Interference Mitigation between CDMA2000-1x & E-GSM networks at border areas

Indonesia – Singapore – Malaysia

ITU Workshop on cross border Radio Frequency Management in Arab States

26th January 2017

Dubai, United Arab Emirates

International Telecommunication Union

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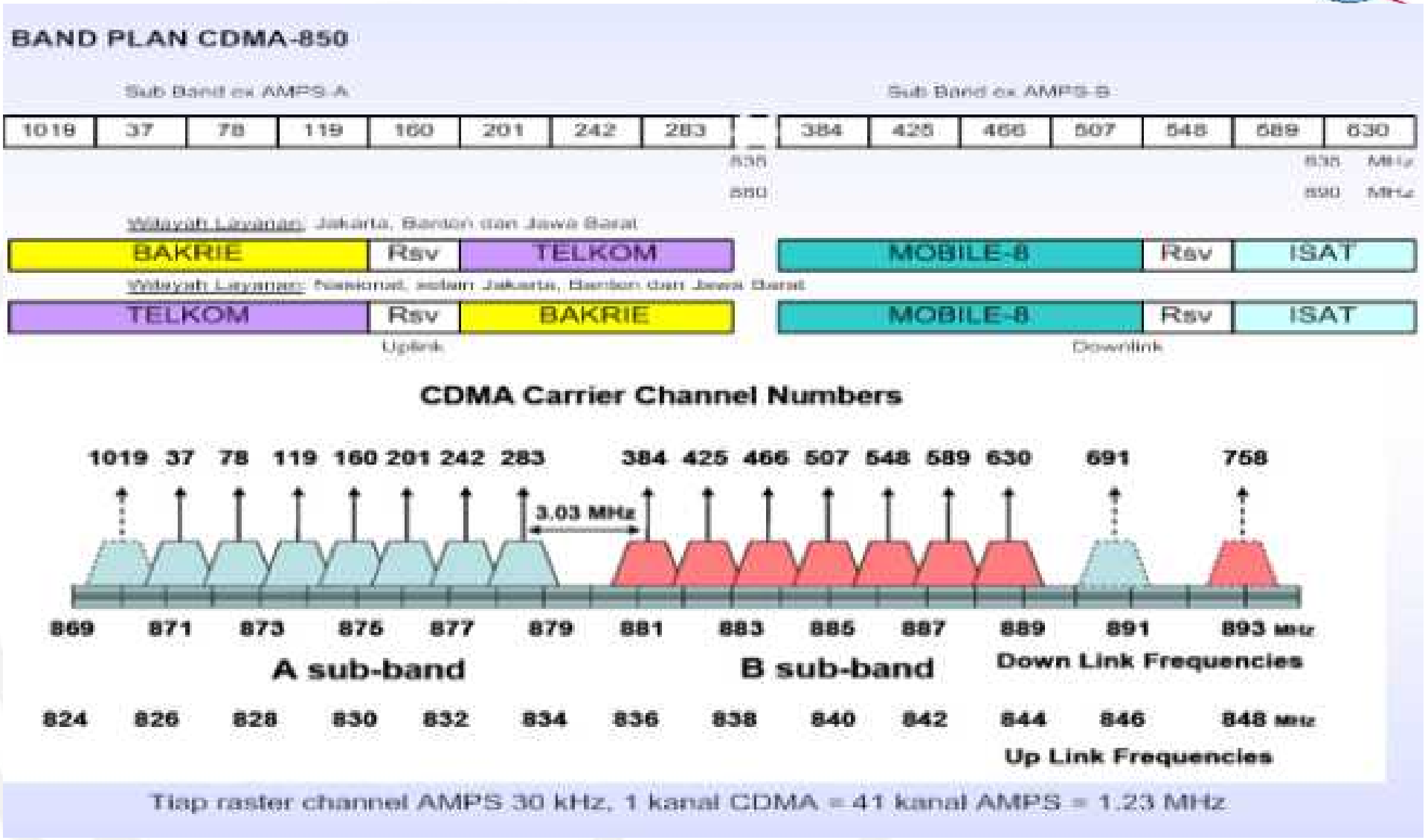
Objectives

- **To have a fair, transparent and accountable assessment of current 880-890MHz band spectrum usage**
  - *For E-GSM and CDMA operations, by individual countries involved i.e. Indonesia (Batam), Malaysia (South Johar) and Singapore on border areas.*
  - *The level (RF) of the interference received by countries due to operations on different technologies*
- **Study mutually favorable possibilities of spectrum utilization**
  - *While respecting the right of each country to be able to use the allocated spectrum without harmful interference within its territory,*
- **Provide NON-BINDING recommendations based on the practical measurement.**

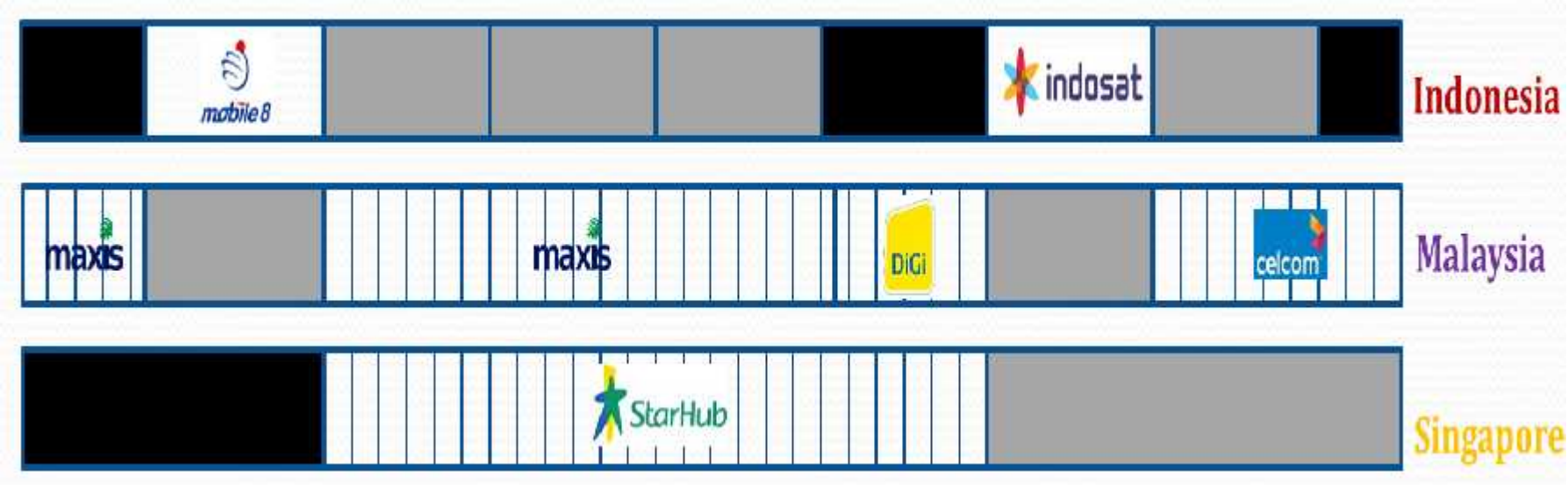
Problem



850 MHz band plan in Indonesia

Problem

Band Splitting Arrangement before study



Project Activities

Project Activities … Concept Paper

➢ Concept Paper

- Defines the project objectives, scope and outcomes.
- Details of the roles of the each partner and stakeholder along-with their respective responsibilities.
- Financial contributions

Developed, discussed and agreed between partners as a first step of the project

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Project Activities … Measurement Methodology

➢ Measurement Methodology

- Objective is to evaluate:
  - Practical worst case scenarios
  - Possible solutions of co-existence with dissimilar technologies *(through recording the results of variation of technical parameters)*

- Provides technical parameters to conduct the measurements including:
  - Identification of Transmitters and Receivers
  - Identification of test Radio Frequencies

- Mitigating interference by studying the effects of
  - Space and Time Diversity
  - Antenna tilting and Adjusting Height
  - Ducting
  - O/P Power adjustments
  - Use of reflectors and natural or artificial obstacles
  - Comparing results of simulation and practical measurements

