Digital Broadcasting Migration Bhutan

A Report for Ministry of Information and Communications Bhutan

ITU Asia-Pacific

Prepared By
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25 January 2010

"The views in this report are those of the expert and do now necessarily represent the views of ITU and its membership."

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List of Acronyms and Abbreviations

ACMA	Australian Communications and Media Authority
AC3	Dolby AC3 Surround Sound System
ATSC	American Televisions Systems Committee
BBS	Bhutan Broadcasting Service, The National Radio & TV Station of Bhutan
BICM Act	Bhutan Broadcasting Information Communications and Media Act
BICMA	Bhutan Broadcast InfoComm and Media Authority
DMB	Digital Multimedia Broadcasting
DTH	Direct to Home Satellite Television Delivery
DVB	Digital Video Broadcasting
DVB S2	Digital Video Broadcasting Satellite Standard 2nd Generation
DVB-S	Digital Video Broadcasting Satellite Standard
DVB-T	Digital Video Broadcasting Terrestrial Standard
DVB-T2	Digital Video Broadcasting Terrestrial Standard 2nd Generation
Dzongkhag	Administrative or Provincial District in Bhutan
ERP	Effective Radiated Power
FTA	Free to Air
Gewog	Administrative sub-district of a Dzongkhag in Bhutan
HDTV	High Definition Television
IEC	International Electrotechnical Committee
IP	Internet Protocol
IPTV	Television carried over Internet Protocol
ITU	International Telecommunications Union
MHP	Multi-Media Home Platform
MOIC	Ministry of Information and Communications
MPEG2	Motion Pictures Expert Group Video Compression Standard 2
MPEG4	Motion Pictures Expert Group Video Compression Standard 4
TVRO	Television Receive Only Satellite Earth Station
UHF	Ultra High Frequency
VHF	Very High Frequency

Acknowledgement

The assistance of members of the MOIC, BBS, and members of the Digital Television Working Committee, plus that of officers of the ITU-D Regional Office Bangkok in the preparation of this report is acknowledged.

1 Executive Summary

1.1 Background

The Ministry of Information and Communication (MOIC) sought assistance of ITU to develop a comprehensive digital migration broadcasting plan for Bhutan and was seeking assistance of an expert to assist in the development of terms of reference for the working committee and assistance to guide the committee. In response, the ITU engaged broadcasting consultant Mr Colin Knowles to undertake a review of the existing Bhutan broadcasting system and to conduct a feasibility study into a future project for developing a roadmap in Bhutan for transition to digital terrestrial broadcasting. MOIC has already nominated the members for its digital migration working committee but they have not yet convened.

This study was to have commenced with the consultant visiting to Bhutan to gather information and to conduct a workshop on digital migration. For various reasons this could not occur and the report has been prepared working remotely but in close consultation with ITU and designated group of experts by MOIC Bhutan. As a consequence, the main information sources used in development of the report have been published documentation from Bhutan, and helpful input through teleconference and email exchanges from various team members in Bhutan. Given the limitations so imposed, this Report has not been able to fully engage with the stakeholders and reflect all of their concerns and views, nor has it been able to make any realistic assessment of the capacity of the Bhutan specialists to carry out the detailed migration planning. For that reason the Report has focused on providing general and specific information about migration and additional reference material that may assist the Bhutan working committee to move forward.

In commenting on the first draft of the consultant's report, the Bhutan Working Committee expressed the view that :

> *"the members of the working committee felt that they are technically and professionally ill-equipped to assume the TOR [Terms of Reference set out in Annex D]*[1]

Should the originally planned in-country visit become possible in 2010 then the consultant will be able to make more specific recommendations on the assistance the Bhutan Working Committee may require.

In the initial teleconference between the consultant, ITU and Team Members from Bhutan, the Bhutan representatives stated:

> *"Digital is an emerging concept, we are unaware of the technology and how it will benefit the Bhutan, we are looking for a migration framework that will assist us to understand how when and why Bhutan should convert to digital television transmission."*

The team advised that there had been discussion in Bhutan about including Digital Radio and IPTV in the digital migration strategy, but the immediate concern was TV migration, and asked that the current study focus on digital terrestrial television only.

The world is progressively moving to full digital conversion, driven by the significant performance and cost benefits derived from digital technologies. This progressive digitization of the analogue world has been steadily progressing for the past 30 years, and has been given considerable impetus by the wide availability of low cost digital computing technologies. In response to this trend, and to the increasing pressure to provide access to spectrum for new applications, particularly mobile applications,

A short introduction to Digital Television is contained in ITU Report ITU-R BT.2140-1 (05/2009) "*Transition from Analogue to Digital Terrestrial Broadcasting*" an extract of which is Annex A to this Report. In the Report the ITU commented:

> *"While market forces and consumer demand will eventually drive the digitalization of broadcasting it is important to remember that the change has been facilitated by technical development. In broadcasting, as in many other industries, changes are brought about as much, if not more, through the emergence and exploitation of new technologies than by a perceived business demand"*[2]

Bhutan was amongst the last countries in the world to establish analogue television. It has a small, widely scattered population, who, outside of the capital, mostly live in small isolated population centres along the river valleys between substantial mountains. The National Public Broadcaster, Bhutan Broadcasting Service (BBS), currently broadcasts 10 hours of news and programmes during weekdays and 13 hours during weekends. The programmes are mostly distributed to transmitters by satellite. Prior to the recent extension of the transmitter network, Local Cable Operators (LCO) in the Dzongkhag (District) headquarters and other urban areas down-linked the BBS-TV signal from Satellite and redistributed it through their cable networks.

At present, because of the incomplete coverage of the terrestrial TV network and the un-affordability of C-Band satellite reception equipment, for the local people, rural areas are often unable to receive TV signals. BBS radio still plays a vital role in fulfilling information and entertainment needs of the rural populace. Considering the power of visual media, BBS has plans to extend terrestrially TV signals to all more rural areas by end of January 2010 by installing at least one TV transmitter in each of the 20 Dzongkhags. BBS has no direct Bhutanese commercial television competitor. There is some DTH reception from foreign satellites; although this is prohibited, it is difficult to police.

1.2 General Observations

Television plays a vital role in education, information dissemination, cultural development, national identity, and the free flow of information to enhance open government. Unlike analogue television, which is able to carry a single television programme per transmitter, digital terrestrial television can typically carry up to five standard definition programmes on a single transmitter depending on quality and the specific technology and other factors. Alternatively, it can carry a mix of high definition and standard definition services in a flexible configuration. The digital terrestrial television system also allows additional information to be carried with the programmes in the form of data services but this capability has not yet been fully exploited by receiver manufacturers or broadcasters.

In countries with well-developed television systems, the introduction of digital television has taken a number of years because it requires new television reception equipment to be acquired by all viewers and full duplication of the existing transmission and distribution infrastructure. In the early years of digital television conversion, in the late 1990s, there were few manufacturers producing equipment, expensive set-top boxes were the dominant means of acquiring the digital signals and displaying it on existing television receivers. Now that many millions of boxes have been produced, and the technology has been substantially integrated into new receivers. Prices have fallen to quite low values and digital reception capability has now become standard in all new receivers in the markets where digital television is in established. The price of consumer set-top boxes has fallen to below USD50.

Digital television migration conversion effectively touches every element of the broadcasting value chain from content production through transmission and reception, all of which require technical upgrading to support digital broadcasts.[3] The challenge is to replace or upgrade the installed base of analogue receivers in the hands of television viewers. Even though television penetration in Bhutan remains limited this will be a serious concern and an important cost to the community who may only just have invested in new analogue receivers in response to the current extension of services.

For a country like Bhutan, where analogue television is still being developed, and where costs are a major consideration for both broadcasters and the receiving public, close consideration needs to be given to the timing and benefits of digital technology. Digital technology can deliver considerable savings in infrastructure costs; particularly for the provision of additional services. It can pave the way for additional national television services as well as commercial services which could share transmission infrastructure. If digital television can be implemented when services are initially rolled out, then analogue to digital conversion could be avoided.

Digital television has significant potential to enhance the implementation of the Bhutan ICT plan and the broadcasting policy; through the establishment of multi-channel infrastructure which should be able to reduce the overall cost of additional services.

The objective of this report is to establish an information base upon which the Digital Migration Working Committee of MOIC can commence its deliberations on a migration strategy for Bhutan. There are many factors to consider so that the strategy reflects national needs. The experience of others can serve as guidance and a comprehensive summary of many aspects of digital broadcast technology, planning and various national implementations can be found in *ITU report ITU–R BT. 2140-1 Transition from Analogue to Digital Terrestrial Broadcasting"* published in May 2009

1.3 Recommendations

The regulatory and legislative framework for broadcasting and information technology in Bhutan provides an excellent foundation for the introduction of digital television. By considering migration after digital technology is well established both at the professional and consumer level, Bhutan can take advantage of the lower costs and mature technologies that are now available for digital television.

Given the relatively new infrastructure for analogue television and its ongoing development, digital conversion costs could be minimized by considering planning for digital television to

use adjacent channels to the existing VHF analogue services which would open the way for future conversion of the existing transmitters.

Given the difficulties both economic and technical of providing comprehensive coverage of Bhutan, the initial implementation of digital television should be based on a multi-service per transmitter model with the multiplexer potentially shared between BBS and future commercial services. At the same time, future planning should provide for additional channel capacity, to be included to permit perhaps a single service licensee per transmitter model post analogue switch-off which will then provide scope for further service expansion, including HDTV, by reuse of the recently established analogue transmitters.

In order to develop a comprehensive plan for digital television migration in Bhutan, the Digital Television Migration Working Committee will need to determine the appropriate answers in Bhutan to a number of fundamental strategic and policy questions which are set out in Section 3.1of this report. Items that should be included in the Terms of Reference for the Working Committee are set out in Annex D to this Report.

2 The Current Broadcasting System in Bhutan

The preamble to the Bhutan Information Communications and Media Act 2006 (The BICM Act) clearly sets out the media objectives for Bhutan. It seeks to:

> *"provide for a modern technology-neutral and service sector-neutral regulatory mechanism which implements convergence of information, computing, media, communications technologies and facilitates for the provision of a whole range of new services; to implement new information and communications technology (ICT) and media policy, particularly to emphasize the Government's priority to information, communications and media industry, as an industry in itself and an important enabler for other areas of human activity, thus promoting universal service to all Bhutanese, especially in the remote and rural areas of the country; to facilitate privatization and competition in the establishment of ICT and media facilities and services; to encourage and facilitate investment in ICT and media industry….to facilitate fair competition among all players, both in the public and private sectors; and to ensure effective use of national ICT and media infrastructure and resources; and to encourage and facilitate an increased use of ICT for new e-services …"*[4]

The Act provides for separation of content and carriage in the regulatory model and it provides a technology neutral platform for the development of all ICT services including broadcasting and endeavours to ensure regulatory transparency across all ICT services to facilitate convergence of services. The Act sets out broad responsibilities and clear policy objectives, and empowers MOIC and the Broadcast and Infcomm and Media Authority (BICMA) to give effect to the objectives through regulations. Thus from a preliminary assessment, the necessary regulatory framework for digital migration in Bhutan might be accomplished by regulation alone.

The MOIC "Bhutan Media Impact Study 2008", while now dated, provides considerable detail about the development of all forms of media in Bhutan. In relation to television it stated:

> *"Access to TV has improved tremendously and has now penetrated rural areas with the Government establishing power connections to 15,000 rural households in the final years of the Ninth Five-Year Development Plan (2005-2007) in a country of about 125,000 households. In February 2006, BBS TV launched satellite TV that has enabled its broadcasts to be beamed directly to more than 44 towns out of 61 towns in Bhutan, and beyond the national boundaries….. This is a major advancement from 2003 when BBS TV broadcasts were sent by VHS tapes even to areas outside Thimphu, Paro and Phuentsholing, and replayed by local cable operators.*
>
> *In 2008, with support from the Japanese government, the Government installed 172 TV sets in gups' offices in all the geogs without cable TV*

services. The first 70 sets were installed just before the elections in February 2008, and the remaining were installed by November 2008….

Cable operators outside Thimphu provide a variety of channels ranging from 20 – 30 channels. This disparity exists despite the flat fee of Nu.300/- for each cable connection set by regulation. Cable service providers in smaller towns like Damphu, for e.g., do not always provide the full range of 30 channels. ……

Residents in rural areas without cable TV services have in recent years installed Direct-to-Home TV (DTH) through service providers in India although the service was not approved by the Government. These services provide up to more than 190 channels, largely Indian channels. BBS TV programmes, which is what the majority of people want, are not available on DTH services. Estimates from the Cable Operators' Association of Bhutan show that there are more than 2,000 DTH users in the country although the figures are not verified (figures from the supplier in India). DTH TV services are also used in some homes in urban towns."[5]

This year, BBS purchased 20 analogue TV transmitters to install in each of the 20 Dzongkhags. BBS has already installed the 10 of the transmitters and remaining 10 will be installed by the end of January 2010. The analogue television network uses the PAL-B standard with 7 MHz channel spacing. The services are broadcast through low-power VHF transmitters in Band III (170-230MHz), with a radiated power output of 150W. All the analogue transmitters are from the same manufacturer (DB Electronica, in Italy) with identical specifications and output power but with different frequency channels such as Channels 5, 6, 7, 9, 11 to avoid interference between the two transmitting stations. The transmitters comprise a KB series Band III linear amplifier (Model KBV-150 VHF TV) proceeded by an analogue modulator. The transmitters are upgradable to digital by replacement of the modulator with a digital modulator manufactured by the same manufacturer.

Terrain obstructions as well as small scattered population centres are significant factors restricting coverage options in Bhutan. BBS is currently responsible for the construction**,** operation and maintenance of its transmitters.

