# 5G Spectrum
# &
# Regulatory Policies

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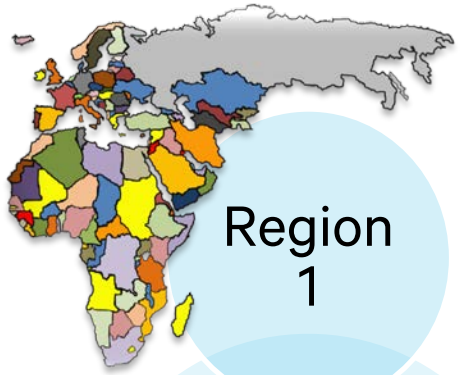
# Outline

- 5G Spectrum Availability
  - Harmonizing Bands
- 5G Spectrum Management
  - Minimizing Interference
  - Maximizing Usage
- 5G Spectrum Affordability
  - Optimizing Price
  - Minimizing Distortions

# 5G Spectrum : Harmonization

**ITU Bands (Set 1)**
- 24.25 - 27.5 GHz
- 31.8 - 33.4 GHz
- 37.0 - 43.5 GHz
- 45.5 - 50.2 GHz
- 50.4 - 52.6 GHz
- 66.0 - 76.0 GHz
- 81.0 - 86.0 GHz



- 3.4- 3.8 GHz
- 5.9 - 6.4 GHz
- 24.25 - 27.5 GHz

Region 1

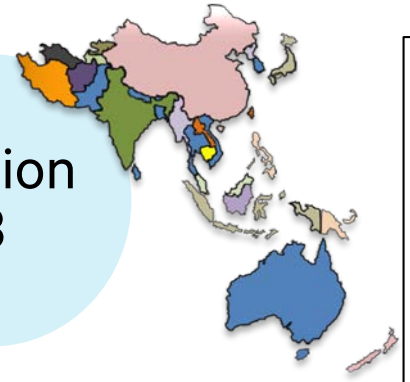
**Other Bands (Set 2)**
- 600 MHz
- 2.5 GHz
- 3.3 - 4.2 GHz
- 26.5 - 29.5 GHz

Global Harmonization

- 600 MHz
- 2.5 GHz
- 3.4- 3.6 GHz
- 3.6 - 4.2 GHz
- 5.9 - 7.1 GHz
- 24.25 - 27.5 GHz
- 27.5 - 29.5 GHz
- 37.6 - 40 GHz
- 64 - 71 GHz

