Report on Implementation of Digital DRM + Radio Broadcasting
In Cooperation between Radio Republik Indonesia and
DRM Consortium

I. Background:

Digital broadcasting that has been going on since 1993 has experienced a very rapid development, Digital Broadcasting via cable, satellite and Terrestrial has coverageed the second generation (second generation standards).

However, the digital broadcasting is more focused on digital video/ digital television broadcasting. Digital radio on the other hand has not received any the attention from stakeholders although the Public Service Broadcasting such as Radio Republic of Indonesia (RRI) together with other institutions had made research, seminars, and Workshops for various formats / standards audio/radio digital.

Terrestrial DRM 30 digital radio broadcasting is digital radio broadcasting for wide coverage area utilizing working frequency below 30 MHz, Medium Wave and Short Wave. In 2015 Radio Republik Indonesia conducted trials using medium wave transmitters located in Sukmajaya - Depok at a frequency of 1242 KHz and in 2016 in Denpasar - Bali. Follow-up implementation of this digital radio standard still does not exist Terrestrial DRM + digital satellite radio is digital radio broadcasting for limited area (local coverage) utilizing the working frequency of band II VHF FM 88 to 108 MHz has not been tested yet.

II. Present condition:

Analog radio broadcasting using FM frequency band 88 to 108 MHz (VHF Band II) in big cities of Indonesia is very dense with less good quality (less clear) due to overlap signal transmitter.

III. FM analog and DRM + simulcast broadcasting:

In order to gain benefits and advantages of DRM + digital radio broadcasting on the Band II band VHF FM, the Directorate of Technology and New Media Radio Republik Indonesia and DRM Consortium has conducted a trial of DRM + digital radio broadcasting for local coverage on May 16, 2017 to May 18, 2017 at TVRI Transmission Station Batam - Riau Islands.

Target to be achieved is:

- Is the digital DRM + radio transmitter equal to the FM transmitter's analog coverage,
- Is analog FM radio transmitter interrupt by digital DRM + radio transmitter

IV. Condition of service area Batam:

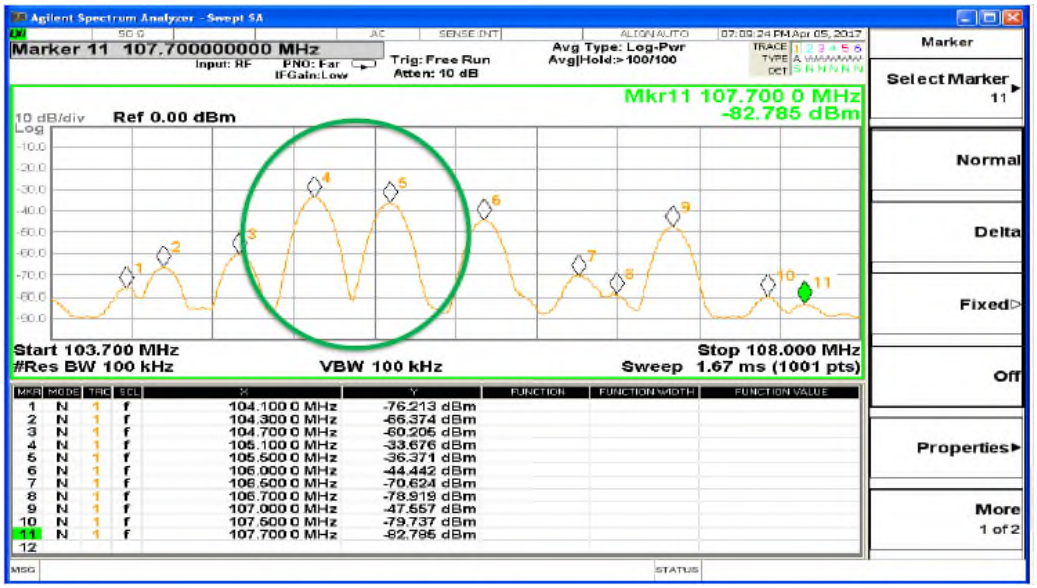
Batam City is the largest city in Riau Islands Province, Indonesia. Batam City Region consists of Batam Island, Rempang Island and Galang Island and other small islands in the Strait of Singapore and the Malacca Strait. Batam Island, Rempang, and Galang connected by Barelang Bridge. According to the Population and Civil Registry of Batam City per 2015, the population of Batam coveragees 1,030,529 people.

Batam is one of the city with a very strategic location. In addition to being on international shipping lanes, the city has a very close distance and directly adjacent to Singapore and Malaysia. The planned city, Batam is one of the fastest growing cities in Indonesia. When built in the 1970s by the Batam Authority (currently called BP Batam), the city is home to only about 6,000 residents and within 40 years of the population of Batam which grew up to 158 times.

The city, which is part of the province of Riau Islands, has a land area of 715 km ², while the total area coverageees 1,575 km ². Batam City has tropical climate with average temperature 26 to 34 degree celsius. The city has a hilly and deserted plain.

Batam City consists of 12 sub-districts and 74 sub-districts

FM radio frequency channels monitored in Batam service area are as follows:



(*Source: DRM Consortium*)

There are three Frequency channels used by Radio Republik Indonesia station in Batam suh as 105.1 MHz (Programa 1), 105.5 MHz (Programa 2) and 90.9 MHz (Programa 3).

V. Batam geographical picture:

Figure 1: Batam Island Region and surrounding areas

Figure 2: There are hills and tall buildings

(Source: https://goo.gl/jf2b2h)

Figure 3: Population mobility is quite high

(Source: https://goo.gl/bx6oR1)

Figure 4: Commerce Center

(Source: https://goo.gl/bVMy9X)

Figure 5: The Sea and the Strait

(Source: https://goo.gl/13Q2sa)

VI. Description of transmitter location:

1. Location of transmitter:

FM Transmitter RRI Batam is placed on location Transmission Unit TVRI Batam in coordinates:

U: 1°; 07 '; 24,154 "; Q: 103°; 56 '; 44,078 "

Figure 6: FM transmitter location RRI Batam (co-located Tower TVRI)

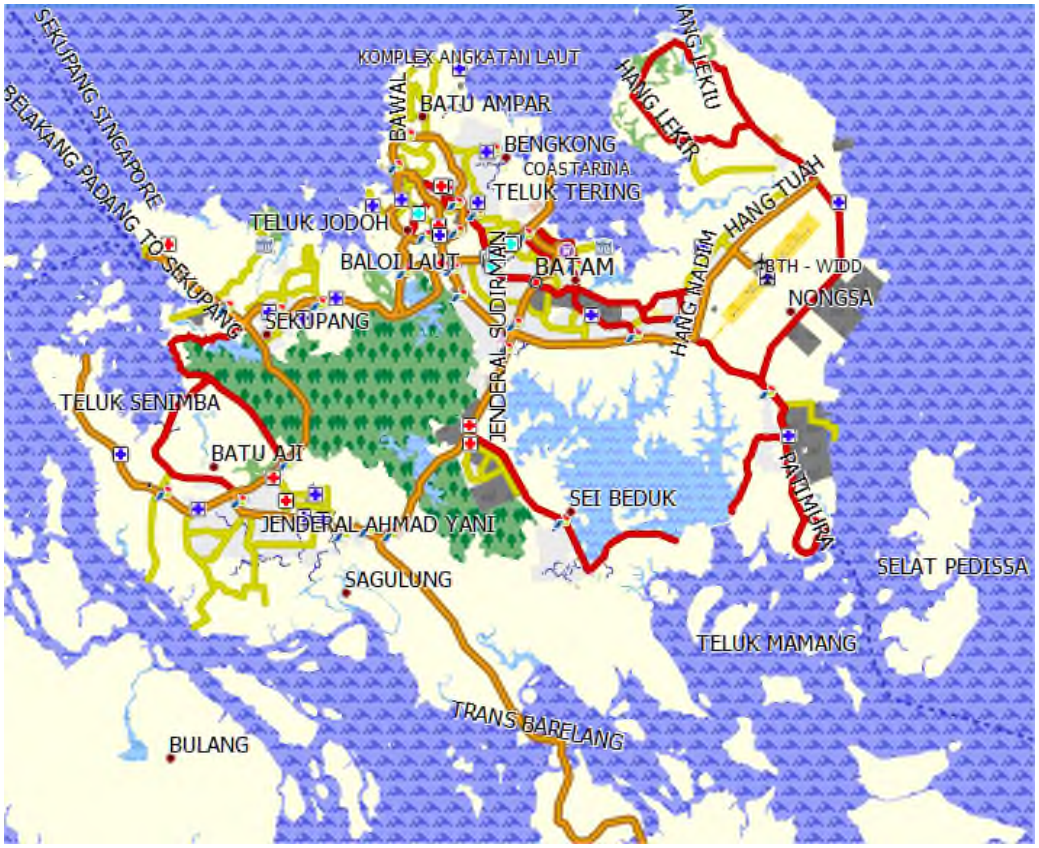


Figure 7: FM transmitter service area RRI Batam

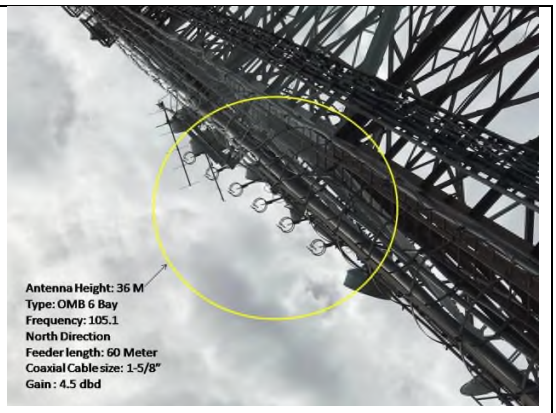
2. Transmitter Equipment:

Data transmitter

Radio Station Name	Frekuensi	Power	Antenna	Antenna height
Pro 1 RRI Batam	105.1 MHz	5000 W	4,78 dB	40 m
Pro 2 RRI Batam	105.5 MHz	5000 W	3 dB	40 m
Pro 3 RRI Batam	90.9 MHz	30 W	yagi	30 m

		 Only exciter (TX Harris off)
TX Pro 1	TX Pro 2	TX Pro 3

3. Tower and antenna

	
Left: TransTV; Middle: TVRI	Antenna FM 6 bay

4. Coverage Prediction:

A. Analogue Coverage prediction simulation:

In order to know the FM transmitter coverage coverage of Pro 1 analog, simulation prediction based on technical data and existing equipment. Simulation of coverage prediction is using *Mobile Radio and Radio Coverage Prediction* application from website http://lrcov.crc.ca/main/index.php