Distribution of the BBS television programme is achieved via a C Band satellite INSAT4A. The service is up-linked to the satellite by BBS, and BBS pays the spectrum fee for the uplink. BBS provides five hours of normal programming and five hours of relayed programming making 10 hours of transmission during weekdays and during the week-ends, an additional three hours of entertainment programmes are broadcast.[6]

The UHF television band is generally unused; apart from a few transmitters using Channel 21. This band is considered by Bhutan planners to be a candidate band for digital terrestrial television.[7]

2.1 Policy and Regulatory Aspects

The Bhutan Government sees ICT as central to the country's development, to enhance the provision of information and services to its citizens, and as a tool of poverty reduction and

sustainable development. The BICM Act defines ICT to include broadcasting services. The 2008-2013 ICT Plan[8] highlights the need to:

a. assist in the development of education, health, and participatory decision-making processes

b. provide ubiquitous, equitable and affordable access to information for educational scientific economic social political and cultural activities;

c. promote cultural and linguistic diversity; and

d. achieve a proper balance between public and private investment.

In a "Draft Broadcasting Policy" on the MOIC web site, states that the policy is *"committed to uphold the principle of independent broadcasting in the dual system of public and private broadcasters"*[9]. The consultant was advised that this policy is currently "on hold"; however, it does affirm the commitment in the Act that points to the eventual introduction of competitive commercial television services. The timing of such expansion of services would be an important consideration, but the introduction of new services during a migration to digital is an important strategic decision that must be considered as an integral part of the digital migration strategy.

Because several digital television programmes can be transmitted through a single digital transmitter chain, shared capacity could deliver significant savings in infrastructure costs for additional services while extension of services is the highest priority.

3 Digital Television Migration

3.1 Strategic Policy Considerations

A digital migration strategy needs to commence with consideration of some fundamental policy matters including:

a. Why consider migration to digital?

b. What are the national and public policy objectives to be advanced through digital migration? What are the major enabling factors (eg content, new types of services, specialist channels such as education and information services...)?

c. To what extent should IPTV and Internet services (which may be used to rebroadcast or allow replay of broadcast programmes) be considered in the framework?

d. What expected future changes in needs or services should be considered in formulation of the strategy so that they can be enabled easily at the appropriate time?

e. What form of digital television is needed to deliver these objectives (eg. multi-channel, HDTV, mobile television, associated data services....)? How will this change over time? Should provision be made in the migration framework to enable such evolution in the future?

f. What is a realistic timeframe for migration given economic capacity of Bhutan, the need to ensure most people can receive services intended for them, the cost of professional and consumer equipment, the resources including technical capacity to implement the migration and to create or acquire any new content needed to assist in the process?

g. Should future extension of services to those places without any television be implemented a digital only services? At what point would this be a sensible strategy (assuming 100% coverage in analogue is not achieved by the time migration commences)?

h. To what extent should broadcasters have freedom to use the data stream (eg can they use the allocated data stream for additional services? Will they be required to hold separate licences for each service? What types of licence would be appropriate?

i. Will new services be considered in the strategy (television, data, and other types of services?

j. How would any new broadcasters be accommodated (eg digital only new services, new services commencing on analogue and migrating to digital...)?

k. What technical standards should be adopted that will best serve the needs of Bhutan, be cost effective and sustainable?

l. What is the preferred video display standard? Should this be mandated or can it be left to the broadcasters to decide what best meets their needs?

m. What particular factors should be considered in reaching a decision on the technical standard?

n. How will consumer migration to digital be accomplished (simulcast, subsidy, new programmes...)?

o. What would be considered an appropriate penetration of receivers to consider migration sufficiently advanced to turn off analogue? (eg x% of the current analogue television penetration? One per household? One per village? Multiple receivers per household?).

p. Will assistance be provided to consumers? What form should that take? At what point would it be announced/decided?

q. Will any assistance be provided to broadcasters and will current assistance through exemption from duties on equipment and software be continued to assist broadcasters achieve the roll-out of digital services in a timely manner?

r. Will any new entrants receive the same assistance as may be contemplated for existing broadcasters (eg BBS)? Would this depend on whether they have to migrate from analogue or commence directly on digital? Would any subsidy apply if they are sharing a common multiplexer and infrastructure?

s. What is the most appropriate spectrum to use for Digital to minimize cost, maximize service delivery etc against potential competing needs for spectrum by other services including other ICT services such as mobile telephone?.

t. What factors will determine the end of analogue transmissions and the end of any simulcast period?

u. What is to happen to the spectrum vacated by analogue transmissions?

v. What other ICT and other services need to be considered in the spectrum and planning decisions? (eg Mobile TV using say DVB-H technology)

w. What role should satellite play in achieving universal coverage of Bhutan and what is the optimal way to achieve this from a technical, cost and user perspective?

x. Assignment of Logical Channel Numbers for Bhutan digital services

Developing answers to these questions should be amongst the first tasks of the Working Committee. Once they are answered much of the remaining work can be delegated to specialist to prepare plans and options.

Some assistance with these questions is provided in the following sections of this Report.

3.1.1 Why Migrate?

Digital technologies are invading almost every aspect of modern life. Higher levels of capability have been achieved at lower cost than would ever have been achieved with analogue technologies. Most of these benefits derive from the advances in mass produced computing technology that has allowed ubiquitous processing systems, driven by specialist software, to provide diverse capabilities like: the mobile telephone, GPS navigation, the Internet, cheap broadcast quality television cameras, video editing systems, and improved perceived quality of services.

The arguments for conversion are different for each stakeholder

a. **For Regulators**, digital technologies allow more services to be accommodated within existing radiofrequency channels. With growing demand for spectrum, particularly in attractive spectrum such as that used for television, the prospect accommodating this demand as well as the associated new sources of revenue from the sale of spectrum and licences may be a primary driver.

b. **For Commercial Broadcasters**, the cost of re-equipping is unlikely to be offset by increased revenue, at least until the audience can be convinced to invest in new receivers or set-top boxes and they may be reluctant to switch. [10]

c. **Public Broadcasters** face additional costs of re-equipment, additional operating costs through the transition period, but they may be able to better address their mandate through the capacity to provide new types of services. However, they must compete for scarce public funds and as a consequence they may face pressures on existing budgets during the transition period. Digital conversion may also open the way for greater competition for audience which will put further pressures on the public broadcaster. Nevertheless, governments in most countries that have engaged in migration have assisted the public broadcaster with capital and programming costs, to be a catalyst for successful migration.

d. **Audiences** are not likely to generate any pressure to have digital services introduced for their own sake. Audience take up is driven much more by the potential benefits (some of which may not be apparent to them until the services commence). Take for example the Internet. If we were to try to convince a consumer that had never seen computing, let alone the internet, to go on-line in 1980 before the world-wide-web came into existence we would face the same problem. Fortunately, many consumers are now much better acquainted with the potential benefits of ICT services and digital migration across the world since the early 1990s has identified what strategies are most likely to encourage consumer take up. Improved quality, wide screen, HDTV, multi-channel sound, and additional services have all been advocated as drivers in most developed countries. Some of these have little value for people who are yet to receive their first television services, and where costs of receivers are a major factor. Access to television and a choice of content are likely to be the primary drivers. The Bhutan Media Impact Study 2008[11] confirmed that Bhutanese viewers have similar aims. Users look for more choices (sport and children's programmes) while others (largely in remote areas) subscribe to DTH because families want TV. "*For many Bhutanese, TV is a sign of modern living that most homes aspire for*". If digital migration can address both the basic need for television as well as providing additional choice, then perhaps digital migration can have a significant place in several facets of improving quality of life in Bhutan.

Irrespective of the drivers, digital migration of broadcast technology is being irreversibly driven by equipment supply to the point where the question is not if, but when, digital migration will become an inevitable necessity.

The UK has defined its reasons for migration as follows[12]:

What are the benefits of switching to digital television?

a. ***Switchover is fairer.*** *The Government believes that people should have a choice of options for getting digital television. Switchover*

brings digital terrestrial TV to nearly all households for the first time increasing the choice of affordable digital TV options. Only by switching off analogue signals will digital terrestrial TV be able to reach the same proportion of households (98.5%) as can currently receive analogue signals.

b. ***Switchover will upgrade the transmission network.*** *Switchover will upgrade the transmission network to the best available technology and ends the costs of broadcasting the same content on analogue and digital.*

c. ***Digital TV is more efficient****. Digital TV can carry many more TV services in the spectrum previously occupied by one analogue service. Switching off the analogue services also frees up spectrum that can be used for a range of new services, such as extra TV channels in either standard or high definition, mobile TV and wireless broadband.*

d. ***Switchover will ensure the UK keeps pace internationally.*** *Switching the terrestrial TV system to digital will ensure the UK keeps pace with other countries. Most European states will have completed switchover by 2012*

3.2 Licensing/Authorization Schemes

In countries burdened by historical legislation that is tied to past technologies, digital conversion has required either substantial changes to legislation, or a complete update of the law. Bhutan's modern BICM Act provides an excellent foundation for establishing digital migration. The Act is technology neutral, it separates content and carriage, and provides for infrastructure access and sharing A preliminary review of the Act seems to indicate that most of the requirements for digital migration could be addressed by regulations made under the Act.

Licensing and Regulation concerns touch on several parts of the digital television chain:

a. Spectrum access;

b. Licensing the operation of transmitters and service areas;

c. Satellite up-link licensing;

d. Possibly TVRO licensing if this is required for interference protection or other regulatory purposes;

e. Ensuring equitable access to infrastructure and land for transmitters and satellite earth stations;

f. Management of the multiplex and establishing the rules for its operation including control, access etc;

g. Content/service licensing;

h. Licensing of broadcast data services carried on the multiplex;

i. Requirements for electronic programme guide (EPG) and sharing of this information between broadcasters;

j. Rules that determine how a broadcaster is permitted to use the data stream (eg can the broadcaster add additional service channels, data etc and what licence requirements might arise from this; and

k. Acceptance or otherwise and licensing of non-broadcast data services on the multiplex.

Figure 1 depicts a typical digital broadcast transmission chain, which will serve to illustrate the various different approaches that have been adopted by administrations around the world.

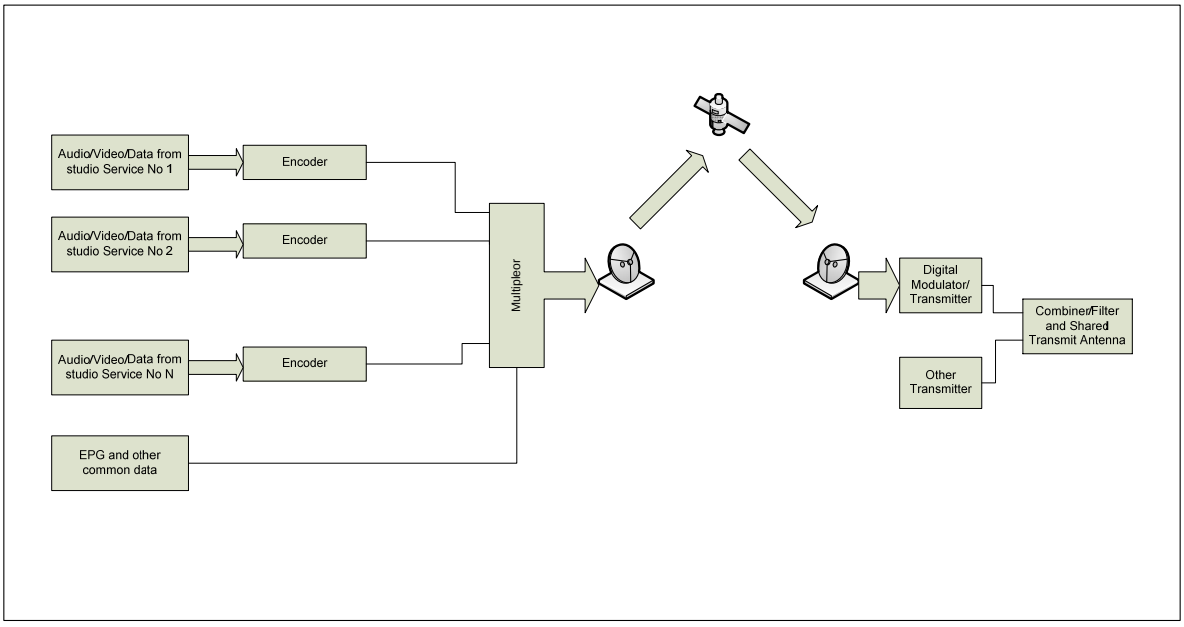


Figure 1: Typical Digital TV Transmission Chain

If all of the programming is supplied by a single broadcaster then there remains a single legal entity which can hold the relevant licences. However, if the digital transmission is to be made up of services from more than one service provider then the issues become more complex:

a. There needs to be a process that ensures equitable access to the multiplexer and how the available capacity will be allocated between the service providers;

b. As the multiplexer must feed a single transmitter, which entity should hold the licence to operate the transmitter or should a new entity which represents the interests of all parties be created to hold the licence (eg a consortium) and manage the transmitter and infrastructure?

c. Could the transmitter and multiplex be operated by a third party holding a radiocommunications licence to operate the transmitter, but be bound by special conditions to use that transmitter only for purpose of delivering licences broadcasting services/

d. What capacity would such a third party have to be able to carry non-broadcasting services on the channel if there is unused capacity; and

e. What form of licence would be needed for such services?

In some countries, broadcasters have been allocated a complete 7 or 8 MHz bandwidth channel which has a nominal data rate capacity of about 20Mbit/s. Separate rules have then been established that limit their use of that capacity to television and related services and restrict carriage of third party services. The advocates of this approach suggest that it allows greater flexibility in the future to realize the full benefits of digital. It has also been a strategy to engage existing analogue broadcasters to eventually give up their analogue channels and as an incentive for them to make the investment to move to digital without any guarantee of additional revenue. Opponents claim that this is a free gift of additional delivery capacity and serves to preserve existing media monopolies or oligopolies.

In other countries, digital television has been established as a multi-channel service where the services of several broadcasters are delivered over the same channel. This model allows the current number of services to be accommodated within significantly less spectrum, so this model has been attractive in those countries where spectrum congestion is an important concern. It has also been easier to implement in those places like the UK where licensed channel sharing has been a feature of broadcasting for many years. However, this approach creates a rather inflexible and fixed channel arrangement that may not easily respond to future demands for services like HDTV. The counter argument is that these services might use alternative delivery vehicles, or be possible, after analogue switch-off.