Region 2

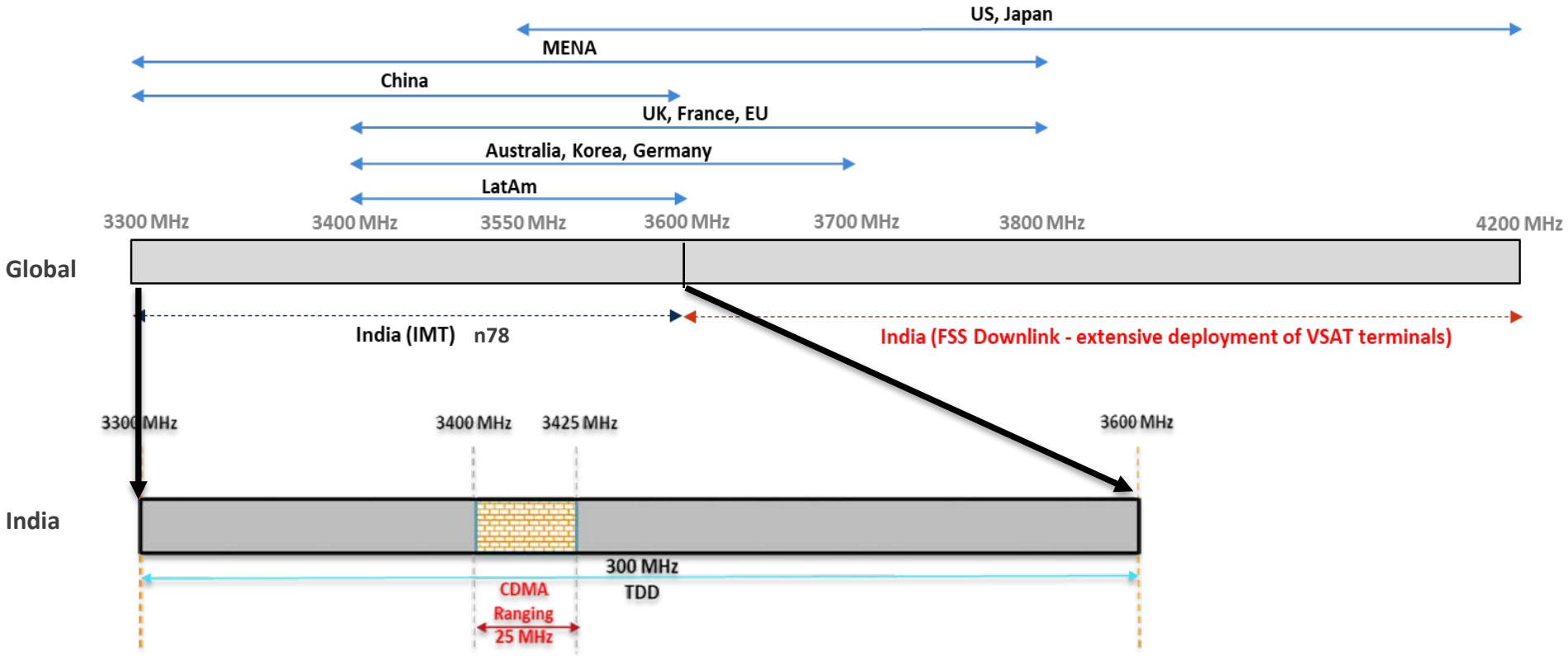
Region 3



- 600 MHz
- 3.3 - 3.6 GHz
- 3.6 - 4.2 GHz
- 4.4 - 4.9 GHz
- 4.8 - 5.0 GHz
- 24.25 - 27.5 GHz
- 27.5 - 29.5 GHz
- 37 - 42.5 GHz

5G Bands Harmonized Globally Are Key for India

# 5G Spectrum : 3.5 GHz

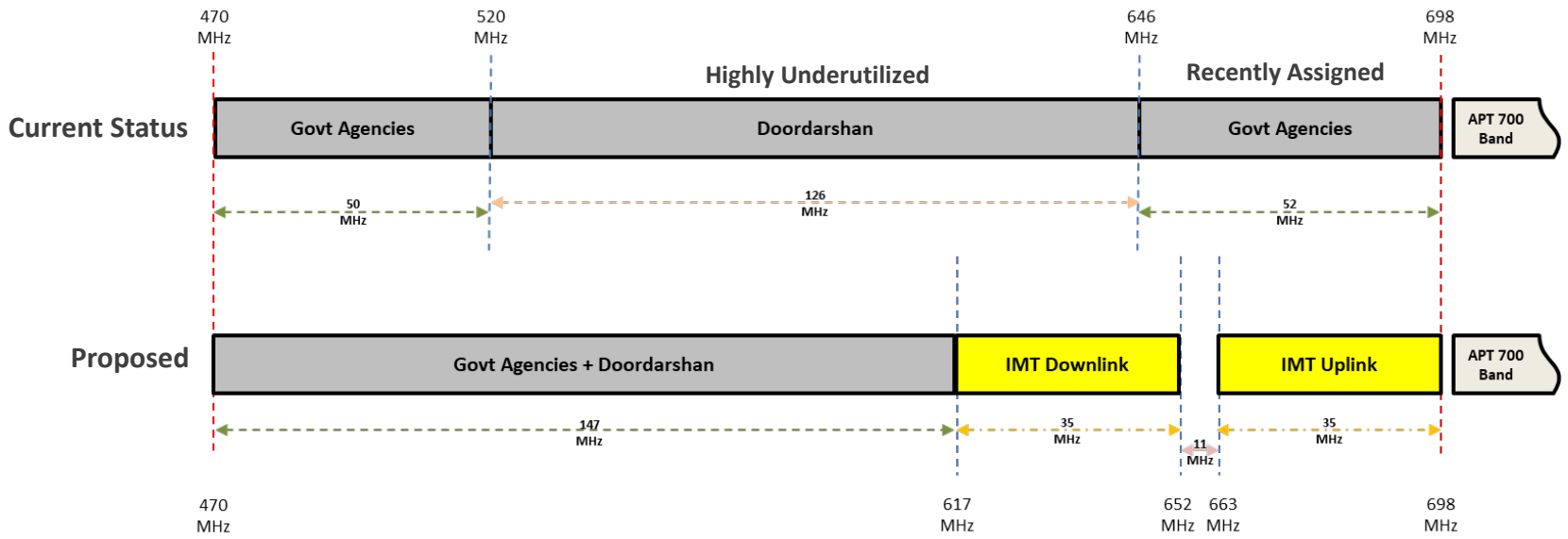



| Global Status : 3.5 GHz | |
|---|---|
| **Region 1** | |
| ➢ UK | - Identified |
| ➢ France | - Identified |
| ➢ Italy | - Identified |
| ➢ Germany | - Identified |
| ➢ EU | - Identified |
| ➢ MENA | - Identified |
| **Region 2** | |
| ➢ US | - Identified |
| ➢ LatAm | - Identified |
| **Region 3** | |
| ➢ China | - Identified |
| ➢ Japan | - Identified |
| ➢ Korea | - Being Auctioned |
| ➢ Australia | - Identified |

- 25 MHz reserved for CDMA Ranging of IRNSS
- Max 17 CDMA Ranging locations
- Exclusion zones to manage interference
- Entire 300 MHz to be used in all other geographies

Total 300 MHz can be Enabled for 5G Services

# 5G Spectrum : 600 MHz




| Global Status : 600 MHz | |
|---|---|
| **Region 1** | |
| ➢ Nil | |
| **Region 2** | |
| ➢ US | - Auctioned |
| ➢ Canada | - Being Auctioned |
| **Region 3** | |
| ➢ NZL | - Being Auctioned |

