
# *Analysis of the economic impact of the usage of C-band - Facts vs Fiction*

## ***Summary Report***

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# Foreword

- The C-Band (3400 – 4200 MHz) has been a cornerstone of many satellite services for decades. In addition to its key function in providing connectivity within and to areas of high rain fall, where other available bands (e.g. Ku and Ka Band) are inappropriate, C-band is used for a number of critical functions and where its ability to be deployed quickly using VSAT terminals is paramount.

- In preparation for the forthcoming 2015 World Radiocommunication Conference (WRC-15) the mobile telecommunications industry has produced a number of documents, which consider the relative economic benefit of assigning the C-Band to mobile services in comparison to allowing its continued use for satellite services. These documents show the economic benefits of the use of the band for mobile being far in excess of its use for satellite and include:
  - ✔ The economic benefits from the use of C-band (3600-4200 MHz) for mobile broadband in the UK (PLUM for Huawei, October 2014)
  - ✔ Economic assessment of C-band re-allocation (Frontier Economics for GSMA, January 2014)
  - ✔ Economic assessment of C-band reallocation in Africa (Frontier Economics for GSMA, January 2015)
  - ✔ Economic assessment of C-band reallocation in the Arab States region (Frontier Economics for GSMA, February 2015)

- This report analyses the consistency of the approach these studies have taken to consider the economic value of the C-Band, their capability to consider key underlying factors, the validity of assumptions and economic modelling, as well as the resulting impact on the validity of the assessment of costs and benefits of C-band reallocation.

# Executive Summary

- The study by **Plum** has a narrow focus, covering only the impacts on capacity upgrade costs for mobile operators, overlooking the impacts on satellite operators, satellite users as well as on mobile users. Key methodological flaws are outlined below:
  - Adopting a mobile-centric view, covering only benefits for mobile operators without considering the current use of C-band and the resulting value;
  - No alternative bands to the C-band are considered, meaning that benefits and costs of spectrum sharing are not compared with those for other possible bands to establish the optimal action;
  - Link-performance aware and advanced frequency sharing are unproven techniques, making most of the study results questionable because large benefits are built on unverified solutions;
  - Considered costs do not cover the disruption of service to current users of the C-band (e.g. Broadcasting, PMSE), leading to an overestimation of total benefits.
- Studies by **Frontier Economics** on C-band reallocation present an incomplete approach to the quantification of costs and benefits, as they overlook the impacts on revenues for satellite operators, lost benefits for users from disrupted / lost services and impacts on new costs for mobile operators. The main flaws under the methodological standpoint include the following:
  - The impact on existing C-band users and the stakeholders they serve is ignored;
  - Economic benefits are overestimated by using auctions on 2.6 GHz - a band with different characteristics - as a benchmark for spectrum value rather 3.5 GHz auction values;
  - Country specific factors, obtained by using an inaccurate calculation approach, further inflate spectrum value for many countries used as case studies. Wrong quantifications are then extrapolated for considered regions. These two errors generate a multiplier effect that leads to further overestimating calculated benefits;
  - Efficiency gains deriving from the usage of alternative methods to provide capacity are expressed qualitatively but are not quantified. Alternative options to C-band for spectrum usage are ignored.

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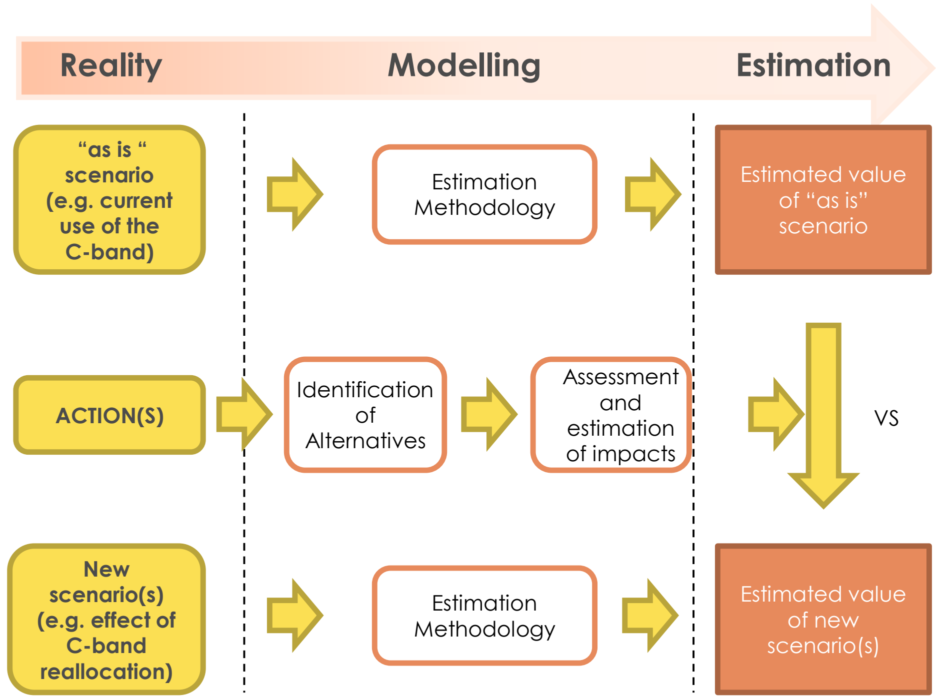
# The right approach to assessing a policy intervention investigates the impact of alternative actions on the current scenario for all stakeholders involved

