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# Capex Planning with and without Additional Spectrum

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***Abstract*****—**This analysis focuses on defining the spectrum evaluation model for telecom operators in terms of total cost of ownership (TCO). A quantitative approach for specific case analysis research methodology was used for identifying the results. Specific input parameters like target User experience, year on year traffic growth, capacity site limit per year, target additional spectrum type, bandwidth, spectrum efficiency, User equipment (UE) penetration have been used for the spectrum evaluation process and desired outputs in terms of the number of sites, capex in USD and required spectrum bandwidth have been calculated. Furthermore, this study gives a comparison of capex investment for target growth with and without addition spectrum. As a result, the combination of additional spectrum bands of 700 and 2600 MHz has a better evaluation in terms of TCO and performance. It is our recommendation to use these bands for expansion rather than expansion in the current 1800 and 2100 bands.

***Keywords*****—**Spectrum, capex planning, case study methodology, TCO, total cost of ownership.

## I. Introduction

TELECOM operators have high capex investment year on year. This investment is determined by company's growth, regulatory requirement, customer demand and business driven value. In this study, requirement of capex to increase capacity had identified for different scenarios like with and without additional spectrum case. A model has been devised based on current practice to identify the required capex. Objective of this study are defining spectrum evaluation model along with input and output parameters and identify the required capex with and without additional spectrum. Total cost of model was use in this model which is better than public domain model like ITUR and GSMA model. Besides this, telecom vendor specific models are use in specific case like Coleago model [1].

## II. Spectrum Evaluation

Best TCO is result of combination of optimum number of capacity sites and additional spectrum. TOC Model has upgrade ladder, which assumes additional spectrum to be added or capacity sites to be added after reaching highest ladder configuration with existing spectrum. It evaluates for a given user experience as input. Spectrum decision is based on TCO evaluation of different scenarios of spectrum addition and capacity sites combination.

Mobile network operators (MNO) use comparison-based, utilization-based and TCO-based evaluation models. TCO-based evaluation model details are illustrated in Fig. 1. The major comparison of Comparison, Utilization and TCO based model has listed in Table I.

The study focuses on TCO based model which helps MNO to assess the spectrum requirement by carefully balancing QoS, existing spectrum utilization, future spectrally efficient technologies and CAPEX unlike other strategies which are limited to only one parameter like Spectrum Portfolio and Spectrum Utilization. In the TCO based model, the basic strategy is to forecast the data consumption volume based on the defined QoS for customers. To deliver the defined QoS, it evaluates the capacity in its existing technology in different spectrum bands as per the MNO configurations. After exhausting the existing capacity, the bifurcation is either to go with new capacity sites or to go for the additional spectrum, both for existing and upcoming technologies. In addition, the model also provides the flexibility to assess the expansion in existing spectrum as per the spectrum availability and regulatory condition. For MNO, TCO based model will be more applicable compared to others as it also helps decide the appropriate spectrum valuation as it compares and analyzes the CAPEX requirement based upon which MNO can prepare its further strategies.

## III. Input and Output Model

Input and output parameters of spectrum evaluation are MNO specific and could be varied based on three different methods of Table I. The major input parameters considered for this method are as Fig. 2.

## IV. Methodology

Quantitative methodology is used for large data sets analysis and case study research technique to use for identifying the capex planning for two scenarios such as with and without additional spectrum. Yearly granularity is used for data volume forecast for 10-year. Specific data set is used for defining parameters as shown in Fig. 2. Mid band 1800 capacity analysis is used for base line for identification of the required number of upgrade cells counts. Country spectrum policy is used to identify the available spectrum for each band.

Linear forecast method is used for identifying daily data volume for ten years in Terabyte units (TB).

Cell capacity is measured as factor of spectrum efficiency. Cell capacity has relationship with user experience which is related with physical radio resource (PRB) utilization.