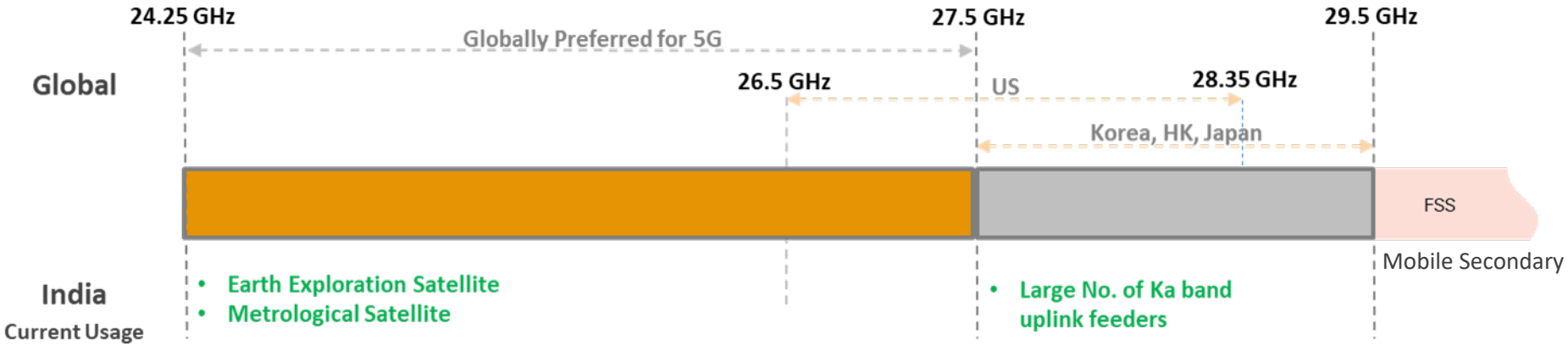
**Note : 600 MHz band identification in next WRC cycle**

Actions Needed

- Adjust Doordarshan and Other Government Agencies within 470-617 MHz
  - Doordarshan can optimize spectrum through digitization
- Adopt Band 71 (n71) plan between 617-698 MHz for 5G
  - FDD (Reverse Duplex) to prevent interference with 700 MHz band

Total 2x35 MHz can be Enabled for 5 GHz Services

# 5G Spectrum : Millimeter Waves




| Global Status : Millimeter Waves | |
|---|---|
| **Region 1** | |
| ➢ UK | - Identified |
| ➢ France | - Identified |
| ➢ Sweden | - Identified |
| ➢ Italy | - Identified |
| ➢ Germany | - Identified |
| ➢ EU | - Identified |
| ➢ MENA | - Identified |
| **Region 2** | |
| ➢ US | - Identified |
| ➢ Canada | - Identified |
| ➢ Brazil | - Identified |
| ➢ LatAm | - Identified |
| **Region 3** | |
| ➢ China | - Identified |
| ➢ Japan | - Identified |
| ➢ Korea | - Being Auctioned |
| ➢ Australia | - Identified |
| ➢ HK | - Identified |

**24.25 - 27.5 GHz**

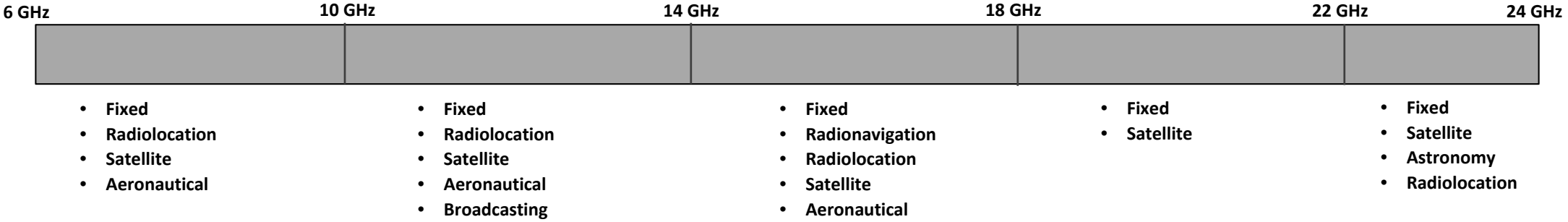
- 5G and EESS can Co-Exist
  - DoS is not seeking any protection for EESS

**27.5 - 29.5 GHz**

- 5G and Ka Band Uplink can Co-Exist
  - 5G Services will not interfere with uplink stations

Immediate Studies Need to be done to Ensure Coexistence

# 6 to 24 GHz : Why It Has Been Left Out?




- Primarily identified for fixed/radars/aeronautical and satellite services
- Extensively used in India for satellite services and backhaul links

