SAMENA Response to TRA Bahrain Consultation on “Award of 800 and 2600 MHz Bands” (TOD/0818/006)

October 2018

Introduction

SAMENA Telecommunications Council welcomes the opportunity to respond to this important consultation in the Kingdom of Bahrain. As outlined below SAMENA Telecommunications Council is an industry association that represents the interests of our members in the region. Our members include the current mobile operators in Bahrain, namely Batelco, Viva, and Zain. In consultation with them SAMENA has prepared this response.

SAMENA has investigated some of the engineering issues related to potential cross-border interference issues, and their possible impacts on 4G/5G deployments in Bahrain. Paragraph 55 of the consultation notes that there are no multilateral agreements with The Kingdom of Saudi Arabia, or The State of Qatar, to control the border spillover of harmful interference. Paragraph 57 notes it is for operators to investigate and assess the potential implications of possible cross-border interference.

SAMENA and its local operator members in Bahrain believe that a common approach, to some elements of cross-border interference, would be in the interests of all parties. Agreement on particular elements could help reduce uncertainty on the use of these bands in Bahrain, and ultimately help promote faster and economically efficient deployment. SAMENA believes this would be in the interests of all operators, as well as Bahraini consumers, and the economy.

SAMENA has undertaken an initial engineering analysis of the potential for cross-border harmful interference based on internationally best practice, as well as relevant technical standards for 4G/LTE network deployment. Based on such levels and the typical parameters for base station transmitters we have examined the potential interference issues. SAMENA believes that this analysis could serve as a starting point for discussions with interested parties to help facilitate a timely and appropriate multilateral agreement.

It seems clear that lack of cross-border interference control agreements could have a major impact on the speed and cost of mobile network deployment.

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About SAMENA

SAMENA Telecommunications Council[1] is tri-regional not-for-profit industry association spanning more than 25 countries, including Afghanistan, Algeria, Bahrain, Bangladesh, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Nepal, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Sri Lanka, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, and Yemen. It represents the interests of more than 85 telecom operators and service providers in the fixed and mobile space, and stakeholders from the wider digital ecosystem, including technology-, equipment- and software manufacturers, internet companies, consulting companies, academia and regulatory authorities.

It is SAMENA's mission to serve as a sector-development partner to governments and industry for the joint creation of a flourishing and sustainable ICT sector to enable sustainable digital transformation. Our key objectives are to enable sustainable growth, incentivize investments and broaden value creation through effecting adoption of new regulatory approaches in the areas of Digital Services, Data Regulation, Spectrum Management, and Industry Fees & Taxation.

Discussion of the Engineering Issues

Approach

The general method used in this paper is to equate an LTE base station power to an electric field strength at the transmitter *(Tx_FS*[2]). The maximum interfering electric field strength that an LTE receiver can work in is then derived (*Rx_Sens*). This value is either calculated (using 3GPP standards) or a figure is taken from a CEPT recommendation. The difference between the maximum interfering field strength an LTE receiver can tolerate, and the field generated by a base station is calculated. This difference is the propagation path loss required to prevent cross-border interference, as shown in the equation below.

$$\text{TX\_FS} - \text{Rx\_Sens} = \text{required Path Loss} \qquad \textbf{equation 1 (in dBs)}$$

This is then compared with path losses likely from Bahrain to Qatar and Saudi Arabia. These path losses are calculated using publicly available software. The results are indicative and would need to be refined using more test points. It should also be remembered that these would be "trigger values" and would not necessarily mean there would be cross-border interference, but that more detailed study would be required.

The Bands and technologies

All other things being equal, one would imagine the 800 MHz band would give rise to the greatest potential for cross-border interference, because of its propagation characteristics (as compared to 2.6 GHz). However, the LTE 800 MHz (3GPP band 20) is FDD, and as such the most difficult interference case of a base station transmitting on the same channel as a base station receive is avoided.

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[1] https://www.samenacouncil.org/index

[2] The field strength at 1m is used.

The consultation document highlights the choice of FDD or TDD[3] for the 2600 band. Thus, there is the added complication of a base station transmitting on a channel being used for a base station receiver (if one country uses FDD and the other TDD). This is because the 2600 band can be used for either FDD (band 7) or all TDD (band 41). If Bahrain were to select FDD for 2600 MHz, and Saudi Arabia were to select TDD, this would effectively add the gain of the base station antenna to the interference link budget. Hence the cross-border field strength level may have to be reduced by around 18 dB as compared to 800 MHz (even allowing for any frequency corrections). There would also be the extra height gain to be considered as the receiver would no longer be a mobile near the ground, but potentially a high mast.

The analysis below assumes a 10 MHz channel bandwidth as a more likely figure than 5 MHz, which is quoted in CEPT figures (although CEPT gives the conversion formula for other bandwidths).