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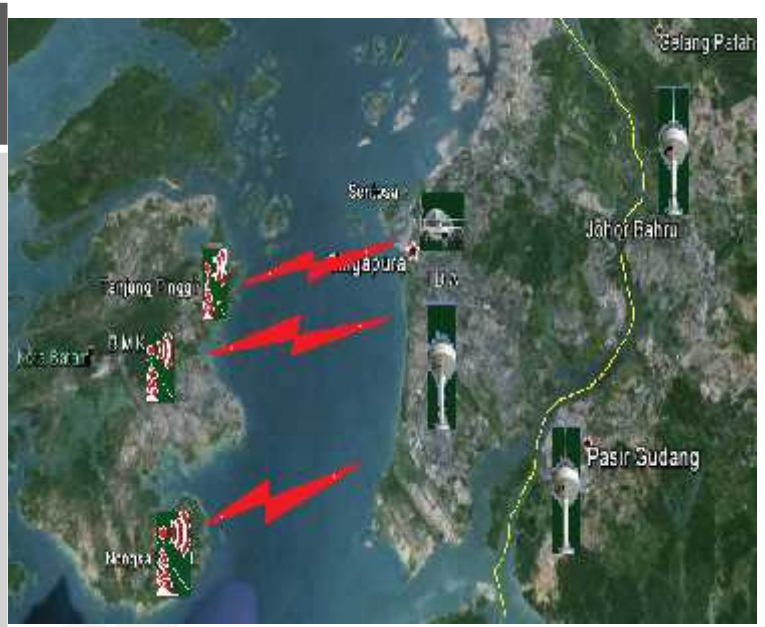
Developed, extensively discussed/modified and agreed between partners and stakeholders of project

Project Activities … Measurement Methodology

Example of Methodology: Test Site Overview

Item With Reference to Fig	Explanation	Details
	Transmitter sites – Actual CDMA BTS in Indonesia sites facility provided by Smartfren and Indosat	**1. BUKIT MATA KUCING - BMK** Coordinates : N1 05 25.5 E103 58 15.4 Height from ground : 114 m TX Signal: 880.025 MHz (F1) – 30 KHz with FM **2. NONGSA** Coordinat : N1 11 43.2 E104 06 06.0 Height from ground : 65 m TX Signal: 880.125 MHz (F2) – 30 KHz with FM **3. TANJUNG PINGGIR** Coordinat : N1 08 22.4 E103 55 18.9 Height from ground : 43 m TX Signal: 887.015 MHz (F3) – 30 KHz with FM
	Receiver sites – Fixed Monitoring station Facility provide by Malaysia or Singapore where applicable	**1. IDA Fixed Monitoring Station (SNG)** Coordinat : N 1,325110; E103,945190 Height from ground : 82 m **2. JOHOR BARU (MLA)** Coordinat : N1,468676 E103,904111 Height from ground : 171 m **3. PASIR GUDANG (MLA)** Coordinat : N1,4686 08 22.4 E103 55 18.9 Height from ground : 68 m
	Receiver site – Mobile Monitoring Van at fixed location provided by Singapore	**Mobile Monitoring Van at fixed location – SNG** Coordinat : N1 18 02.4 E103 54 41.9 Height from ground : 15 m



Note:
The transmitting test signal frequencies were assigned under the condition that these frequencies will not interfere with the networks of the operators at 3 different countries.

Under this criterion, the available frequency band was so limited, that finding 3 slots for 200 KHz GSM equivalent bandwidth is not possible. As a compromise, 30 KHz FM signals were used.

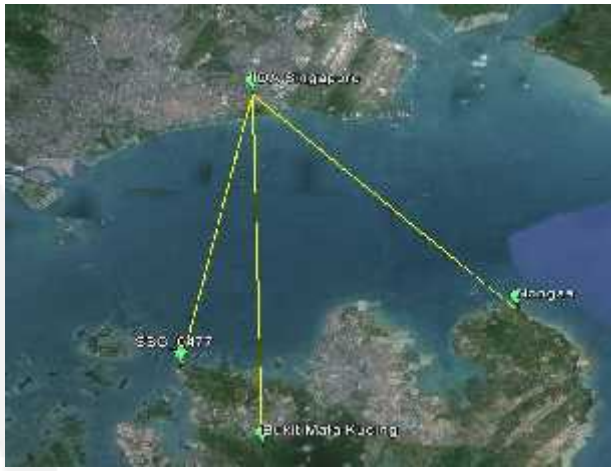
Project Activities … Preliminary Simulation

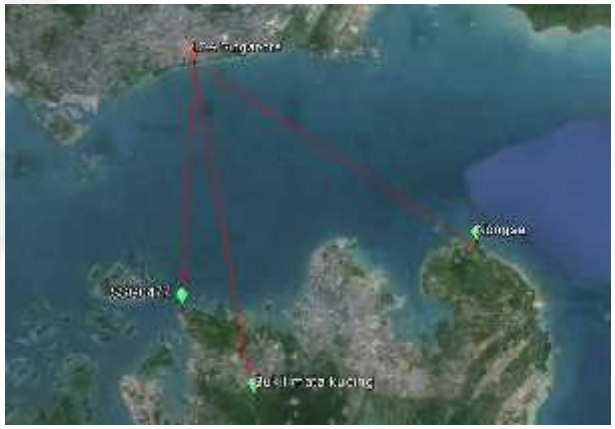
➢ Preliminary Simulation using agreed Measurement Methodology

- Undertaken to approximate the extent of Interference received and to cross relate with the actual measurements

Results of these measurements showed:

1. *The highest theoretical mitigation objective is at **36.80 dB** for Singapore*
2. *Tilting the antenna at Batam area could reduce the mitigation objective by 15 dB into (36.80 – 15) dB = 21.80 dB. If a special purpose antenna is used which has side lobe rejection up to 20 dB then the mitigation objective is reduced to (36.80 -20) dB = 16.80 dB.*
3. *Lowering down the antenna heights at both sides could reduce the mitigation objective by another 20 dB into (16.80 – 20) dB = -3.20 dB. (3.2 dB mitigation margin)*
4. *Reducing the transmitted power by 10 dB could further provide -13.20 dB mitigation margins. This margin might be required to compensate additive effects of CDMA signals (CDMA correction factors) whenever necessary (the factor which increases the reception of CDMA signals by ~13 dB).*



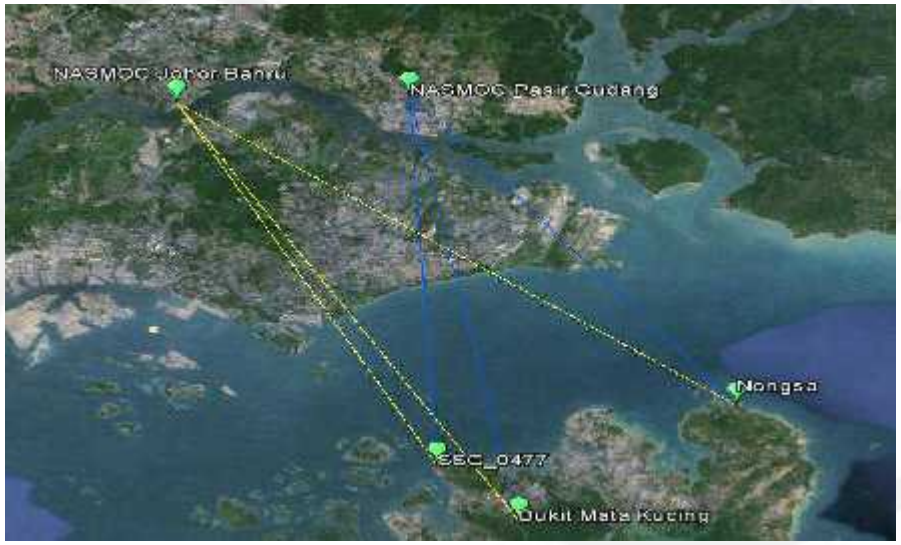


Project Activities … Preliminary Simulation

Results of simulation *contd….*:

5. *Reversing the direction of the antenna (the use of reflectors) could give extra isolation if necessary since the front to back ratio of the antenna is in the order of 35 dB*