6 to 24 GHz Has Not Been Identified by ITU for Deploying 5G Services

# 5G Spectrum : Management Issues

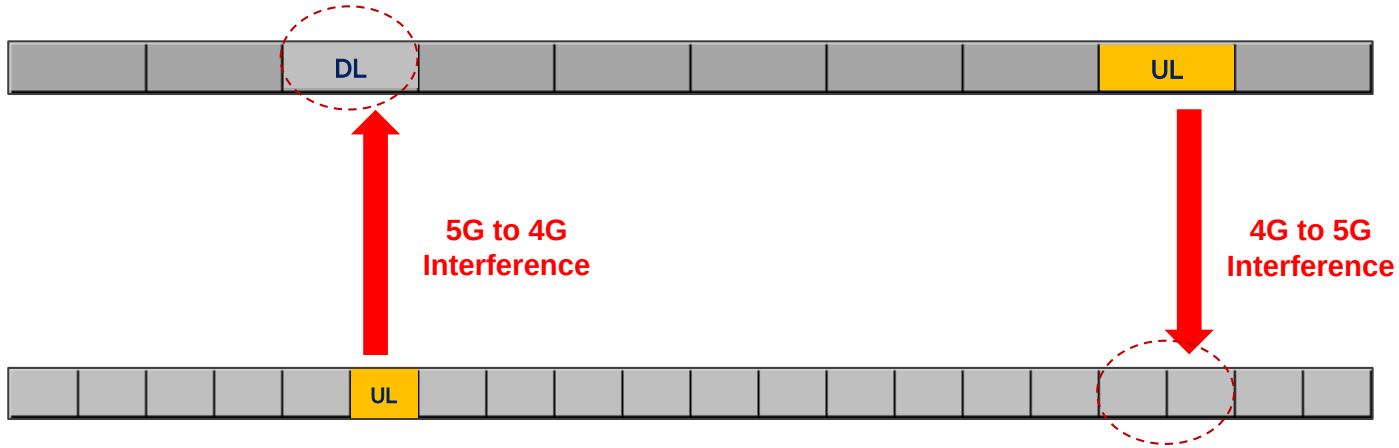
- FDD assignment for lower spectrum bands
  - Will ensure interference free operations
  - Will maximize spectrum usage efficiency
  - Will enable Circle level assignment
- TDD assignment only for higher frequency bands
  - Avoid multiple technology deployment in same band
    - Else will need guard bands for prevent interference
  - Assign spectrum in larger blocks
    - Else will fragment spectrum and reduce efficiency
  - Avoid Circlewise Assignment
    - Else will cause Cross Border Interference

