Spectrum Forecasting for Future Use: *Methods &Techniques*

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AIM

- Introduce the key factors, approaches and methods applied in developing demand forecasts for spectrum.
- National Spectrum demand forecast example for cellular Mobile services.
- Publishing and Implementation

Approach

- Current spectrum usage Data
- Spectrum Demand Drivers
- Qualitative and Quantitative growth Analysis
- Assumptions

Current Spectrum Usage Data

- **First steps** *involve establishing an estimate of the current utilisation using information on assignments and utilization from the NRA spectrum licence database*
  - reasoned assumptions are made where data is not readily available and reliable.
  - Alternative sources should also be considered.

- **Calculating the current utilisation**
  - Important and non-trivial task as calculation requires information on
    - Spectrum re-use,
    - Geography
    - Differences between regional and/or urban and rural allocations (if any)

Spectrum Demand Drivers - Devices

Technological Growth of Devices: Examples

- ***Automotive devices*** *(in-vehicle infotainment devices)*
- ***Cellular devices*** *(basic and feature phones, smartphones, mobile hotspots)*
- ***Computing devices*** *(desktops, mini-notes, notebooks, tablets)*
- ***Networking devices*** *(broadband routers, residential gateways, wireless access points, FTTH residential gateways, network attached storage)*
- ***Peripheral devices*** (*multifunction peripherals, ink jet printers, laser printers, USB adapters)*
- ***Portable Consumer Electronics devices*** (*digital still cameras, E-readers, portable media players [PMPs], personal navigation devices [PNDs], handheld game consoles)*
- ***Stationary Consumer Electronics devices*** (*Blu-ray players, digital photo frames, digital televisions, cable set top boxes, IP/DSL set top boxes, satellite set top boxes, standalone PVRs, terrestrial set top boxes, video game consoles)*

Spectrum Demand Drivers - Services

- **Aeronautical and Maritime Services –** *Increased demand from Communications, Navigational Aids and Surveillance*
- **Amateur Radio –** *no changes*
- **Broadcast –** *DSO initially and as cable access increases need for terrestrial broadcast may subside. Enough spectrum identified for sound broadcast for medium term atleast.*
- **Cellular –** *immediate and medium term requirements likely satisfied except for competition related issues*

Current Spectrum Availability for IMT *(from the RR)*

Frequency bands (bandwidth) in MHz	RR provisions identifying the band for IMT
450-470 (**20**)	5.286AA
694/698-960 (**266/262**)	5.312A, 5.313A, 5.316B, 5.317A
1 710-2 025 (**315**)	5.384A, 5.388
2 110-2 200 (**90**)	5.388
2300-2400 (**100**)	5.384A
2500-2690 (**190**)	5.384A
3400-3600 (**200**)	5.430A, 5.432A, 5.432B, 5.433A

Additional Spectrum Requirements (from CPM15 Report)

User density	Total requirement by 2020 (MHz)	Region 1		Region 2		Region 3	
		Already identified (MHz)	Additional demand (MHz)	Already identified (MHz)	Additional demand (MHz)	Already identified (MHz)	Additional demand (MHz)
Low	1 340	981-1 181	159-359	951	389	885-1 177	163-455
High	1 960		779-979		1 009		783-1 075

Spectrum Demand Drivers – Macro Economic

- **International Markets and Globalization –** *the need to be competitive*
- **Government use –** *(Security, Military, Govt. projects)*
- **International developments –** *(ITU, ICAO, IMO, ETSI)*
- **Frequency dependent propagation characteristics**
  - *(E.g.: weather radars)*
- **Competition in radio services -** *(C-Band: satellite or IMT)*

Quantitative & Qualitative growth Analysis

- **Commercial services**
  - Linkage between infrastructure growth, technology advancement, traffic growth, and spectrum demand is reasonably well understood and has been modelled.

- **Non-commercial services**
  - More difficult and lend themselves to qualitative analysis
  - *To help reduce uncertainty several growth scenarios can be developed: low, expected, hyper-growth for example.*

- **Other services** *(E.g.: Mobile radio, aeronautical and maritime, and public safety etc.)*
  - Not readily forecastable given usually to a lack of reliable data.
  - For these services, forecasts are typically based on qualitative analysis using ITU documents and references, WRC planning efforts, planning activities completed by other regulators etc.