6. *Overall, as the worst case there are requirements to lower down the antennas to below 25 m ASL, tilting antenna more than 10 degrees, and reduce the operating power to below 28 dBm if it is required to isolate CDMA from EGSM networks.*



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Project Activities … TX & Rx Config. Plans

- **Different configurations of Transmitter and Receivers were tested over the period of 4 days**
- **Mock pre-tests performed to ensure that operational networks do not have any effect during the testing procedure.**
- **Due regard was given to ensure that all practically possible configurations were tested**


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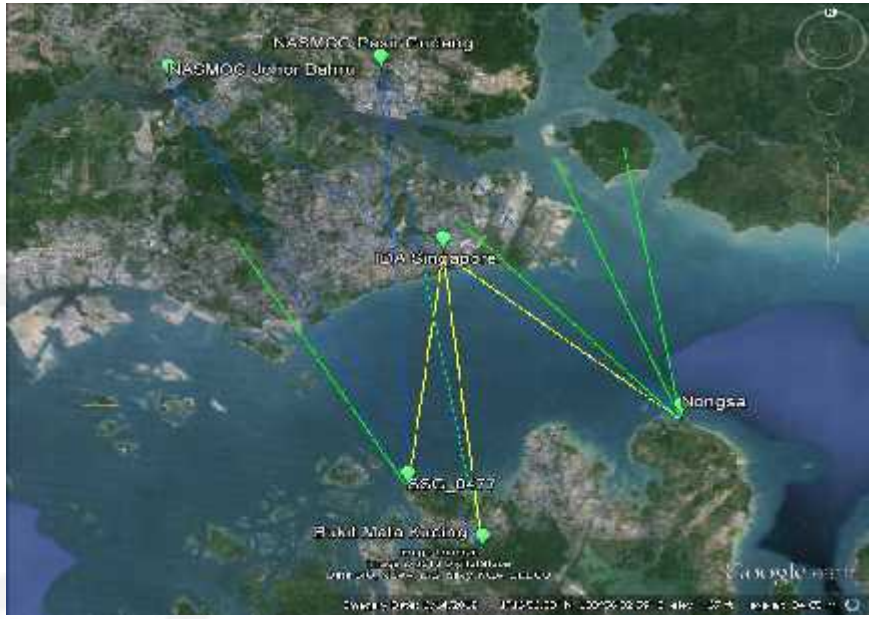
Microsoft Word
Document

Project Activities … TX and Rx configurations

- **12 configurations at each transmitter involving changes in:**
  - Power output
  - Antenna Height (*not similar across all identified Tx sites*)
  - Antenna tilting
  - Inward Transmission only

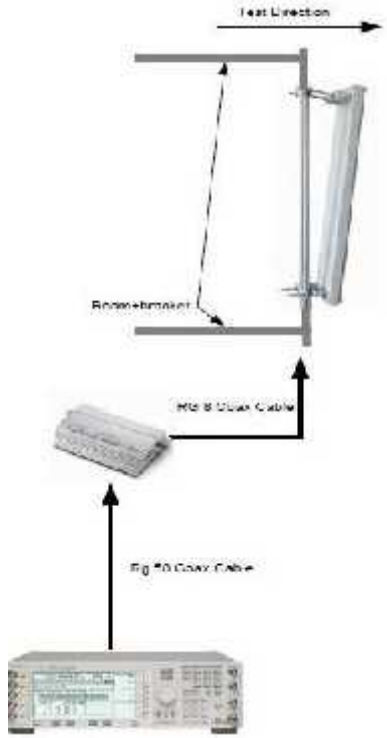
- **Fixed Receivers**
  - Geographically separated at 4 locations
  - Different heights



Project Activities ... Equipment

➢ Transmitters *(Indonesia)*

Item	Details
Antenna	Andrew DB858DG90ESX
Connecting cables	RG58
Outdoor amplifier	AT-6200C
Signal Generators	Agilent E4421B / Aeroflex IFR 2023A



➢ Receiver *(Malaysia)*

Item	Details
Directional Finder	TCI Model 641 and 715
RX Antenna gain	2 – 9 dBi (TCI 641), calibrated to 0 dBi
RX noise figure	< 9 dB (TCI 715)
Resolution Bandwidth	Resolution Bandwidth

➢ Receiver *(Singapore)*

Item	Details
Directional Finder	NA
RX Antenna gain	Analysis made on the basis of 0 dBi calibration

Project Activities … TX and Rx configurations

➢ Reflection of changes in transmitter configurations

Transmitter		Day 1 Mon, 30 Sep 2013	Day 2 Tue, 1 Oct 2013	Day 3 Wed, 2 Oct 2013	Day 4 Thu, 3 Oct 2013
Tanjung Pinggir	Frequency	887.025 MHz	887.025 Mhz **Change to**: 887.015 MHz on request of SNG **Time of Change:** 14.00[INS]/15.00[MLA/SNG]	887.015 MHz	887.015 MHz
	Bandwidth	50 kHz **Change to** : 30 kHz due to limitation on MLA receiver **Time of Change:** 15.41[INS]/16.41[MLA/SNG]	30 kHz		
	Antenna	DB858 DG90ESX ANDREW with Antenna Gain : 16,4 dBi Azimuth Beam Width: 90°, Elevation Beam Width: 7.5°.			
	True Bearing	330°			
	Height	53 m	53 m	22 m	22 m
	Tilting	0°	5°	0°	5°
BMK	Frequency	880.025 MHz			
	Bandwidth	30 kHz			
	Antenna	DB858 DG90ESX ANDREW with Antenna Gain : 16,4 dBi Azimuth Beam Width: 90°, Elevation Beam Width: 7.5°.			
	True Bearing	380°			
	Height	70 m	70 m	19 m	19 m
	Tilting	0°	5°	0°	5°
Nongsa	Frequency	880.075 MHz			
	Bandwidth	30 kHz			
	Antenna	DB858 DG90ESX ANDREW with Antenna Gain : 16,4 dBi Azimuth Beam Width: 90°, Elevation Beam Width: 7.5°.			
	True Bearing	350°	338°	317°	317°
	Height	44 m	44 m	22 m	22 m
	Tilting	0°	5°	0°	5°

Reading the Results

Analysis – CDMA signal addition from multiple sources

➢ Why?

In the CDMA environment, the signals from different BS arrived at the receiver at the same frequency and the corresponding RSL are added up power-wise. e.g. using Rake receivers

- **Whereas**

The reception of individually transmitted FM signals at different frequencies will not give a similar additive result hence a correction factor is needed to have results represent actual situation

- **Theoretical Calculation**
  - Meeting with CDMA operators in Indonesia
  - Based on discussions with related operators it is that calculated that at worst, geographically only 50% of BS (i.e. 22) have beams towards Malaysia/Singapore
  - Based on this number, the cumulative power of the CDMA signals is 10 log(22) dB ~ **13.4 dB** above individual CDMA carrier power at worst.

Analysis – RSL reading consistency

➢ Why the need?

- The data came from different receiving environments/equipment
- Sometimes incomplete information on characteristics (e.g. amplifier/cable loss etc.) of receiving equipment

Normalization measures were taken, so that analysis of data coming from sources give more accurate conclusions.

➢ How to make data reading consistent?

Normalize the, i.e. the level when there is no signal transmitted, theoretically *Johnson–Nyquist noise*:

$$N_{out} = F\ dB - 174 + 10 \log B \quad dBm$$

- F : Noise figures of the front-end circuitry

- B : Resolution bandwidths, which has to be normalized, because they are the source of inconsistent noise level and power readings, which could be seen in the following figures.