The appropriate approach to assessing the impact of an action should be as comprehensive as possible, in terms of:

- The **analysis of the "as is" scenario** in the absence of actions (i.e. maintaining the current allocation of C-band spectrum). Key activities are the mapping of involved players (satellite operators, users, downstream industry, society etc.) and the quantification of value (e.g. of C-band services);
- The identification of the **different types of actions** (e.g. reallocation of the C-band) to achieve a desired **result** (e.g. solving the capacity constraints faced by the mobile industry), as well as the assessment of their impacts in terms of costs and benefits on relevant stakeholders;
- The **analysis of the new scenario(s)**, covering the new costs and benefits for existing players and new entrants as an effect of the investigated action. In the case of C-band reallocation, this means understanding not only the new benefits and costs for mobile operators, but also the effects on satellite players and their users, as well as the "domino effect" caused by the unavailability of previously provided satellite connectivity services.




Total benefits should be estimated as: ΔBenefits - ΔCosts for every considered action

where Δ=Estimated "Intervention scenario" value – Estimated "as is" scenario value

Finally, **total net benefits** of different actions can be quantified by comparing costs and benefits of the "intervention scenario" against those of estimated value of the "as is" scenario, for all stakeholders involved. The impact evaluation framework suggested above, which supports the policymaking process of institutions such as the European Commission, offers a powerful and comprehensive decision support tool based on a deep understanding of the real world and a thorough analysis of possible alternatives and their impact.

# The methodologies proposed are not comprehensive and complete

- 1. The methodologies proposed by both the Plum and the Frontier Economics reports are incomplete when compared to an appropriate framework for the evaluation of impacts. Both methodologies:
  - fail to consider the value of the C-band based on its current use;
  - do not compare the action of C-band reallocation with any alternatives; and
  - analyse the effect of reallocation only on part of the players impacted by the potential decision.
- 2. Benefits and costs are quantified in a partial and deficient way with regards to stakeholders impacted and the type of impact, leading to an overestimation of the ratio between benefits and costs:

**Comprehensiveness of PLUM study**

| | Existing players and users | New players and users |
|---|---|---|
| Impact on costs | Spectrum sharing impacts on satellite operators and users | Impacts on capacity upgrade costs for mobile operators |
| Impact on benefits | Impacts on revenues for satellite operators<br><br>Lost benefits for users from unavailability or disruption of existing services | Impact on benefits for mobile users |

**Comprehensiveness of Frontier Economics studies**

| | Existing players and users | New players and users |
|---|---|---|
| Impact on costs | Impacts on reallocation costs of satellite operators | Impacts on costs for mobile operators |
| Impact on benefits | Impacts on revenues for satellite operators<br><br>Lost benefits for users from disrupted / lost services | Impacts on benefits for mobile operators |

**Covered** by the methodological approach **Not covered** by the methodological approach

- The steps and logic suggested to perform a comprehensive evaluation are outlined in the following page.



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# The Plum study estimates the savings for mobile operators from spectrum sharing

## Overall logic

The study considers the economic benefit of bringing forward the availability of 3600-3800 MHz and 3800-4200 MHz for mobile data services in the UK. The logic flow is as follows:

1. **Growing mobile traffic demand**: Mobile broadband traffic in the UK is forecast to grow rapidly over the next 10-15 years

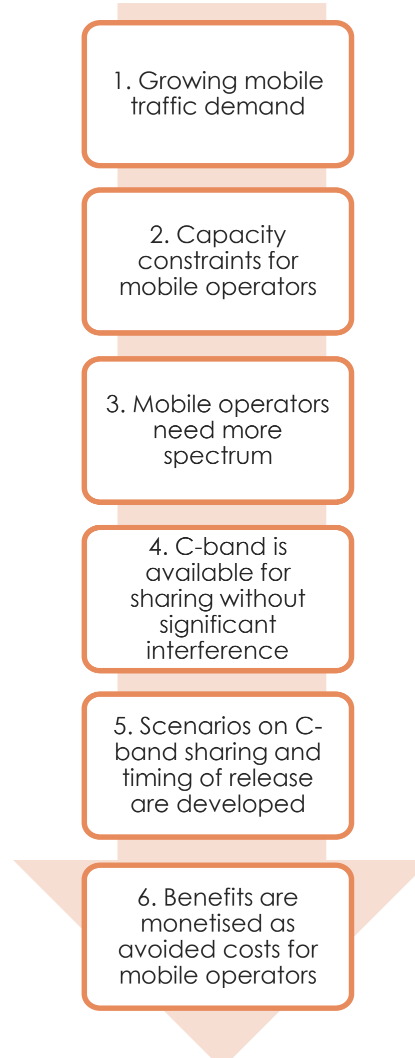
2. **Capacity constraints for mobile operators**: It is possible that the UK may face a spectrum shortfall

