THAILAND

Implementing digital TERRESTRIAL TELEVISION IN THAILAND

Report

Telecommunication Development Sector

Implementing digital terrestrial television in Thailand

This report has been prepared by International Telecommunication Union (ITU) expert Peter Walop. The work on this report was carried out in the framework of a joint effort between ITU and the National Broadcasting and Telecommunication Commission (NBTC) of Thailand on the implementation of digital terrestrial television broadcasting (DTTB). ITU would like to thank the NBTC for their valuable input and support, as well as the Ministry of Science, ICT, and Future Planning (MSIP), Republic of Korea in facilitating ITU for the implementation of the transition from analogue to digital terrestrial television broadcasting case study in Thailand.

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Table of contents

Page

1 Introduction

Considering the advantages of digital terrestrial television broadcasting (DTTB) ITU has undertaken several activities towards promoting the transition from analogue to digital broadcasting. Next to its regular spectrum management duties ITU is also providing assistance to National Regulatory Authorities (NRAs) in the transition from analogue to digital broadcasting.

As a first step in providing assistance ITU has developed guidelines for the transition from analogue to digital broadcasting. The first edition of the ITU Guidelines was published in May 2010. Subsequent updates were published in October 2012 and January 2014[1]. In a further effort to help countries to switch over to DTTB, ITU has selected a number of countries to assist in the development of a national roadmap for the digital switch-over (DSO) process.

Thailand roadmap

Thailand is one of the beneficiary countries for assistance and a roadmap was jointly developed by a team of ITU experts and the National Broadcasting and Telecommunications Commission in Thailand (NBTC)[2]. This work was carried out in September and October 2012. Following the development of this roadmap, the NBTC and ITU entered into an agreement to jointly implement this roadmap in December 2012.

The Thailand roadmap is divided in four phases: (phase 1) DTTB policy development; (phase 2) Licensing policy and regulation; (phase 3) Planning and execute auctions and tenders; and (phase 4) DSO communications and supervision. At the end of December 2013 the auction of the service licences took place. This auction marked the final milestone of roadmap phase 3.

After this service licence assignment to the commercial broadcasters, the broadcasters selected their network operator. Subsequently the network operators embarked on the joint deployment of the first phase of the DTTB networks. In June 2014 the first phase of the digital television network (including 11 main DTTB stations) was put into operation.

Roadmap objectives

The NBTC embarked on this journey of implementing DTTB with the following main policy objectives in mind:

1. to provide access to the Thailand broadcasting spectrum for public and commercial entities as well as citizen, to develop and introduce television services;
2. to reap the benefits of the technological advances that DTTB incorporates, including spectrum efficiency gains and having more television services, as well as new service features;
3. to reform the Thailand media landscape whereby content diversity is promoted by means of:
    a) opening the market for new market entrants;
    b) having thematic services for defined audiences;
    c) ending the system of concessions.

The NBTC roadmap decisions and activities should be viewed in the light of these policy objectives, as well as the regulatory framework it should obey.

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[1] See www.itu.int

[2] Roadmap reports have been drafted for several countries including Angola, Cambodia, Ethiopia, Mali, Mongolia, Nepal, Sri Lanka, Tonga and Thailand. These reports are available on www.itu.int.

Scope of report

This report includes a case study on the implementation of the DTTB roadmap for Thailand. The case study provides practical insights and lessons learned in the process of DTTB policy development (phase 1), designing licensing policy and regulation (phase 2) and assigning licences (phase 3). It also includes the preparations and the deployment of the first DTTB network phase. NRAs, DTTB service and network providers in other countries may find useful information and input for preparing and executing their digital migration efforts.

The ITU Guidelines and the various roadmap reports have been drafted on the basis of previous experiences and good practices in other countries across the world. The ITU Guidelines and roadmaps are based on commonalities between the countries and this resulted in a standardized framework of functional building blocks[3], i.e. comprehensive set of key decisions to be made. However depending on the local situation the scope of decisions, the actual decisions and the order they are made (i.e. the roadmap) differ between countries.

In this country case the focus is not on the commonalities but on the differences. In other words what were the specifics of the Thailand DTTB implementation and what learning points can be offered to other countries that are embarking on or are in the early stages of their digital migration journey. For example the auction of broadcast licences[4] in Thailand was such a country specific event that drew worldwide attention in the telecom and broadcast industry. Also having multiple Thailand DTTB network operators and the specific challenge that creates regulatory, competition and consumer issues are interesting specifics to learn from.

This report has been composed and drafted in close cooperation with the NBTC. In June 2014 staff from the office of the NBTC and the chairman of the Broadcast Commission were interviewed. Input was gathered as well as a list of topics to be covered in the report. The following topics were selected:

- network licensing and deployment;
- service licensing and auction;
- network planning;
- DSO planning and communications.

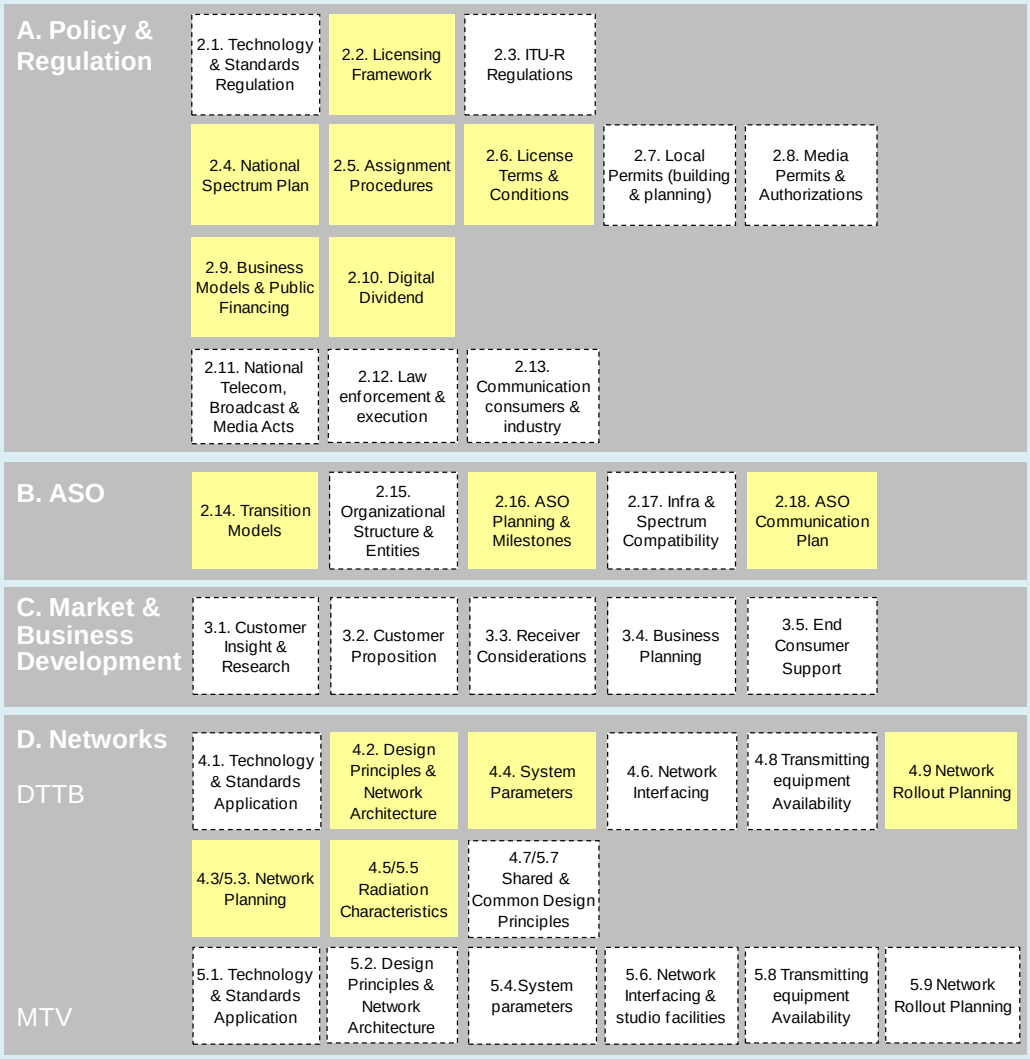
As stated above, the ITU Guidelines and the Thailand roadmap report have been drafted on the basis of a standardized framework of functional building blocks. The above selected DTTB issues are indicated in the framework as the yellow shaded functional building blocks[5].

[3] See ITU Guidelines for the Transition from Analogue to Digital Broadcasting, January 2014, pp 1-6.

[4] The term 'broadcast' licence is a generic term and more specifically the Service licences for commercial purposes, including the spectrum right, were auctioned. For more details please refer to Sections 2.4 and 4.1.

[5] For more information on the functional building blocks please refer to the ITU Guidelines for the Transition from Analogue to Digital Broadcasting.

Figure 1: Selected function building blocks



Source: ITU

Report structure

After this Introduction a comprehensive overview of the Thailand television market is provided in Chapter 2. The following chapters build on the information provided in this chapter and they correspond to the selected topics as listed above. Each of these chapters is concluded with a list of insights or lessons learned. Hence this report is structure as follows:

1 Introduction

2 Television market in Thailand

3 Network licensing and deployment

4 Service licensing and auction

5 Network planning

6 DSO planning and communications

2 Television market in Thailand

This chapter provides a comprehensive overview of the Thailand television market that will help understanding the DTTB policy decisions that were made for the introduction of DTTB services. This chapter is structured as follows:

2.1 Market structure

The television broadcasting value chain can be broken down into six subsequent steps or functions in delivering television services to end consumers, i.e. the television viewer. Figure 2 shows these six functions.

Figure 2: The value chain for television broadcasting

Content Creation	Content Aggregation	Multiplex Operations	Service Provisioning	Content Distribution	Reception
Create content and services	Aggregate content and service into customer oriented packages and service streams	Divide available spectrum in capacity units and allocate to (type of) services	Support or enhance the operations and marketing of content and services	Provide infrastructure or manage access to or delivery of the content	Provide decoding, navigation and interfacing equipment or software
	Manage advertisers, agencies and advertising space		Manage client relationship and invoice services		

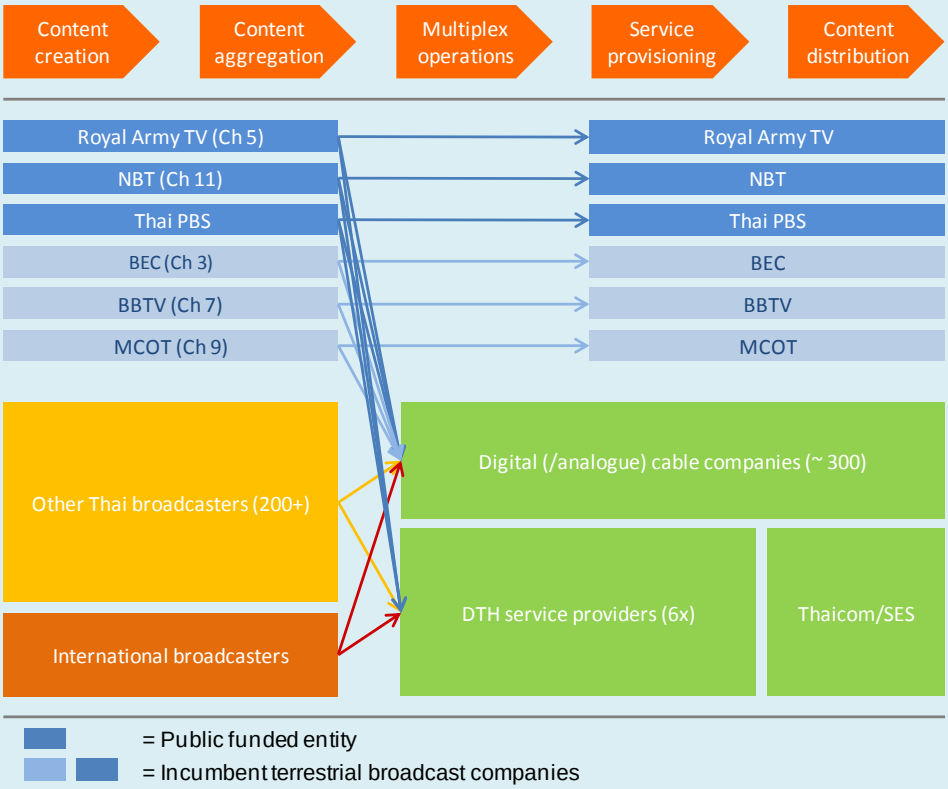
Source: ITU

Figure 2 includes both the analogue and digital value chain. Compared to analogue television broadcasting the digital value chain has an extra function/player: the multiplex operator. By nature of the digital broadcast technology, where multiple programmes or services can be carried on one frequency (i.e. multiplex), assigning the multiplex capacity to the various services is an extra function compared to the analogue broadcast value chain[6].

The Thailand broadcast market comprises both analogue and digital platforms, including terrestrial, cable and satellite networks. The Thailand television market structure can be illustrated on the basis of the value chain as depicted in Figure 2. Figure 3 shows the market situation before the introduction of DTTB (i.e. March 2014).

[6] In the analogue value chain, each frequency can carry only one service (1-to-1 relationship) and the frequency licence holder is very often the broadcaster. In the digital value chain the relationship is 1-to-N and the broadcaster is not necessarily the frequency licence holder.

Figure 3: Market structure of Thailand television broadcasting (before DTTB)



Source: ITU

What can be observed from Figure 3 is the following:

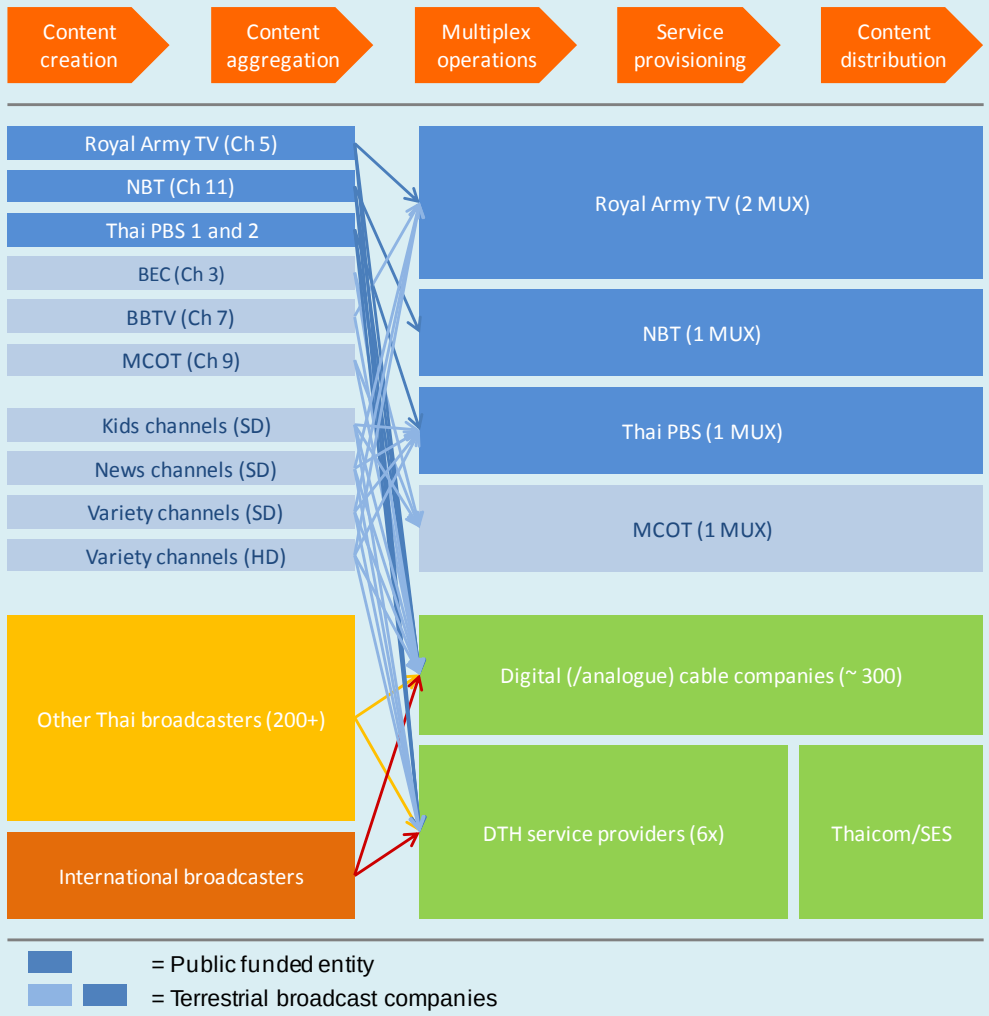
1. The six incumbent terrestrial television broadcasters are vertically integrated companies. They cover all functions of the value chain, exempting the multiplexing function as this function is not included in the analogue broadcasting value chain;
2. The six incumbent broadcasters are present on all platforms, terrestrial, cable and satellite;
3. The large number of Thailand broadcasters, next to the six incumbent broadcasters, which don't have access to the terrestrial platform;
4. The six direct-to-home (DTH) satellite service providers which provide varying free-to-air (FTA)[7] television service bouquets, as well as set-top-boxes (STB) and installation services. They purchase satellite transponder capacity from satellite operators like Thaicom and SES New Skies.

In April 2014 the four licensed DTTB network operators launched the FTA digital services[8].This changed the market structure considerably as 24 new commercial terrestrial services were launched. This new situation is depicted in Figure 4.

[7] Except for True Vision, which offers next to its FTA package a pay-tv package too.

[8] The DTTB networks will be deployed in several stages and in April 2014 the DTTB service was commercially launched at four locations, including Bangkok. For more information on network deployment see Section 3.2.

Figure 4: Market structure of Thailand television broadcasting (after DTTB)



Source: ITU

From Figure 4 the following can be observed:

1 The incumbent terrestrial broadcasters do not only distribute their own broadcast services but also the services of third party broadcasters. Four of the six incumbent broadcasters operate DTTB networks and act as independent network providers to commercial and public broadcasters. They cooperate in the joined deployment of the DTTB platform.

2 The number of DTTB multiplexes totals five at this stage of the network deployment. Although planned for, the sixth multiplex has not been assigned to a network operator yet[9]. This sixth multiplex will carry the community services[10].

[9] For more details on the DTTB network planning and deployment see Section 5.2.

[10] Community services are non-commercial television services intended for serving local communities and 39 local community areas have been defined. In each local area 12 Community services will be made available.

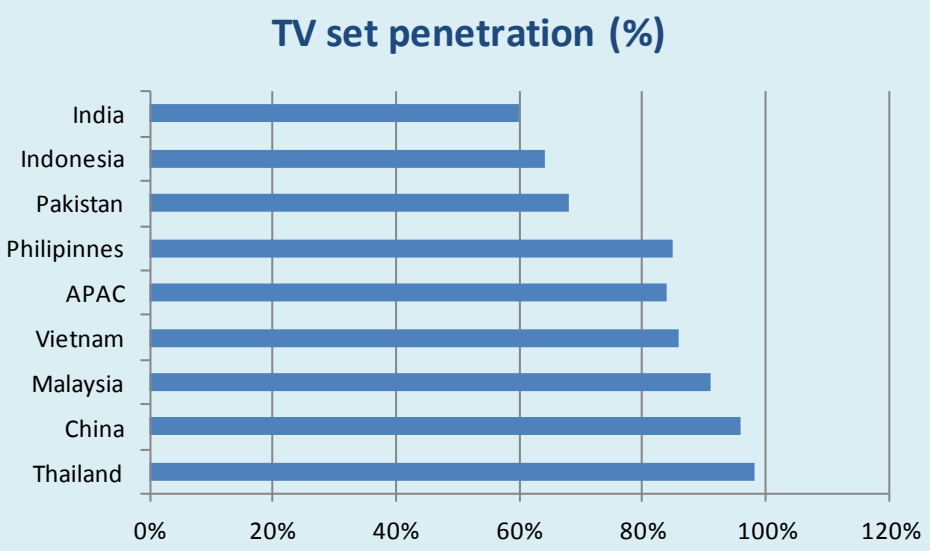
3 The number of terrestrial broadcast services has increased considerably. From the six incumbent broadcast services it has increased to 27 at the launch of the DTTB platform and eventually to 48 when all services have been licensed[11].

4 All digital terrestrial services are made available on the satellite and cable platforms[12].

2.2 Market shares

The total population in Thailand is approximately 64.5 million with the total estimated number of households at 22.8 million. Television set penetration in Thailand households stood in 2012 at 98 per cent (see Figure 5) versus the Asia Pacific (APAC) average of 84 per cent. Hence there are approximately 22.3 million television households (TVHH).

Figure 5: TV set penetration in APAC countries



Source: Credit Suisse

In the television industry market shares are often expressed in the number of viewers or subscribers and revenues per service and/or platform. Revenues can be broken into three main categories per platform; (a) advertising revenues (which coincide with FTA broadcasting), (b) subscription of pay per event revenues and (c) line extensions which include revenues from program related events and merchandising. The latter group will not be considered in this report.

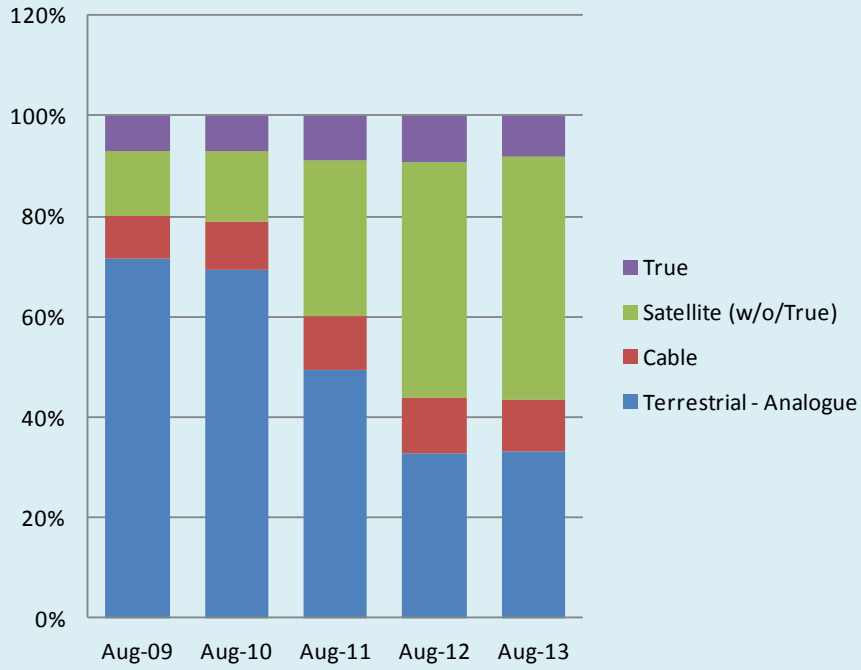
[11] The number of 27 services comprises 3 Public Service Broadcasting (PSB) services, 3 Kids services in Standard Definition (SD) picture quality, 7 News services (SD), 7 Variety services (SD) and 7 Variety services in High Definition (HD). These 27 services include the 6 incumbent terrestrial services. This number of 27 services will eventually increase to 48 services when more PSB and Community services will be assigned. For more details on the service licensing see section Sections 2.4 and 4.1.

[12] The NBTC has required that licensed DTTB services providers will provide their service to cable and satellite platforms and that these cable and satellite service providers re-distribute the DTTB services with any charge (i.e. FTA).

2.2.1 Number of viewers and subscribers

In Thailand the penetration of satellite and cable TV is growing fast while analogue terrestrial penetration is declining, as illustrated in Figure 6. It should be noted that this figure shows the situation before the DTTB introduction in March 2014. There are no figures available on the number of TVHH with DTTB receivers yet.

Figure 6: Number of TVHH per platform (%)

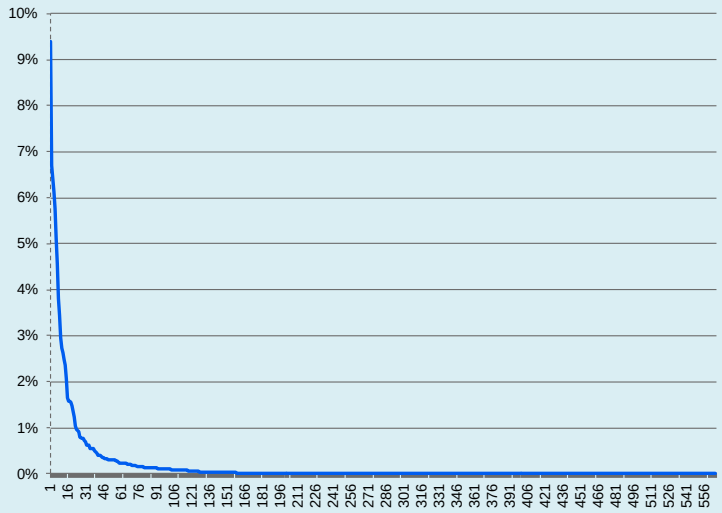


Source: AC Nielsen

Before the DTTB launch and as can be observed from Figure 3 the six incumbent broadcasters were present on all television distribution platforms. This figure also shows the very high number of other Thailand broadcasters (200+) present on selective satellite and cable networks. Figure 7 shows their viewing share on the satellite platform, excluding the six incumbent broadcasters. The figure illustrates the extreme 'long tail' character of the Thailand television broadcast industry[13].

[13] The figure also includes international broadcasters. The top-20 includes all Thai broadcast services and they range from top-end 9.39 per cent to bottom-end 1.37 per cent viewing share.

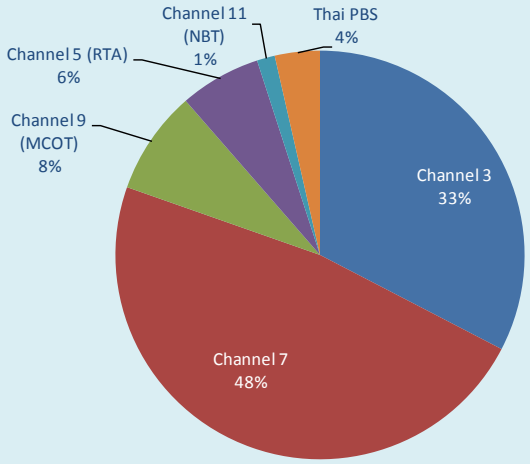
Figure 7: Viewing shares between TV services on the satellite platform



Source: AC Nielsen

The six incumbent broadcasters have the majority (> 75 %) of all the television viewers. The distribution of the viewers between the six incumbents and before the DTTB launch is shown in Figure 8. The commercial services Channel 3 and 7 have the largest market share[14].