Assumptions 1/2

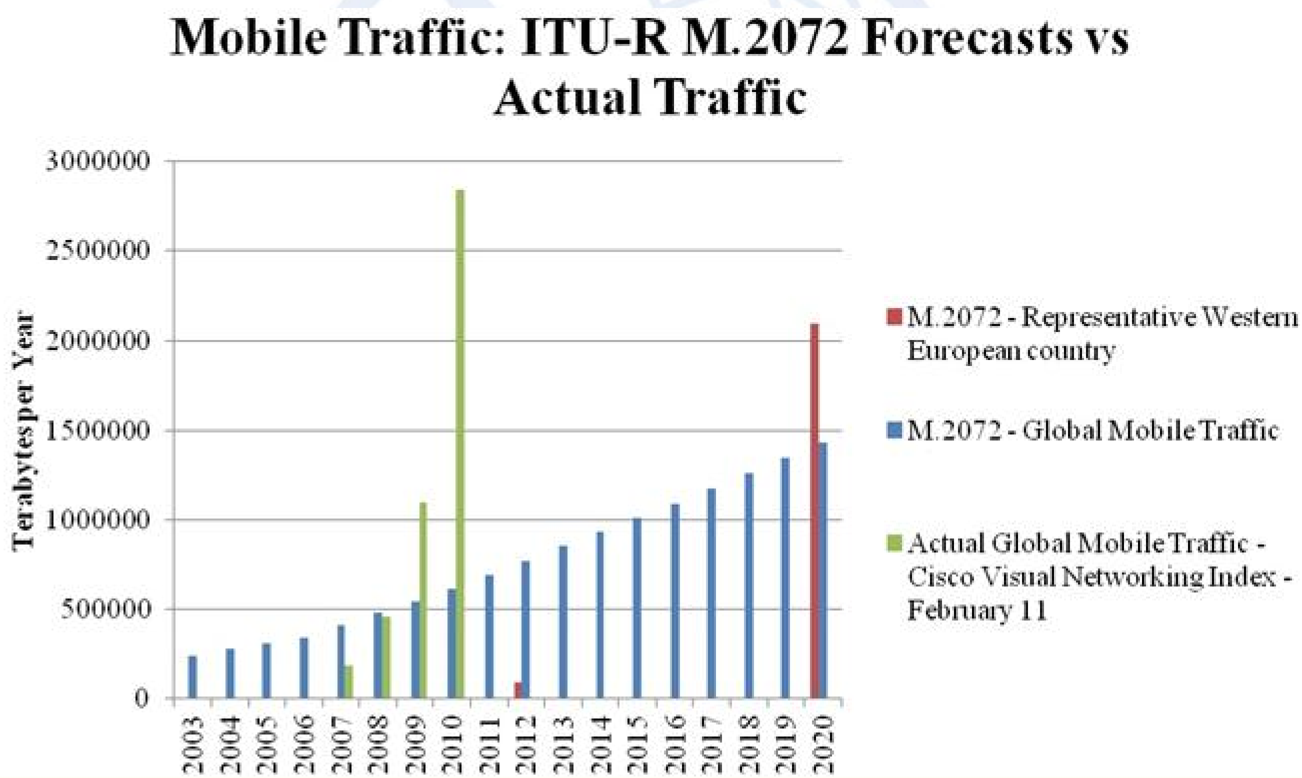
- **Assumptions are to be concerning the timing and capabilities of future technology developments. Especially its**
  - Availability
  - Cost
  - life cycle.

Note of Caution:

Future spectrum forecast assessment makes necessary assumptions about future technologies and market developments on some tangible basis, however the use of any particular assumption should not be taken to imply that an alternative development is not equally likely.