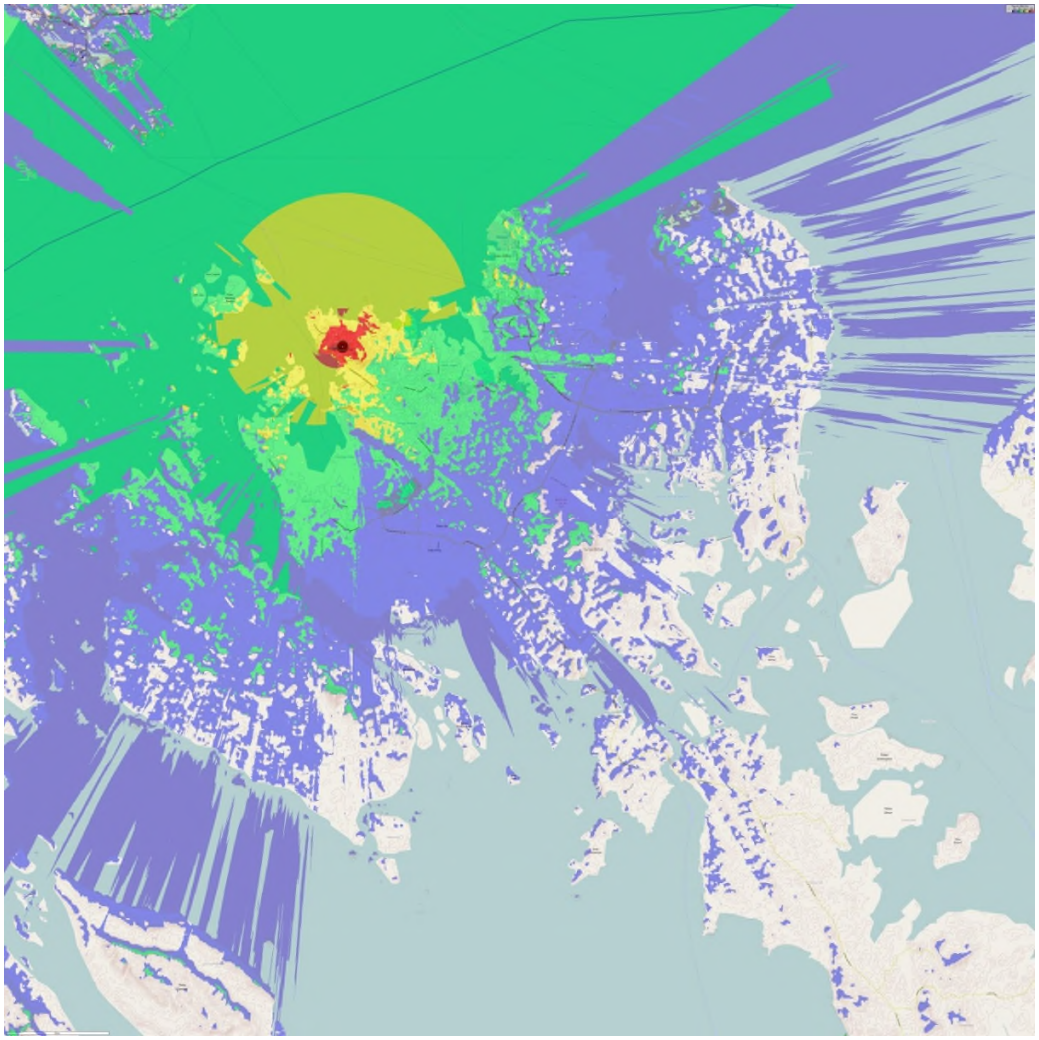


Figure 8: Coverage Prediction Simulation using Mobile Radio application

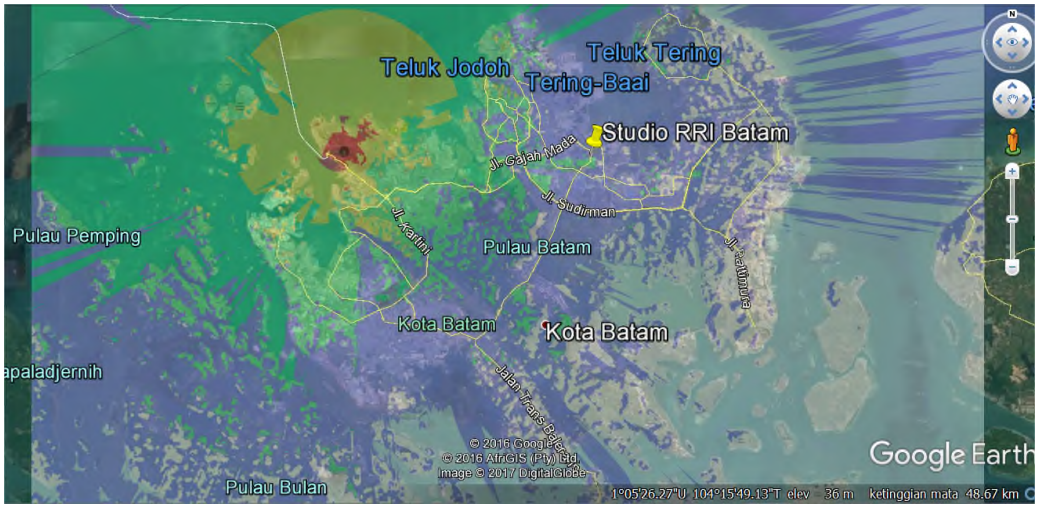


Figure 9: computer simulation overlay in Google earth

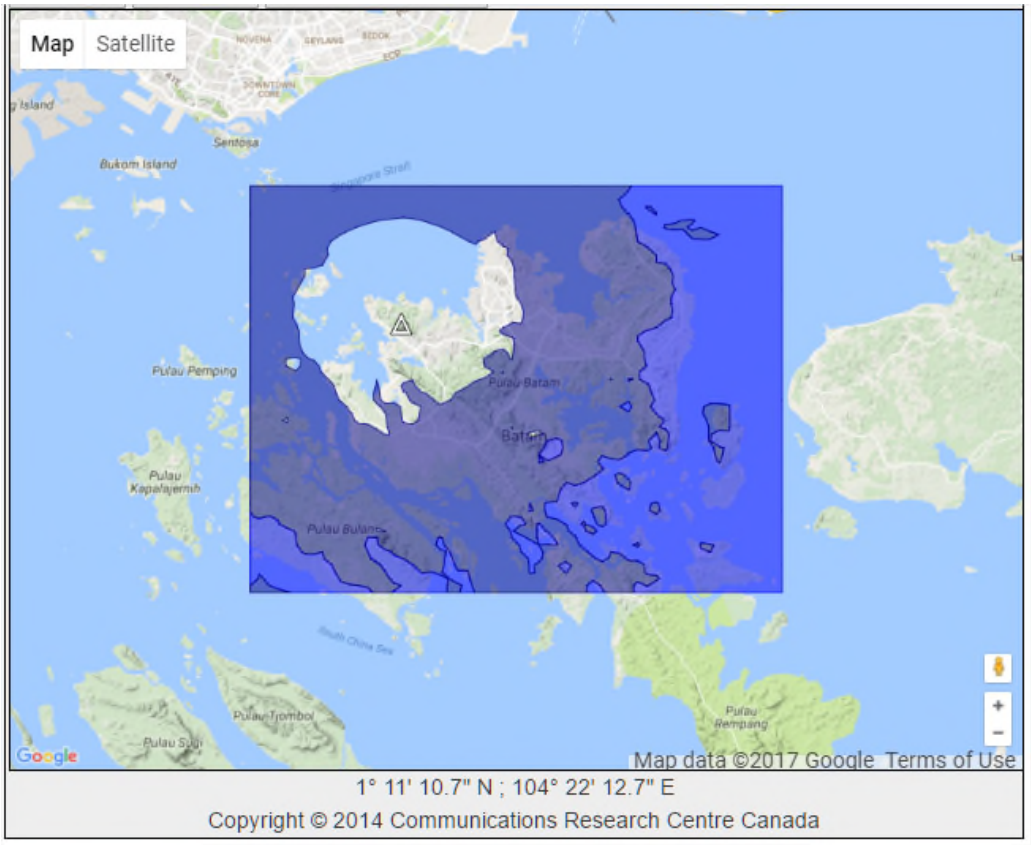


Figure 10: Coverage Prediction Simulation using the application from the website

B. Digital coverage prediction simulation:

In order to know the coverage of digital radio transmitters DRM, simulation of coverage prediction was made using Mobile Radio application and application from the website.

