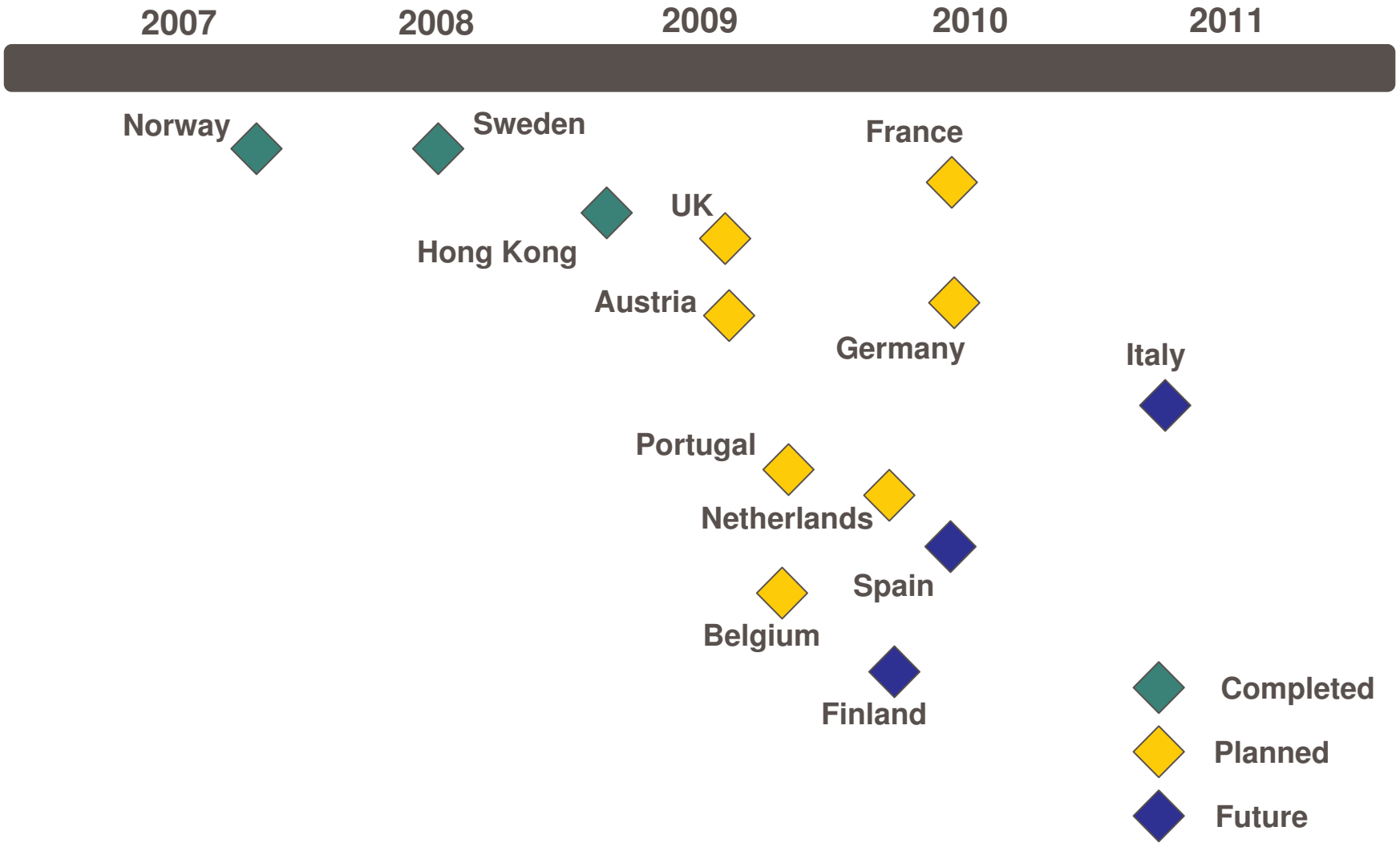
LTE 3GPP Spectrum View

3GPP New Spectrum

- LTE will happen in many bands and flavours
  - US – 700MHz, AWS
  - Europe – 2.5GHz, 1.8GHz, 2.1GHz, 900MHz (Finland)
  - Japan 2.1GHz, 800MHz
  - China 2.3GHz (TDD)

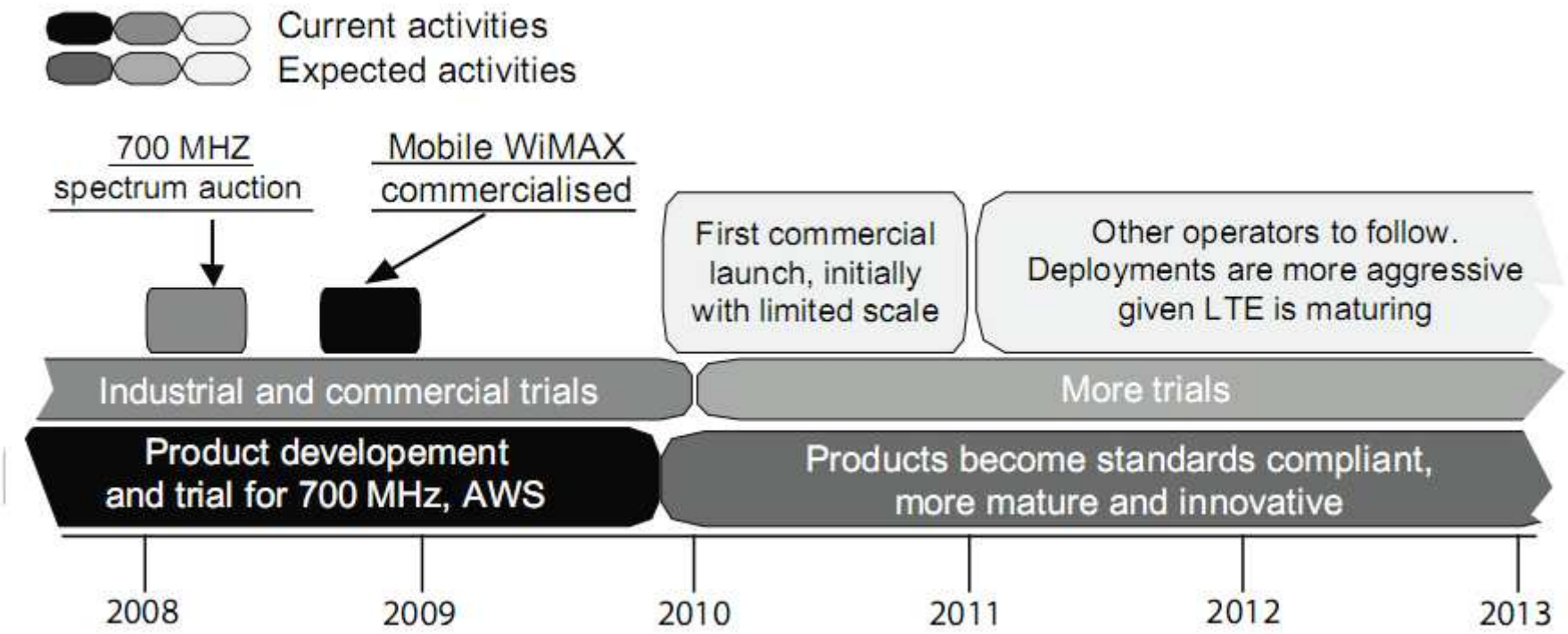
Band	Uplink (MHz)	Downlink (MHz)	Carrier Bancwidth (MHz)
700 MHz	746 - 763	776 - 793	
AWS	1710 - 1755	2110 - 2155	
IMT Extension	2500 - 2570	2620 - 2690	
GSM 900	880 - 915	925 - 960	
UMTS Core	1920 - 1980	2110 - 2170	
GSM 1800	1710 - 1785	1805 - 1880	
PCS 1900	1850 - 1910	1930 - 1990	
Cellular 850	824 - 849	869 - 894	
Digital Dividend	470 - 854		

