



Technical Challenges of DVB-T2 Implementation in Indonesia

Tantangan Teknis Implementasi DVB-T2 di Indonesia

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Abstrak— Transisi dari penyiaran analog ke digital yang menjanjikan banyak kesempatan baru telah memotivasi Organisasi Telekomunikasi Internasional (International Telecommunication Union atau ITU) untuk memberikan dorongan yang besar kepada Negara-negara di dunia untuk segera mewujudkannya. Sebagian besar Negara-negara di dunia juga sudah menyadari begitu pentingnya transisi tersebut. Akan tetapi, banyak tantangan yang membuat proses transisi berlangsung relatif lambat, termasuk di Indonesia. Penelitian ini memilih Swedia dan Inggris yang sudah terlebih dulu melakukan transisi total ke penyiaran digital untuk menggali tantangan-tantangan teknis dan usaha yang dilakukan untuk menghadapi tantangan tersebut. Penelitian ini menganalisa status transisi Indonesia saat ini dan menghasilkan rekomendasi-rekomendasi.

Kata kunci— transisi digital, DVB-T2, tantangan teknis

Abstract— Transition from analogue to digital broadcasting which promises many new opportunities has motivated International Telecommunication Union (ITU) to urge all countries to immediately perform it. Most countries also have realized the importance of it. However, there are many challenges which make the transition process are relatively slow, including in Indonesia. This study chose Sweden and United Kingdom which have totally switched off their analogue broadcasting and migrated to digital. It was done to explore their technical challenges and the efforts to cope with it. It analyzed the current status and circumstances in Indonesia and created the proposed recommendations.

Keywords— digital transition, DVB-T2, technical challenge

I. INTRODUCTION

The broadcasting technology has emerged since 1900 and before the invention of television, it was primarily used for radio and wireless telegraph (Luo, 2011). Television used high-frequency radio wave to send the television signal and at the beginning, the information was transformed and sent as analog signals. Analog transmission utilizes a prolonged carrier signal which the amplitude, frequency, or phase varies in the proportion to the analog message (voice and image). It uses frequency modulation (FM) and amplitude modulation (AM).

The development of digital broadcasting was started since 1990s. It gives better quality, bigger transmission rates, better resistance to the interference, and tackles the problems caused by channel noise. Digital broadcasting sends the broadcast information using digital data. It only forwards the discrete messages in the form of digital symbols.

In June 2006, the United Nations specialized agency for information and communication technologies – International Telecommunication Union (ITU) – signed the agreement which stated that the transition from analogue to digital broadcasting should end in June 2015, although some countries proposed an extra five-year prolongation for the VHF band (ITU, 2006). ITU stated that the switchover from analogue to digital broadcasting will establish new distribution networks and enlarge the opportunities for wireless innovation and services, i.e.: because of the efficiencies in spectrum usage, it can allow more channels to be carried across fewer airwaves and direct to greater convergence of services. There are many challenges and problems in the transition process. It

usually needs 2 until 8 years for the preparation and the planning time, and 1 until 14 years for the implementation and the analogue switch-off (ASO) time (Hai, 2013). Figure 3 shows the period between Digital Terrestrial Television Broadcasting (DTTB) launch and analogue switch-off in some countries in Europe.

Digital Broadcasting is one of the four most prioritized issues of the ICT development in Indonesia besides Economic Broadband, E-Commerce, and ICT in Rural Areas (MCIT, 2012a). Analogue to digital broadcasting should be performed because it can economize the frequency spectrum. It has to be done because the radio frequency spectrum is a limited natural resource that is very important in telecommunication and the utilization must be undertaken in an apprehensive, efficient as required, and does not cause dangerous interference.

Indonesia has made several trials and chose a digital broadcasting transmission standard (MCIT, 2012a). Indonesia has launched several regulations and licenses for the digital television (DTV) stakeholders as well. Figure 1 shows the frequency spectrum planning of Indonesia. It can be seen that Indonesia decided to use 526 to 694 MHz for the digital terrestrial television (DTT) free-to-air (FTA) (Setiawan, 2013). It will release 694 to 806 MHz frequency spectrum that nowadays is still used by analogue broadcasting. The discharge of the frequency spectrum as a result of the transition of terrestrial television broadcasting from analogue to digital is known as digital dividend (ITU, 2012b). Indonesia plans to use it for mobile broadband improvement.

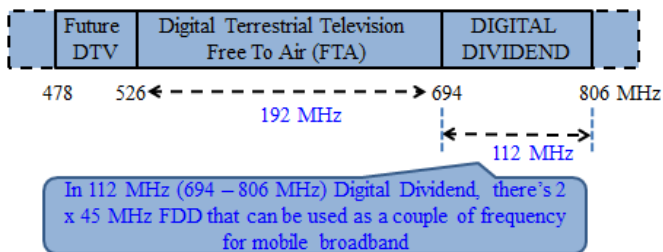


Figure 1. Digital Dividend of Digital Broadcasting in Indonesia (Setiawan, 2013)

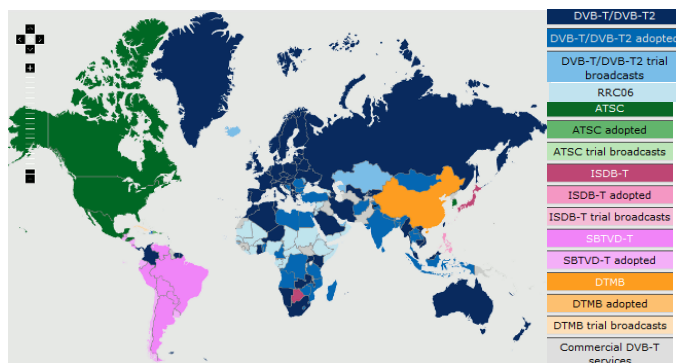


Figure 2. Digital TV Standard in the World(dtvstatus.com, 2013)

There are some transmission standards that are used in digital broadcasting. Most countries have stated their decision

to adopt which standard. Figure 2 shows the digital broadcasting transmission standards that have been adopted by all countries. It can be seen that the standard mostly adopted is DVB-T (Digital Video Broadcasting - Terrestrial).