Figure 8: Market share of the six incumbent broadcasters (2013)



Source: NBTC

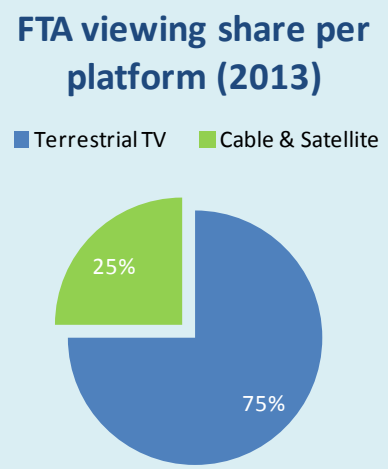
2.2.2 Revenues

In Thailand television revenues comprise basically two sources; advertising income (on FTA platforms) and subscription fees for premium packages. The cable and satellite platforms both have pay-tv packages on top of an extensive bouquet of FTA services. This FTA bouquet includes the six incumbent television services, attracting most viewing (see Figure 7 and Figure 8). Although the market share of the cable and

[14] Please note that Channel 3 and 7 operate their business on the basis of a concession (including the spectrum rights) awarded to them by respectively MCOT (Channel 9) and RTA (Channel 5).

satellite are growing rapidly (see Figure 6), most FTA viewing is still by far on the terrestrial platform, as shown in Figure 9.

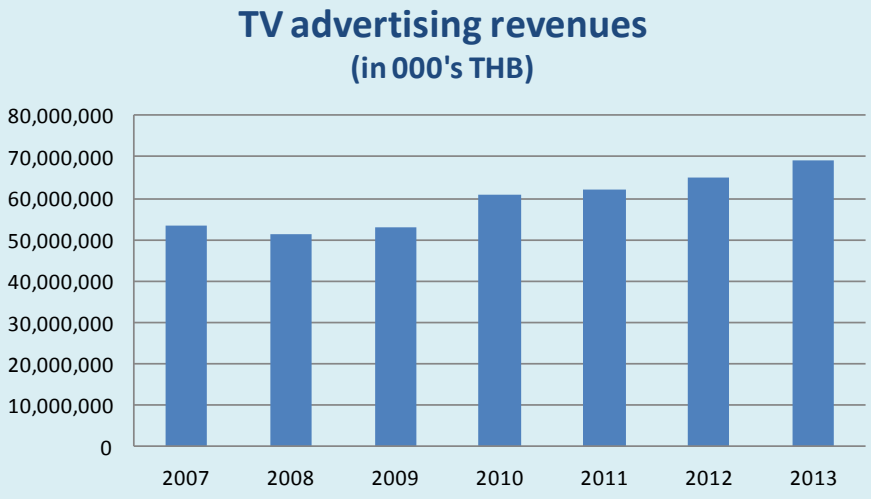
Figure 9: FTA viewing per television platform



Source: NBTC

Like elsewhere in the world, TV advertising remained strong and growing at a steady pace over the years. Figure 10 shows the television advertising revenues over the period 2007 to 2013 with a CAGR of 3.8 per cent. The total television advertising revenues stood at THB 69b (~ USD 2b) in 2013.

Figure 10: TV advertising revenues over the years



Source: NBTC

Pay-tv revenues range between THB 10-15b per year (~USD 0.29-0.35b). Cable television services are offered in the main cities. The average subscription fee ranges from USD 8 to 10/month for respectively an analogue bouquet of 80 services and a digital bouquet of 200 services (including the rental fee for the STB). Satellite premium packages are on average around THB 2 000 (~USD 60).

2.3 Terrestrial television networks

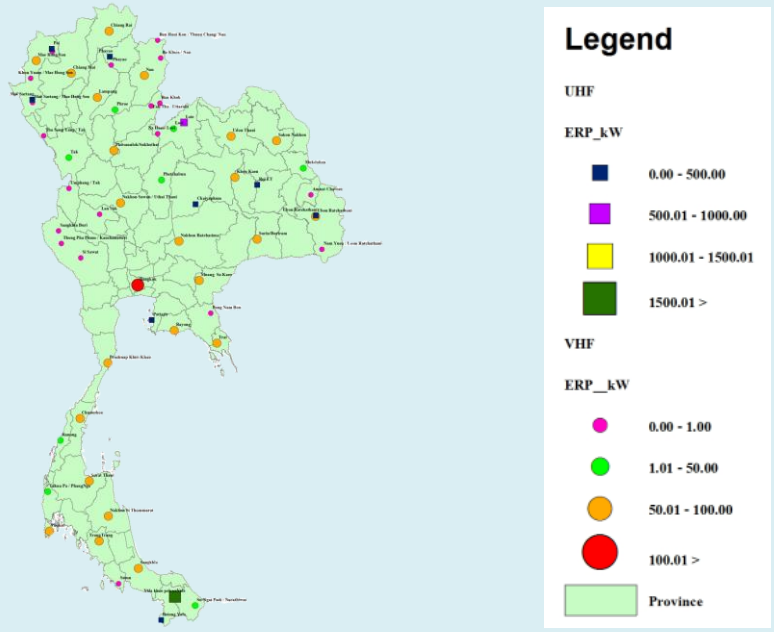
Currently analogue and digital terrestrial networks are in operations in Thailand. As can be observed from Figure 3 the six incumbent broadcasters operate their own analogue television (ATV) network and they claim that their ATV coverage ranges from 85 per cent to 90 per cent. The number of transmitter sites per ATV network is provided in Table 1.

Table 1: ATV Transmitter sites per network

Broadcaster	Ch 3	Ch 5	Ch 7	Ch 9	Ch 11	TPBS
VHF stations	34	53	48	50	51	0
UHF stations	6	10	7	3	18	52
Total stations	**40**	**63**	**55**	**53**	**69**	**52**

The transmitters per network as included in Table 1 comprise VHF and UHF transmitters. Thai PBS (TPBS) deployed its network after the other broadcasters and operates a full VHF network. For the other broadcasters UHF transmitters were added to the VHF network to either increase population coverage or the replace the VHF service with UHF service. The number of added UHF sites is relative small. Figure 11 shows the location and the VHF (53 stations) and UHF (10 stations) sites of one of the ATV networks.

Figure 11: VHF and UHF transmitter sites of an ATV network[15]

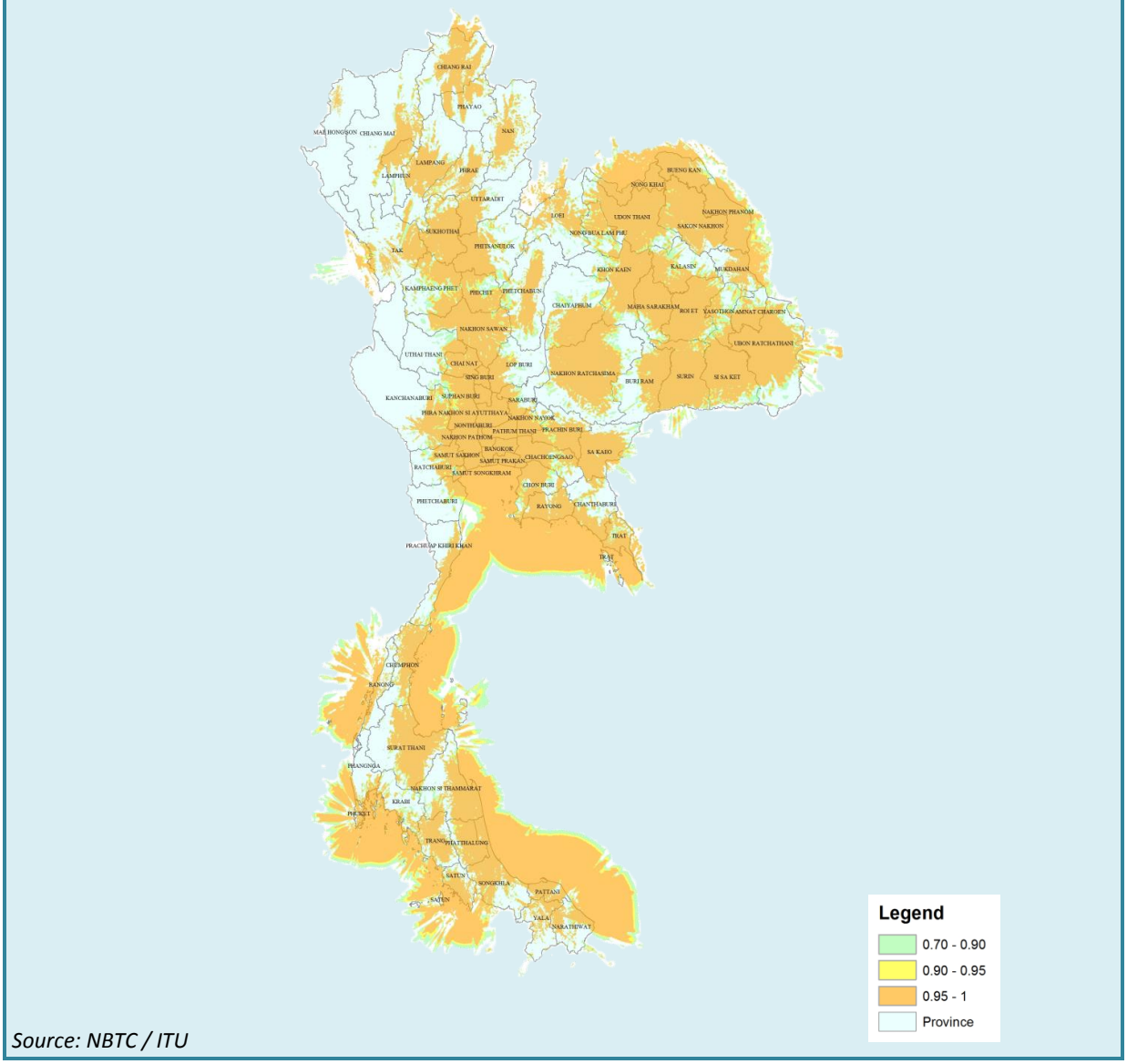


Source: NBTC / ITU

[15] The designations employed and presentation of material in this publication, including maps, do not imply the expression of any opinion whatsoever on the part of ITU concerning the legal status of any country, territory, city or area, or concerning the delimitations of its frontiers or boundaries.

As indicated in Section 2.1 the first DTTB phase (of four) has been deployed. The selected standard for the DTTB platform is DVB-T2. The DTTB platform includes five multiplexes (to be extended later to six) and these networks carry the six incumbent television services and hence the six incumbent television services are simulcast in the DTTB coverage areas[16]. In the fully deployed stage (phase 2) the DTTB network will cover 95 per cent of the households in Thailand. Figure 12 shows the calculated network coverage of (one of) the DTTB network(s) for the 39 main transmitter sites (phase 2) covering approximately 77 per cent of the Thailand households.

Figure 12: Calculated DTTB Coverage for one DTTB network (phase 2)[15]



Source: NBTC / ITU

[16] Please note that as can be observed from Figure 4 all DTTB services are also re-distributed on the cable and satellite platform and hence they are also simulcast on these platforms too.

The DTTB network operators have published their transmission fees to be paid by the service providers (i.e. broadcasters). For a fully deployed DTTB network (covering 95 per cent of the households) the charge for a SD and HD services is respectively USD 135 000/month and 430 000/month[17]. Although not in the same picture quality the distribution of a television service over satellite is about USD 23 000 to 40 000/month.

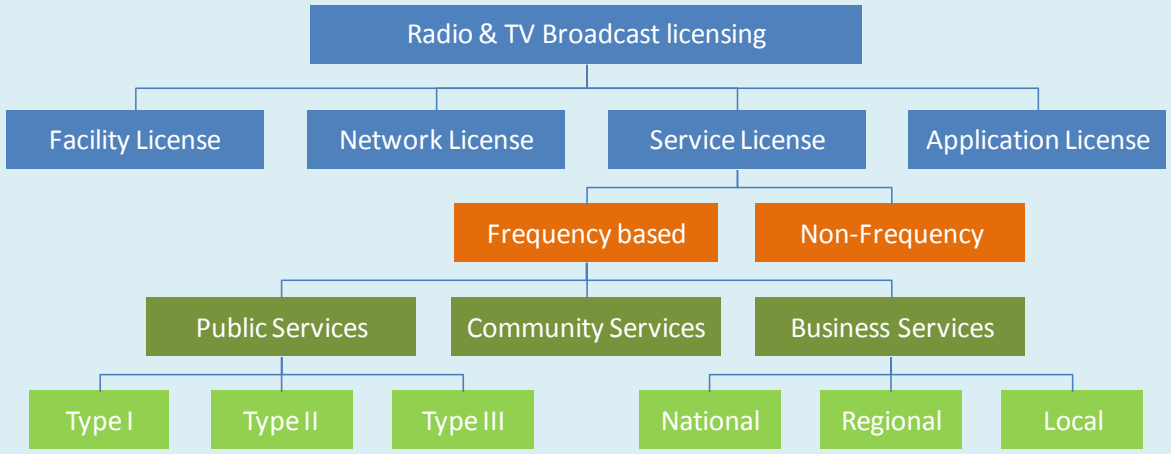
2.4 Regulatory framework

In this section a brief overview is given of the Thailand regulatory framework, covering the licensing framework and the national spectrum plan.

2.4.1 Licensing framework

The licensing framework for broadcast services and distribution is based on the Broadcast Business Act (2008) and the Act on Organization to Assign Radio Frequency and to Regulate the Broadcasting and Telecommunications Services (2010). The licensing framework is depicted in Figure 13.

Figure 13: Licensing Framework for Broadcasting



Source: NBTC

In addition to above mentioned legislation, the NBTC has published several Notifications governing the regulation of broadcast licences. In particular the following Notifications are relevant for DTTB policies and licensing:

1. Criteria and Means of Licensing for Provision of Facilities for Radio or Television Broadcasting, B.E. 2555 (2012);
2. Criteria and Means for Granting License for Provision of Radio or Television Broadcasting Network, B.E. 2555 (2012);
3. Additional Criteria and Means for Granting License for Provision for Digital Terrestrial Television Broadcasting Network-, B.E. 2556 (2013);
4. Criteria and Means for Granting Spectrum for Radio and Television Broadcasting Business Services, B.E 2556 (2013);
5. License Fees for Operating Radio or Television Broadcasting Services, B.E. 2555 (2012);

[17] Source: Bangkok Post and The Nation.

6 Criteria and Means for Spectrum Auction of Digital Television Business Services – National Level, B.E. 2256 (2013).

In the above mentioned Notifications, under item 3, the roll-out obligation for the DTTB network operators is stated. This obligation is defined as a minimum coverage requirement (for fixed rooftop reception[18]) as a percentage of households. The percentages per period after the network licence assignment are as follows:

1 50 per cent within 1 year;

2 80 per cent within 2 years;

3 90 per cent within 3 years;

4 95 per cent within 4 years.

The network licence as included in Figure 13 includes an operating right[19]. The service licence includes the spectrum rights as well as the right to broadcast television content (i.e. the broadcasting right). The Act on Organization to Assign Radio Frequency of 2010 stipulates that spectrum rights for business/commercial purposes should be auction. Consequently the DTTB service licences have to be auctioned for assigning spectrum rights to commercial broadcasters.

It is important to note that the licensing framework as depicted in Figure 13 was introduced after licences were assigned for ATV. Hence four of the incumbent broadcasters operate their business on licences (including broadcast, operating and spectrum rights) which run beyond 2020. Two of the incumbent broadcasters operate their business under concession with RTA and MCOT. The BBTV Channel 7 concession with RTA expires in 2023 and the BEC Channel 3 concession with MCOT expires in 2020.

2.4.2 National Frequency Plan

In the VHF Band the National Frequency Plan (NFP) designates the following Bands for *television* broadcasting services:

1 47 – 68 MHz (VHF Band I)[20];

2 174 – 230 MHz (VHF Band III).

In the VHF Band I and III available channels are in use and are grouped together in channel group V1 (including channels 3, 5, 7, 9 and 11) and V2 (including 2, 4, 6, 8, 10 and 12). The two channel groups are used across the country at 33 main sites and 18 additional sites (see also Table 1).

In the UHF Band the NFP designates the following bands for *television* broadcasting services:

1 510 – 790 MHz (UHF Band IV and V, channels 26 to 60).

Currently all frequencies of this Band are allocated to the DTTB services (and Mobile Television – MTV). However the NBTC is currently considering a possible reallocation of the 700 MHz band (channels 49-60 in Band V) to IMT after TV ASO has taken place. In addition to this spectrum reconsideration channels 21 to 25 may be reallocated to DTTB. Such a re-allocation of spectrum would require a re-planning of the current DTTB networks.

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[18] An additional deployment requirement stipulates that the DTTB network operators should also provide indoor coverage in municipalities. For more details on the network design see Chapter 5.

[19] For more information on the different licence types and rights, please refer to the ITU Guidelines for the Transition from Analogue to Digital Broadcasting, January 2014, pp. 21-25, freely available on www.itu.int.

[20] VHF Band II is the FM Band and in Thailand this band runs from 87-108 MHz.

3 Network licensing and deployment

As Figure 4 shows the DTTB broadcasters are distributed by four network operators[21]. Comparing Figure 4 with Figure 3 it also becomes evident that these network operators are separated entities from the six incumbent ATV broadcasters (i.e. vertically integrated entities). This separation of service and network provisioning has been a common phenomenon in the telecommunications industry as well as in the European broadcasting industry. Separation of these functions was the very reason for introducing the broadcasting licensing framework (as depicted in Figure 13). In this way the Thailand television market would be opened up for more broadcasters.

However the resulting market structure, at the network provisioning level, was that four network operators would have to deploy the DTTB networks. This posed questions on how to minimize infrastructure duplication and to provide a coherent DTTB service bouquet to the Thailand television viewer. That is to say, the networks deployed in the same pace and with the same service levels (across all multiplexes).

This chapter illustrates how the NBTC dealt with these concerns and the trade-off when deciding the network licensing regulatory framework as well as managing the network deployment. This chapter builds on the information provided in the introduction and covers network licensing and network deployment, and offers some further insights into these issues.

3.1 Network licensing

The Thailand broadcasting market has been under regulated for a long period and the broadcasting commission was only recently established as part of the formerly known National Telecommunications Commission of Thailand (NTC). Hence when the Broadcasting Commission started in 2011 the incumbent broadcasters were licensed under a different licensing regime. As discussed in Section 2.4 they have long running spectrum rights, extending well beyond 2020.

3.1.1 Assigning licences

The network licence grants the licensee an operating right to deploy and manage a broadcasting network. The Broadcasting Act provides several instruments to assign this type of licence including public tender. However the NBTC decided to assign five network licences by priority to the incumbent broadcasters. The following aspects were considered in this trade-off between public tender and assigning licences by priority:

1. Given the fact that the licences were assigned under a previous licensing regime, the NBTC had limited means to revoke the long lasting spectrum rights from the incumbent broadcasters. Such a revoking procedure, if at all possible, would seriously delay and more likely block the introduction of the DTTB in Thailand. Especially considering that all incumbent broadcasters were operating their ATV networks in significant parts of the UHF Band[22] (i.e. the Band needed for the selected DVB-T2 transmissions standard). A DTTB delay of many years would hamper the efficient use of the Thailand spectrum and promoting spectrum efficiency is a core task of any NRA.

[21] The first five multiplex are operated by RTA (2 multiplexes/networks), MCOT, NBT and Thai PBS. The sixth multiplex (i.e. a regional network carrying the community services) still has to be assigned to a network operator.

[22] See Table 1.

2. Although the Thailand Broadcasting Act provides for site sharing [23] it was assessed that negotiating the price between licensed network operators and the tower owner (i.e. the incumbent broadcaster) would significantly delay the deployment of the DTTB networks. In addition, the cooperation of the incumbent broadcasters was also needed at a content level as they broadcast the most popular services and programming (see Section 2.2);
3. In the Thailand television market all distribution platforms are available, including cable, satellite and IPTV networks. Especially the penetration of satellite is high (see Section 2.1). In such a market broadcasters have several options to distribute their content to large parts of the television viewers. Like elsewhere in the world distribution becomes a commodity and competition primarily takes place at the service provisioning level (i.e. between service licensees). Hence the NBTC assessed that assigning network licences by public tender[24] was not critical for arriving at a competitive television market with a diverse and high quality service offering.
4. In addition the NBTC introduced several regulatory measures to ensure competitive network services and limit the risk of network operators charging too high prices. These measures included:
    a. the obligation of network operators to issue a reference offering to the NBTC for approval (for more details see below);
    b. the obligation for broadcast tower owners (and other facility providers) to request a facility licence from the NBTC. This licence arranges for the long term availability (i.e. for the duration of the licence) of these essential facilities[25] and transparent pricing of these facilities.

3.1.2 Reference offers

A reference offer is a binding offer from the network operators/providers in which the distribution service is defined, as well as the service levels and pricing.

DTTB broadcasters (i.e. the service providers) can only distribute their television services by contracting a licensed network provider. Consequently the network providers have an exclusive position. In addition, the incumbent broadcasters simultaneously carry out network and service provisioning in the same television market.

Hence to ensure a level playing field between service providers, it was deemed critical that the NBTC requested from the network operators to publish, in sufficient detail, reference offers for these network services. These reference offers had to be approved by the NBTC.

The NBTC requested reference offers from both the facility licensees (offering access to tower and antenna infrastructure for the 39 main sites[26]) and the network licensees. In this report only the reference offer for the network services is addressed.

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[23] The Broadcasting Act includes obligations to sharing facilities including broadcast towers. The provisions in the Act arranges for access and pricing of what are considered 'essential facilities'.

[24] Noting that with a public tender the market test is at the beginning of the network licence period of 15 years and not during the 15 years period. In other words a public tender is only a market test every 15 years and competition at the network level is more facilitated by having several distribution platforms available in the market.

[25] For more on the Essential Facilities theory and its application see ITU Guidelines, January 2014, pp. 54-59.

[26] The 39 DTTB main sites comprised existing ATV sites and for 35 of these main sites Thai TPBS already operates an UHF antenna system (see also Table 1) capable of carry the DTTB frequencies. For more details see Chapter 5.

The NBTC stipulated that the network providers had to offer the following *minimum service* to licensed service providers, including:

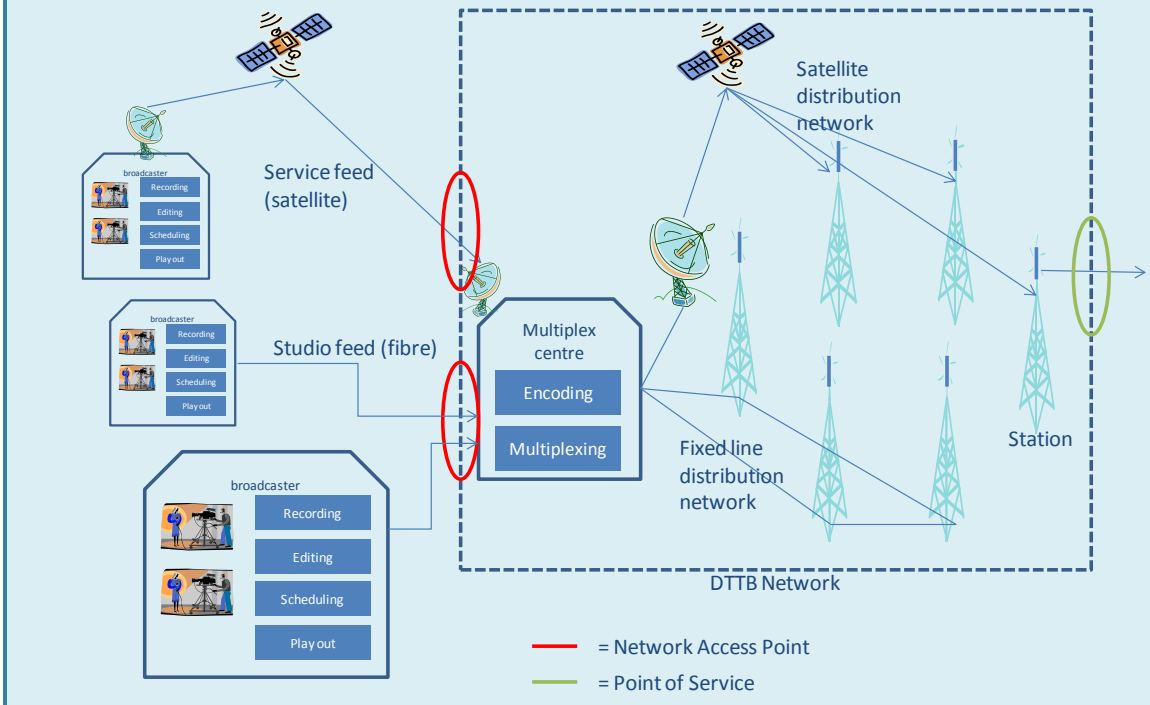
1 encoding and multiplexing of service feeds;

2 the distribution of a DVB-T2 compliant national[27] SD or HD service in calculated coverage areas and covering a minimum population as included in the Network Deployment Plan (i.e. in compliancy with their network roll-out obligation);

3 not exceeding the maximum permissible powers (and hence interference levels) as included in the Frequency Plan.

Licensed network providers could also provide auxiliary services, such as the supply of studio or service feeds to the national head-end system or to a satellite uplink station. Figure 14 shows an overview of the reference offer' scope, technical interfaces and point of service (PoS).

Figure 14: Scope of the reference offer for network services



Source: ITU, NBTC

The network operators have a roll-out obligation to deploy their network in four stages (see Section 2.4). In the final stage their network should cover 95 per cent of the households in Thailand. The reference offer had to consider this staged deployment. Hence, for the DTTB service delivered at each site, grouped together in the four deployment stages, the network operators had to include the following:

1 calculated rooftop and indoor coverage per site or SFN, plotted on maps, and in sufficient detail to assess the quality of the coverage areas[28];

[27] This excludes the requirement for provisioning of regionalised services. A separate reference offer for regionalised DVB-T2 services should be drafted.