2.6 GHz Spectrum
Auctions



LTE Timetable US

Figure A.2 **LTE roadmap in US**



Source: Ovum

(UMTS Forum Report #42)

LTE Timetable – Japan / China

Figure A.5 **LTE roadmap in Japan**

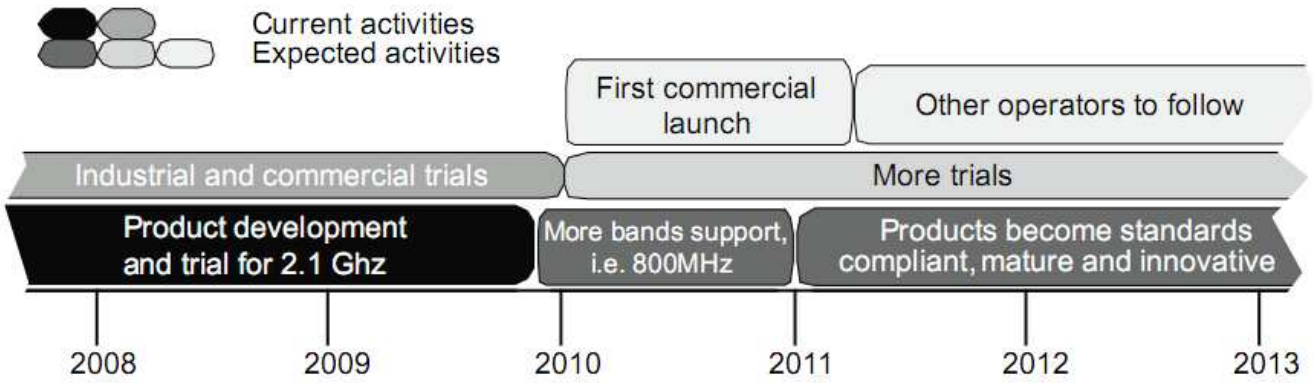
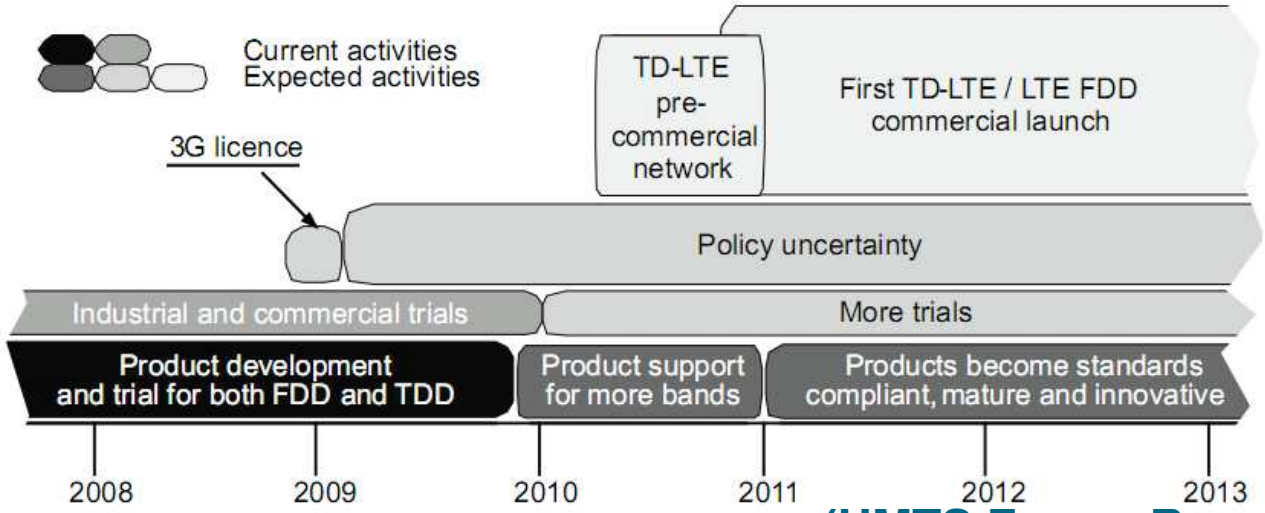