The CEPT also assumes that the impact of cross-border interference is reduced significantly if centre frequencies are not aligned, or if preferential physical-layer cells identities (PCIs) are used. As there are some 504 PCIs available, it is assumed that these can be shared equitably between all 3 administrations - to help reduce the impact of such interference in border locations. If that were not the case, it should still be possible to use centre frequency offsets as a fall-back.

800 MHz Band

CEPT field strength levels

There are a number of cross-border agreements that cover the issue of interference spillage mentioned in paragraphs 55 and 56 of the consultation. CEPT/ECC Recommendation (11)04 deals with 790 – 862 MHz for terrestrial mobile/fixed communications. It details specific field strength levels as well as other information (such as information to be exchanged and guidance on propagation models). An extract of the recommendation is given in Annex 1 showing the appropriate electric field strength values that should be applicable at the borders.

It can be seen from the table that at the border a level of 62.0 dBμV/m/10MHz [4] is suggested, if the centre frequencies are not aligned, or PCIs are shared (measured 3m from the ground). It seems likely that the primary use of these bands will be for LTE/4G/5G and 10 MHz is a common choice for operators for LTE.

The ECC recommendation does not specify how the levels of electric field strength were calculated. SAMNEA believes that this 62 dBμV/m/10 MHz (at 3m) figure is probably the most appropriate level to be used in this situation.

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[3] Frequency division and time division duplex.

[4] The figure given is 59 dB for centre frequencies aligned using preferential PCI codes per 5MHz. 3dB is added to convert to a 10 MHz channel.

Using 3GPP standards to derive a field strength value

SAMENA believes that it is also important to be able to derive a figure using the relevant 3GPP standards, to allow comparison of the two numbers (the CEPT value and a calculated value).

Using the assumption of LTE deployment allows for the appropriate figures from the 3GPP standards to be used[5]. According to 3GPP TS 36.141 (v14.3.0 release 14) the test requirement for in-channel selectivity is given in table 7.4-1. The table suggests a figure of -77 dBm for an E-UTRA bandwidth of 10 MHz. The in-channel selectivity is a measure of the receiver's ability to receive a wanted signal in the presence of interference on the same channel, with a wanted signal specified at -96.7 dBm. At -77 dBm the receiver can achieve a throughput of at least 95% of its maximum for a 10 MHz channel, operating near its maximum usable sensitivity (thermal noise floor plus the receiver noise figure).

Using formulas in ITU-R P.525-3, it is possible to convert this -77 dBm power in the victim receiver to a field strength level of 58.3 dBμV/m for a 10 MHz channel. This is 4 dB less than the CEPT value (62 dBμV/m for 10 MHz) – if preferential PCIs are assumed. It seems to SAMENA that the two approaches are consistent, especially if one assumes the use of preferential PCIs probably adds to the in-channel selectivity. SAMENA therefore suggests this 62 dBμV/m per 10 MHz (at 3m) figure, at the border could be used as a starting point.

Analysis using 62 dBμV/m as the border limit

A typical LTE base station might be 25 W power and 18 dBi antenna gain, which is around 1300 W EIRP (31 dBW). Assuming a 1300 W LTE base station (EIRP) equates to a **field strength of some 166 dBμV/m**. For this to fall to 62 dBμV/m requires 104 dB of path loss. For free space this is around 4.6 km (at 800 MHz). In practice there will be greater loss due to diffraction (if there is no line of site path).

If PCI preferential codes are not used, or centre frequencies are aligned, the CEPT figure gives 44 dBμV/m per 10 MHz (at 3m) figure. This would require 122 dB path loss, which we might think of as "worst case" and would require around 35 km free space loss. In practice the diffraction loss will tend to add loss to the free space figure (as noted in *equation 6* of ITU Recommendation P.526-7).

To give a more accurate picture it is necessary to look more closely to see what the likely propagation loss is, considering the earth's curvature and actual terrain profiles. Using publicly available software the following results were obtained (see Annex 3 for full details):

Bahrain to Saudi Arabia path is about 40 km (Riffa to Al Khobar) with a free space loss of 122.5 dB and with a minimum diffraction loss of 13.5 dB (136 dB total). This should provide the 104 dB required based **on this initial analysis**. However, the coverage of traffic over the bridge will need a special arrangement.

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[5] http://www.3gpp.org/

Bahrain to Qatar path (Petal Beach to nearest landfall near Al Nu'man) is 35.5 km. The worst part would be Hawar Island which is adjacent to Qatar territory. This may need some sort of preferred frequency block arrangement.

For the suggested path (from Petal Beach), the distance is 35.5 km, with a free space loss of 121.5 dB and a minimum diffraction loss of 16.5 dB (138 dB total). Apart from Hawar Island there should be enough path loss to meet the figure of 62 dBμV/m.

It should also be remembered that the CEPT figures are for 3m above ground (mobile reception), whereas the plots assume 20m or more. Reducing the height of the receiver to 3m will increase the path loss.