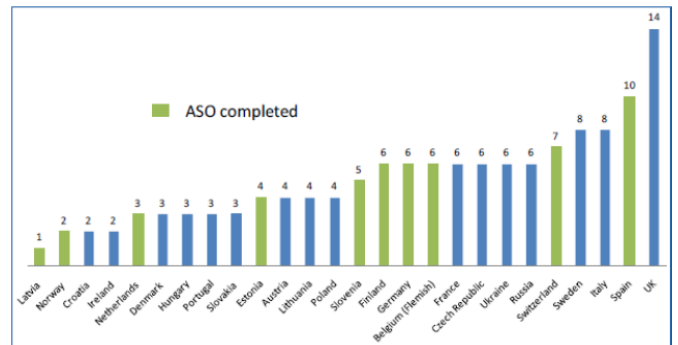


Figure 3. Period between DTTB launch and the analogue switch-off (Hai, 2013)

World organizations and various stakeholders have made many efforts to support the countries to confront the challenges and problems. ITU in cooperation with stakeholders organize several general meeting annually to trace the transition in some countries, giving some inputs and best practices (ITU, 2012c, 2013), and publishing guidelines for certain region or country (ITU, 2011, 2012a, 2012b; Southwood, 2011). However, there was no publication which discuss about the challenges of the implementation of a standard specifically.

Digital broadcasting has been issued in Indonesia since 2002 and now it is still in developing phase. While ITU targeted the end of the transition from analogue to digital broadcasting in 2015, Indonesia stated that it cannot be done until 2018. It will be three years in advance. It is very important to explore the challenges and efforts that have been done by other countries for the transition. By doing that, Indonesia can get the best practices, implement it, and accelerate the transition in Indonesia.

This research was aimed to formulize the recommendations to encounter the technical challenges in digital television transition, especially in DVB-T2 – the transmission standard that has been chosen by Indonesia.

II. DVB-T2

DVB-T2 or Digital Video Broadcasting - 2nd Generation Terrestrial is a European standard which was released in 2009. It is the second generation of DVB-T which was published earlier in 1997. DVB-T2 has several new technologies that is not available in DVB-T, i.e. Multiple Physical Layer Pipes, Alamouti coding, constellation rotation, extended interleaving, and future extension frames. Those new improvements allow DVB-T2 to offer much higher data rate than DVB-T.

Table 1 shows new specifications which are owned by DVB-T2. It is showed by bold font style. Those new specification finally resulted the improvement in the typical and maximum data rate.

Based on Figure 2 about Digital TV Standard in the World, there are five digital broadcasting transmission standards: DVB-T/DVB-T2, ATSC (VSB), ISDB-T, SBTVD-T, and DTMB. SBTVD-T is based on the modulation BST-OFDM of the ISDB-T system (Chen, 2008). In November 2007, ITU introduced another standard called T-DMB (Jo, 2007). Table 2 shows some comparisons of these standards for fixed and mobile reception. It can be seen that DVB-T2 has the highest maximum data rate for both fixed and mobile reception.

III. PREVIOUS RESEARCH ABOUT TECHNICAL CHALLENGES OF DVB-T2

Most researches about DVB-T2 were about the core technology, such as the improvement of the architecture efficiency and enhancement of the performance reliability. The discussion about the method to overcome the challenges or problems in the implementation of DVB-T2 were only found very limited in the organizational publication which were published along with the purpose to encourage the transition from analogue to digital broadcasting or as a periodic or final report of the transition.

Li et al (2009) stated that the system of substantial output, low complexity and latency architectures for a principle of modulation with certain diversity in DVB-T2 were some great challenges. By using a rotated demapper dedicated to the four constellations of the DVB-T2 which detected over classical Rayleigh fading channels and fading channels with erasures, Li et al (2009) made a demonstration using a prototype based on a Field-Programmable Gate Array (FPGA) device. It showed the efficiency of the flexible architecture of Bit-Interleaved Coded Modulation (BICM) with Signal Space Diversity (SSD) that has been applied into the DVB-T2 standard.

Channel condition, hard reception conditions and environments, high number of parameters that need to be tested during the initial scan were reported by Jokela et al (2010) as the challenges in the DVB-T2. They found that the transmission of the most important system parameters and the discovery of the existence of DVB-T2 signal from the P1 symbol are very strong. The transmission of the residual of physical layer signaling in the P2 symbols also can be set adequately intense in slightly fixed reception condition (P1 and P2 symbols are pilot symbols in DVB-T2 (ETSI, 2009)). For rapid mobile reception condition, the signal strength could not be high enough because of the shortage of time discrepancy.

Dai et al (2012) mentioned other challenges in DVB-T2, i.e. high spectral efficiency and reliable performance, capability of supporting higher order modulation schemes, and

the optimal rotation angle under different scenarios. Dai et al (2012) addressed that DVB-T2 provides improved use of the spectrum which is obtained by merging vast of edge-cutting signal processing technologies – one of those is extended Orthogonal Frequency Division Multiplexing (OFDM) transmission. The time-frequency training OFDM (TFT-OFDM) scheme is the optimum method to reach high spectral efficiency and credible performance.

TABLE 1. DVB-T2 IMPROVEMENT THAN DVB-T

	DVB-T	DVB-T2 (new/improved options in bold)
FEC	Convolutional Coding+Reed Solomon 1/2, 2/3, 3/4, 5/6, 7/8	LDPC + BCH 1/2, 3/5, 2/3, 3/4, 4/5, 5/6
Modes	QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM, 256QAM
Guard Interval	1/4, 1/8, 1/16, 1/32	1/4, 19/128 , 1/8, 19/256 , 1/16, 1/32, 1/128
FFT Size	2k, 8k	1k, 2k, 4k, 8k, 16k, 32k
Scattered Pilots	8% of total	1%, 2%, 4%, 8% of total
Continual Pilots	2.0% of total	0.4%-2.4% (0.4%-0.8% in 8K-32K)
Bandwidth	0, 7, 8 MHz	1, 7, 8, 9, 10 MHz
Typical data rate (UK)	24 Mbit/s	40 Mbit/s
Max. data rate (@20 dB C/N)	31.7 Mbit/s (using 8 MHz)	45.5 Mbit/s (using 8 MHz)
Required C/N ratio (@24 Mbit/s)	16.7 dB	10.8 dB

Source: DVB Fact Sheet - August 2013, dvb.org

TABLE 2. COMPARISON OF DIGITAL TERRESTRIAL TRANSMISSION STANDARD

	DVB-T2	VSB – ATSC	ISDB-T	DTMB China	T-DMB Korea
Fixed reception:					
Maximum data rate	45.5 Mbps in 8 MHz (dvb.org, 2013)	19.39 Mbps in 6 MHz (ATSC, 2007)	16.85 Mbps (dibeg.org, 2008)	21.66 Mbps (ASTRI, 2012)	1.152 Mbps in 1.536 MHz (Y. Kim, 2011)
Modulation	QPSK, 16QAM, 64QAM, 256QAM	8-VSB, 16-VSB	64QAM	64QAM	DQPSK, BPSK, QPSK (D. Kim, 2009)
Code rate	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/2, 2/3, 1/4	3/4	2/3	1/2, 2/5, 1/3, 1/4
Mobile reception:					
Maximum data rate	4 Mbps (EBU, 2013)	10.76 Msymbols/s (Semmar, 2004)	416 Kbps QPSK, 2/3 (Imamura, 2007)	674 kbps	1.088-2.304 Mbps in 1.536 MHz (D. Kim, 2009)
Modulation	256-QAM	8-VSB	QPSK	4 QAM	DQPSK, BPSK, QPSK
Code rate	1/3, 2/5	2/3	2/3	0.4	1/2, 2/5, 1/3, 1/4

Dai et al (2012) also mentioned that up to now, the maximum order of the modulation systems is 256 QAM. It was only achieved by the DVB-T2 and at first was implemented in UK. Dai et al (2012) stated that in the future, it was expected that more optimum order modulation systems will be released, e.g. 512 QAM, to enhance the spectral efficiency.