Figure A.4 **LTE roadmap in China**

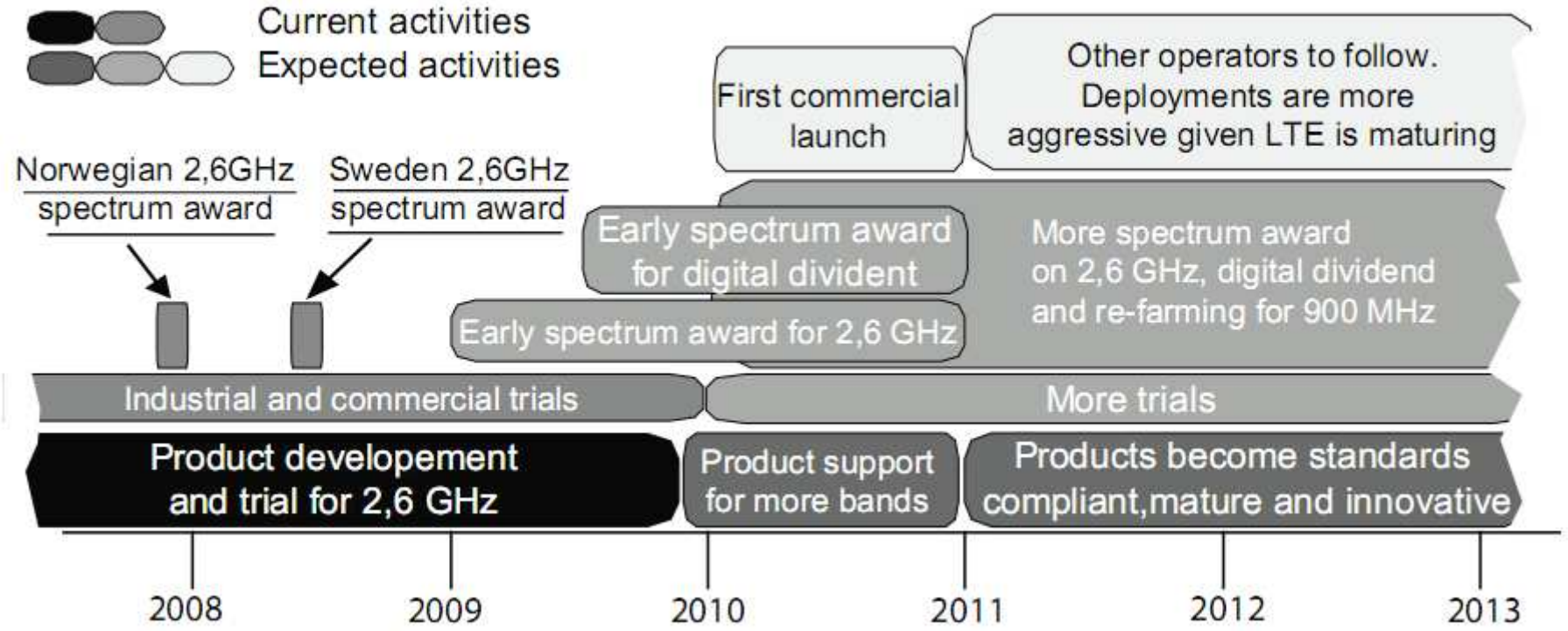


Source: Ovum

(UMTS Forum Report #42)

LTE Timetable - Europe

Figure A.3 **LTE roadmap in Western Europe**

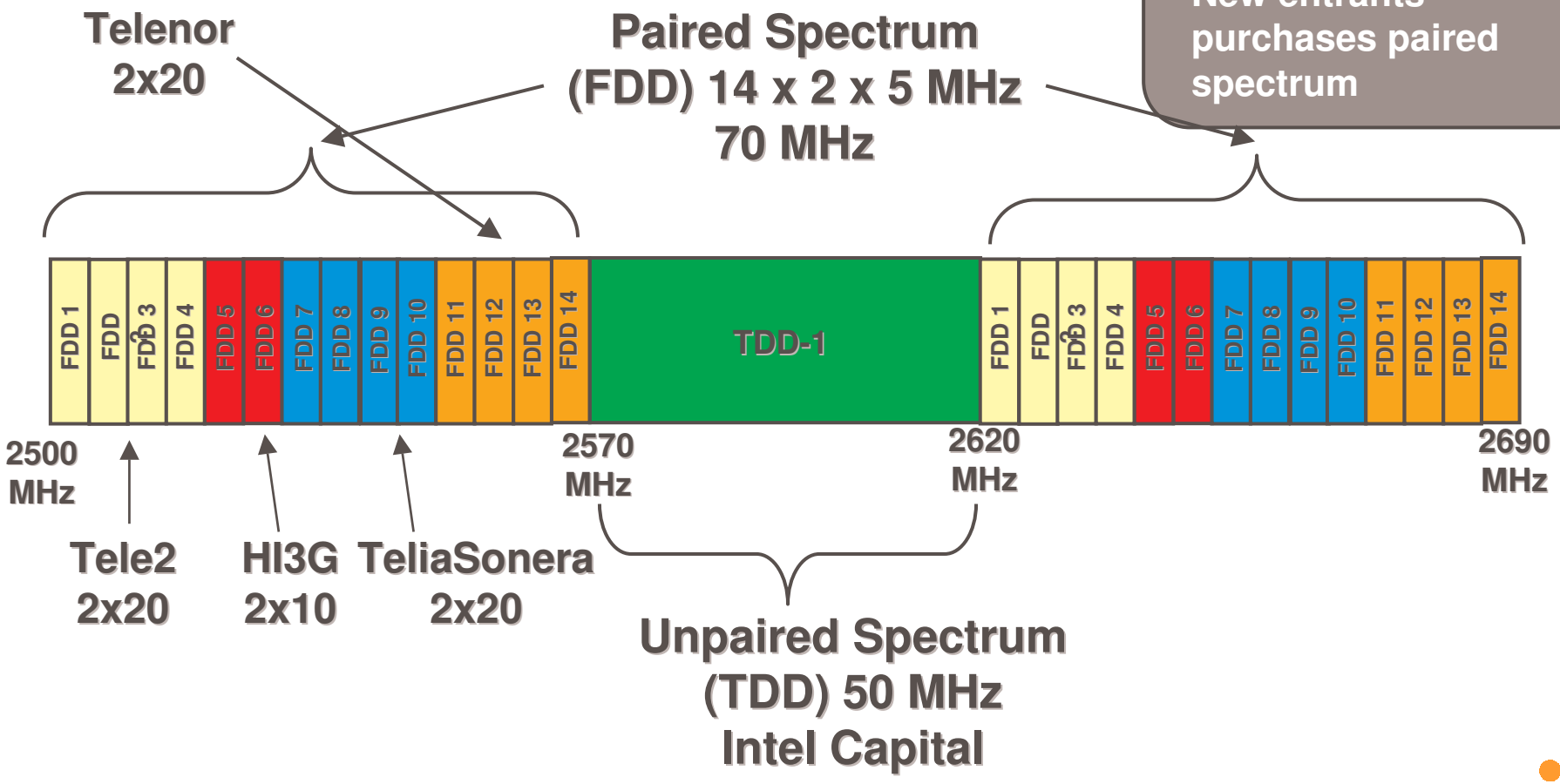


Source: Ovum

(UMTS Forum Report #42)