Conclusion on 800 MHz

It appears that even if the "worst case" figure of 44 dBμV/m is used there would likely be enough path loss in most cases. **However, in the interests of efficient management of the scarce resource of spectrum, the figure of 62 dBμV/m per 10 MHz (at 3m) would seem to be a suitable basis of future discussions, in conjunction with using preferential PCI codes (or ensuring centre frequencies are not aligned).**

2600 MHz Band

As mentioned above, in this case there is the added complexity of if the band will be used for all TDD (band 41) or adopt a portion for FDD (band 7).

The consultation document raises the options of either FDD or TDD, and notes a preference for the FDD option, but that this can be revisited. The difficulty comes if Saudi Arabia were to latter decide to implement TDD after Bahrain operators deployed FDD.

Ideally, in terms of controlling cross-border interference it would be best for all countries in an area to use the same band plan. The most difficult will be when base transmit of one country uses the base receive band of another. This is because you effectively have the gain of the victim receiver being 18 dB or so, as compared with 0 dB (or less) in a mobile. You also have to add in the height gain of the base station (field strength will tend to increase the higher up one measures).

Using the same 3GPP analysis for this as above (-77 dBm maximum received power in the victim) suggests a field strength of 68 dBμV/m per 10 MHz in this band. This agrees with the value given in Recommendation (11)05 for the 2.6 GHz band. However, this is for FDD (preferential PCIs or centre frequencies not aligned). For TDD unsynchronised, the figure given by CEPT is 33 dBμV/m for 10 MHz. This is some 35 dB tighter than for FDD.

This would be the case effectively is Bahrain were to use FDD (band 7) when Saudi Arabia decided to use TDD in the whole 2.6 GHz band (band 41).

A simple analysis would be to assume the figure for unsynchronised TDD should be the FDD figure plus 18 dB for the victim receiver gain (base station), but another 17 dB has been added. But that would ignore the fact that the victim receiver (a base station) would not be at 3m but rather at 20m or more. Hence there is a significant height gain, i.e. the field strength at 20 m is greater than at 3m. The exact amount of height gain to be used would need to be explored further but moving from 3m to say 30m could be significant. According to *CEPT Report 29* moving from 1.5m to 10m receiver height, at 800 MHz, can increase the field strength by 18 dB (Section 4.2). In practice the height gain's maximum value will generally be limited to that value which gives the total propagation loss as the line of sight value.

Analysis using 33 dBμV/m per 10 MHz (at 3m) as the border limit

The plot for 2.6 GHz (Bahrain to KSA) shows a path loss of around 145 dB. To meet the 33 dBμV/m requires 133 dB of path loss (166-33), which is met in this situation. The plot also assumes a 50m height receive antenna, so one might argue using the 33 dBμV/m is too conservative.

Overall Conclusions

SAMENA Telecommunications Council believes that the issue of cross-border spillover and interference agreements is an important issue, and one that would benefit from an agreed position of all interested parties based on best engineering practice. Such agreements should be actively pursued as soon as possible.

SAMENA Telecommunications Council has given an outline of a possible approach, but further work would be required. This should specifically include more extensive link plots to calculate the likely path loss that would be applicable, using current base station deployment information. As SAMENA understands it there are some 1,500 sites in Bahrain currently[6] and that plots should be done from a suitable sample of these.

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[6] https://www.towerxchange.com/wp-content/uploads/2018/07/TX_MENAProspectus_2019.pdf

Annex 1

Extract ECC Recommendation (11)04 - Amended Feb. 2017

Cross-border Coordination for Mobile/Fixed Communications Networks (MFCN) in the frequency band 790-862 MHz

The following table gives an overview of the trigger values of the field strength and the relevant sections of this Annex.

Table 1: Trigger values at a height of 3 m above ground for MFCN FDD systems

Non-Preferential frequency usage			**Preferential frequency usage**
Centre frequencies aligned		**Centre frequencies not aligned**	Based on bi-or multilateral agreements/ arrangements (paragraph 3)
Using preferential PCI codes	Using non-preferential PCI codes	Using all PCI codes	
59 dBµV/m/5 MHz@0 km and 41 dBµV/m/5 MHz@6 km (paragraph 1)	41 dBµV/m/5 MHz@0km (paragraph 2)	59 dBµV/m/5 MHz@0 km and 41 dBµV/m/5 MHz@6 km (paragraph 1)	

@ stands for “at a distance inside the neighbouring country”.

For field strength predictions the calculations should be made according to Annex 3. In the case of channel bandwidth other than 5 MHz, a factor of 10 x Log_{10} (channel bandwidth[1]/5MHz) should be added to the field strength values.