Bhutan has wider choices because of the current limited number of television services and transmitters in operation and its priority to reach most of the population as quickly as possible. The terrain requires a significant number of local transmitters to achieve terrestrial coverage, but the transmitters are small and less costly to establish. The television services currently provided by BBS occupy only part of the day so programme cost in probably a major concern. Additional output requires more programming so, for the immediate future at least, providing high quality multi-channel content that advances Bhutan's desire for more relevant Bhutanese programming may be a challenge for BBS.

At this stage of television development in Bhutan, a multi-channel approach through single channel shared between perhaps one or two BBS services, and future services such as education, national focus, cultural programming, or future commercial services. Typically, a single digital channel could provide between 4-6 standard definition channels of equivalent technical quality to the existing PAL service. The final number of SDTV channels that can be accommodated will depend on technology choices discussed later in this Report. Such an approach could include eventual duplication of the transmitters and multiplexer infrastructure in the future should there be a need to accommodate HDTV or other types of television services that demand more capacity.

A multi-channel single transmitter approach would easier to plan and to integrate with the existing analogue infrastructure. Once analogue services are terminated then it may be possible to convert the analogue transmitters to digital operation and so provide a second multiplex in those places which already have analogue services.

The shared multiplexer model is the most complex model to regulate, so it has been used here to illustrate the specific issues the Working Committee and associated agencies will need to address in the Bhutan digital migration plan.

The separation of carriage and content licenses in the BICM Act makes this problem easier to solve. The most normal approach is to issue a transmitter licence to a company which may be a consortium of the broadcasters seeking to provide services, or a third party operator who has no rights to provide services. The transmitter licence holder is responsible for the proper operation of the transmitter for the purposes stated in the licence and must maintain the transmitter operation in technical compliance with the radiocommunication licence authorizing the operation of the transmitter. There will be a separate of transmitter licences for each transmitter across the country.

Unless there is a need for local input at the transmitter, a single multiplexer can be used to aggregate the services at the studio or satellite uplink point, for distribution to the transmitters. This significantly reduces the cost and complexity at the transmitting. Unless this is done all of the services have to be separately sent to each transmitter for combining. Given the distribution of population and the many small towns and villages to cover, there seems to be limited requirement for other than a standard package of services at this time. If some local services are required in the short-term perhaps they would be limited to the few large population centres where direct feed to the transmitter may be practical. The multiplexer will almost certainly not be directly associated with the transmitters and a separate management arrangement will be needed if the multiplexer is to be shared between services.

One of the service providers (eg BBS) or a third party operator could operate and maintain the multiplexer. Regulations need to define the basis upon which service providers can gain access to the multiplexer on an equitable basis (it will be a natural monopoly), and to appropriately limit how the multiplex channels can be used.

The approach used in Australia for digital radio multiplexer sharing between the national public broadcasters has been to locate a multiplexer at each broadcaster's offices (so as to provide a physically redundant solution). Both multiplexers are configured in the same way so that in the event of a failure the other can deliver the programme to the transmitter via an independent signal path. Programme feed is delivered to each multiplexer by the broadcasters to achieve this. The associated regulations define how the capacity is to be shared between the broadcasters, and the operating standards establish the minimum performance standard (bit rates) that can be used for the various channels. This sets a ceiling on the maximum number of individual services.

Again using DAB as an example of shared multiplex; Australian commercial broadcasters were required to establish a consortium to establish and operate a multiplexer for a number of commercial and community broadcasters. The consortium holds the transmitter licence, and the regulations define how the capacity is to be shared between the licensed service providers, and how new service licence holders, who are not part of the consortium, can obtain access to the multiplex in the future.

Depending on how land, broadcast transmission buildings and antenna systems are obtained in accordance with the relevant Regulations in Bhutan, it might also be needed to ensure

equity of access to such facilities were multiple transmitters are to be installed (eg sharing with a telecommunications site or another broadcaster). Digital television transmitters need to be collocated with existing analogue transmitters, so that viewers can use the same receive antennas, the digital channels can use existing transmit antennas, and interference between digital and analogue transmissions is minimized.

Digital television technology has been designed to allow the digital signal to use channels adjacent to existing analogue services. For analogue transmission there had to be a gap between channels to accommodate limitations in the receivers. If adjacent channels are used for planning digital television then collocation of the digital transmitters with the analogue transmitters is vital; otherwise there will be interference between the services. If a different frequency band is used for digital (eg UHF) then collocation is less important, but arrangements for ensuring all future digital transmitters collocate are necessary for spectrum efficiency and viewer convenience.

3.2.1 Spectrum Planning

MOIC and BICMA are no doubt fully conversant with the principles and recommendations on spectrum planning, interference protection, band-planning etc At the International and National level. An outline of the broad principles, relevant references to the Radio Regulations, and ITU Recommendations are contained in the ITU Report on Digital Broadcasting Migration[13]. An extract of the spectrum management principles set out in the Report is Annex B to this report.

The Report sets out the following guidance on regulatory and spectrum management[14]:

> ***3.1 Regulatory considerations***
>
> *Regulation should allow multimedia service provision through all types of delivery networks, and regulations should ensure that a level playing field exists for all actors in the new horizontal markets and should correct imperfections of the market. To facilitate this process, the existing political and regulatory structures need to be adapted.*
>
> *It is also important that spectrum policy (which includes and takes into account items such as allocations, assignments, and liberalization) provide access for all contenders in a harmonized, open, transparent and non-discriminatory way, and the means for sufficient and appropriate delivery capacity. In order to facilitate the development of global service and delivery, as well as interoperability and economies of scale in the production of equipment, a globally harmonized spectrum usage should be encouraged, without preventing, at the same time, the flexibility needed for the creation of a competitive and technologically advanced scenario through spectrum management and licensing. In addition, the spectrum usage should also allow for regional differences in the amount of spectrum required for content delivery and for interactive services, since customer demand and interest may differ between regions.*
>
> *Both telecommunications and broadcast networks have until now evolved under separate, vertically oriented standards and regulations. Broadcasting has been for radio and TV, and telecommunication has*

been for voice. Recently also data communications has evolved under its own IT-labeled umbrella. With digitization the borderlines between telecommunication, TV and radio services and data communication are disappearing. As a result, it will become increasingly difficult to define or categorize future delivery structures by the type of services that are delivered through them. Accordingly, new definitions will be needed in relation to regulatory aspects.

The new regulatory environment should also allow multimedia service provision through all types of delivery networks (broadcasting and mobile). In fact, network usage expands and becomes more flexible when it is not bound to the transmission of certain kinds of content. The expansion of usage will increase the desire to invest in the building of networks, and their technological improvement.

3.2 Efficient usage of broadcasting spectrum

The migration from analogue to digital broadcasting has already commenced in some countries and is expected to continue throughout the world for the next few years. The actual duration of parallel analogue and digital broadcasting, i.e. the date when the analogue transmissions will end, will vary from country to country (2010 has been stated as an objective for a number of European countries concerning digital TV).

There are a number of elements to this transition:

–the switch on of digital TV,

–the switch-off of analogue TV, and

–how to deal with the reuse of analogue TV spectrum ("refarming").

This development will bring about significant new capacity for new services, as digital content can be broadcast in a fraction of the radio bandwidth that would be required for the equivalent transmission in analogue mode. Consequently, a much larger offering of digital TV programming is technically feasible while using less of the available radio spectrum. Furthermore, new types of digital services and content can be offered through this digital broadcast spectrum, both during the introduction of the digital technology is introduced but even more so also once analogue broadcasting has ceased - even while significantly increasing the quantity of broadcast TV (video) programming. Thus there is a significant opportunity for both additional TV and radio broadcasting, as well as for other interactive services in the fixed, portable and mobile environments, for example IP datacasting and interactive services.

The full benefits of the all-digital future will only be realized once analogue switch-off has been completed. The key issue will be to ensure the availability of many different services by many different service providers, as well as to guarantee openness and neutrality, which will pave the road for innovative services, technological innovation and

vigorous competition to the benefit of the consumer and the entire economy.

Internationally, the main pressures for other services to move into television spectrum come from the mobile telephone companies who would like to secure UHF spectrum above 860MHz. There are already sharing provisions in the Radio Regulations enabling this. Given the low ERPs, mountain barriers to adjacent countries, and current limited spectrum demand, the consultant does not expect that this will be a constraint in future television planning for Bhutan**.**

In countries where there is strong demand for access to the broadcast spectrum by other services those administrations are looking to achieve a "digital dividend" from analogue switch-off and in some cases are considering restacking the digital channels to make more spectrum available for use by these new services which are expected to bid significant money to acquire the spectrum.

3.2.2 Service Planning

Apart from some general considerations set out below, the principles that apply to digital television service planning are essentially identically to those used for analogue television planning. The protection ratios are different for protection between digital services, and between digital to analogue and analogue to digital (digital to analogue is usually the limiting factor due to relative poor adjacent channel rejection performance of typical analogue television receivers. All of the necessary planning parameters are set out in ITU Recommendation *ITU-R BT.1368 Planning criteria for digital terrestrial television services in the VHF/UHF bands.*

Analogue systems suffer progressive degradation of quality through the addition of electrical noise and other impairments, whereas digital systems performance is largely governed by the quality of the conversion process; provided the capabilities of the channel are not exceeded. This is known as the cliff effect, and sometimes is perceived to be a significant deficiency of digital television. In the analogue case the signals progressively degrade to the point where they are no longer useable.

Digital technology is very successful at eliminating the impairment caused by multi-path propagation (ghosting), and while the signals progressive are impaired by low signal levels and noise as the receiver moves further from the transmitter, very effective error correction in the receiver is able to mask the impact and continue to produce perfect pictures and sound up to the point where the error correction can no longer work and the picture will fail completely. Over a very small margin of signal to noise the image may commence to break up momentarily. Because viewers have become used to the progressive degradation of analogue, the perfect to nothing characteristic of digital is difficult for them to understand.

From a planning perspective, it can mean that in a limiting case a person on one side of the street can obtain reception but a person on the opposite side gets no reception. Yet both previously had analogue reception. The lesson from this is: provide adequate digital transmission power levels.

Planning for adequate signal levels at the receiver are more critical in Digital than Analogue planning so as to avoid the "cliff effect" issues mentioned earlier. However, in the case of

Bhutan where coverage is not expected to cover more than a few kilometres before the path is obstructed this should not be an issue and transmitters for VHF could be around 6dB down on VHF ERP, and about the same levels as VHF if UHF is uses. It would perhaps be worth conducting a short coverage assessment in a typical environment to establish a standard power level (as has been done for VHF analogue) during the planning phase. This would give a greater level of assurance that there was adequate provision to address local topographic influences

Digital transmission power levels for the same frequency can generally be 6dB lower than for analogue using the same frequency band, but this sometimes needs to be adjusted to take account of local conditions and obstructions. (See Annex C. for recommended planning levels and note these assume outdoor receiving antennas and higher levels will be needed for indoor reception).

From a preliminary examination of the typical size, and location of towns in Bhutan and the surrounding topography (using Google Earth), this should not prove to be of significant concern in planning digital services in Bhutan. Satisfactory digital coverage may indeed reach viewers further away who may currently suffering severe ghosting. However, at the low-power levels in use, ghosting is probably not a significant factor limiting coverage.

Digital television systems have been designed to co-exist with analogue television and are able to use adjacent channels that were taboo in analogue planning. Television planning in Bhutan is currently centred on Band III VHF, so the first preference would be to possibly use adjacent channels to existing analogue services. This would mean that viewers who use receive antennas will not need to replace their existing installations. Television planners in Bhutan will be familiar with the reception arrangements in different localities and can take these into account.

3.2.3 Transmitter Planning

At the transmitter, the most common approach for adding digital services on the same frequency band is to share the antenna a feeder by combining the analogue and digital services through a linear combiner that incorporates a high performance adjacent channel filter. While a separate feeder could be used in low-power installations to avoid the combiner cost, an adjacent channel filter would still be necessary to obtain sufficient isolation between the transmitters even with vertical separation of the antennas on the same mast. A benefit of the adjacent channel VHF approach would be that the transmitters currently being installed could be adapted to provide additional digital services, or relocated to provide services elsewhere once they are no longer needed for analogue.

If a new frequency band is to be used then a new feeder antenna system combination will need to be installed and adjacent channel operation is unnecessary. However, a transition to UHF will effectively wipe out any power savings that might be achieved with digital. Given the current 150W ERP this is perhaps not an important consideration. UHF transmitter sizes would need to be approximately equal to the current VHF ERP (See Annex C).

The Bhutan team has suggested UHF would be a candidate band for Digital over VHF. From a practical viewpoint, UHF performance in difficult hilly terrain can sometime work better for analogue but this is related to the narrow beam-width and higher gain of compact UHF antennas which assist in the reduction of multipath issues. VHF on the other hand provides

better distance coverage. The compact antenna size of UHF antennas is sometimes useful in places where heavy ice and snow conditions impact on transmission towers or viewers installations. For Bhutan with its low-power transmitters, most of these considerations are unlikely to be important and the main reason for considering VHF would be to maintain compatibility with existing infrastructure, and possibly opening the way for future conversion of analogue transmitters to digital.

The Australian Communications and Media Authority (ACMA) has published, and available free for download, a comprehensive series of documents on digital broadcasting planning which are contained in its Broadcasting Planning Manual[15]. This is available from http://www.acma.gov.au/WEB/STANDARD/pc=PC_91711. It provides particular guidance on implementation of the DVB-T system in 7MHz channel spacing environment. This manual reflects the outcome of considerable research and review of international practice and field work carried out in Australia by a joint Industry/Regulator Task Force. It brings together in one place relevant ITU recommendations, and practical guidance on spectrum and service planning. A number of regulatory instruments that form part of the digital television plan in Australia are also located on this www site.