Predicted coverage of 200 watt DRM Transmitter

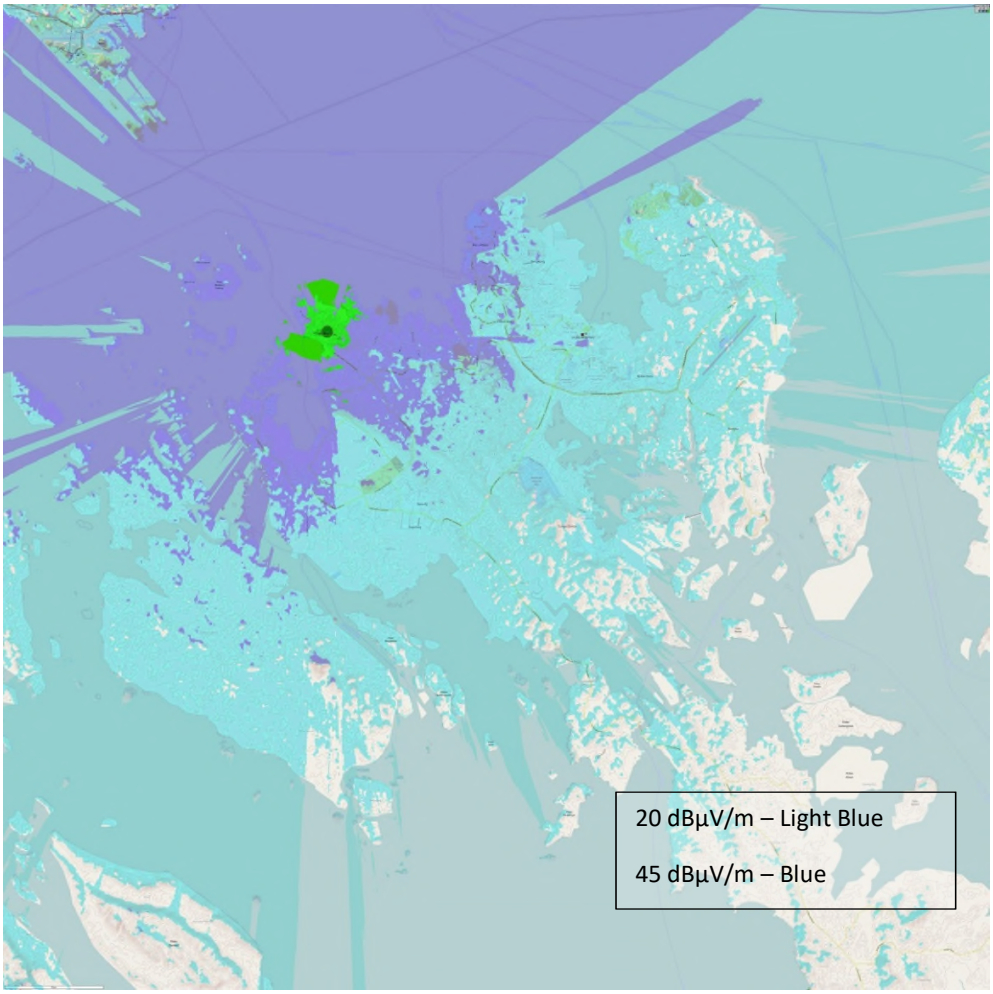


Figure 11: Coverage Prediction Simulation using Mobile Radio application

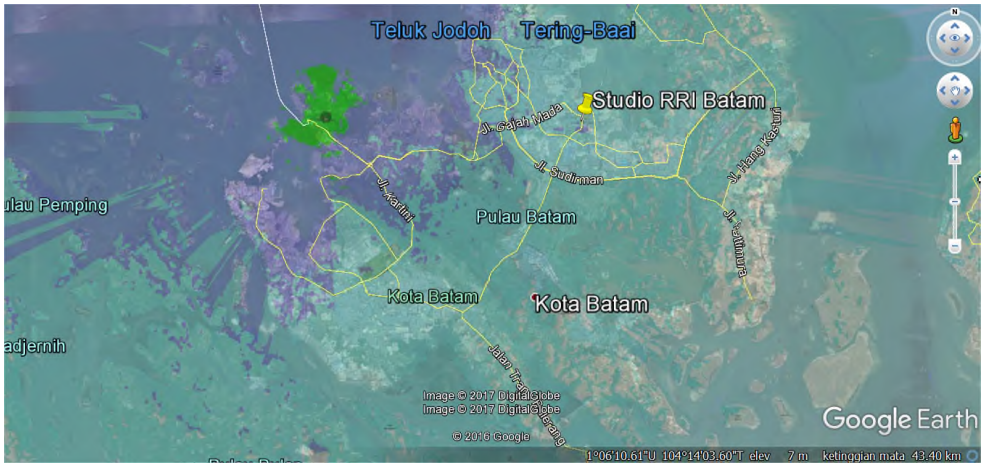


Figure 12: computer simulation overlay in Google earth

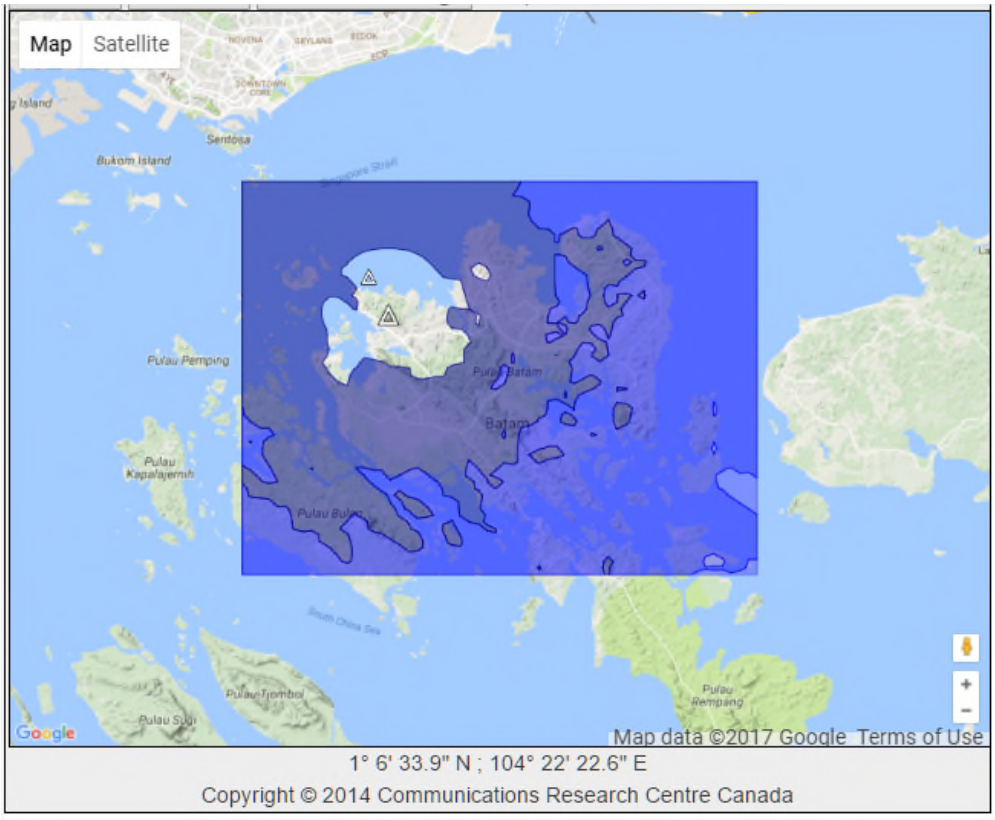


Figure 13: Coverage Prediction simulation using the application from the website

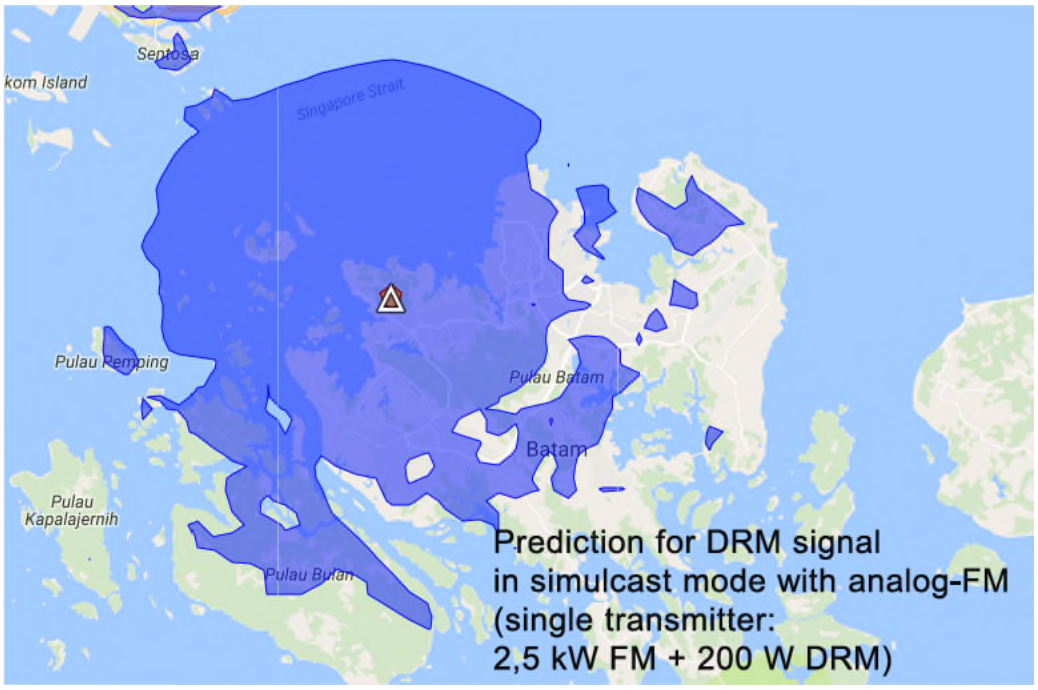
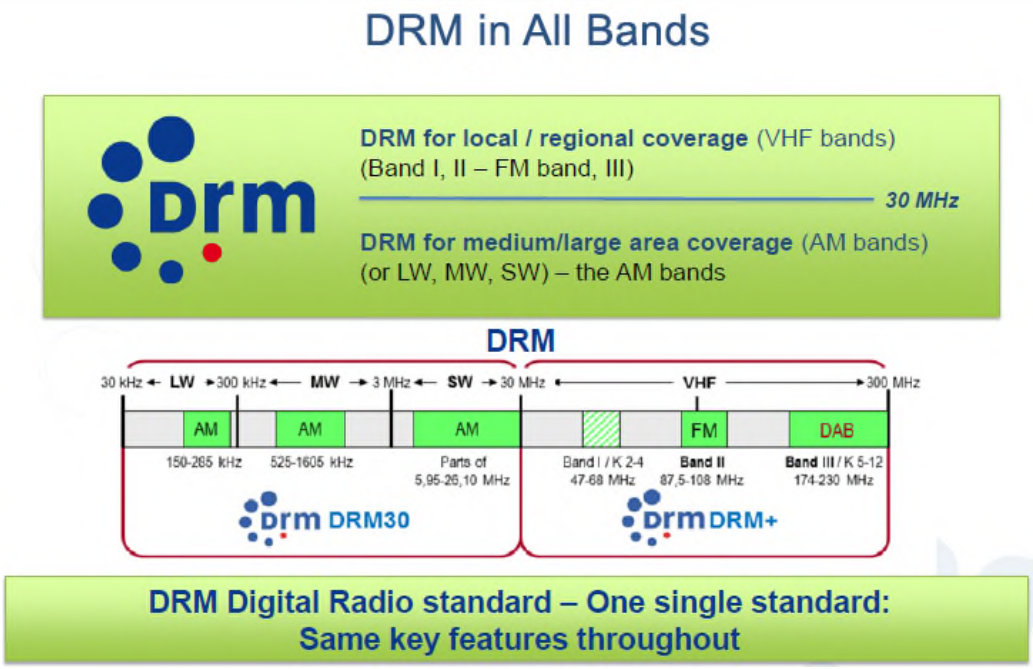


Figure 14: Prediction Simulation Coverage by DRM Consortium

VII. A brief of Digital Radio Mondiale (DRM):

A. As one of the open standard digital radio systems, below are the Digital Radio Mondiale Key Factors:

- Has become the global standard of terrestrial digital radio,
- Can be utilized in coverage: local, regional, national and international with the use of all AM / FM frequency band (VHF),
- Can operate in full Digital mode, or simulcast AM signal or FM signal,
- Transmitter and receiver equipment with multi-standard chips including various model radios for vehicles already available in the market including ease of upgrading of existing AM / FM transmitter equipment system,
- ITU has support for operations worldwide,
- Standard is open and available on the ETSI website and has been published,
- ITU has confirmed that DRM is a digital radio standard, published in 2003 for DRM standard 30 / AM and in 2011 DRM / VHF standard including FM II band.