Table 2: Trigger values at a height of 3 m above ground between TDD systems

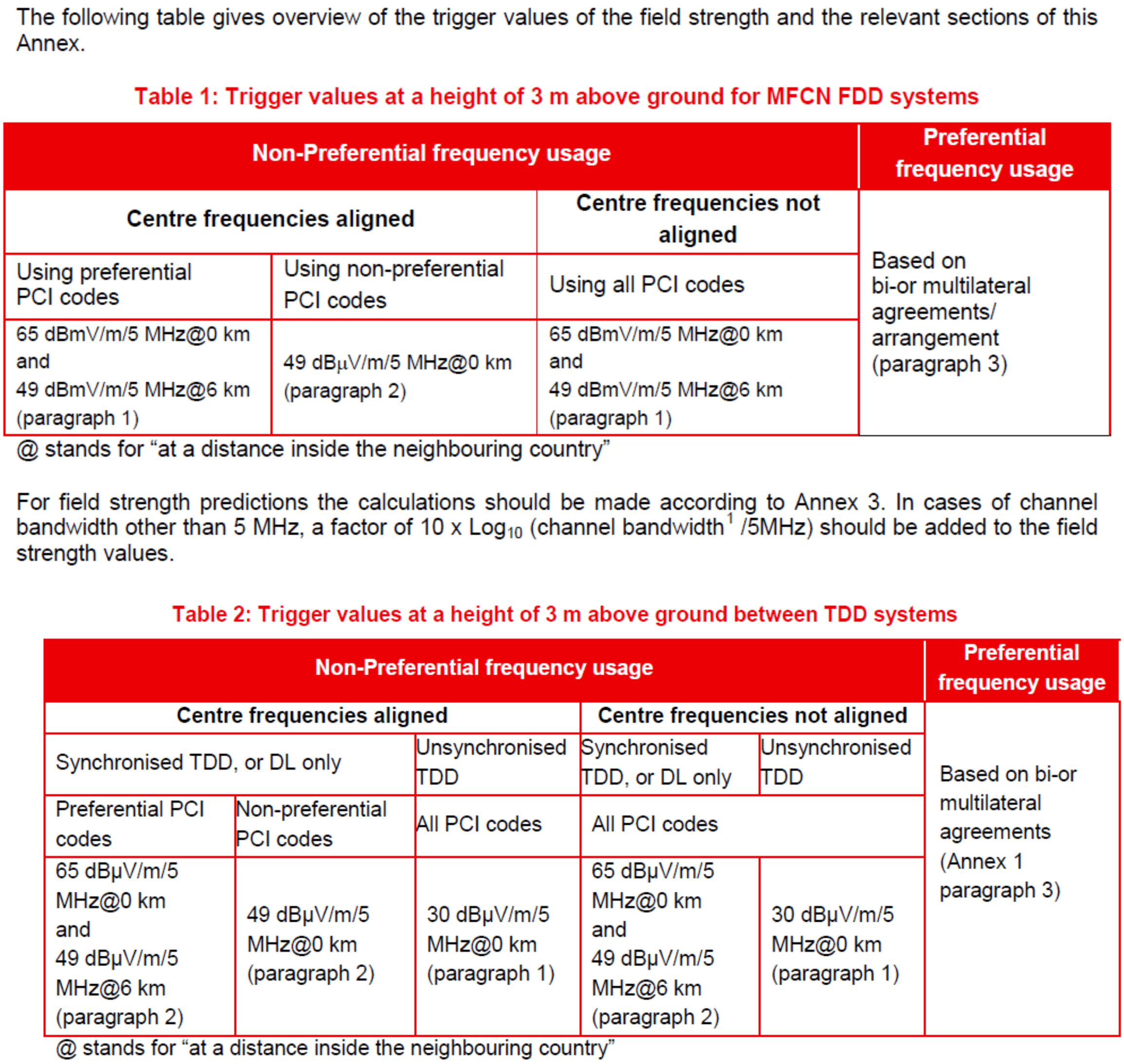
Non-Preferential frequency usage					**Preferential frequency usage**
Centre frequencies aligned			**Centre frequencies not aligned**		Based on bi-or multilateral agreements (Annex 1 paragraph 3)
Synchronised TDD, or DL only		Unsynchronised TDD	Synchronised TDD, or DL only	Unsynchronised TDD	
Preferential PCI codes	Non-preferential PCI codes	All PCI codes	All PCI codes		
59 dBµV/m/5 MHz@0 km and 41 dBµV/m/5 MHz@6 km (paragraph 2)	41 dBµV/m/5 MHz@0 km (paragraph 2)	24 dBµV/m/5 MHz@0 km (paragraph 1)	59 dBµV/m/5 MHz@0 km and 41 dBµV/m/5 MHz@6 km (paragraph 2)	24 dBµV/m/5 MHz@0 km (paragraph 1)	

@ stands for “at a distance inside the neighbouring country”.

Annex 2

Extract ECC Recommendation (11)05 - Amended Feb. 2017

Cross-border Coordination for Mobile/Fixed Communications Networks (MFCN) in the frequency band 2500-2690 MHz



The following table gives overview of the trigger values of the field strength and the relevant sections of this Annex.