3. **MOs need more spectrum**: operators will have to make costly investments in infrastructure to support traffic growth unless sufficient spectrum is made available

4. **C-band is available for sharing without significant interference**: two technical alternatives "link performance aware frequency sharing" and "advanced frequency sharing" are available

5. **Scenarios on C-band sharing and timing of release are developed**: economic scenarios based on the technical alternatives and on the timing for the availability of spectrum (2022 and 2028)

6. **Benefits are monetised as avoided costs for mobile operators**: Benefits are calculated as the potential change in cost that operators could experience from having access to larger amounts of spectrum (e.g. savings on macro cell and outdoor small cell deployments)




## Methodology used

To derive the economic benefit results, the study performs an evaluation of the protection required for C-Band satellite installations under several scenarios. The benefit from avoided costs is computed as the difference in NPV of total radio access network cost between a base case and an alternative case with greater spectrum availability

## Results

The use of 3600-4200 MHz for mobile broadband could generate benefits of as much as £1.4 billion in the UK. This is comprised of benefits arising from the early release of the spectrum plus the use of the two frequency sharing scenarios

# The Plum report offers a mobile-centric assessment of C-band sharing

1. Growing mobile traffic demand

2. Capacity constraints for mobile operators

**GAP 1** ← The study focuses on a problem for mobile operators, i.e. the expected high cost of further network deployment in the absence of new spectrum available. After the identification of the problem, it suggests to share C-band as the only proposed solution and provides the analysis of the benefits for the mobile operators, without considering the other key stakeholders and the users of the C-band

3. Mobile operators need more spectrum

**GAP 2** ← The study does not provide a detailed analysis of the actual use of the C-band. The current value of C-band for key stakeholders, users and the whole society is not estimated

4. C-band is available for sharing without significant interference

5. Scenarios on C-band sharing and timing of release are developed

**GAP 3** ← Even if different alternatives for sharing are considered, C-band is the only candidate identified for spectrum sharing. As a result, by not comparing different alternative bands, the report offers only a partial analysis of the impact of sharing C-band between mobile operators and satellite operators

6. Benefits are monetised as avoided costs for mobile operators

**GAP 4** ← The future value is calculated as net benefits (benefits – costs) of the proposed action for mobile operators. The study does not consider the impact of sharing C-band spectrum on other categories of players , including providers and users of existing services

# No alternative actions and options have been identified in the report

The Plum study identifies only one solution to the capacity constraints that the mobile operators are claimed to be facing in the next decade: sharing C-band spectrum between mobile services and existing services operating in the band through the use of Licensed Shared Access (LSA).

It also considers that small cells (indicated as necessary to supply the necessary capacity) will be implemented 'in frequencies above 2.6 GHz', meaning that they assume that all small cells will be in C-band only. This significantly skews the results as other frequencies might be available.

There are five key areas that the study has failed to consider:

- Other users of the C-band which includes fixed links ("This study considers coexistence with satellite services. The analysis of co-existence with fixed links was not considered in this study") and PMSE
- Alternative methods of providing additional capacity (e.g. UMTS, LTE, LTE-Advanced, 5G, etc.)
- The cost of protecting C-band earth stations from interference
- The impact on mobile networks of the management of frequencies within C-band for the provision of satellite services
- Alternative frequency bands (e.g. 4.4 – 4.5 GHz; 4.8 - 4.99 GHz)

These missing areas are described in the following pages.

# Plum study failed to consider five key areas (1/3)

**Other C-band users**

The Plum study claims that there are currently around 40 fixed links operating in C-band. Many of these will be relatively long-distance links taking advantage of the good propagation characteristics of the band. No account is taken of the cost of moving these links to an alternative frequency or technology (e.g. fibre).

The Plum study also fails to consider the use of C-band for programme making and special events (PMSE). PMSE use of the C-band is almost exclusively for wireless cameras (e.g. at sporting or music events). The number of frequency bands available for such services (especially below 6 GHz) is vastly reducing meaning that C-band is a vital resource for these users. No account is taken of the cost of moving these users to alternative bands, or the potential loss of the use of the spectrum.

**Alternative methods of providing additional capacity**

The Plum study only considers the use of small cells, in C-band, for providing additional capacity beyond that provided from existing cells (using all frequency bands). It is not clear which technology is assumed, and the extent to which the study assumes a migration from 2G to UMTS to LTE and LTE-Advanced, or the adoption of a future 5G technology which is assumed to be more spectrally efficient.

*"… the establishment of 5G have not been quantified within the avoided cost model of this report"*

It is to be expected that existing 2G and 3G (UMTS) spectrum will be migrated to LTE or LTE-A in the timescales considered in the study, but it is not clear how this has been taken into account to determine the need for spectrum and resulting savings from C-band sharing.

The study also does not consider the potential for use of C-band only for indoor cells (e.g. in shopping centres, railway stations, homes, theatres), where interference potential is far more limited.