[28] The NBTC can request the in- and output files from the network operator's planning software tool. It is also noted that the wanted coverage areas are not defined. Only the required population coverage of a whole network is defined (≥95%). Consequently there can be coverage gaps.

2 calculated rooftop and indoor coverage per site or SFN, expressed in number/percentage of households/population;

3 monthly charge per site per service (point of service) allowing for charging distribution fees proportional to the deployment stage.

Some special requirements were necessary in the reference offers as to ensure a coordinated deployment between the four network operators. The design, deployment and operations of the sites should be coordinated between the network operators in such a way that the viewer needs to direct its antenna in one direction while receiving all available services with optimal signal strength.

Also the network operators should coordinate and plan together any System Software Updates (SSU) they may wish to carry out. SSU should be tested before they are carried out. This coordination and SSU planning had to be described and included in the description of the operational and maintenance procedures of the reference offer. Similarly, service information (i.e. PSI/SI) should be shared between the network providers and should be carried in each multiplex.

The pricing structure and pricing model were also defined by the NBTC. The costing methodology for calculating the cost of the *minimum service* had to be based on long run incremental cost (LRIC)[29]. The increment is defined as a DTTB service (or programme channel). The principle of the LRIC model can be defined as the difference between the companies cost level with and without the minimum service. Figure 15 illustrates this in the form of a simple formula.

Figure 15: LRIC Model

$$LRIC\ of\ the\ minimum\ service = \frac{(\text{Cost of providing the minimum service} - \text{Cost without the minimum service})}{\text{Total number of services in the network/multiplex}}$$

Source: ITU

The cost of the *minimum service* comprised the following cost elements:

1 Capital expenditure (Capex): investment costs in the DTTB network which are directly relevant to the provision of *minimum service* such as encoder, multiplexer, transmitter etc.

2 WACC: reasonable return on capital invested in the DTTB network calculated based on weighted average cost of capital (WACC)[30].

3 Operating expenditure (Opex): expenses which are directly relevant to the provision of *minimum service* such as operation and maintenance cost.

4 Common cost: costs which are relevant to the business operation but cannot be directly or indirectly allocated to *minimum service* such as general and administration costs, regulatory costs etc.[31]

Table 2 includes the assets lives and price trends that had to be applied for the various asset categories.

[29] For more details on the applied LRIC model see Annex A: LRIC model.

[30] For non-public financed entities the WACC was set at 11%. Please note that bank loan interest rates for broadcasters vary between 7-8% in Thailand.

[31] The distribution of common cost to access to the minimum service had to be based on equal proportional mark up (EPMU) method.

Table 2: Asset Lives and price trends

Asset category	Life (in yrs)	Price trend (%)
Multiplexer	10	-5%
Transmitters	10	-5%
Tower	20	2%
Antenna system	20	2%
Combiner	10	-5%
TVRO	10	-5%
Site buildings	20	2%
Tools & Instruments	10	-5%
Monitoring system	10	-5%

The four network operators submitted their reference offers to the NBTC for approval. The NBTC approved all offers and the average distribution charges for a fully deployed network are included in Table 3.

Table 3: Average monthly distribution charge per DTTB service

DTTB service type	Monthly charge (in m THB)
High Definition	14.0
Standard Definition	4.6
Source: Bangkok Post and The Nation	

3.2 Network deployment

When deploying several multiplexes/networks with different network operators several regulatory measures are necessary to minimize infrastructure duplication and to provide a coherent DTTB service bouquet to the Thailand television viewer. The NBTC applied a coherent set of measures, ranging from having provisions in the Broadcasting Act (i.e. site sharing obligations), the application of facility licences (i.e. ensuring long lasting supply of essential facilities and transparent pricing) and operational directives. Here two examples of these operational directives are addressed:

- multiplex loading scenarios;
- limits for site location differences.

3.2.1 Multiplex loading scenarios

For ensuring minimum picture quality levels for HD and SD services the NBTC prescribed several multiplex loading scenarios. These scenarios also served the purpose of balancing the services over the available multiplexes. Two critical input parameters for deciding these multiplex scenarios were:

1. the net effective transport capacity per multiplex, and;
2. the number of HD and SD services in the DTTB service bouquet.

In developing the DTTB policy these two parameters changed over time. Under the supervision of the NBTC the network operators were carrying out field trials to gain experience with the DVB-T2 technology and for agreeing the system parameters, which in turn determined the effective net transport capacity. At the same time the NBTC organized public hearings to acquire input from the broadcast industry as to determine the optimal number of services. In the latter several factors had to be balanced, including resulting market structure after assigning the DTTB service licences as well as DTTB service diversity and minimum content requirements.

A complicating factor was that the Broadcasting Act required a reservation of at least 20 per cent of the available *spectrum* for radio and television community services. Although simple in its formulation the requirement of *20 per cent of spectrum* does not have meaning in real terms if not 'translated'. One translation option was to define this requirement in terms of available multiplex capacity (i.e. a number of Mbit/s). This is a technical interpretation and does not necessarily reflect a viewer's or broadcaster's perspective.

Viewers will first consider the number of community services they can enjoy (and picture quality secondly). In addition, access to the DTTB platform will be important for community broadcasters and that is expressed in the number of services, i.e. the number of service licences. Hence the NBTC decided to translate the 20 per cent into the number of community services over the total number of available services which better reflects the intent of the Broadcasting Act.

At the time of this policy making process the NBTC had established the following:

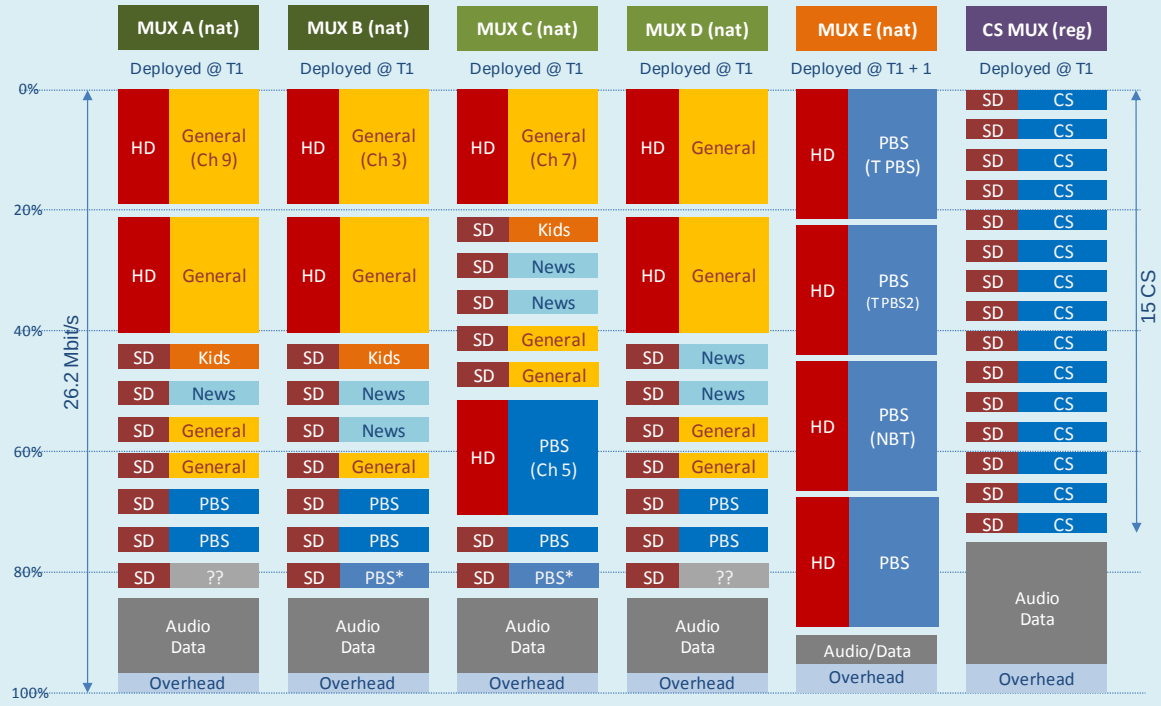
1. System variant: implying a net multiplex capacity of 26.2 Mbit/s (the final multiplex capacity was set at a more robust mode of 22.0 Mbit/s[32]).
2. Number of national services: 24 commercial services (of which 7 HD General, 7 SD General, 7 SD News and 3 SD Kids, 12 PBS services (of which 4/5 HD) and 12-15 community services in SD (ultimately the number of community services was set at 12 in each local area)[33].

In loading the multiplexes near future encoder quality was assumed because the networks would not be deployed at the time of the policy formulation. Figure 16 illustrates a multiplex loading scenario whereby 15 community services are included in the DTTB service bouquet. Please note that in this example the deployment order of the six multiplexes over time was different to the final order in which the multiplexes were deployed.

[32] See Section 5.1.

[33] The NBTC approved 3 multiplex loadings: 2 HD and 6 SD services, or 3 HD and 3 SD services or 1 HD and 9 SD services.

Figure 16: Multiplex loading scenario (Example 1)



Source: ITU, NBTC

Figure 17 illustrates another scenario whereby the number of community services is reduced to ten services. Also in this example the deployment order of the multiplexes is different to the order in which they were finally deployed.

Figure 17: Multiplex loading scenario (Example 2)

Source: ITU, NBTC

Figure 16 and Figure 17 illustrate only two of a wide range of scenarios that were considered. Figure 18 illustrates some pros and cons that were balanced for the scenario presented in Figure 17.

Figure 18: Example of balancing pros and cons of one possible scenario (Figure 17)

Pros	Cons
1. Balanced client portfolio between commercial network providers 2. One network with local insertion 3. Capacity available for (future) additional services or improved picture quality(1) 4. 10 Community services (10/51 = 20%) or (10/47 = 21%) 5. Sixth PBS HD service 6. All Network operators carry their own national service 7. Simulcast of all incumbent services without limiting the number of SD PBS licenses that can be directly assigned	1. Less (10) community services

Source: ITU, NBTC

3.2.2 Limits for site location differences

As addressed in the reference offers (see Section 3.1.2), a key concern was that the deployment of networks would be coordinated between the network operators in such a way that the viewer only needs to direct its antenna in one direction while receiving all available services with optimal signal strength.

A pragmatic directive had to be developed to provide the network operators clarity about the degree of freedom they would have in selecting their sites independently from each other. Only the essence of this directive is discussed here.

The NBTC had concerns about two main effects of having different transmitter site locations:

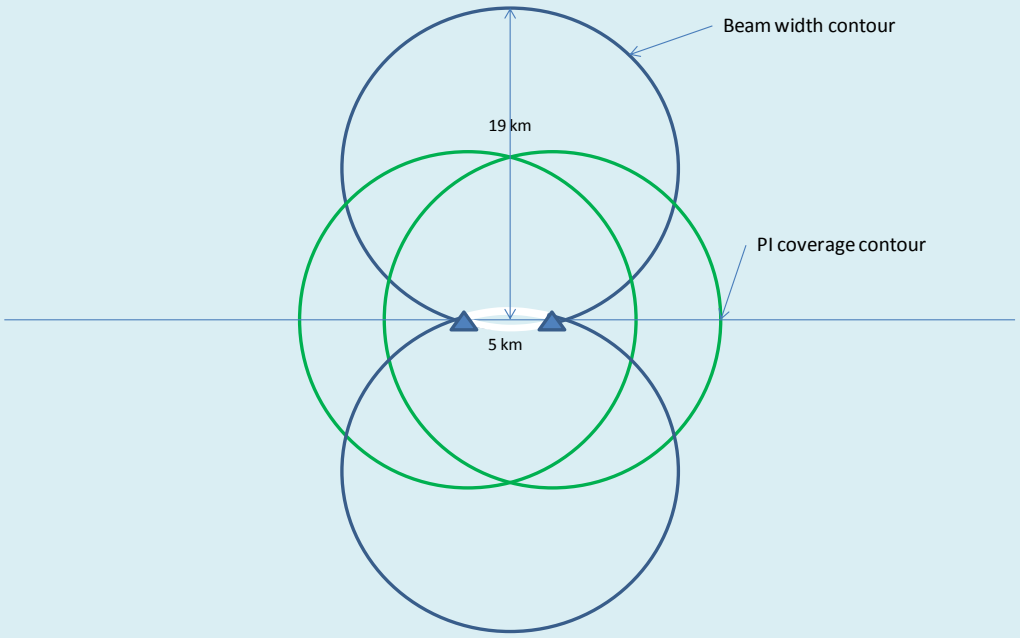
1 beam width limitations of the receiver antenna;

2 distant site interference.

In the case two (or more) different multiplexes are transmitted from two separated sites, the distance between the sites cannot be too large as the receiving antenna will not be able to receive both multiplexes (and hence will only receive the services of one multiplex). In other words the beam width limitation of the receiving antenna limits how far two towers (of two different network operators) can be separated. This beam width limitation occurs relatively close to the sites.

However if the field strength of the DTTB signal is high enough this beam width effect can be offset. This high field strength is present in the coverage area where there is portable indoor reception. Hence in the area where the portable indoor coverage area of both sites overlap there is no problem with beam width limitation. Figure 19 illustrates the beam width contour (inside which the receiving antenna has problems receiving the signals from both towers) and the overlapping portable coverage area (in which the beam width problem is eliminated) in the case the two sites are five kilometres apart.

Figure 19: Beam width contour and portable indoor coverage (5 km)

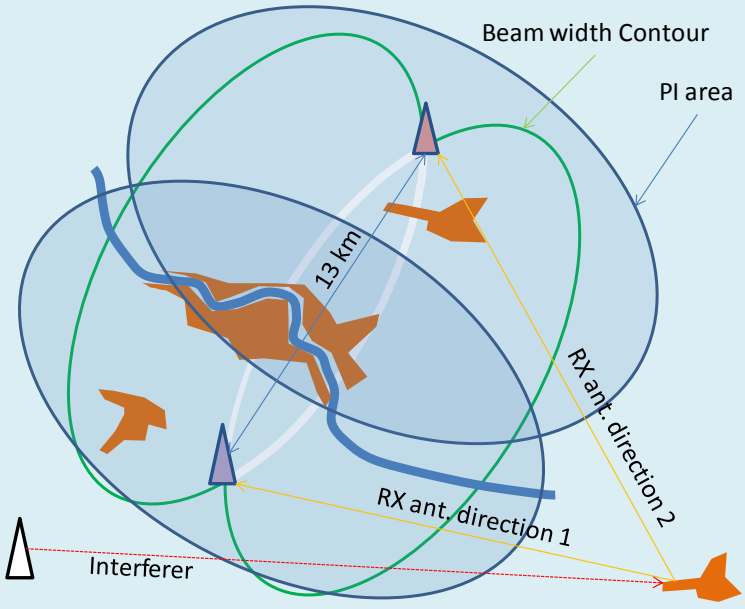


Source: ITU, Nectec

Figure 19 shows that in significant areas around the transmitter sites viewers will have problems receiving all services as the beam width contour is much larger than the overlapping portable indoor coverage area. The beam width contour will be smaller when the sites are located closer together. When the sites are two kilometres apart the beam width contour will fall with the overlapping portable indoor coverage area and hence the viewers will have no problem receiving all services.

Accordingly, the NBTC set the maximum separation distance of two transmitters sites (of different network operators) at two kilometres. The second effect, distant site interference, is illustrated in Figure 20.

Figure 20: Beam width contour and distance site interferer



Source: ITU, NBTC

Although the receiving antenna may be outside the beam width contour (in the small village in the bottom right corner) and has no problems receiving both signals, it may suffer interference from the distant site (white) as the antenna is facing this site directly. In a situation with one site (broadcasting all services) the antenna would be facing for example the top transmitter site (pink) and the interfering signal will arrive at the side of the antenna (where it is not sensitive for other signals).

Unfortunately this second effect cannot be accurately predicted and will require a case-by-case analysis. Hence no pragmatic limit could be formulated here.

3.3 Insights

Considering the topics that have been covered in Sections 3.1 and 3.2 the following insights can be provided:

1. Assigning network licensing (including an operating right) not necessarily have to be assigned by means of a competitive procedure (i.e. either auction or public tender). Assigning network licences by priority can serve the purpose of promoting spectrum efficiency. As the Thailand case has demonstrated, such a decision between competitive bidding and assigning by priority is dependent on several factors, including:
    a. the market structure and the position of incumbent broadcasters;
    b. an assessment of at which level competition will primarily take place (i.e. at the level of service or network provisioning);
    c. the possibility to enforce (additional) regulatory measures (such an obligations to issue reference offers for the NRA approval).
2. Deploying several multiplexes/networks with multiple network operators raises concerns about infrastructure duplication and providing a coherent set of DTTB service to the viewers. Regulatory measures can however reduce the risk of these concerns happening. At a legislative level site sharing rules could be incorporated in the relevant Acts and additional requirements can be applied such as the requirement for having a facility licence (as applied in Thailand). But also pragmatic directives could be issued to ensure a coordinated network deployment (such as setting limits on the degree of freedom to select sites independently between multiple network operators).
3. In general site sharing rules are set to serve the purpose of:
    a. avoiding 'horizon pollution' (i.e. having several towers at the same broadcast location, for example on a mountain top; this is an aesthetic consideration);
    b. access to market as broadcast towers could be considered as essential facilities which cannot be duplicated in an economic viable manner[34]; consequently blocking new market entrants;
    c. reducing cost levels and hence promoting the competitive position of terrestrial platforms. Sharing of facilities will reduce the total cost level of all networks together, e.g. a redundant transmitter, antenna system or tower can be shared between all network operators.

[34] Whether broadcast towers cannot be duplicated in an economic viable way is also dependent on the regulatory framework. Long procedures for acquiring planning/building permission could also imply non-viability.

4. However most site sharing rules (including the rules set in Thailand) seem to lack the purpose of having a coordinated deployment between multiple network operators. The site sharing rules (and in the case of Thailand the facility licence too) secure access, long term availability and fair and transparent pricing of towers, antenna systems and other facilities. However they lack measures to ensure that viewers will have a coherent service bouquet. This is especially relevant in the case of having multiple network operators.

4 Service licensing and auction

All that has been written about auction theory in recent years has been in connection with auctions of telecommunications licences and spectrum. There is very little recent experience (practically none[35]) in the use of auctions in assigning broadcast licences. In this light it is of special interest to have a closer look at the Thailand auction in which the service licences (see Section 2.4) were assigned to commercial broadcasters in December 2013.

In preparing an auction of this nature many decisions have to be made and only a few are covered in this report. The selected topics are presented here to illustrate the type of decisions the NBTC faced. This chapter builds on the information provided in the introduction, and is structured as follows:

4.1 Auction lots;

4.2 Auction design;

4.3 Auction results;

4.4 Insights.

4.1 Auction lots

Auction lots refer to the item(s) or object(s) being offered to bidders. First and foremost, a successful auction requires a clear understanding by auction participants of what rights and obligations are imposed upon them through the licence. If there is any uncertainty about the rights and obligations contained in the licence and imposed upon them competitive bidding will be discouraged by there being fewer bidders participating or inactive bidding by those participating in the auction.

As explained in Section 2.4 the service licence includes a shared spectrum right, i.e. the spectrum right is not assigned to the multiplex operator[36]. This posed the question how winners in the auction (i.e. a commercial broadcaster) will select a network operator and will it not introduce too much uncertainty and potentially a deadlock. A deadlock situation could occur whereby too many winners select the same preferred network operator and overstretch its available capacity.

To overcome this potential deadlock situation the NBTC devised a ranking system whereby the highest bidder would acquire the right to select a network operator first. This seems simple at first sight but turned out to include some complexity when considering that also aggregation rules had to be obeyed and auction design principles. The following sections illustrate this complexity.

At that time the NBTC had decided that the following number of licences in each category would be made available[37], as illustrated in Figure 21.

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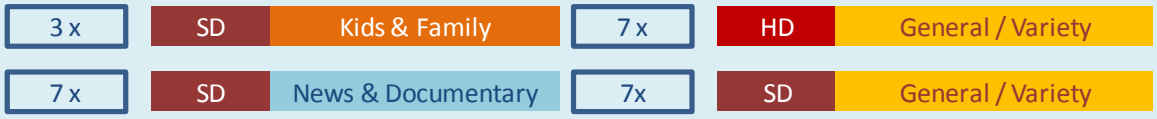
[35] Recently in Italy broadcast licences were also assigned by a form of auction. However these results were not available at the time of the auction preparations in Thailand.

[36] Having a shared spectrum right is not a unique situation. A similar licensing framework for DTTB services exists in France. Like in France a key consideration for having a shared spectrum right is that assigning these rights to the multiplex operator would concentrate too much market power in a single entity.

[37] Next to economic and market structure considerations, the number of licences was technically driven by the available spectrum capacity and the multiplex loading. For more details on these technical aspects see Section 3.2.1.

Figure 21: Lot definition and number of lots in each licence category



Source: ITU, NBTC

In addition the following lot aggregation rules had to be obeyed. Each single qualified bidder could acquire service licences to the following maximum:

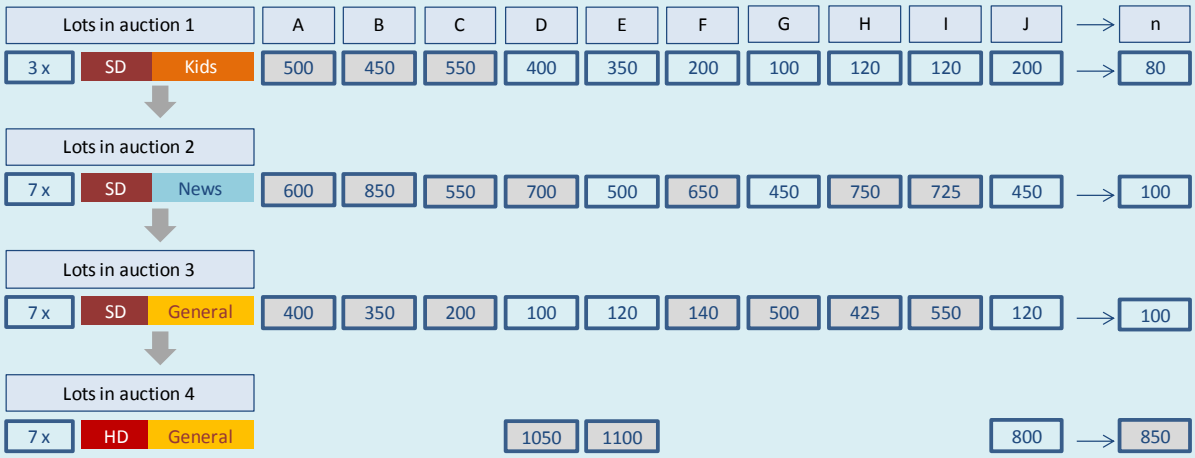
1 1 Kids (SD) and 1 News (SD) and 1 General (SD), or;

2 1 Kids (SD) and 1 General (SD) and 1 General (HD).

The available licences in each licence category would be assigned in separate auctions. Taking into account the aggregation rules, this would mean that in the qualifying phase of the auction bidders had to decide what licence types they would like to qualify and bid for.

Taking into account the aggregation rules and having the four subsequent auctions, the final bids in each auction could result as illustrated in Figure 22. Please note that the order in which the four auctions were actually carried out was different and that the bidding prices are examples only[38].

Figure 22: Example of final bids in four consecutive auctions



Source: ITU, NBTC

On the basis of the final bids the ranking system would be applied. However the NBTC had to consider two variants:

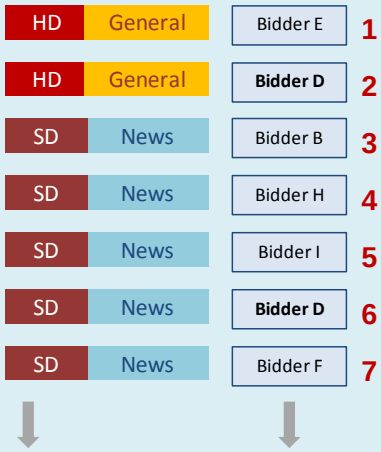
1 All winning bids, regardless of licence type, are ranked from highest to lowest bid.

2 Winning bids per service category are ranked from highest to lowest bid and subsequently across the categories the bids are ranked again in a defined order.

The first ranking variant is illustrated in Figure 23. The red numbers included in the figures represent the queue number by which the winning bidders can select their preferred multiplex and network operator.

[38] The actual order of the auctions was; HD General, SD General, SD News and SD Kids.

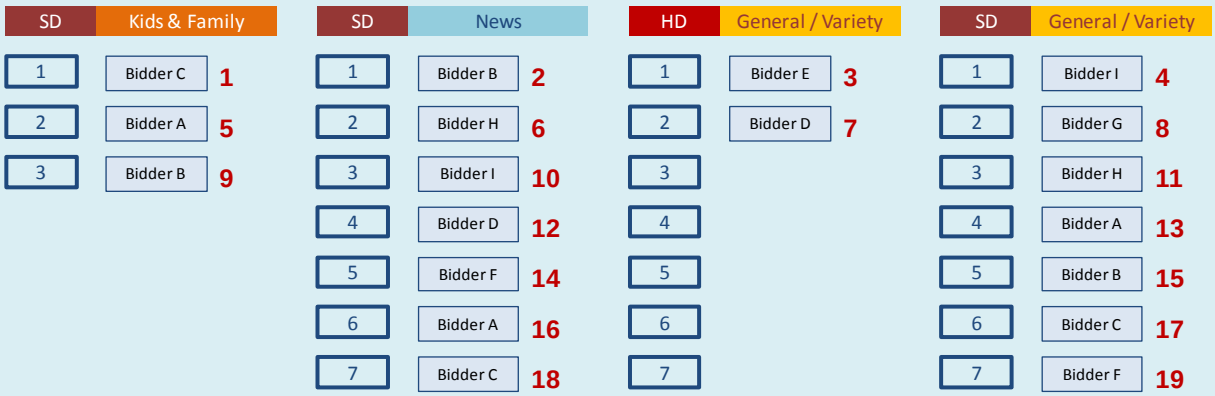
Figure 23: Ranking system (Variant 1)



Source: ITU, NBTC

The second variant is shown in Figure 24.