Assumptions 2/2

- **Assumptions on demand side can also be inaccurate e.g**
  - Traffic



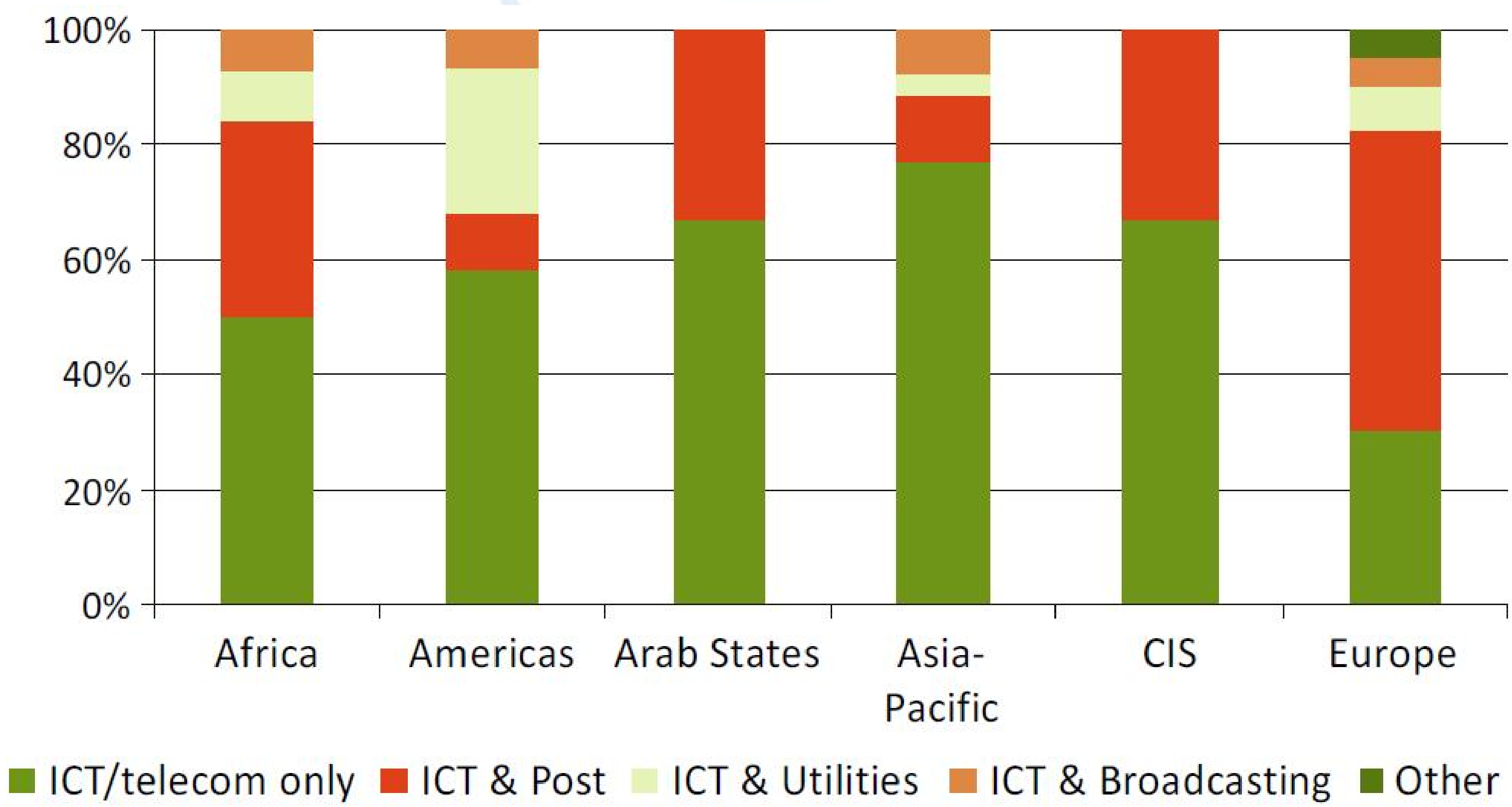
General Caution

- Forecasting end user demand is neither easy nor trivial.
- This explains is why initial forecasts of end-user demand especially for new services are often quite far off the mark and have to be repeated.
- Demand analysis is iterative, repeated and is only as good as the starting point.

National Spectrum demand forecast example for cellular Mobile services

Why Mobile Service?

Mandate of Modern NRA



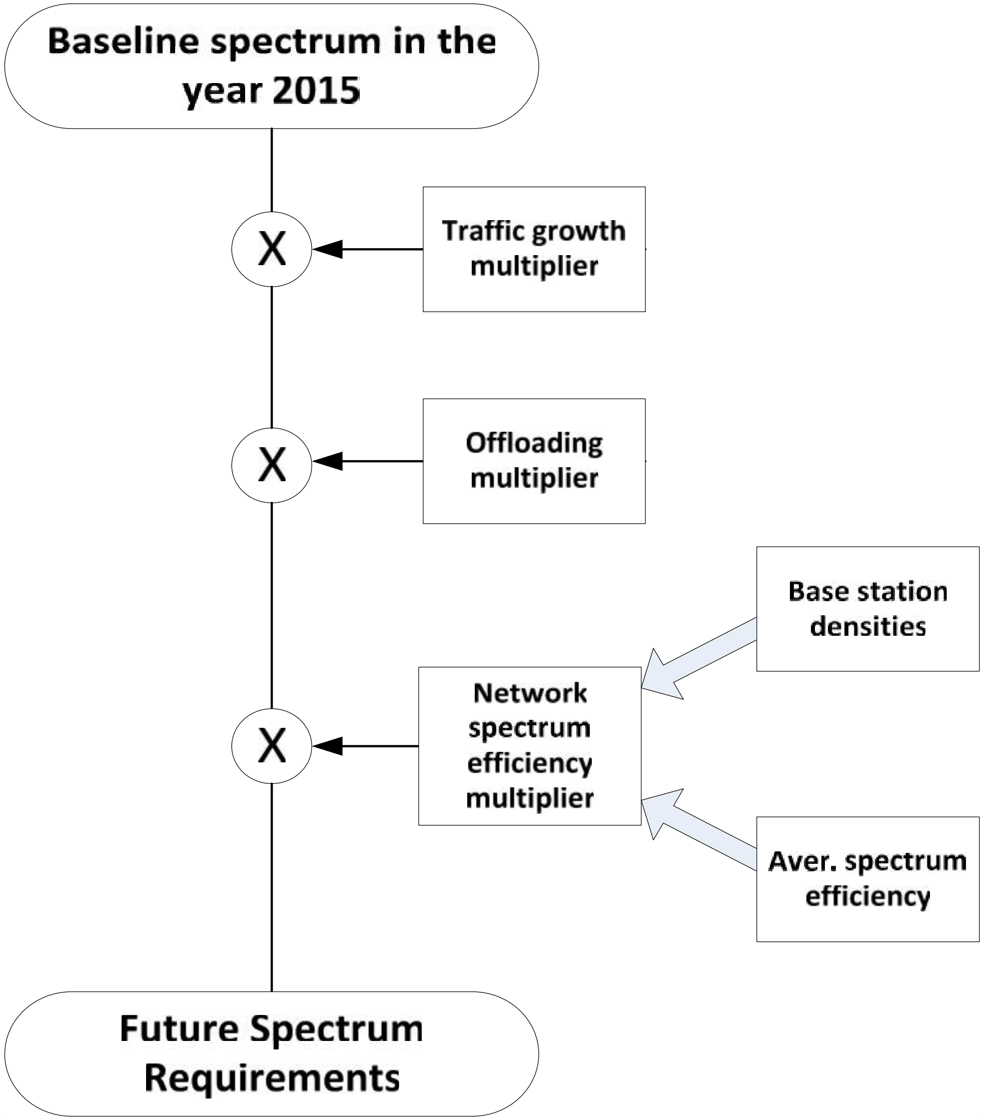
Source: ITU – Based on data form 158 countries

Scenario

- **Geographically small country with relatively reasonable population density and diversity**
- **2 operator market**
- **Year of Making forecast : 2015**
- **AIM**