# Plum study failed to consider five key areas (2/3)

**Protecting C-band earth stations from interference**

No costs have been considered for the necessary changes that would be required in order to modify existing C-band earth stations to operate in a high interference environment such as would be presented by the proposed solutions. This may involve:

- Wholesale re-engineering of equipment including new filters and amplifiers
- Building protective shielding around C-band earth stations
- Moving C-band earth stations to other locations

**Impact on mobile networks of C-band use and use of unproven techniques**

The proposed “link performance aware” and “advanced frequency sharing” techniques take no account of the fact that C-band earth stations are often used on an ad-hoc basis, meaning that the exact frequency in use, and the specific satellite in use, may change from time-to-time and without notice.

As the proposed techniques rely on knowing the specific frequency usage of the C-band earth station, it is not clear:

- How the mobile network knows which frequency is in use
- How the mobile network adapts to changes in frequency use
- How any protection methods adapt to the changes in the mobile network

These restrictions may impose very significant costs on the mobile network operator and the satellite earth station operator, and these costs are not considered in the report.

Moreover, link performance aware” and “advanced frequency sharing” techniques are concepts that are not tested nor proven. Any assumptions made about spectrum availability using these techniques are therefore flawed, bringing the study into question.

# Plum study failed to consider five key areas (3/3)

**Alternative frequency bands**

Furthermore, this study focuses on the economic benefits of releasing C-band spectrum, without identifying other alternative options and demonstrating its added value compared to them. As a result, the Plum study does not consider the possible alternatives to the C-band, making it impossible to assess the most adequate "target" for mobile use:

- Sub-700MHz UHF (470–694/8MHz): it can be used by mobile services in rural areas and deep inside building thanks to high quality delivery and wide area coverage. With the latest technology, broadcasting services could be maintained in a smaller amount of spectrum;
- L-band: is already partially allocated to mobile services (but not to IMT). It can be used to deliver additional capacity and coverage over relatively large areas, including inside buildings;
- 1800 and 2100 MHz band extensions – may only offer a relatively modest increase in spectrum availability but would be aligned with existing mobile allocations (e.g. adjacent to existing bands);
- 2300MHz band (2300-2400 MHz): is currently used for airborne, civil and military applications. Incumbents use spectrum intermittently, thus LSA is a suitable solution and a significant opportunity for mobile services in the short term, allowing a more efficient use of the spectrum;
- 2.7–2.9GHz: it can be an efficient solution for mobile operators thanks to its existing cell sites infrastructure. It is used for civilian and military aircraft navigation and radar-based location but it is still under-utilised.
- 4.4 – 4.5 and 4.8 to 4.99 GHz: very similar propagation characteristics to C-band and with a similar amount of overall spectrum availability. Mostly used for military purposes but LSA could be used to release its use.

# The unique characteristics of the C-band are not explained

Nothing in the Plum study considers why any additional spectrum, should such spectrum eventually be necessary, needs to be in the C-band:

- Whilst the study talks of '60 MHz of contiguous spectrum' such large pieces would potentially be available in other bands (e.g. 2.7 – 2.9 GHz and 4.8 – 4.99 GHz)
- Similarly, the propagation characteristics of 2.7 – 2.9 GHz and 4.4 – 4.99 GHz would be very similar to C-band, making them equally compatible
- Much of the focus of 5G is on frequencies above 30 GHz which would provide significantly greater capacity than C-band and the technology may be available in similar timescales

There is only a small existing ecosystem of user devices and equipment in C-band (only 26 mobile devices available on the market and 11 networks globally as of April 2015 compared to 1322 devices and 176 networks in the 1800 MHz band according to the GSA - Global GSM Suppliers Association) so a decision at this point to focus on a different band would not leave mobile operator assets stranded.

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# The three Frontier Economics studies look at the potential benefits to mobile operators of having access to 400MHz of C-band spectrum by 2025

### Overall logic

The studies aim at estimating the net benefits (benefits minus costs) of C-band re-allocation, calculated as the gross-value added (GVA) created in the economy. The three studies focus on three different regions: Asia Pacific, Africa and Arab states. The logic flow is as follows:

1. **Growing mobile traffic demand**: Demand for mobile services and mobile data in particular is rapidly increasing