Table 1: Trigger values at a height of 3 m above ground for MFCN FDD systems

Non-Preferential frequency usage			Preferential frequency usage
Centre frequencies aligned		Centre frequencies not aligned	Based on bi-or multilateral agreements/ arrangement (paragraph 3)
Using preferential PCI codes	Using non-preferential PCI codes	Using all PCI codes	
65 dBmV/m/5 MHz@0 km and 49 dBmV/m/5 MHz@6 km (paragraph 1)	49 dBµV/m/5 MHz@0 km (paragraph 2)	65 dBmV/m/5 MHz@0 km and 49 dBmV/m/5 MHz@6 km (paragraph 1)	

@ stands for "at a distance inside the neighbouring country"

For field strength predictions the calculations should be made according to Annex 3. In cases of channel bandwidth other than 5 MHz, a factor of 10 x Log_{10} (channel bandwidth[1] /5MHz) should be added to the field strength values.

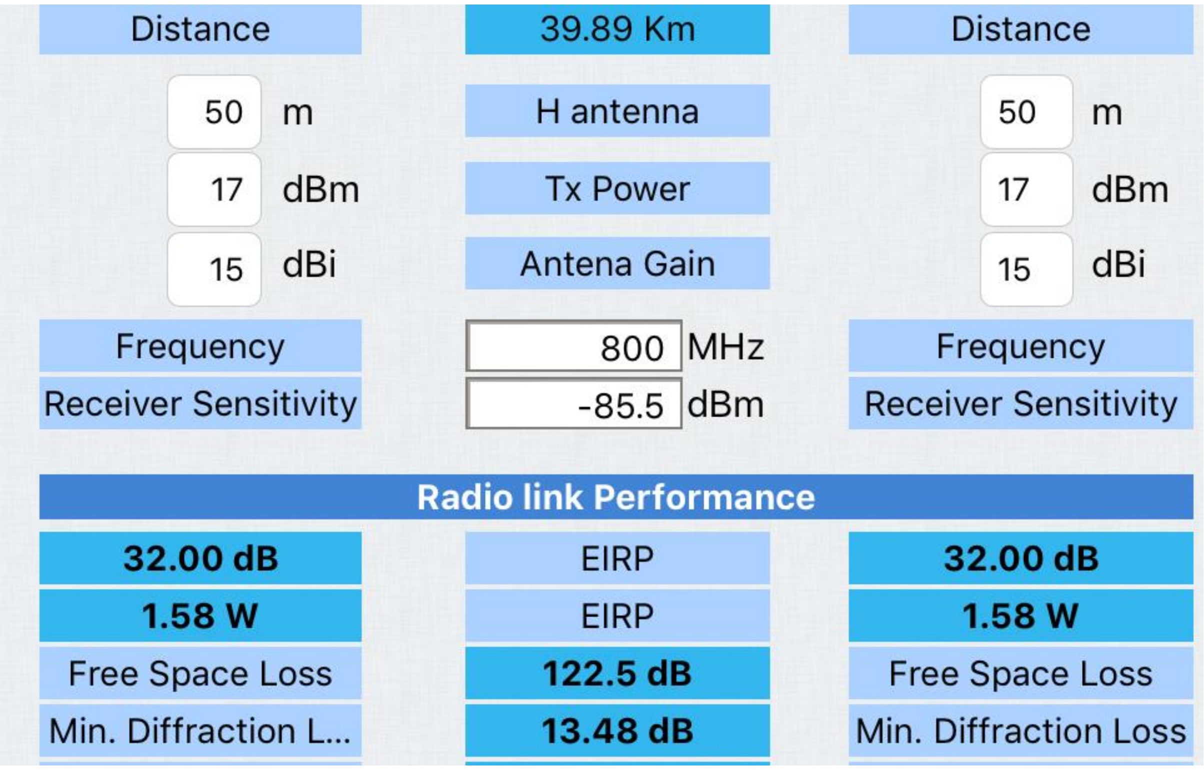
Table 2: Trigger values at a height of 3 m above ground between TDD systems

Non-Preferential frequency usage					Preferential frequency usage
Centre frequencies aligned			Centre frequencies not aligned		Based on bi-or multilateral agreements (Annex 1 paragraph 3)
Synchronised TDD, or DL only		Unsynchronised TDD	Synchronised TDD, or DL only	Unsynchronised TDD	
Preferential PCI codes	Non-preferential PCI codes	All PCI codes	All PCI codes		
65 dBµV/m/5 MHz@0 km and 49 dBµV/m/5 MHz@6 km (paragraph 2)	49 dBµV/m/5 MHz@0 km (paragraph 2)	30 dBµV/m/5 MHz@0 km (paragraph 1)	65 dBµV/m/5 MHz@0 km and 49 dBµV/m/5 MHz@6 km (paragraph 2)	30 dBµV/m/5 MHz@0 km (paragraph 1)	