IV. INDONESIA CURRENT STATUS

Indonesia is a large country in the boundary of the North Pacific and the Indian Ocean. It is also laid between two big continents: Asia and Australia. Indonesia is consisted in South East Asia region and shares the land boundary with Malaysia, East Timor, and Papua New Guinea.

Indonesia is the 14th largest land area (1,811,570 km²) (WorldBank, 2011) and the 4th biggest population (246,864,191) (WorldBank, 2012c). Coupled with the GDP per capita as much as US\$ 3,557 (WorldBank, 2012b), the decrease of the GDP growth from 6.5% to 6.2% in 2011 and 2012 respectively (WorldBank, 2012a), and the number of television broadcasting companies were 500 (infoasaid.org, 2012), those are several main challenges that is faced by Indonesia.

The formulation, establishment, and implementation of the policy in the field of communications and informatics, including the digital broadcasting transition, are done by Ministry of Communications and Information Technology (MCIT, 2013a).

Indonesia held the first digital broadcasting trial in 2006 (Putra, 2006). The trial used UHF 27 frequency to test Digital Terrestrial Multimedia Broadcasting (DTMB) developed by China and UHF 34 to test DVB-T and DVB-H (DVB for Handheld receivers such as mobile telephones and PDAs) (dvb.org, 2011; MCIT, 2006). The DTMB used 500 watt and 16 antenna panel transmitter, whereas the DVB-T/H used 425 watt and 4 antenna panel transmitter. Those 2 transmitters were located at the same place and there was another transmitter which located in the different area to test the Single Frequency Network (SFN) – a network in which a number of transmitters perform on the same radio frequency (dvb.org, 2012).

In this trial, Indonesia succeeded to perform Overlay Multiplexing both at the DVB-T and DVB-H signals and those signals could be transmitted in one frequency spectrum UHF 34 (578 MHz) in 8MHz bandwidth. It proved the efficiency of the frequency channel usage in which it could be used by three programs for DVB-T (MPEG-2 streaming at 2Mbps) and 8 programs for DVB-H (MPEG-4at 384 Mbps).

Indonesia made another trial for DVB-T at different location in 2008 (MCIT, 2012a). And after the release of DVB-T2 in 2009, Indonesia performed trial for the new technology at the same year and it was also successful. Then Indonesia ruled the adoption of this new transmission standard

in 2012. Figure 4 shows the road of the digital broadcasting transmission standard adoptions in Indonesia.



Figure 4. The Road to DVB-T2 in Indonesia

Yusuf (2012) also mentioned that DVB-T was selected because of the bandwidth-efficient guarantee that can be achieved through multiplexing technology. Yusuf (2012) also quoted the explanation of MCIT that the DVB-T2 was chosen to replace DVB-T because of the new technology improvement in it, such as the use of MPEG-4, the energy-efficient, and the capability to load 12 content programs while DVB-T only allows 6 content programs (Yusuf, 2012).

The roadmap of digital broadcasting transition is divided into 3 phases: Phase I in 2009 to 2013, Phase II in 2014 to 2017, and Phase III in 2018. The first phase concentrates on the field trial and the selection of new licensing for digital broadcasting and the implementation of simulcast broadcasting. This phase also strives to promote local industry to produce set-top-box. The second phase will continue the simulcast period and speed up the new licensing in the less developed economies district. The last phase is the analog switch off in all area of Indonesia (MCIT, 2012a). Figure 5 shows the detail of the roadmap.



Figure 5. The Roadmap of Digital Broadcasting Transition in Indonesia (MCIT, 2012a)

There are 718 analogue terrestrial television transmission stations and 79 broadcast license holders in Indonesia (Figure 6 and 7). And it continues to increase although the issues about the digital broadcasting have been raised. There are five types of broadcast company or institution in Indonesia: public, private, community, subscription, and foreign broadcast company (President of the Republic of Indonesia, 2002). Public made some association based on these types, such as The Association of the Local Television of Indonesia, The Association of Democracy Television of Indonesia, The

Association of the Community Television of Indonesia, and The Association of the Private Television of Indonesia (asteki.com, 2013; atvki.com, 2013; atvli.com, 2013; p3i-pusat.com, 2013).

The transition from the analog to digital broadcasting required the changes in the business model. Indonesia stated that these changes are from vertical to horizontal. In the analog broadcasting, the broadcaster organizes the content and the use of frequencies, owns the infra-structures and the tower. But in the digital broadcasting, there is another function, i.e. the broadcast multiplexing operator (BMO) or LPPPM (in Indonesian). The BMO hold the frequency, provide towers and multiplexing infrastructures. The program content will be provided by broadcast program operator (BPO) or LPPPS (in Indonesian). Figure 8 describes the new business model.

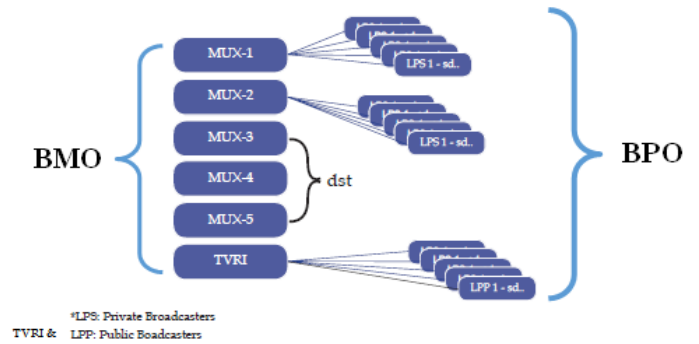
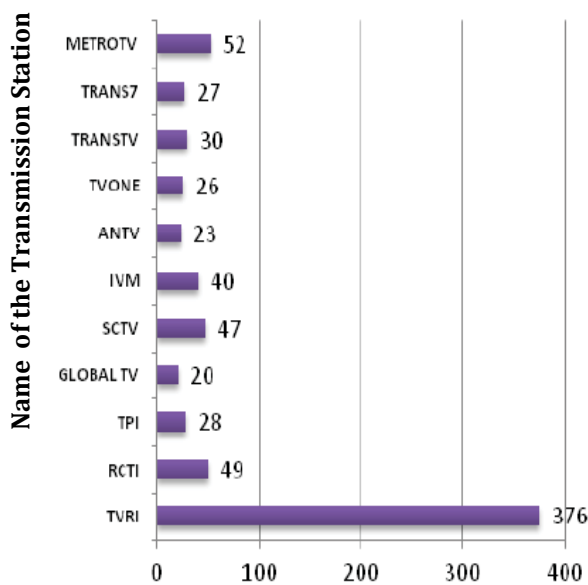


Figure 8. The Business Model of Digital Broadcasting in Indonesia(MCIT, 2012a)

Indonesia divides its large area into 15 zones digital broadcasting transition. Figure 9 shows the map of these zones.