Figure 24: Ranking system (Variant 2)



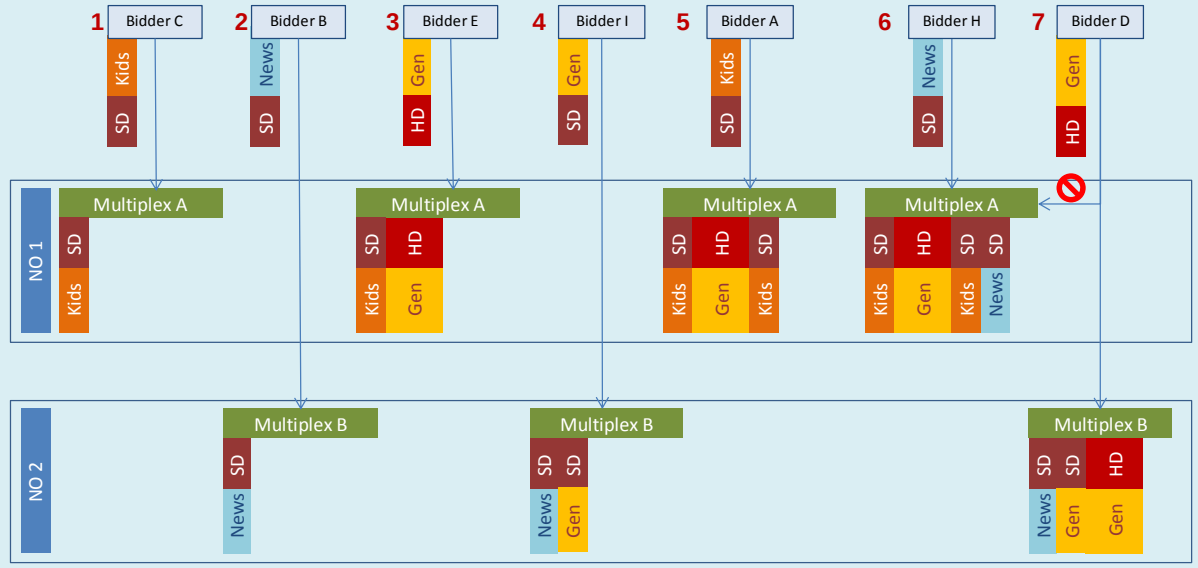
Source: ITU, NBTC

As can be observed from Figure 23 bidder D has two queue numbers assigned to it. This raised the question whether bidder D can only agree one contract at a time. First a contract for a slot for an HD service and secondly for an SD news service. Variant 2 had the same operational issues (see for example C has queue number 1 and 18).

Taking their order in terms of their queue number, the winners can agree on a network contract[39] with their preferred network provider, only as long as there is capacity available. If too many winners prefer the same network provider then the network provider may run out of capacity. The bidder has to go to another network provider. This capacity constraint (deadlock) is illustrated in Figure 25 for variant 2 but both variants suffered from this capacity constraint.

[39] This contract is part of the network operator reference offer, as well as the service levels and the prices for the network services. For more details see Section 03.1.2.

Figure 25: Capacity constraints when selecting a network provider



Source: ITU, NBTC

NBTC decided to go for variant 1 and to allow winners to negotiate for multiple slots at the same time[40]. In addition NBTC added two sets of additional rules. Firstly a set of rules of how the multiplexes could be loaded with SD and HD services, limiting the possibilities of allocating lots over the available capacity. Secondly the NBTC stipulated that it could intervene in negotiations if parties could not agree in the distribution of the lots over the multiplexes.

4.2 Auction design

In preparing the auction the NBTC was face with many design decisions as no or little experience was available to directly apply. As Figure 21 shows four licence categories were available and the question was to auction these lots simultaneously or sequentially. Also the application of sealed bid versus open ascending was a key decision as there were concerns for collusion and winners curse.

The most favoured auction format (for mobile spectrum) in recent years has been open ascending where information and price disclosure are considered the predominant beneficial feature as this limits the risks of the winner's curse occurring, outweighing concerns about preventing collusion. This auctions format is adopted especially in the case where there are:

1. multiple high-value spectrum blocks available;
2. multiple interested parties; and,
3. auction rules and controls can be readily managed by the auction authority.

[40] The option of having auction lots whereby the lots are defined to include the network operator and multiplex was considered to be complex and was assessed to have resulted in network operators/multiplexes not to be bid for in the auction.

The OECD recently reviewed the pros and cons of simultaneous vs. sequential auctions in its Working Paper on Spectrum and the results can be summarized as follows[41]:

1. **Pros**: To calculate their bids in a sequential auction, buyers have to guess the outcome of future auctions, which makes their task much more complicated. A simultaneous auction releases more information, and allows bidders to switch among licences given the flow of information. Bidders therefore have more flexibility and more information, which reduces the winner's curse[42];
2. **Cons**: Simultaneous auctions can facilitate collusion as bidders can increase the price on some licences to punish bidders deviating from collusive agreements or to signal which licence they want. Simultaneous auctions are more difficult to implement; sequential auctions have been extensively used in practice and are therefore less risky in terms of success.

In general, however, the greater flexibility and flow of information generated by simultaneous auctions are believed to outweigh its drawbacks. Again, there was no broadcast experience to draw upon on directly. There was only anecdotal evidence from 3G auctions in Europe where different lots were auctioned in series with the result that bidding activity was reduced and subsequent licences were won at very low prices where reserve prices were not adequately set.

The NBTC decided for a single round multiple sequential auction for each of the four licence types with a 60 minute time limit on each auction segment. Licences were not being pre-packaged. However aggregation rules were applicable. Bidders were able to aggregate up to a maximum of three licences, one in each category. This maximum was restricted in the way that a News licence could not be combined with a HD General licence. In the qualifying phase of the auction bidders had to decide what licence types they would like to qualify and bid for. The whole bidding process was live televised at several broadcast stations as to show the transparency of the auction.

During the auctions bidding information was continuously updated as bids could be put in at any moment within the 60 minute time limit. The information disclosure to an individual bidder was limited to the following:

1. The bidder's ranking (i.e. which position the bidder's latest valid bid has amongst all other valid bids, at a given time in the auction);
2. The minimum winning bid price (i.e. the necessary minimum bid price to acquire a licence of the 3 or 7 licences on offer, at a given time in the auction).

No waiver or eligible point system was applied. In addition the following bidding rules were included:

1. A valid opening bid should be above or equal to the reserve price;
2. A fixed bid increment;
3. A maximum number of bids (per minute and/or hour).

[41] See OECD Working Paper 'Actions and Comparative Selection Procedure – Simultaneous open bidding versus sequential auctions.

[42] Sequential auctions of identical items led to the well-known "declining price anomaly" (see for instance McAfee and Vincent (1993)). Prices of identical items follow a decreasing pattern. In simultaneous auctions, it has generally been observed that similar licences sell for (almost) the same prices, as they should. Therefore, there are adverse effects in sequential auction bidding which are not present in simultaneous bidding.

In balancing the pros and cons of the auction design elements the NBTC was led by the principles of avoiding the *winners' curse* and keeping bid prices down (so that winners would have more funds available for producing high quality content), as well as avoiding collusion. Also sequential auctions had been extensively used in practice and therefore were considered less risky in terms of success and would keep the auction design simple. The 60 minute time limit was set as the NBTC felt that the risk of collusions was high and that it was not possible to keep bidders for longer bidding periods in the secured bidding rooms.

4.3 Auction results

In December 2013 the 24 licences were auctioned. 29 companies qualified and they submitted a total of 42 applications for a licence in one of the categories. For each category the demand exceeded supply. All licences were assigned in the four auctions. Table 4 shows the winners in each auction as well as their rank in terms of final bid price.

Table 4: Winners per licence type and ranking

Rank	Company	Rank	Company
HD General		**SD General**	
1	BEC Multimedia	**1**	Thai Broadcasting (Workpoint)
2	Bangkok Media and Broadcasting	**2**	True DTT
3	BBTV (CH 7)	**3**	GMM SD
4	Triple V (Thairath)	**4**	BEC Multimedia
5	MCOT	**5**	RS
6	Amarin	**6**	MONO Broadcast
7	GMM HD	**7**	Bangkok Business (Nation)
News & Documentary		**Kids & Family**	
1	NBC Next Vision (Nation)	**1**	BEC Multimedia
2	Voice TV	**2**	MCOT
3	Thai TV	**3**	Thai TV
4	Spring News		
5	TNN (True)		
6	DN Broadcast		
7	Bright TV		
Source: NBTC			

Table 5 shows the total auction proceeds of the four auctions as well as the value paid above the set reserve price level.

Table 5: Total auction proceeds as compared to minimum price level

Total auction proceeds in THB	
Final Bid Price	50 862 000 000
Reserve Price	15 190 000 000
The value above the reserve price level	35 672 000 000
Source: NBTC	

When observing Table 4 and Table 5 the following can be concluded:

1. The auction showed competitive bidding as the number of applications exceeded supply (i.e. 42 applications over 24 lot) and the total bid value exceeded the reserve price by 235 per cent (i.e. THB 15.2b over 50.9b);
2. Licences were assigned to companies with ties in the broadcasting and media industries. For example BBTV, GMM, BEC, MCOT, True, RS and Workpoint were all present on the Thailand television market already. Companies like Amarin, Nation and Thairath are new market entrants on the television market but have strong positions in the media market (print and publishing). The digital terrestrial television business will extend their media portfolio and spread risks. As their current business is already advertising based they are likely to have inroads and established relationships with advertisers and their agencies.

In explaining the value of the DTTB licences it should be considered that additional licence terms and conditions were set by the NBTC. For example the maximum number of advertising minutes per editorial hour is 12 minutes for the DTTB platform as for cable and satellite this is limited to 6 minutes per hour. Also the auction proceeds (see Table 5) was earmarked for contributing to a voucher system whereby any DTTB receiver would be subsidized, lowering the barrier for consumers to switch to this digital platform. Also the Thailand television market is primarily an advertising market (see Section 2.2) whereby most FTA viewing is on terrestrial platform (see Figure 9). With a voucher system in place and having a speedy DTTB network deployment it can be expected that this FTA viewing will continue on the terrestrial platform.

A simple Net Present Value (NPV) check is included in Figure 26 showing that the DTTB value is in principle present in the television market. The NPV check is at an industry level (i.e. all 24 winners/broadcasters together) and is based on some basic assumptions, including:

1. Total television advertising expenditure (ADEX) keeps growing at a steady pace of CAGR 3 per cent and totalled THB 69b in 2013.
2. Top-3 largest cost categories for a broadcaster are (a) transmission costs for all television platforms (including ATV to be switched-off in year 5)[43], (b) content costs (i.e. costs of content production/sourcing of 40 per cent of revenues) and (c) staffing (i.e. 25 per cent of revenues).
3. Auction payments (THB 50.9b) to be paid in one installment[44] and financed by bank loans with an interest of 8 per cent and to be paid back within 5 years.
4. NBTC licence fees of 2 per cent and 2 per cent (for broadcast and telecommunications fund) over revenues for all platforms.

[43] As the NBTC's must-provide rule stipulates that all DTTB services should be distributed over satellite and the cable head ends pick up their feeds from satellite, the cable distribution costs are assessed to be nil for the broadcasters. No data was available on the OPEX of the ATV networks. However they will stop after ASO.

[44] The actual payment schedule is that the reserve price is payable in five yearly instalments, starting directly after assigning the licence. The value paid above the reserve price is payable in five yearly instalments, starting after one year of assigning the licence.

Figure 26: NPV projection for 15 years (only 10 years showing) - (THB in millions)

		1	2	3	4	5	6	7	8	9	10
ADEX	69,250	71,328	73,467	75,671	77,941	80,280	82,688	85,169	87,724	90,356	93,066
ATV transmission costs (OPEX only)		no data	no data	no data	no data	0	0	0	0	0	0
DTTB transmission costs	2,094	2,136	2,179	2,222	2,267	2,312	2,358	2,405	2,453	2,503	2,553
Satellite transmission costs	369	376	384	391	399	407	415	423	432	441	449
Cable transmission costs	0	0	0	0	0	0	0	0	0	0	0
Content/programming costs		28,531	29,387	30,269	31,177	32,112	33,075	34,068	35,090	36,142	37,226
NBTC license fees (2% + 2%)		2,853	2,939	3,027	3,118	3,211	3,308	3,407	3,509	3,614	3,723
Staffing		17,832	18,367	18,918	19,485	20,070	20,672	21,292	21,931	22,589	23,267
Other		3,566	3,673	3,784	3,897	4,014	4,134	4,258	4,386	4,518	4,653
Loan repayments		10,172	10,172	10,172	10,172	10,172	0	0	0	0	0
Interest payments		4,069	3,255	2,441	1,628	814	0	0	0	0	0
~ free cash flow		1,792	3,112	4,447	5,799	7,168	18,726	19,315	19,923	20,549	21,195

WACC	12%
NPV	82,333 THB

Source: ITU, NBTC, annual reports

Figure 26 shows that the auction value of THB 50.9b seems to be accepted by the market as the calculated NPV is higher. However the big question is whether new market entrants are able to gain market share from the incumbent broadcasters. In other words it will be crucial if the large income disparity, as reflected in Figure 7, can be levelled. Like in other markets, new entrants failing to gain market share from their competitors will not survive or have to rely on the deep pockets of their strategic investors[45].

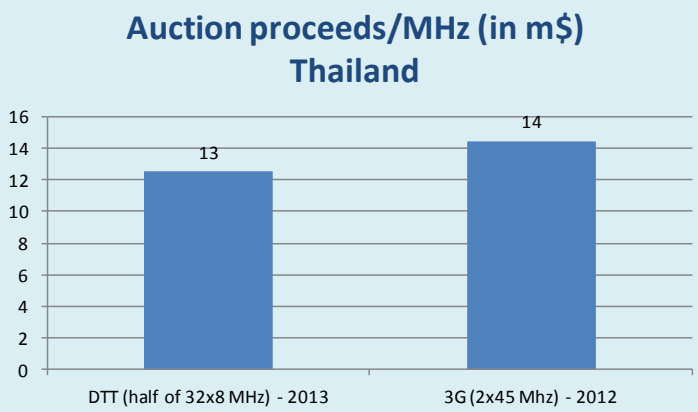
Interestingly this broadcast auction came one year after the auction of 3G mobile licences. As both auctions took place in Thailand comparing spectrum value between mobile and broadcasting services becomes easier as social, cultural and demographic differences are not present[46]. Also the key licence terms were the same; licence duration and coverage obligation (respectively 15 years and 95 per cent population, in both cases). The value per MHz for respectively DTTB and 3G services in Thailand is shown in Figure 27[47].

[45] Strategic investors are here considered to be companies that manage a larger business portfolio whereby losses can be compensated or levelled out over different business lines.

[46] When comparing auction proceeds between countries the per-MHz price is often corrected for population count.

[47] For carrying the 24 DTTB services it is assessed that 32 frequencies (each 8 MHz wide) will be needed. It should be noted that this number can down when more efficient encoding will be applied over time. For more details on the number of frequencies needed see Chapter 5.

Figure 27: Auction proceeds for broadcasting and mobile in Thailand



Source: ITU, NBTC

As Figure 27 shows the price paid per MHz are very close between licences for broadcasting and mobile services, respectively USD 13m and USD 14m. This is an interesting fact as broadcast spectrum was always deemed to be significantly lower as spectrum for mobile services. A topic heavily debated in the wider discussion of allocating any freed-up spectrum after migrating to DTTB (i.e. the digital dividend).

4.4 Insights

Considering what was covered in Sections 4.1 to 4.3, the following insights are presented here:

1. Assigning broadcast licences (including the spectrum rights) by means of auction is possible and requires careful preparations. In these preparations due care should be given to the local situation (what is the dominant business model and structure), the existing legal framework (in what way are spectrum rights embedded in licences) and supporting policy measures (in what way can market interest in broadcast licences be promoted/supported). These local conditions will vary from country to country and hence not a single auction recipe can be provided;
2. Broadcasting licences can have significant value and can be priced in monetary terms. Thailand has shown that the value of broadcasting licences is even the same as to that of mobile licences. The Thailand auction results seems to support the conclusions of a recent study carried out in the UK whereby the marginal value of mobile services is assessed to be relative low (as the predicted mobile traffic growth stems from an increase of none-paid video) and digital terrestrial licences to have a relative high marginal value[48];
3. The long term success of developing the Thailand television market (i.e. having a diverse bouquet of television services with high quality content programming) will largely depend on whether the new market entrants are able to gain market share and level the large income disparity in the Thailand television market.

5 Network planning

Network planning or frequency planning is a technical planning process whereby specified planning targets (like population coverage and protection of ATV services) have to be reached with minimal spectrum usage.

[48] See Communications Chambers, "The value of Digital Terrestrial Television in an era of increasing demand for spectrum", dated January 2014.

This detailed planning process was carried out by the NBTC, with support of ITU. On the basis of the detailed planning results the four network operators could order their transmitter and antenna equipment.

As discussed in Section 3.2, the NBTC key concern was to facilitate a coordinated network deployment whereby the viewer would receive a unified DTTB service offering. For this reason, and in agreement with the network operators, the NBTC decided to carry out the detailed frequency planning.

A detailed description of a common DTTB planning process can be found in the ITU Guidelines[49]. In this chapter we focus on some specific challenges the NBTC faced and the (pragmatic) decisions it took in planning the six DTTB networks. This chapter is structured as follows:

5.1 Planning context;

5.2 Overview of planning results;

5.3 Practical planning guidelines;

5.4 Insights.

5.1 Planning context

This section provides some elementary information on the applied planning parameters, constraints and approach. This information is needed to better understand the presented results and practical guidelines as provided in following sections.

5.1.1 Planning parameters and targets

As indicated in Section 2.4 the DTTB networks are deployed in four phases over a period of four years, providing fixed (FX) rooftop coverage for 95 per cent of the Thai households. A major part of the first two phases have been planned. The scope of the presented planning process and results cover the 39 DTTB main sites only. More additional sites are needed for the last two phases to reach the planning target[50].

The band allocations for broadcasting services in the National Spectrum Plan deviates from the international band allocation in this region, as provided in the ITU Radio Regulation. The available spectrum is limited on the lower side of the UHF Band. Channels 21 to 25 are allocated to mobile services and consequently only channels 26 to 60 (i.e. 510 -790 MHz) were available for planning the DVT-2 services. The planning also had to obey some international frequency coordination agreements with neighbouring countries, in particular the agreement with Malaysia. In an area of 100 kilometres form the Malay/Thailand border, only the even number channels could be used[51].

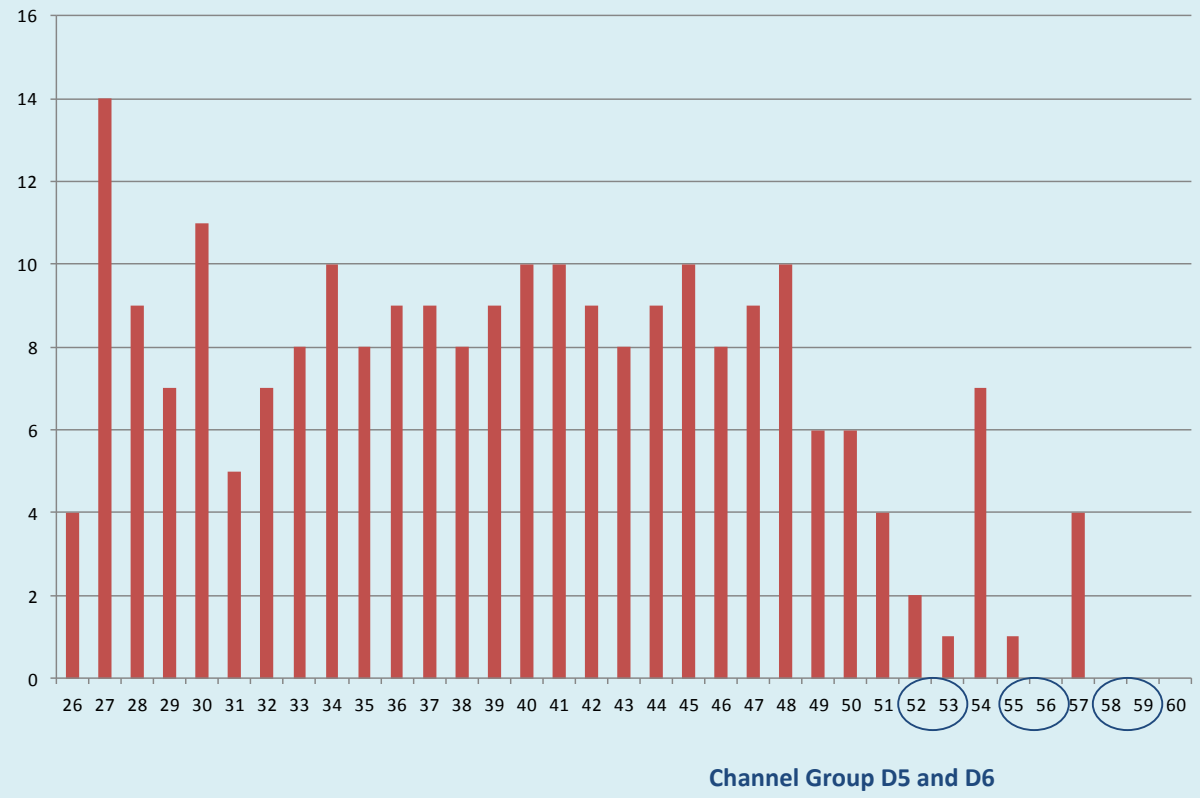
Before embarking on the detail planning of the 39 DTTB main sites, the initial Frequency Plan (FP) had to be analysed (referred to as Plan 1.0). This initial plan was designed for different planning targets and with other assumption about the network deployment. Hence the initial Plan was assessed not to be able to deliver the current planning target of 95 per cent. The applied powers (ERP) where too high and the plan channel arrangement was unbalanced. Figure 28 illustrates the number of assignments per frequency in the available UHF Band of Plan 1.0.

[49] See ITU Guidelines for the Transition from Analogue to Digital Broadcasting, January 2014, Part 4.

[50] A total number of 160-170 DTTB is needed to reach the 95% households with fixed rooftop reception.

[51] In these same areas, at the request of the NBTC, channel 48 should also be avoided as much as possible.

Figure 28: Number of assignments per frequency



Source: ITU, NBTC

The frequencies were grouped together in channel groups and as Figure 28 shows the frequencies in channel groups D5 and D6 were infrequently used. Creation of additional channel groups and redistribution of channels in the groups was necessary for resolving incompatibilities (i.e. internal network interference) cases. A new channel arrangement was designed and an overview is included in Table 6.

Table 6: Applied channel groups

Group	MUX1	MUX2	MUX3	MUX4	MUX5	MUX6	Derived from	Changes compared to Plan 1.0
Da	28	31	35	39	47	51	D1	43 moved to De
Db	26	29	32	36	40	44	D2	48 moved to De
Dc	27	30	33	37	41	49	D3	45 moved to De
Dd	34	38	46	50	54	57	D4	42 moved to Df
De	43	45	48	53	56	59	D6	43, 45, 48 added
Df	42	52	55	58	60		D5	42, 60 added
T-Da	26	30	34	38	42	46	T-D1	50 deleted
T-Db	28	32	36	40	44	48	T-D2	52 deleted

Thailand carried out numerous field tests to determine and agree the DVB-T2 system parameters (what is basically a trade-off between signal robustness and available transport capacity) between the four network operators. A set of system parameters (i.e. the DVB-T2 system variant) were agreed, defined and stipulated

by the NBTC. Table 7 provides an overview[52]. This set reflects a balance between enough transport capacity (for delivering 48 HD/SD services) and also having enough signal robustness to provide indoor coverage (and hence keeping the number of DTTB sites down and consequently the network costs).

Table 7: DVB-T2 system variant

Parameter	Value
FTT size	16k, extended bandwidth
Modulation scheme	64 QAM
Code rate	3/5
Pilot pattern	PP2/PP3
Guard interval	266 µs

Thai PBS operates a nationwide network of UHF transmitters (see Table 1) and the applied antenna systems were technically assessed to provide enough capacity to accommodate also the DTTB frequencies. Hence the planning of the 39 main sites had to be based on reusing these UHF transmitter sites[53].

The following planning targets were defined:

1 FX rooftop coverage for 95 per cent of Thailand households;

2 Regional FX rooftop coverage in 39 regions for providing community services[54];

3 Portable indoor (PI) coverage in target municipalities[55];

4 Protection of operational ATV services in the UHF band (see Table 1).

Planning targets 1 to 3 are defined in the regulatory framework, i.e. NBTC Notifications. It should be noted however that the PI target was not clearly defined at the beginning of the planning process. First it was unclear if the Notification meant *all* target municipalities and secondly when was a target municipality considered to be covered (for example when 70 per cent or 100 per cent of the areas were covered)[56].

As this target could not be clarified in time a pragmatic solution was applied to deal with this uncertainty. The first step in the planning was to design the DTTB networks for FX rooftop reception and then calculate what the resulting PI coverage would be. At the time that the FX network would be deployed the policy makers would have reached a conclusion on the PI target and additional PI sites could be planned at a later

[52] For details on the applied planning principles and parameters see Annex B: Detailed planning parameters.

[53] Of the 39 main sites 35 UHF systems could be reused from Thai PBS and for the four remaining sites new antenna systems had to be designed and purchased.

[54] For this requirement the sixth multiplex needs to apply Multi Frequency Network (MFN) architecture. This does not exclude the application of Single Frequency Networks (SFN) with a single region. For the national multiplexes (1 to 5) SFNs are applied as much as possible for reasons of spectrum efficiency. However their application is limited by internal network interference (i.e. signals from SFN sites should arrive within the guard interval at any reception location within the SFN coverage area).

[55] Municipalities are sub-districts with a special status and political relevance. Thailand counted 184 target municipalities in 2013/4. It should be noted that these target municipalities can change over time.

[56] It should be noted that the definition of PI and FX coverage for a single coverage location (for example 100 x 100 m) is well defined in ITU Recommendations.

stage[57]. This approach would also allow the regulator to monitor the uptake of the DTTB services and how well the service providers would do in earning advertising income on the DTTB platform.