Spectrum Assignment Reforms Must for Successful 5G Implementation

# 5G TDD : Why Avoid Deploying 4G Adjacent to 5G?

4G TDD Frame : 10 ms
4G Slot : 1 ms

5G TDD Frame : 10 ms
5G Slot : 0.5 ms

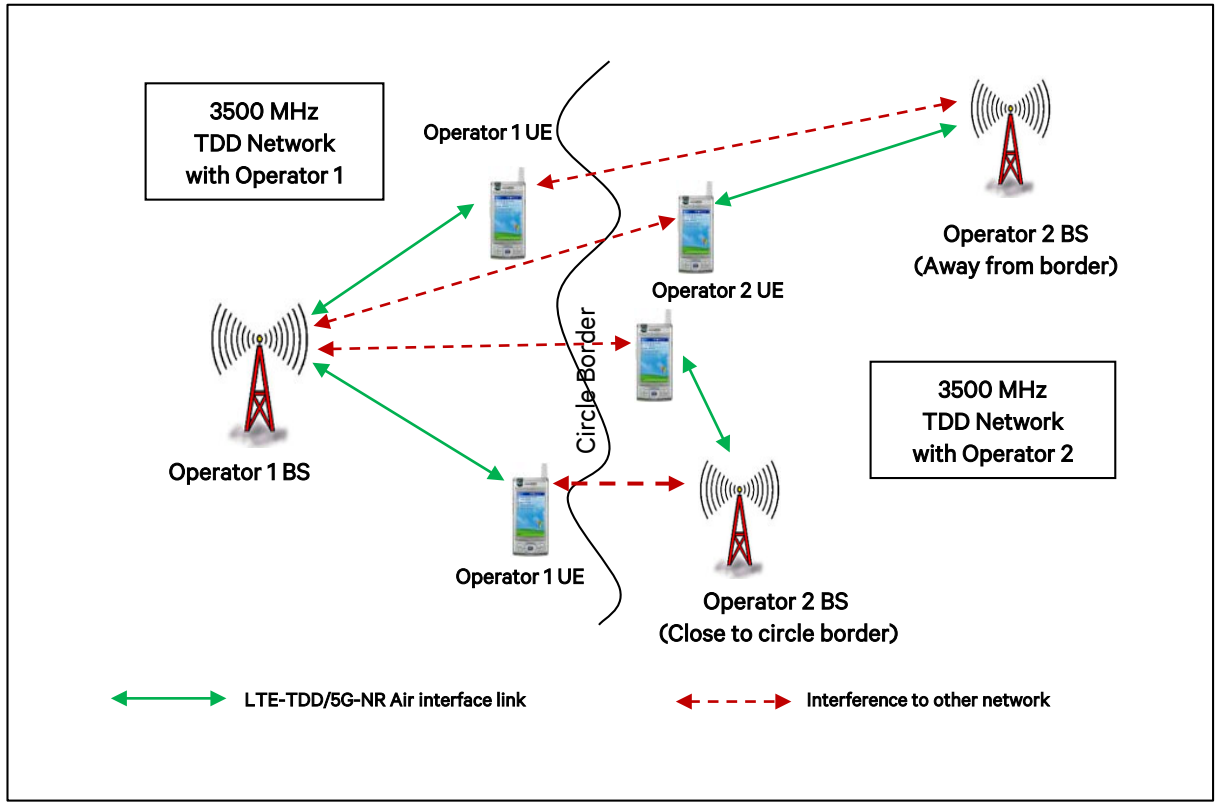



- **Coexistence of 4G and 5G will cause interference**
  - Timing Sync does not help
  - DL & UL Slots always overlap
- **Coexistence of 5G carriers can be managed**
  - Timing Synchronization
  - Same DL-UL Config Index

Guard Band is Must Between Two Adjacent Blocks of 4G & 5G

# 5G TDD : Why RF Signals Interfere Across Borders?

## Same TDD spectrum slot allocated to different operators across circles



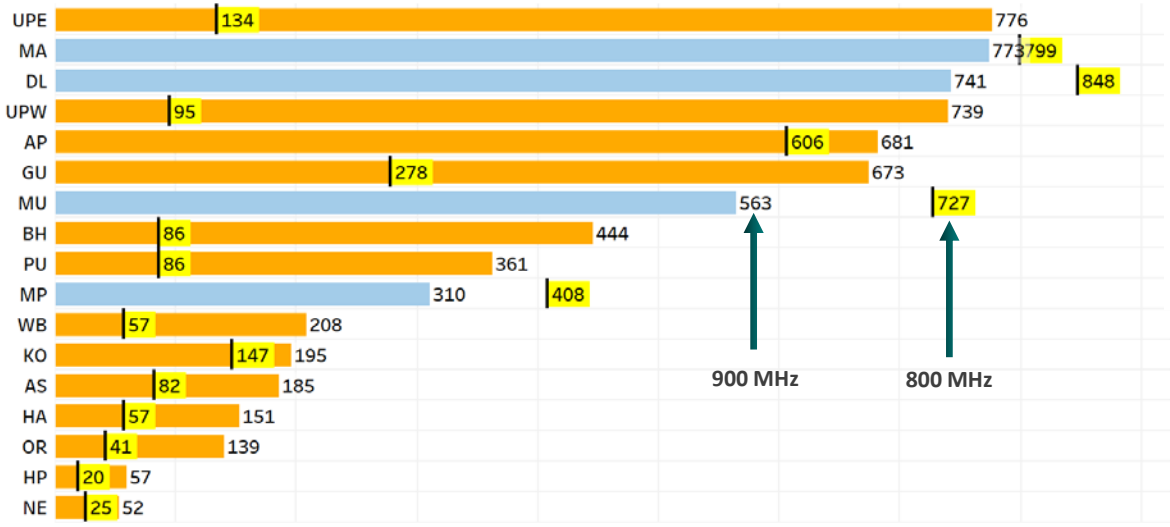

- Managing interference is difficult
  - Down tilting antenna will mitigate interference for operator 2 at the cost of coverage of operator 1
  - Handovers across borders between operator 1 and 2 will be difficult to manage
  - Severe near-far effect issues at borders
  - Unusual distant propagation from elevated Base Stations
  - Severe in band interference near circle borders