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TABLE I
SUMMARY OF COMPARISON, UTILIZATION AND TCO METHOD FOR SPECTRUM EVALUATION MODEL

| Type | Comparison | Utilization | TCO |
|---|---|---|---|
| Methodology | Compare against a benchmark Operator from a market with high data/user and high QoS | Calculate based on traffic growth, site growth & spectrum efficiency. | Calculate based on TCO of new sites & upgrades vs TCO of additional spectrum deployment. |
| Assumptions | Each MNO will follow a similar per user data growth pattern to the benchmark operator at its own pace.<br>Data/user/MHz for benchmark operator represents an optimum spectrum efficiency. | An optimum site density exists for the highest utilized areas.<br>Additional spectrum will use once maximum MIMO upgrade had completed.<br>An optimum spectrum efficiency value | Either new sites or additional spectrum can cater for the traffic demand.<br>Additional spectrum or capacity sites will use once maximum MIMO upgrade had completed.<br>There is an optimum combination of capacity sites and spectrum addition that gives the best TCO.<br>TCO of existing spectrum upgrades can be discard since both paths will follow existing ladder upgrade. |
| Metrices used | Data/user/MHz<br>average user throughput. | Traffic growth, Spectrum efficiency, Site growth. | New site, Spectrum Upgrade TCO,<br>Traffic & growth.<br>User experience target. |
| Pros | Simplest model | Good balance of complexity and outcome | Most accurate model |
| Cons | Does not adequately capture OpCo specific requirement and market conditions. | Does not capture impact on different spectrum costs, upgrade costs. | Overly complex and opco specific |