5.1.2 Planning approach

The operational ATV networks had to be protected from DTTB interfering these networks (and hence the ATV viewers) and reversely the DTTB network should be made compatible with these ATV networks. Also the network topology should be kept, as much as possible, the same when transitioning from the simulcast period (in which ATV service had to be protected) to the all digital situation (after television ASO in the UHF band).

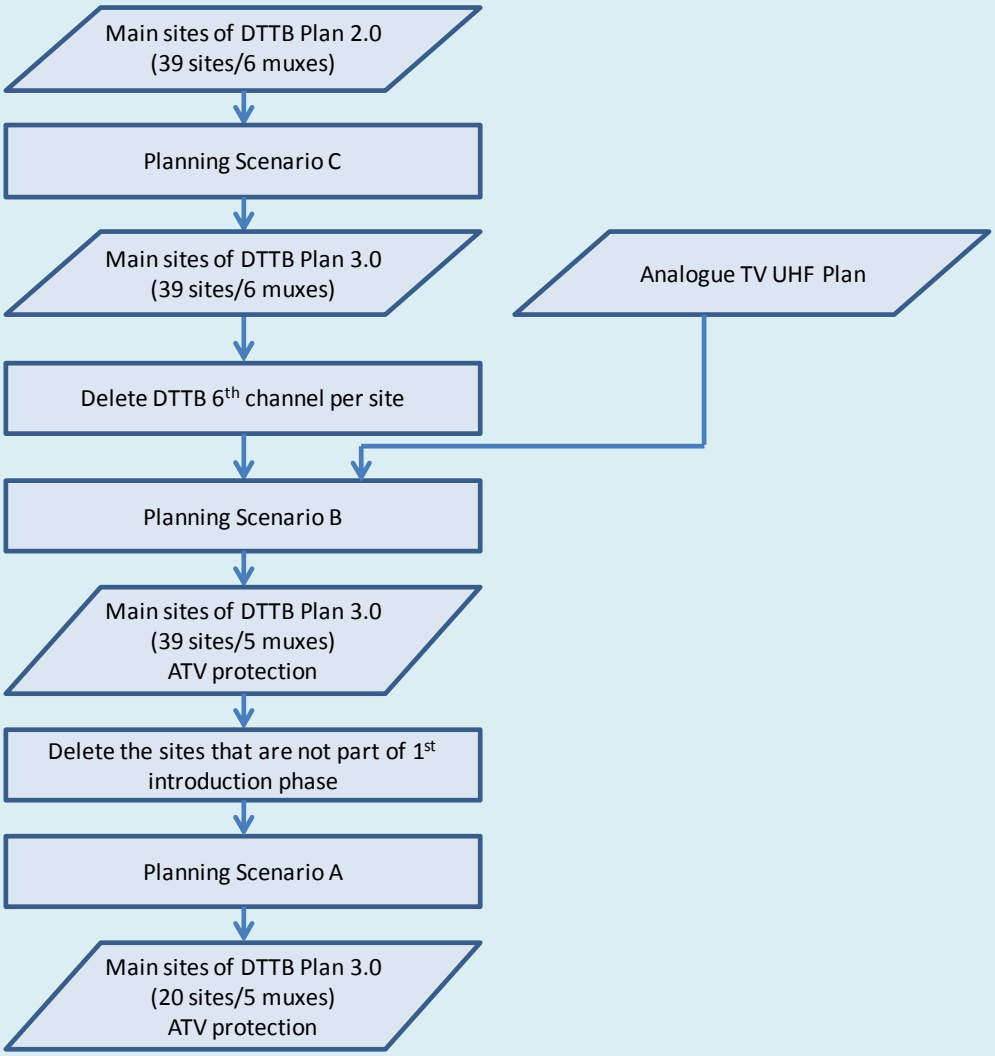
The adopted planning approach to cater for this was to first plan for the all-digital situation. For the all-digital situation the network would be optimize to reach the planning targets and to minimize spectrum usage. This planning scenario was labeled scenario C. For protecting ATV services either some interference on the ATV networks had to be accepted (i.e. acceptable interference)[58] or temporarily frequency had to be applied. The number of frequency changes should be kept to a minimum as this would increase network costs as well as complicate the network deployment. This simulcast scenario was labeled scenario B. The launch scenario (i.e. a subset of the 39 main sites under scenario B) was labeled A.

An overview of this planning approach is provided in Figure 29.

[57] It should be understood that this approach is a compromise. A PI network could have designed in a different way by applying the principle of power distribution. With this approach PI coverage in large build up cities would be planned with two to four middle power stations in SFN around the city. As opposed to having a high powered transmitter site in the centre city with additional smaller sites to provide PI coverage.

[58] Some level of interference has to be accepted otherwise no other service can be introduced in the same band. Some pragmatic rules where developed to define this level. See Section 05.3.

Figure 29: Applied Planning Approach



Source: ITU, NBTC

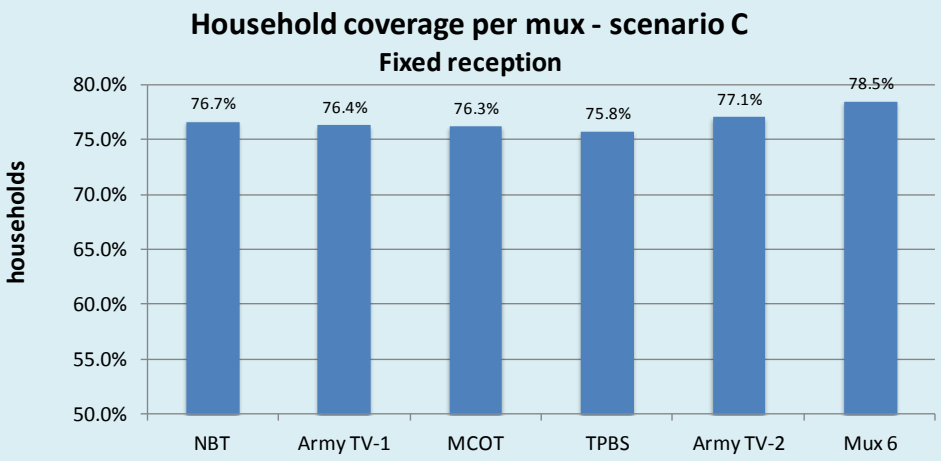
In the next section the main planning results are shown. They refer to planning targets and scenarios discussed in this section.

5.2 Overview of planning results

In planning the DTTB multiplexes it was important to consider the difference between the multiplexes. They should be kept to a minimum as to have in each coverage location the same number of multiplexes (i.e. the number of DTTB services). In addition the four network operators should have the same position in the market of offering distribution services to the broadcasters (i.e. the licensed service providers).

The population coverage with fixed reception for the different multiplexes in scenario C is shown in Figure 30. It should be noted that Figure 30 corresponds with the coverage map as presented in Figure 12.

Figure 30: FX Household coverage in scenario C



Source: ITU

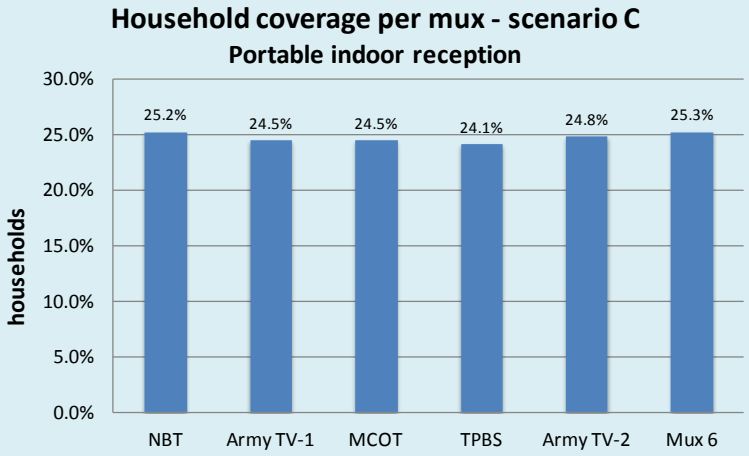
The household coverage ranges from about 76 to 78 per cent. The differences are minimal between the multiplex and are mainly caused by propagation differences between lower and higher channels. In multiplexes 1 to 5 the channels per site were arranged to obtain equal coverage per multiplex. Multiplex 6 contains many channels in the lower part of the band, but was excluded from this arrangement, because most channels in multiplex 6 are in operation by Thai PBS analogue TV (in scenario A and B).

A simple check to assess the spectrum efficiency of the plan is to compare what is called the noise limited with the interference limited coverage. With noise limited the planning only considers that the wanted DTTB signal is above a defined noise level. Noise limited can be considered as the theoretical maximum achievable. An interference limited planning considers inference from other DTTB sites as well as ATV sites.

The interference limited coverage figures, as presented in Figure 30, are about 1 per cent below the noise limited coverage figures. This can be considered as a good balance in the trade-off between the power of the sites and the coverage that can be achieved in the available spectrum.

When these FX rooftop networks will be deployed, PI coverage will also be provided near the main DTTB transmitters sites, although not necessarily in the target municipalities. Figure 31 shows the resulting PI coverage in terms of household percentages.

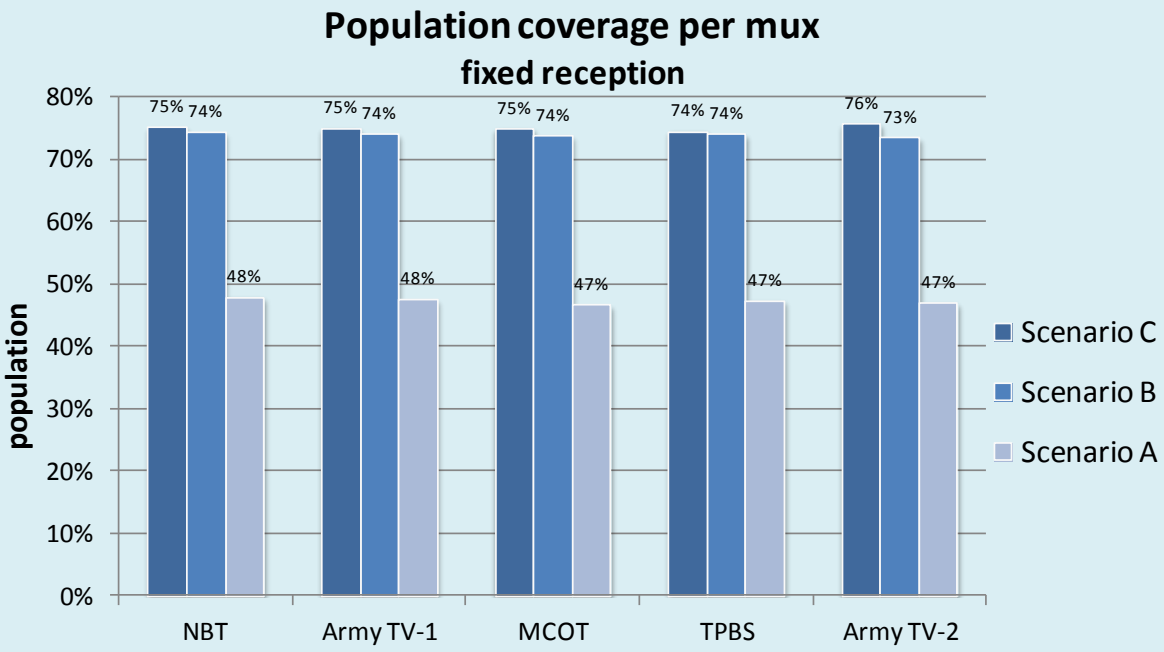
Figure 31: PI Household coverage in scenario C



Source: ITU

Next to planning the networks in the most frequency efficient way in scenario C, the temporarily situation of scenario B should not result in too much coverage loss (as well as the coverage areas should not differ too much) due to the application of temporary frequencies. Figure 32 shows that the population coverage differences between scenario B and C are limited between the multiplexes to 1 per cent (please note the figure also includes the population coverage of Scenario A – only 11 main sites).

Figure 32: Population coverage differences between scenario B and C (and A)



Source: ITU

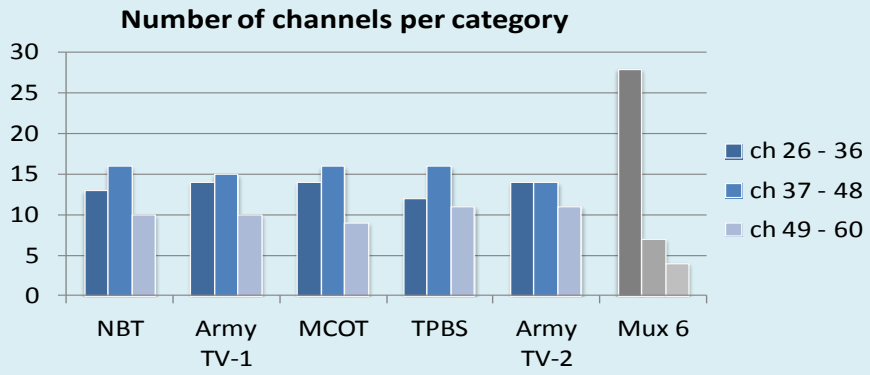
The number of channel or frequency changes per network operator had to be balanced too, without affecting the balance achieved in the household coverage between the multiplexes as presented in Figure 30 and Figure 31. The total number of channel changes after analogue TV switch-off is 26. The resulting number of channel changes per network operator and multiplex is indicated in Table 8.

Table 8: Number of channel changes per network operator

Network operator	Number of channel changes
NBT	5
RTA 1	5
MCOT	5
TPBS	6
RTA 2	5

On top of balancing the coverage and the number of frequency changes between the network operators/multiplexes, also the frequency categories (low, mid and high range frequencies) had to be balanced. This balance should not affect the coverage between the networks and the number of channel changes. Figure 33 shows the balance.

Figure 33: Balance of Channel Categories between Multiplexes



Source: ITU

The above discussed channel changes (as included in Table 8) are primarily driven by changes in the ATV networks (i.e. ASO). For this report it would go too far to discuss all these factors. However an overview is provided in Annex C: Frequency plan overview.

5.3 Practical planning guidelines

The ITU Guidelines already provides a wide range of practical planning guidelines[59]. In developing the frequency plan for Thailand some other pragmatic guidelines had to be applied for deciding some key network design parameters. The following two practical guidelines are presented here as they may be useful for frequency planners facing similar design situations:

1 pragmatic limits on applied powers;

2 framework for accepting ATV interference.

5.3.1 Pragmatic limits on applied powers

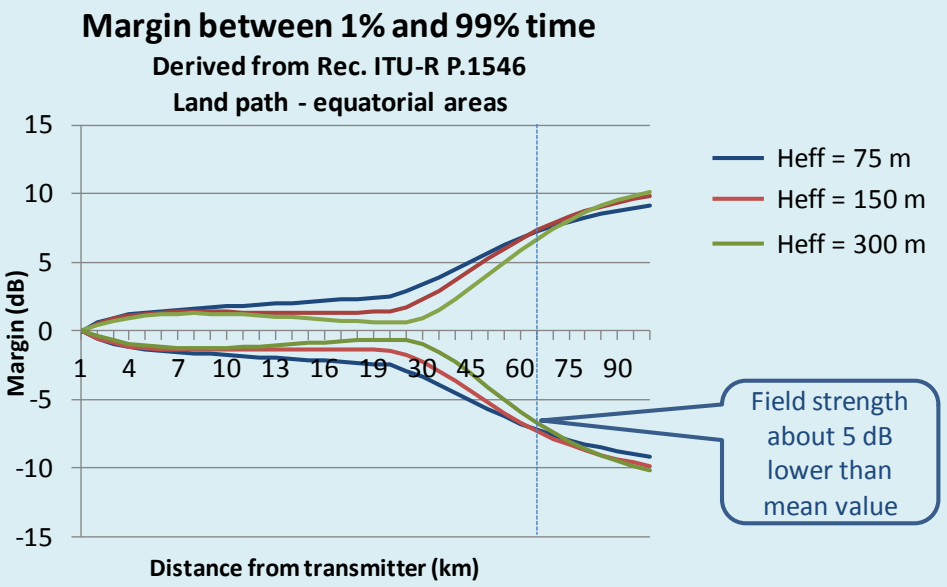
In the analysis of the initial plan (see Section 5.1.1) it was found that the applied powers were too high causing incompatibilities and resulting in large areas where the coverage areas of the main sites would overlap each other. This would result in spectrum inefficiencies. As the network was planned in stages it would also result in a significant risk of not reach the 95 per cent household target when the applied powers for the main sites would be too high[60]. This situation posed the questions what pragmatic limit could be applied when determining the powers (ERP).

Transmitter sites with high powers will obviously have large coverage areas. However in large coverage areas, near the edge of the coverage, the received field strength is subject to time variations and could be lower than the minimum required value in a considerable period of time, resulting in a black screen (for DTTB). To illustrate this effect Figure 34 shows the field strength variation between 1 and 99 per cent of time as function of the distance from the transmitter (for effective antenna heights of 75 m, 150 m and 300 m).

[59] See footnote 48.

[60] A common misunderstanding is that the interfering signal of a DTTB site travels as far as its wanted coverage area. This misunderstanding results in applying very high powers as this would increase the wanted coverage. However the re-use of frequencies will be severely limited and the same frequency cannot be applied elsewhere. Consequently the planning target will not be reached as the frequency planner runs out of frequencies.

Figure 34: Field strength variations in time



Source: ITU

Figure 34 shows that up to about 25 km from the transmitter the time variation is relative small. At larger distances the variation increases and is about 10 dB higher than the mean value for 1 per cent of time and about 10 dB lower for 99 per cent of time[61]. The frequency planner is faced here with the question of what an acceptable variation is.

It is common practice in frequency planning to calculate interfering signals, normally arriving from a large distance, for 1 per cent of time. It is also good practice to calculate the wanted signal for 50 per cent of time in the assumption that the wanted signal is stable within the coverage area. However if the assumption of a stable wanted signal is not fulfilled in certain areas, these areas may be presented as having good coverage, while in practice there is no coverage for certain times in a year. For that reason in some countries the wanted signal is calculated for 99 per cent of time.

Two methods were considered to take account of time variations of the wanted signal; (a) a power limitation and (b) calculating all wanted signals for 99 per cent of time. Judging the impact of both methods the choice was made to limit the ERP to 50 kW. With this limitation the coverage radius does not exceed about 50 km. In cases where still reception problems would arise, the margin of about 5 dB can be compensated by using an antenna amplifier. Table 9 summarises the aspects of both methods.

[61] To put this variance into perspective, +3 dB corresponds to a doubling of the transmitted power (ERP).

Table 9: Aspects of methods for incorporating time variations

Aspect	Wanted signal calculated for 99% time	Maximum power of 50 W
Probability that field strength is below minimum value at edge of coverage	1% of the time.	About 2 to 5 dB below minimum value at 1% of the time.
Overall impact compared to calculation of wanted signal for 50% time	All coverage areas, including small ones decrease; Overall population coverage reduction of 14%.	Limits coverage of large areas, no impact on small coverage areas.
Compensation of coverage loss compared to calculation of wanted signal for 50% time	Power increase at all sites of 2 dB to 5 dB and consequently more interference.	Use of antenna amplifier at receiving locations near edge of coverage.

5.3.2 Framework for accepting ATV interference

When planning scenario B a compatibility analysis was carried out to identify DTTB interference to analogue TV, in addition to the already existing interference from other analogue TV stations. Some level of interference of the ATV stations should be allowed. Not accepting any level of interference would result in stopping to take any DTTB stations into operations (as adding DTTB stations, will always result in some additional interference)[62]. Here the frequency planner is faced with the questions what is still an acceptable level of interference.

In this trade-off not only technical considerations are included. Viewer considerations could also be included. Accepting interference can be made easier when the affected ATV viewer has alternatives. Section 2.3 showed that the ATV viewer has two alternatives; (a) the DTTB platform carrying the affected ATV service and (b) the VHF network when its coverage is (partly) duplicated on the UHF network (see also Table 1)[63]. For the first option the DTTB coverage has to overlap the ATV coverage and this should be checked (as illustrated in Figure 38).

Incompatibilities to ATV services were resolved by applying the following pragmatic rules:

1. Replacement of DTTB channels that cause critical interference to analogue TV by using the channel of the sixth multiplex (as this multiplex would be introduced later), where possible (as Thailand TPB is still operating the majority of this frequencies);
2. Acceptance of critical interference to ATV services in the following situations:
   a. If affected viewers < 30% and < 100 000;
   b. With VHF overlap, if affected UHF viewers < 1 000 000 and:
      i. assignment of interfering DTTB channels to the operator that owns the related ATV site (i.e. the incumbent broadcaster that broadcast its ATV service from that site)[64];
      ii. indication of DTTB ERP reductions to reduce interference;
3. temporarily replacement of DTTB channels if critical interference to analogue TV was not acceptable.

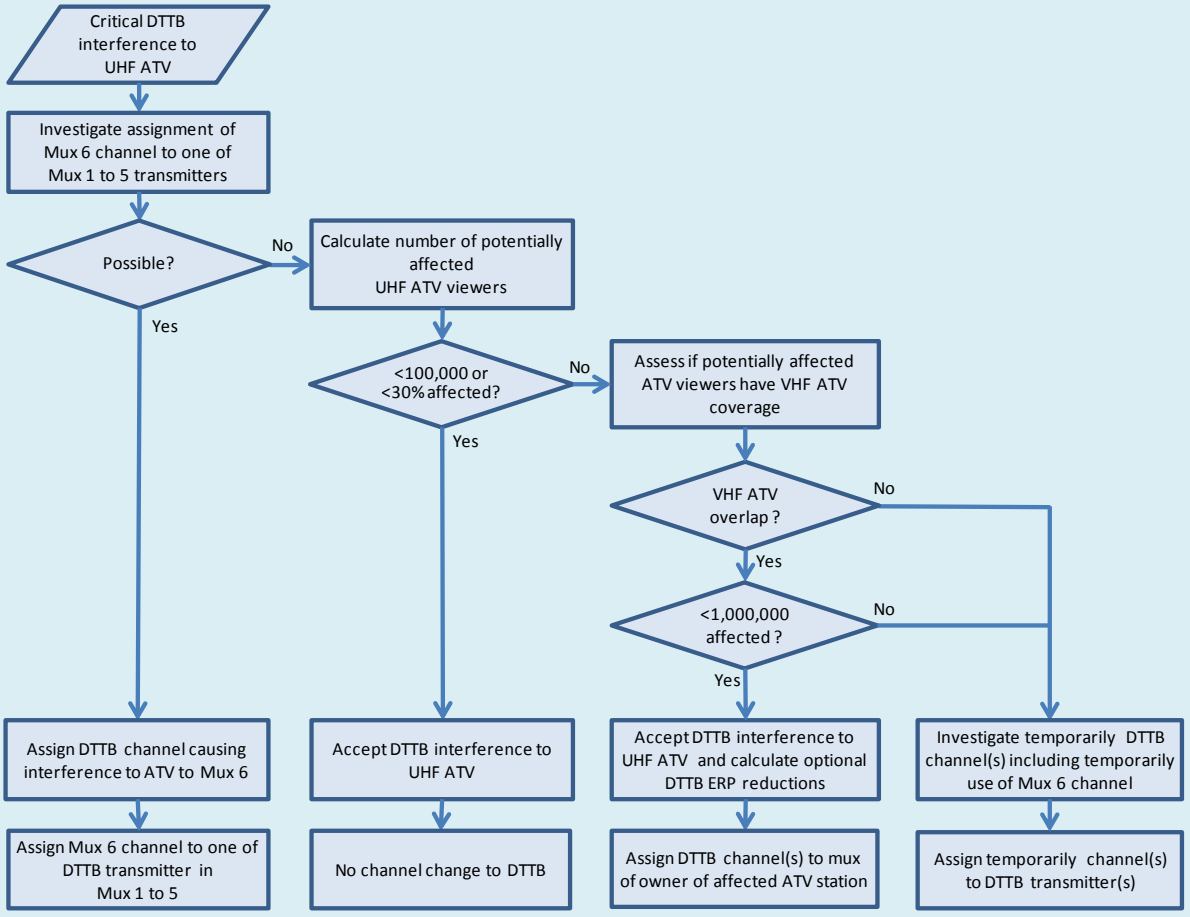
[62] See also footnote 57.

[63] In the past the ATV network operators introduced UHF technology to replace the older VHF technology and duplicated the VHF network coverage for some parts. The UHF band was also used to extend the VHF network coverage.

[64] In this way the affected broadcasters can make the trade-off between using the interfering DTTB channel (and have DTTB services) and interfering its own ATV service. Please note that interfering ATV services as mentioned here would not result in not having any ATV reception. The viewer will have (more) ghost images and noise.

Figure 35 shows the above described decision tree in a flowchart.

Figure 35: Flowchart for resolving incompatibilities to analogue TV



Source: ITU, NBTC

The essence of the above presented guideline is that in frequency planning pragmatic rules have to be applied to bring the planning process further and to open up opportunities. Accepting some interference of the ATV services can also serve as an extra incentive for ATV viewers to migrate to the DTTB platform.

5.4 Insights

On the basis of what was covered in Sections 5.1 to 5.3 the following lessons learned can be presented:

1. Having multiple network operators deploying a number of DTTB networks and striving towards a coherent DTTB service bouquet, will put some extra constraints and requirements on the frequency planner. Creating a level playing field between the network operators has to be obeyed, also when designing a frequency plan. As shown in this chapter, for example the number of frequency changes have to be balanced between the operators, as well as the frequency categories.
2. Practical guidelines will have to be developed on the job and are necessary to move the frequency planning work forward. For example setting power limits and defining acceptable interference. These pragmatic guidelines may be dependent on the local situation, including the market structure (vertical integrated companies or not) and alternative platforms available to affected viewers. In addition, frequency planning work is often carried out under uncertainties, for example when planning targets are still under (political) consideration. Pragmatic solutions should be sought where concessions have to be made.

3 As demonstrated in Section 5.2 the frequency plan has been carried out carefully and with the objective to minimize spectrum usage. A measure to check its efficiency is to compare the difference between noise limited and interference limited coverage, as well as the channel use across the available frequency band (see for example Figure 28). Also a temporary frequency plan to protect ATV services during the simulcast period (i.e. labelled scenario B in this report) should be efficient in terms of coverage loss. Any coverage loss in the simulcast period should be minimized as this is the launch situation and DTTB coverage should be as large as possible from the start. Frequency changes are already difficult to explain to viewers, let alone explaining that their coverage will increase over time due to network changes (i.e. not coverage extension due to progressing network deployment).