Analysis – RSL reading consistency

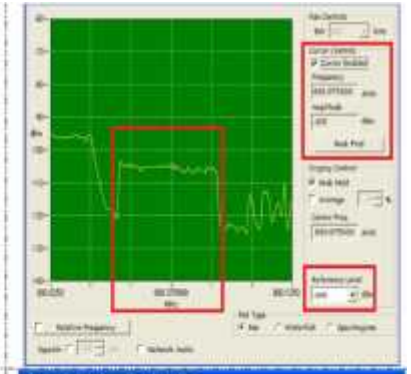
MLA Pasir Gudang 10000 KHz Span

MLA Johor Baru 10000 KHz span

MLA Pasir Gudang 100 KHz span

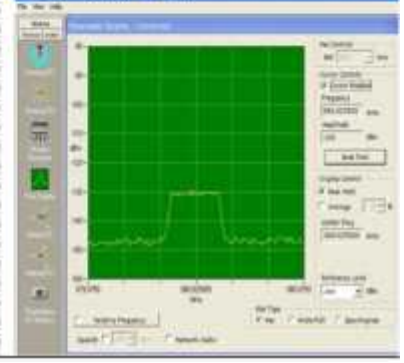
NG Bedok Fixed Station 10000 KHz span

SNG Bedok DF Fixed Station 100 KHz span



SNG Mobile DF 10000 KHz span

SNG Mobile DF 100 KHz span



Analysis – Noise Figures

- **Considering**
  - Different noise figure
  - Amplifier gain at each site
- **Based on**
  - Measurement data,
  - Normalization to 30 KHz resolution bandwidth
- **Values of the Noise floors used**

Site	Noise floor level @ 30 KHz (dBm)
Johor Baru	-124.1
Pasir Gudang	-115.1*
IDA - Bedok DF	-125
IDA - Mobile DF	-125

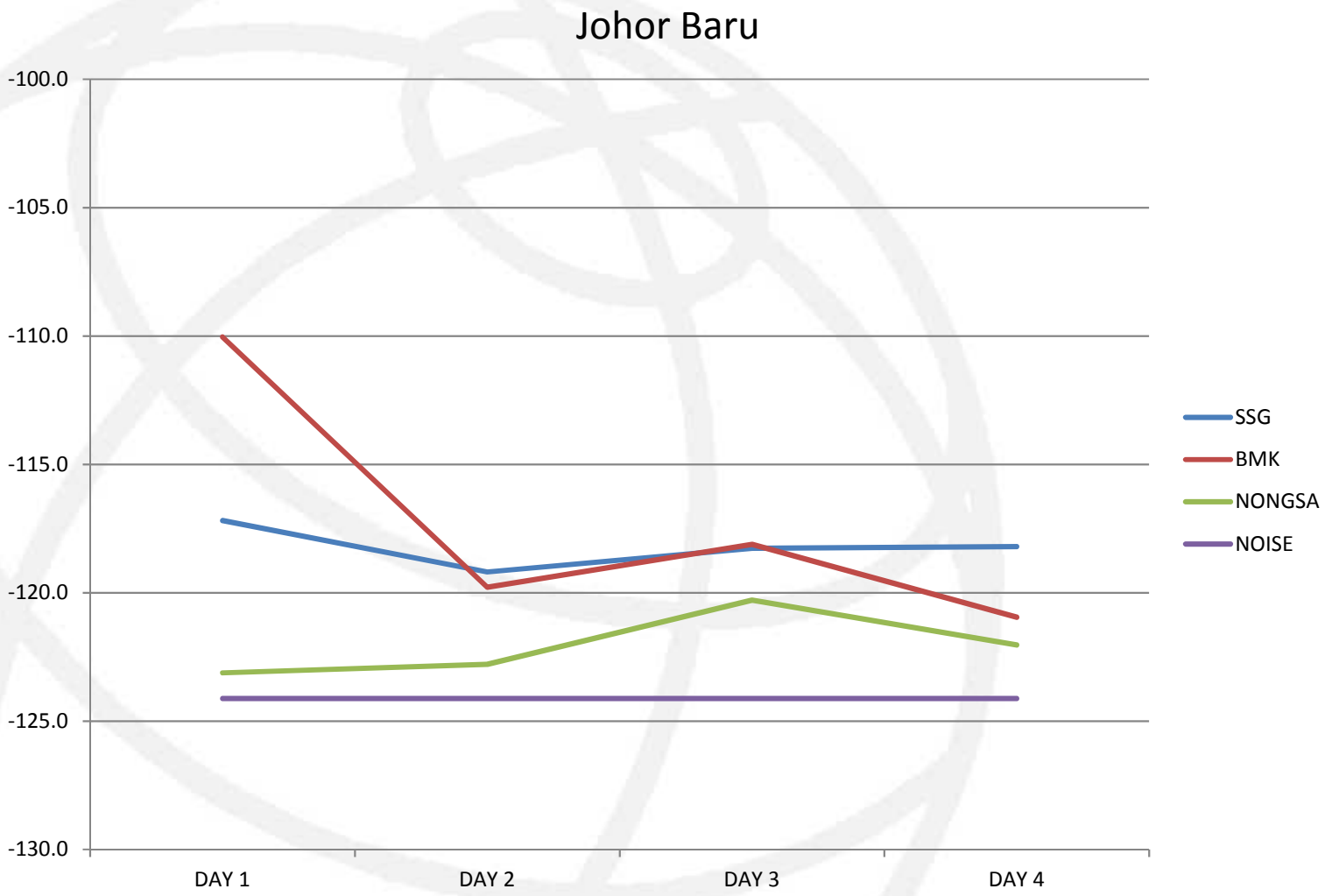
** a significant deviation from the majority behavior (+/- 1 dB), possibly caused by different noise figure and/or system gain*

Analysis – Data Organization

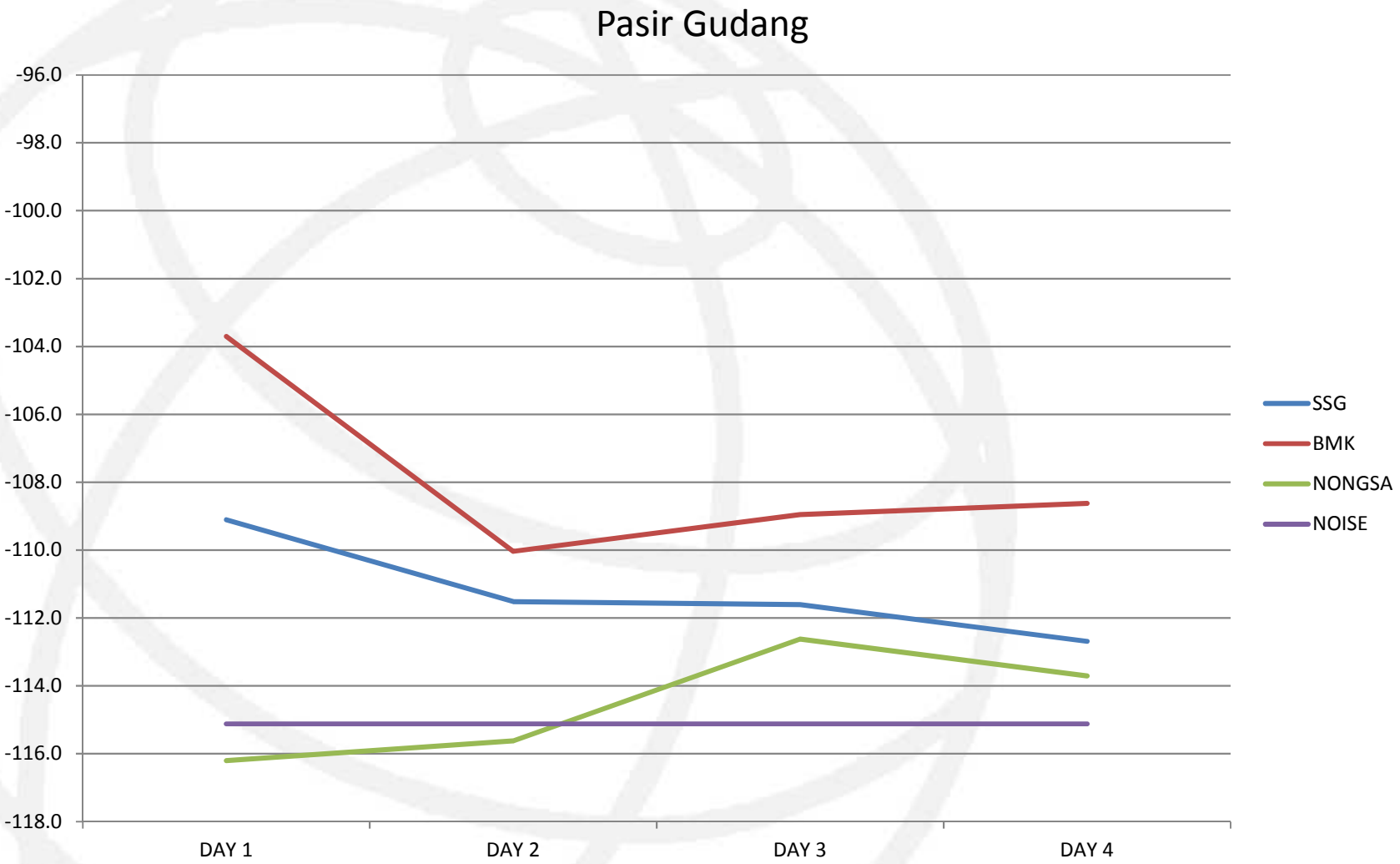
- **Primary data was organized according to the receiver site**
- **For a particular RX site the following information was recorded:**
  - Received signals from 3 different TXs sources (SSG, Bukit Mata Kucing and Nongsa)
  - Noise floor
  - Theoretical worst case signal reception based on simulation and geometric calculation