Source: ADO Statistic, Dir. of Control, D.G.PPI, 2011

Figure 6. The Number of Analogue Terrestrial Television Transmission Station in Indonesia(MCIT, 2012a)

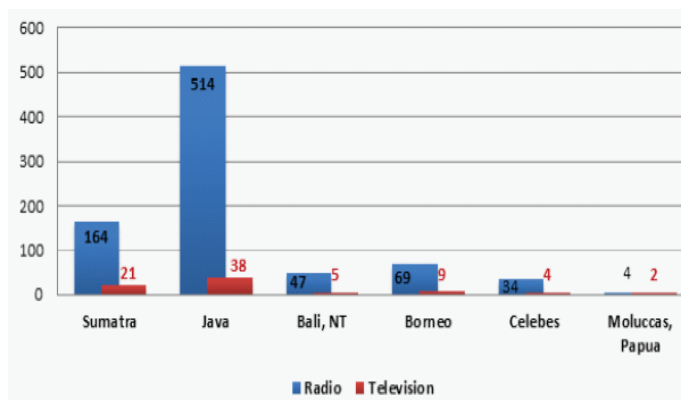


Figure 7. The Number of Broadcast License Holder per Area in Indonesia(MCIT, 2012a)



Figure 9. The Map of Digital Television Zones in Indonesia (Nugraha, 2012)

Having done several trials in 2006 to 2009 and changed from DVB-T to DVB-T2, Indonesia also has made socialization mechanism through internet, conference, talk show, and audience survey. In 2010, Indonesia launched the digital transmitter in three metropolitan cities (MCIT, 2012a). MCIT launched several regulations in 2011 to 2012. And until 2013, MCIT has selected the BMOs in 7 zones: zone 1, 4, 5, 6, 7, 14, and 15 (ak, 2013) and all BMOs have built the infrastructures as the commitment (MCIT, 2013b). Figure 10 and 11 shows the achievement from 2007 to 2010 and 2011 to 2013 respectively.

Indonesia already ruled the DVB-T2 technical parameters that must become the direction to build the infrastructure or equipment in digital broadcasting. Table 3 shows the technical parameters. The regulation which rules the technical parameter for the transmitter has been authorized but not yet for the receiver.

V. RESEARCH METHODOLOGY

Analyzing the current status of DVB-T2 implementation in Indonesia was the first step done in this study after reviewing the literature. Two benchmarking countries which also chose DVB-T2 – Sweden and United Kingdom – were selected in this study. Sweden was chosen because it is one of the first countries which switched off their analogue broadcasting in the earliest time, whilst UK was preferred because it is the country which recently switched off their analogue broadcasting. This research explored the technical challenges

that have been dealt by both countries, examined the efforts done, and created the recommendations based on both countries' best practices while considering the circumstances in Indonesia.

The information was collected from the official web sites of ITU, Indonesia, Sweden, and UK. It was also obtained from the official web sites of other neighboring countries and stakeholders that are involved in the transition.

VI. CASE STUDIES

This paper studied two European countries: Sweden and United Kingdom (UK) as those countries already totally switched off the analogue broadcasting and migrated to digital broadcasting. Sweden already migrated since 2008, whereas UK just migrated in 2012. Table 4 shows some conditions of Indonesia, Sweden, and UK. While Table 5 and 6 shows the road of Sweden and UK in their transition of digital broadcasting respectively.

This study found several similar and different technical challenges that were faced by both Sweden and UK:

1. Technical Parameter

None of Sweden and UK mentioned the technical parameter as their challenge. However, this study found many differentiations among Sweden and UK that is shown in Table 7. It is also different to Indonesia if we compare it to Table 3.

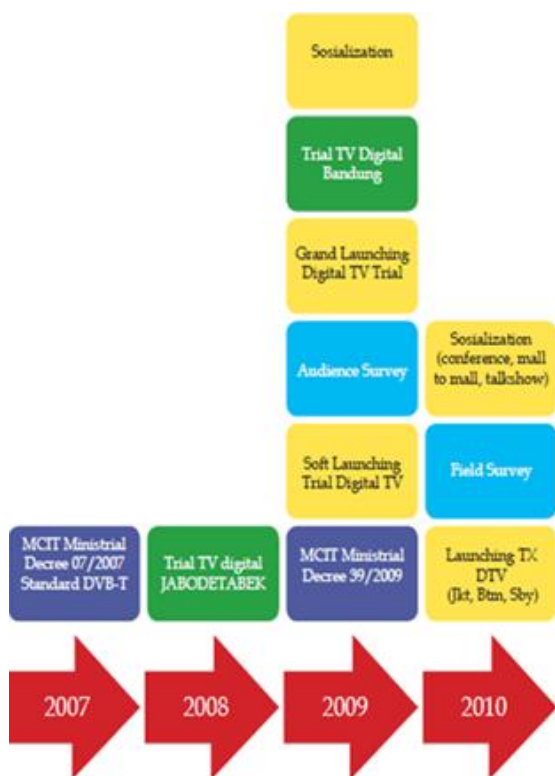


Figure 10. The Development of Digital Television Broadcasting in Indonesia from 2007 to 2010 (MCIT, 2012a)