4 Finally the system variant as selected in Thailand (see Table 7) reflects a choice for signal robustness as to provide as much as possible for PI coverage. Thailand is one of the first countries to actual deploy a network with these parameters. In this context it is interesting to note that already one Thailand manufacturer supplies smartphones and tablets with a DVB-T2 receiver incorporated in the device. Clearly with these devices the manufacturer targets portable and mobile reception.

6 DSO planning and communications

Drafting the national digital switch-over (DSO) and analogue switch-off (ASO) planning is delicate and often a technically complicated process. Skill sets other than technical are needed, foremost are leadership and political skills, especially in situations where long lasting spectrum rights are granted and multiple stakeholders interact and compete, such as in the case of Thailand.

This chapter illustrates the trade-offs the NBTC made in this DSO process. It also provides insights to what measures it took to promote a rapid DTTB deployment and how the viewer could be informed about this deployment accurately.

This chapter is structure as follows:

6.1 DSO planning;

6.2 DSO communications;

6.3 Insights.

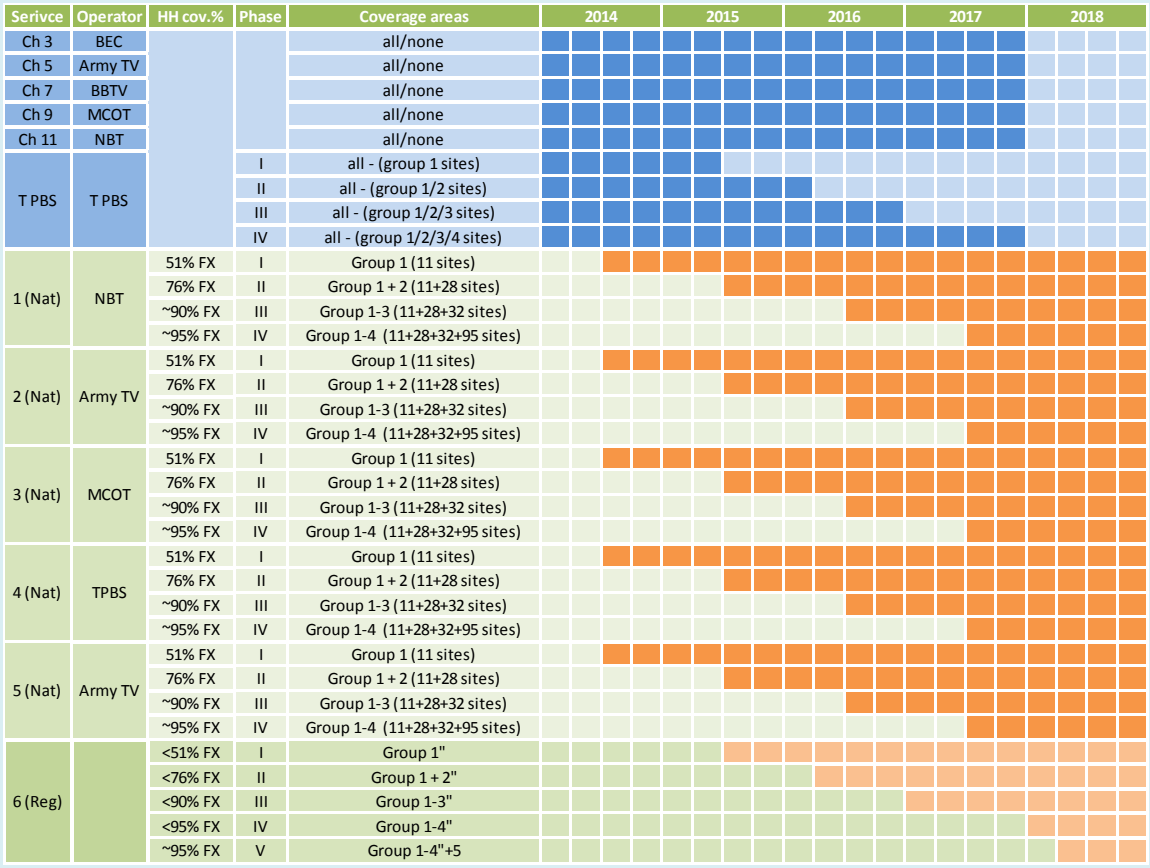
6.1 DSO planning

The DSO planning describes the time schedule in which the DTTB service will be introduced. However the DSO planning should also consider the simulcast period in which (selected) incumbent services (often the PBS services) will be broadcast on both platforms, the ATV and DTTB platform. With determining the (minimum) simulcast period, implicitly the ASO date(s) is also set. As discussed in Section 3.1.1 the incumbent broadcasters have long lasting spectrum rights and revoking these rights is a delicate matter. Hence the ASO date(s) had to be negotiated and consider the migration speed of ATV viewers to the DTTB platform.

6.1.2 DSO and ASO scenarios

In this negotiation process several DSO planning scenarios have been discussed and evaluated. Figure 36 illustrates one of the DSO planning scenarios.

Figure 36: DSO planning scenario example



Serivce	Operator	HH cov.%	Phase	Coverage areas	2014	2015	2016	2017	2018
Ch 3	BEC			all/none					
Ch 5	Army TV			all/none					
Ch 7	BBTV			all/none					
Ch 9	MCOT			all/none					
Ch 11	NBT			all/none					
T PBS	T PBS		I	all - (group 1 sites)					
			II	all - (group 1/2 sites)					
			III	all - (group 1/2/3 sites)					
			IV	all - (group 1/2/3/4 sites)					
1 (Nat)	NBT	51% FX	I	Group 1 (11 sites)					
		76% FX	II	Group 1 + 2 (11+28 sites)					
		~90% FX	III	Group 1-3 (11+28+32 sites)					
		~95% FX	IV	Group 1-4 (11+28+32+95 sites)					
2 (Nat)	Army TV	51% FX	I	Group 1 (11 sites)					
		76% FX	II	Group 1 + 2 (11+28 sites)					
		~90% FX	III	Group 1-3 (11+28+32 sites)					
		~95% FX	IV	Group 1-4 (11+28+32+95 sites)					
3 (Nat)	MCOT	51% FX	I	Group 1 (11 sites)					
		76% FX	II	Group 1 + 2 (11+28 sites)					
		~90% FX	III	Group 1-3 (11+28+32 sites)					
		~95% FX	IV	Group 1-4 (11+28+32+95 sites)					
4 (Nat)	TPBS	51% FX	I	Group 1 (11 sites)					
		76% FX	II	Group 1 + 2 (11+28 sites)					
		~90% FX	III	Group 1-3 (11+28+32 sites)					
		~95% FX	IV	Group 1-4 (11+28+32+95 sites)					
5 (Nat)	Army TV	51% FX	I	Group 1 (11 sites)					
		76% FX	II	Group 1 + 2 (11+28 sites)					
		~90% FX	III	Group 1-3 (11+28+32 sites)					
		~95% FX	IV	Group 1-4 (11+28+32+95 sites)					
6 (Reg)		<51% FX	I	Group 1"					
		<76% FX	II	Group 1 + 2"					
		<90% FX	III	Group 1-3"					
		<95% FX	IV	Group 1-4"					
		~95% FX	V	Group 1-4"+5					

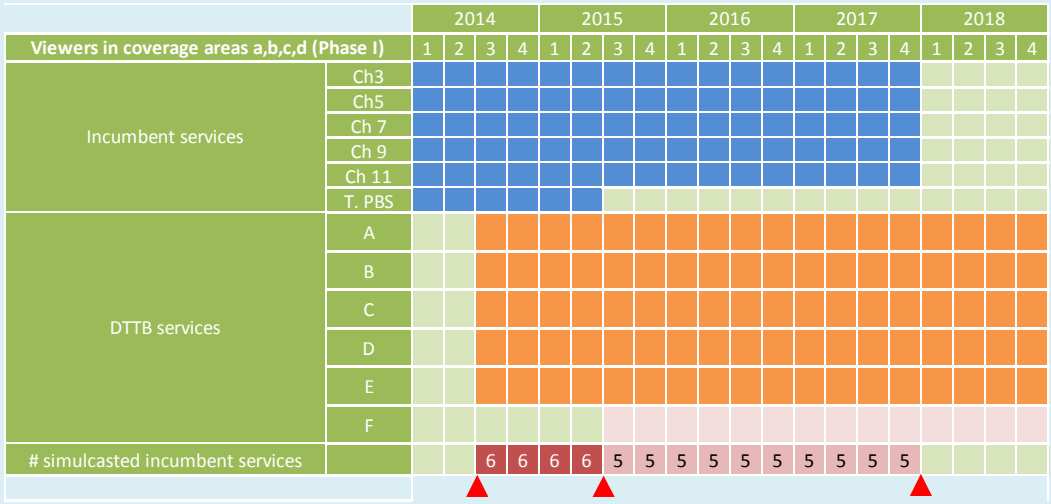
Source: ITU, NBTC

In Figure 36 the blue bars refer to availability of the ATV services and the orange bars to the introduction of the six multiplexes in the four different deployment stages. In this figure the regional multiplex (carrying the community services) is deployed later as the network licence for this regional multiplex still have to be assigned.

In this example scenario the public broadcaster (Thai PBS) would lead the ASO process by switching off their ATV analogue transmitters in the areas where the DTTB network would have been deployed. From Figure 36 it can be observed that the simulcast period in each deployment stage is not the same. In the first deployment stage the simulcast period is 12 months (where the blue and orange bars of the same service overlap each other in time). For stage two, three and four the simulcast period is respectively nine and six months.

From a viewer's perspective Figure 36 would look differently, depending on which coverage area the reception location is situated. Figure 37 shows this viewer's perspective for households in the first deployment stage (please note that for other deployment areas the viewer's perception is different).

Figure 37: Viewer's perspective of an example DSO planning scenario



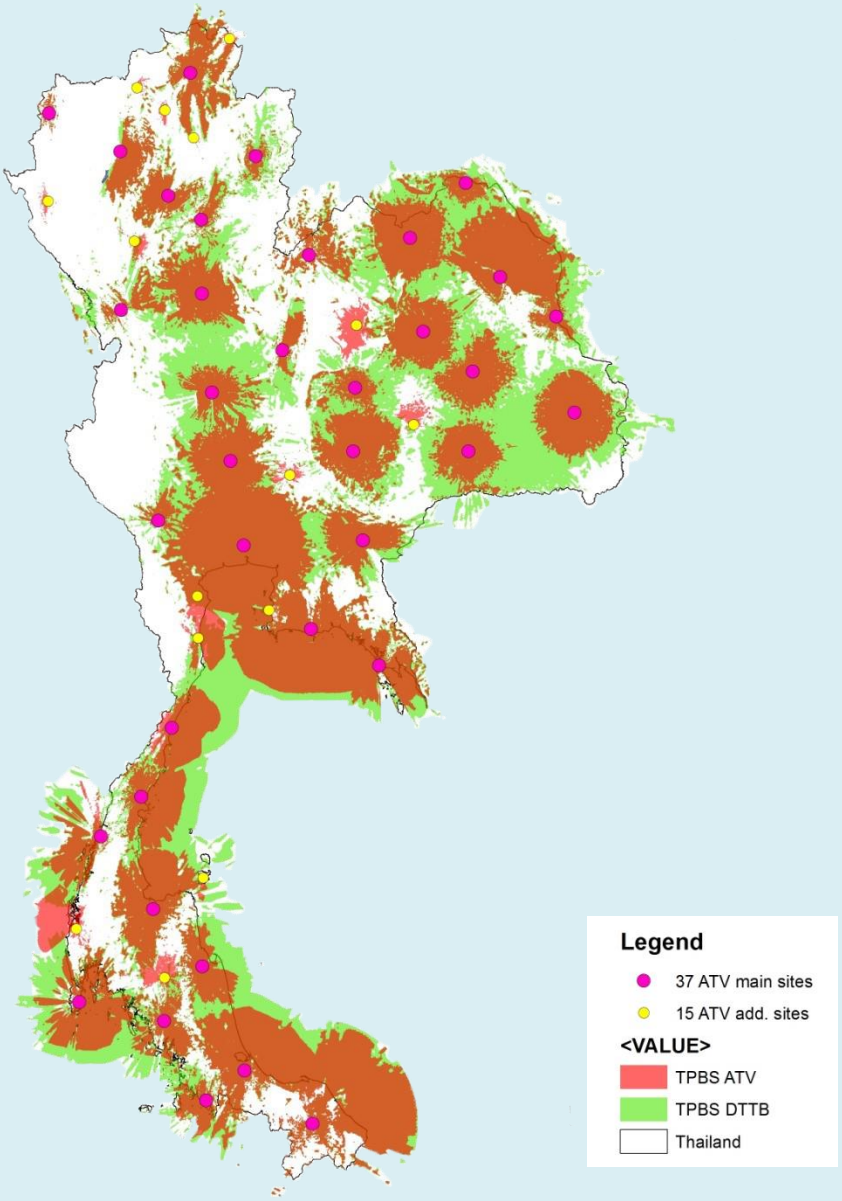
Source: ITU, NBTC

In Figure 37 the red triangles indicated a change in the viewer's terrestrial reception situation. In the this example at the time of the second triangle two events take place; the ASO of the Thai PBS service and the introduction of community services carried on the sixth multiplex (labelled F in Figure 37). These changes in the viewer's reception situation will require communication (see Section 6.2). The number of these communication events should be kept to a minimum and a coordinated ASO between the ATV services is preferable.

6.1.3 Detailed simulcast analysis

The DSO planning scenario as presented in Figure 36 is a simplified representation of what the deployment looks like in practice. A detailed coverage prediction of both the analogue and digital television services will tell in which areas simulcast is actually offered. Figure 38 shows such a detailed analysis (when 39 DTTB main sites are deployed and all Thai TPB ATV transmitters are still operational).

Figure 38: Detailed analysis of simulcast areas



Source: ITU, NBTC

The brown coverage areas in Figure 38 are the areas where there is overlap between the ATV and DTTB network carrying the Thai PBS service and hence simulcasting is provided in those areas. In the pink coverage areas there is only ATV coverage (and no DTTB coverage). Such an analysis is needed to determine in detail the offered simulcast period for households at the subsequent deployment stages. It can also be used to prioritize the order of deploying sites in each deployment stage. For example the first sites after the 39 main sites should be deployed in the pink (ATV) coverage area as to speed up the ASO date.

As said the ASO date(s) have to be negotiated. For broadcasters it will be a big step to switch off their ATV service, especially considering that most FTA viewing takes place on the terrestrial platform (see Figure 9). However nowadays any simulcast period of more than 12 months seems to be relatively long as the necessity of offering a roll-back (i.e. people can roll back to their ATV service when the DTTB service doesn't work) is not really there anymore. Modern DTTB receivers are 'plug and play'. In addition, the NBTC will

offer coupons for each Thai household to acquire a DTTB receiver. Experience elsewhere has shown that the majority of households receiving a coupon will switch-over within a few months.

Moreover, it could be argued that a short simulcast/switch-over (to DTTB) period is needed as people will be made aware of digital television. They will be mobilized for switching to DTTB. But also satellite and cable providers will try to benefit from these 'terrestrial' marketing campaigns. So it is important that people switch quickly to DTTB (and not 'forget' their coupon). Conveying a message that ASO is not eminent can hamper this effort.

Also for Thailand a relatively long simulcast period will also delay the introduction of the community TV services as they are planned on the sixth multiplex which utilizes most of the Thai PBS ATV frequencies (see Table 1). Moreover in a DSO/ASO schedule whereby additional sites will be deployed in 'ASO areas' temporarily frequency changes can be avoided[65]. Avoiding frequency changes is advisable as:

1 DTTB deployment costs can be reduced;

2 communication efforts can be reduced (by not having to explain frequency changes to the public).

6.1 DSO communications

A DSO communication strategy focuses on effective and impartial communications with the general public, broadcasting and retail industry about the introduction of the DTTB services. Especially in Thailand the NBTC has an important coordinating task as four network operators will deploy the DTTB networks. The communication efforts of the different parties should be consistent and well planned.

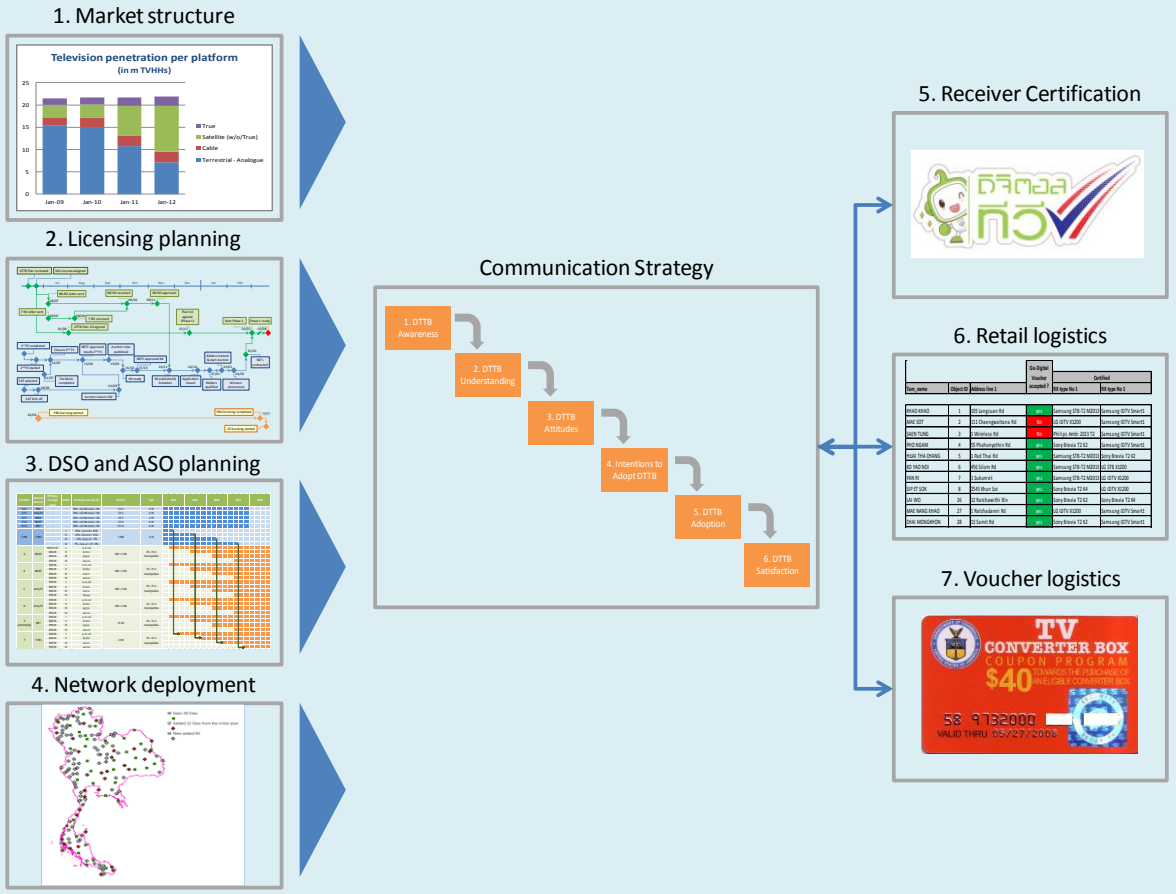
This report focuses on the introduction of DTTB services. However the DSO communication strategy should anticipate on an ASO. The DSO communications effort will span several years and within this timeframe analogue services will be discontinued.

6.1.1 DSO communications framework

For drafting the DSO communication strategy the NBTC based its work on a comprehensive framework. This framework provided insight what was needed and what factors drove these DSO communications. Equally important it helps in understanding what the key interrelationships are with other work efforts (i.e. work streams). An effective strategy will cater for changes in these drivers and interrelationships. Figure 39 illustrates the applied framework, with on the left hand side the key drivers and on the right the most important interrelationships.

[65] Temporary frequencies are used to protect analogue television services and whereby in the all-digital situation (i.e. after ASO in a specific area) another more optimal frequency can be used (i.e. a frequency that either will improve network compatibility and/or coverage areas). For more details see Chapter 5.

Figure 39: DSO communications framework



Source: ITU, NBTC

For the four subsequent drivers the following implications on DSO communications were listed:

1 **Market structure:** It is against the market structure and trends, as described in Sections 2.1 and 2.2 that the DSO Communications will take place and hence the following should be incorporated:

   a The DSO Communications will have to span a large number of TVHHs (approximately 22 million) and the organizational structure will have to be able to handle the associated volumes (for example for door-to-door information leaflets or local newspapers).

   b The viewing figures show that the incumbent analogue services are very popular and viewers should be well informed about where and when these services can be found on the DTTB platform.

   c The significant size and rapid growth of the other digital platforms will imply that the DSO Communications have to explain the difference with DTTB services but also provide information about these alternative platforms when ATV viewers are considering migrating to digital television services.

2 **Licensing planning:** The DSO Communications will have to continuously incorporate the licensing planning and any changes that will occur in it. Given this licensing planning the following should be monitored:

a The DSO Communications will have to cater for the various dates licences will be assigned and notifications published. Especially the licensing of new services (i.e. the multiplex loading over time) will have to be continuously communicated to the public[66]. For example this has an impact on the design of the website and other information platforms.

b The licensing of the (commercial and PBS) service licences and their Logical Channel Numbers (LCN)[67] assignment will have to be included in the communications.

3 **DSO and ASO planning:** As explained in Section 6.1 the DSO and ASO planning is driven by a negotiation process and hence the planning will continuously change over time:

a As the DSO/ASO planning determines the launching dates of the various DTTB multiplexes in the different areas the communications should be detailed and continuously updated to inform the viewers in terms of what services they can receive when and in what areas. A new service introduction will also imply a rescanning of the DTTB receivers and viewers should be informed accordingly.

b The DSO/ASO planning also determines when ATV services will be discontinued and hence what simulcast periods will be offered for the different ATV services. The DSO Communications should incorporate this information in a flexible manner catering for any changes that may occur.

4 **Network deployment:** The network deployment is carefully planned (and accurate coverage predications are available, see chapter 5) and the networks are deployed accordingly:

a The detailed network planning can provide information on where and how services, carried on the six multiplexes, can be received. For any defined geographical position the planning tool can provide this information. This will imply functionality that relate any entered geographical position (e.g. on the national DSO Website or in the call centre) to a prediction entry in the frequency planning software.

b The frequency planning software provides predictions of *planned* services. It is crucial that the communications includes the latest information on the actual network deployment. It is common that certain planned sites are changed or replaced because of implementation constraints which were not foreseen. Both the communications and the frequency planning software should provide a rolling forecast and should be updated regularly.

The above drivers will impact the DSO communication strategy and in turn the communications have important relationships with other work streams. The following interrelationships had to be managed with the following work streams:

1 **Receiver certification:** For acquiring an import licence DTTB receiver manufacturers have to comply with NBTC's receiver specifications[68]. The NBTC certificate sticker, together with the Go-Digital logo, were introduced to the public in several media campaigns (as part of creating DTTB Awareness, see also Section 6.2.2). In Figure 40 the logo and certificate sticker are shown. The following implications were identified for the receiver certification process:

a The certification process is on-going process as more and more receivers will be imported to Thailand. The DSO communications should be updated accordingly and regularly. Also the DSO communications work stream will acquire feedback (by means of DSO surveys, see

[66] In Thailand for example the PSB and Community service licensing will be executed in stages. Hence the broadcasting of the PBS services will commence at different dates and the DSO communication should have the flexibility to cater for this.

[67] The LCNs determine the order in which the DTTB receiver will scan-in the services. For example a DTTB service with LCN 'one' will be placed under the channel selection button 'one' of the remote control.

[68] The NBTC published two Notifications on the receiver specifications, respectively in 2012 (NBTC BS 4002-2555) and in the second quarter of 2013. See Annex D: Receiver specifications.

Section 6.2.2) on the DTTB satisfaction of viewers and this should be shared with the work stream receiver certification.

b The manufacturers will provide a planning on when they will have production lines ready and when they can start shipping receivers and in what quantities. This information should be incorporated in the DSO communications. The manufacturers will also provide product roadmaps and this is important information to be shared with the public.

c Part of a receiver is also the antenna and the certification process also includes these antennas. Especially for PI reception good quality antennas can help viewers receiving the DTTB signal in more challenging situations or alternatively can provide a safety margin. Consequently the DSO communications should incorporate this information on certified antennas.

2 **Retail logistics:** Having sufficient number of STBs and IDTVs in retail outlets is critical for the uptake of DTTB services and the following implications were identified:

a The DSO communications work stream should work closely together with selected retailers to estimate DTTB sales figures and to monitor actual sales. Information collected in periodic DSO surveys can be shared with the retailers to better estimate sales figures in consecutive network deployment stages.

b The DSO communications work stream should inform the retailers about what receivers and antennas have been certified so that transport and floor/shelf space can be available in time. Also information collected on DTTB satisfaction should be shared with the retailer as to further improve their sales and retail strategy.

c Information on installer networks should be collected and made available to the public in the same way as the retailer information and this data should be kept up to date.

3 **Voucher logistics:** The following interrelationships between the DSO communications work stream and the voucher logistics work stream were identified:

a Information on the voucher value, scope and logistics should be exchanged with the retailers and reversely information on actual voucher sales should be shared with the DSO communications work stream. This information should be shared with the public as an incentive to acquire a DTTB receiver.

b Information on the voucher system (i.e. how it works and where and for what receivers the vouchers can be used) should be made available to the public. Reversely the periodic DSO survey provides information on the uptake and usage of vouchers and can be shared with the retailers.

c The application of a voucher system for the DTTB platform only, may result in complaints from the satellite and cable industry as not being fair and disrupting a level playing field. DSO communication should inform and involve the alternative platforms. The DSO communications should inform the public about alternative ways of getting digital television.