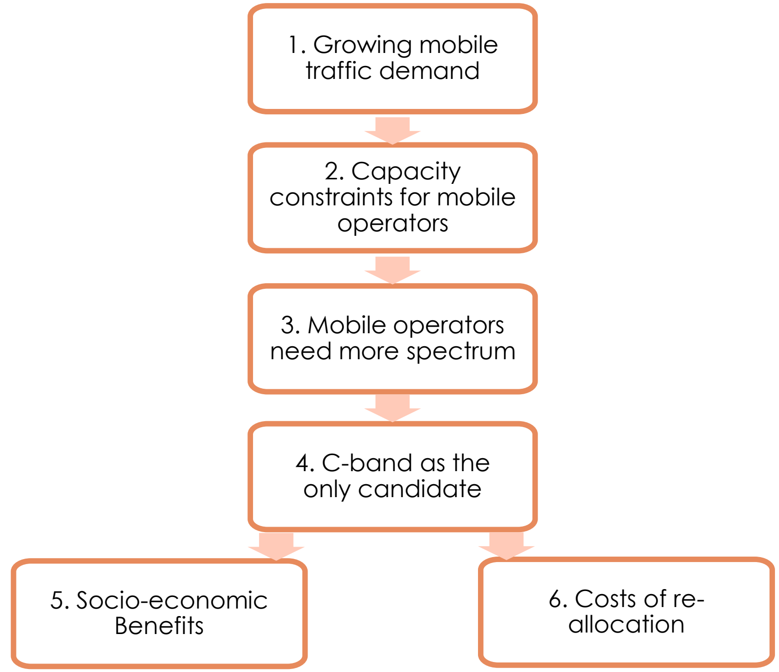
2. **Capacity constraints for mobile operators**: It is likely that there will be a shortfall in supply of spectrum to International Mobile Telecommunications (IMT) in the future

3. **Mobile operators need more spectrum**: To meet the growing demand, mobile operators are likely to need access to additional spectrum

4. **C-band as the only candidate**: The C-band is a frequency range that is suitable for mobile operators, in particular for providing additional capacity to networks in urban areas

5. **Socio-economic benefits**: the economic value of C-band is estimated based on auction benchmarking

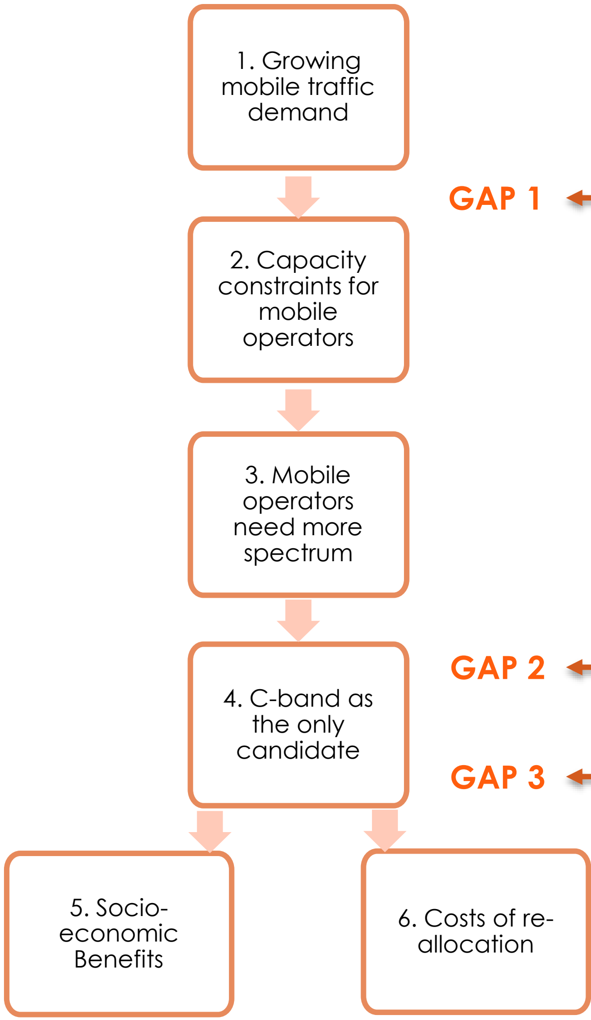
6. **Costs of re-allocation**: the costs are estimated as net costs of re-allocating 400MHz to mobile use: costs of migration of existing C-band services to other frequency bands and additional costs related to dealing with potential interference




### Methodology used

To derive the economic benefit results for the whole region, the reports are based on case-study analysis. The studies perform an evaluation of the costs and benefits for identified case study countries, and then derive indicative results for the whole region. The net benefits are computed as the difference of potential benefits to mobile operators of having access to C-band spectrum and the costs of re-allocation of satellite applications that currently use C-band to other bands.

# The reports offer a very partial analysis considering only the net benefits for mobile operators, without assessing alternative options and impacts on users




**GAP 1**

The studies focus on the capacity issue for mobile operators, i.e. the expected shortfall in supply in the absence of new spectrum available. The actual use of the C-band is not considered in detail in the study. The current value of C-band is not estimated.

**GAP 2**

C-band is the only candidate identified in the report as suitable for providing additional capacity to networks of mobile operators.

**GAP 3**

Re-allocation of spectrum by migrating existing satellite applications to other bands is the only suggested solution. Alternative actions such as licensing or sharing spectrum are not considered.

**GAP 4**

The future value is calculated as benefits of the proposed action for mobile operators and the costs of re-allocation for satellite operators. The costs deriving from services that cannot be relocated and the impact on users of existing services (i.e. quality of the service ) are not taken into account.