Summarized Results of Measurements

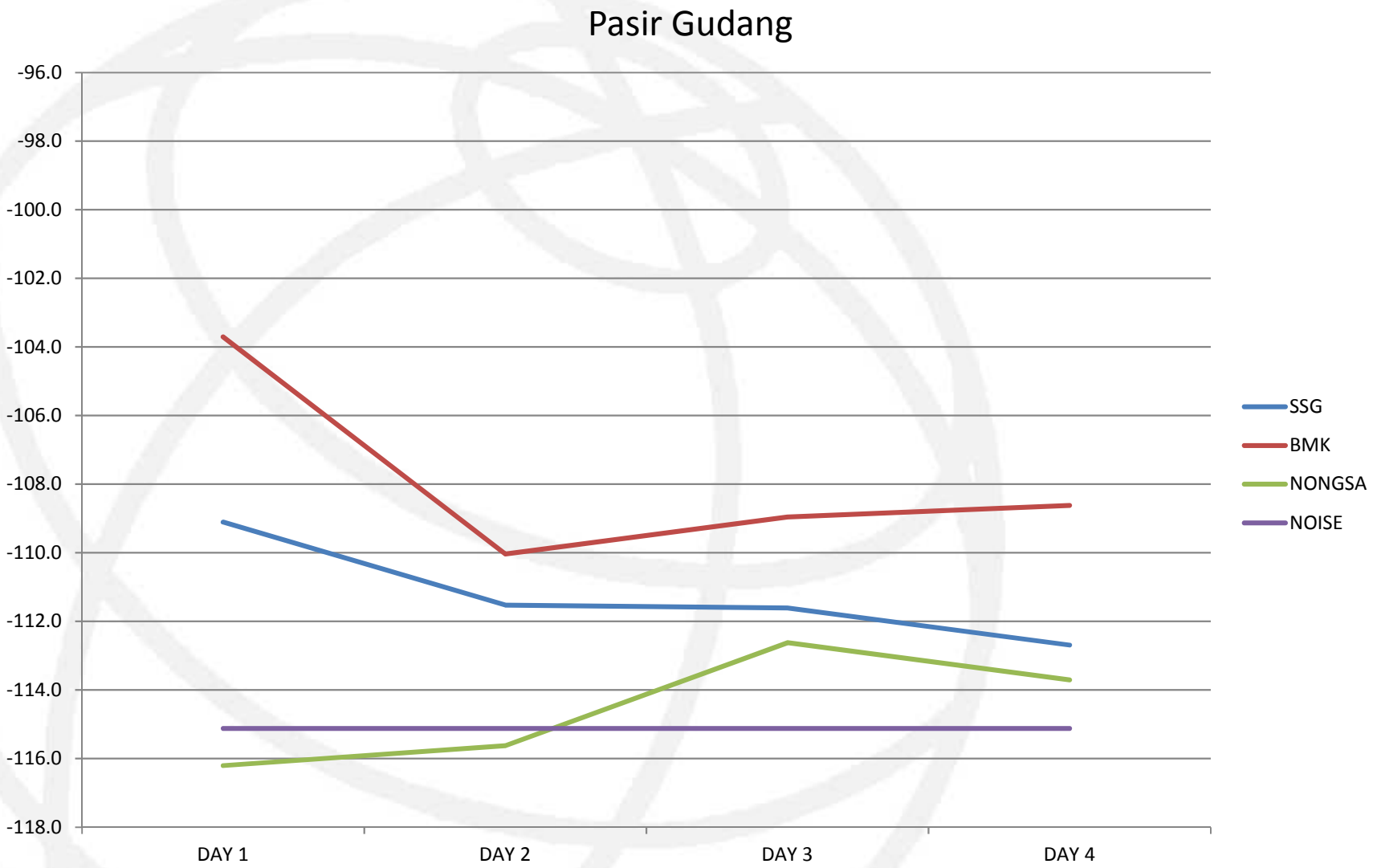
Results - RSL


Johor Baru
-100.0
-105.0
-110.0
-115.0
-120.0
-125.0
-130.0
DAY 1
DAY 2
DAY 3
DAY 4
SSG
BMK
NONGSA
NOISE

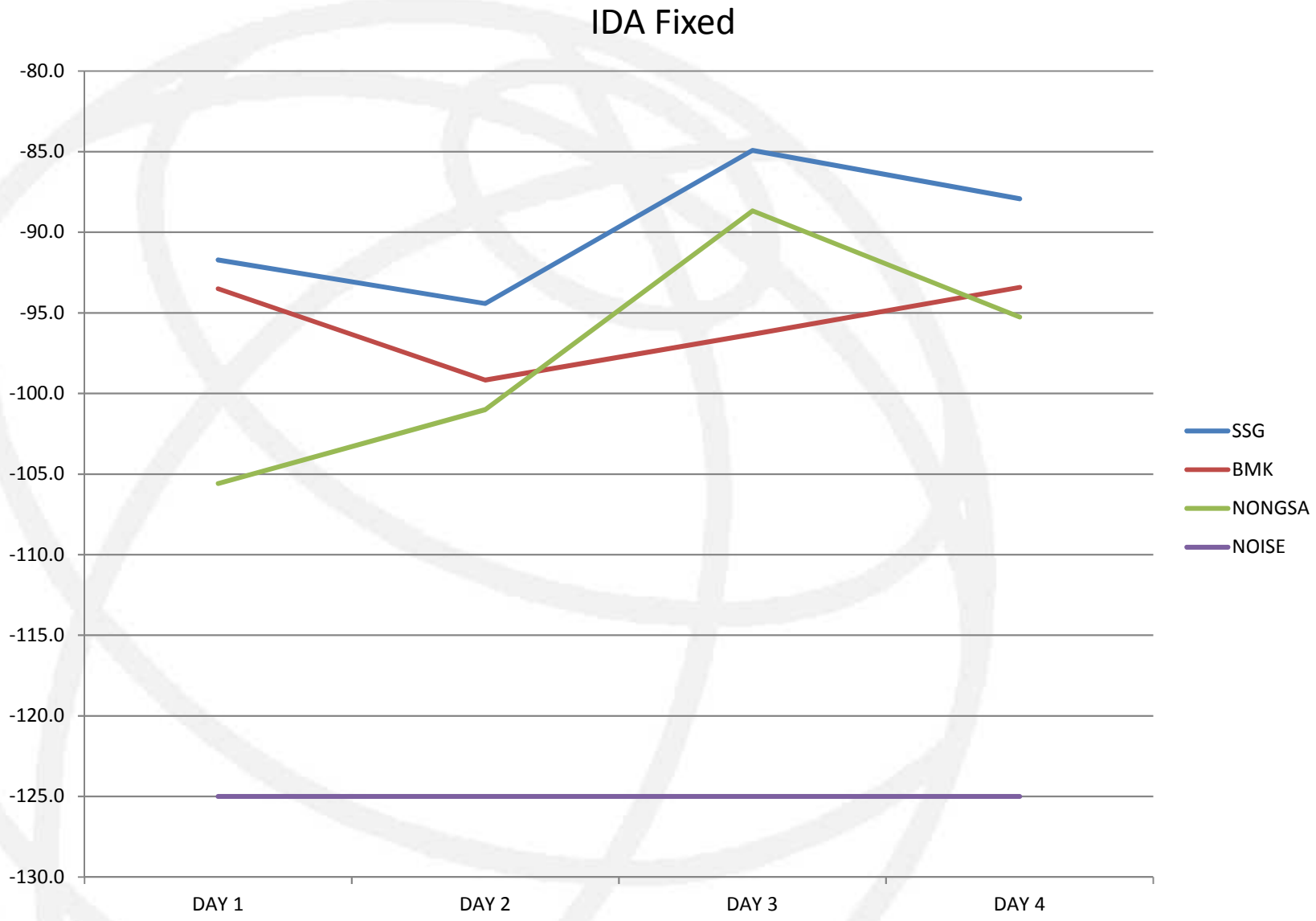
Results - RSL


Pasir Gudang
-96.0
-98.0
-100.0
-102.0
-104.0
-106.0
-108.0
-110.0
-112.0
-114.0
-116.0
-118.0
DAY 1
DAY 2
DAY 3
DAY 4
SSG
BMK
NONGSA
NOISE

