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Subject: Key considerations for the allocation of 2500 to 2520MHz and 2670 to 2690 MHz to terrestrial or satellite IMT-2000

The objective of this contribution to CEPT/ECC PT1, developed by GSME[1], is to provide an aggregated source of data pertinent to the discussion regarding the future allocation of the 2500 to 2520MHz and 2670 to 2690MHz sub-band. Various sources of published information have been combined into a single document for comparison purposes. In addition a brief analysis of the impact of a future decision has been included.

GSME considers it of vital importance that the decision regarding this band is focussed on achieving the maximum economic benefit to the member administrations of CEPT.

Where other organisations are in possession of data of improved accuracy over that included within this document, GSME welcomes the inclusion of such data into the discussion and analysis. In addition should other organisations identify additional metrics of value to the discussion, GSME will work with its members to provide inputs to represent accurately the performance of the cellular industry.

Based upon published data GSME has identified that:

- At the end of 2002 there existed approximately 643,000 MSS subscribers, and 1,129,693,000 terrestrial cellular subscribers worldwide. Within the combined market this can be represented as 0.06% MSS to 99.94% terrestrial cellular.
- Between 1995 and 2002 the global MSS subscriber base grew by an average annual rate of 41%, and the terrestrial cellular subscriber base grew by an average annual rate of 44%.
- At the end of 2002 there existed an estimated 238,000 MSS subscribers, and an estimated 410,064,000 terrestrial cellular subscribers within Europe. Within the combined market in Europe this can be represented as 0.06% MSS to 99.94% terrestrial cellular. This is based upon an estimate of 37% MSS

[1] GSM Europe is the European interest group of the GSM Association, the premier global body behind the world's leading wireless communications standard. GSM Europe represents around 143 operators in 50 countries/areas in Europe and counts around 416 million subscribers.
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subscribers within Europe and 36.3% terrestrial cellular subscribers within Europe.

- At the end of 2002 the numbers of subscribers/MHz within deployed spectrum in Europe was approximately 2,400 subscribers/MHz for MSS, and approximately1,863,930 subscribers/MHz for terrestrial cellular.
- It is forecast that in 2010 there will be approximately 6,685,000 MSS subscribers, and 2,260,000,000 terrestrial cellular subscribers worldwide. Within the combined market this can be represented as 0.30% MSS to 99.70% terrestrial cellular.
- These forecasts equate to an average annual growth between 2002 and 2010 of 35% for the global MSS subscriber base and 9% for the global terrestrial cellular subscriber base.
- Within Europe in 2010 it is estimated based upon these forecasts there will be 2,473,000 MSS subscribers and 697,000,000 terrestrial cellular subscribers. Within the combined market this can be represented as 0.40% MSS to 99.60% terrestrial cellular. This is based upon an estimate of 37% MSS subscribers within Europe and represents a forecast of 30.8% terrestrial cellular subscribers within Europe.
- Should the additional spectrum be allocated to MSS, within Europe a total of 199MHz would be allocated to MSS and a total of 515MHz would be allocated to terrestrial. This can be represented as 28% MSS and 72% terrestrial.
- Should the additional spectrum be allocated to terrestrial, within Europe a total of 159MHz would be allocated to MSS and a total of 555MHz would be allocated to terrestrial. This can be represented as 22% MSS and 78% terrestrial.
- Should the additional spectrum be allocated to MSS, in 2010 the numbers of subscribers/MHz within deployed spectrum would be approximately 12,400 subscribers/MHz for MSS, and approximately 1,353,400, subscribers/MHz for terrestrial cellular.
- Should the additional spectrum be allocated to terrestrial, in 2010 the numbers of subscribers/MHz within deployed spectrum would be approximately 15,600 /MHz for MSS, and approximately 1,255,900/MHz for terrestrial cellular.
- Reversing the duplex direction of a terrestrial IMT-2000 system using FDD Internal pairing would require an additional 6.6% sites to provide contiguous coverage.
- Retaining a conventional duplex direction would result in approximately 10.5% of the total spectrum remaining unused in a guard band between the mobile satellite and the terrestrial cellular services. If this were taken wholly

from the terrestrial component, it would reduce the size of the terrestrial component by 13.3 %.