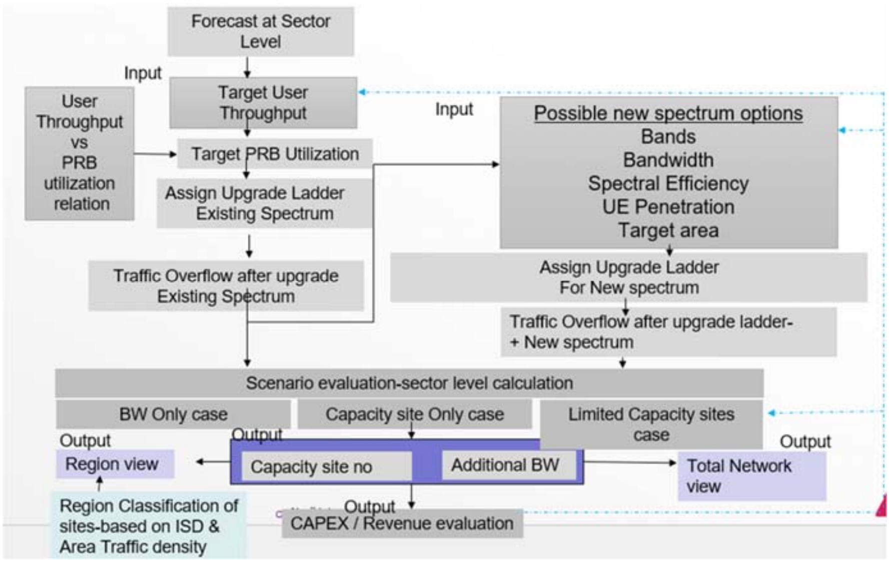


Fig. 1 Spectrum Evaluation flow chart

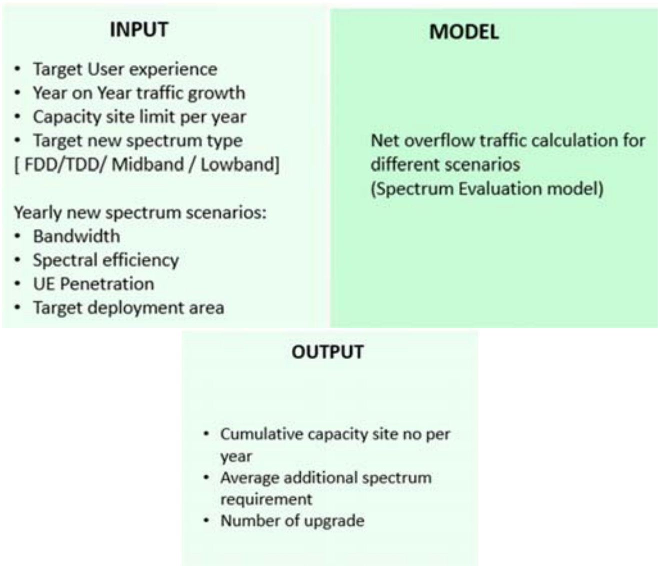


Fig. 2 Input/Output model

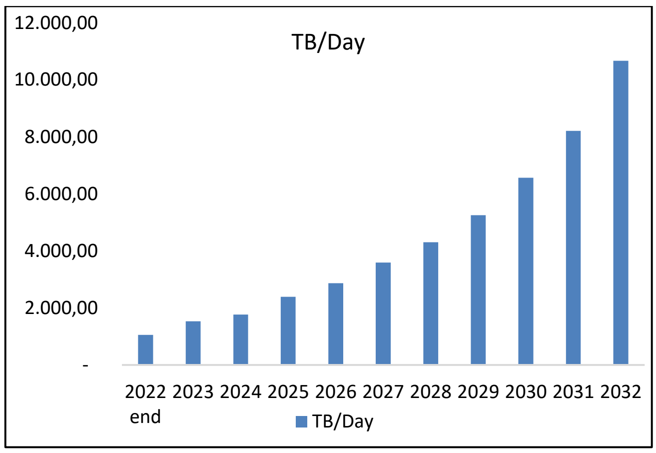


Fig. 3 Forecasted data volume for ten years in Terabyte

The formula used for identifying the cell capacity is as shown in Fig. 4. Per site three cell in each band is considered for capacity planning.

| |
|---|
| ***Cell Capacity*** = ***spectrum efficiency*** * *80%* * *BW* * *3600/8/1000000* |

Fig. 4 Cell capacity using spectrum efficiency.

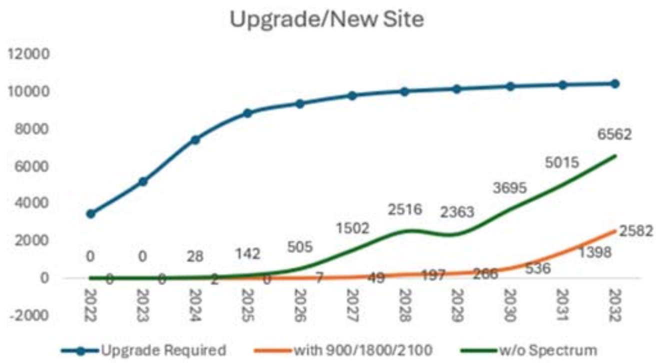


Fig. 5 Result of case1 for cell count for upgrade and new sites (with and without spectrum)