# No alternative actions and options have been identified or quantified in the report (1/2)

Frontier Economics studies identify only one solution to the capacity constraints that the mobile operators are claimed to be facing in the next decade: re-allocating C-band spectrum (3.4-4.2GHz) that will provide additional capacity for mobile operators in APAC region, African countries and Middle East. There are three key areas that the study has failed to consider:

- 1. Other users of the C-band which includes fixed-wireless operators and PMSE
- 2. Alternative methods of providing additional capacity
- 3. Alternative frequency bands

**1. C-band users**

Frontier Economics studies fails to consider C-band users and in particular the use of C-band for programme making and special events (PMSE) or for fixed links. PMSE use of the C-band is almost exclusively for wireless cameras (e.g. at sporting or music events). The number of frequency bands available for such services (especially below 6 GHz) is vastly decreasing meaning that C-band is a vital resource for these users. Many fixed links at C-band are long distance and would be substantially more expensive in another (higher) frequency band. No account is taken of the cost of moving these users to alternative bands, or the potential loss of the use of the spectrum.

**2. Alternative methods of providing additional capacity**

The studies list a series of alternatives methods of satisfying additional mobile traffic demand (more efficient use of spectrum, additional network deployment, offloading mobile traffic onto fixed networks), but the costs and benefits of these solutions are not quantified.

# No alternative actions and options have been identified or quantified in the report(2/2)

**3. Alternative frequency bands**

Furthermore, the studies focus on the economic benefits of releasing C-band spectrum, without identifying other alternative options and demonstrating its added value compared to them. As a result, the studies do not consider the possible alternatives to the C-band:

- Sub-700MHz UHF (470–694/8MHz): can be used by mobile services in rural areas and deep inside building thanks to high quality delivery and wide area coverage. With the latest technology, broadcasting services could be maintained in a smaller amount of spectrum;
- L-band: is already partially allocated to mobile services (but not to IMT). It can be used to delivering additional capacity and coverage over relatively large areas, including inside buildings;
- 1800 and 2100 MHz band extensions – may only offer a relatively modest increase in spectrum availability but would be aligned with existing mobile allocations (e.g. adjacent to existing bands);
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- 4.4 – 4.5 and 4.8 to 4.99 GHz: very similar propagation characteristics to C-band and with a similar amount of overall spectrum availability. Mostly used for military purposes but LSA could be used to release its use.

As a consequence, the studies are not in the position to assess the most adequate "target" for mobile use.

# 2.6 GHz spectrum should not be used as a benchmark for 3.5 GHz

The use of 2.6 GHz as a benchmark for auction prices for 3.5 GHz spectrum is not appropriate:

- The coverage of a 3.5 GHz cell is ~1.8 times smaller than a 2.6 GHz one, which limits its value for mobile applications as more cell sites are required;
- The ecosystem of mobile device models at 2.6 GHz is much further developed than at 3.5 GHz meaning the 2.6 GHz band has a far higher value;
- There have been several auctions of 3.5 GHz spectrum that could have been used as a reference (Australia, Austria, Brazil, Bulgaria, Canada, Germany, Portugal, Switzerland, and UK).
- The 2.6 GHz band can be used largely without impediment or restriction as it is free of other services. There is still a need to protect C-band earth stations (and fixed links) in the 3.5 GHz band, making the 3.5 GHz spectrum less geographically available and thus less valuable.

- The factors applied to 'adapt' values for 2.6 GHz thus are attempts to make figures for 2.6 GHz appear more valid when considering C-band.

# Economic Benefits of C-band spectrum for Africa are overestimated by 375%, as an effect of improper methodological choices

1. Growing mobile traffic demand
2. Capacity constraints for mobile operators
3. Mobile operators need more spectrum
4. C-band as the only candidate
5. Socio-economic Benefits
6. Costs of re-allocation

## Quantification by Frontier

Benefits are quantified in **15.4 $PPP billion** for Africa.

## Analysis of quantification logic

Benefits are by far overestimated

by at least **375%.**

**Economic Benefits of C-band spectrum**

**375% overall overestimation, resulting from 150% and 250% overestimations in two different steps**

= **Price of C-band spectrum $PPP /MHz/Urban Population** (150% overestimation) × **Adjustment Factors** (250% overestimation) × **Quantity of C-band spectrum** × **Urban population** × **Ratio of economic value to spectrum price**

**Price of C-band spectrum:**

$PPP 0.06/MHz/Urban population = median value of 2.6 auctions

x 50% (adjustment factor)

$PPP **0.03**/MHz/UP

However, the use of 2.6 GHz plus a series of assumptions as a benchmark rather than 3.5 GHz auction value overestimates spectrum value by **150%**, as suggested by the fact that the auction value in the UK was $PPP 0.02

**Adjustment Factors:**

Country-specific adjustment factors are based on population density, 3G penetration rate and ARPU

- Adjustment factor for Egypt = 146% → Egypt represents North Africa
- Adjustment factor for Nigeria = 127% → Nigeria and the DRC represent Tropical Africa
- Adjustment factor for DCR = 87% → Nigeria and the DRC represent Tropical Africa
- Adjustment factor for South Africa= 101% → South Africa represents Southern Africa