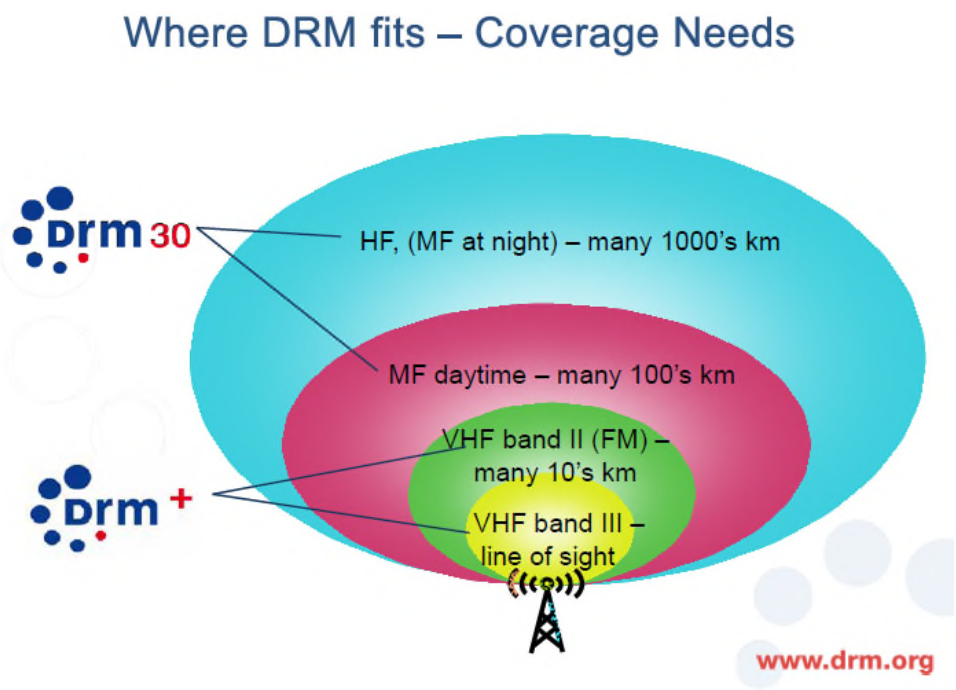
B. More key DRM factors

- The choice of content program for listeners up to 3 (three) audio programs with the addition of 1 (one) multimedia data program at 1 (one) transmitter frequency, broadcasting can be broadcast simulcast analog broadcast and digital broadcast,
- Good sound / audio quality, no distortion, stereo quality and 5.1 surround sound,
- Multimedia applications that benefit the listener and potential acceptance for broadcasters,
- Optimal coverage with strong signals can utilize single frequency network (SFN)}, and green (green) and energy efficient techniques,

- Automatic frequency tuning systems, with optional lists of free-to-air broadcasting agencies, need only re-tunes if they leave the digital broadcasting coverage,
- Can implement early warning system (EWS) with alert / alert information (alert) in the form of voice and writing information (text),

C. DRM utilization needs to match area coverage:

- For national and international coverage is using DRM 30, while for local and regional coverage is use DRM + as shown below:



D. DRM radio broadcasting for local and regional coverage include:

Utilizes the frequency spectrum on:

- Band I 47 MHz - 68 MHz,
- Band II 87.5 MHz - 108 MHz,
- Band III 174 MHz - 230 MHz.
- It has been supported by ITU since 2011 in the form of:
- ITU - R Rec. BS. 1114 (system),
- ITU - R Rec. BS. 1660 (planning parameters),
- ETSI standards have been ratified in 2011,
- International compatibility for the spectrum is 100 KHz bandwidth,
- Bit rate of content program: 27 kbps - 186 kbps$

- Flexible configuration in the planning: because between - signal strength, - coverage area, - transmitter power, interplay,
- Significant cost reductions: energy efficiency - green energy efficient.

E. The transmission system of DRM broadcasting on VHF Band II:

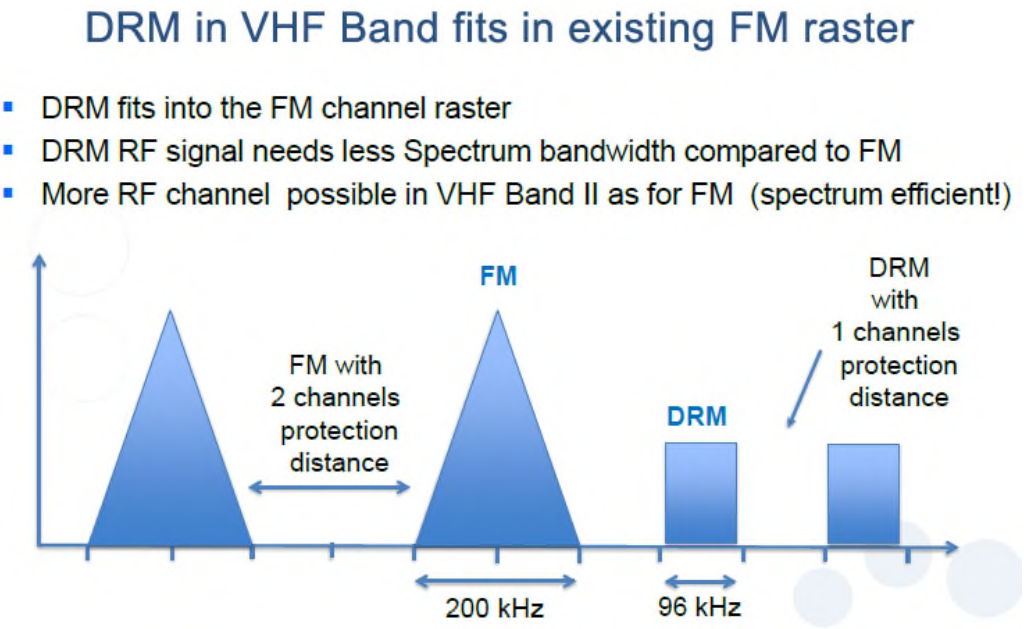
The important parameters used by DRM on the transmission system are as the following table:

General Paramaters	
Frequency Coverage	47 MHz to 254 MHz
RF Channel Bandwidth	96 KHz, conform to FM raster (100 KHz nominal)
Audio Coding	MPEG xHE-AAC, MPEG4 HE-AAC (5.1 surround)
Data Rate	37 kbit/s to 186 kbit/s (scalable)
Modulation	COFDM, 216 carrier
Sub-Carrier Modulation	4 QAM/ 16 QAM
Transmission Power	-8 dB to – 20 dB to coordinated FM Power
Services	Up to 3 services plus Multimedia (Audio, Data)

F. Coverage of DRM transmission to VHF Band II

- Very flexible to be configured at various coverage needs,
- With DRM the results achieved are:
- Broader coverage of transmitters in field strength (same filed strength),
- The same transmitter coverage with lower / smaller transmitter power,
- Combined from both of the above, which resulted in a broad transmitter coverage with a lower transmitter day.
- There are important options that are tailored to the needs of broadcasters, such as coverage, transmitter power, content capacity.

G. DRM transmission on VHF band II corresponds to the existing FM channelization, as shown below:



H. Advantages of flexible transmission network planning on DRM use in VHF bands include:

- Reusable (Re-use) of existing VHF Band II frequency spectrum,
- Supports simulcast DRM service broadcasting options with FM services and simultaneously transmitted side by side on Band II,
- Will result in a wider, better and reliable coverage with single frequency network design (SFN)
- Improve frequency spectrum efficiency because DRM can transmit 3 (three) radio content programs at 100 kHz bandwidth to replace 1 (one) radio content program at 200 kHz FM bandwidth,
- The required transmitter power is lower than FM transmitter power to meet / coverage the same coverage.

I. Advantages for broadcasters are:

- Use of existing / existed ITU standards, available transmission lines, existing transmitting locations and transmittable equipment may be used,
- There are opportunities for advanced network planning utilizing SFN options,
- Significantly decrease all the costs of radio broadcasting system (transmission, operational, service) and highly specialized is the decrease of energy / power used,

J. List of countries that have tried and operated the DRM transmitter

Country	Year	Frequency/ Band
Kaiserslautern/ Jerman	2008-2010	Band II, III
Hannover/ Jerman	2008-2011	Band II, III
Paris/ Prancis	2009	Band I
Turin/ Itali	2011	Band I, II
Edinburgh/ Inggris	2011	Band II
Roma/ Vatikan	2011	Band II
Sao Paolo/ Brazil	2010-2011	Band II
Colombo/ Sri Lanka	2010	Band II
New Delhi/ India		Band II
Nice/ Prancis	2013	Band I
Trondheim/ Norwegia	2013	Band II
Stockholm/ Swedia	2014	Band II

VIII. Setup FM transmitter

To find out the configuration and modeling of the DRM broadcasting system, the following descriptions and key issues related to DRM (Broadcast chain DRM) broadcasting chain:

a) Chain of broadcasting

In the following diagram blocks a simple DRM broadcast chain is described:

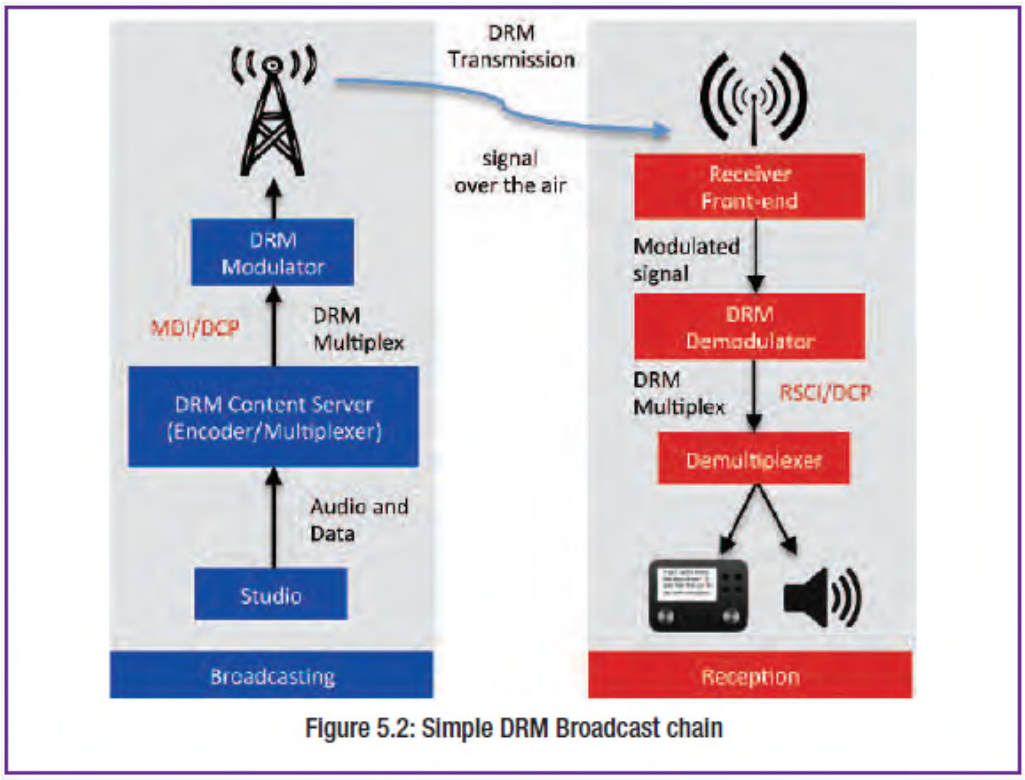


Figure 5.2: Simple DRM Broadcast chain

(Sumber: DRM Introduction and Implementation Guide)

The most important part of DRM is the Encoder and Multiplexer which is a single unit in DRM Content Server, in this part encoding and multiplexing audio / sound program content and multimedia data.

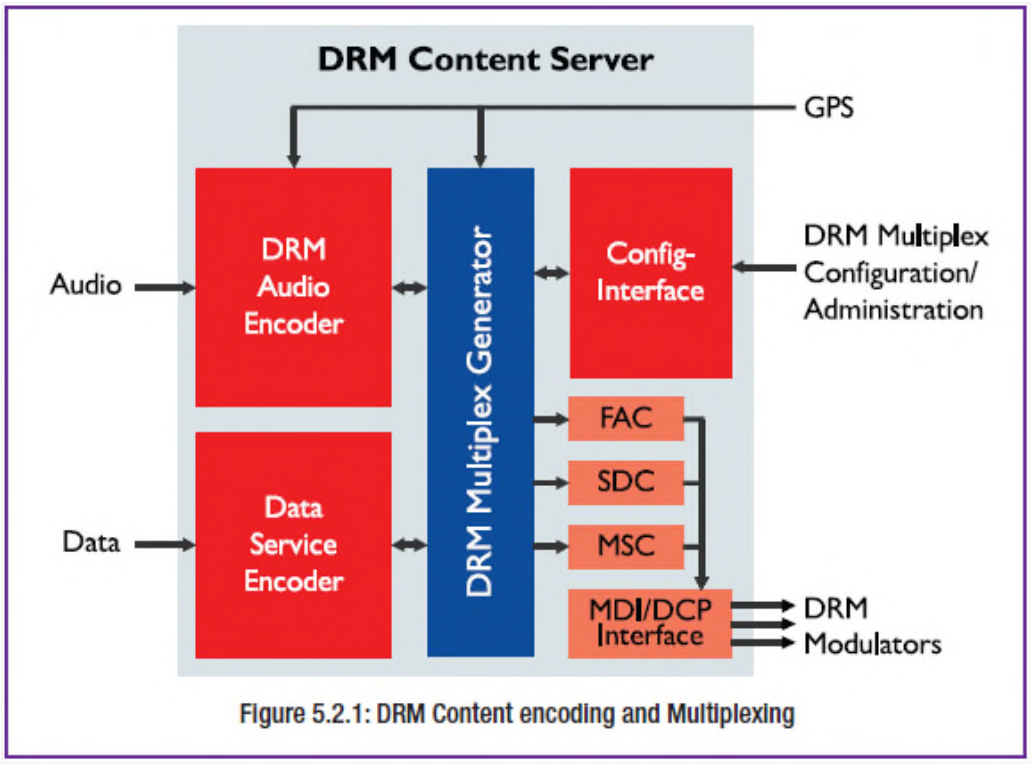


Figure 5.2.1: DRM Content encoding and Multiplexing

(Sumber: DRM Introduction and Implementation Guide)

The result of merging on DRM Content Server is processed on DRM modulator so that it can be transmitted by the transmitter used. The following figure is the concept diagram block of the DRM modulator:

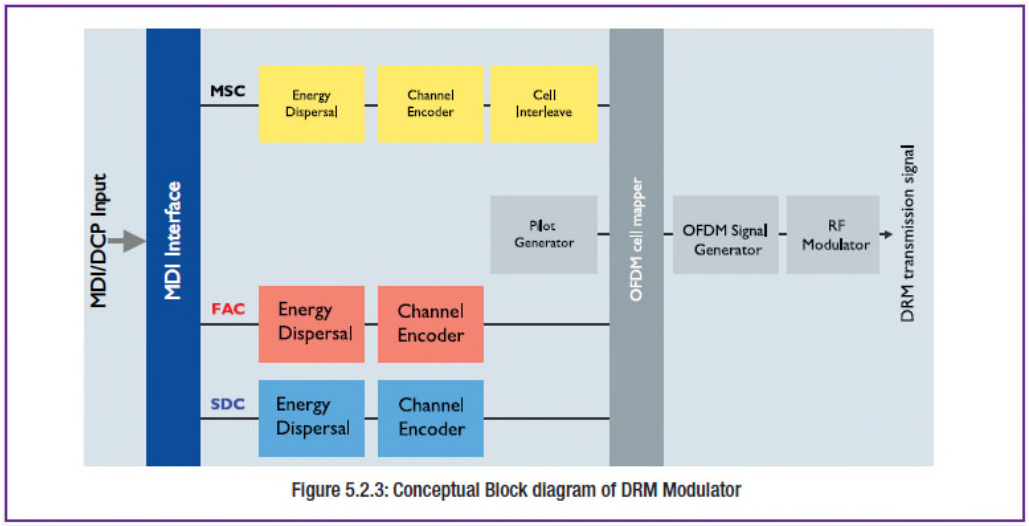


Figure 5.2.3: Conceptual Block diagram of DRM Modulator

(Sumber: DRM Introduction and Implementation Guide)

b) DRM + transmitter parameters

In general the transmitter parameters as the following tables:

General Parameters	
Frequency Range	47 MHz to 254 MHz
RF Channel Bandwidth	**96 kHz**, conform to FM raster (100kHz nominal)
Audio Coding	MPEG xHE-AAC, MPEG4 HE-AAC (5.1 surround)
Data Rate	**37 kbit/s to 186 kbit/s** (scalable)
Modulation	COFDM, 216 carrier
Sub-Carrier Modulation	4 QAM / 16 QAM
Transmission Power	-8 dB to -20 dB to coordinated FM Power
Services	**Up to 3 services** plus Multimedia (Audio, Data)

(Sumber: DRM Consortium)

Minimum median field-strength level E_{med} for 4-QAM, R = 1/3 in VHF Band II

DRM modulation		4-QAM, R = 1/3					
Receiving situation		FX	PI	PI-H	PO	PO-H	MO
Minimum receiver input power level	$P_{i,\,min}$ (dBW)	−142.68	−136.68	−136.68	−136.68	−136.68	−138.48
Antenna gain	G_D (dBd)	0.00	−2.20	−19.02	−2.20	−19.02	−2.20
Effective antenna aperture	A_a (dBm^2)	0.70	−1.50	−18.32	−1.50	−18.32	−1.50
Feeder-loss	L_c (dB)	1.40	0.00	0.00	0.00	0.00	0.28
Minimum power flux-density at receiving place	φ_{min} (dBW/m^2)	−141.97	−135.17	−118.35	−135.17	−118.35	−136.69
Minimum field-strength level at receiving antenna	E_{min} (dB(μV/m))	3.79	10.59	27.41	10.59	27.41	9.07
Allowance for man-made noise	P_{mmn} (dB)	10.43	10.43	0.00	10.43	0.00	10.43
Antenna height loss	L_h (dB)	0.00	10.00	17.00	10.00	17.00	10.00
Building penetration loss	L_b (dB)	0.00	9.00	9.00	0.00	0.00	0.00
Location probability	%	*70*	*95*	*95*	*95*	*95*	*99*
Distribution factor	μ	*0.52*	*1.64*	*1.64*	*1.64*	*1.64*	*2.33*
Standard deviation of DRM field strength	σ_m (dB)	*5.80*	*5.80*	*5.80*	*5.80*	*5.80*	*5.10*
Standard deviation of MMN	σ_{MMN} (dB)	*4.53*	*4.53*	*0.00*	*4.53*	*0.00*	*4.53*
Standard deviation of building penetration loss	σ_b (dB)	*0.00*	*3.00*	*3.00*	*0.00*	*0.00*	*0.00*
Location correction factor	C_l (dB)	3.10	10.91	7.96	9.73	6.25	12.77
Minimum median field-strength level	E_{med} (dB(μV/m))	**17.32**	**50.92**	**61.37**	**40.74**	**50.66**	**42.27**

(Source: Rec. ITU-R BS.1660-7)