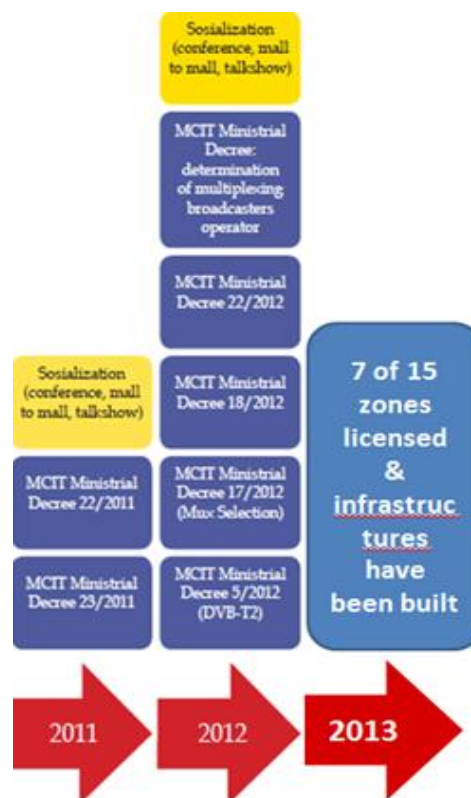


Figure 11. The Development of Digital Television Broadcasting in Indonesia from 2011 to 2013(MCIT, 2012a)

TABLE 3. THE DVB-T2 TECHNICAL PARAMETERS OF INDONESIA

Technical Parameter	Value
Guard interval	1/4, 19/256, 1/8, 19/128, 1/16, 1/32, 1/128 (MCIT, 2012b)
FEC (Forward Error Correction)	1/2, 3/5, 2/3, 3/4, 4/5, 5/6 (planned) (MCIT, 2012c)
Mode	4, 16, 64, 256QAM
Code rate	1/2, 3/5, 2/3, 3/4, 4/5, 5/6
FFT size (Fast Fourier Transform)	Not mention (Regulation only contains the abbreviation of FFT)
Pilots	Not mentioned
P1/P2 overhead	Not mentioned
Capacity	Not mentioned

TABLE 4. SOME CONDITIONS OF INDONESIA, SWEDEN, AND UK

	Indonesia	Sweden	UK
Land area (2011)	1,811,570 km ²	410,340 km ²	241,930 km ²
Population (2012)	246,864,191	9,516,617	63,227,526
GDP per capita (2012)	US\$ 3,557	US\$ 55,245	US\$ 38,514
GDP growth (2012)	6.2%	0.7%	0.3%

	Indonesia	Sweden	UK
First launched of digital broadcasting	2006	1999	1998
Analog switch off (targeted)	2018	2007	2012

Source: World Bank

TABLE 5. THE ROAD OF SWEDEN TO THE ANALOGUE SWITCH OFF

Year	Program
1999	First launched of digital broadcasting with 3 DVB-T muxes and 50% coverage (Ratkaj, 2009)
2003	Parliament's decision on gradual switchover
2004	The Digital TV Commission were formed (SwedishBroadcastingAuthority, 2012)
2004-2005	The Commission plans the switchover
2005	Switch-off began on Sept 19, in an island of Gotland
2006-2007	Phase 2 through 5 were performed in line with the plan
2007	Analog switch off on October 15, ahead of the government mandated switch-off date of Feb 2008 (Papanicolau, 2010)
2008	5 muxes continue to use DVB-T 2 muxes uses DVB-T2 for HDTV 10 free-to-air & 27 pay DTT services

TABLE 6. THE ROAD OF UK IN THE TRANSITION OF DIGITAL BROADCASTING

Year	Program
1998	First launched of pay-TV services (Ratkaj, 2009)
2002	Launched of Free-view free-to-air services
2004	Creation of SwitchCo (now Digital UK) to lead switchover process
2005	Set up Digital UK (lead responsibility for the switchover) and announced the switchover
2008	6 muxes: 30 to 40 free-to-air DTT services 1 pay DTT bouquet (on-demand TV)
October 24, 2012	Analog switch off (Hough, 2012)

TABLE 7. THE DVB-T2 TECHNICAL PARAMETERS OF SWEDEN AND UK

Parameter	Sweden	UK
Guard interval	1/16, 19/256 (Ek, 2012)	1/128 (DigiTAG, 2009)
FEC (Forward Error Correction)	7/8, 3/4, 5/6	2/3 LDPC + BCH

Parameter	Sweden	UK
Mode	256 QAM (DigiTAG, 2010)	256 QAM (Enensys Technologies, 2012)
Code rate	2/3*	2/3 (Faria, 2009)
FFT size (Fast Fourier Transform)	32k-E, 32k	32k
Pilots	PP2, PP4	Scattered: 1%; continual: 0.35%
P1/P2 overhead	Not mention	0.7%
Capacity	36.6 & 30.8 Mbit/s	40.2 Mbit/s

2. Prioritizing the Area to Switchover

Sweden chose a single island rather than metropolitan area to begin the switchover (Digital TV Commission, 2008). Digital TV Commission (2008) believed that the switchover in the metropolitan areas should be done after they got more experience because it dealt with the huge number of people at the same time. Each metropolitan area should be switched over at the different time. They also believed that it also contributed to keep the interest of the media to be active.

Ofcom (2012) mentioned that in defining the multiplex coverage, at first UK defined the number of location to be covered in Phase 1, then selected the locations for that phase. Although they considered the number of populations to choose it, they did not include the locations which have specific challenge although it is the largest city in UK, such as Sheffield. It was because the surrounding terrain is hilly and it needed more infrastructures required more time to accomplish.

Ofcom, 2012 spelled out that considering the number of population was tightly related to the interest of local television to provide the services. Because it was believed that more populations in an area might enlarge the potential of advertising revenue.

Department of Communications, Information Technology and the Arts of Australia (2005) also mentioned that the priority of UK to switchover was the availability of major commercial broadcaster rather than geographic regions. It is believed that it might limit the potency for consumer disruption and minimize the costs and risks.

UK also did not prioritize the area where the population is averagely spread out such as the south of Scotland. Again, because it needed more infrastructures, in this case was smaller transmitter, to connect to the main transmitters.

On the other hand, Department of Communications, Information Technology and the Arts of Australia (2005) also stated that the priority of UK was also considered

based on the necessity to manage the interference. In UK, the digital signal coverage was limited by the potency of the interference with the analogue services and several areas might not be able to receive digital terrestrial signals before the analogue switch-off.

3. Coverage and Frequency Planning

Before the switchover, the network provider had to guarantee that the digital terrestrial network had been expanded to reach the sufficient coverage. It was done by Sweden to equalize the distribution of households and transmitter sites.

Brown et al (2002) stated that UK predict the coverage using profile extraction, radial prediction, and clutter data to consider the effect of the buildings and trees. In addition, UK also used the transmitter and population databases.

Starks (2007) mentioned that UK chose to have the digital terrestrial coverage to be matched with the near-universality with the analogue terrestrial transmission. It was expensive for the transmitter investment but simple from the consumer point of view (Broadcasting Commission of Jamaica, 2012). It was also stated that in UK, the digital terrestrial services were launched on the temporary frequencies at the beginning and then switched to the old analogue frequencies at the point of analogue switch-off.