Sweden 2.6 GHz Auction Completed April 2008

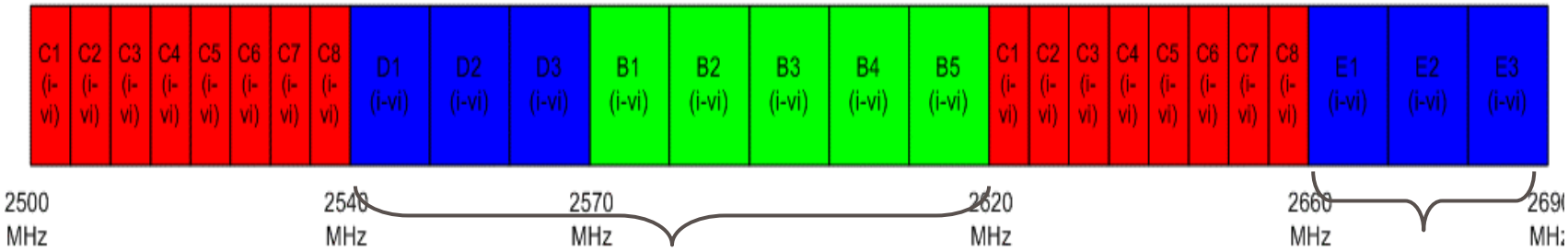
- Incumbents purchase paired spectrum
- New entrants purchases paired spectrum



Norway 2.6 GHz Auction Completed 2007b

- Incumbents purchase paired spectrum
- New Entrants purchase unpaired spectrum

Paired Spectrum (FDD) 2 x 40 MHz



Unpaired Spectrum (TDD) 80 MHz

Unpaired Spectrum (TDD) 30 MHz

Traditional 3GPP Operators

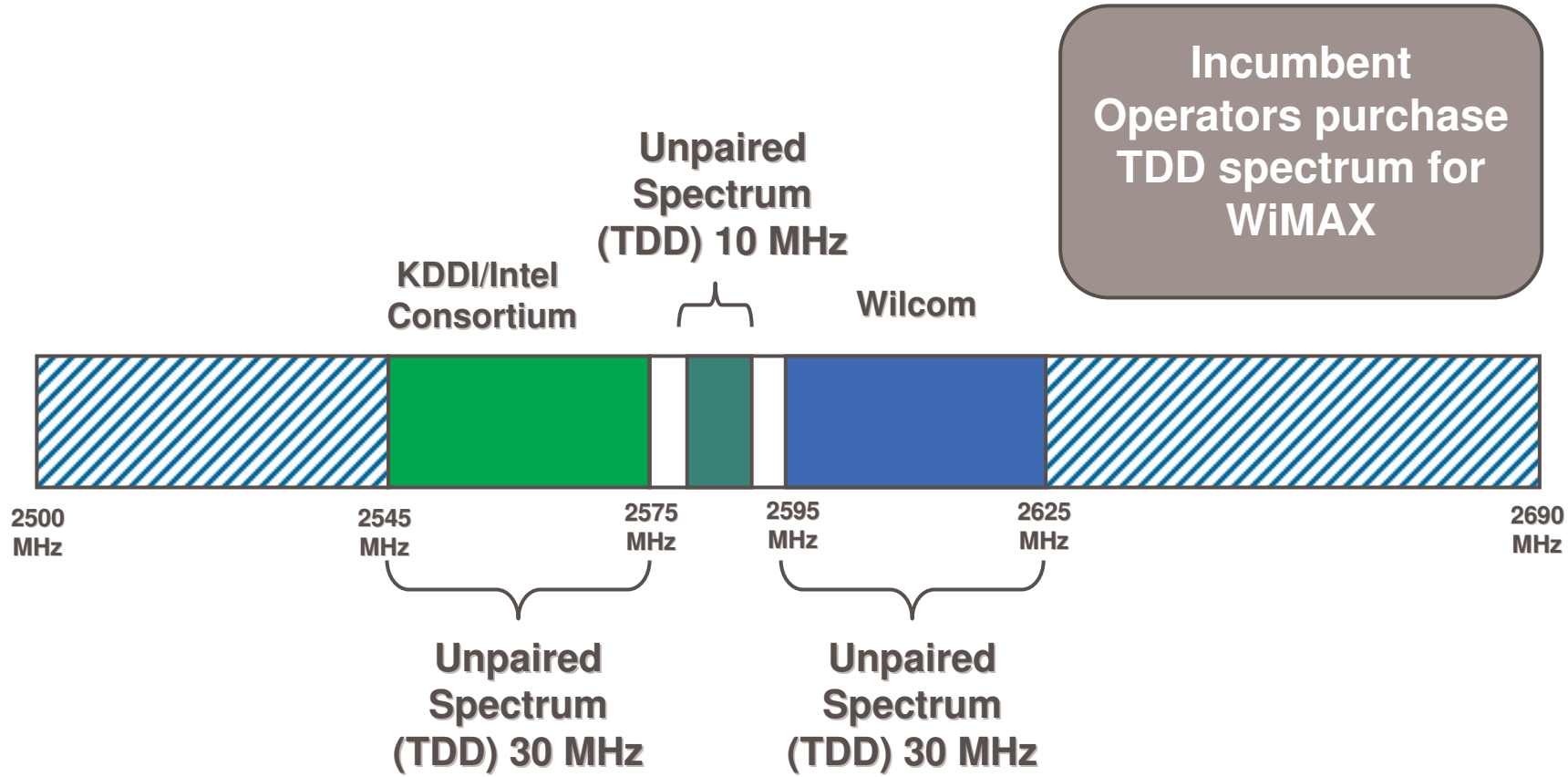
TeliaSonera (Netcom) 2 x 20 MHz FDD
Telenor 2 x 20 MHz FDD
Telenor 40 MHz TDD