Minimum median field-strength level E_{med} for 16-QAM, R = 1/2 in VHF Band II

DRM modulation		16-QAM R = 1/2					
Receiving situation		FX	PI	PI-H	PO	PO-H	MO
Minimum receiver input power level	$P_{r,min}$ (dBW)	−136.08	−128.58	−128.58	−128.58	−128.58	−131.18
Antenna gain	G_D (dBd)	0.00	−2.20	−19.02	−2.20	−19.02	−2.20
Effective antenna aperture	A_a (dBm²)	0.70	−1.50	−18.32	−1.50	−18.32	−1.50
Feeder-loss	L_c (dB)	1.40	0.00	0.00	0.00	0.00	0.28
Minimum power flux-density at receiving place	φ_{min} (dBW/m²)	−135.37	−127.07	−110.25	−127.07	−110.25	−129.39
Minimum field-strength level at receiving antenna	E_{min} (dB(μV/m))	10.39	18.69	35.51	18.69	35.51	16.37
Allowance for man-made noise	P_{mm} (dB)	10.43	10.43	0.00	10.43	0.00	10.43
Antenna height loss	L_h (dB)	0.00	10.00	17.00	10.00	17.00	10.00
Building penetration loss	L_b (dB)	0.00	9.00	9.00	0.00	0.00	0.00
Location probability	%	*70*	*95*	*95*	*95*	*95*	*99*
Distribution factor	μ	*0.52*	*1.64*	*1.64*	*1.64*	*1.64*	*2.33*
Standard deviation of DRM field strength	σ_m (dB)	*3.80*	*3.80*	*3.80*	*3.80*	*3.80*	*3.10*
Standard deviation of MMN	σ_{MMN} (dB)	*4.53*	*4.53*	*0.00*	*4.53*	*0.00*	*4.53*
Standard deviation of building penetration loss	σ_b (dB)	*0.00*	*5.00*	*5.00*	*0.00*	*0.00*	*0.00*
Location correction factor	C_l (dB)	3.10	10.91	7.96	9.73	6.25	12.77
Minimum median field-strength level	E_{med} (dB(μV/m))	**23.92**	**59.02**	**69.47**	**48.84**	**58.76**	**49.57**

(Source: Rec. ITU-R BS.1660-7)

Basic protection ratios PR_{basic} for DRM interfered with by DRM

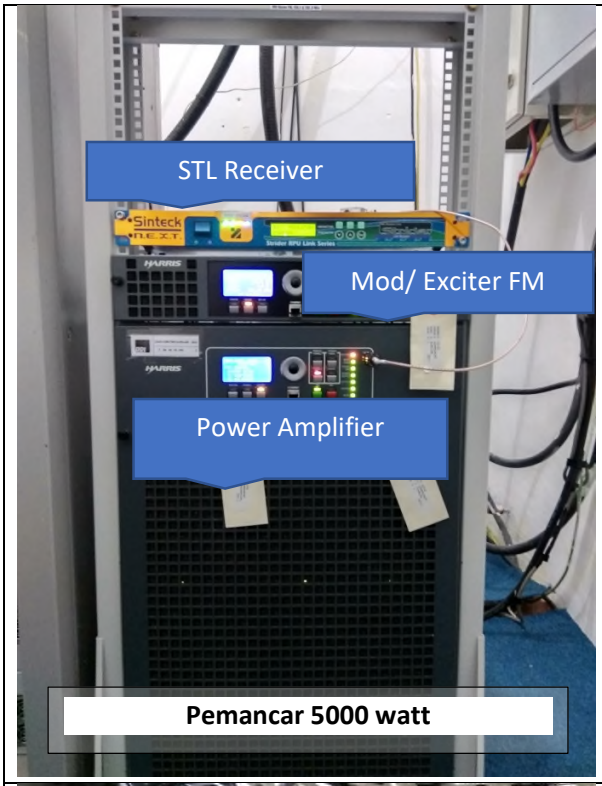
Frequency offset (kHz)		0	±100	±200
DRM (4-QAM, R = 1/3)	PR_{basic} (dB)	4	−16	−40
DRM (16-QAM, R = 1/2)	PR_{basic} (dB)	10	−10	−34

(Source Rec. ITU-R BS.1660-7)

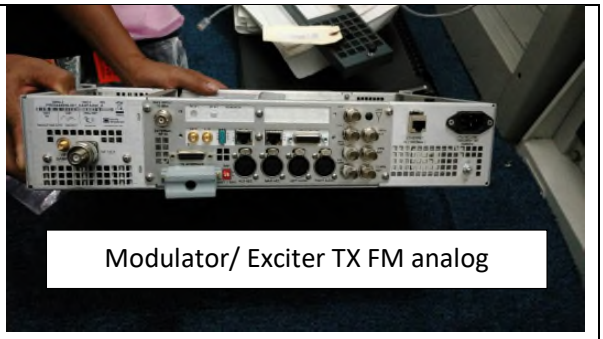
c) Transmitter apparatus for testing:

As per the description of DRM key factor above; For DRM broadcasting, it is possible to use existing transmitters through the upgrades / modifications of available transmitters; Various analog FM transmitter models that have been produced in the last 5 years have been designed to have compatibility to be used as analog FM transmitters or DRM + digital transmitters

The RADIO REPUBLIK INDONESIABatam transmitter used for analog simulcast FM simulcast and DRM + transmitter is transmitter Programa 1 frequency 105.1 MHz 5000 watt power with the addition of DRM module / card in modulator / exciter FM transmitter, as shown below:

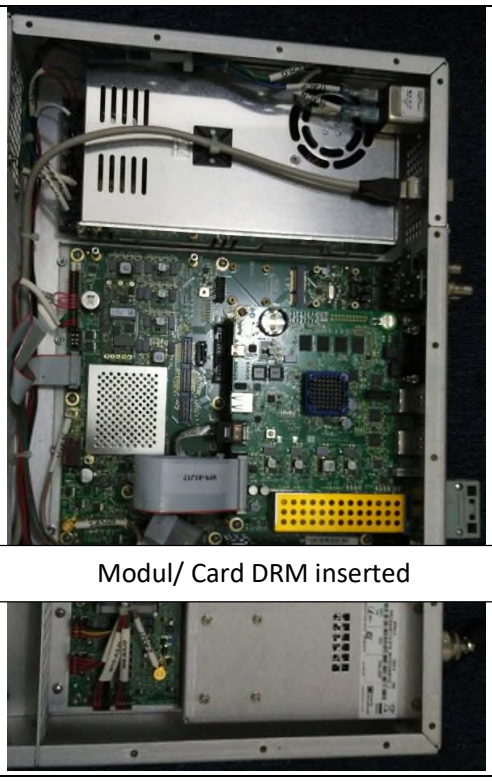


Pemancar 5000 watt

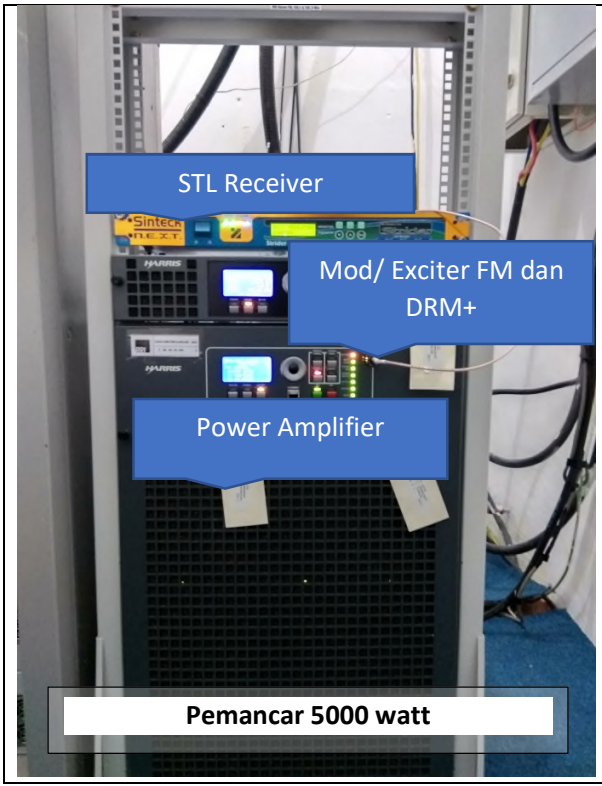


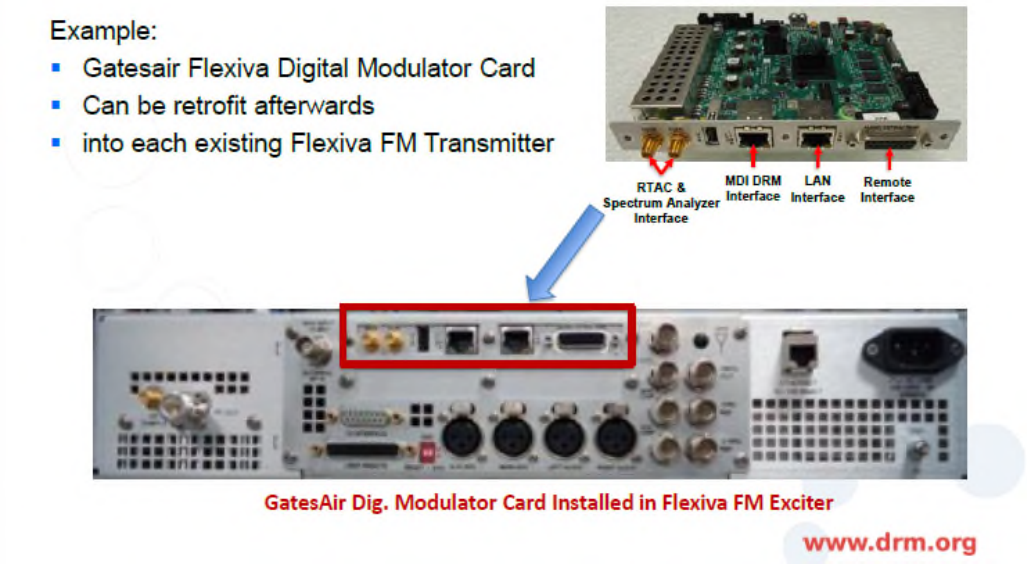
Modulator/ Exciter TX FM analog

Modul/ Card DRM yang ditambahkan

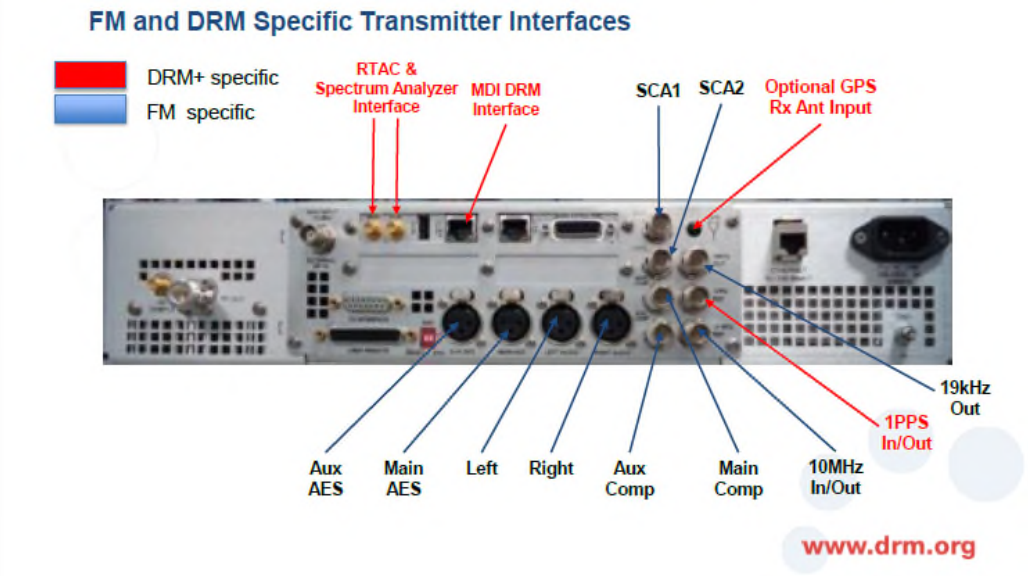


Modul/ Card DRM inserted





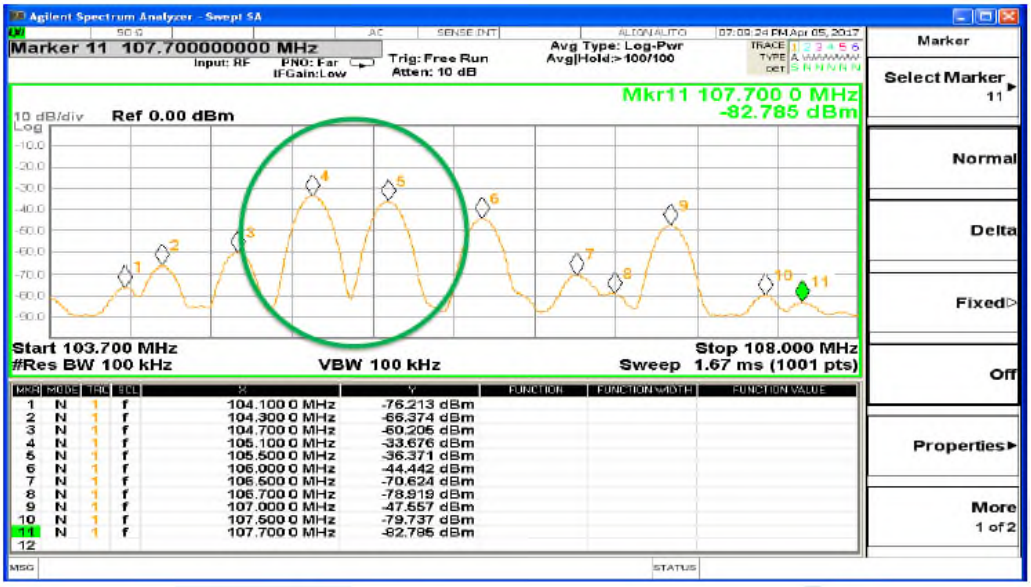
The DRM module / card is added to the analog FM transmitter / exciter modulator



Rear View Modulator / Exciter FM transmitter after added module for DRM

d) The analog simulcast analog and DRM + simulcast broadcasting results

- In observation of frequency spectrum in Batam before simulcast trials can be seen picture of FM transmitter frequency spectrum between 104 MHz up to 107 MHz where there are transmitter frequency channel Programa 1 and Programa 2 RADIO REPUBLIK INDONESIAas follows::

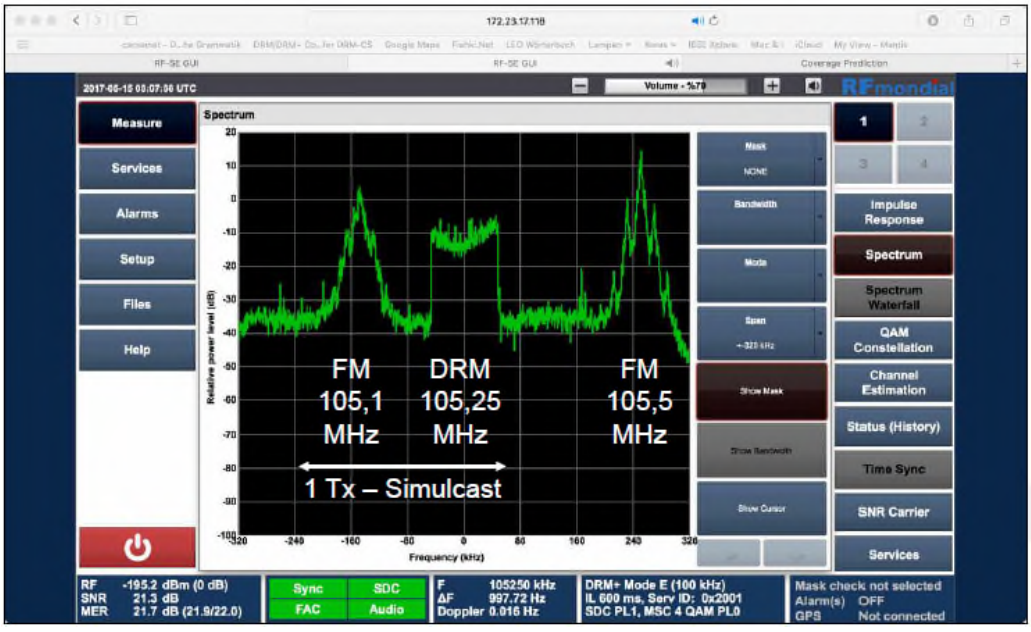


Describing the frequency spectrum condition are two carrier FM transmitter frequencies at 105.100 MHz (Programa 1) and 105,500 MHz (Programa 2) with carrier spacing of 400 kHz.

- For the execution of the DRM + trial in Batam modifications have been made to the transmitter used as described above, for program content content of all 2 audio / sound services and Journaline services for 30 minutes has been recorded into the content server and then run by Multiplex Distribution Interface player (MDI Player) in looping.
- In transmitting analog FM simulcast and DRM + transmitter output power in settings for:
  - FM analog= 2.5 kW,
  - DRM += 200 watt.
- The parameters of setting and used for the implementation of this trial can be seen in the following table:

DRM Parameters	Simulcast Mode FM+DRM
Transmitter Power	2.5 KW
The DRM signal	10dB-12dB lower
DRM Mode	Mode E (DRM+)
Modulation	4QAM
Protection Level	PL0
Content (The 30minute content was pre-recorded and plays in the Loop	2 Audio Services (16kbit and 17.7 kbit/s) and Journaline Service
Minimum field strength	Mobile reception 40dBuV/m

- Here is a picture of the frequency spectrum after the transmitter broadcasts analog FM and DRM + simulcast broadcasts



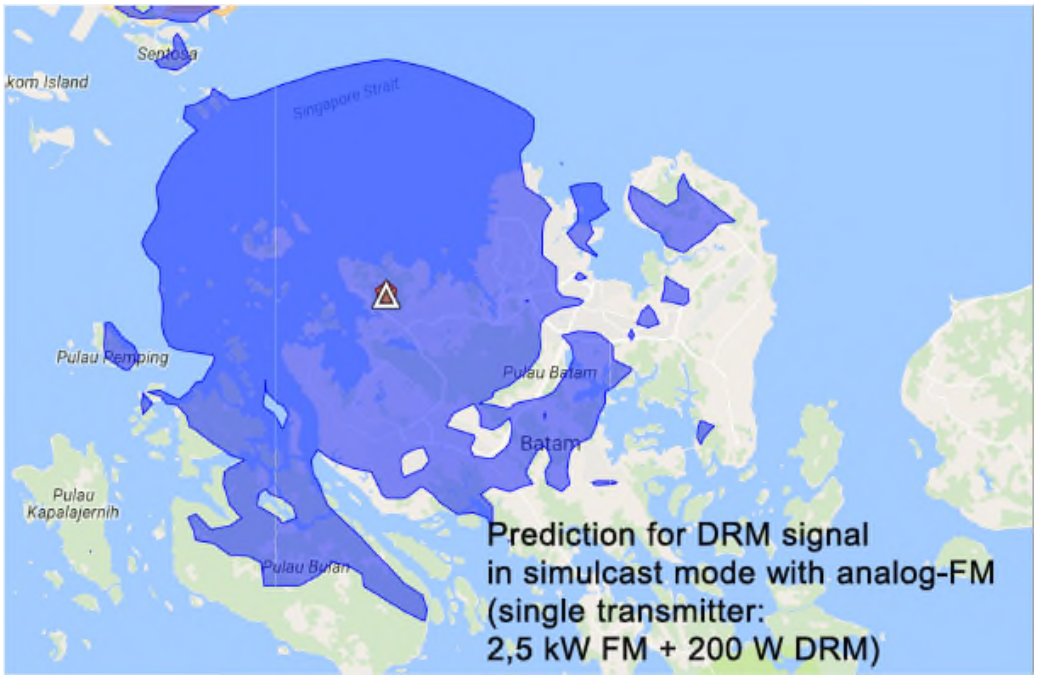
The result of measurement with demodulator obtained picture as follows:

- the frequency center of the analog FM transmitter Programa 1 is 105.10 MHz (no change),
- combined / incremental DRM + transmitter at the 105.25 MHz frequency center, with 100 kHz bandwidth
- center frequency FM analog transmitter Programa 2 fixed at 105.50 Mhz (no change)

Measurement of field strength and drive test to determine the quality and extent of the transmitter coverage:

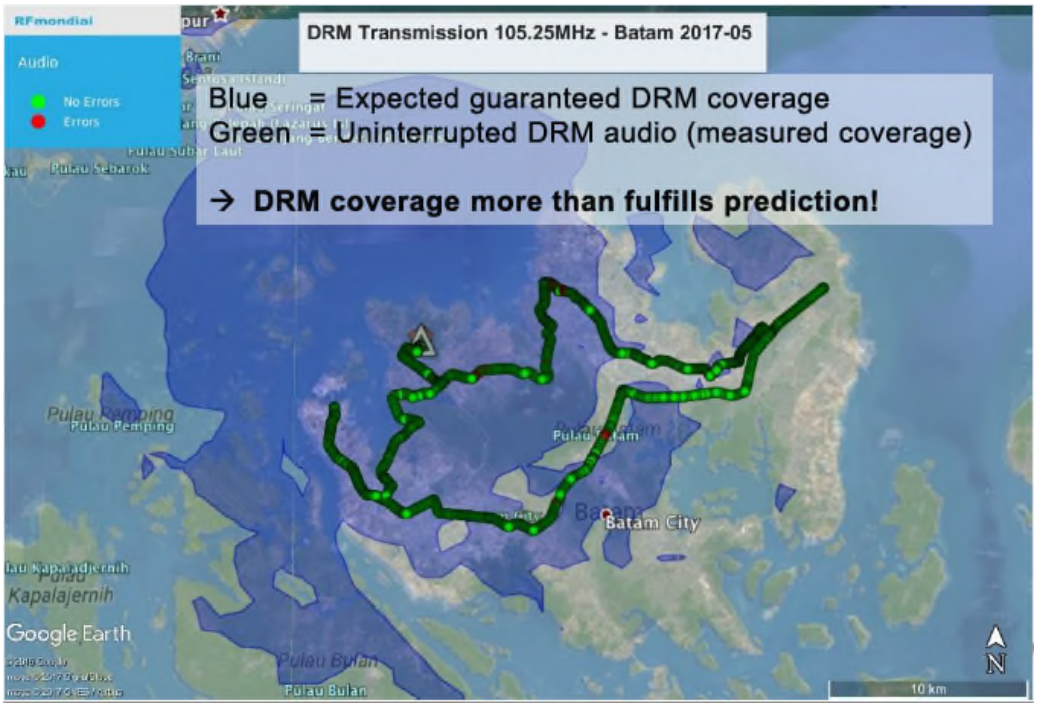
- Setting of measuring equipment and monitoring:

- Visualisasi prediksi jangkauan:



This is the predicted coverage of Expert Team simulation results from DRM Consortium

- Initial measurements of field strength and transmitter coverage

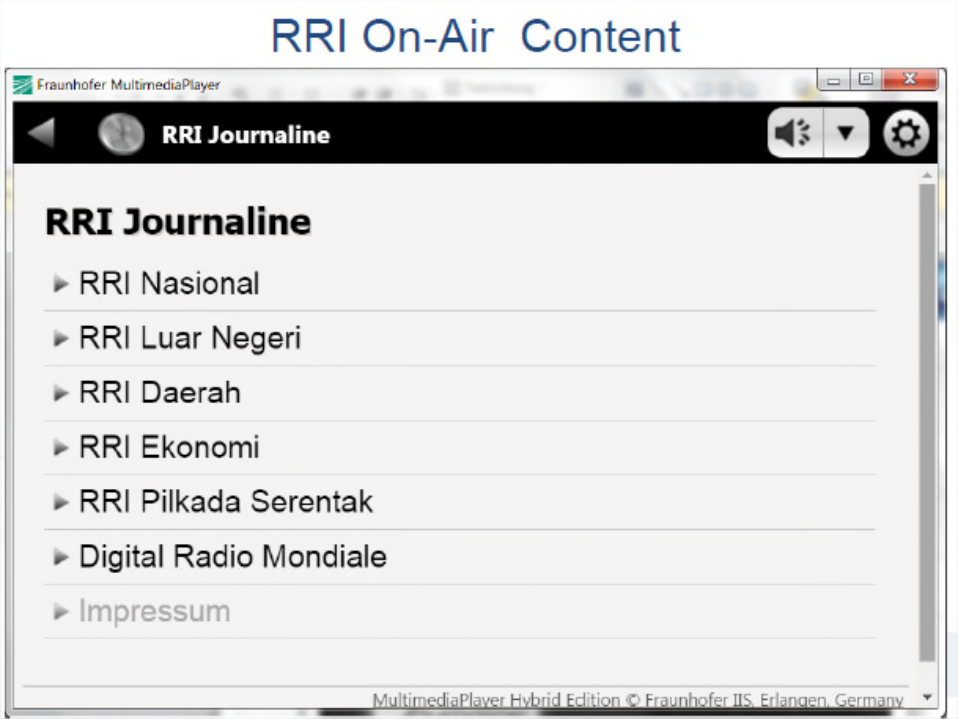


This is the result of the coverage measurements, showing that the DRM + coverage exceeds the coverage prediction

(Green dots are an uninterrupted audio reception)

RRI On-Air Content display on DRM + trial

RRI On-Air Content display on DRM + trial



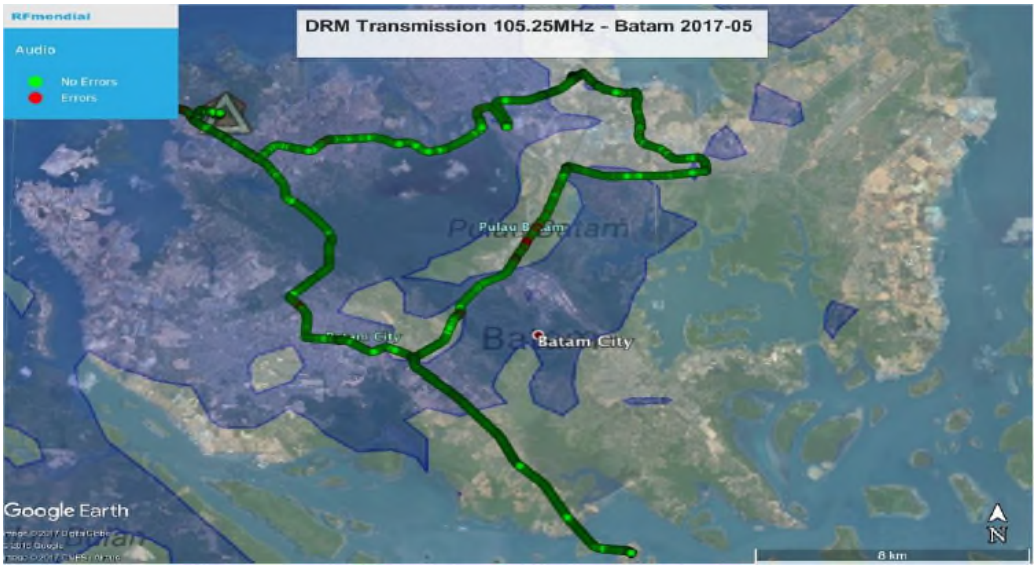
RRI On-Air Content display on DRM + trial

RRI On-Air Content display on DRM + trial

- Overall field measurement results:

Strong field quality / monitored strength

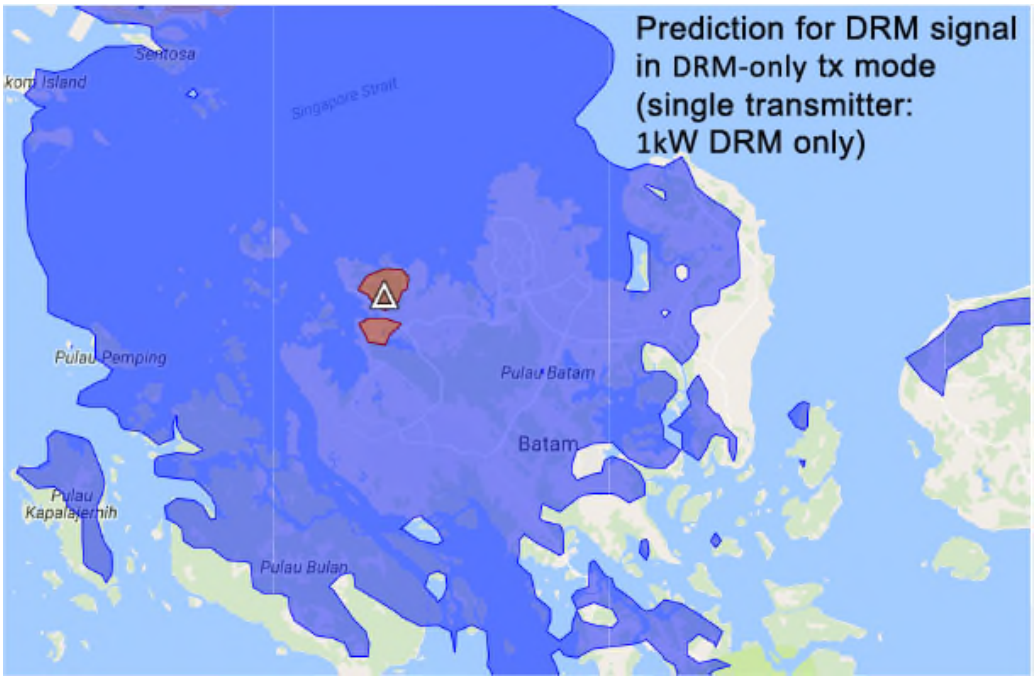
Signal Quality Modulation Error Ratio



DRM + audio quality, there is error / disturbance at red dots caused by made man noise (motor vehicle)

Conclusion:

1. In transmitting experiments using 1 (one) transmitter simulcast FM analog and DRM + has been proven that the transmitter can function simultaneously emit analog FM signal at frequency 105.10 MHz and DRM signal at frequency 105.25 MHz,
2. FM 2.5 kW transmitter and transmitter DRM + 0.2 kW,
3. The DRM + signal is inserted on the existing VHF band II frequency spectrum,
4. Predicted DRM coverage areas that have been calculated are 40 dBµV / m,
5. Indoor reception (indoor) and mobile (mobile) quality is good,
6. Wider DRM coverage area although with DRM transmitter only about 10% analog FM transmitter power,
7. No disturbance to the adjacent transmitter (frequency 105.10 MHz and frequency 105.50).
8. Prediction for full digital DRM broadcasting is required only 1 (one) DRM transmitter with 1 kW power



Predicted coverage to coverage Batam City is only required

1 (one) digital transmitter DRM + with power 1 kW (full digital)

Suggestion:

1. Develop roadmap implementation of digital radio broadcasting DRM in LPP RRI,
2. Conducting socialization and roadshow to RADIO REPUBLIK INDONESIAwork units and stakeholders throughout Indonesia on digital radio broadcasting DRM,
3. Conducting education and training related to digitalization of DRM digital radio broadcasting system to all RADIO REPUBLIK INDONESIAhuman resources throughout Indonesia,
4. Propose to the Ministry of Communications and Informatics to be able to implement DRM digital radio broadcasting standard in Indonesia.