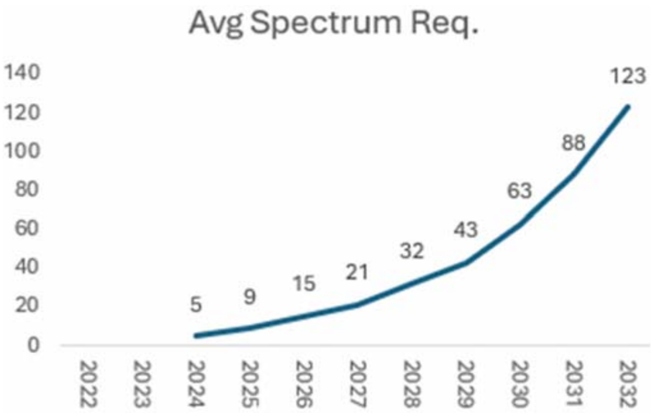


Fig. 6 Forecasted data volume for ten years in Terabyte

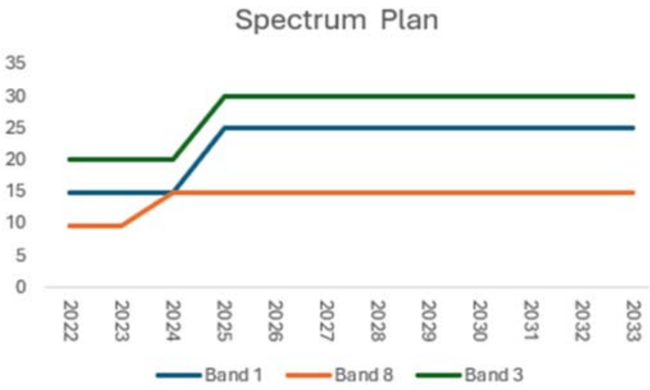


Fig. 7 Result of case1 for avg spectrum requirement and plan of use spectrum

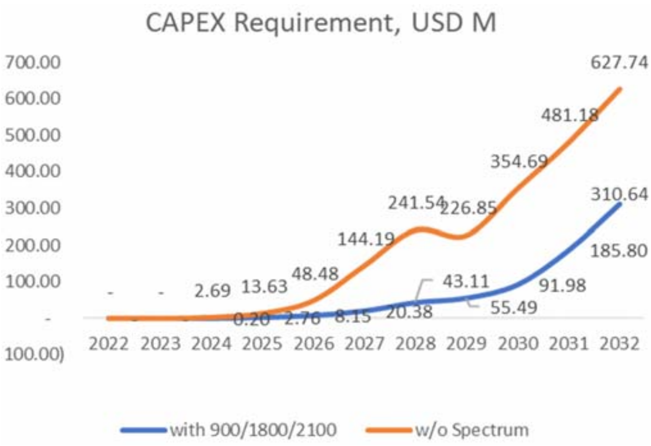


Fig. 8 Result of case1 for capex requirements for with and without spectrum

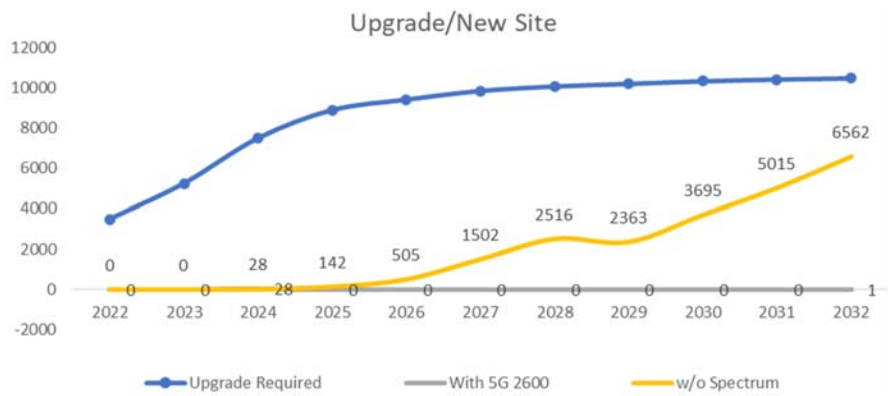


Fig. 9 Result of case2 for cell count for upgrade and new sites (with 5G 2600 and without spectrum)

## V. Results

Two cases are evaluated for spectrum evaluation case:

1) Addition spectrum in mid band (1800 and 2100) is evaluated for 4G capacity: Accumulated capex of 627M USD will be required for 10 years, whereas 310M USD will be with additional available spectrum. Additional band width required for Year on Year (YOY) growth will be 123 MHz as shown in Fig. 6, the cell upgrade count and the site count (without spectrum and with spectrum) is illustrated in Fig. 5 and plan of use spectrum is listed in Fig. 7 for mentioned forecasted (Fig. 3) data volumes.

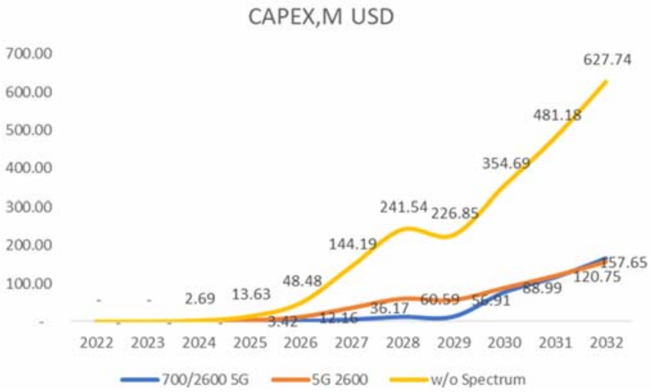


Fig. 10 Result of cell count for capex requirements for case2 i.e. with new spectrum 700/2600 5G and first case

2) In second case, new spectrum bands, 2600 & 700, are evaluated along with 5G capacity. The capex requirement for this case was significantly less and will be around 120M USD.

Though capex for this case will be less, annual spectrum cost needs be evaluated carefully for better output.

## VI. Conclusion

Rather than investing in mid band (1800 and 2100) with 4G dimension, it will be more efficient to investment in bands 2600 and 700 with 5G services since capex is reduced significantly. The capex requirements comparison is illustrated in Fig. 11.