Further detail of this data, the sources of the data and methods of estimation are included within the attached annexes.

Based upon the data presented GSME concludes that the 2500 to 2520MHz and 2670 to 2690MHz sub-band should, through rational analysis focussed on achieving the maximum economic benefit to the member administrations of CEPT, be allocated to terrestrial IMT-2000 use. In particular GSME notes:

- There are currently almost 800 times more terrestrial cellular users per MHz of deployed spectrum in Europe than there are MSS users. Should current forecasts prove accurate there would still be a difference of approximately 110 times in the number of subscribers benefiting per MHz of allocated spectrum between terrestrial cellular and MSS within Europe in 2010.
- Releasing the sub-band to terrestrial cellular use will reduce barriers to expansion in the future terrestrial cellular output market, supporting maintenance of quality of service standards without the need to constrain consumer demand. MSS will retain access to 2x30MHz of spectrum at 2GHz, which is currently allocated but not deployed. This spectrum will allow deployment of advanced MSS technologies in parallel to the operation of existing systems, providing a test for the viability of IMT-2000 satellite systems. As a result, CEPT will be able to encourage more efficient use of current MSS allocations while supporting the proven and competitive terrestrial cellular services market.
- Retention of the allocation of the band by MSS would impose additional costs on terrestrial IMT-2000 systems due to measures required to ensure compatibility between the two systems. A proportion of the costs incurred by terrestrial cellular operators as a consequence of any MSS allocation are likely to be borne by consumers.

A Criteria for a decision

The question of allocating the 2500 to 2520MHz and 2670 to 2690MHz to either satellite IMT-2000 terrestrial IMT-2000 is essentially the first stage in a process that will ultimately end with the assignment of spectrum to specific users.

While a scenario might be to follow an open and fair competition to determine the assignee, regardless of whether the assignee is a terrestrial or satellite operator, this is unfortunately not practical for a number of reasons:

- The requirement to assign satellite IMT-2000 spectrum on a regional basis contrasts with the current legislative requirement to assign terrestrial IMT-200 spectrum on a national basis
- The requirement to identify the allocation of the band in advance of assignment for purposes of co-ordination
- A period of approximately 4 years is required to develop standards, infrastructure and terminals for deployment of the spectrum

Given the impracticality of determining allocation based on open and fair competition, PT1 is required to take a decision, under the direction of the European Commission's 5th Mandate.

The decision within PT1 should aim to identify the category of communications provider which, in the balance of probabilities, will provide the maximum total economic benefit to member administrations of CEPT.

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B Historical Statistics and Future Forecasts

Data upon which the decision can be based fundamentally falls into two categories:

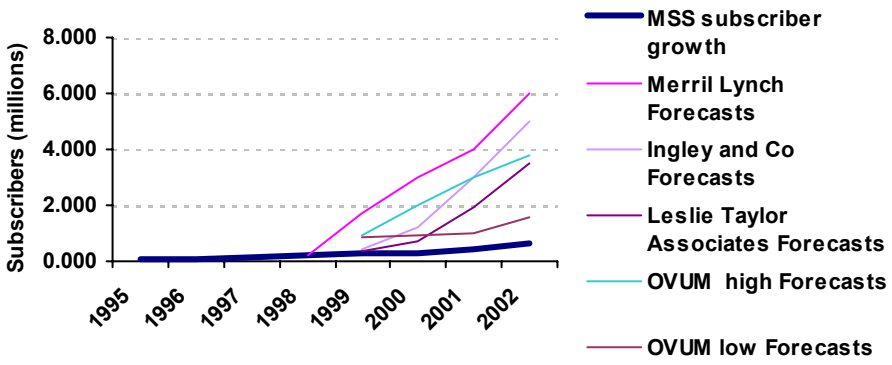
- Historical Statistics — The current and past performance and trends in terrestrial and satellite mobile service industries. Such data is measurable to a reasonable degree of accuracy.
- Future Forecasts — Future forecasts of subscribers and traffic, leading to forecasts of future spectrum requirements. Such data is subject to uncertainty in its accuracy.