**Quantity of C-band spectrum:** 400 MHz

**Urban population:** Benefits are scaled up using urban population

**Ratio of economic value to spectrum price:** **1,5** = expected profits are 50% higher than the price paid for spectrum

The use of a wrong quantification approach for **adjustment factors** overestimates spectrum value, by **250%** or more (**see next page**)





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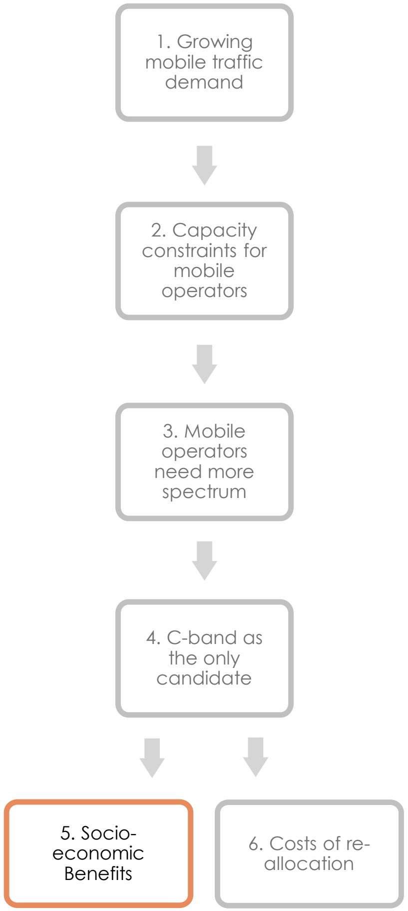
# Focusing on **adjustment factors**, economic benefits have been overestimated by 250% or more




## Quantification by Frontier

The adjustment factors are estimated as follows:

- First 3 ratios (country's population density, 3G penetration rate and ARPU) are calculated, dividing the values of the country case study (Nigeria, DCR, Egypt, South Africa) by the values of the auction sample's average;
- Then, the simple average of these the three ratios is calculated to obtain the final adjustment factor.

## Analysis

**EXAMPLE**: Consider a fictional European country and a fictional African country. The African country has a much higher urban population density (4 times higher). In turn, the European country has ARPU and 3G penetration 4 higher than the African country:

| Country | Urban Pop. Density (number of inhabitants / km2) | ARPU | 3G Penetration |
|---|---|---|---|
| African Country | 10000 | 5 $PPP | 20% |
| European Country | 2500 | 20 $PPP | 80% |
| Ratio African / European Country | **400%** | **25%** | **25%** |

The logic suggested by Frontier would lead to calculating the following three ratios: 400%, 25%, and 25%. The **average of ratios would be 150%**, explaining how countries with low ARPU and 3G penetration such as Egypt or Nigeria end up in receiving "upwards" adjustment factors. By contrast, **multiplying the ratios** to correctly reflect the causal chain linking ARPU, urban population density and 3G penetration **(400% x 25% x 25%)** would lead to an appropriate adjustment factor of **25%.**

In the example above, the bias by Frontier brings the adjustment factor to a striking **600%** of the appropriate value (150% divided by 25%). Benefits calculated in the report would then be inflated accordingly, as an effect of the adopted methodology.

| | Urban Pop. Density | ARPU | 3G Penetration | Adjustment factor Frontier (average) | Correct adjustment factor (multiplication) | Error |
|---|---|---|---|---|---|---|
| Ratio African / European Country | 400% | 25% | 25% | **150%** | **25%** | **600% of correct value** |

Although Frontier did not disclose the values on urban population density, ARPU and 3G penetration used for the benchmark and the case study countries, data from Demographia (urban pop. Density), MTN/GSMA (ARPU) and GSMA (3G penetration) suggest that the bias can be estimated to be as **250% of the correct value**.

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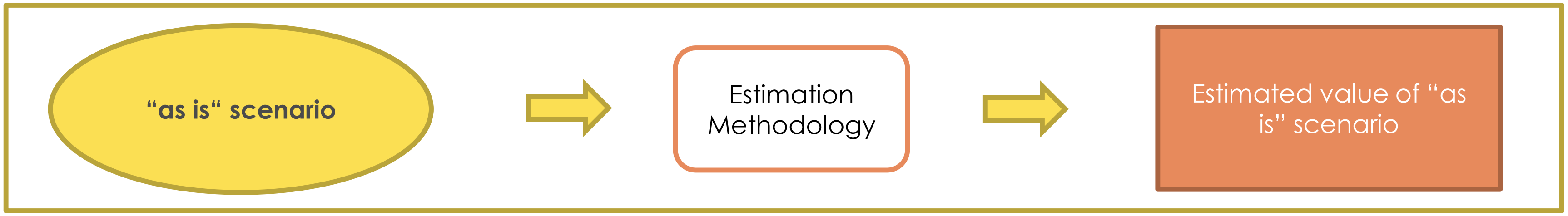
# The evaluation of the "as is" scenario enables to identify and estimate current drivers of value creation before assessing the impact of new actions




The first step to correctly assess the impact of an action is to evaluate the "as is" scenario. The analysis should start from the evaluation of the status quo in the absence of interventions (i.e. the current use of C-band and its value for all the involved stakeholders and users). In order to estimate the value of a scenario, the modelling activity provides a simplified version of the reality that captures the key drivers of costs and benefits.