@ stands for "at a distance inside the neighbouring country"

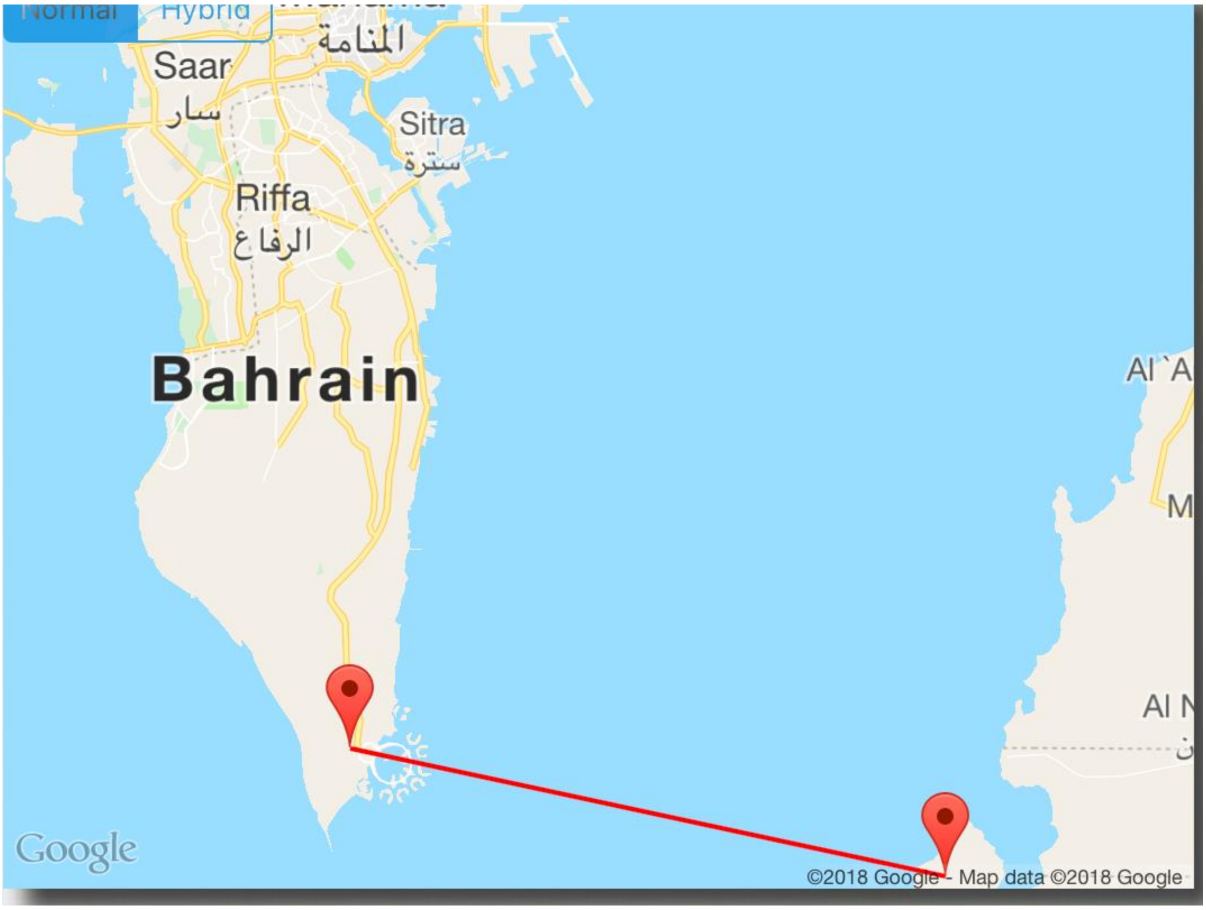
Annex 3 – Link plots for path loss

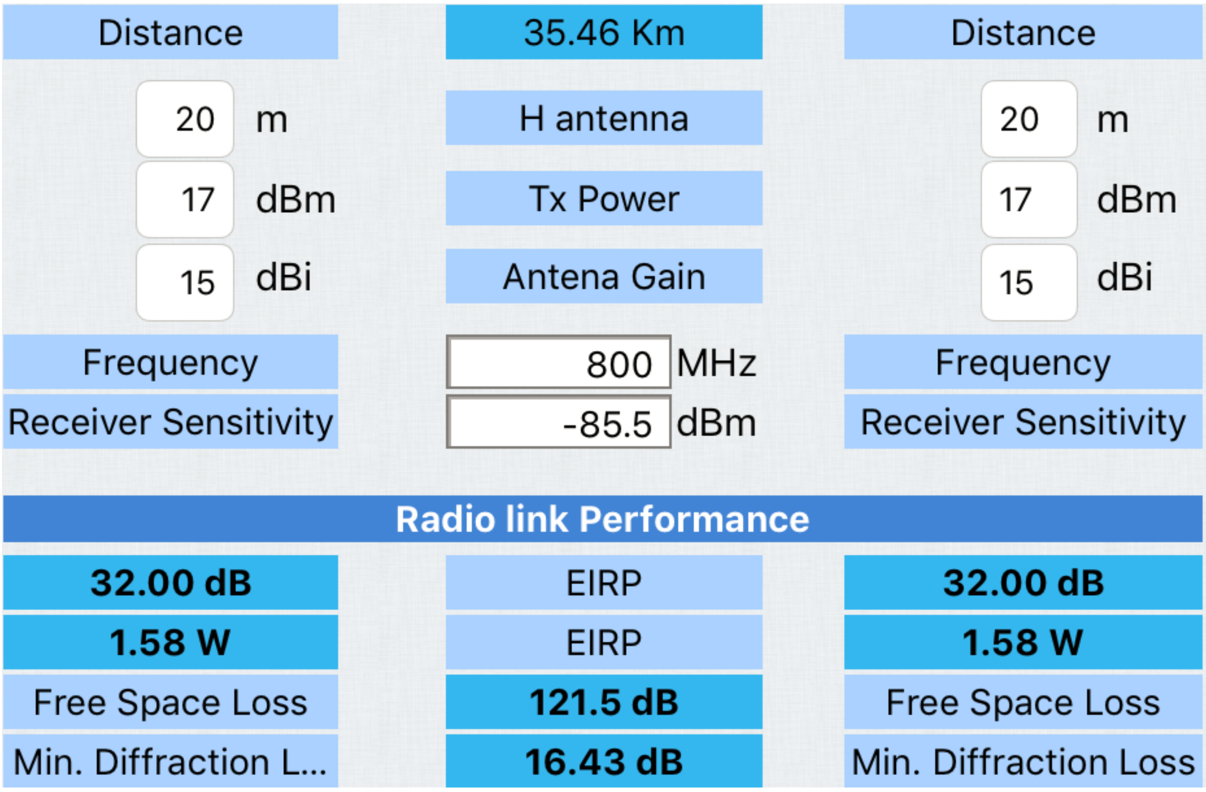
KSA- Bahrain (800 MHz)



Distance	39.89 Km	Distance
50 m	H antenna	50 m
17 dBm	Tx Power	17 dBm
15 dBi	Antena Gain	15 dBi
Frequency	800 MHz	Frequency
Receiver Sensitivity	-85.5 dBm	Receiver Sensitivity
	Radio link Performance	
32.00 dB	EIRP	32.00 dB
1.58 W	EIRP	1.58 W
Free Space Loss	122.5 dB	Free Space Loss
Min. Diffraction L...	13.48 dB	Min. Diffraction Loss

Qatar – Bahrain (800 MHz)