To provide context to the accuracy of future forecasts, past forecasts are shown alongside the historical performance of the technologies. GSME welcomes any additional historical forecasts to be included within the analysis.

B.a Historical Subscriber Statistics

B.a.i MSS Historical Subscriber Statistics

The following figure shows the global uptake of MSS over the period 1995 to 2002. At the end of 2002 there were 0.643 million MSS subscribers worldwide[2]. A number of prior subscriber forecasts are shown for comparison purposes.

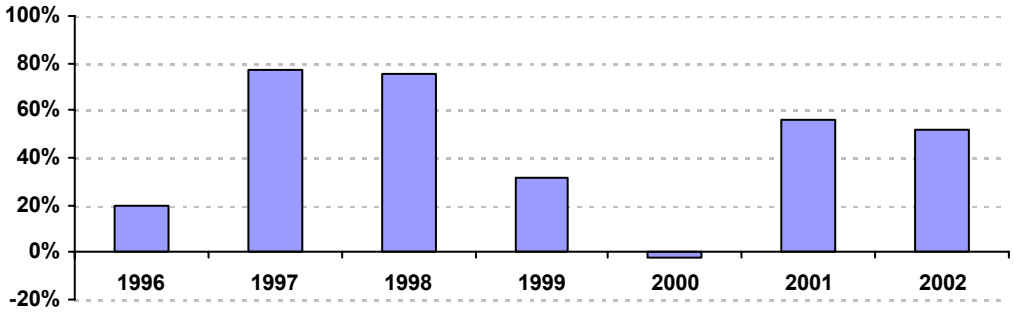


Global MSS Subscriber Growth (1995 – 2002)

A regional subscriber estimation made by Orange based upon usage statistics for INMARSAT in 1998 (the last year of the treaty organisation provisions), estimated that 37% of MSS subscribers are located within Europe. Based on this percentage it can be estimated that at year end in 2002 there were approximately 0.238 million MSS subscribers in Europe.[3]

Subscriber annual growth rates based on the observed growth may be shown to be:

[2] Frequency Arrangements in 2.5GHz Band, ECC-PT1(03) 100, UMTS Forum 2003
[3] GSME welcomes contributions from the MSS industry to improve upon the accuracy of this estimation

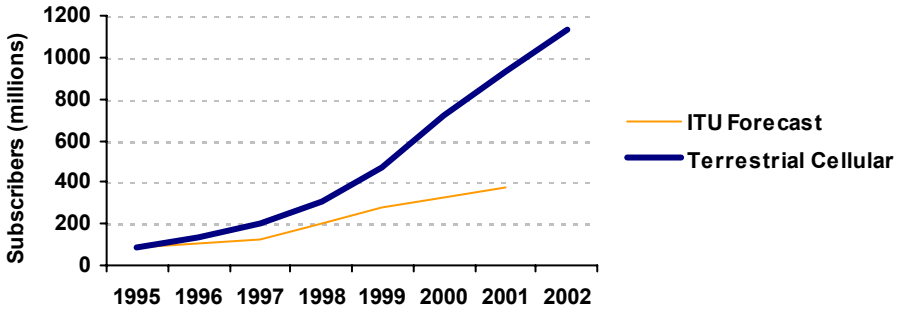


Global MSS Subscriber Annual Growth Rates (1995 to 2002)

The growth achieved by MSS over the period 1995 to 2002 is the equivalent of an average annual growth rate of approximately 41%.

B.a.ii Terrestrial Cellular Historical Subscriber Statistics

The following figure shows the uptake of terrestrial cellular services over the period 1995 to 2002. At the end of 2002 there were 1129.653 million terrestrial subscribers worldwide[4]. One of a number of prior subscriber forecasts are shown for comparison purposes.