Figure 40: Go-digital logo and receiver certificate sticker

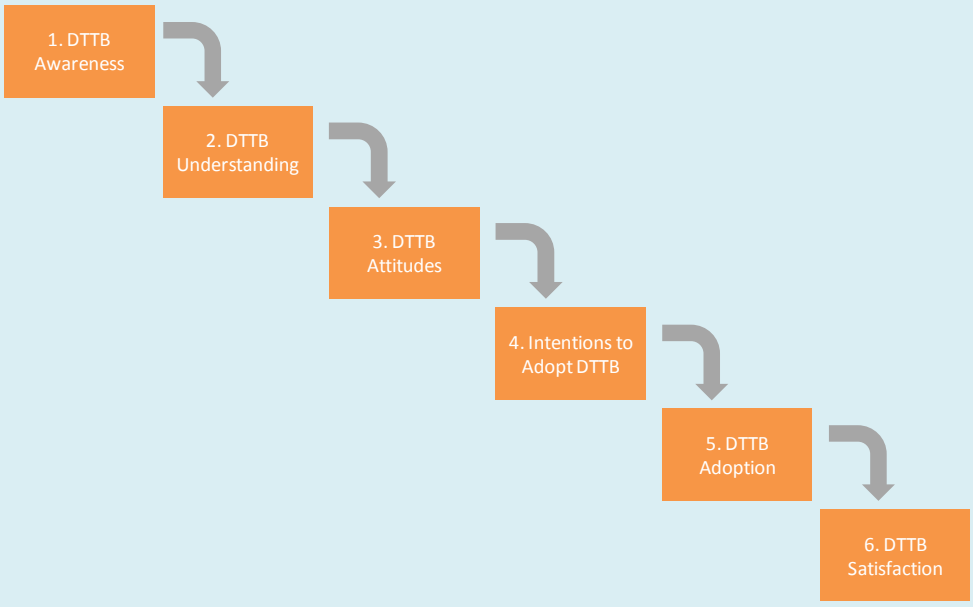
Source: NBTC

On the basis of the above described communications framework the NBTC commenced on the implementation of the DSO communication strategy. The DSO communication phases are described in the next section.

6.2.2 DSO communication phases

The DSO communication phases follow the same basic marketing phases as for any other service or product introduction. In Figure 41 the subsequent communication phases are depicted.

Figure 41: DSO communication phases



Source: ITU, NBTC

Although Figure 41 shows a sequential order of the different phases, in practice the phases overlap. However the different phases cannot be skipped. For example, explaining what people have to do to receive DTTB services whilst people are unaware of DTTB will not be effective. For more details on the consecutive phases please refer to the ITU Guidelines[69].

[69] See footnote 3.

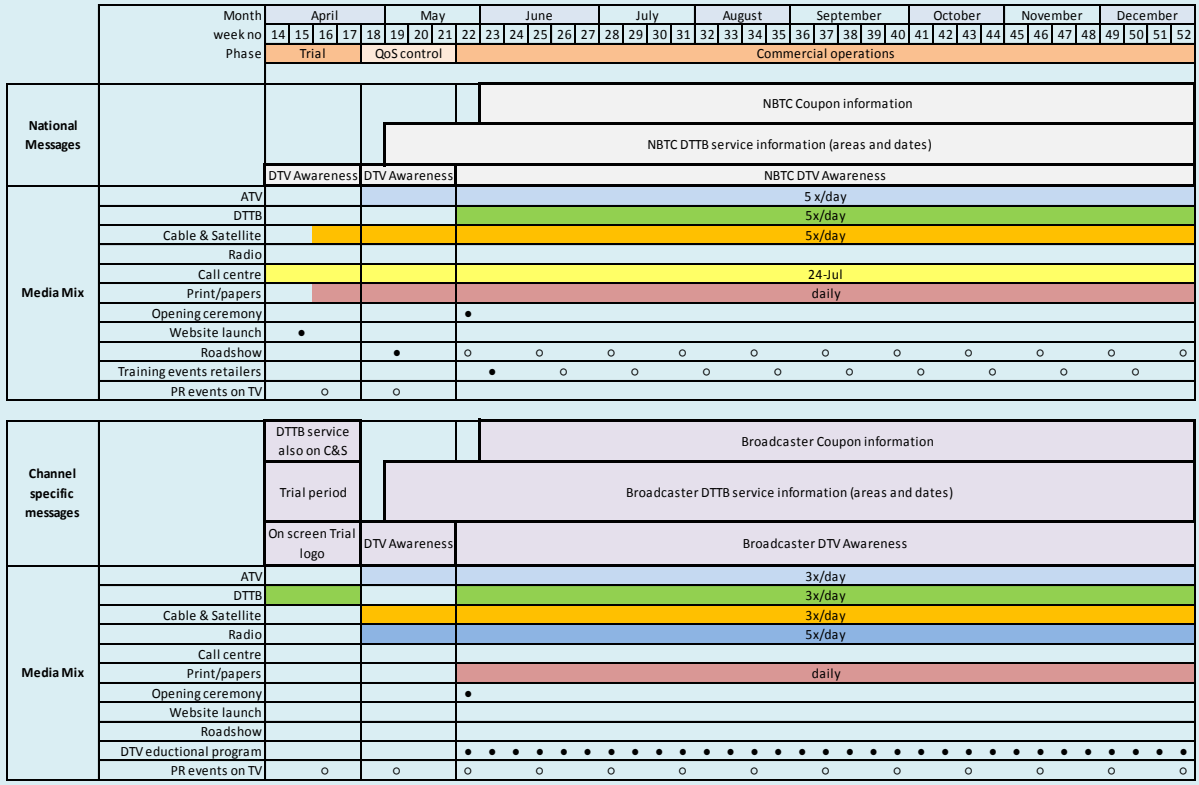
In implementing these communication phases the NBTC decided to divide the communication messages between the incumbent broadcasters and the NBTC itself. Hence the communications plan included two types of messages:

a '**National messages**': content production and (arranging for) distribution by the NBTC;

b '**Channel specific messages**': content production and (arranging for) distribution by licensed broadcasters, under NBTC's editorial approval and supervision.

For the DTTB launch year (2014) the communication plan included details on the message content, scheduling and media mix. An overview is provided in Figure 42.

Figure 42: Communication plan for DTTB launch year



Source: ITU, NBTC

As can be observed from Figure 42 the communications plan includes the call centre operations of both the NBTC as well as the call centres of the licensed broadcasters. Coordination was required between the call centre operations, including:

1 Call centre operations including the minimum opening times and referral to other parties (like retailers, manufacturers, cable/satellite providers and NBTC);

2 Agreement on in-bound and out-bound calling (this could include commercial/sales activities);

3 Escalation procedures in case of emergencies/large call volumes;

4 Information exchange, including call centre reporting (on volumes, call categories, call handling) and information inputs (i.e. network and service deployment schedule, coverage predictions, Notifications, etc.);

5 Minimum call script requirements (impartial and unbiased messages/questions).

For after the launch of the DTTB services in April 2014, a 'tracker board' was developed for following progress on the DTTB migrations process. With carrying out regular DSO surveys vital information can be collected, as discussed in Section 6.2.1. This tracker board was based on the tracker board as applied by Digital UK and adapted for the situation in Thailand. Figure 43 shows and overview of this tracker board for the first three DSO communication phases and a part of the network deployment.

Figure 43: Tracker board for monitoring DSO progress

Example Only

DSO Progress report	[DATE]

Prov_code	Province Name	Other name	Phase 1	Phase 2	Phase 3	Phase 4	Base size	1. DTTB Awareness		2. DTTB Understanding				3. DTTB Attitudes	
								a. DSO intro	b. Logo	a. What to do for DSO	b. 2nd set limitation	c. VCR/DVDR limitation	d. Phase 1 date	a. Overall opinion	b. Personal comfort
	Nation Wide		01/07/14				5575	20%	10%	5%	10%	10%	0%	40%	30%
1	BANGKOK						125	25%	20%	10%	10%	15%	0%	40%	33%
2	KANCHANABURI						125	23%	23%	12%	8%	10%	0%	25%	20%
3	KALASIN						125	9%	20%	10%	10%	15%	0%	40%	33%
4	KAMPHAENG PHET						25	10%	10%	3%	4%	5%	0%	30%	12%
5	KHON KAEN						125	23%	23%	12%	8%	10%	0%	25%	20%
6	CHANTHABURI						25	8%	12%	4%	5%	5%	0%	25%	10%
7	CHACHOENGSAO						125	20%	10%	5%	10%	10%	0%	40%	30%
8	CHON BURI						25	8%	12%	4%	5%	5%	0%	25%	10%
9	CHAI NAT						0								
10	CHAIYAPHUM						125	23%	23%	12%	8%	10%	0%	25%	20%
11	CHUMPHON						125	9%	20%	10%	10%	15%	0%	40%	33%
12	TRANG						25	8%	12%	4%	5%	5%	0%	25%	10%
13	TRAT						25	10%	10%	3%	4%	5%	0%	30%	12%
14	TAK						125	25%	20%	10%	10%	15%	0%	40%	33%
15	NAKHON NAYOK						125	20%	10%	5%	10%	10%	0%	40%	30%

Source: ITU, NBTC

6.2.3 DSO communication tools

As Figure 42 shows the NBTC applies a wide range of communication tools. Here two tools are presented in more detail; the website and smartphone applications for DTTB network coverage and service information. These two tools are showcases of what is possible with modern communication technology nowadays. In early DSO/ASO countries, like in Europe, the widespread availability of broadband Internet and smartphones were not present and means where limited. In Thailand mobile penetration is very high as well as the use of smartphones[70]. This provided opportunities for the NBTC informing the public accurately.

Figure 44 shows the graphical user interface of one of the web pages of NBTC's coverage checker[71]. It shows the common information found on any other typical coverage checker websites[72], including:

[70] For 2013 research revealed smartphone sales units across the country to be more than quadrupled (344%) compared to the year before. Growth is forecasted to continue and by the end of 2014 the smartphone sales volume will reach at least 70%.

[71] This checker was made available for tablets and smartphones using Android or iOs.

[72] See ITU Guidelines on the Transition from Analogue to Digital Broadcasting, January 2014, pp 169-170. Also the following example website could be consulted; http://transition.fcc.gov/mb/engineering/dtvmaps/ or http://www.csa.fr/csatvnumerique/television_couverture

1 A text box to enter the position of the reception location.

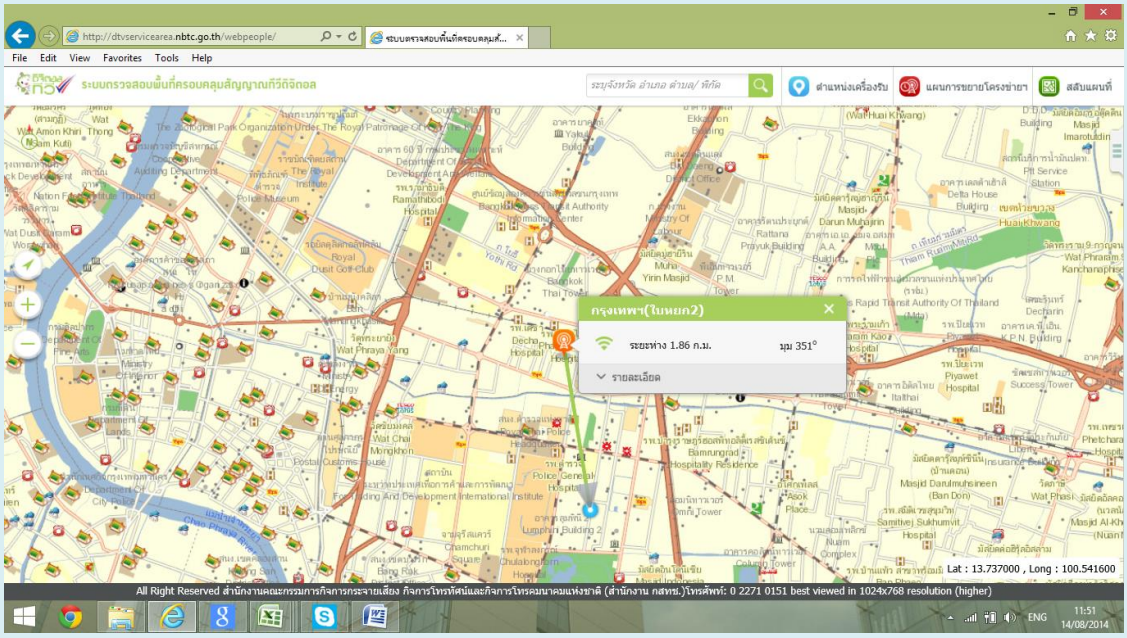
2 The location of the nearest or best transmitter site (indicated on the map with a tower symbol).

3 An indication of the signal strength and quality (indicated with a signal strength symbol, typically found on mobile telephone hand-sets).

4 The number of multiplexes available on this transmitter site (and click through pages to the available services on each multiplex).

5 Indication of the antenna direction angle (azimuth angle) towards the nearest or best transmitter site (indicated on the map with a green line)[73].

Figure 44: Graphical user interface of coverage checker



Source: NBTC, ESRI

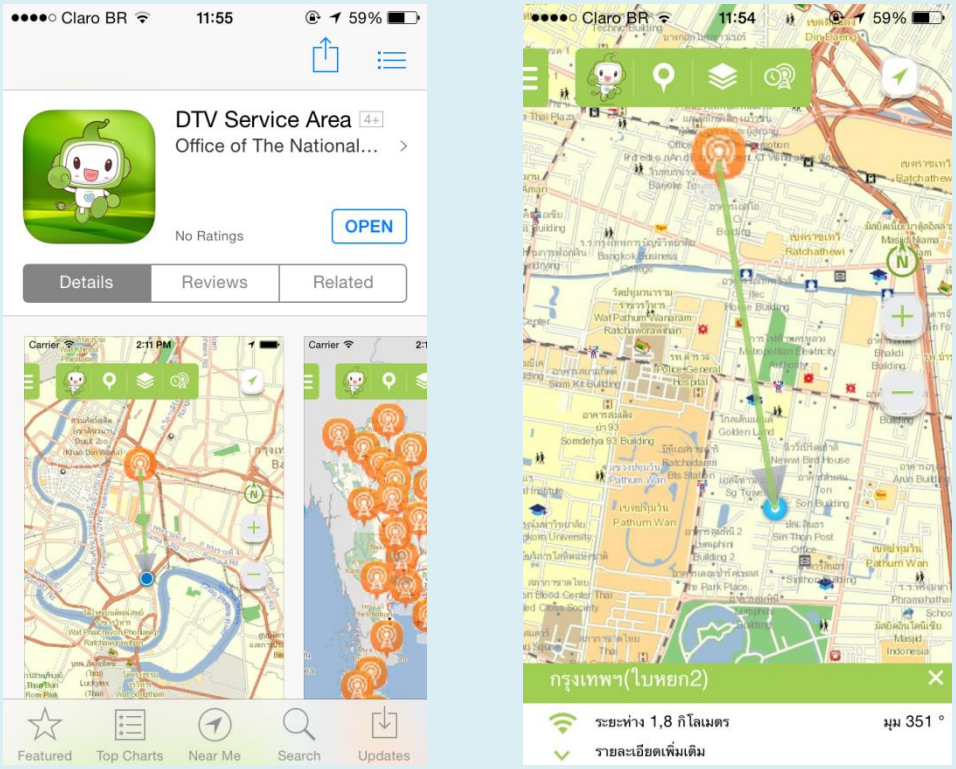
Modern smartphones have GPS, Wi-Fi and compass functionality and these technologies are used to locate the exact position of the smartphone. Location based services, like Google Maps or Uber, use this positioning information. Similarly the coverage checker on the smartphone can be designed as a location based service.

A smartphone at any reception location can automatically use the positioning information to let the coverage checker software[74] know where the reception location is. In addition, using the compass functionality the smartphone can be directed to the best server transmission site. This is particular helpful for people having difficulties in reading maps and figuring out the azimuth angle (for directing their receiving antenna). Figure 45 shows the smartphone user interface for this functionality.

[73] This angle is based on what is called the 'best server' information. A modern frequency planning tool can calculate which transmitter site provides the best signal quality/strength at any given reception location. With the coordinates of this best server transmission site and the reception location the azimuth angle can be calculated.

[74] In turn this web based software pulls the DTTB coverage information from the frequency planning tool. For more details see Chapter 5.

Figure 45: Smartphone user interface



Source: NBTC, ESRI

Another local based application the NBTC developed was entering network measurement data. This is an application for NBTC's network monitoring task and is not intended for the general public. Engineers measuring signal strength and other DVB-T2 system parameters across the network coverage areas can enter this data and automatically the exact position of these measurements can be uploaded to a central database. This application is especially useful for carrying out indoor measurements.

6.3 Insights

On the basis of what was covered in Sections 6.1 and 6.2 the following lessons learned can be provided:

1. In a situation where spectrum cannot be easily revoked or without great costs, the process of planning the DSO and setting ASO dates could result in a (long) negotiation process whereby the various interests have to be balanced. In this process principles of spectrum efficiencies and access to market can be key considerations from national regulatory authority (NRA) perspective. In addition, process skills will be essential, such as leadership and political skills, supported by good technical insights and information (like presented in Section 6.1.2).
2. Simulcast periods longer than 12 months seems to be relatively long as the necessity of offering a roll-back is not really there anymore. Modern DTTB receivers are 'plug and play'. Especially in the situation whereby the NRA will offer receiver coupons simulcast periods can be shortened. As experience abroad has shown the majority of households receiving a coupon will switch-over within a few months.
3. Moreover, it could be argued that a short simulcast period is needed as people will be made aware of digital television. They will be mobilized for switching to DTTB. Satellite and cable providers will grasp this opportunity of 'terrestrial' marketing to sell their digital television proposition.
4. Monitoring DSO progress is critical as it will provide insight, amongst other performance indicators, in the number of households on digital television platforms. This insight will ease the decision to discontinue ATV services (i.e. to set the ASO date in the various areas). This monitoring seems especially relevant in the situation that the DSO and ASO planning is part of a negotiation process.
5. The coverage checker applications, as shown in Section 6.2.3, demonstrate how modern communication technology can help DTTB viewers in finding and installing DTTB services, as well as NRAs carrying out network monitoring tasks.

Annex A: LRIC model

This Annex provides some more details on the applied LRIC model as mentioned in Section 3.1.

The costing methodology for calculating cost of the minimum service should be based on long run incremental cost (LRIC). The LRIC modeling incorporates assumptions of modern efficient technology, current investment cost and efficient service provision. The increment of the minimum service is defined as a DTTB service. LRIC of the minimum service should be reported on a per unit basis measuring change in total cost associated with a specific increase or decrease in output. The below Figure illustrates the formula used for LRIC calculation of Minimum service.

The following paragraphs explain the calculations for each cost element of the LRIC model.

Capital Expenditure and Cost of Capital

Capital expenditures of assets which are directly relevant to the provision of the minimum service should be evaluated according to gross replacement cost (GRC) principle based on current cost accounting (CCA) valuation method. The following methodologies can be applied:

1. Indexation based on historical investment cost and price trend;
2. Absolute valuation;
3. Modern equivalent asset (MEA).

The capital expenditure evaluated in the previous step should be annualized based on tilted annuity calculation taking into account asset life, price trend and cost of capital, as reflected in the formula included in Figure 46.

Figure 46: Tilted Annuity Formula

$$TA = GRC * \left[\frac{(WACC - PT)}{1 - \left[\frac{(1 + PT)}{1 + WACC)} \right]^{N}} \right]$$

Source: Detecon

The following notations apply for the formula as included in Figure 46:

TA = tilted annuity cost

GRC = gross replacement cost

WACC = pre-tax weighted average cost of capital

PT = price trend

N = asset life

The following asset lives and price trends should be applied for each asset category in the tilted annuity cost calculation. These lives and price trends are included in Table 10.

Table 10: Asset Lives and Price Trends

Asset category	Life (in yrs)	Price trend (%)
Multiplexer	10	−5%
Transmitters	10	−5%
Tower	20	2%
Antenna system	20	2%
Combiner	10	−5%
TVRO	10	−5%
Site buildings	20	2%
Tools & Instruments	10	−5%
Monitoring system	10	−5%

Operating Expenditure

The operating expenditure includes annual operating costs which are directly relevant to the provision of the minimum service. Costs that can be included in the calculation are:

Transponder lease;

1 Satellite / Fiber bandwidth lease;

2 Electric power;

3 Operation and maintenance;

4 Site rental;

5 Site security;

6 Direct and indirect staff cost.

Costs which cannot be included in the calculation are:

1 Marketing and sale costs;

2 Other costs incurred from inefficient operation, e.g. bad debt.

Common Cost

The common cost includes annual costs which are relevant to the business operation but cannot be directly or indirectly allocated to Minimum service. Costs that can be included in the calculation are:

1 General and administration;

2 Business and spectrum licence fees;

3 Contribution to NBTC Fund.

The distribution of common costs to Minimum service should be based on equal proportional mark up (EPMU) method.

Annex B: Detailed planning parameters

Table 11 includes the applied planning principles and parameters for panning the 39 DTTB main sites in Thailand.

Table 11: Applied Planning Principles and Parameters

3	DTTB planning principles	Specification
3.1	**Frequency band for DTTB plan**	a. Channels 26-60 b. In border area with Malaysia: – Even numbered channels in accordance with coordination agreement; – Only channels below 49 at request of NTBC to take account of IMT use in Malaysia (see (see also the Note 2 at the end of the Annex); – However, in Scenario B, due to lack of channels, channels above 48 are allowed.
3.2	**International coordination results**	In so far as incorporated in the transmitter data bases specified in 1.2 and 1.3.
3.3	**DVB-T2 system variant**	16k, extended bandwidth, 64QAM, code rate 3/5, PP2, guard interval 266 µs.
3.4	**Planning parameters**	a. Protection ratios and minimum field strength: Rec. ITU-R BT.2033 (including adjacent channel protection ratios); b. FX receiving antenna characteristics: Rec. ITU-R BT.419-3; c. Outdoor reception standard deviation: 5.5 dB; d. Indoor reception: – Building penetration loss 11 dB and standard deviation of 6 dB (according to Rec. ITU-R P.1812).
3.5	**Signal summation**	Log normal method
3.6	**Reception mode**	a. FX reception for planning and coverage presentations of the 39 main sites; b. PI reception for coverage presentations of the 39 main sites.
3.7	**DTTB coverage target**	a. Optimal population coverage of the main sites within the limits of: – given main sites, antenna heights and antenna patterns; – the planning principles specified in 3.1, 3.2, 3.3, 3.4, 3,5, 3.6 and 3.8; b. Similar coverage of all multiplexes per site.
3.8	**Reception criteria**	Good reception if in a pixel of the terrain database: – The reception probability is at least 95% of locations with interference calculated for 1% of time; – The wanted field strength ≥ minimum median field strength.
3.9	**Power limitations**	a. Maximum ERP based on engineering judgement taking into account coverage and site characteristics; b. Directional antenna pattern (different from the pattern specified in 1.3) in case no other solution are available to resolve interference, will be indicated as option.

Annex C: Frequency plan overview

Table 12 shows a summary of the DTTB Plan (Plan 3.0) and includes the necessary channel changes to protect ATV services, as well as the events that trigger these channels changes. It is to illustrate the complexity of applying channel changes within a given network deployment schedule.

Column C shows the maximum ERP in kW and column D the channel group in scenario C.

In the columns headed with the DTTB network operators (columns E to I) the assigned channels are presented as follows:

- Channel numbers printed in red are temporarily channels, separated by a slash from the channel to be used after switch-off of the related analogue TV stations indicated in column K;
- Single channel numbers printed in red are channels originating from a shift with the channel in multiplex 6;
- Bold printed channel numbers indicate that the channel has been assigned to a specific multiplex resulting from:
    - The measures for resolving incompatibilities;
    - The requirement that multiplex 6 contains different services per site and should not operate in SFN.

Column L shows the analogue TV stations where critical interference from DTTB has been accepted resulting from the measures for resolving incompatibilities.