3.2.4 Single Frequency Networks

One new feature provided by the DVB family of standards is the possibility of using the same frequency across a number of transmitters. This is known as Single Frequency Networking. While this is fairly easy to plan in a "green field" approach, it is more problematic when the digital services have to interleave existing analogue services, because the use of the single frequency may conflict with other planning constraints at the adjoining analogue sites. In the main SFNs work best to fill in black spots (locations of poor coverage) within the coverage of a main transmitter). For them to work the programme feed to each transmitter must be identical and time synchronized. This generally implies satellite delivery to all transmitters in the network. It also requires some additional equipment.

The current VHF analogue planning suggests that there may not be any significant benefit in using SFNs in Bhutan because the added complexity and cost would appear to outweigh the benefits. Its most common usage is as gap-fillers within the coverage of a main transmitter covering an area. As the areas to be covered in Bhutan are small the only potential application for SFNs would be extension of the service say along a river valley, but this might be more easily done by planning a separate frequency in most cases in the Bhutan planning environment.

3.2.4.1 Mobile Television

Mobile Television has been considered in a few countries. Singapore uses the characteristics of DVB-T to provide a system that works on public transport busses around Singapore. The Japanese system is designed to allow improved mobile operation in conjunction with fixed reception through a different design. In the DVB world most of the focus has been on the DVB-H (DVB-Handheld) [16]solution which allows a large number of low bit rate channels to be transmitted over VHF or UHF television broadcast channels to handheld receivers such as mobile phones. Other handheld solutions are described in the references cited below.

The DVB-H service is compatible with the DVB-T transmission model but uses low bit-rate intended for reception on small handheld receivers.. At this point in time the take up of

DVB-H has been limited and receivers remain expensive. The full benefits of the DVB-H system generally need to be linked to a mobile telephone service so that there is an interactive return path available so this is a further limiting factor. DMB system developed in Korea as an adjunct to DAB provides mobile reception using DAB type transmission techniques.

There remain many options for mobile but since the real benefits seem to flow from linking this to mobile telephone, it does not seem particularly useful to try to plan for mobile television reception in Bhutan at this point in time. If there is a desire to make future provision for a system, this can be done by allocating one additional 7MHz channel at each site as part of the overall digital frequency allotment plan. (See ITU Report BT2140-1 pages 55-107 for a more comprehensive description of the capabilities of each of the different digital television systems) Additional information can be found on the web sites found in the references.

3.3 Applicable Standards

ITU Report BT2140-1 describes the various digital terrestrial television systems that have been developed and submitted for inclusion in the ITU record:

> ***Description of Digital Television Broadcasting Systems***
>
> *Various digital television systems have been developed for terrestrial broadcasting. The relevant systems are:*
>
> *a. ATSC DTV- Advanced Television Systems Committee - (System A).*
>
> *b. ATSC-M/H- Advanced Television Systems Committee Mobile & Handheld.*
>
> *c. China DTV - (GB 20600-2006: "Framing structure, Channel coding and modulation for digital television terrestrial broadcasting system".*
>
> *d. DVB-H - Digital Video Broadcasting Handheld.*
>
> *e. DVB-T - Digital Video Broadcasting Terrestrial- (System B).*
>
> *f. ISDB-T - Integrated Services Digital Broadcasting Terrestrial- (System C).*
>
> *g. T-DMB compatible with T-DAB (Recommendation ITU-R BT.1833, ETSI TS 102 427 and ETSI TS 102 428).*
>
> *h. ISDB-T_{SB} - Integrated Services Digital Broadcasting-Terrestrial Sound Broadcasting - (Recommendation ITU-R BT.1833 Multimedia System F).*
>
> *i. FLO – Forward Link Only (Recommendation ITU-R BT.1833, Multimedia System M, TIA-1099).*
>
> *Details of systems A, B, C may be found in Recommendation ITU-R BT.1306 and in Report ITU-R BT.2035 - Guidelines and techniques for the evaluation of digital terrestrial television broadcasting systems. Recommendation ITU-R BT.1833 - Broadcasting of multimedia and data*

applications for mobile reception by handheld receivers, defines T-DMB as Multimedia System "A" , ISDB-T one segment as Multimedia System "C", ISDB-T_{SB} as Multimedia System "F", DVB-H as Multimedia System "H" and Forward Link Only (FLO) as Multimedia."[17]

Each of these systems has been built to respond to particular economic, technical, or service needs of the proponent countries. Some evolve from the same basic concepts, and others started from a particular set of service objectives unique to the countries in which they were designed. In the latter case, those countries have sufficient population to provide a very large local market and are not dependent on a substantial world market to assist in driving the price down. In each instance, the standards relate to the way in which the signals are encoded for transmission to receivers and descriptions of the transport stream that has to be decoded in the receiver. The standards essentially allow each manufacturer to determine they way in which the transport stream decoder is implemented. To further complicate matters, each standard essentially provides a "tool box" of operational options that need to be standardized in each market (eg the way in which Service Information is used, EPG, assignment of logical channel numbers etc) that are used by all broadcasters in the market so that there are no conflicting elements of data that might create conflict in the receiver. These are matters that will have to be resolved in detail once a system selection has been made.

Already MOIC has indicated a preference for the European DVB-T system because of its compatibility with neighbouring India's decisions and its wide acceptance by a number of other countries. DVB-T is a mature system to which improvements have been added over recent years. The other large neighbour the Peoples Republic of China (PRC) uses a system that has its roots in the same technologies as used by DVB-T but has been developed independently in China in response to what is saw as difficulties in the quantum of royalties it may have had to pay for the DVB system. Notwithstanding, most of the DVB receivers on the market today are manufactured in the PRC for mainstream brands as well as for independent Chinese branded receivers.

The DVB System comprises a family of standards and the relevant standard for Terrestrial Television is DVB-T (See http://www.dvb.org for full details of the DVB system and associated specifications). The most recent version of this DVB-T2 is claimed to achieve spectrum efficiencies in the order of 30-50% compared with DVB-T. Because the major users of the DVB-Terrestrial standard commenced service using DVB-T it is currently the dominant version in the market place DVB Variants. The following advice appears on the DVB web site http://www.dvb.org/technology/dvbt2/[18]:

What are the implications of DVB-T2 for countries planning to launch DVB-T services in the short to medium term?

A significant number of countries, in Europe, Southeast Asia, Africa, the Middle East and Latin America, are planning for the launch of DVB-T services in the next 2-3 years. These countries will benefit from the use of a mature technology that is flexible enough to meet their individual market requirements. In particular they will benefit from the existence of a well-established world market both for receivers and for head-end equipment. These conditions will enable the rapid roll-out and take up of DTT services in these countries, with access to cheap receivers being the

key factor. The transition from analogue to digital services is what DVB-T is designed for.

In this timeframe it is neither feasible nor advisable to consider launching services with DVB-T2. The new standard is designed for a post-ASO environment, where DVB-T services are already well-established. Products that implement the DVB-T2 standard are not likely to become widely available until 2010. Whilst prices will fall over time, in line with past experiences for DVB technologies, they can be expected to be relatively high initially. This means that DVB-T2 should not, in the short to medium term, be considered for the launch of free-to-air multi-channel standard definition services targeted at migrating a general population from analogue to digital. DVB-T is ideal for these purposes.

What are the implications of DVB-T2 for countries that ha

In some countries, notably in Latin America and parts of Asia, debate continues as to which of the available DTT transmission systems should be adopted and deployed. The DVB Project believes that the adoption of DVB standards in such territories would bring maximum benefit for all stakeholders, including broadcasters, regulators, manufacturers and, perhaps most importantly, viewers. Regardless of which analogue transmission system is used, and regardless of the channel bandwidth used, DVB-T offers a uniquely flexible solution that will enable a smooth transition to DTT. The key factor, particularly in countries with a high penetration of terrestrial TV and relatively low average incomes, will be the price and range of receivers. It is clear that DVB-T is the ideal technology in these circumstances.

Such countries will also benefit from the future availability of DVB-T2. The DVB Project is unique in ensuring that it continues to develop state-of-the-art solutions that closely match the requirements of the individual markets. DVB-T is THE standard for transitioning from analogue to DTT; and DVB-T2 is the ideal technology to exploit opportunities after ASO.

The initial digital television systems were built around the MPEG2 digital television compression and encoding standard available at that time. The MPEG4 standard initially developed for mobile telephone and internet uses subsequently evolved to a standard suitable for broadcast transmission. The MPEG4 standard allows lower bit-rates to be achieved for the same picture quality and thus allows more channels to be carried within a given transport stream. Improvements are typically 30-40 percent efficiency gain depending on the type of material being encoded. Initially MPEG4 encoders and decoders were substantially more expensive that MPEG2 but the price difference is becoming smaller over time. The potential advantage in considering MPEG4 as an option would be to adopt the most recent standard and so provide a degree of future proofing by not starting with a legacy system. In practice with the improvements in MPEG2 and the use of statistical multiplexing

techniques in the broadcast transmission, some of the direct differences in efficiency between MPEG2 and MPEG4 can be reduced unless very low bit rates and limited quality is required. If receivers and equipment were available at the same price point for MPEG2 and MPEG4 then the decision would have to be taken in favour of adopting MPEG4.

DVB-T2 with MPEG4 encoding is currently being deployed in the UK as a combined High Definition/Standard Definition service. The UK expects that T2 Set Top Boxes will be available from early 2010 and a complete range of consumer equipment by mid 2010[19]. Whether DVB-T2 will be a suitable solution for Bhutan requires much more detailed evaluation of the receiver supply issues because up to this time there has not been any widespread implementation of this more recent standard. However, migration in Bhutan will take time so the question will be important to explore. Considerable work is being undertaken amongst the Asian countries which have adopted DVB to try to standardize on a receiver and set-top box design which will allow lower cost supply and more capable receivers.

European DVB-T Systems Deployment

A comprehensive overview of the current implementations of the DVB-T system globally is maintained by the DVB Organization and can be found at http://www.dvb.org/about_dvb/dvb_worldwide/index.xml [20]. Information specifically about deployments in Europe and Digital Switch Over can be found on the Digitag www site. These are already comprehensive and closure of analogue services in many European countries is now progressing towards a completion targets around 2012/2013. The dark shaded countries in Figure 2 have already deployed or committed and those in lighter are committed to DVB-T and are progressing towards implementation[21].

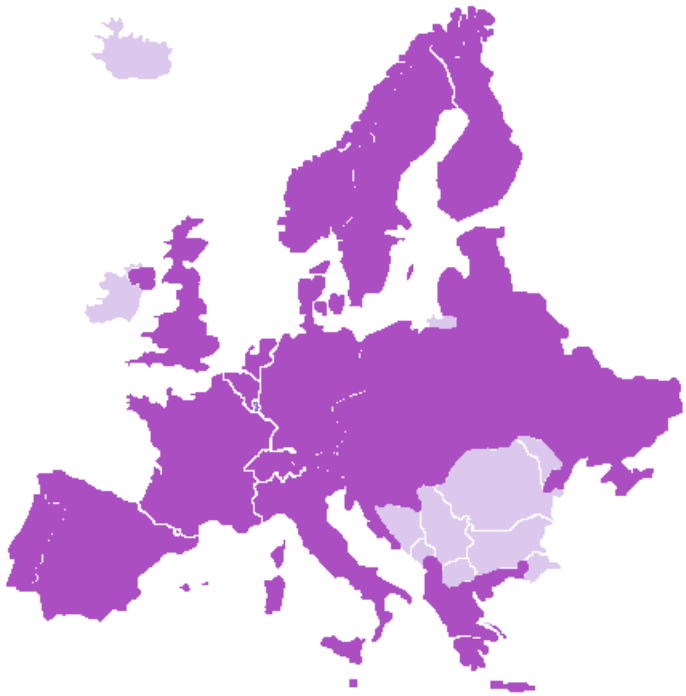


Figure 2; DVB-T Deployments in Europe

As the above information shows, the DVB-T standard is widely accepted throughout Europe and the Asia Pacific. It is a mature standard now moving into its second generation. Depending on the timing of digital television implementation in Bhutan, adoption of this later generation standard may be beneficial depending on the relative cost of receivers at the time.

3.3.1 Electronic Programme Guide

A feature of all digital television systems is the Electronic Programme Guide. This makes it easy to find channels and programmes in a multi-channel environment. Most people are familiar with the EPG from pay television. Initially broadcasters and regulators spent considerable effort to try to derive a common programme guide that would be required to be transmitted by all broadcasters covering all channels within a service area. However, this is particularly difficult to implement when there is a mix of satellite and terrestrially delivered services, or overlapping service areas or overspill of services from an adjacent service area. Receiver manufacturers seem to have independently found a solution to this problem by scanning the EPG information from the transport stream of all of the channels it has discovered in a channel scan when it was set up. The receiver then displays this composite information for all of the channels that can be received. Manufacturers see this as a way of differentiating their product from other manufacturer's products. From a broadcaster perspective, it is less satisfactory than a uniform presentation of the EPG controlled by the broadcaster as it prevents some controls that broadcasters may sometimes wish to apply, such as blocking the capacity to record programmes or to skip advertisements in recorded programmes. However, this now seems a lost cause and most of the common EPG initiatives have been shelved.

While much of this may be of limited interest to Bhutan at this time, there is a need to define a requirement for all broadcasters to broadcast a "Now and Next" and perhaps a "7 day" EPG. This is even more relevant when access to print media etc which might contain programme information may be limited. If the approach of allowing multiple services to share a transmission multiplex, then the EPG information from all broadcasters sharing the multiplex will need to be compiled into a single EPG for transmission, because there can be only a single EPG stream per transport data stream.

3.3.2 Satellite Distribution

The most efficient way to deliver the composite programmes to transmitters via satellite is to send a single ASI data stream over the satellite to the TVRO facilities at the transmitter locations. This can then be simply fed directly into the transmitter modulator for transmission. However, the ASI stream is not appropriate for DTH. If a DTH standard such as DVB-S2 is used for distribution (see http://www.dvb.org/technology/standards), then it would be able to be received by any DTH receiver (assuming no encryption) and so provide a service across the Kingdom and beyond. However, if this approach is adopted then the signals need to be re-multiplexed at the transmitter to allow them to be received on DVB-T receivers. The transmitter thus becomes more costly to implement because additional equipment is needed at each transmitter. There are some emerging solutions that may assist in addressing the problem and these can be investigated as the work on migration planning proceeds.