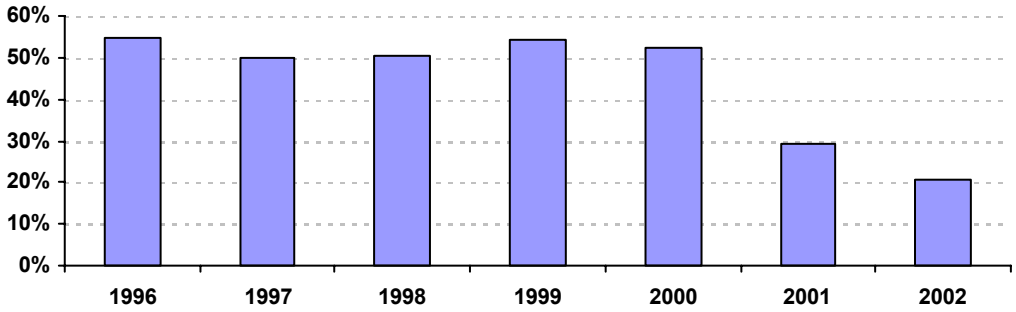


Global Terrestrial Cellular Subscriber Growth (1995 – 2002)

In June 2002 approximately 36.3% of world cellular subscribers were within Western and Eastern Europe[5]. Based on this percentage we estimate that at year end in 2002 there were approximately 410.064 million terrestrial subscribers in Europe.

[4]Frequency Arrangements in 2.5GHz Band, ECC-PT1(03) 100, UMTS Forum 2003

[5] Source EMC World Cellular Database, composite of Eastern and Western Europe percentages. The breakdown for other regions can be viewed at http://www.gsmworld.com/news/statistics/index.shtml



Global Terrestrial Cellular Subscriber Annual Growth Rates (1995 to 2002)

The growth achieved by terrestrial cellular over the period 1995 to 2002 is the equivalent of an average annual rate of approximately 44%.

B.a.iii Comparison of Historical Subscriber Statistics

At the end of 2002, on a global basis for the combined markets, the ratio of subscribers on terrestrial networks to satellite networks was approximately 1757:1. Thus approximately 99.94% of subscribers for the combined market were connected via terrestrial networks and approximately 0.06% of subscribers were connected via satellite networks.

Within Europe at the end of 2002, based on the estimated figures, the ratio of subscribers on terrestrial networks to satellite networks was approximately 1723:1. This is still approximately 99.94% of subscribers for the combined market were connected via terrestrial networks and approximately 0.06% of subscribers were connected via satellite networks.

B.b Allocated Frequencies within IMT-2000 Bands (Excluding 2.6GHz band)

B.b.i Allocated Frequencies for MSS within IMT-2000 Bands (Excluding 2.6GHz band)

Within Europe a total of 159MHz is currently available for MSS services in bands that have been allocated for IMT-2000, excluding the 2.5-2.69GHz band, comprising the following bands:

Uplink Band (MHz)	Downlink Band (MHz)	Bandwidth (MHz)
1626.5 – 1660.5	1525 – 1559	2x 33
1610 – 1626.5	2483.5 – 2500	2 x 16.5
1980 – 2010	2170 – 2200	2 x 30

MSS Allocations Within IMT-2000 Allocated Bands in 2002

It should be noted that systems in the 1980-2010 and 2170-2200 MHz band are not currently deployed. I.e. systems are currently deployed within top two bands, totalling 99MHz.

B.b.ii Allocated Frequencies for terrestrial within IMT-2000 Bands (Excluding 2.6GHz band)

Within Europe a total of 365MHz is currently available for terrestrial mobile services that have been allocated for IMT-2000 and excluding the 2.5-2.69GHz band, comprising the following bands:

Uplink Band (MHz)	Downlink Band (MHz)	Bandwidth (MHz)
880 - 915	925 - 960	2x 35
1710 - 1785	1805 - 1880	2 x 75
1900 – 1920		20
1920 – 1980	2110 – 2170	2 x 60
2020 – 2025		5

Terrestrial Cellular Allocations Within IMT-2000 Allocated Bands in 2002

It should be noted that while there has been wide scale deployment within the IMT-2000 core bands, there has as yet been few commercial launches, and those networks that have been launched are in the early stages of operation. The vast majority of subscribers within Europe at year end 2002 were carried within the 220MHz of spectrum allocated to GSM.