5G Spectrum in 3.5 GHz Band Should be Assigned Nation Wide

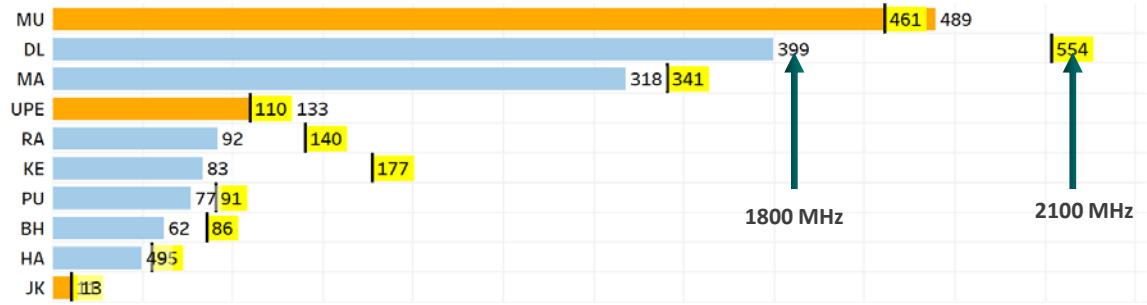
# Auction : Past Experience

Price are in Rs Cr/MHz

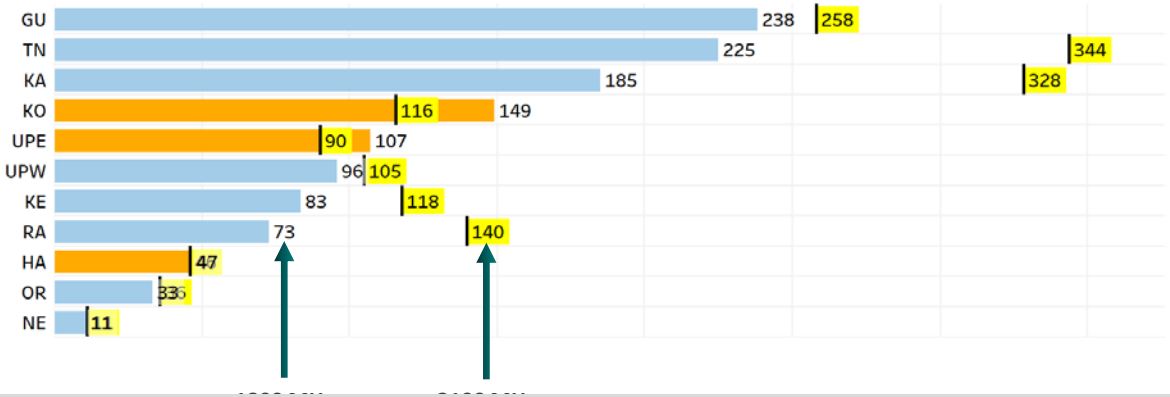
900 vs 800 (Auction Year - 2014 & 2015)



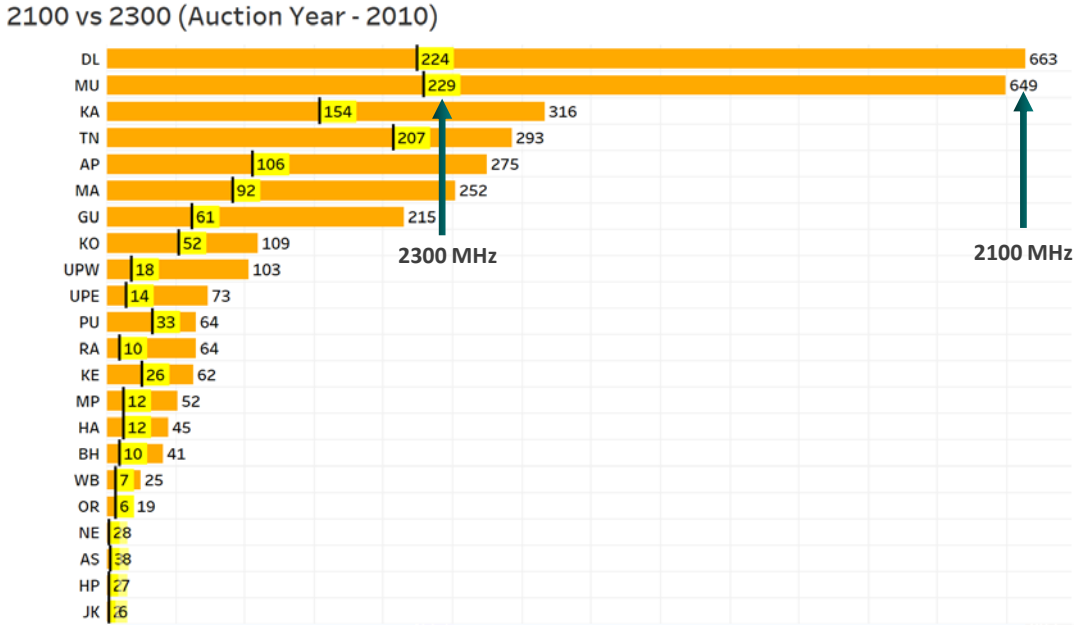

1800 vs 2100 (Auction Year - 2016)




1800 vs 2100 (Auction Year - 2015)

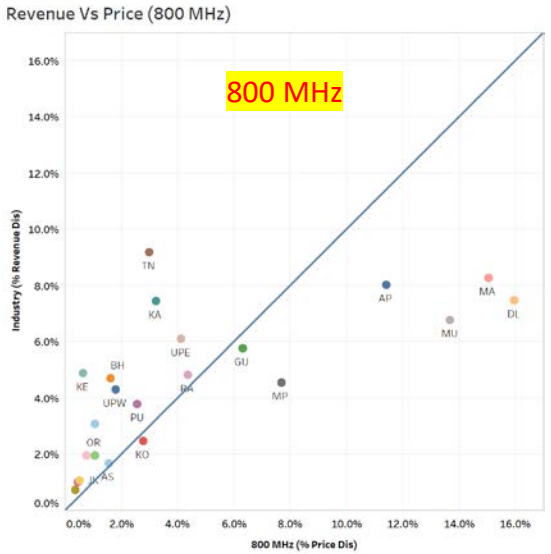



2100 vs 2300 (Auction Year - 2010)