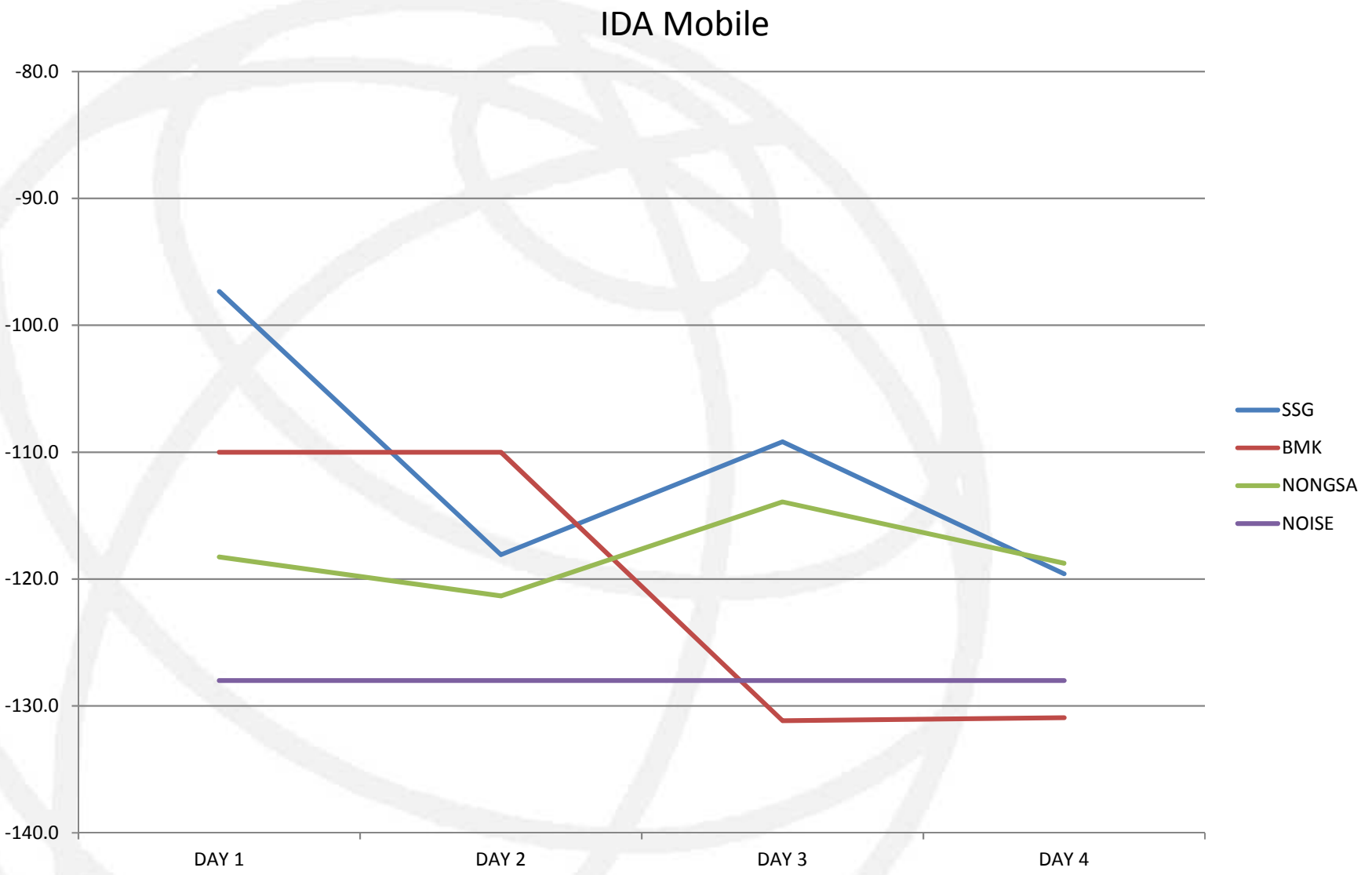
Results - RSL


Pasir Gudang
-96.0
-98.0
-100.0
-102.0
-104.0
-106.0
-108.0
-110.0
-112.0
-114.0
-116.0
-118.0
DAY 1
DAY 2
DAY 3
DAY 4
SSG
BMK
NONGSA
NOISE

Results - RSL


IDA Fixed
-80.0
-85.0
-90.0
-95.0
-100.0
-105.0
-110.0
-115.0
-120.0
-125.0
-130.0
DAY 1
DAY 2
DAY 3
DAY 4
SSG
BMK
NONGSA
NOISE

Results - RSL


IDA Mobile
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
DAY 1
DAY 2
DAY 3
DAY 4
SSG
BMK
NONGSA
NOISE

Results – Results at Johor Baru

S. No.	Item	SSG	Bukit Mata Kucing	Nongsa
1	Signal deviation (+)	1.3	3.4	1.8
	Signal deviation (-)	-0.9	-3.8	-2.4
2	SMARTFREN C/N	17.0		
3	STARONE C/N	14		
4	Test signal C/N	2	14.1	1
5	The impact of 5 deg tilting	0.9	8.3	-0.9
6	The impact of lowering	2.0	8.8	-2.2
7	The impact of lowering and tilting	1.6	11.2	-2.3
8	Test signal to EGSM threshold (-113 dBm)	(14.1 -11.1) = 3 value 11.1 is difference of EGSM threshold and the noise figure of the receiving site		

* the CDMA correction factor (17.0 -14.1) = 2.9 dB

Results – Results at Pasar Gudang

S. No.	Item	SSG	Bukit Mata Kucing	Nongsa
1	Signal deviation (+)	1.3	3.8	4.7
	Signal deviation (-)	-2.1	-5.4	-3.3
2	SMARTFREN C/N	10.0		
3	STARONE C/N	11.9		
4	Test signal C/N	2.1	11.4	0
5	The impact of 5 deg tilting	2.1	5.2	-1.1
6	The impact of lowering	2.5	7.5	-2.9
7	The impact of lowering and tilting	3.8	5.6	-2.3
8	Test signal to EGSM threshold (-113 dBm)	(11.4 -2.1) = 9.3 Value 2.1 is difference of EGSM threshold and the noise figure of the receiving site		

* the CDMA correction factor is (11.9 -11.4) = 0.5 dB

Results – Results at iDA Fixed

S. No.	Item	SSG	Bukit Mata Kucing	Nongsa
1	Signal deviation (+)	4.9	6.3	5.1
	Signal deviation (-)	-5.8	-10.1	-13.0
2	SMARTFREN C/N	34.0		
3	STARONE C/N	30.0		
4	Test signal C/N	8.3	31.5	19.4
5	The impact of 5 deg tilting	21.9	12.2	3.8
6	The impact of lowering	10.3	5.4	-10.2
7	The impact of lowering and tilting	14.2	7.2	-2.8
8	Test signal to EGSM threshold (-113 dBm)	(31.5 -12) = 19.5 Value 12 is difference of EGSM threshold and the noise figure of the receiving site		