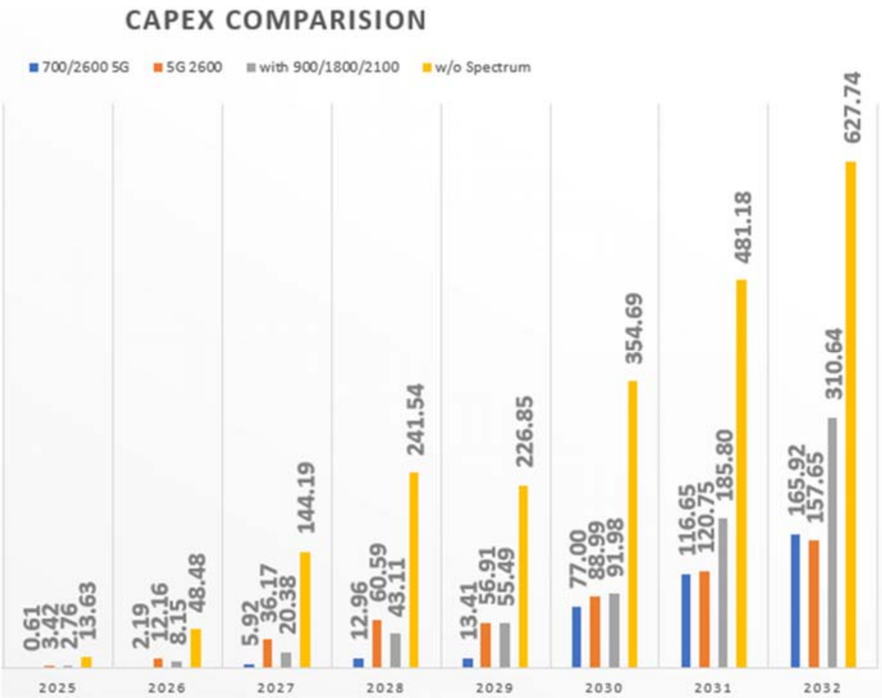


Fig. 11 Capex comparison

To achieve the output as illustrated in Fig. 11, spectrum of 4G band 41 needs to be to fully converted to 5G by 2028-2029 as shown in Fig. 12.

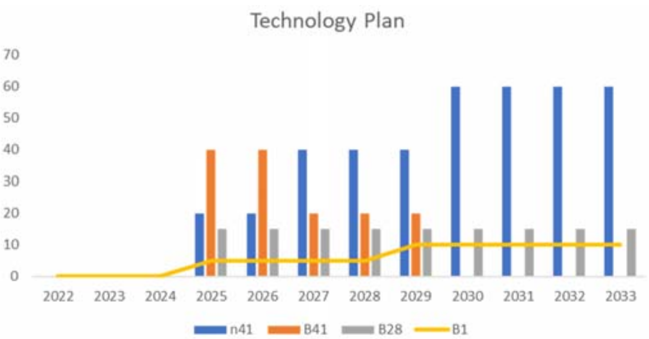


Fig. 12 YOY spectrum use plan

## VII. Recommendations

Convergence of mobile data service to fixed wireless access (FWA) is a key use case of 5G networks [3]. Compound annual growth rate of data usage per month will be 16% by 2028 that supports 5G service in India, Bhutan, and Nepal so spectrum and investment should align with this [4]. Handset ecosystem will be matured with N41 so this will support MNO to invest in this band [5].

| Frequency Bands | | | 800 MHz Band | 850 MHz Band | 900 MHz Band | 1800 MHz Band | 2100 MHz Band | 2300 MHz Band | Total |
|---|---|---|---|---|---|---|---|---|---|
| Allocated Frequency Range | | | 852-862 MHz paired with 811-821 MHz | 824-834 MHz paired with 869-879 MHz | 880-915 MHz paired with 925-960 MHz | 1710-1785 MHz paired with 1805-1880 MHz | 1920-1980 MHz paired with 2110-2170 MHz | 2300-2400 MHz | |
| Available System Bandwidth | | | 2×10 MHz (FDD) | 2×10 MHz (FDD) | 2×35 MHz (FDD) | 2×75 MHz (FDD) | 2×60 MHz (FDD) | 100 MHz (TDD) | 2×190 MHz (FDD) 100 MHz (TDD) |
| Assignments | 1. | Nepal Doorsanchar Company Ltd. (Nepal Telecom) | 2×10 | 2×1.25 | 2×9.6 | 2×20 | 2×10 | 10 | 2×50.85 (FDD) 10 (TDD) |
| | 2. | Ncell Axiata Ltd. | - | - | 2×9.6 | 2×20 | 2×15 | - | 2×44.6 (FDD) |
| | 3. | United Telecom Ltd. | - | 2×2.5 | 2×5 | 2×12 | - | - | 2×19.5 (FDD) |
| Total Assigned Frequency (MHz)# | | | 2×10 | 2×3.75 | 2×24.2 | 2×52 | 2×25 | 10 | 2×114.95 (FDD) 10 (TDD) |
| Unassigned Frequency (MHz)## | | | - | 2×6.25 | 2×10.8 | 2×23 | 2×35 | 90 | 2×75.05 (FDD) 90 (TDD) |

Fig. 13 Current spectrum allocation details of Nepal [2]

## ACKNOWLEDGMENT

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