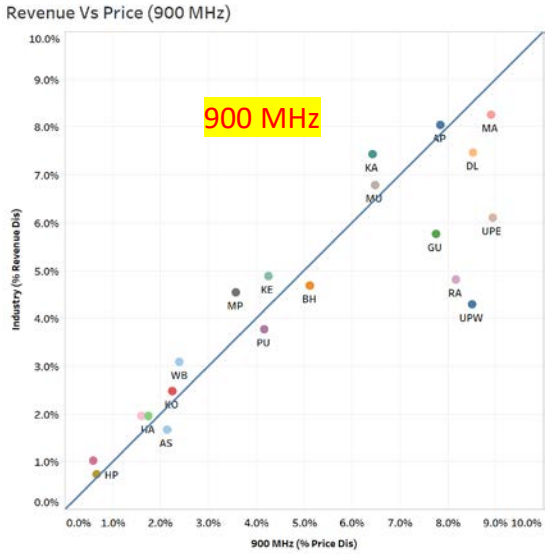


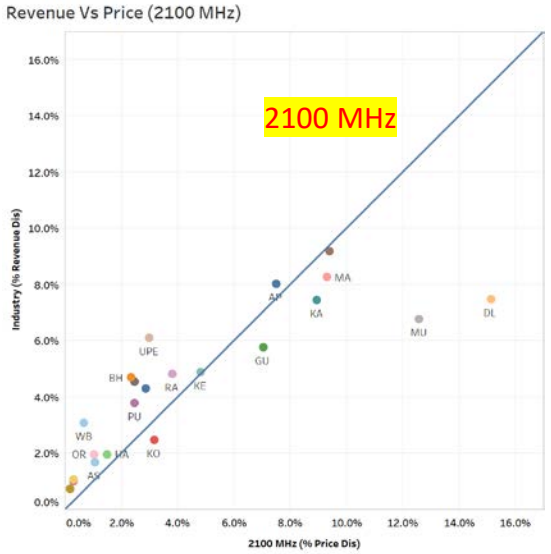

Similar Bands Priced Dissimilarly

# Auction : Past Experience








Similar Circles Price Dissimilarly

# New Pricing Model : Basic Principle

- Input to the pricing model should be unambiguous
  - **Ambiguous** input is **hard to quantify** administratively
  - **Unambiguous** inputs will make the **process robust**
  - **Unambiguous** inputs will **remove** element of **discretion**
- Input to the pricing model should act as feedback
  - **Feedback** will prevent **distortions** percolating in **future auctions**
  - **Feedback** will promote **responsible bidding**
- Input to the pricing model should be integrative
  - **Integrative** model will **prevent distortion** across **bands**
  - **Integrative** model will **prevent distortion** across **circles**

In Nutshell, the model should promote **transparency**, **consistency** and **predictability**

# The Model : Calculating Reserve Price

**Input 1**

| Price Index (2010 As Reference) | |
|---|---|
| Year | Factor |
| 2010 | 1.00 |
| 2011 | 1.10 |
| 2012 | 1.20 |
| 2013 | 1.32 |
| 2014 | 1.44 |
| 2015 | 1.52 |
| 2016 | 1.58 |

**Input 2**

| Band Index (800 MHz As Reference) | |
|---|---|
| Band | Weights |
| 700 | 1.15 |
| 800 | 1.00 |
| 900 | 0.92 |
| 1800 | 0.48 |
| 2100 | 0.43 |
| 2300 | 0.35 |
| 2500 | 0.32 |

**Input 3**

Past Auction Prices for all Circles & Years

**Input 4**

| Total Industry Revenue % Distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LSA | AP | AS | BH | DL | GU | HA | HP | JK | KA | KE | KO |
| Rev % | 8.0% | 1.7% | 4.7% | 7.5% | 5.8% | 2.0% | 0.7% | 1.1% | 7.4% | 4.9% | 2.5% |
| LSA | MA | MP | MU | NE | OR | PU | RA | TN | UPE | UPW | WB |
| Rev % | 8.3% | 4.5% | 6.8% | 1.0% | 2.0% | 3.8% | 4.8% | 9.2% | 6.1% | 4.3% | 3.1% |