900 MHz, 1800 MHz and 2.1 GHz Spectrum In Service

Various New Entrants

70 MHz TDD

Japan
Completed 2007

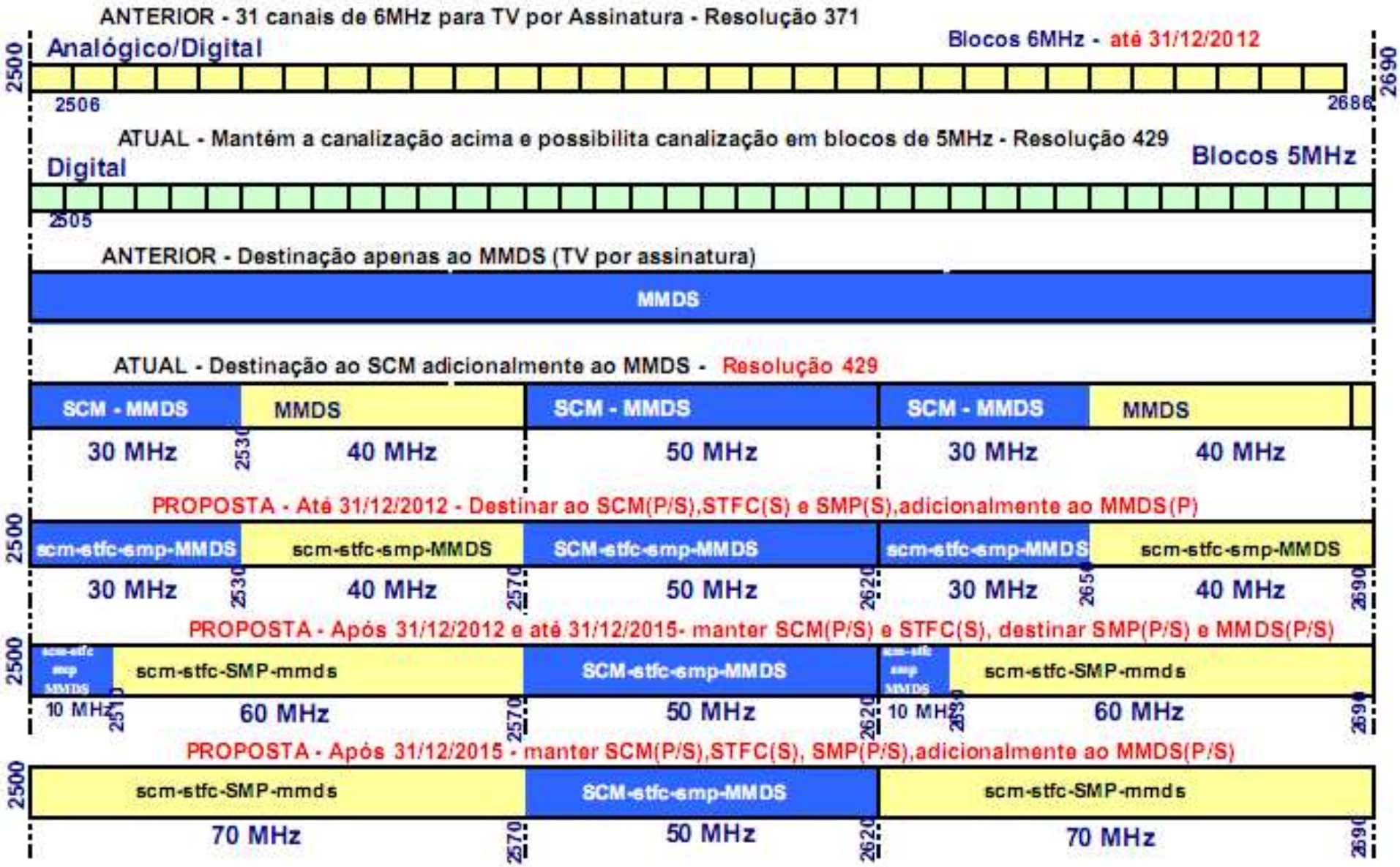


LTE Adoption - World

- Japan – 2010/11 – 2.1GHz
- USA – 2011/2012 – 700MHz
- China – 2011/2012 – 2.3GHz TDD
- Europe – Auctions until 2011 - Deployment from 2012 onwards. Other bands will be used too: 900MHz, 2.1GHz and 1.8GHz

Brazilian Outlook

CP31 Proposal



A quick Summary

- 2.5GHz Spectrum will shrink continuously, being removed from current licensees

- By 2015:
  - there will be 70+70 MHz LTE dedicated and LTE ready
  - 50MHz for TDD (WiMAX) that can be shared by two operators in new bids or by one current licensees.

- A regulation issued in 2006 will be revoked after 3 years in effect

What are the consequences?

- Spectrum on the market and ready for broadband will be removed and returned to ANATEL
- This spectrum will not be returned to society (through an auction) before 2015:
  - Because of Operator investment and install new technologies limits
  - LTE Maturity
- Unless there are new Spectrum auctions:
  - Efficient Wireless Broadband offers will not appear in the market before 2015/2016
  - Wireless Broadband will be synonymous of SMP – No technology nor business Model Diversity

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LTE Adoption in Brazil

- Cellular Operators:
  - Have just invested on 3G spectrum auction – $2.8B
  - Are busy deploying and expanding the 3G network
  - Have coverage commitments spanning until 2015