A series of steps should usually be taken into account when assessing the current scenario:

- **Definition of the appropriate scope of the analysis:** It is necessary to identify the type of object - an asset, a market, a project, .. - and to understand it (i.e. C-band is a global, scarce but renewable resource)
- **Identification and assessment of the players** involved or potentially involved, as well as of their role in the value chain and the competitive arena (i.e. satellite operators, users, downstream industry, society, etc.). Different methodologies can be used such as value chain analysis, Porter 5 forces analysis, etc.
- **Assessment of the products and/or services** involved and of their characteristics, as well as sizing of their markets (i.e. oil and gas, banking and financial, education, rural connectivity, etc.)
- **Quantification of the value (and cost)** of products and services **for each player,** including public benefits. The value can be assessed through two different approaches:
  - Expected final value to end users and the society (i.e. the willingness to pay to use it);
  - Estimation and sum of the marginal contributions at different stages of the value chain, enabling to understand the role of costs for all players involved in the provision of the service or product.
- **Forecasting** of the scenario over time, considering the evolution of all dimensions outlined above.

# The identification and assessment of possible alternative actions is necessary to adopt the optimal decision

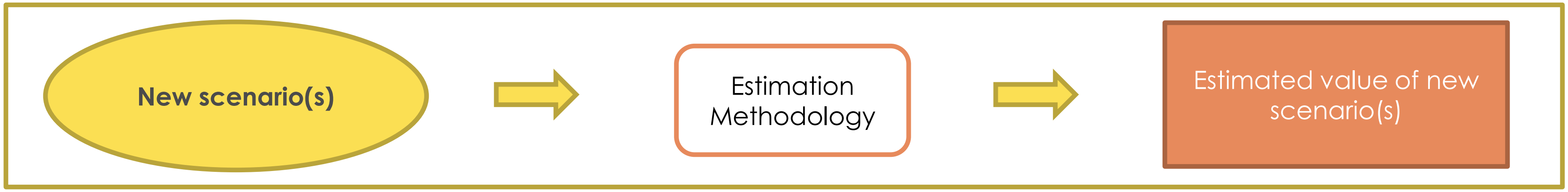

The following steps support the identification of the alternative actions that the regulator can undertake:

- **Identification of alternatives to achieve a result**: in the studies under analysis, the result to be achieved is solving the capacity constraints suffered by the mobile industry. Possible options of action should be screened and identified (these indeed include C-band reallocation, but also several other options such as improving efficiency of spectrum usage, reallocation of L-band, 2.7–2.9GHz, etc.);
- **Description of the alternatives**: qualitative assessment of the options and their expected outcome;
- **Prioritization of alternatives**: definition of priority actions based on expected likelihood of successful outcomes and selection of alternatives to be analysed quantitatively;

Once the key alternatives have been identified, it is necessary to assess those that are feasible and estimate their impacts, through:

- **Analysis of technical feasibility:** to verify whether the action can be implemented with the existing technology and within the existing business environment (e.g. feasibility of sharing C-band between satellite and mobile operators, feasibility of providing satellite services on the C-band in spite of lower spectrum availability)
- **Analysis of economic feasibility**: to estimate the socio-economic viability of the action through a **cost-benefit analysis** to quantify its net benefits. Key steps include:
  - Identification of the expected benefits and costs for existing players and new entrants;
  - Definition of the estimation methodology;
  - Quantification of benefits and costs and calculation of net results.

# The assessment of options enables the definition of the related scenarios, to be compared with the status quo so to calculate net benefits




As an effect of the assessment of prioritised actions, the future value of the "intervention scenario" is determined by:

- Verifying key changes to the **initial scenario** (e.g. C-band spectrum usage moved from satellite operators to mobile players) as an effect of the intervention;
- Identifying if the **players involved** are the same as in the "as is scenario", as well as if there are changes in the value chain and in the competitive arena (in this case, mobile operators potentially starting to use the C-band should be considered in addition to existing players, whereas no significant competition impacts are expected, because the C-band will be used mobile operators and satellite players to provide different services to different markets);
- Assessing if the **products and/or services** involved and their characteristics, are the same (e.g. will it be possible to deliver the satellite services previously offered? Will this happen with the same quality? Will alternative frequencies be required?)
- Understanding the impacts on the **size of related markets** (both for mobile operators and satellite operators);
- **Quantifying the new value (and cost)** of products and services to each player, including **public benefits**
- Verifying the effect of the action on **forecasts and future trends**

Total benefits should be estimated as: Δ Benefits - ΔCosts for every considered action

where Δ = Estimated "Intervention scenario" value – Estimated "as is" scenario value

Thanks to this activity, the different scenarios can be assessed in terms of **net benefits** (changes in benefits from the "as is" scenario to the "new scenario" minus changes in costs) and compared to each other, in order to select the optimal action.