Forecasting national Spectrum requirements for Cellular mobile industry until 2025

Methodology



Parameters

- **Baseline year spectrum supply (S_{2014})**
  - 900 MHz (2x10 MHz for GSM900),
  - 1 800 MHz (2x20 MHz for LTE1800)
  - 2 100 MHz (2x40 MHz for UMTS2100)
  - **Total utilized bandwidth** S_{2014}=140 MHz

Assumptions 1/3

Traffic growth assumptions ($N_{traffic}$)

- For traffic growth assumption the Report ITU-R M.2243 and UMTS Forum traffic forecast for the period between 2010 and 2020 are used.
- Traffic will increase 33 times or something around 40% growth annually.
- **Note**: Some APT countries demonstrate much higher annual traffic growth. E.g. according to the Report ITU-R M.2243 Japan showed the increase ratio of 64% in 2010

Assumptions 2/3

Offloading factor assumption ($N_{offloading}$)

- IEEE 802.11 standards wireless technology are used for traffic offload. The Report ITU-R M.2243 mentions 20% of traffic offloading on Wi-Fiwhich is also used in this analysis. Accordingly the offloading multiplier is set 0.9.

Network spectrum efficiency (N_{NSE}) bps/Hz/cell

- It is the integral measure of the networks capacity increase, which incorporates base stations density growth and average spectrum efficiency increase in the future.

Spectrum Efficiency, DL			
GSM	UMTS	LTE	LTE-A
0.3	0.68	1.3	2.6

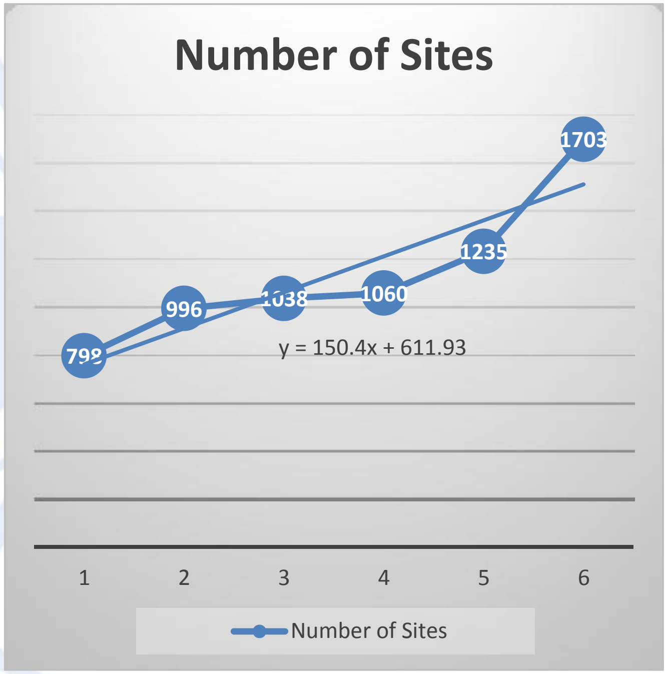
Based on data from:

- Data Capabilities: GPRS to HSDPA and Beyond. Rysavy Research, 2005.
- 4G Capacity Gains.Real Wireless Ltd., 2011.

Assumptions 3/3

Network Infrastructure growth

Network Operator	Technology	Years					
		2009	2010	2011	2012	2013	2014
A	3G		127	169	171	251	494
	LTE					95	310
	GSM	641	641	641	661	661	671
B	3G	157	228	228	228	228	228
Total site number		798	996	1038	1060	1235	1703



National Network Infrastructure growth = 14.45% approx.

Results

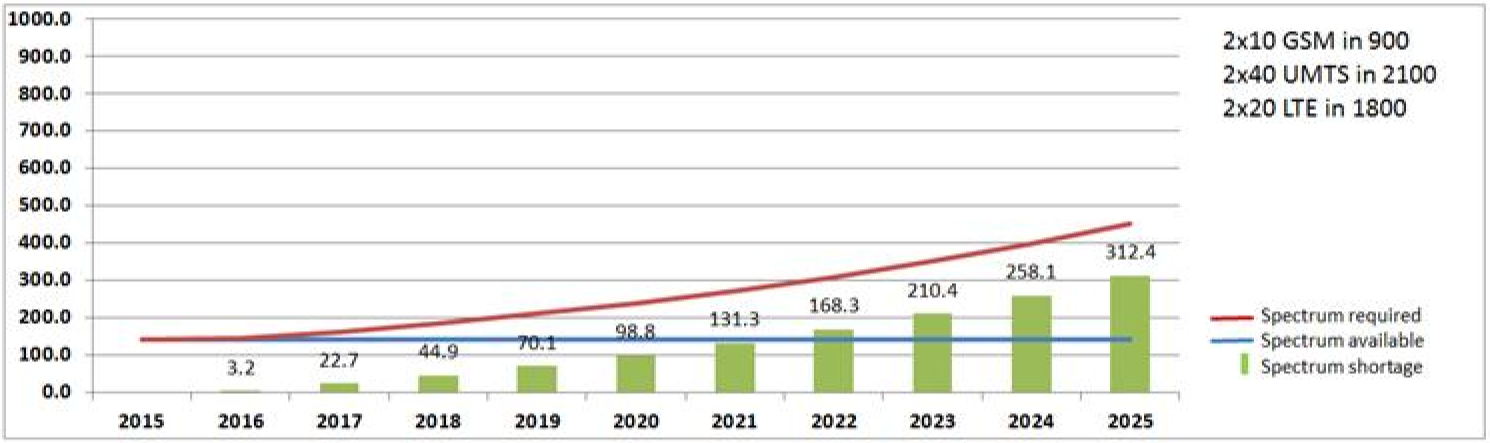


Figure 3.12 NG – 10% annually, TG – 25% annually. No technology changes. No new spectrum.