There is little likelihood LTE will enter Brazil before 2015

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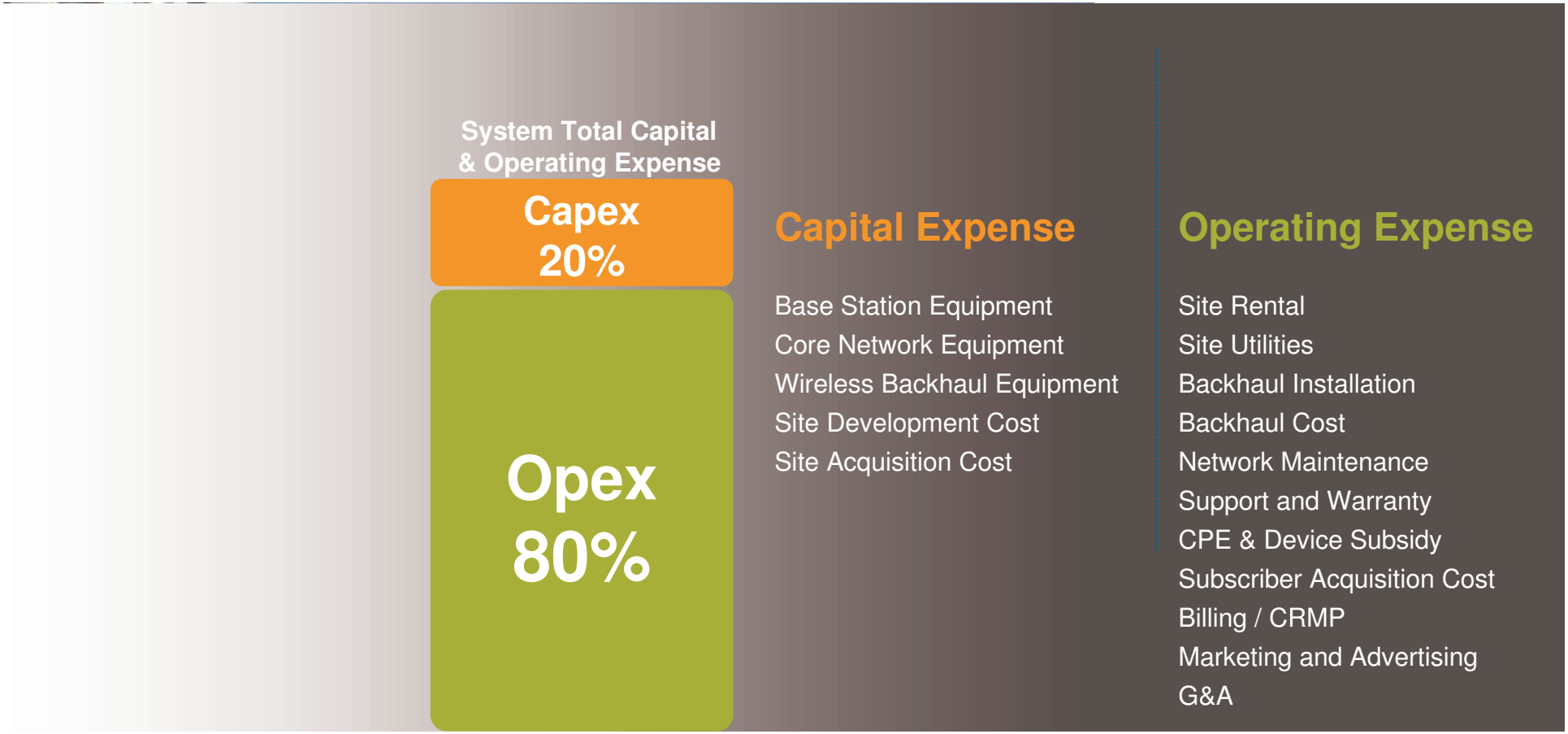
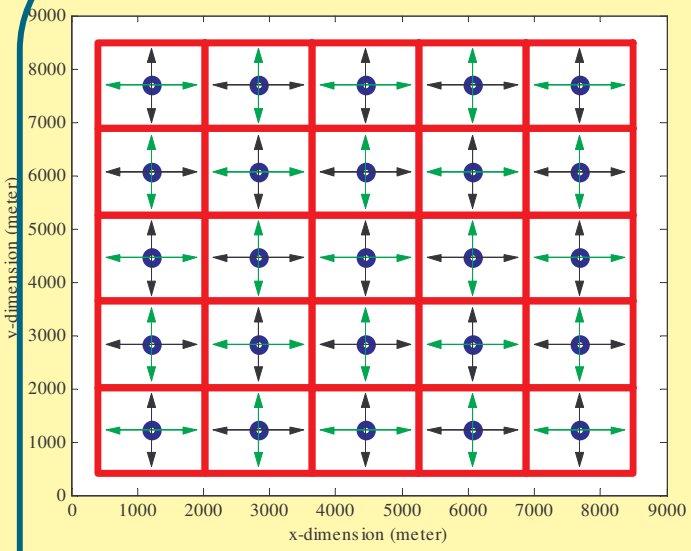
Wireless Broadband and Growth

- New technologies require a lot more spectrum to work efficiently
- Growing of wireless broadband capacity is possible by
  - Adding sites
  - Adding more carriers
- Economical growth is through adding carriers – even more spectrum:

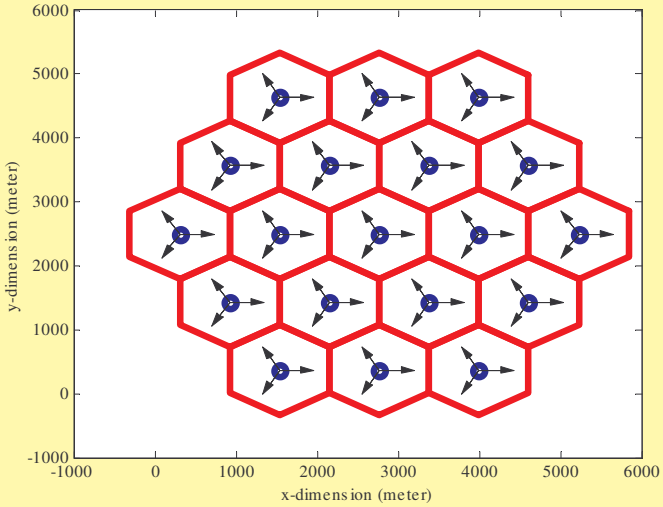


Frequency Reuse

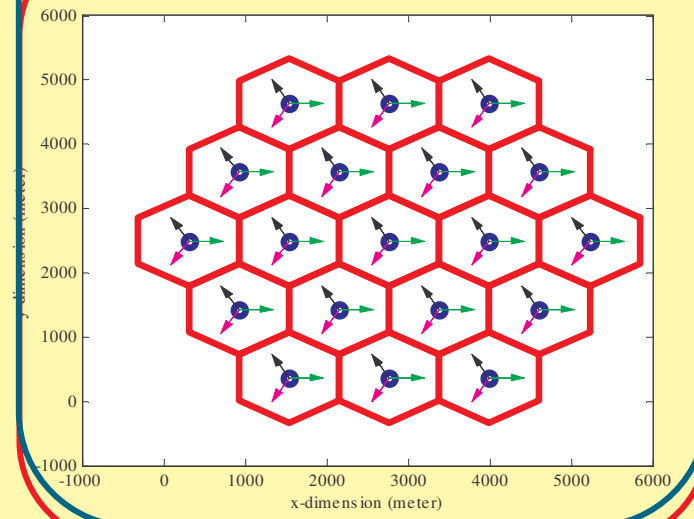
1x4x2



1x3x1



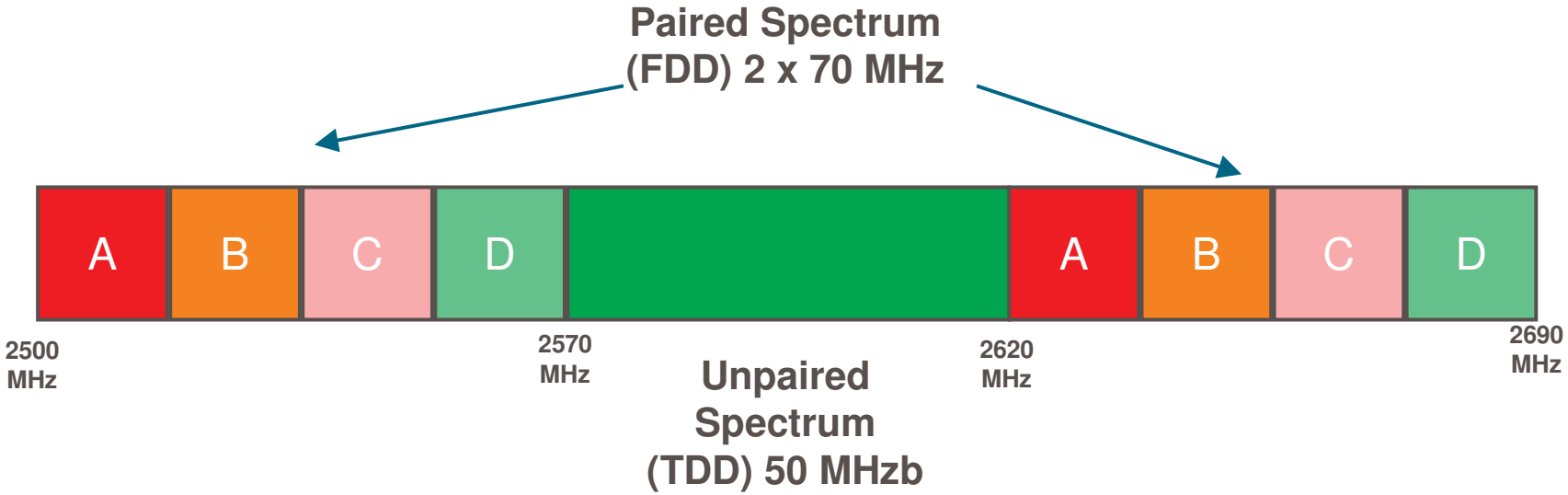
1x3x3



WiMAX

LTE

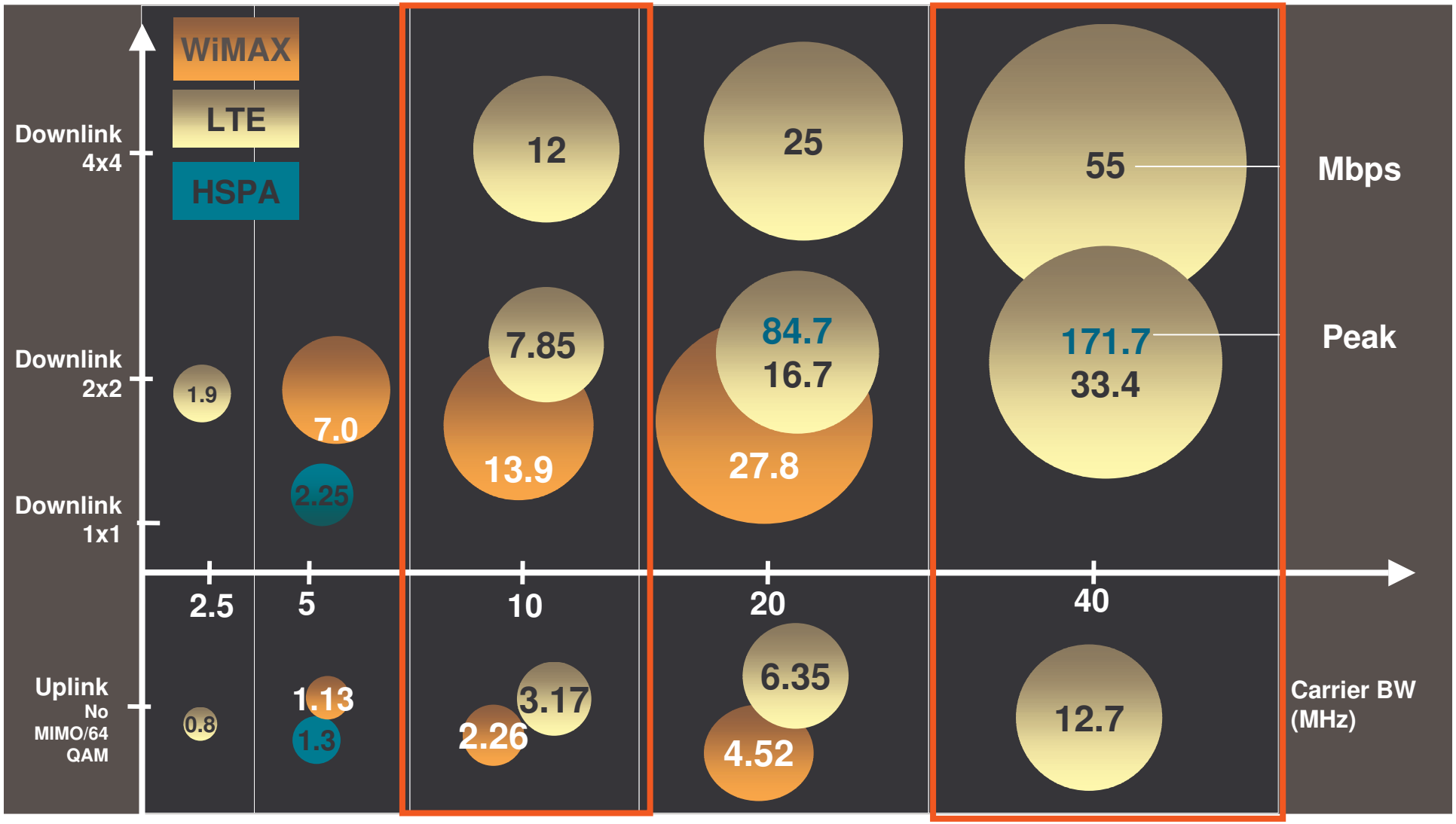
CP31 4 Operator Scenario



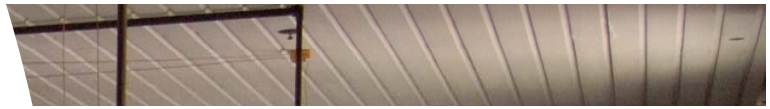
Number of Operators	Spectrum per Operator	Spectrum per Carrier (LTE profile)
3	23.3	7.7MHz (5+5MHz)
4	17.5MHz	5.8MHz (5+5MHz)
5	14	4.66MHz (?)

A More Realistic View

Taking FDD into account, WiMAX Rel 1.5



Conclusion



Broadband is the Electricity of the 21st Century

Diversity of ecosystem

Regulation should ensure a diverse and healthy ecosystem

- Similar companies operating with same technology will have similar performance and actions

USA Offering:

- Verizon and Sprint EVDO Rev/A
- AT&T /TMobil GSM / HSDPA
- Clearwire – WiMAX

- WiMAX has a new Data-Centric model closer to the computer industry than to Telecom

Example: EUA Clearwire is a new model

Suggested Actions

- Auction of more spectrum for Wireless Broadband
  - 3.5GHz
  - 2.3GHz
  - 2.1GHz
- Analyze the possibility of re-using SMP dedicated frequencies with new technology
- New Mindset - Allow assignment of higher amounts of spectrum to operators – Prepare for the new Broadband Market

Conclusions

- Existing Regulatory Environment:
  - Delays the delivery of wireless Broadband in Brazil
  - Makes system growth more expensive – business case less viable – higher prices

- It is critical to make more spectrum available to the market to:
  - Increase offer and business model diversity
  - Increase competition outside of a single model
  - Expedite Wireless broadband introduction

Thank You

www.wimaxforum.org

BACKUP

Current Mobile Spectrum

SMP allocated bands		
Sub-band	**Limit(MHz)**	**Total**
800 MHz	12,5 + 12,5	25MHz
900 MHz	2,5 + 2,5	5MHz
1.800 MHz	25 + 25	50MHz
1.900 e 2.100 MHz	15 + 15	30MHz

- Cellular operators already have a total of 340MHz of spectrum allocated
- Maximum per operator is 85MHz

	Uplink			Downlink		
Subfaixa A**	824	835	11	869	880	11
	845	846.5	1.5	890	891.5	1.5
Subfaixa B**	835	845	10	880	890	10
	846.5	849	2.5	891.5	894	2.5
Subfaixa D	910	912.5	2.5	955	957.5	2.5
	1710	1725	15	1805	1820	15
Subfaixa E	912.5	915	2.5	957.5	960	2.5