## Calculation Model

Step 1 : **Readjust** Past **Auction Prices** with **Cost Inflation** Numbers

Step 2 : **Readjust** Past **Auction Prices** with **Band Index** Numbers

Step 3: **Calculate Average** Price Across Circles for all Auction & Years

Step 4: **Add** these **Averages** to Arrive at a **Single "Pan India"** Number

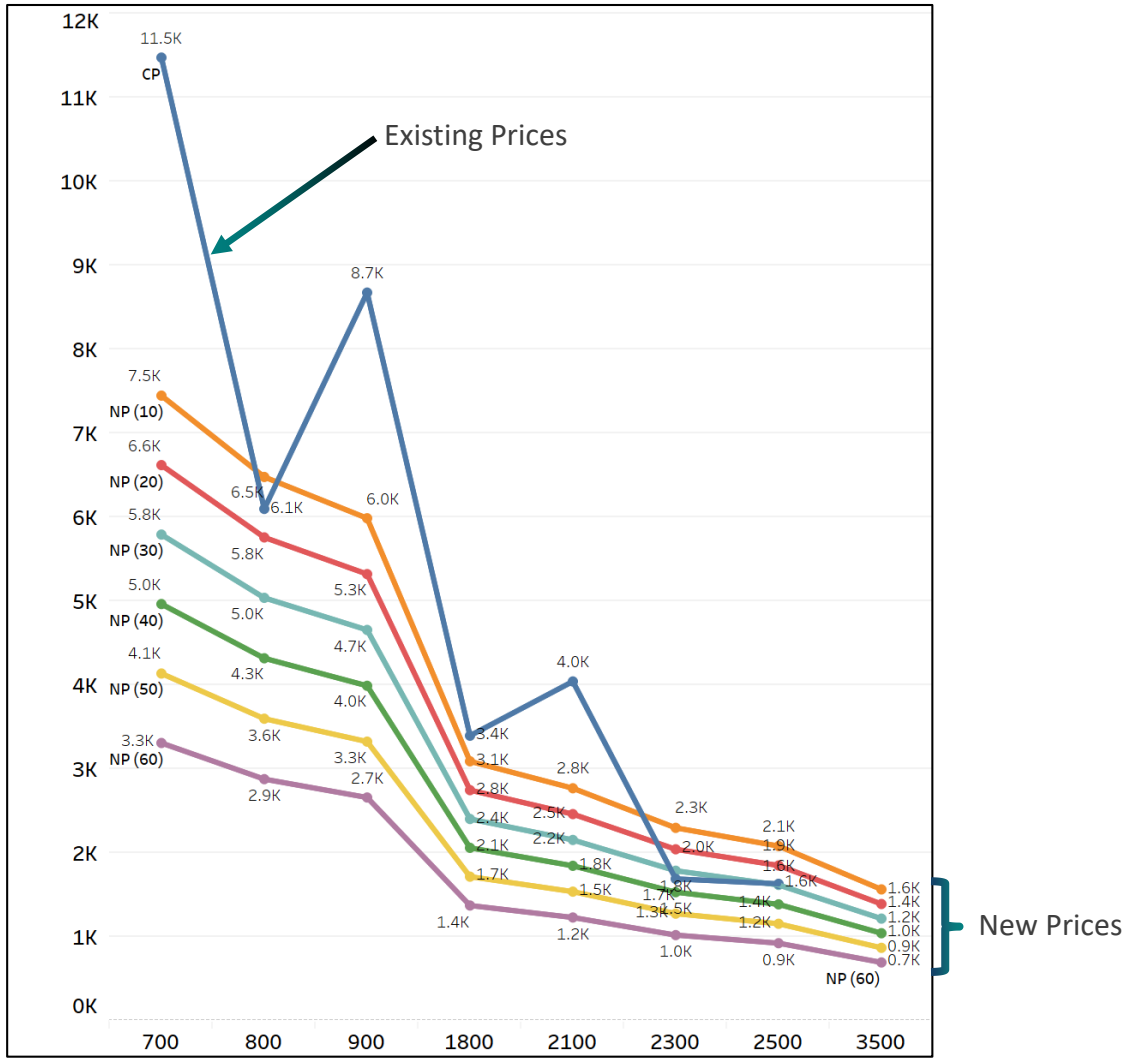
Step 5: **Multiple above** with **Revenue Weights** to arrive at circle values

Step 6: **Readjust** Above for **Individual Bands** with Band Index Numbers

Step 7: **Reduce** the Number Above by **50%** to Arrive at **Reserve Price**

Prices will get automatically curated for distortions

# Reserve Prices : Calculated With New Model




| New Reserve Price vs Old Price (50% Discount) | | | | |
|---|---|---|---|---|
| Band | AP/RP (Rs Cr) | New RP (Rs Cr) | % Change | Type |
| 700 MHz | 11485 | 4141 | -64% | Decrease |
| 800 MHz | 6104 | 3603 | -41% | Decrease |
| 900 MHz | 8683 | 3329 | -62% | Decrease |
| 1800 MHz | 3400 | 1719 | -49% | Decrease |
| 2100 MHz | 4047 | 1541 | -62% | Decrease |
| 2300 MHz | 1693 | 1279 | -24% | Decrease |
| 2500 MHz | 1634 | 1158 | -29% | Decrease |
| 3500 MHz | | 871 | | |

## The New Model Will

- Prevent **bidding distortion** percolating into future auctions
- Prevent **irresponsible bidding** by penalizing speculative actions
- Prevent **volatility** in auction prices and make it more predictable
- Prevent **moral hazard** resulting out of drastic corrections in prices
- Prevent **undue competitive advantage** to a few players
- Prevent **randomness** of auction prices across bands and circles
- Prevent **accusation** by audit agencies on bureaucratic actions

Prices will get automatically curated across bands

# Summary

- 5G Spectrum Availability
  - Align Spectrum Globally
  - Refarm Spectrum
  - Do Co-existence Studies
- 5G Spectrum Management
  - FDD Assignments : < 1 GHz
  - TDD Assignments : Higher Frequency Bands
  - Min Block Size : 50 MHz (TDD)
  - Mixed Band usages : Avoid in TDD
  - Assign on Pan-India Basis : Must in TDD
- 5G Spectrum Affordability
  - Unambiguous Pricing Model

# Thank You