The Working Committee will need to decide the extent to which is wants to implement a DTH digital service, and the options of adding the services to a pre-existing DTH service

versus providing a simple distribution service to the transmitters. There are clear attractions in having the option to use DTH for isolated communities. What solution is the most appropriate for Bhutan will need more complete analysis once the objectives are better defined and technology options and costs investigated more completely.

3.4 Broadcasting Network Structure (ownership, multiplex transmission network)

The general concept of multiplexing and multiplexer ownership and management was discussed in Section 3.2. Simply put a multiplexer is the device which enables a number of separate programme streams to be combined together for carriage over a single transmission chain. From the audience viewpoint, the services appear as if they were individual services.

Because the transmission channel has limited capacity (in the case of Television around 20M bits/sec) this must be shared between the services to be carried. The system itself requires some capacity for control signals, system information (which tells the receiver how the services are configured in the transmission so that they can be separated correctly) combined electronic programme guide, and other transmission overheads. The total available capacity for programmes is also influenced by the degree of error correction etc that is required. The signal can be made more robust by applying higher levels of error protection at the expense of programme capacity.

In countries where the multiplex was not shared but all of the capacity allocated to a single broadcaster, the approach has varied from that of allowing the broadcaster to use the capacity for HDTV, or multi-channel services and in some cases limited data services. The arrangements generally restrict the use of this flexibility to the broadcast of broadcasting services content. Such broadcasts are covered by the broadcaster's primary licence. By tying the broadcast services to the primary licence, the broadcaster is prevented from on-selling capacity to others. Such generous provisions are generally regarded as an incentive for broadcasters to use the capacity to drive consumer demand, and as an exchange for the analogue spectrum they will eventually be required to give back. In these instances, the Governments have generally placed strict controls on the extent to which the capacity can be used for additional services; mostly because of complaints from subscription television operators who perceived free-to-air multi-channel as serious competition to their services. Unfortunately, this removes one of the clear incentives for viewers to switch to digital: more services.

Some countries have established digital television as a shared multiplex operation. This tends to limit the scope for service enhancement in the future. This approach has usually been driven by the necessity to overcome severe spectrum shortage which prevented any consideration of providing each broadcaster with a new digital transmission channel. Therefore to make digital transition possible, the few available channels need to be shared.

Almost universally, the approach to migration has required existing analogue content to be carried on the digital system. If there is additional capacity available on the multiplex (shared or otherwise), then new services can be added subject to the appropriate service licence cover.

In a country like Bhutan, the adoption of a shared multiplexed approach would have the benefit of providing additional channel capacity with a single transmission infrastructure, as compared with multiple transmitters that would be required if there were one transmitter per channel. If a decision were taken to implement digital migration in this way, there is nothing to prevent a transition to a single service per multiplexer solution at a future date should circumstances and economic factors support this.

To support the introduction of a multi-service multiplexed service, are a number of regulatory matters need to be taken care of in order to ensure that broadcasters can obtain access to the multiplexer on fair commercial terms. The most recent and comprehensive implementation of shared multiplexer legislation can be found in the Australian Digital Radio broadcasting legislation in the *Australian Radio Communications Act 1992 (see http://www.comlaw.gov.au/ComLaw/Legislation/ActCompilation1.nsf/current/bytitle/53F0BF080E67E4CCCA25753E0008F3E4?OpenDocument&mostrecent=1 Division 4B clauses 118NA-QJ*. These provisions define the share of the multiplexer available to a broadcaster, arrangements for allocation of excess capacity, equitable access to infrastructure, and matters relating to appeals disputes etc. This is perhaps an example of the most complex level of management, because it allows broadcasters to form a consortium to own and operate the multiplex, it must allow carriage of services from broadcasters who are not members of the consortium on fair commercial terms, and it also permits the consortium to arrange for technical operation and management to third parties.

In some markets, multiplexed licences have been sold by auction and the owner of the licence required to provide access to the facility to holders of appropriate broadcasting service licences and to transmit their programmes for a carriage fee. This model is akin to the common carrier model of telecommunications except for the restrictions to permit carriage broadcasting services only.

3.5 Strategies and Processes of Transition to DTTB?

The transition to digital television needs to start with a clear definition of the strategic policy objectives and the progress through detailed macro level planning as to how the services should be accommodated and rolled-out against a realistic budget and time-line. Decisions need to be made on the selection of the transmission standard and the method of distribution and then the specific aspects of these (in particular system information definitions for the country and other user defined parameters) set as national standards or operating practices so that the audience can receive all of the services without difficulty. A range of typical documentation developed by the Australian Television Industry can be found at http://www.freetv.com.au/Content_Common/pg-Engineering-Guides.seo which covers the operational arrangements for broadcasters using the DBV-T system.

These operational practices assume that the receivers and transmission arrangements follow the national standard. Because the ETSI standard for DVB-T allows considerable flexibility in the use of some variables, these need to be defined by national standards. In the case of Australia they were established through a consensus standardization process involving both industry and Government and these are defined by formal Australian Standards published by the national standards organization [22] The Australian Standards are based on the ETSI standard and define the specific requirements for DVB-T implementation in Australia:

a. ***AS 4599.1-2007***
Digital television - Terrestrial broadcasting - Characteristics of digital terrestrial television transmissions

b. ***AS 4933.1-2005***
Digital television - Requirements for receivers - VHF/UHF DVB-T television broadcasts

c. ***AS/NZS 1367:2007***
Coaxial cable and optical fibre systems for the RF distribution of analogue and digital television and sound signals in single and multiple dwelling installations

These standards define such things as channel frequencies, system information, electrical safety requirements, and so on. While manufacturers produce receivers for world markets that are very similar, they include software programming which allows them to configure the receivers to the standards and requirements of a particular market. The receivers are delivered with this software pre-programmed against the national standards. Like all computer systems, the software occasionally needs to be updated either because of problems discovered in the systems, or when there is a significant change to the national system. This can be either loaded from a PC by the service technician, or now more commonly, by downloading the updates over-the-air. Over-the-air updates require a further set of standards and arrangements to ensure that only those receivers that require the update are affected, and so that one manufacturer cannot inadvertently modify the receiver of another manufacturer. This is flagged here as a future rather than immediate consideration because in general receiver manufacturers have now managed to produce stable products and upgrades are a common occurrence. Nevertheless, given the difficulties of access to many parts of Bhutan, this may be an important feature to allow for because it could eliminate the great difficulty of having technical assistance reach some of the viewers.

Multi-dwelling (high rise) buildings with shared antenna systems have proven to be a particular challenge in ensuring efficient delivery of digital television services to the audience. This difficulty arises where analogue cable installations are unsuited for digital distribution. This may be an issue for the largest towns/cities in Bhutan. It could also be a matter to address if viewers obtain their services through a shared cable system. Rules may need to be established to ensure that the cable operator transmits the digital signals correctly through the cable without modification. Specific publications on this topic have been developed by the Australian Government's Digital Switchover Task Force.[23] (See http://www.digitalready.gov.au/publications.aspx).

There is no simple and easy way to avoid the progressive series of steps needed to establish Digital Television on a sound footing. Bhutan can take advantage of the many years of effort undertaken on other countries to establish digital television, where many of the issues came to light only after initial digital commencement.

A range of initial policy questions that will set the agenda for a migration strategy were set out in Section 3 of this Report. A general list of tasks that flow from the policy decisions that will build a complete conversion strategy will include the following. These tasks can proceed somewhat in parallel and the list is not intended to be exhaustive nor is it in any particular order:

a. Decisions on how DTV will be implemented (eg. Shared multiplexer or one multiplexer per broadcaster);

b. Decisions on the particular system of DTV to be adopted (eg DVB-T)

c. Development of national standards (including adoption of international standards) which will apply to DTV in Bhutan;

d. Decisions on the likely timetable for introduction of DTV and whether some centres who have no analogue television will be planned as DTV only installations;

e. Decisions on the extent to which complete population coverage is to be achieved through terrestrial broadcast and how the residual viewers will be served (this touches on the question as to whether DTV will be distributed as a simple rebroadcast package to transmitters or whether it has to double as a DTH service as this has implications for the system design and in particular the transmitter installations and costs;

f. Determine the broad spectrum planning requirements (is DTV to be a UHF service only or will it endeavour to use vacant channels adjacent to the existing analogue VHF services;

g. Establishing a national channel plan and channel assignments and specifications for DTV transmitters;

h. Drafting of legislative instruments to give effect to the policy decisions;

i. Establishing relationships with retailers and suppliers about digital television supply, standards etc;

j. Establish education programmes for installers and retailers;

k. Engage the public and broadcasters about the objectives, timetables and establish appropriate consultative mechanisms;

l. Determine how the services will be funded and for all involved to take action to secure that funding (funding will be a major determinant of the possible timetable and cost must be considered very early in the decision process even before the initial decision to migrate is taken. It is important to maintain credibility and public confidence that the plan is sensible and achievable;

m. Plan the roll-out and the order in which services will be established;

n. Have any specific structural arrangements for multiplexer management, and so on established and approved;

o. Arrange for satellite distribution capacity to coincide with the planned roll-out (for example if DTV were to commence in Thimpu first and then to one or two other larger population centres, it may be possible to delay satellite distribution for a period until the wider roll-out was scheduled to take place;

p. Determine how the supply of receivers is to be arranged (will this be subsidized, or will it be a normal retail transaction, how will they be distributed , and what numbers are expected to be required over time);

q. Undertake some preliminary trials to identify any particular local issues with planning, coverage, and configuration and the progress to on-air testing. This will be

a way to provide retail suppliers and the public with demonstration signals. (there may need to be provision for initial trail arrangements and programming included in the regulations);

r. Ahead of the launch date, establish with broadcasters lead up publicity for viewers to explain the changes and opportunities provided by DTV;

s. Depending on the decisions taken about competitive services, there may need to be a licence allocation process along the way;

t. Establish arrangements where viewers can obtain advice (eg telephone call centre etc) and possibly to report any interference that may result from the introduction of the new digital services (the risk of this depends on whether adjacent channels etc are used and also on the location of transmitters. The consultant does not anticipate this will be a significant issue in Bhutan because of the expected low ERP of the facilities. However, if they are located near telecommunications facilities (eg mobile telephone installations) then there is a small possibility that some interference issues may need to be managed; and

u. Issue licences and construct and test facilities.

3.6 Measures to Promote Investment and Switchover

Promotion of investment and final switch-over affect several groups of stakeholders:

a. Government and its government agencies;

b. Broadcasters who much establish the additional transmission services;

c. Equipment suppliers and retailers;

d. The viewers who must purchase new receivers

The task of Government and its agencies is to establishing the framework for migration. It involves a number of new projects tasks, not only in preparing regulations, but also in detailed technical planning and standardization. Right from the start there are costs to the broadcasters working with Government and other stakeholders to establish the framework for migration (a cost of time and people resources) and then the capital outlays to convert to digital.

Digital migration requires broadcasters to make a "leap of faith" to invest in establishing a service which for the immediate-term is not going to improve their revenues. In the case of the public broadcasters, it is another cost they have to carry unless there is a direct supplement from Government. These costs can have an impact on the analogue services if the budgets impacts are sufficient to impact on programming supply funding. The outlays can be phased over a period to assist in reducing the cash flow required but this does not reduce the magnitude of the total capital investment required.

In some countries, Governments have provided some assistance to broadcasters through subsidies, waiver of some fees and charges, special arrangements for infrastructure access, and so on to encourage aggressive roll-out. If the Public broadcasters are adequately funded they can play a very important role in the rapid deployment of services. The key point being that services are operating there is little incentive for viewers to purchase receivers. At the

same time this has to be balanced against the capacity of the retail industry to supply receivers and distribute them across the country.

Most countries have defined a specific closure date for analogue services as a way of driving the roll-out of digital. Notwithstanding such pronouncements, it will not be possible to turn off analogue services unless there is almost complete penetration of digital services and receivers. This may involve subsidisation of some viewers to purchase receivers. The specific requirements of Bhutan will need to be considered in developing an appropriate strategy. The existing analogue television roll-out remains incomplete at this time and in some instances strategies of providing receivers in centralised locations have been used as a way to ensure that at least there is some access to television and the important information services it carries it even the most remote and poor villagers[24].

Once the majority of viewers are able to obtain digital reception the focus needs to switch to the problem of converting viewers so that the broadcasters can turn off the analogue transmissions and reduce their costs. This has proven to be a complex problem in the developed countries as is evidenced by the experiences of the United Kingdom and United States. In the United Kingdom and in Australia the approach being adopted this for closure of analogue services to progress on an area by area basis. Such an approach is unlikely to be as appropriate to the needs of Bhutan where there are few large population centres, a number of remote villages, and limited disposable income. To date no developing country has reached a point where it has to consider analogue closure. As mentioned in earlier paragraphs, digital technology may be appropriate for delivery of the first services to some of the Bhutanese villages.

Different strategies will be needed if additional broadcasting services (say from a new commercial licensee) are to be implemented during the transition period. Most developed countries have avoided introducing additional services during the transition period by allowing for a moratorium on new services so that the incumbent broadcasters do not face additional competition at the time they have to invest heavily in digital technologies. In those markets there is already commercial competition. The consultant is not aware of any market where digital only Free to Air (FTA) commercial television services have commenced as a driver of digital take-up; however, additional services carried by existing broadcasters have proven to be a useful incentive to encourage audience to switch to digital reception. Additional programming of relevance to the audience is perhaps the most powerful incentive for audiences to switch. In general improve technical quality is not an incentive unless the viewers currently experience particularly bad reception. This does not appear to be a particular concern in Bhutan given the limited coverage required of the transmitters to service the geographically small population centres.