B.b.iii Comparison of Currently Allocated Frequencies within IMT-2000 bands

Currently approximately 70% of the total allocation is to terrestrial mobile, and 30% of the allocation is to satellite.

Within Europe, of the spectrum in wide scale use, approximately 69% of the total allocation is to terrestrial mobile, and 31% of the allocation is to satellite.

B.c Subscribers/MHz

B.c.i MSS Subscribers/MHz

When the number of MSS subscribers is divided by the frequency allocation we can identify the number of subscribers that benefit on average from each MHz of spectrum.

Scenario	Bandwidth (MHz)	European Subscribers (millions)	Subscribers/MHz (thousands)
Current Deployment	99	0.238	2.40
Total Currently Allocated	159	0.238	1.50

Calculation of Subscribers/MHz for MSS in Europe in 2002

B.c.ii Terrestrial Cellular Subscribers/MHz

When the number of terrestrial cellular subscribers is divided by the frequency allocation we can identify the number of subscribers that benefit on average from each MHz of spectrum.

Scenario	Bandwidth (MHz)	European Subscribers (millions)	Subscribers/MHz (thousands)
Current Deployment	220	410.064	1863.93
Total Currently Allocated	365	410.064	1123.46

Calculation of Subscribers/MHz for Terrestrial Cellular in Europe in 2002

B.c.iii Comparison of Subscribers/MHz

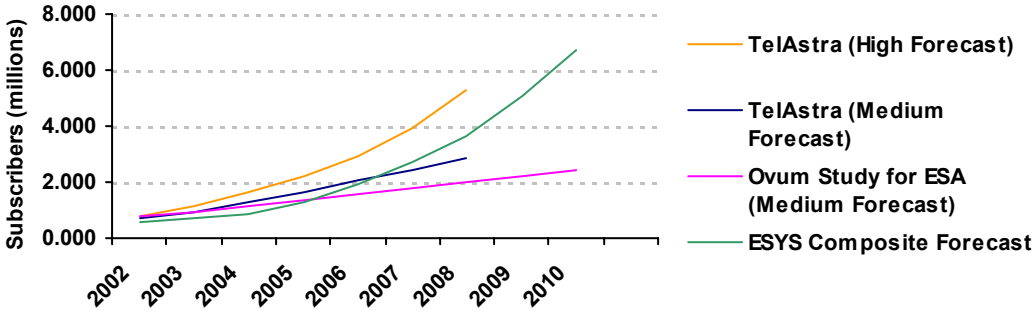
Currently the ratio of subscriber efficiency, as estimated above, is approximately 776:1 for terrestrial to MSS when based on spectrum which is currently deployed, or 749:1 when based upon the total allocation.

B.d Future Subscriber Forecasts

B.d.i Future MSS Forecasts

The following figure shows the forecast uptake of MSS systems. The ESYS composite forecast is currently proposed by the MSS community as the most probable evolution of subscriber numbers. This forecast predicts that there will be 6.685 million subscribers in 2010[6].

[6] Forecast of MSS Traffic and Spectrum Requirements for 2010, ECC-PT1 (03) 118A1, ASMS-TF, 2003