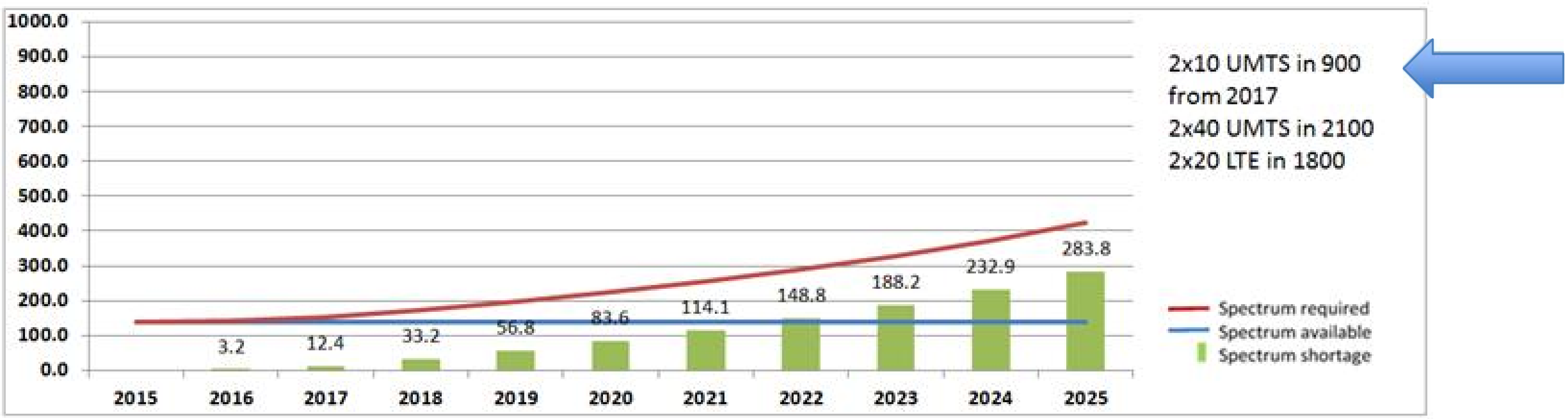


Figure 3.13 NG – 10% annually, TG – 25% annually. GSM900 converted to UMTS900 in 2017. No new spectrum.

Results

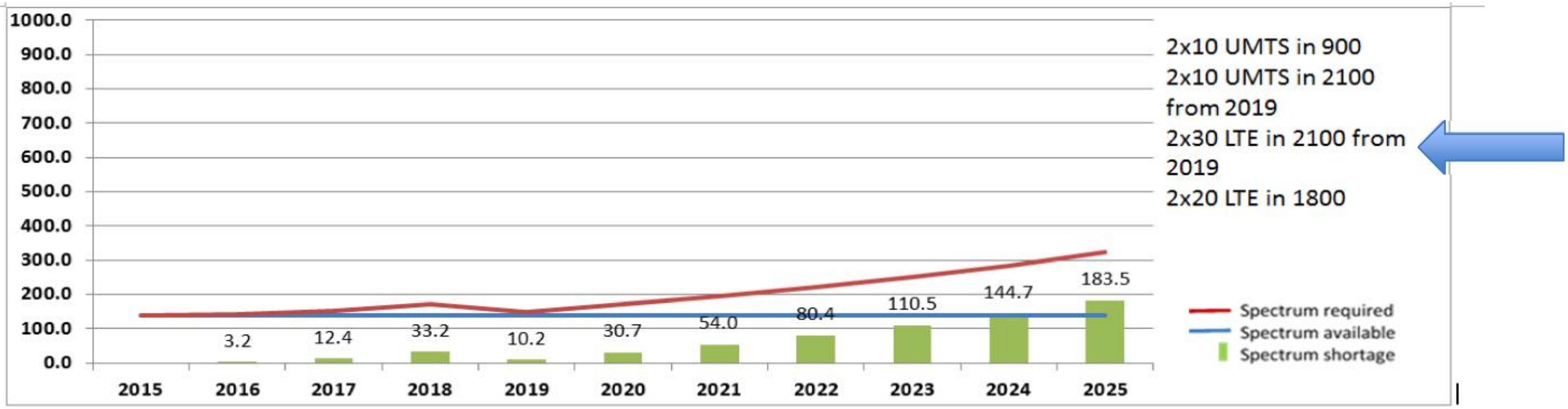


Figure 3.14 NG – 10% annually, TG – 25% annually. 2x30 MHz converted to LTE2100 in 2019. No new spectrum.