4. Reception Difficulties

The occupant of multiple-unit dwellings (MUDs) such as apartment, might get a reception difficulties that might obstruct digital conversion (DCITA, 2005). Digital Broadcasting Australia (DBA) undertook a study and found that 18 of 29 buildings would need an upgrade to the master antenna system to allow them to accept free-to-air digital TV. The upgrade could be costly and the MUD management might not support it before switchover.

UK overcame this challenge by providing a number of publications to help the resident, landlords, building owners, and the aerial installers to upgrade the MUD antenna systems.

5. Transmitter Tuning

At the beginning of the switchover, Sweden incorporated the digital and analogue transmitter (ExirBroadcasting&Telecom). Each digital transmitter needed 2.5 kW, while each analogue transmitter required 30 kW. Sweden used Constant Impedance Combiners to incorporate these transmitters. The combiners need to be set at least to 40 kW. The wave guide filters of this tool can control higher effects with less insert loss and give more flexibility for the incoming expansions or alteration. The order of the channel can be compounded or modify if it is needed. Figure 12 shows the typical digital/analogue combiner chain in Sweden.



Figure 12. A typical digital/analogue combiner chain in Sweden(Exir Broadcasting and Telecom)
(The first analogue combiner is a patch panel. To the left is space reserved for the forthcoming extension of channels 5 and 6)

6. Operation Security and Reliability

Sweden mentioned that they got very high requirement of the operation security and reliability. They dealt with this challenge by building parallel systems in the bigger broadcasting stations. The parallel systems were consisted of two combiner chains and two separate cables which plugged to the antenna. The transmitter was connected by a 6-port patch panel and power splitter to both chains. The parted height-wise, a lower and upper part, maintained the radiation and the one side did not get entirely knocked out. This allowed the possibility to operate another half of the system if there was problem in one of the chains or at a planned service stop.

7. Low Capability of the Antenna

Another challenge faced by Sweden was that the existing antenna could not handle the large frequency band needed. To solve this, Sweden used UHF Hybrid Antenna System that was combined to the existing system. This system was cost-effective solution and enabled the incoming changes or expansion.

8. Reflection Problem

In broadcasting system, reflections are a big problem. Reflection could cause a heavy disruption in the system. And in Sweden it indeed became a bigger matter because at first they combine the analogue and digital transmitter. The reflections increased along with the number of transmitter and it had to be minimized. Sweden got over this challenge by using analysis software to avoid the reflection. Before they succeeded to implement it, they created a test desk that contained a chain and eight combiners. Those instruments were tested with nine channels in a real broadcasting system to get the real problem and able to find the solution at once.

9. Receiver Features and Testing Model

Sweden got several claims from public about the necessary features of the receiver for the blind, visually impaired, and dyslexic users, such as the menus must be accessible through audio (Digital TV Commission, 2008). A proposed solution was to create the services directly into

the receiver so it could read the text for movies, menus, program guides, etc. It entailed that the text must be accepted as text and not as images, as the case at that time.

Other claims were about the complexity and un-useful functions of the remote control and the need to use several remote controls for several different devices. It is mentioned that there was a suggestion to provide feature to choose buttons and function separately, simple access to different functions that the user needs, e.g. audio description, sign language, descriptions for the deaf, etc.

Sweden also mentioned about the sound to text requirement. It was to provide the translation from sound to text so if there was any other person sleeping in the same room, for example, were not disturbed by the sound of the television.

Sweden and UK required that the equipment must be suitable for different content providers, so that the viewers can change the providers even after having purchased the equipment (Mijatovic, 2010).

Sweden also mentioned the testing model for the receiver as their challenge (Digital TV Commission, 2008). Sweden Digital TV Commission stated that the enhanced quality assurance would support the contribution of the digital television receivers and decline the uncertainty of the customers. Sweden involved the digital television network provider (Teracom), consumers policy agency (Swedish Consumer Agency), and the electronic industry to fulfill this issues (Bjerkessjö; Ministry of Justice of Sweden, 2012). The challenge was to model the receiver tests for the freeview television in the terrestrial network that were sold without a bundle to a subscription or operator.

None of the network provider and the consumer policy agency had the intention to test it. They concerned about the funding to finance it. The Digital TV Commission also did not have a budget to support it. It was then solved by letting independent players to perform the test. On June 2005, a good intention from Teracom was released. They launched a technically simplified free of charge receiver test for three months until September 2005. After that date, the test cost was SEK 100,000. It was indeed still cheaper than the longer tests that were done by Teracom for pay-TV operator.

Another challenge in UK was to support the receiver with updated software via Over the Air Downloads (OAD) (Australian Broadcasting Corporation, 2005). OADs were suggested to guarantee the continuity of the digital service as well as the minimal consumer and manufacturer interruption and cost.

10. Technology Update

The matter in here was to choose whether to adopt the technology change or update or not. Sweden mentioned that they always emphasized the appointed stakeholder to anticipate technology update in every planning, produced

new equipment or tools as the development of the technology, made huge investments to subsidize the new equipment so the consumers were ready to upgrade (boxer.se, 2013).

11. Multiplexing Model

Mijatovic (2010) stated that the channel license in Sweden was obtained from the selection mechanism performed by the regulator or government through public procedures. There is a separation between the network provider which is done by PayTV, and the content provider which is performed by the broadcasters (boxer.se, 2013).

Sweden also mentioned that they concentrate on the local area involved in each of the switch-off phase at the beginning stage. They raised the attention of the public, and entangled local media to observe and commented the process critically (Digital TV Commission, 2008; Digital UK, 2008).

On the contrary, UK ruled to direct Ofcom (UK regulator) to reserve the spectrum (Ofcom, 2012). They allocate a single standard digital channel for each of the broadcaster incumbents to enable simulcast of their analog programs during the conversion period and gave the remaining digital spectrum to the new entrants (Australian National University, 2010). Multiplex operator has influence on the content offering of the multiplex (Mijatovic, 2010). The operator is relatively free to make use of capacity and can select available channels.

12. Tariff Calculation

Sweden always improved their efforts to succeed their digital switchover. One of the challenges was also about the tariff calculation. The PayTV that Sweden adopt uses metering system. In 2006, when the switchover was started, the tariff calculation in the metering system was altered to anticipate the effect of the digitization. It was changed to a new, state-of-the-art meter that could measure all digital channels and the new TV devices (Papanicolau, 2010).

UK gave a strong incentive for the broadcasters to adopt strategies that help the rapid take up of the digital platforms by decreasing the fee paid for the use of the frequency connected to the number of viewers that adopts one of the three digital platforms (Mijatovic, 2010).

VII. DISCUSSION

Based on the findings in the previous chapters, it was obtained that:

1. The DVB-T2 technical parameter that was mentioned in the regulations of Indonesia were more various than in Sweden and UK. Sweden and UK tended to choose only single or fewer parameter values.