Once the migration journey has been established, a provisional closure date for analogue services can be announced as an incentive to a more aggressive migration. This needs to be coupled with a commitment by all parties to strongly promote switchover so that consumer resistance can be overcome as far as possible. In all instances of switchover strategies developed so far, the final closure of analogue has been linked to minimum audience penetration levels. The Australian Digital Switchover Task Force measures this by means of a Digital Tracker (See: http://www.digitalready.gov.au/publications.aspx). Subsidies are generally been constrained to assist in the purchase of a single receiver per household, and

are directed at those people who would not otherwise ever convert (the poor and elderly and some recipients of government living assistance).

The ITU-R Report on Digital Transition, sums up the issues in this way[25]

> *These must be traded against the perceived cost of new equipment and possible subscription costs. It is essential therefore that the audience is presented with an attractive package of services and applications at a price that it is prepared to pay. The drivers on the industry are therefore the production of more and increasingly attractive programme content and the deployment of receivers at appropriate prices.*
>
> *Receiver price is driven by a number of factors, not least the willingness of the broadcaster or regulator to subsidize the cost in order to promote sales and uptake of the service. DVB-S receivers in the UK are 'free issued' as part of an interactive subscription package. Any switch over strategy must recognize that, the user community can generally be divided in three in its willingness to invest in new technology. The 'early adopters' tend to be enthusiastic about technological development and will invest in new machinery simply in order to have it at an early stage. Such people will typically be prepared to pay a high price for new equipment. In the early stages of product life, the manufacturers rely on this community to offset some of the high development costs of new consumer equipment. The early adopters are followed by the 'mainstream'. These users will be much more circumspect about price and will compare the value they put on the new service/application with the cost of making the change before actually buying a new receiver. These people know that they intend to make the change but do so when the cost of the receiver has dropped (as it inevitably will) to the level they are prepared to pay. The third group, the 'unwilling' have typically decided that they will never change or they have sufficiently little interest in the subject that they are unaware of the development. These people will only change when they absolutely have to (perhaps because the analogue service is withdrawn) or when the price becomes so low that it is not important and digital has anyway become the standard.*
>
> *This simplistic model of the market is clearly going to be distorted by factors such as subsidies and the threat of discontinuing the analogue services. The threat of discontinuation is a (market) driver that must be used with extreme caution. Public service broadcasters as well as the advertisers who fund a large part of the broadcasting industry will not be pleased to find themselves "cut off" from an established audience if 'switch-off" is contemplated before a substantial proportion of it is able to receive the new service. The community of broadcasters will be unwilling to turn any of their services off before the audience drops to the point where the transmission cost is not viable.*
>
> *One thing can be stated with certainty. Continued technical development and an ever expanding consumer base will mean that the cost of producing receivers will fall. This in turn will push down the purchase*

price. Continuous development in the integrated technology sector means that systems of ever greater complexity can be accommodated on small silicon chipsets. Receivers with diverse capabilities and single function machines can all use elements of the same chipset, the manufacturing cost of which depends far more on production volumes than on functionality. Stifled development of purely analogue receivers will mean that the time will come when they are more expensive than their much more capable digital brothers. At this point the pressure for switch over will be unstoppable.

While the broadcasters are potentially easier to persuade than the audience when it come to deploying new equipment, the process is not cost free. If transition is to be achieved within realistic timescales and budgets, every effort must be made to re-use existing analogue plant if at all possible. Thankfully, where services are to be mounted in existing frequency bands, the transmitters and antennas, which at the lower frequencies are usually expensive and difficult to replace, can often be adapted to work with the digital transmissions. Most of the DRM transmissions now currently being broadcast around Europe are carried on analogue transmitters which have been adapted. While these transmitters are not usually optimized for carrying digital transmissions, the design considerations are quiet different, this strategy can allow the plant to continue to be used for analogue services as well as digital during the transition period. In addition the cost of producing and transmitting analogue and digital versions of the same programme material at the same time must not be ignored.

There is a wealth of information available from the UK, Australia and the United States on switchover strategies and arrangements to encourage viewers to migrate: (See: http://www.digitalready.gov.au (Australia), http://www.dtv.gov (USA), http://www.digitaltelevision.gov.uk (United Kingdom) which have well developed strategies and consumer advice)

3.7 Cost and Benefits Analysis Related Issues

The costs of digital conversion initially centre on the cost of providing duplicate transmission equipment and distribution infrastructure and the costs to consumers. Beyond this there are the additional costs of programming if additional channels are to be implemented the cost of publicity and administrating the transition process, and importantly the internal costs to broadcasters for adapting their programme creation and presentation equipment to the needs of digital transmission. For many broadcasters digital conversion of their studio facilities has been an ongoing process for a number of years. This is because most equipment now available in the market uses digital technology which is much cheaper than its previous analogue equivalent. There is also a large amount of low-cost equipment available which has enabled a much larger pool of people to become television producers. Nevertheless, professional broadcasters do need to consider every aspect of the programme production chain.

An area which is often overlooked is the archive. For broadcasters who have established a significant archive of analogue material, they will at some point need to contemplate conversion of the archive to digital storage in order to preserve it for the future.

The costs to consumers have already discussed. In general consumers existing antenna installations will be sufficient for digital reception provided the transmissions occur in the same frequency band. The electricity consumption for digital reception is similar to that of analogue for the same screen sizes; however since digital television has also spawned the development of large flat screen displays electricity consumption can be higher. This is an important consideration where there is no mains electric power and consumers must rely on solar cells and batteries to power there television receiver.

However, there is a scarcity of definitive studies that attempt to established a true economic value of digital television migration . Most studies speculate heavily on the economic benefit of the digital dividend to be gained from sale of spectrum for other uses and speculation about the economic multiplier of the new services that may be established as a result.

Most countries have accepted that this is a new technology that has significant potential to improve quality of life, to expand information services and to open up the opportunities for services not yet thought of to be established. It is a technology that is an enabler for the future, it parallels developments in all other forms of electronic communication and from the content creation point onwards makes it easier to integrate converting services at various levels.

Digital television initially promised high levels of programmable interactivity that the take-up of such services has been limited and there is not very much Manufacturer interest in including such capabilities within receivers. Part of this problem is the lack of agreement between all of the parties as to what form such interactivity might take. At the time these ideas were conceived Internet access was frequently very limited and certainly broadband access was largely non-existent. With the very aggressive rollout of broadband services by either wired all wireless means, television which is essentially a one-way device, has great difficulty in computing or conceding an interactive solution which will have the same audience appeal as direct Internet connection to a broadband service. Indeed, developed broadcasters now frequently seek to have their material available online as an adjunct to their broadcast services. The general perception in implementing services is that broadcasting services remain an ideal way to deliver one-too-many content and mass coverage, while broadband services are best suited to one-to-one interactivity.

The main candidate system for interactive development in DVB is MHP which is described as follows by DVB Consortium[26]

> *"MHP, or the Multimedia Home Platform, is the collective name for a compatible set of middleware specifications developed by the DVB Project. MHP was designed to work across all DVB transmission technologies. The use of an open standard for interactive TV middleware means that receiver manufacturers can target multiple markets rather than developing products to the specification of a particular broadcaster. Equally applications based on MHP can be developed by multiple service providers, enabling a horizontal market in that area. Three versions of*

MHP have now been published; each adding new features useful in a broadband world. In all versions, a broadcast-only profile can be supported, although most modern deployments include broadband connectivity".

At this point, and without the benefit of a field visit, the consultant does not have sufficient information about the local situation to be able to estimate the magnitude of costs that might be involved in implementing digital television in Bhutan. The factors that will make up the implementation costs include:

a. Capital investment in establishing transmitters at all sites (per transmitter costs themselves will be similar to those extended for the analogue network that there will be the additional cost of a digital modulator, for which BBS may already have a price estimate. For filtering or combining services if adjacent channel frequencies are to be used;
b. Additional satellite channel capacity will be required to distribute the programmes to the digital transmitters; however the scheduling of this could be delayed until regional roll-out occurred;
c. Additional communications links between studio, satellite uplink, and all transmitters will need to be established;
d. There will be costs for additional programming if the new services are to carry you programmes;
e. Capital investment into consume receivers and possibly antenna installations if there are new frequency bands used; and
f. Administration, publicity, promotion, and project management costs.

3.8 Content Guidelines in the Digital Standards

There is no particular difference between the requirements of digital and analogue television in relation to content standards. That is, existing content standards for programming remain equally valid for digital television as they do for today's analogue television. However, because digital television transmissions can carry additional material in the form of data regulatory provisions need to be included: which clarify the ability of broadcasters to include data transmissions within their broadcasts; define what part of the broadcast service elements of those data transmissions will be considered part of the broadcast service? and what would be considered to be a new service?. Because digital TV also includes extensive provision for parental and other control over programme content standards may also need to be established as to whether these controls are to be implemented or not.

An important element of digital production which may already have been addressed in Bhutan, a standards for the exchange of programme material and associated metadata which make it easier to track and administer the recording of programmes when they are transferred between broadcasters and to and from the national archive. Modern systems provide for metadata (information about the content which previously may have been carried on the tape label or on separate records) to be carried electronically with the programme.

Other considerations in digital implementation will depend on the model adopted in Bhutan. If multi-channel services are permitted then there may need to be standards established as to how the multi-channel will be used. For example, if the intention is to allow additional programmes to be transmitted to encourage digital conversion, or to enhance the availability of services across the country, then these will need to be defined. Where there are special transitional provisions to enable promotion of digital technology or other benefits, sunset clauses will need to be introduced so that content providers understand how and when their obligations start and finish.

The general provisions of the be the BIMC Act, already contain extensive arrangements to cover content. These will equally apply to digital; therefore the main concerns will focus on the use of the channel, particularly during the transition period.

3.9 Convergence and Competition Policies

Convergence has been loosely defined as a merger between information services, broadcasting, and print media. Convergence has already occurred extensively at the technology level where the same underlying technologies of computing service tools to enable efficient transfer of information across all media. This move to more universal means of moving content and information has enabled more inefficient transfer of material from one medium to another. For example, the Internet now serves as a strong cross promotional vehicle for radio and television and can carry additional material such as transcripts and additional content that previously could not be carried through the broadcasting stream. With the advent of IP communications technology, television can now be carried through broadband networks using IPTV models. Already there are many examples of consumer level exchange of video and other content over the Internet using the most basic of tools.

International standards, coordination and regulatory organisations such as the ITU and the IEC have devoted considerable efforts towards harmonisation of standards to allow free flow of information across all media.

Competition is concerned with the introduction of new services which operate in the same space as existing services. Competition can come from unrelated sources such as Internet services being competitors the broadcasting services, Internet services competing with print media. For the point of our current discussion competition beat the considered primarily as to how and when competing services might be introduced into the broadcasting bands and whether the progressive roll-out of broadband services will introduce additional competition in over time.

Consideration of competition is important if new services are to be introduced during the migration period. Any competitor needs to be given a “level playing field” under which to establish services. This will lead to consideration as to whether you services might commence on analogue, which is the way most viewers currently receive their services or whether the service might commence on digital only. In a multi-channel context, it would be economically more attractive to use shared infrastructure for the establishment of new services rather than see duplication of existing analogue facilities which would ultimately increase the cost of digital migration. Given that the Bhutan currently has only a national television broadcaster BBS, supplemented with some cable operators, the considerations will be quite different to those where existing competing commercial services already exist. At

the same time it will be necessary to ensure that aggressive competition does not hamper the migration to digital.

If competition is introduced, then any assistance provided to the new entrant and incumbent broadcaster BBS will need to be balanced so as to ensure some equity. There are various ways in which this could be achieved including providing a rent free or subsidized access to multiplexing equipment and transmitters during the transition period.

3.10 Economic Aspects

In its Report ITU-R SM.2012-2 the ITU summarizes some of the economic and national considerations of spectrum management[27]:

INTRODUCTION TO ECONOMIC CONSIDERATIONS IN SPECTRUM MANAGEMENT

1.1 Need for spectrum economic approach

The increasing use of new technologies has produced tremendous opportunities for improving the communications infrastructure of a country and the country's economy. Further, the ongoing technological developments have opened the door to a variety of new spectrum applications. These developments, though often making spectrum use more efficient, have spurred greater interest and demand for the limited spectrum resource. Thus, the efficient and effective management of the spectrum, while crucial to making the most of the opportunities that the spectrum resource represents, grows more complex. Improved data handling capabilities and engineering analysis methods are key to accommodating the number and variety of users seeking access to the spectrum resource. If the spectrum resource is to be used efficiently and effectively, the sharing of the available spectrum has to be coordinated among users in accordance with national regulations within national boundaries and in accordance with the Radio Regulations (RR) of the International Telecommunication Union (ITU) for international use. The ability of each nation to take full advantage of the spectrum resource depends heavily on spectrum managers facilitating the implementation of radio systems, and ensuring their compatible operation. Furthermore, the imbalance between the demand for radio frequencies and the availability of spectrum keeps growing, especially in urban areas. According to economic theory, when demand exceeds supply, a price system should be implemented. As the frequency spectrum is a scarce resource, decisions concerning spectrum management should also consider the economic point of view. Therefore, to improve national spectrum management all available means including economic methods are needed.

This Report has been developed to assist administrations in the development of strategies on economic approaches to national spectrum management and their financing. In addition, the Report presents a discussion of the benefits of spectrum planning and strategic development and the methods of technical support for national spectrum management.

These approaches not only promote economic efficiency but can also promote technical and administrative efficiency.

Before the economic approaches can be discussed it is first necessary to consider what is an effective spectrum management system and what areas of spectrum management can be appropriately supported by other means.

1.2 Requirements for national spectrum management

Effective management of the spectrum resource depends on a number of fundamental elements. Although no two administrations are likely to manage the spectrum in exactly the same manner, and the relative importance of these fundamental elements may be dependent on an administration's use of the spectrum, they are essential to all approaches. For further information on spectrum management functions see the ITU Handbook on National spectrum management.

1.3 Goals and objectives

In general, the goals and objectives of the spectrum management system are to facilitate the use of the radio spectrum within the ITU Radio Regulations and in the national interest. The spectrum management system must ensure that adequate spectrum is provided over both the short and long term for public service organizations to fulfil their missions for public correspondence, for private sector business communications, and for broadcasting information to the public. Many administrations also place high priorities on spectrum for research and amateur activities.