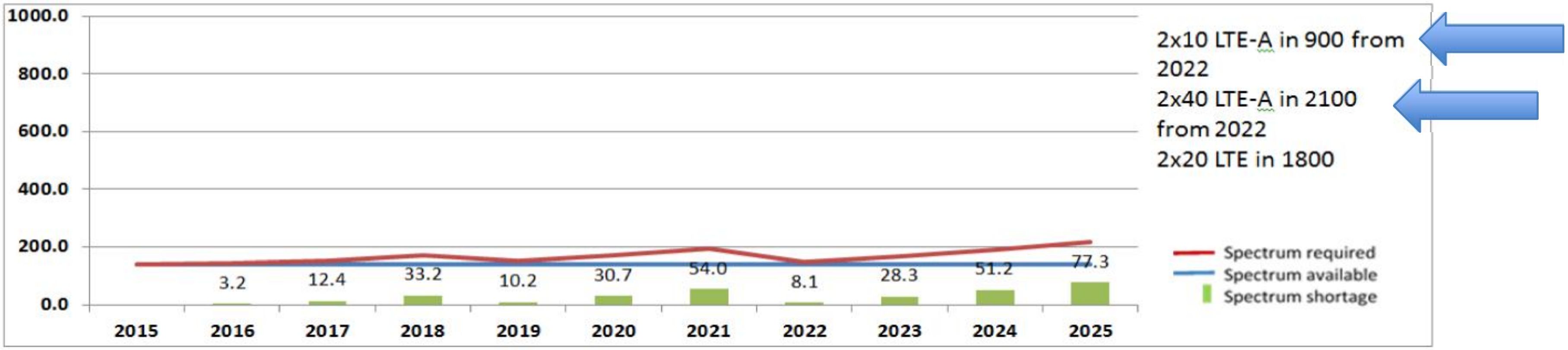


Figure 3.15 NG – 10% annually, TG – 25% annually. 2x10 MHz converted to LTE-A in 900 from 2022. 2x40 MHz converted to LTE-A in 2100 from 2022. No new spectrum.

Results

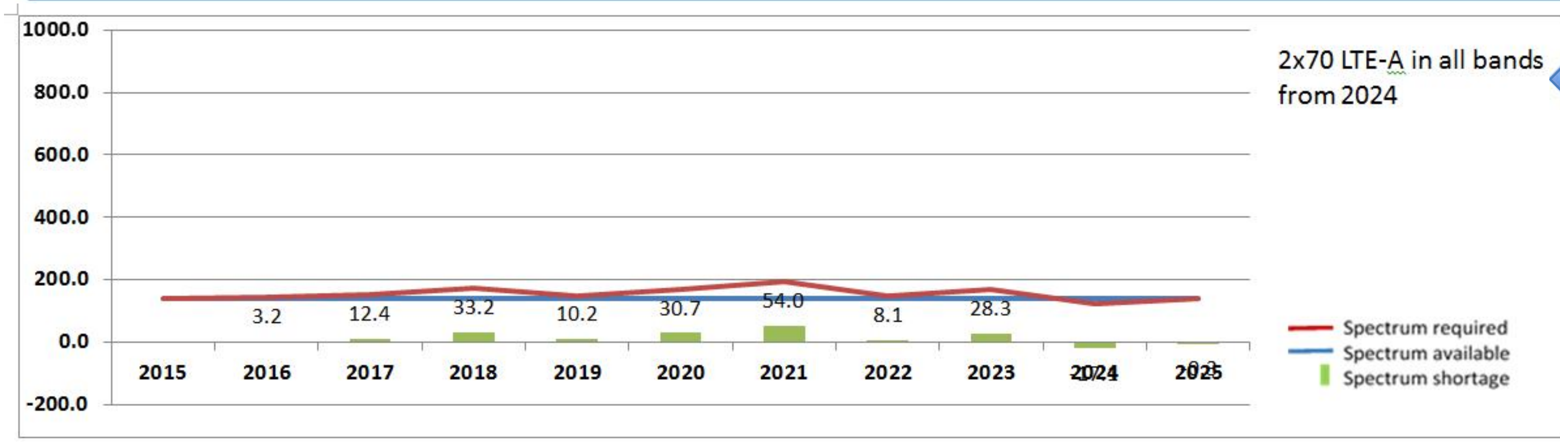


Figure 3.16 NG – 10% annually, TG – 25% annually. 2x70 MHz used for LTE-A in all bands from 2024. No new spectrum.