In the UK, before DVB-T2 was upgraded the existing 17 dB DVB-T network, two operating points have been weighed: 256QAM with the code rate 3/5; and 256QAM with the code rate 2/3 (Faria, 2009). The first operating

point yielded 36Mb/s at a 16dB C/N threshold; whereas the second operating point resulted 40Mb/s at an 18dB C/N threshold.

The last operating point was chose and improved the broadcast throughput by 66% without modifying the radiated power in the service area. If a 64 QAM with the code rate 3/5 were chose, the DVB-T2 network would delivered 26Mb/s with a C/N threshold of 12dB. It means that the strength would be a smaller bit rate gain but a great +5dB gain. It would enhance the service to the portable receivers because it would not get any benefit from the gain provided by a rooftop antenna.

On the other hand, Dai (2012) explained that the maximum order of the modulation systems is 256 QAM. It is only achieved by DVB-T2 and at first was implemented in UK. In the future, it is expected that there will be released more optimum order modulation systems, e.g. 512 QAM, to enhance the spectral efficiency.

Those considerations above are very important to be analyzed by Indonesia to improve the technical parameters defined. In addition, Indonesia still only authorized the regulation for the transmitter technical parameter and not yet for the receiver. Therefore, it is still a good opportunity for Indonesia to assess it.

2. There have been some local industries which stated their readiness to produce the equipment locally (indotelko.com, 2013). However, they are still reluctant to start the production before the regulations is authorized because they concern that the regulation authorized may define different specification than the equipment that they have produced. Besides local industries, Indonesia also encourages the vocational schools to produce the receiver (Noor II, 2012). Indonesia expects that the digital television also must raise the local industry (Galih, 2012).
3. Considering the number of population, Sweden began the first switchover in a small populated island which had 155,000 households. The provinces which have the small number of households are Papua Barat (168,100 households), Gorontalo (244,000 households), Sulawesi Barat (258,600 households), Kepulauan Bangka Belitung (311,200 households), Bengkulu (432,900 households), and Kepulauan Riau (441,800 households) (StatisticIndonesia, 2013).

Papua Barat – although it has the smallest number of households – the land area is larger than the other provinces above (97,024.27 km²). The land areas of Gorontalo, Sulawesi Barat, Kepulauan Bangka Belitung, Bengkulu, and Kepulauan Riau (Kepri) are 11,257.07 km², 16,787.18 km², 16,424.06 km², 19,919.33 km², and 8,201.72 km² respectively. It results the population of Kepri is denser than Papua Barat: 205/km² and 8/km² respectively (StatisticIndonesia, 2013).

UK did not prioritize the area where the population is averagely spread out because it needed more

infrastructures, in this case smaller transmitter, to connect the main transmitters. An accentuation must be noticed in here. Not prioritizing an area did not mean overriding an area. In fact, UK has totally switched off the analogue broadcasting.

Kepri is the best choice if Indonesia wants to follow the best practice of Sweden in deciding the small island for the first switchover. In addition, Kepri is the only area in its digital zone, whereas Gorontalo, Sulawesi Barat, Kepulauan Bangka Belitung, and Bengkulu are not a single area in its zone (MCIT, 2011).

For the reason to prevent the people choosing more television programs from very close neighboring countries, in 2012, MCIT prioritized the auction for broadcast multiplexing operator (BMO) in Kepri, although it is in the last digital zone of Indonesia (Syailendra, 2012). The digital transmitters also have been built in this zone (Setiawati, 2012; MCIT, 2013b).

Considering the best practice of UK to prioritize the area which had bigger number of population because it related to the interest of local television to provide digital television service, Kepri also has a good point. It has a fastest growing municipalities in the nation, with a growth rate of 11.7% in 2010 (Firman, 2012) and there have been three BMO won from the auction (Yuniar, 2013).

However, the information about the success status of the switchover in this zone was not found. The last information found was about the receiver subsidy proposed by its local government (Suryanto, 2012).

4. The switchover phases in Sweden and UK were tightly related to the area. They tended to focus in one area before dealing with another area. They used the experiences got in an area to develop the following area. They made sure that the infrastructure could cover the area before the switchover began.

The spread out of population in Indonesia is a big challenge to define a good coverage by using efficient infrastructure because it could be very costly for the network provider (BMO) to establish it.
5. The number of the high building in Indonesia is not as much as in Europe (Hendrantoro, 2009). However, it is important to guarantee the good quality of reception because it is one of the advantages that were propagated to urge the digital television.
6. There are 718 analogue terrestrial television transmission stations in Indonesia (MCIT, 2012a). It is important for Indonesia to analyze about combining the analogue and digital transmitter at the beginning of switchover.
7. The width of an island in Indonesia could be similar as whole country of Sweden and UK (Table 8). The reflection problem possibility definitely will be higher.
8. The percentage of urban population in 2012 in Sweden, UK, and Indonesia were 85%, 80%, and 51% respectively

(WorldBank, 2012). In addition, the school enrollment ratio for the age of 16-18 years old in Indonesia was only 61.06% (StatisticIndonesia, 2013). The awareness of people in Indonesia about the features that could be available in the receiver might be low. However, Indonesia must notice these requirements for the people who have special condition.

9. MCIT stated that Indonesia will subsidize the receiver from the national budget and obligation that is ruled to the digital television network provider (Djumena, 2013; Rachmatunisa, 2012). The digital television network provider of Sweden – Teracom – achieved the net income as much as SEK 266 million or US\$ 39.9 million in September 2013 (1 SEK = US\$ 0.15 on December 27, 2013) (Teracom, 2013). Whereas one of the television broadcaster companies in Indonesia which will be a digital television network provider – MNC – reached higher net income as much as 530 billion Indonesian Rupiah or US\$ 43.46 million in June 2013 (1 Indonesian Rupiah = US\$ 0.000082 on December 27, 2013) (MNC, 2013).

Although the number of household in Indonesia are bigger than in Sweden, the higher net income of a BMO mentioned above shows the good sign or possibility for Indonesia to motivate the investment from the network provider. In addition, there are about 8 other companies who will be the network provider.

10. The regulation that defines the mechanism to distribute the digital television receiver has not been authorized in Indonesia (MCIT, 2012a).

11. There are some skepticisms of the public about the multiplex model in Indonesia. There is a concern that there will be monopoly from television broadcaster companies to dominate the digital television. Some observers stated that the opportunities to be broadcast multiplexing operator (BMO) should be more opened, not only for the television broadcaster companies which have had the license, but also for the new television broadcaster companies which have not had the license or the telecommunication operator company. In addition, in Indonesia there is no function separation as in Sweden. The BMO also has the privilege to be the broadcast program operator (BPO). It raised the unfair situation for the BPO. In addition, there was a report which mentioned there is BMO which uses all of the channels that were allocated to them (Subiakto, 2013).