In order to accomplish these goals, the spectrum management system must provide an orderly method for allocating frequency bands, authorizing and recording frequency use, establishing regulations and standards to govern spectrum use, resolving spectrum conflicts, and representing national interests in international fora.

The economic implications of digital migration in Bhutan will be significant; but they will not be as great as they may have been there was extensive analogue network of competing services to manage. Already appropriate steps have been taken with the purchase of ready transmitters, which can easily be modified for digital transmission. The broad range of economic impacts have already been set out in Section 3.7

The Government will need to consider what license fees that may apply to broadcasters during the transition period. Broadcasters will be required to operate to transmitters during this period and depending on how the regulations are structured may require additional service licences.

3.11 Consumer Aspects

Consume aspects have already been discussed at some length in Sections 3.6 3.7 and more generally elsewhere. The key to success is ensuring early placement of receivers into the hands of viewers by whatever means. Helpful guidance to possible strategies can be found in

the various international web sites mentioned earlier that describe the approaches being adopted in those countries.

4 Development of Migration Plan

The regulatory and legislative framework for broadcasting and information technology in Bhutan provides an excellent foundation for the introduction of digital television. By considering migration after digital television technology has been well established internationally, Bhutan can take advantage of the lower costs and mature technologies that are now available for digital television.

The relatively new infrastructure for analogue television is relatively new and its development is continuing. Digital conversion costs could be minimized if digital channels were planned around adjacent channels to the existing VHF analogue services. This would simplify down-stream reutilization of the analogue transmitters and minimize the impact on viewers. The extent to which this is completely practical will need to be evaluated during detailed planning of services around the existing frequency allocations.

The provision of comprehensive television coverage of Bhutan confronts economic and technical difficulties. This suggests that the initial implementation of digital television might best be based on a multi-service per transmitter model with the multiplexer providing for additional services or perhaps being shared between BBS and future commercial or community television services. By conversion of the recently established analogue transmitters additional channel capacity could be provided in the longer-term which might permit a single service licensee per transmitter or additional services as the demand and financial capacity to deliver these so justifies.

In order to develop a comprehensive plan for digital television migration in Bhutan, the Digital Television Migration Working Committee will need to determine the appropriate answers in Bhutan to a number of fundamental strategic and policy questions which are set out in Section 3.1of this report. Items that can be included in the Terms of Reference for the Working Committee are set out in Annex D to this Report.

In its comments on the draft consultancy report, the Bhutan Working Committee said:

> *"Working committee will only be able to assist the Consultant in provide information and express needs and would like to be trained by the consultant while executing the work"*

Judging by the excellent work and sound thinking evident in the Ministry documents reviewed from the MOIC and BICMA web sites, the consultant feels that the issues are more that the committee is not confident about how to proceed rather than not having the technical capacity to undertake the work. Some of these concerns can be addressed during the proposed in-country visit and workshop where the committee can be assisted through consideration of the basic policy and technical questions. Development of a specific set of recommendations ahead of the visit would involve the consultant making a large number of fundamental assumptions about policy and planning issues without any dialogue with the key stakeholders. Digital migration must be based on relevant local needs and accurate information and an externally imposed/or implied solution would be totally inappropriate.

To provide some clarification of the task ahead draft Terms of Reference for the Working Committee have been prepared and are shown in Annex D to this Report, and a flow chart

and draft timetable for the Working Committee's deliberations has been prepared and is discussed in this section as general guidance to the committee. As the consultant has no specific knowledge of the skills and capabilities of the Working Party and its support team other than what can be implied from documents reviewed in the preparation of this report, there are inevitably gaps in assumptions and knowledge that will need to be addressed during the future workshops so that the Working Committee has the knowledge and confidence to proceed

Development of a Digital Television Migration Plan for Bhutan is clearly feasible but its realization will depend on access to appropriate policy, technical, and financial assessment skills to arrive at the best decisions about how, and when to migrate television to digital and the migration timetable which inevitably will need to be linked to the national capacity to fund the transition. The following guidance is intended to assist the Working Committee to give attention to the critical issues in the decision process. It cannot provide the answers as they will emerge from detailed deliberations between the Working Committee members, and the Bhutan Government. As the flow charts that have been prepared to outline the process show, arriving at some of the decisions will be an iterative one as various assumptions are tested against the economic and political models that prevail in Bhutan.

4.1 Policy, Planning and Approval Phase

The basic functions of the Working Committee are to determine the how, when, and why questions about digital television migration in Bhutan.

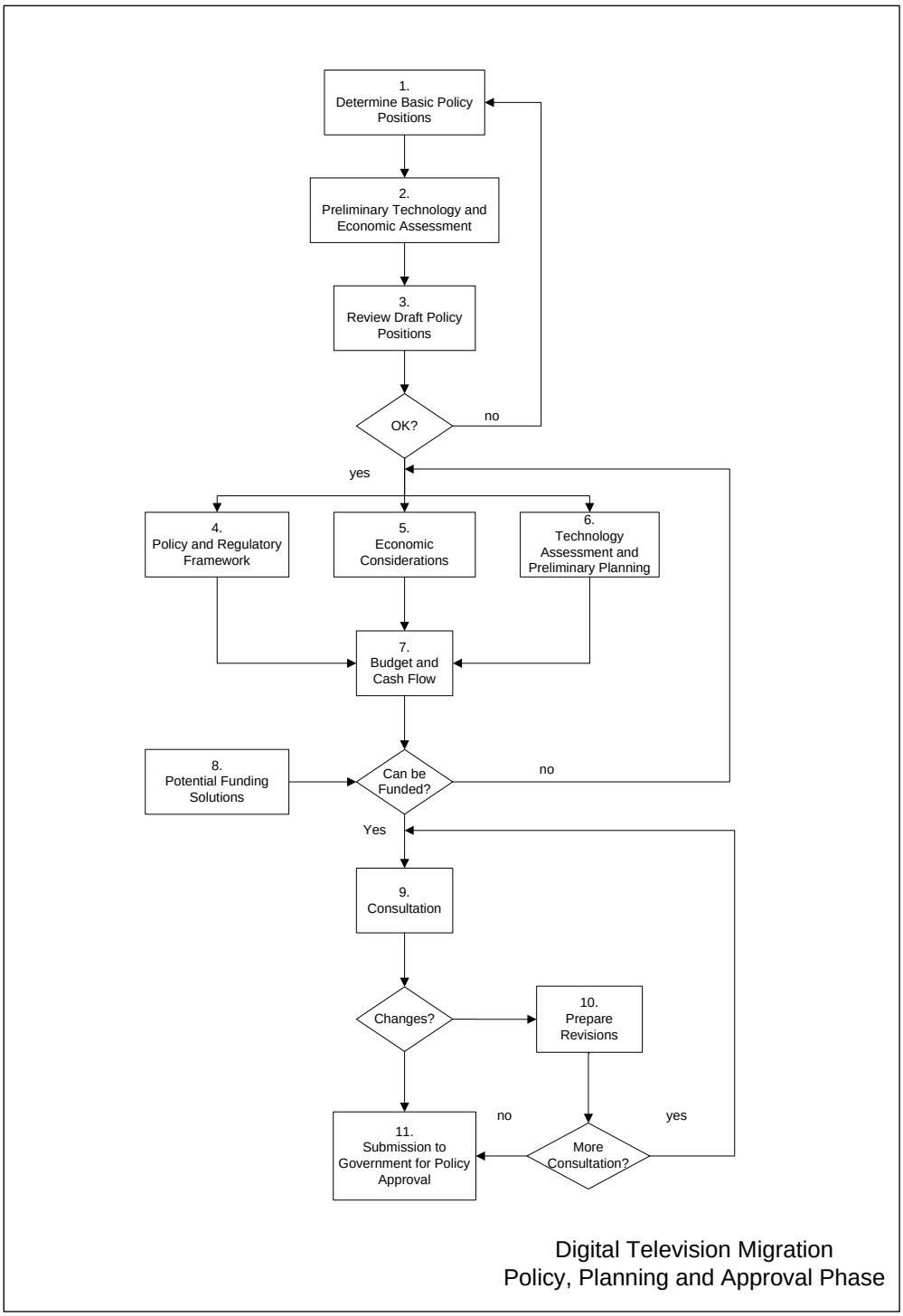
This broad range of activities and process flows for this first phase is shown in Figure 3 (a copy of the flow chart is also provided as Annex E to this Report) The specific content of each major step is explained in more detail in the sub-sections that follow.

The first step is to establish some fundamental policy foundations for the assessment of options. Initially these might be provisional policy principles against which initial assessments can be made and from the results of those preliminary assessments of outcomes, the policy principles can be fine-tuned to achieve a workable plan with realistic expectations about what can be achieved with the resources available.

These foundational policy principles then form the basis of detailed examination of the Policy and Regulatory (Legislation and Regulation requirements), Technology and Technical Planning Assessments and estimates of the resources and timetables to achieve the agreed objectives. All of these elements then come together to provide a draft economic impact statement, and task budgets and cash flows. At this point there should be a clear understanding of the costs, and from that funding strategies can be developed that are consistent with National objectives, and affordability.

In most countries, this work will come together in some form of report or policy paper that will be released to stakeholders and interested parties for comment before the final submissions are presented to Government. In most places, the draft policy paper would require at least ministerial clearance before release. The requirements of course need to follow the established practice in country and in relationships between officials and Government.

Government endorsement of the strategy and policy will usually also involve appropriate budgetary decisions to support the strategy and implementation. These decisions of Government then become the trigger for detailed work on legislation and other necessary administrative and planning tasks that form part of the implementation phase.



Digital Television Migration
Policy, Planning and Approval Phase

Figure 3: Television Migration Policy, Planning and Approval Phase

4.1.1 Establishment of the Policy Agenda

This first step is to establish and document an agreed motivation and objectives for digital migration including a notional timetable for migration that is linked to wider national ICT objectives and plans. By way of thought starters, some potential objectives for Bhutan might be:

a. Maintain step with global television migration (from analogue to digital) trends and timing to enable Bhutan to benefit from lower cost of supply of consumer and professional television equipment; thereby enabling the ongoing expansion of television services at a reduced cost;

b. To facilitate the introduction of additional national and/or competitive television services at reduced entry and infrastructure operating costs (using multi-service delivery model);

c. To allow viewers to take advantage of new and lower cost equipment and capabilities such as Personal Video Recorders (PVRs) which may enhance the role of television as a delivery platform for education and information (at possibly wider access and lower cost than on-line – especially while on-line is still being rolled out or is too expensive for some viewers (eg an education/information channel on a multiplex could be delivered nationwide at virtually no extra cost for infrastructure or transmission.

d. Allow realization of a "digital dividend" – or most likely to match Bhutan spectrum planning with international planning of next generation mobile telephony services which will ensure ready supply of lower cost handsets and infrastructure through international harmonization of the services and operating frequencies.

e. To start the migration in areas not yet served with television so that the analogue legacy problem is not extended.

f. Adopt latest technology solutions (DVB-T2, MPEG4) provide the cost penalty at launch is [say less than 20% and will fall over time] so that the life of the digital system is maximized. However, this may limit the available supply of lower cost reception equipment from say India, if the Indian system is locked to the current DVB-T MPEG2 standard. [The supply of equipment and costs will need to be a separate study based on the expected timetable for migration in Bhutan, and the decisions of neighbours and potential supplier countries]

g. The aspirations of Bhutan for additional services, including the capacity to program such new services, and in parallel to extend coverage to the unserved populations. A decision is also needed about when and if High Definition services will be part of the mix or whether it will centre on Standard Definition only.

h. What incentives might be provided to assist migration?

These are all policy questions for which some of the potential answers and linkages are already elaborated in various policy papers within Bhutan, particularly the relationships to other ICT objectives, and the Working Committee should with minimal assistance be in a position to propose some agreed draft objectives upon which more detailed work can proceed. The proposed in-country workshop will provide a catalyst to guide the working committee reach these decisions.

In discussing the objectives and options it may be useful to explore the Strengths, Weaknesses, Opportunities and Threats provided by the various approaches and what solutions might be available to address these in the migration plan.

The outcome of these deliberations should be:

i. Nominal service objectives considering needs 5-10 years out, (numbers of channels, HD, SD, mixed, system preferences, suggested mix of service types, timing of competition and arrangements under which competitive services might be introduced, ideas about whether digital services might be rolled out instead of analogue for future expansion of coverage during the transition period.

j. An in principle decision about migration, timing of commencement, and target for completion taking into account realistic economic capacity to deliver.

k. Coverage expectations (percentage of population to be served terrestrially- which will determine the number of transmitters) and the role of satellite (ie will there be a role for DTH services and how will these be accessed).

l. Draft policy position on competitive services/criteria for introduction/ possible timing, and relationship between these and the migration strategy.

m. National spectrum objectives (eg digital dividend).

n. Preliminary views about possible incentives for broadcasters and the public

o. Organizational and management arrangements to lead the transition (if there are to be structures and responsibilities other than the Working Committee and normal structures of BIMA and BICMA for example)

4.1.2 Regulatory Impact

The policy positions provide the basis for assessment of the existing legislative and regulatory instruments and how they may need to be modified to implement the migration strategy. At this point the assessment needs to estimate the amount of work involved in making the legislative changes, and the likely timetable for this work from commencement to final passage into law. The purpose is to provide an input into the migration timetable, and a cost estimate. The practical work in implementing the changes will follow from formal Government endorsement of the policy and strategy. No practical assessment of the legislative changes can be made before there is at least in principle decision about policy objectives.

4.1.3 Technology Consideration

Like the regulatory impact question, the Technology assessment at this stage needs to take a preliminary position on the system standard (ie confirm desire to proceed using the DVB-T system and to make a preliminary decision on whether the DVB-T2 and MPEG4 option should be further explored. The basic decision on the use of DVB-T or other systems will impact on the planning work required for the digital services. An assessment of the magnitude of this task is needed to allow a realistic budget to be established. Some guidance may be needed for this work but most of the necessary detail to assist the planners is

contained in the documents referenced in this Report and will also be covered in the proposed workshops to be held in Bhutan.