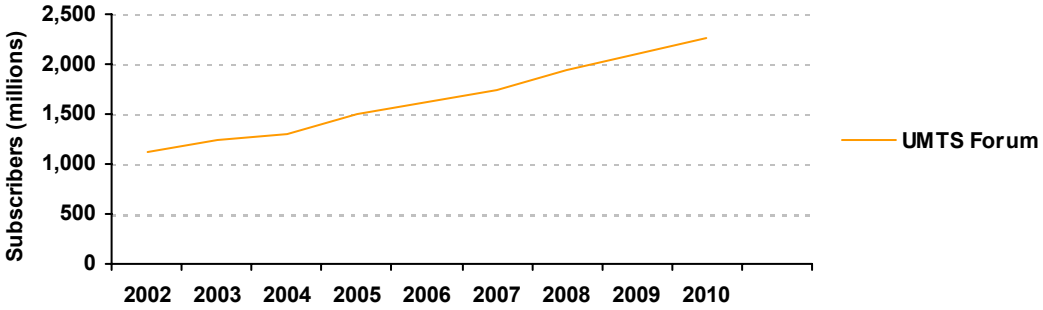
Global MSS Subscriber Growth Forecasts(2002 – 2010)

It has not been possible to identify clearly regional subscriber forecasts. Based upon the historic estimate of 37% used above, this would result in approximately 2.473 million MSS subscribers within Europe.

When considered over the period 2002 to 2010 this would equate to an average annual growth rate of approximately 35%.

B.d.ii Future Terrestrial Cellular Forecasts

The following figure shows the forecast uptake of terrestrial systems. The UMTS Forum forecast predicts that there will be 2260 million terrestrial cellular subscribers in 2010[7].



Global Terrestrial Cellular Subscriber Growth Forecasts(2002 – 2010)

Additionally the UMTS Forum has forecast that of this forecast, there will be 697 million subscribers within Europe in 2010, or 30.8% of the worldwide subscriber base.

When considered over the period 2002 to 2010 this would equate to an average annual growth rate of approximately 9%.

B.d.iii Comparison of Subscriber Forecasts

[7] UMTS Forum 2001

At the end of 2010, on a global basis for the combined markets, the forecast ratio of subscribers on terrestrial networks to satellite networks is approximately 338:1. Thus approximately 99.70% of subscribers will be connected via terrestrial networks and approximately 0.30% of subscribers will be connected via satellite networks.

Within Europe at the end of 2010, based on the estimated figures, the ratio of subscribers on terrestrial networks to satellite networks is approximately 281:1. Thus approximately 99.60% of subscribers for the combined market will be connected via terrestrial networks and approximately 0.40% of subscribers will be connected via satellite networks.

B.e Future allocated Frequencies within IMT-2000 Bands

Ignoring the requirements for guard bands the options are essentially to allocate the 40 MHz of spectrum for satellite IMT-2000 (Option 1) or terrestrial IMT-2000 (Option 2); this is illustrated in the table below.

	Satellite IMT-2000 allocations (MHz)			**Terrestrial IMT-2000 allocations (MHz)**		
	Existing allocations	Additional allocations	Total Satellite	Existing allocations	Additional allocations	Total mobile
Option 1	159	40	199	365	150	515
Option 2	159	0	159	365	190	555

Impact of Different Allocation Options for the 2.6GHz band

Should the 2x20MHz be allocated to Satellite IMT-2000 then 72% of the resource would be allocated to terrestrial and 28% of the resource would be allocated to satellite.

Should the 2x20MHz be allocated to Terrestrial IMT-2000 then 78% of the resource would be allocated to terrestrial and 22% of the resource would be allocated to satellite.

B.f Comparison of Future Subscribers/MHz

B.f.i MSS Forecast Subscribers/MHz

Scenario	**Bandwidth (MHz)**	**European Subscribers (millions)**	**Subscribers/MHz (thousands)**
Option 1	199	2.473	12.4
Option 2	159	2.473	15.6

B.f.ii Cellular Terrestrial Forecast Subscriber Efficiency/MHz

Scenario	Bandwidth (MHz)	European Subscribers (millions)	Subscribers/MHz (thousands)
Option 1	515	697	1353.4
Option 2	555	697	1255.9

B.f.iii Comparison of Forecast Subscribers/MHz

Based on forecasts, as estimated above, there would be approximately a subscribers/MHz ratio of 109:1 for terrestrial to MSS when based on option 1. This becomes 81:1 when based upon option 2.