Table 12: DTTB frequency plan for 39 main sites

A	B	C	D	E	F	G	H	I	J	K	L
Site N°	***Site name***	***ERP (kW)***	***Sc C CG***	***NBT***	***RTA1***	***MCOT***	***TPBS***	***RTA2***	***Mux 6***	***ATV stations to be switched off before scenario C channel can be used***	***ATV stations with accepted critical DTTB interference***
1.0	Bangkok_DTT	50	Db	26	36	40	44	32/52	29	Bangkok Ch3 (32) Bangkok TPBS (29)	
2.0	Kanchana Buri_DTT	25	Dc	49	37	41	30	27	33	No constraints	Kanchanaburi Ch7 (48)
3.0	Singburi_DTT	15	Da	35	51	47	39	31/55	28	Singburi Ch11 (31) Singburi TPBS (28)	
4.0	Rayong_DTT	50	De	45	59	53	56	43	48	Pattaya Ch11 (48)	
5.0	Sakaeo_DTT	50	Dd	54	50/42	46	38	57	34	Sakaeo Ch7 (50) Sakaeo TPBS (34)	Pattaya Ch5 (38)
6.0	Trat_DTT	50	Dc	33	37	41	49	30	27	Trat TPBS (27)	
7.0	Prachaub Khiri Khun_DTT	20	Dd	46	50	54	57	38	34	Prachaub Khiri Khun TPBS (34)	Pattaya_TPBS (46) Pattaya Ch7 (50) Pattaya Ch5 (38)
8.0	Nakhon Ratchasima_DTT	50	Dc	41/58	49/52	30	33	37	27	Nakhon Ratchasima Ch3 (41) Chaiyaphum Ch5 (49) Nakhon Ratchasima TPBS (27)	
9.0	Chaiyaphum_DTT	15	Da	31/55	47	39	35	51	28	Chaiyaphum Ch11 (31) Chaiyaphum TPBS (28)	
10.0	Surin_DTT	50	Db	26/42	32	40	36	44	29	Khon Kaen Ch11 (26) Surin TPBS (29)	

A	B	C	D	E	F	G	H	I	J	K	L
Site N°	***Site name***	***ERP (kW)***	***Sc C CG***	***NBT***	***RTA1***	***MCOT***	***TPBS***	***RTA2***	***Mux 6***	***ATV stations to be switched off before scenario C channel can be used***	***ATV stations with accepted critical DTTB interference***
11.0	Sisaket_DTT SFN	20	Dc/f	41	30/52	33/58	27/37	49	37	Ubon Ratchathani Ch5 (30) Ubon Ratchathani Ch11 (33) Ubon Ratchathani TPBS (27)	Roi ET CH5 (49)
12.0	Ubon Ratchathani_DTT SFN	50	Dc	41	30/52	33/58	27/26	49	52	Ubon Ratchathani Ch5 (30) Ubon Ratchathani Ch11 (33) Ubon Ratchathani TPBS (27)	Roi ET Ch5 (49)
13.0	Mukdahan_DTT	20	Da	47	39	35	28	51	31	Roi ET Ch11 (31)	
14.0	Roi ET_DTT	50	Dd	57	50	46	54/60	34/55	38	Mahasarakham Ch7 (54) Chumpuang_TPBS (34) Pratay N Ratchasima Ch11 (38)	Roi ET Ch5 (49)
15.0	Khon Kaen_DTT	50	De	59	45	53/52	56	48	43	Mahasarakham Ch7 (53) Roi ET Ch9 (43)	
16.0	Loie_DTT	20	Dd	46	50/42	57	54	38	34	Loie Ch5 (50) Loie TPBS (34)	
17.0	Udonthani_DTT	50	Da	47	35	31/55	39	51	28	Udonthani Ch9 (31) Udonthani TPBS (28)	
18.0	Buengkan_DTT	10	Db	44	32	36	40	26/52	29	Buengkan Ch11 (26) Buengkan TPBS (29)	

A	B	C	D	E	F	G	H	I	J	K	L
Site N°	***Site name***	***ERP (kW)***	***Sc C CG***	***NBT***	***RTA1***	***MCOT***	***TPBS***	***RTA2***	***Mux 6***	***ATV stations to be switched off before scenario C channel can be used***	***ATV stations with accepted critical DTTB interference***
19.0	Sakhon Nakhon_DTT	50	Dc	30	49	41	33	37/58	27	Sakhon Nakhon Ch11 (37) Sakhon Nakhon TPBS (27)	Roi ET Ch5 (49)
20.0	Chiang Mai_DTT	50	Dd	46/60	50	54	57	38	34	Chiang Mai Ch3 (46) Chiang Mai TPBS (34)	
21.0	Mae Hong Son Doi kong mu_DTT	1	Dc	37	41	49	30	33	27	Mae Hong Son Doi kong mu TPBS (27)	
22.0	Lampang_DTT	50	Db	26	44	32	36	40	29	Lampang TPBS (29)	
23.0	Chiang Rai_DTT	50	Dc	49	30	33	37	41	27	Chiang Rai TPBS (27)	
24.0	Nan_DTT	50	Da	28	31	35	39	51	47	No constraints	
25.0	Phrae_DTT	30	De	45	48	59	56	43	53	No constraints	
26.0	Utaradit_DTT SFN	2	Dc/f	41	30	33	37/52	49	52	Sukhothai Ch3 (37)	
27.0	Sukhothai_DTT SFN	50	Dc	41	30	33	37/52	49	27	Sukhothai Ch3 (37) Sukhothai TPBS (27)	
28.0	Tak_DTT	50	Da	31	35	39	51	47	28	Toen TPBS (28)	Tak_TPBS (34) Toen Ch11 (31)
29.0	Nakhon Sawan_DTT	50	Dd	57	46	50	54	38	34	Nakhon Sawan TPBS (34)	
30.0	Phetchaboon_DTT	10	Db	40	44	29	32	36	26	No constraints	
31.0	Chumphon_DTT	50	Da	51	47	31	35	39	28	Chumphon TPBS (28)	
32.0	Ranong_DTT	15	Dc	49	30	37	41	33	27	Ranong TPBS (27)	
33.0	Surat Thani_DTT	50	Db	26	36	40	44	32	29	Surat Thani TPBS (29)	
34.0	Phuket_DTT	25	Da	35	39	51	47	31	28	No constraints	Thung Song_TPBS (51)

A	B	C	D	E	F	G	H	I	J	K	L
Site N°	***Site name***	***ERP (kW)***	***Sc C CG***	***NBT***	***RTA1***	***MCOT***	***TPBS***	***RTA2***	***Mux 6***	***ATV stations to be switched off before scenario C channel can be used***	***ATV stations with accepted critical DTTB interference***
											Takua Pa_TPBS (28)
35.0	Nakhon Sri Thumarat_DTT	30	Dc	30	33	37	41	49	27	Nakhon Sri Thumarat TPBS (27)	
36.0	Trang_DTT	40	De	43	59	48	53	56	45	Thung Song Ch11 (45)	
37.0	Song Khla_DTT SFN	50	TDa’	50	42	46	38/54	26	34	Song Khla Ch3 (38) Song Khla TPBS (34)	Satun Ch7 (51) Trang Ch7 (50) Trang_TPBS (46)
38.0	Satun_DTT SFN	30	TDa’/f	50/52	42	46/60	38	26	52	Trang Ch7 (50) Trang TPBS (46)	Song Khla Ch3 (38)
39.0	Yala_DTT	30	TDb	32	48	36	44	28	40	No constraints	

Annex D: Receiver specifications

The DTTB receiver specifications for Thailand are included in this Appendix. The receiver specifications are in two parts. The second part includes an amendment. The two parts are titled as follows:

1 Notification of the National Broadcasting and Telecommunications Commission Re: Technical Standard for Digital Terrestrial Television Receiver (No. 1) B.E. 2555 (2012);

2 Notification of the National Broadcasting and Telecommunications Commission Re: Technical Standard for Digital Terrestrial Television Receiver (No. 2) B.E. 2556 (2013).

Part 1

(UNOFFICIAL TRANSLATION)

Notification of the National Broadcasting and Telecommunications Commission

Re: Technical Standard for Digital Terrestrial Television Receiver

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Whereas it is deemed appropriate to set out technical standard for digital terrestrial television receiver in order to ensure that the public are able to use such receiver to view the broadcast digital television programs in an efficient, standardized and quality manner with advanced technology as a way of protecting consumers and contributing to the industry as a whole;

Pursuant to Section 27 (10) and (24) and Section 37 of the Act on Organization to Assign Radio Frequency and to Regulate the Broadcasting and Telecommunications Services B.E. 2553 (2010), which contains certain provisions regarding the restriction of the rights and freedom of an individual as permitted to be done under the law by Article 29, together with Articles 35, 36, 41, 43, 45, 46, 47, 61 and 64 of the Constitution of the Kingdom of Thailand; the National Broadcasting and Telecommunications Commission hereby prescribes the technical standard for digital terrestrial television receiver, as detailed in the Technical Standard No. NBTC BS 4002-2555 appended hereto.

This Notification shall come into force as from the day following the date of its publication in the Government Gazette.

Announced on the 2nd day of November B.E. 2555 (2012)

Colonel

(Natee Sukonrat)

Chairman of the Broadcasting Committee

Officiating for Chairman of the National Broadcasting

and Telecommunications Commission

1. Scope

This Technical Standard specifies the minimum technical specifications for digital terrestrial television receiver, including both receiver with display screen (Integrated Digital Television, iDTV) and receiver without display screen (set-top-box), which are capable of receiving digital television signal in the Second Generation Digital Terrestrial Television Broadcasting System (DVB-T2) in both Standard Definition (SD) format and High Definition (HD) format.

2. General Requirements

2.1 Technical Requirements of Electrical Characteristics and Safety

The receiver shall comply with the electrical characteristics and safety requirements as defined in TIS 1195-2536 [1].

2.2 Technical Requirements of Electromagnetic Compatibility

The receiver shall comply with the electromagnetic compatibility standard as defined in CISPR 13 [2] or TIS 2185-2547 [3].

2.3 Installation and Usage

The receiver shall be supplied with an installation manual and instruction manual, available in both Thai and English languages.

2.4 Remote Control

The receiver shall be supplied with a remote control with tactile marking placed on the number '5' button.

3. Technical Requirements of Connectors and Interfaces

The receiver shall have connectors and interfaces in accordance with the specifications in Table 1.

Table 1: Technical requirements of connectors and interfaces

Type of Connectors	Requirements
RF input connector	Female connector shall be in accordance with IEC 60169-2 [4], with input impedance of 75 ohm. The receiver without display screen (set-top-box) shall support DC power supply of 5V for active antenna, with users being able to set on/off by themselves, and the default shall be set to "off."
RF loop-through	The receiver without display screen shall have the male connector in accordance with IEC 60169-2.
Video and audio connectors	The receiver without display screen (set-top-box) shall have output connectors as follows: 1. RCA-phono socket for stereo audio signal output bundled with cable. 2. RCA-phono socket for composite video signal output bundled with cable. 3. HDMI socket with HDCP for digital signal output bundled with cable.

4. RF Tuner and Decoder Requirements

4.1 Radio Frequency Requirements

Radio frequency requirements of RF tuner in the receiver shall comply with the requirements in Table 2.

Table 2: Properties and requirements of RF tuner in the receiver

Properties	Requirements
Frequency range of receiver	470-862 MHz
Bandwidth	8 MHz
Noise Figure (NF)	Not exceeding 6 dB
Receiver sensitivity	Below -78.3 dB for FFT 32K (extended), 256-QAM, code rate 2/3, SISO and pilot pattern PP7
Channel offset	Able to receive carriers within an offset of up to ±125 kHz from the nominal center frequency.

4.2 DVB-T2 Operating Modes

The operation of DVB-T2 receiving and decoding modes shall comply with ETSI EN 302 755 [5] and shall support the minimum requirements in Table 3.

Table 3: Required DVB-T2 operating modes

Parameter	Minimum Requirements
FFT size	1K, 2K, 4K, 8K (normal), 8K (extended), 16K (normal), 16K (extended), 32K (normal), and 32K (extended)
Modulation	QPSK,16-QAM, 64-QAM, and 256-QAM
Code rate	1/2, 3/5, 2/3, 3/4, 4/5, and 5/6
Guard interval	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, and 1/4
Pilot pattern	PP1 to PP7
Service type	1. Support both Single PLP (Mode A) and Multiple PLP (Mode B) 2. Support Single Frequency Network (SFN) in accordance with ETSI TS 101 191 [6]

5. Technical Requirements of De-multiplexing and Transport Stream

De-multiplexing and decoding for MPEG-2 transport stream of the receiver shall comply with ETSI TS 101 154 [7] and ISO/IEC 13818-1 [8].

6. Technical Requirements of Video and Audio Signals

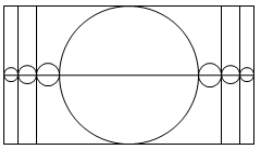
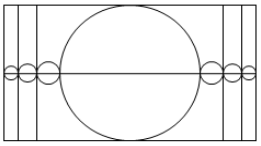
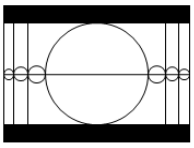
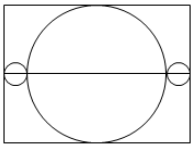
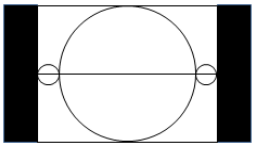
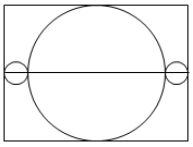
Technical specifications of video and audio signals shall comply with the requirements in Table 4.

Table 4: Video and audio requirements

Characteristics	Required Standards
Video decoder	MPEG-4 AVC/H.264 in accordance with ISO/IEC 14496-10 [9]
Video display	Support High Definition (HD) format with 1920x1080 interlaced (1080i) Frame rate : 25 frames/sec Aspect ratio : 16:9
	Support High Definition (HD) format with 1280x720 progressive (720p) Frame rate : 50 frames/sec Aspect ratio : 16:9
	Support Standard Definition (SD) format with 720x576 interlaced (576i) Frame rate : 25 frames/sec Aspect ratio : 16:9 and 4:3
Audio decoder	Decoding stereo audio signal, MPEG-4 HE AACv2, in accordance with ISO/IEC 14496-3 [10]

The video display shall support display types in accordance with the specification of Active Format Description (AFD) under the ETSI TS 101 154 standard, by supporting at least two types shown in Table 5.

Table 5: Video signal display formats

Input Video Signal				Output Video Display	
Source Video Signal		Broadcast Aspect Ratio	AFD Code		
Source Video Aspect Ratio	Source Image from Input Video Signal			16:9	4:3
16:9		16:9	1000		
4:3		4:3	1001		

7. Technical Requirements of Data Processing and Display

7.1 Processor and Memory

The receiver shall have processor and memory that are equal to or better than the following specifications:

1. DDRAM Memory : minimum 64 MB

2. Flash Memory : minimum 8 MB
3. CPU Processor Speed : minimum 300 MHz

7.2 Character Set

The receiver shall support character set as specified in ETSI EN 300 468[11] in Character Code Table 00 – Latin alphabet with Unicode equivalents and Character Code Table 07 - Latin/Thai alphabet with Unicode equivalents.

7.3 On Screen Display (OSD) Language

The receiver shall support Thai and English menu, with the default being set to Thai or the user being able to select language at the first time of use.

7.4 Subtitling System

The receiver shall support the subtitling system in accordance with ETSI EN 300 743 [12] and shall also be able to decode and display in Display Definition Segment (DDS) under such standard.

7.5 Support of Multi-Language Display

The receiver shall support multi-language audio output and subtitling and allow users to choose the primary language of their own, and shall at least support the languages specified in Table 6.

Table 6: Support languages

Language	ISO 639-3 [13] Code
Thai	THA
English	ENG
Original Audio	QAA

7.6 Service and Channel Number

The receiver shall be able to receive all signals in each service area by scanning through frequency range specified in Clause 4.1.

All services shall have a logical channel number (LCN), and the digital terrestrial television channel with original network ID (ONID) of Thailand shall be arranged as the first priority. The channel plan shall cover from number 1 through number 999 and shall be assigned as follows:

1. Number 1 to 799 shall be reserved for domestic channels which have ONID of 0x22FC.
2. Number 800 to 999 shall be reserved for channels which have other ONID.

If the digital terrestrial television network is updated or changed as follows:

1. addition or deletion of multiplexes,
2. change in frequency of multiplex,
3. addition or deletion of television channels,
4. change in channel number, or
5. any other change that affects the television channel,

The receiver shall be fully updated and correctly display television channels.

7.7 Logical Channel Descriptor

The receiver shall support the Logical Channel Descriptor Version 2, which is the information on channel list in service area, as detailed in Table 7.

Table 7: Structure of local channel descriptor

Structure	Bit	Data Type
Logical_channel_v2_descriptor (){		
descriptor_tag	8	Uimsbf
descriptor_length	8	Uimsbf
for (i=0;i<N;i++){		
channel_list_id	8	Uimsbf
channel_list_name_length	8	Uimsbf
for (i=0;i<N;i++) {		
char	8	Uimsbf
}		
country_code	24	Uimsbf
descriptor_length	8	Uimsbf
for (i=0;i<number_of_services;i++){		
service_id	16	Uimsbf
visible_service_flag	1	Bslbf
reserved_future_use	5	Bslbf
logical_channel_number	10	Uimsbf
}		
}		
}		

Following are parameter descriptions:

Descriptor_tag shall be 0x87 (or 135 in decimal).

Descriptor_length is 8-bit field for specifying the length of descriptor.

Channel_list_id is 8-bit field and is used for specifying a channel list for each service area. Such value shall be unique within the Original Network.

In case more than one list of channels is found when scanning, users shall be able to select their desired list. The receiver shall arrange the channels according to each list.

Channel_list_name_length is 8-bit field and is used for identifying number of bytes that follow this field (name of the channel list) that specifies the number of characters in the name of the channel list. Such name is limited to a maximum of 23 bytes.

Char is 8-bit character. A String of characters is used for describing the name of the channel list. Such information shall be in reference to the character set defined in Character Code Table 00 – Latin alphabet with Unicode equivalent in accordance with ETSI EN 300 468.

Country_code is 24-bit field used for specifying country name in a three-character type in accordance with ISO 3166 [14]. Each character shall be coded into 8 bits in accordance with ISO 8859-1 [15] and shall be inserted respectively in this 24-bit field. This field must be set to "THA."

Service_id is used for specifying service ID on the transport stream.

Visible_service_flag is set to 1 when desiring to display the television channel (visible) and is set to 0 when desiring not to display the television channel (not visible).

Reserved_future_use shall be set to 1. The receiver must ignore this field.

Logic_channel_number is channel number.

7.8 Electronic Program Guide (EPG)

The receiver shall support processing and display of electronic programme guide (EPG) from DVB SI EIT p/f Table and DVB SI EIT Schedule in accordance with ETSI EN 300 468. The display must include at least the following data:

1. Current date (day/month/year) and time
2. Start time of present programme (now/present) and next programme (next/follow)
3. End time of present programme (now/present) and next programme (next/follow)
4. Logical Channel Number (LCN)
5. Event name and/or title of programme
6. Short description
7. Program category

The receiver shall be able to store and display EPG in advance of at least 7 days (24 hours/day).

7.9 Display of Signal Strength and Signal Quality

The receiver shall be able to display the signal strength and signal quality on panel of the receiver or through the display screen.

8. System Software Update (SSU)

The receiver shall support the software update functions as specified in ETSI TS 102 006 [16] and shall at least support simple profile.

9. Conformity of Technical Standard

The receiver shall demonstrate the conformity of technical standard as described in Notification of the National Broadcasting and Telecommunications Commission with respect to conformity assessment of radiocommunication equipment and equipment for broadcasting service. While the said notification has not yet come into force, the Supplier's Declaration of Conformity (SDoC) shall apply, whereby the operator, the producer, the merchandiser or the importer of digital terrestrial television receiver who is responsible for such device shall issue the official confirmation to certify that the receiver complies with the technical standard specified herein.

Glossary

AFD	Active Format Description
AVC	Advanced Video Coding
Bslbf	Bit serial, leftmost bit first
DDS	Display Definition Segment
DVB-T2	Second Generation Digital Terrestrial Television Broadcasting System
EPG	Electronic Program Guide
EIT	Event Information Table
ETSI	European Telecommunication Standards Institute
FFT	Fast Fourier Transform
HDCP	High-Bandwidth Digital Content Protection
HDMI	High-Definition Multimedia Interface
HDTV	High Definition Television
iDTV	Integrated Digital Television
LCN	Logical Channel Number
MPEG	Moving Pictures Expert Group
OSD	On Screen Display
ONID	Original Network ID
PLP	Physical Layer Pipe
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RCA	Radio Corporation of America
RF	Radio Frequency
SD	Standard Definition
SDoC	Supplier's Declaration of Conformity
SDTV	Standard Definition Television
SFN	Single Frequency Network
SI	Service Information
SSU	System Software Update
STB	Set-top-box, which is equivalent to a digital terrestrial receiver
Uimsbf	Unsigned integer most significant bit first

References

[1] TIS 1195-2536: Mains Operated Electronic and Related Apparatus for Household and Similar General Use: Safety Requirements

[2] CISPR 13:2009: Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement

[3] TIS 2185-2547: Sound and television broadcast receivers and associated equipment: Radio disturbance limits

[4] IEC 60169-2: Radio-frequency connectors, Part 2: Coaxial unmatched connector

[5] ETSI EN 302 755 v1.3.1 (2012-04): Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)

[6] ETSI TS 101 191 v1.4.1 (2004-06): Digital Video Broadcasting (DVB); DVB mega-frame for Single Frequency Network (SFN) synchronization

[7] ETSI TS 101 154 v1.10.1 (2011-06): Digital Video Broadcasting (DVB); Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream

[8] ISO/IEC 13818-1:2007: Information technology - Generic coding of moving pictures and associated audio information: Systems

[9] ISO/IEC 14496-10:2012: Information technology - Coding of audio-visual objects - Part 10: Advanced video coding

[10] ISO/IEC 14496-3:2009: Information technology - Coding of audio-visual objects - Part 3: Audio

[11] ETSI EN 300 468 v1.13.1 (2012-08): Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems

[12] ETSI EN 300 743 v1.4.1 (2011-10): Digital Video Broadcasting (DVB); Subtitling systems

[13] ISO 639-3: Codes for the representation of names of languages - Part 3: Alpha-3 code for comprehensive coverage of languages

[14] ISO 3166: Codes for the representation of names of countries and their subdivisions

[15] ISO 8859-1: Information technology - 8-bit single-byte coded graphic character sets - Part 1: Latin alphabet No. 1

[16] ETSI TS 102 006 v1.3.2 (2008-07): Digital Video Broadcasting (DVB); Specification for System Software Update in DVB Systems

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Part 2

(UNOFFICIAL TRANSLATION)

Notification of the National Broadcasting and Telecommunications Commission

Re: Technical Standard for Digital Terrestrial Television Receiver

(No. 2) B.E. 2556 (2013)

It deems expedient to adjust the Notification of the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver in order to be appropriate, effective and maximum benefit to the public and to promote the business on the digital terrestrial television.

By virtue of Section 27 Paragraph One (10) and (24), Section 37 of the Act on Organization to Assign Radio Frequency and to Regulate the Broadcasting and Telecommunications Services B.E. 2553 (2010) consisting of some provisions with limitation of exercise of rights and freedom of individual, whereas Section 29 supplementing with Section 35, Section 36, Section 41, Section 43, Section 45, Section 46 Section 47, Section 61 and Section 64 of Constitution of the Kingdom of Thailand allow to do such manners under the enactment of legislation. The National Broadcasting and Telecommunications Commission hereby deems expedient to prescribe the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 additionally as follows:

Section 1: This Notification shall come into force after its date of publication in the Government Gazette.

Section 2: Paragraph 2.1 of the Section 2 related to General Requirements in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following paragraph:

"2.1 **General Requirement on the Nature of Electric and Safety**

The digital terrestrial television receiver shall be qualified in relation to the nature of electric and safety according to the Thailand Industrial Standard (Mor.Or.Gor.) 1195 [1] or a current version."

Section 3: Paragraph 2.2 of the Section 2 related to General Requirements in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following paragraph:

"2.2 **General Requirement on the Electromagnetic Compatibility**

The general requirement on the electromagnetic compatibility for the digital terrestrial television receiver shall be in accordance with either standard as follows;

1. CISPR 13 [2] or the current version
2. Thailand Industrial Standard (Mor.Or.Gor.) 2185 [3] or a current version
3. EN 55013 [3.1] or a current version."

Section 4: Paragraph 2.4 of the Section 2 related to General Requirements in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following paragraph:

"2.4 Remote Control

The digital terrestrial television receiver shall come together with a remote control. It shall have tactile marking over the button No. 5 and the button for audio description. The audio description button may be made in general like the "Audio" button or specifically like the "AD" button.

Section 5: Paragraph 2.5 of the Section 2 related to General Requirements in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be added as follow:

"2.5 General Requirement on Electric Capacity

The digital terrestrial television receiver both the Set-Top-Box and the Integrated Digital Television (iDTV) shall have electric capacity not exceeding 1 watt in the following modes:

1. OFF Mode means the mode that electric device is connecting with the main power supply and not ready to change in any other modes such as Standby Mode, Network Mode or Active Mode including Normal Mode.
2. Standby Mode means the mode that electric device is connecting with the main power supply and functioning:

    2.1 to change to other modes by way of using the internal or time setting; or

    2.2 constantly in:

        2.2.1 displaying the mode and time on the screen

        2.2.2 activating the sensor

To check the electric capacity, it shall be pursuant to IEC 62301 [17].

In addition, Network Mode means the mode that the electric device is connecting with the main power supply as well as the Internet but it has yet communicated or transferred the information through the Internet.

Active Mode means the mode that the electric device is connecting with the main power supply and activating at least one function (please note that the "on", "in-use" or "normal operation" have similar meaning with this mode).

Section 6: The Table 1 of Section 3 related to the General Requirements on Connectors and Interfaces in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following table:

Table 1: The Requirements on Connectors and Interfaces

Type of connector	Requirement
RF Input Connector	Female connector shall be in line with the IEC 60169-2 [4] while the input impedance is equal to 75 ohm. In addition, the Set-Top-Box shall supply the direct current in the amount of 5 volt to the active antenna. The user shall be able to turn on/off the current by himself while the starting mode shall be OFF.
RF Loop-through	The Set-Top-Box shall have the male connector according to the IEC 60169-2.
Vision and audio connector and interface	The Set-Top-Box shall have output interfaces as follows; 1. The RCA-phono socket for the stereo audio that comes with cable or other connectors and the cable that enable to convert to the RCA-phono socket; 2. The RCA-phono socket for the composite that comes with cable or other connectors and the cable that enable to convert to the RCA-phono socket; 3. To support the HDMI connection that enables to protect the duplication in the event of digital output and comes with cable.

Section 7: Paragraph 4.2 of the Section 4 related to the RF Tuner and Decider Requirements in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following paragraph:

"4.2 **DVB-T2 Operating Modes**

The method of RF tuner and decoder for the DVB-T2 system shall be in line with the ETSI EN 302 755 v.1.2.1 [5] or a current version of the ETSI EN 302 755. However, it shall support to function according to the Table 3."

Section 8: Paragraph 7.5 of the Section 7 related to General Requirements on Information Evaluation and Display in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be added as follow:

"Moreover, the digital terrestrial television receiver shall support the audio description in a manner of Broadcast Mix according to ETSI TS 101 154 [7]. In this regard, the user shall be able to turn on/off the audio description by pressing the "Audio" button in general or "AD" button specifically on a remote control."

Section 9: Paragraph 7.7 of the Section 7 related to General Requirements on Information Evaluation and Display in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following paragraph:

"**7.7 Logical Channel Descriptor**

The digital terrestrial television receiver shall support to function according to the Logical Channel Descriptor version 2 while the Private Data Specifier ID (PDS ID) is equal to 0x0000 22FC. In addition, such Logical Channel Descriptor version 2 is information related to channel arrangement in the service area as detailed in the Table 7."

Section 10: Paragraph [3.1] in between [3] and Section [4] of the reference in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be added as follow:

"[3.1] EN 55013:2001 Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement"

Section 11: Paragraph [5] of the reference in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following reference:

"[5] ETSI EN 302 755 v1.2.1 (2011-02): Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)"

Section 12: Paragraph [17] of the reference in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be added as follow:

"[17] IEC 62301 Edition 2.0 2011-01: Household electrical appliances – Measurement of standby power"

Announced on the Date of 9 May 2013

Colonel Natee Sukolrath

Chair of the Radio and Television Broadcasting Businesses Commission, Acting on Behalf of Chair of the National Broadcasting and Telecommunications Commission

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