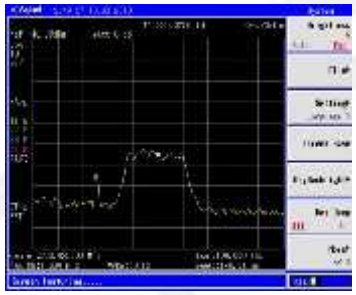
* the CDMA correction factor is (34.0 -31.5) = 2.5 dB

Results – Results at iDA Mobile

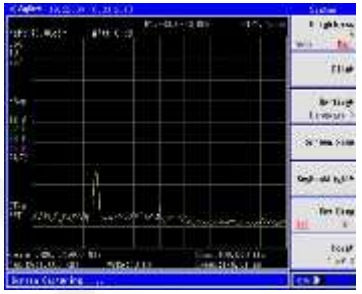
S. No.	Item	SSG	Bukit Mata Kucing	Nongsa
1	Signal deviation (+)	9.3	8.4	15.3
	Signal deviation (-)	-7.5	-8.3	-9.8
2	SMARTFREN C/N	14.0		
3	STARONE C/N	10.0		
4	Test signal C/N	27.7	18.0	9.8
5	The impact of 5 deg tilting	23.4	9.7	11.9
6	The impact of lowering	16.4	9.6	4.4
7	The impact of lowering and tilting	21.0	13.8	9.4
8	Test signal to EGSM threshold (-113 dBm)	(18 -15) = 6 Value 15 is difference of EGSM threshold and the noise figure of the receiving site		

* the CDMA correction factor is (14.0 -18.0) = -4.0 dB

Results – Front to back lobe rejection



Front lobe reception Bukit Mata Kucing, RSL -95.7 dBm at 1,444 m



Back lobe reception Bukit Mata Kucing RSL -124.73 dBm at 995 m

Location	RSL_F (dBm)	RSL_B (dBm)	dF/dB	F/B (dB)
SSG	-68.38	-120.63	265 m/1000 m	40.7
Bukit Mata Kucing	-95.7	-124.73	1444 m/995 m	32.2
Nongsa	– 83.59	-126.67	551 m /969 m	38.2

5th Day Testing

Conclusion of Measurements

Conclusion of Study

Maximum unwanted signal during the study

As per the results obtained, the largest mitigation challenge was at IDA Fixed Station where the C/N reached 34.0 dB with respect to noise floor, or (34 -12) = 22 dB with respect to EGSM threshold, because of the exceptional antenna height.

Microsoft Word Document

Mitigation

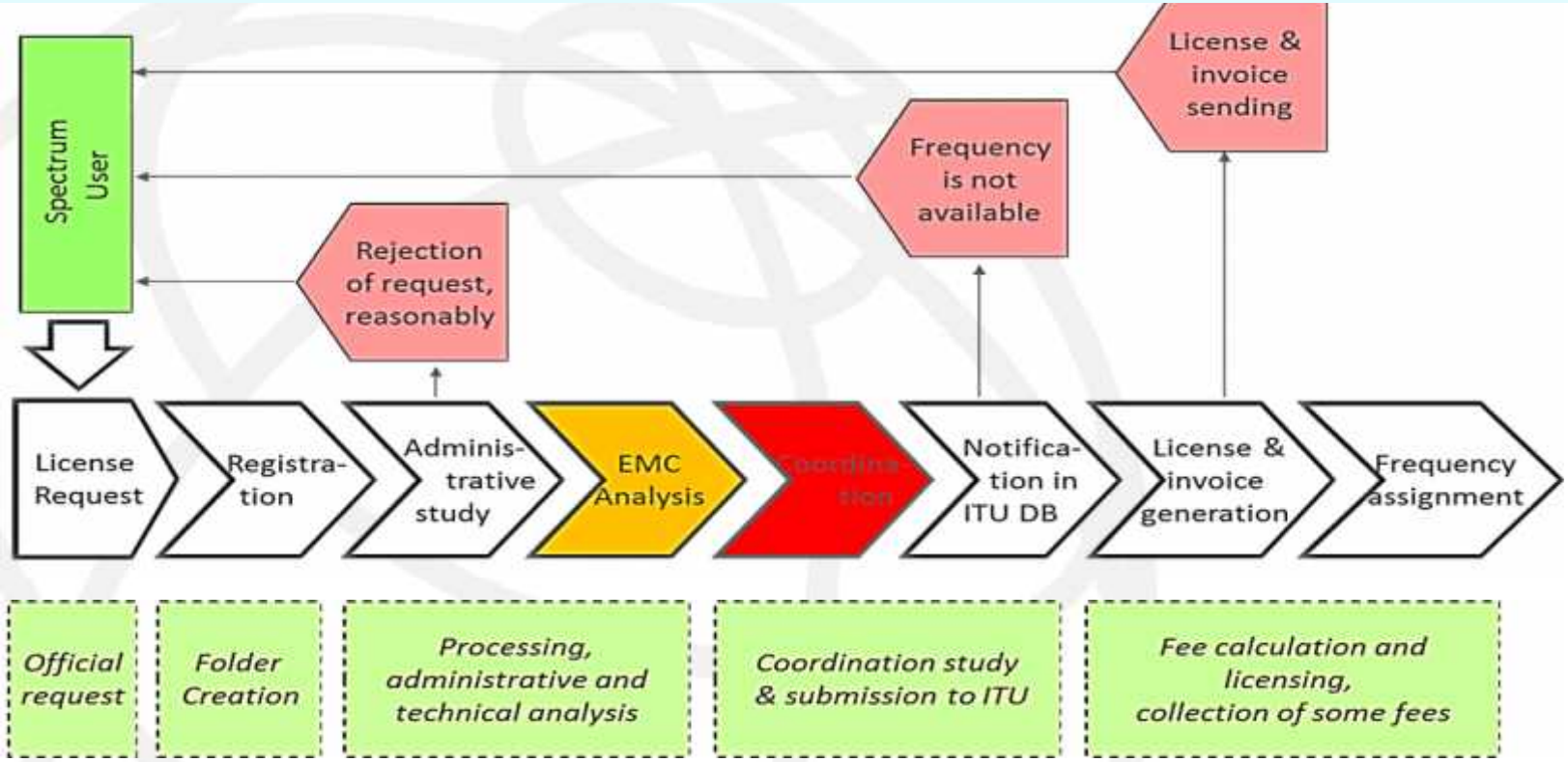
A combination of 10 degrees* tilting which yield 20 dB additional loss and 10 dB power level reduction. In addition, putting antenna reflector, i.e. by making the antenna direction towards Indonesia could provide 30dB isolation, if needed.

** Only 5 degree tilting was used in practical measurements. This figure is based on extrapolation of the results observed from practical study.*

Recommendations

Recommendations

➢ **RF Site authorizations after due coordination** *(especially in border areas)*



- The function highlighted in red is especially important to control unwanted interference within country and across borders.
- Coverage audit before authorization operation
- Once authorization granted constant Monitoring required.