B.g Additional Sources of data

GSME welcomes the use of additional sources of data in the evaluation of the benefit, and thus optimal allocation of the bands considered.

In particular, GSME acknowledges that subscriber numbers offer a simplistic analysis of the benefit achieved. Different subscribers achieve a different benefit from the systems that they use, and it is a reasonable assumption to assume that the benefit is different for MSS and terrestrial cellular systems. As a result GSME would welcome suggestions of additional metrics that may be used to benchmark the average value achieved by a subscriber between terrestrial systems and MSS systems.

C Additional considerations regarding allocation

C.a Allocation to Satellite IMT-2000

Should the spectrum be allocated to satellite IMT-2000, coexistence with terrestrial IMT-2000 at the boundary between the two technologies would require one of two actions to mitigate against the effects of adjacent system interference:

- Reversal of the terrestrial duplex direction
- Allocation of a guard band between satellite IMT-2000 DL and terrestrial IMT-2000 UL at 2520MHz

These two options are considered in the following sections. In summary:

- *Reversal of the terrestrial duplex direction may require 8% more sites than a conventional duplex direction*
- *Should a guard band be required this may be 20MHz, or 10.5% of the total allocation. This may necessitate a reduction of the terrestrial allocation equivalent to 13.3%.*

C.a.i Reversal of Duplex Direction

If spectrum were allocated to mobile satellite, the mobile satellite service would need to have reversed duplex direction to ensure compatibility with the adjacent radioastronomy band. As a consequence of this it may be necessary for the adjacent terrestrial spectrum to have its duplex direction reversed. Reversing the duplex direction of terrestrial FDD will increase the path loss of the coverage limited uplink. The consequence of further increasing the uplink path loss would be particularly detrimental to any new entrant within the band, or to an existing operator deploying a new and innovative technology requiring contiguous coverage within the band.

To summarise this effect, a simple comparison of frequency dependant path loss using COST-231 Hata was carried out. The frequency dependant path loss term was calculated by the following formula:

$$\textit{Frequency Path Loss (dB)} = 33.9 * \log(\textit{Frequency(MHz)})$$

This is the same approach taken within the 3GPP Feasibility Study into the use of the band[8]. A comparison with the top and bottom frequency of the core band uplink was made with possible uplink bands in 2.6 GHz, assuming only FDD Internal allocation. This is the best case scenario resulting in the least additional path loss due to reversal. This may be visualised in the following diagram:

[8] 3GPP TR 25.889 v6.0.0 (2003-06) Feasibility Study considering the viable deployment of UTRA in additional and diverse spectrum arrangements (R 6)

It should be noted that the 3GPP came to the conclusion that the disadvantage of the 2.6 GHz band was 2.57dB compared to the core band. Note that this was based on calculating a path loss difference between 2.1 GHz and 2.5 GHz, rather than between equivalent points within possible sub-bands.

MSS DL	FDD	Duplex Gap (containing TDD, FDD DL External or other)	FDD	MSS UL
20MHz	60MHz	30MHz	60MHz	20MHz

Frequency Description	Frequency (MHz)	Frequency Path Loss Term (dB)	Difference to Bottom of Core Uplink (dB)	Difference to Top of Core Uplink (dB)
Core Uplink Bottom	1920	111.30	0.00	-0.45
Core Uplink Top	1980	111.76	0.45	0.00
Expansion Conventional Duplex Direction Bottom	2520	115.31	4.00	3.55
Expansion Conventional Duplex Direction Possible Top	2580	115.65	4.35	3.90
Expansion Reverse Duplex Direction Possible Bottom	2610	115.82	4.52	4.07
Expansion Reverse Duplex Direction Top	2670	116.16	4.85	4.40

From the above table we can see with a conventional duplex direction, when looking at the bottom of the uplink band we might expect a disadvantage of 4.0dB compared with the 2 GHz core band, with a reversed duplex direction this becomes 4.5dB, an additional disadvantage of 0.5dB.