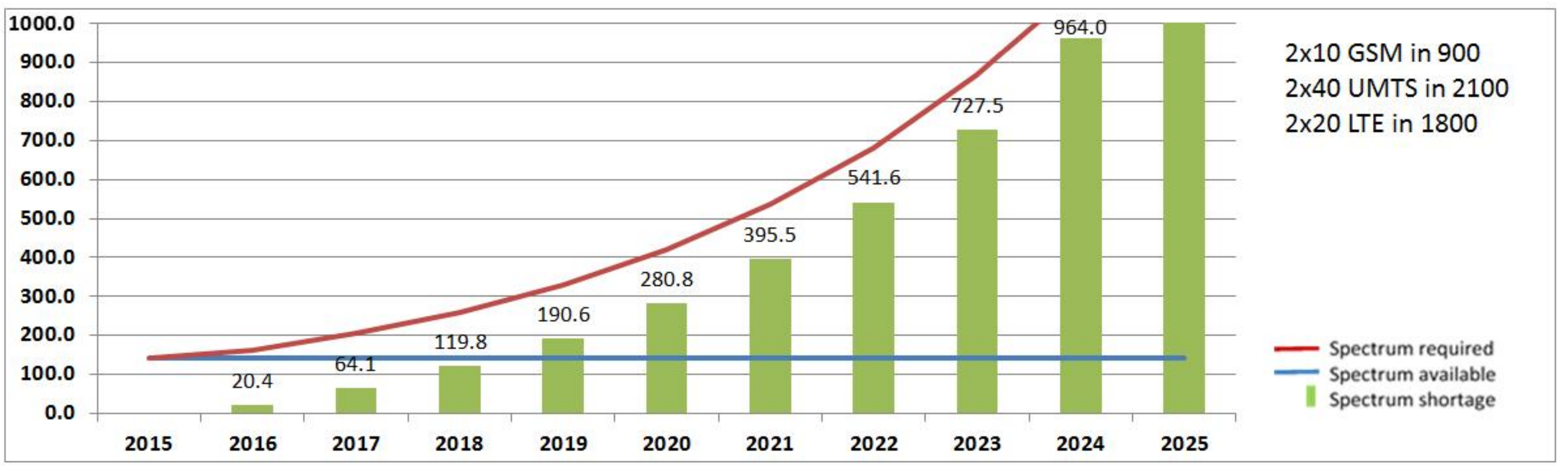


Figure 3.17 NG – 10% annually, TG – 40% annually. No technology changes. No new spectrum.

Results

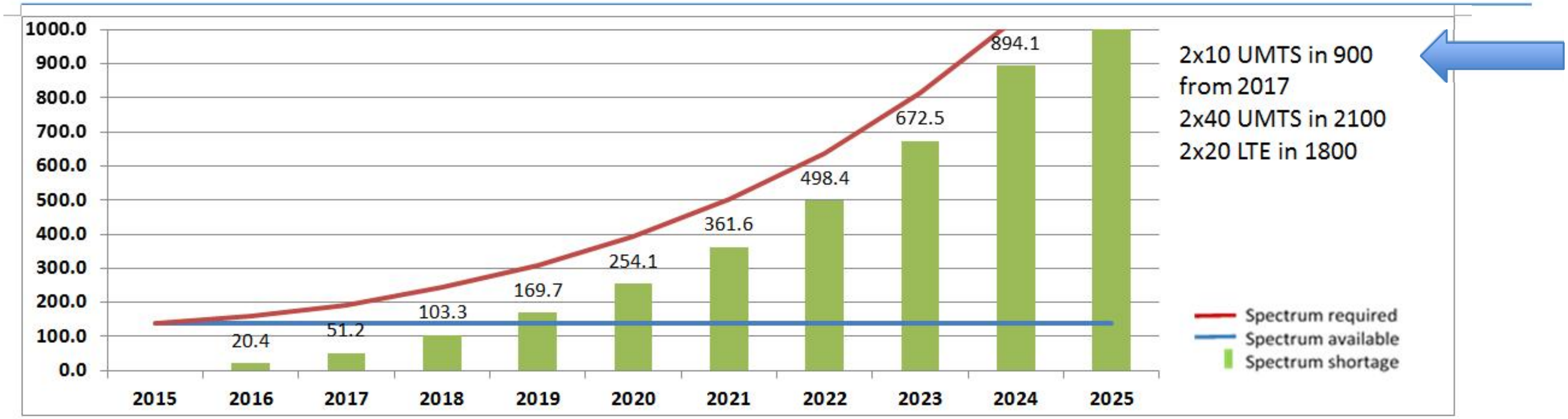


Figure 3.18 NG – 10% annually, TG – 40% annually. GSM900 converted to UMTS900 in 2017. No new spectrum.

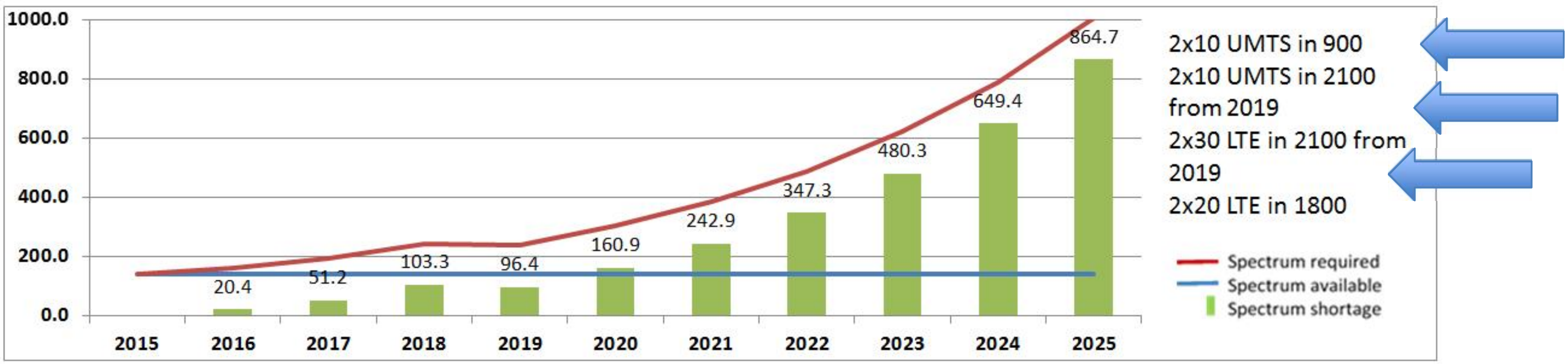


Figure 3.19 NG – 10% annually, TG – 40% annually. 2x30 MHz converted to LTE2100 from 2019. No new spectrum.