	1740	1755	15	1835	1850	15
TOTAL			**60**			**60**
Sufaixa de Ext.	898.5	901	2.5	943.5	946	2.5
	907.5	910	2.5	952.5	955	2.5
	1725	1740	15	1820	1835	15
	1775	1785	10	1870	1880	10
TOTAL			**30**			**30**
F*	1920	1935	15	2110	2125	15
G*	1935	1945	10	2125	2135	10
H*	1945	1955	10	2135	2145	10
I*	1955	1965	10	2145	2155	10
J*	1965	1975	10	2155	2165	10
L	1895	1900	5	1975	1980	5
M	1755	1765	10	1850	1860	10
TOTAL			**70**			**70**
Subfaixa de Est.	1765	1770	5	1860	1865	5
	1770	1775	5	1865	1870	5
TOTAL			**10**			**10**
TOTAL DE ESPECTRO			***170***			***170***

WiMAX FORUM®

Capex versus Opex

Total cost of ownership comprised of both initial capital outlay and ongoing operational expense of managing and maintaining the WiMAX service

Significant capital cost reductions engineered in leading WiMAX solutions

Capital Expense

- Base Station Equipment
- Core Network Equipment
- Wireless Backhaul Equipment
- Site Development Cost
- Site Acquisition Cost

Operating Expense

- Site Rental
- Site Utilities
- Backhaul Installation
- Backhaul Cost
- Network Maintenance
- Support and Warranty
- CPE & Device Subsidy
- Subscriber Acquisition Cost
- Billing / CRMP
- Marketing and Advertising
- G&A

ITU-T Recommendation M.1036 (cited by CP31)

- **IMT2000 Frequency arrangements.**

Frequency arrangements	Mobile station transmitter (MHz)	Centre gap[1] (MHz)	Base station transmitter (MHz)	Duplex separation[2] (MHz)
A1	824-849	20	869-894	45
A2	880-915	10	925-960	45

Frequency arrangements	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	Un-paired spectrum (e.g. for TDD) (MHz)
B1	1 920-1 980	130	2 110-2 170	190	1 880-1 920; 2 010-2 025
B2	1 710-1 785	20	1 805-1 880	95	None
B3	1 850-1 910	20	1 930-1 990	80	1 910-1 930
B4 (harmonized with B1 and B2)	1 710-1 785 1 920-1 980	20 130	1 805-1 880 2 110-2 170	95 190	1 900-1 920; 2 010-2 025
B5 (harmonized with B3 and parts of B1 and B2)	1 850-1 910 1 710-1 770	20 340	1 930-1 990 2 110-2 170	80 400	1 910-1 930

ITU-T Recommendation M.1036 (cited by CP31)

Frequency arrangement	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	Centre gap usage
C1	2 500-2 570	50	2 620-2 690	120	TDD
C2	2 500-2 570	50	2 620-2 690	120	FDD DL (external)
C3	Flexible FDD/TDD				