Recommendations

➢ Spectrum Sharing for band 880 – 890MHz in current scenario

Noting

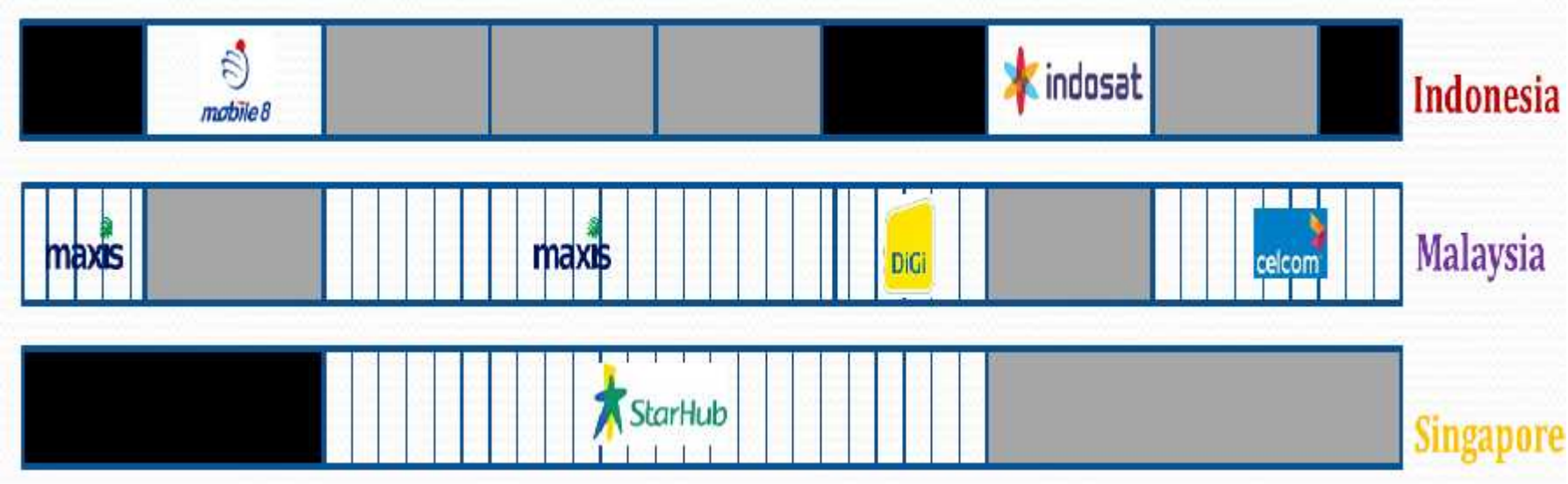
- Each country has the right to have full control on allocation of all the available spectrum within its territory.
- Assuming that current spectrum splitting mechanism is retained by all the three countries i.e. Indonesia, Singapore and Malaysia,

Suggested

- Countries may agree to usage of the band allocated by another administration to its own Licensee so on the secondary basis. *(may be with reduced fees) - Concept of pluralistic licensing*

Recommendations

➢ Spectrum Sharing for band 880 – 890MHz in current scenario



Current country allocation of 880-890 band as per decisions of 7th trilateral meeting

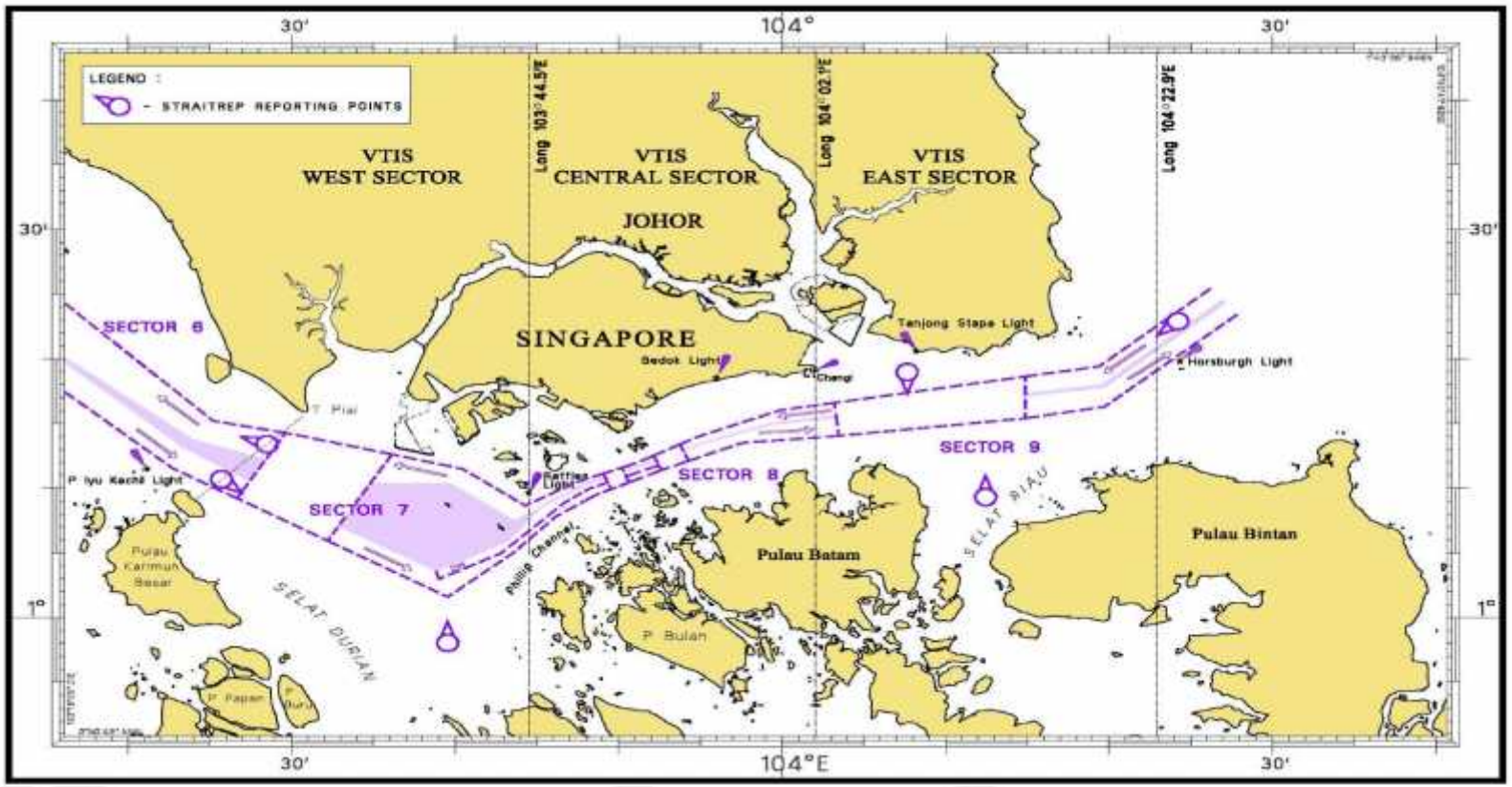
Example

- In current arrangement between the three countries, bands being used by Indonesia CDMA operator Indosat and is not being allocated by either Malaysia or Singapore.
- However with this suggested scenario Singapore or Malaysia may allocate the same to its Licensees on Secondary basis while recognizing that the Primary user has to be Indosat.

Recommendations

➢ Creating Network Isolation

- Recommended not to allow antenna beams of transmitting antennas in border region to be directed towards other countries (*a practice observed in order to tap into the market of the visiting ships in the Singapore Strait).*



STRAITREP OPERATIONAL AREA (SECTORS 7 TO 9) Appendix 2

Recommendations

➢ Creating Network Isolation

- Analysis of measurements show that network isolation amongst dissimilar operational technologies can be achieved by employing a mix of various configurations including height, antenna tilting, adjusting power output and antenna discrimination.

- Careful RF planning at borders taking into account the natural and artificial obstacles could help in achieving network isolation and thus resolving the issue of interference.

Recommendations

➢ Spectrum Re-allocation and technology Harmonization

- Adoption of harmonized APT-700MHz band plan would also help mitigating interference
- Motivate the current Licensees to migrate from current technologies to more efficient and harmonized future technologies. (*e.g. it has been deliberated observed that network operations using LTE are cost effective to operators compared to older technologies*)
- Fragmentation of contiguous spectrum may be avoided as possible (*while ensuring competitive market*)
- Strongly recommended to only allow spectrum usage for technologies whose RF bands and characteristics have been harmonized
    - To *ensure that even if there exists a mismatch of Downlink and Uplink channels across different technologies, the effects and counter measures of co-existence have been well studied before standardization of band.*

Recommendations

➢ Bilateral, Regional Agreements

- To counter the long term challenges of cross border mitigation a
- Countries this Trilateral forum are recommended to work towards having agreements at multiple level (Bilateral with neighbors, ASEAN, APT etc)

How ITU can help based on its previous experiences/activities in other regions of the world?

I Thank U

"Committed to connecting the WORLD"

Major ITU SM Events in 2017

ITU COE online training on Spectrum Management (Legal and wireless innovation Issues)
13 - 24 February 2017

ITU COE training on Spectrum Engineering and Cross border Coordination
Xian, China, May 2017

ITU-Forum Global regional workshop on Spectrum Management
Bangkok-Thailand, Q2/3 2017

ITU Study Group Meetings
ITU-D (Res. 9) and ITU-R SG1

Your active participation in and contribution to these events is most welcome!