Results

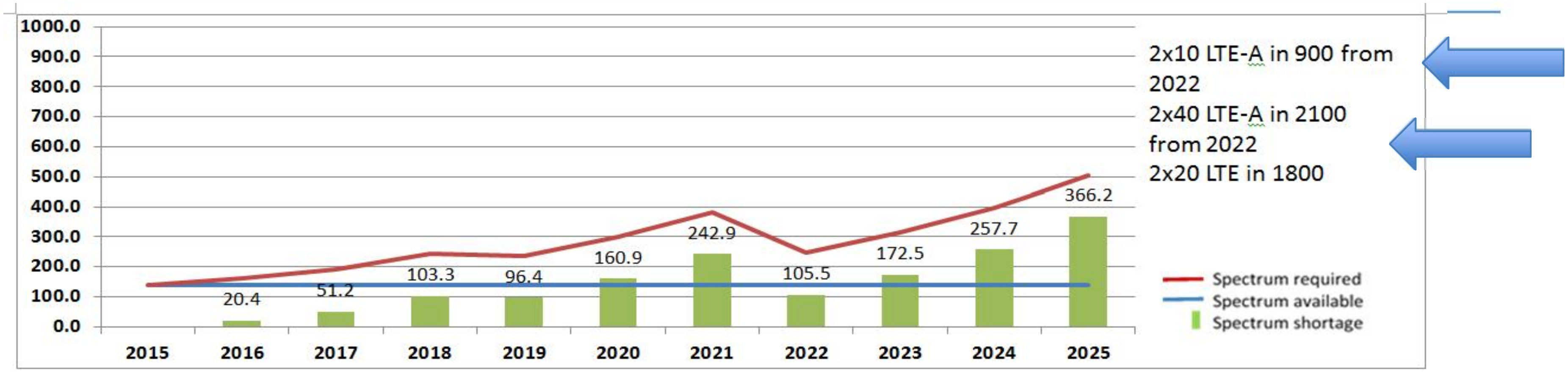


Figure 3.20 NG – 10% annually, TG – 40% annually. 2x10 MHz converted to LTE-A in 900 from 2022. 2x40 MHz converted to LTE-A in 2100 from 2022. No new spectrum.

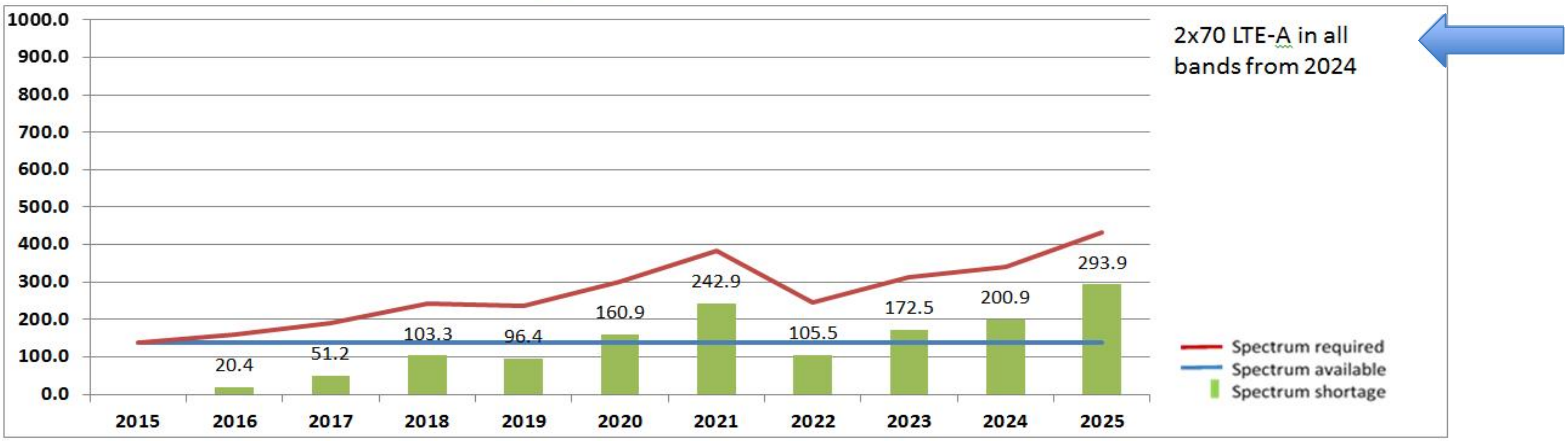


Figure 3.21 NG – 10% annually, TG – 40% annually. 2x70 MHz used for LTE-A in all bands from 2024. No new spectrum.

Need to identify more spectrum

How to publish and implement the forecast

- **Publishing:** *Different Approaches*
  - Spectrum Policy
  - Spectrum outlook
  - Telecommunication market sector outlook
  - Spectrum master-plan

- **Implementation:** *set of feasible action plans on*
  - Consultation with Stakeholder
  - New Band Plans and re-farming
  - Spectrum Demand and Supply Studies
  - Licensing Requirements
  - Monitoring and Enforcement

I Thank U

"Committed to connecting the WORLD"

Major ITU SM Global Events in 2015

ITU-D Study Group Meeting (Res. 9)
14 – 18 September 2015,
Geneva, Switzerland

World Radio-communication Conference
2 – 27 November 2015,
Geneva Switzerland

Your active participation in and contribution to these events is most welcome!