12. MCIT stated that all of the BMOs selected have built the infrastructure for the digital television. However, there is no one of the BMOs which has released the rent tariff for the channels that have been allocated to them (MCIT, 2013b).

VIII. CONCLUSION

This study has presented the technical challenges of DVB-T2 implementation in Sweden and UK as well as the efforts to deal with it. By analyzing the current status and the circumstances of Indonesia in the transition of the digital broadcasting and viewing the technical challenges of Sweden and UK which have previously migrated to digital broadcasting and switched off the analogue broadcasting, this study found the recommendations that need to be performed or analyzed further.

The results indicated that there were some similar challenges faced by both Sweden and UK. However, the efforts for those challenges were not same. This study also found that not all of the best practices of Sweden and UK can be applied in Indonesia because of the situations difference.

Indonesia may choose the best practices of these countries that are proper with the situations and conditions. It was expected that the recommendations will give the input and support for the acceleration of the digital transition process. This study can be reference for Indonesia to accelerate the digital switchover and for other countries to anticipate the technical challenges for their DVB-T2 implementation.

The uncertain circumstances in the digital television transition in Indonesia made government and broadcast multiplexing operators were reluctant to give or publish many information. This was the limitation of this study. For the future studies, it could be done by analyzing more deeply the best practices that could be applied in Indonesia or check the feasibility of all recommendations using particular methods and approaches. Another study that also can be done is investigating the position, responsibility, and authority of the regulatory body which has the biggest role in the digital broadcasting migration in Sweden or UK.

IX. RECOMMENDATIONS

Based on the discussion above, this paper suggested:

1. For the single or fewer technical parameter values that were defined by Sweden and UK, Indonesia may re-consider those technical parameter values to be specified in the DVB-T2 equipment specification in Indonesia, both for the transmitter and receiver. Indonesia also needs to regulate the provision of the standard and special features for blind, visually impaired, dyslexic, or other disability person such in Sweden. The transmitter and receiver regulations also need to be authorized, so the local industry could start the production and the expectation of Indonesia for the growth of the digital television local industry will emerge. It will support the subsidy mechanism that has been planned, speed up the trial of the digital television by the public, allow Indonesia to start the switchover largely, measure the success, get the experience, and use the experience for the next area to switchover.

TABLE 8. THE LAND AREA OF EACH PROVINCE IN INDONESIA

Province	Land Area (km ²)	Percentage to Indonesia	Number of Islands
Aceh	57,956.00	3.03	663
Sumatera Utara	72,981.23	3.82	419
Sumatera Barat	42,012.89	2.2	391
Riau	87,023.66	4.55	139
Kepulauan Riau	8,201.72	0.43	2,408
Jambi	50,058.16	2.62	19
Sumatera Selatan	91,592.43	4.79	53
Kepulauan Bangka Belitung	16,424.06	0.86	950
Bengkulu	19,919.33	1.04	47
Lampung	34,623.80	1.81	188
Sumatera	480,793.28	25.16	5,277
DKI Jakarta	664.01	0.03	218
Jawa Barat	35,377.76	1.85	131
Banten	9,662.92	0.51	131
Jawa Tengah	32,800.69	1.72	296
DI Yogyakarta	3,133.15	0.16	23
Jawa Timur	47,799.75	2.5	287
Jawa	129,438.28	6.77	1086
Bali	5,780.06	0.3	85
Nusa Tenggara Barat	18,572.32	0.97	864
Nusa Tenggara Timur	48,718.10	2.55	1,192
Bali, Nusa Tenggara	73,070.48	3.82	2141
Kalimantan Barat	147,307.00	7.71	339
Kalimantan Tengah	153,564.50	8.04	32
Kalimantan Selatan	38,744.23	2.03	320
Kalimantan Timur	204,534.34	10.7	370
Kalimantan	544,150.07	28.48	1061
Sulawesi Utara	13,851.64	0.72	668
Gorontalo	11,257.07	0.59	136
Sulawesi Tengah	61,841.29	3.24	750
Sulawesi Selatan	46,717.48	2.44	295
Sulawesi Barat	16,787.18	0.88	-
Sulawesi Tenggara	38,067.70	1.99	651
Sulawesi	188,522.36	9.87	2500
Maluku	46,914.03	2.46	1,422
Maluku Utara	31,982.50	1.67	1,474
Papua	319,036.05	16.7	5,98
Papua Barat	97,024.27	5.08	1,945
Maluku & Papua	494,956.85	25.9	5,439
Indonesia	1,910,931.32	100	17,504

Source: (StatisticIndonesia, 2013)

2. The number of buildings, the various terrain, and the spread of the population must be the factors that also

considered by Indonesia to guarantee the good coverage, frequency planning, and the reception.

- Indonesia may make the analysis to get the cost-benefit of the best practices done by Sweden and UK related to combining the digital television transmitter with the analogue at the beginning of the switchover.
- Indonesia could also analyze the digital terrestrial coverage that is matched with the near-universality with the analogue terrestrial transmission and launch the digital terrestrial services on the temporary frequencies at the beginning of the switchover, then move it to the analogue frequencies at the time of the analogue switch-off such implemented in UK. It is also recommended to build the parallel system to guarantee the operation security and reliability and analyze the conformity of UHF Hybrid antenna system such in Sweden or other method to increase the capability of the antenna. Analyzing the reflection problem and the method to deal with it is the following recommendation. Indonesia must guarantee the good quality of the digital television transmission.
- Indonesia must check the readiness of the broadcast multiplexing operators (BMOs) in providing the sufficient infrastructures in the coverage area. It is needed to ensure that the switchover will be performed well.
- Focusing the first distribution of the receiver and switchover in Kepri until the adoption of the digital television reach 100% of all households will be in line with the best practice of Sweden and UK. Indonesia may also analyze the affectivity of prioritizing the switchover area based on the capability to manage the interference as in UK.
- The separation function between the broadcast multiplexing operator (BMO) and the broadcast program operator (BPO) such in Sweden and UK is better than the multiplex model in Indonesia, in which the BMO may also be the BPO. It will be better in order to relieve the unfair concerns of the BPO. The best practice of UK to provide a digital channel for each broadcaster is also good to be analyzed to solve this.
- To get rid of the concern about the channel rent tariff, MCIT must hold the discussion with the representative of all the stakeholders involved in the digital broadcasting transition to find the most reasonable tariff which is agreed by most of the stakeholders. Government also needs to monitor the channel usage by the BMOs in order to avoid the misappropriation such reported by some stakeholders.

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