If we consider how this will impact the range and area of sites, we can determine that with a reversed duplex direction an additional approximately 6.6%[9] sites are required to provide contiguous coverage when compared with a conventional duplex direction, due to the additional path loss. When compared to the number of sites required to provide contiguous coverage in the 2 GHz core band, reversing the duplex direction increases the number of additional sites required from 64% to 75% for the same mobile transmit power, or if the mobile transmit power is 3dB higher it increases the number of additional sites from 13% to 21%.

[9] Comparing the requirement of an additional 75% of sites for reversed duplex with an additional 64% for conventional duplex (1.75/1.6416 => an additional 6.6% of sites)

The need for additional base stations to compensate for the reversing of the duplex will create further demand for new sites which are already very difficult to find; this will also have associated environmental issues.

Duplex Direction	Mobile Transmit Power (dBm)	Path Loss Difference (dB)	Distance Ratio	Area Ratio	Additional Sites
Conventional	21	-4.00	78.05%	60.92%	64.16%
Reversed	21	-4.52	75.59%	57.14%	75.00%
Conventional	24	-1.00	93.98%	88.32%	13.23%
Reversed	24	-1.52	91.02%	82.84%	20.71%

Should less FDD Internal Spectrum be allocated this will increase the impact of reversing the duplex direction. For example should only 2x30MHz be allocated the scenario will become:

MSS DL	FDD	Duplex Gap (containing TDD, FDD DL External or other)	FDD	MSS UL
20MHz	30MHz	90MHz	30MHz	20MHz

This scenario results in an additional path loss of 0.7dB, which in turn leads to an additional 9 % of sites to provide contiguous coverage.

It should be noted that this analysis relies upon the COST-231 Hata model. Analyses based upon the COST-231 Walfisch-Ikegami model[10] can show up an 15% reduction in coverage due to reversal of duplex direction, from an additional path loss of approximately 1.35dB.

It should be noted, that while IMT-2000 core band operators have the possibility of utilising additional terrestrial spectrum purely for capacity enhancement purposes, and to a certain extent the coverage disadvantage may be controlled by radio resource management algorithms, this would not be an option for a new operator within a market, or for any new technology requiring contiguous coverage.

The result of reversing the duplex direction is a reduced value of spectrum for existing terrestrial operators, an increased barrier to market entry for a new operator and an increased barrier to innovation and the use of new technologies. For a network designed to provide contiguous coverage at 2.6GHz more than 6.6% additional sites may be required.

C.a.ii Allocation of a Guard Band

[10] As recommended in urban and suburban areas by ITU-R in ITU-R M 1034-1 'Requirements for the radio interface(s) for International Mobile Telecommunications 2000 (IMT-2000)'

If the duplex direction is not reversed then a guard band would be required at 2520MHz.

Studies have identified that to support such a configuration the following guard bands would be required[11]:

IMT-DS (FDD) uplink adjacent to 2 520 MHz	Requires guardband of 20 MHz for S-DMB. For SRI-E, MESs may not be able to operate in pedestrian-micro areas.

It should be noted that a 20MHz guard band is 10.5% of the 190MHz of the 2.6GHz band.

Such a guard band would need to be allocated from the spectrum available to the terrestrial component. If any of the guard band were allocated from the satellite IMT-2000 element the result would be a greater allocation required for the guard band than is additionally allocated to satellite IMT-2000 downlink. As a result the total spectrum available for allocation to terrestrial IMT-2000 would be reduced to 130MHz. This is a reduction of 13.3% of the spectrum available to terrestrial IMT-2000.

This effectively modifies the ratio of resources allocated to terrestrial IMT-2000 and satellite IMT-2000. With a 20MHz guard band removed 29% of the total resource would be allocated to satellite and 71% of the resource allocated to terrestrial.

The result of allocating a guard band to allow compatibility with satellite IMT-2000 systems is that a significant amount of spectrum would be required as a guard band, and be unused for either system.

[11] Sharing and adjacent band compatibility between Terrestrial IMT-2000 and the Mobile-Satellite Service in the 2.5 GHZ band, Liaison statement from WP8D to WP8F, 5th December 2003