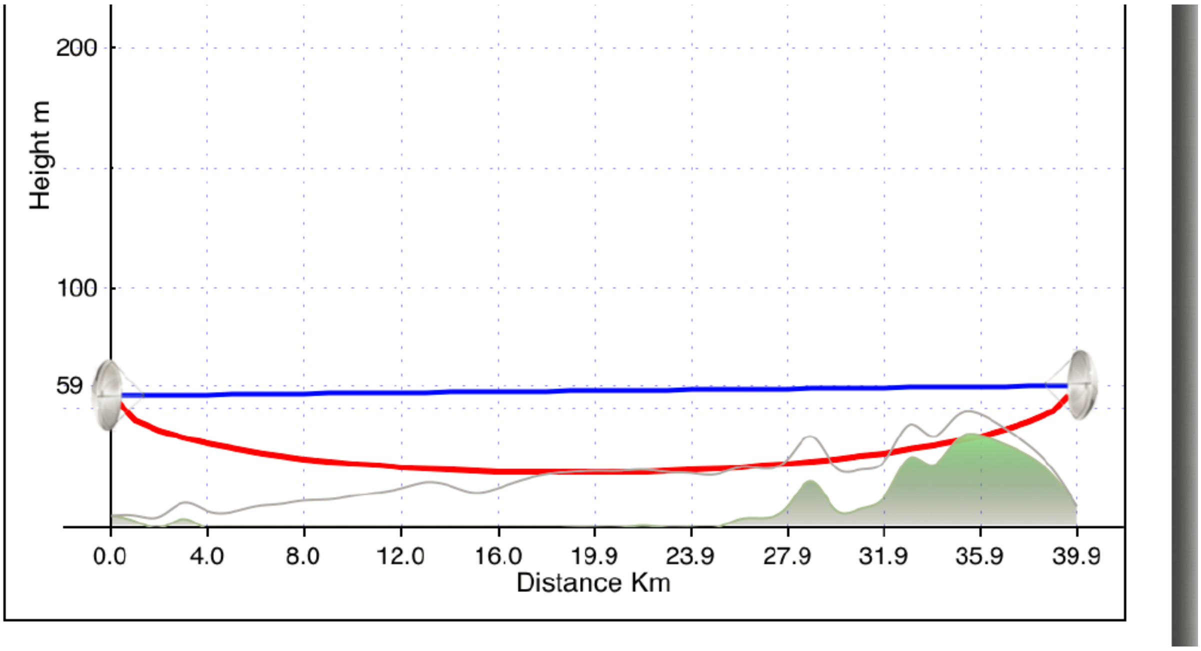


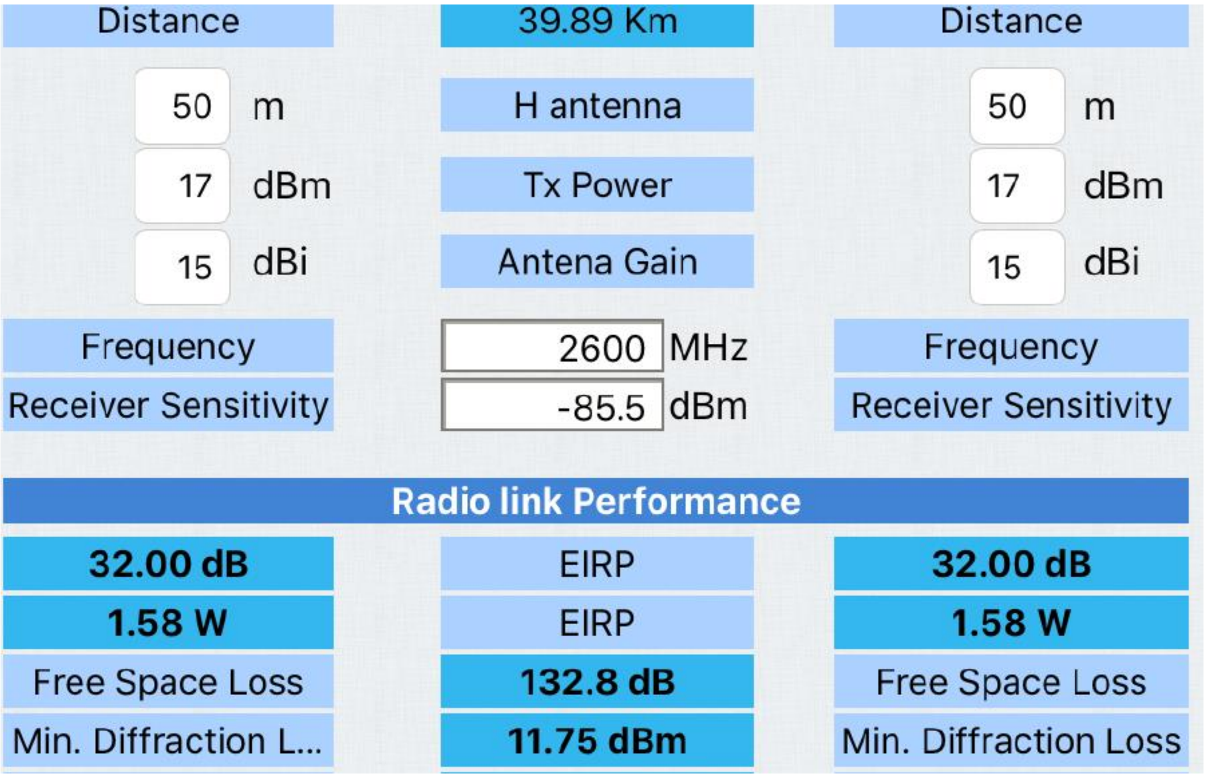


Distance	35.46 Km	Distance
20 m	H antenna	20 m
17 dBm	Tx Power	17 dBm
15 dBi	Antena Gain	15 dBi
Frequency	800 MHz	Frequency
Receiver Sensitivity	-85.5 dBm	Receiver Sensitivity
	Radio link Performance	
32.00 dB	EIRP	**32.00 dB**
1.58 W	EIRP	**1.58 W**
Free Space Loss	**121.5 dB**	Free Space Loss
Min. Diffraction L...	**16.43 dB**	Min. Diffraction Loss

KSA – Bahrain (2600 MHz)

(same path as 800 MHz)





Distance	39.89 Km	Distance
50 m	H antenna	50 m
17 dBm	Tx Power	17 dBm
15 dBi	Antena Gain	15 dBi
Frequency	2600 MHz	Frequency
Receiver Sensitivity	-85.5 dBm	Receiver Sensitivity
	Radio link Performance	
32.00 dB	EIRP	**32.00 dB**
1.58 W	EIRP	**1.58 W**
Free Space Loss	**132.8 dB**	Free Space Loss
Min. Diffraction L...	**11.75 dBm**	Min. Diffraction Loss