4.1.4 Economic and Budgetary Considerations

Economic and Budgetary considerations can flow from the above considerations. These need to be examined in the light of the potential sources, availability and timing of funds, against a practical implementation timetable derived from the preceding analysis. There is little point in proposing a plan without adequate resources. In an extreme case the inability to find the resources and the assessment of the economic impact might lead to a decision to defer migration until it can be resourced, and has less economic impact.

4.1.5 Work and Resource Plan

The work and resource plan will take account of all of the above work and provide a template and timetable against which the migration planning and implementation will progress once the direction has been agreed by Government and resourced.

4.1.6 Policy Approval

The final step in this first phase of migration strategy will be that of any formal consultation processes outside of the Working Committee, MOIC, and BICMA, and the preparation of formal submissions to Government for endorsement of the policy and the agreed resourcing strategy.

4.2 Implementation Planning Phase

The preceding stages are perhaps the most complex to manage because there are so many variables to consider. Once final decisions have been taken on the policy, timing, and funding questions, the detailed work can proceed from a stable foundation. At this stage there will be detailed examination and drafting of legislation and regulations, technical standards and guidelines, and detailed technical planning for transmitters.

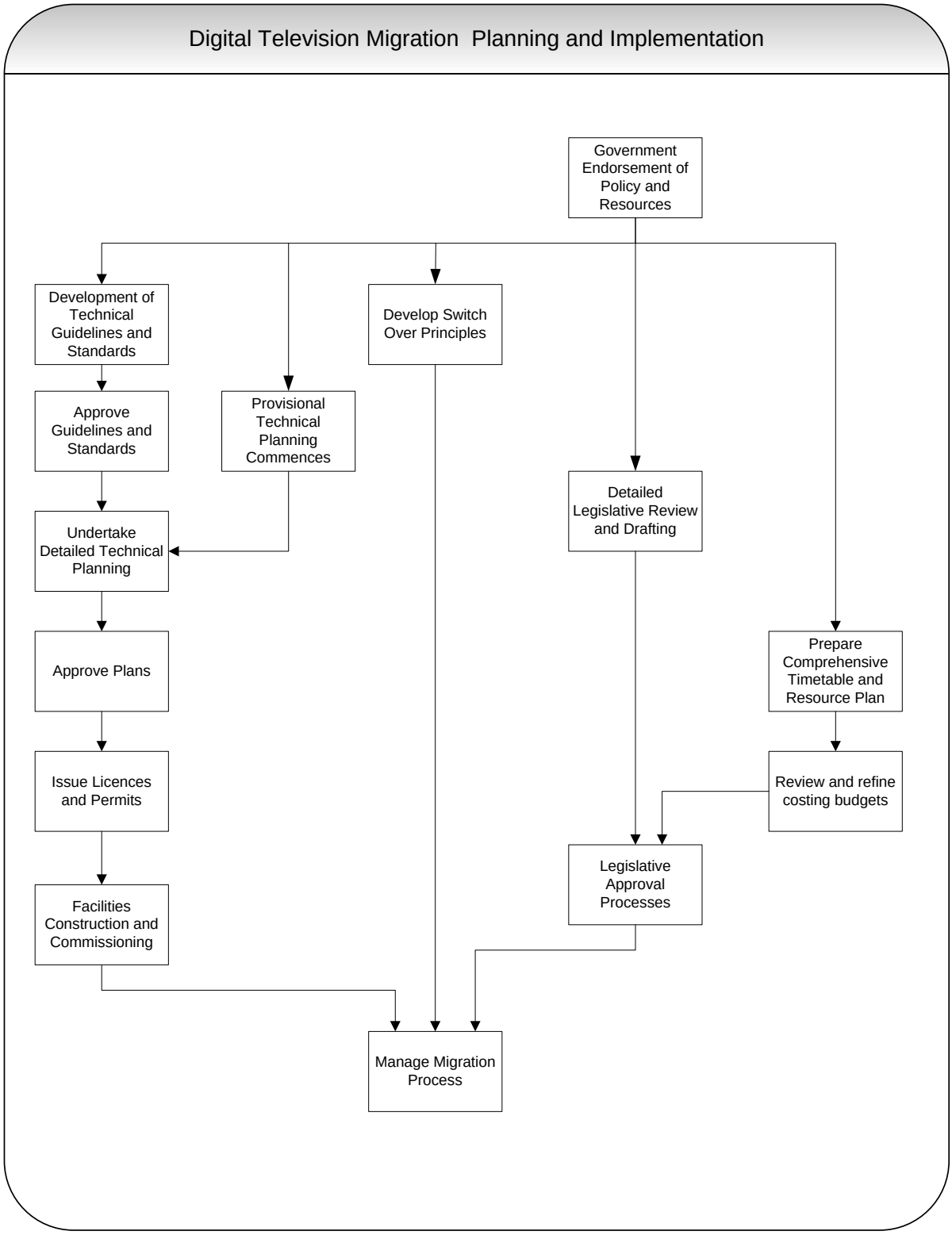


Figure 4 Planning and Implementation Phase

4.2.1 Legislation and Regulations

As stated earlier, a detailed review of the legislation and regulations that may be required cannot be started until there is clarity of the policy direction. As in any such review, the work will commence from a statement of drafting principles which can then be used to draft

the specific new or amending legislation that may be required. As mentioned earlier in this paper, preliminary assessments of the current legislation suggest that most of the provisions will not require changes to the BICM Act bit should mostly be addressed by Regulation. However, there are likely to be consequential changes needed to other legislation once a detailed assessment has been made. Any consideration of the wider legislative and consequential changes that may be required is well beyond the scope of the present consultancy.

4.2.2 Technical Standards and Guidelines

The foundations for the necessary technical standards and guidelines can best be found in the work of others who have adopted the preferred system. Considerable efforts have been made within the ITU, and in the various countries which have implemented DTV to provide useful guidelines and standards. In most instances, they would be happy to share this information with appropriate acknowledgements. There is little point in trying to develop these guidelines and standards from the ground up as Bhutan is unlikely to have the time or resources to duplicate the extensive body of work that is already enshrined in the published guidelines and standards. The work in Bhutan should be to review some of these and adopt and or modify them to provide a Bhutan centric solution that can provide the necessary regulatory and technical models.

4.2.3 Technical Planning and Licensing

Technical planning rules and licensing requirements will flow from the technical standards, guidelines, and legislation as has been the case for the existing analogue network; therefore this work is expected to be well within the capability of existing personnel in Bhutan. As the technical planning must take account of existing infrastructure and facilities, technical planning is best carried out as a collaborative exercise between the broadcasters, and regulators. This streamlines the process and assists in ensuring that the technical solutions provide the lowest cost to broadcasters and public.

Note that the migration will most likely require a satellite distribution service for the digital signals in parallel with existing analogue distribution so this must be included in the plans.

4.2.4 Operating Practices

Operating practices are important when there is more than one broadcaster in the country. At present BBS as the sole broadcaster can establish its own practices with little need to consider harmonization with other broadcasters on such matters as captioning, EPG etc. However, once competitive services are introduced then certain operating practices need to be agreed industry wide so that viewers equipment is not confused by different use of signals in the transmission stream, and programs can be easily interchanged as necessary between broadcasters. As mentioned earlier, there are various examples of operating practice documents available from other countries upon which to assess the Bhutan needs and to serve as a basis for Bhutan specific documentation.

5 Implementation Phase

The implementation of digital migration is expected to take several years. However, if money were not of concern, the low transmitter powers used across Bhutan make the roll-out process relatively simple compared with countries which have many high-power transmitters

and substantial tower infrastructure to deal with in the transition. The first step is to establish transmitters with digital program output because until there are programs to receiver there is little point in consumers purchasing receivers. The most common approach in developed countries which implemented digital migration early was to first deliver digital services to the largest cities so that receiver supply volumes would be maximized and ultimately increase availability and reduce price. In Bhutan, supply may not be the same concern and other considerations might suggest that early implementation might occur in places that currently do not have Television. This point has been discussed earlier.

5.1 Transmission Roll-Out

Transmission roll-out can proceed in parallel with planning of services. The roll-out will need to follow the policy guidance and be linked to a communications strategy that will inform the viewers of the changes. Were a 100% simulcast solution is proposed, the existing analogue network can be used to promote digital switchover. If the switchover is to occur using existing transmitters then simulcast would not be possible, but it may still be feasible to do this in smaller communities where other approaches to communicating and assisting the switchover might be used and so avoid the need for duplication of infrastructure. These are options that can be explored further in the proposed in-country workshops.

5.2 Switch-over Management

Switch-over management needs to drive the conversion process. Its primary focus will be ensuring that the broadcasters roll-out the transmitters against the agreed schedule, and most importantly, that there is a continuous flow of information to viewers, suppliers, equipment retailers, Government etc about the switchover and its progress. This activity will need to be resourced within MOIC or BICMA and should involve close collaboration with all stakeholders.

6 Recommendations

Since circulation of the first draft report, Section 4 of this report has been drafted to provide some further assistance to the Working Committee. From experience, the Consultant believes that this Report provides sufficient guidance to allow the Working Committee to commence its work with confidence. However, to reach that conclusion, the Consultant has made many assumptions about the level of resources and skill base available by reference to published documents available on the MOIC web site. Those assumptions will inevitably be wrong if the documents are the work of external experts rather than MOIC specialists. Until the proposed in-country visit and workshop are undertaken and detailed discussions take place with all stakeholders it is impossible to make a useful assessment of the indigenous capabilities and knowledge needs, and the costs, method and extent to which additional direct consultancy assistance can be usefully deployed.

The Consultant's one week in-country visit being considered by the ITU is expected to be scheduled in the first quarter of 2010. The current proposal involves a three day workshop in Bhutan and a further two days of industry and Government consultation. This workshop should provide the basis for addressing the basic questions of policy and planning for digital migration and assist the Working Committee in its deliberations.

In the light of the additional material provided in Section 4 and the proposed in-country workshop the Consultant considers that additional recommendations on implementation of the next phase would make too many assumptions about the skills and capabilities and resources available to the Working Committee members and about the needs of Bhutan. Assessments of these aspects will be made during the in-country visit and appropriate recommendations can then be prepared from a position of knowledge rather than speculation. The proposed workshop will be planned around providing the maximum transfer of knowledge and assistance to the Working Group so that they can become largely self-sufficient, and perhaps ongoing assistance might be simply provided by reviews of work produced.

The feasibility of migration of analogue television to digital in Bhutan will depend on the required time-frame and availability of money and resources to deliver a digital solution and to enable viewers to switch over. Digital migration will have a significant economic impact but also has potential benefits. These two components need to be assessed from a Bhutanese perspective and will be explored further in the future workshop where direct dialogue with stakeholders will be possible. The first task is to establish the policy framework for migration and that will be facilitated by the proposed in-country workshop. The guidance provided in Section 4 of this Report should provide the basis for early consideration of the issues by the Working Committee perhaps in preparation for the proposed workshop.

A draft timetable based on an assessment of the resources, capabilities, and tasks and informed by practical experience will be prepared during the proposed workshop in consultation with the stakeholders.

7 Annexes

A. An Introduction to Digital Terrestrial Television Broadcasting

B. Extract from ITU Report on Digital Television Migration: Chapter 4: Spectrum Management

C. Power Levels for Digital Television Reception

D. Draft Terms of Reference for Digital Television Working Committee

8 References

Australian Communication and Media Authority (ACMA) *Broadcasting Planning Manual* 2007 http://www.acma.gov.au/WEB/STANDARD/pc=PC_91711

Australian Communication and Media Authority (ACMA) *Technical Planning Guidelines 2007* http://www.acma.gov.au/WEB/STANDARD/pc=PC_91711

Bhutan Ministry of Information and Communications, *Bhutan BIPS Strategies 2009*

Bhutan Ministry of Information and Communications, *Technical Guidelines on Information and Communications Technology (ICT) for Preparation of the Tenth Five Year Plan 2008-2013* , August 2006, www.moic.gov.bt/pdf/tg.pdf

Bhutan Ministry of Information and Communications, *Broadcasting Policy (Draft) 2009* http://www.moic.gov.bd/pdf/broadcast%20%Policy%20(draft).pdf

Report Ministry of Information and Communications, *Bhutan Media Impact Study 2008* http://www.moic.gov.bt/pdf/mediaimpact_2008.pdf

Bhutan Broadcasting Service BBS , *Bhutan Broadcasting Service BBS Annual Report 2008*

Digital Terrestrial Television Action Group DigiTAG, *Understanding DVB-2 – Key technical, business, and regulatory implications*, Geneva 2009

Digital Terrestrial Television Action Group DigiTAG, *Analogue switch-off; Learning from experiences in Europe,*, Geneva 2008

Digital Terrestrial Television Action Group DigiTAG, *The Digital Dividend & the Future of Digital Terrestrial Television – DigiTAG Position Paper*, Geneva 2009

Government of Bhutan, *Bhutan Information Communications Media Act 2006*

Bhutan Ministry of Information and Communications *Bhutan Media Impact Study 2008* (www.moic.gov.bt)

Government of Bhutan, *Bhutan Telecoms Act 1999*

Bhutan InfoComm and Media Authority *BICMA Annual Report 2009*

DVB Consortium *DVB Fact Sheet 2nd Generation Satellite DVB-S2 July 2009*

DVB Consortium *DVB Fact Sheet Multimedia Home Platform – Open Middleware for Interactive TV July 2009*

DVB Consortium *DVB Fact Sheet DVB-H*

DVB Consortium *DVB Fact Sheet DVB-T2*

International Telecommunications Union (ITU) *Recommendation ITU-R BT.1368- Planning criteria for digital terrestrial television services in the VHF/UHF bands*

International Telecommunications Union ITU *Report ITU-R BT.2140-1 Transition from analogue to digital terrestrial broadcasting*.2009

International Telecommunications Union ITU *Report ITU-R BT2149-2 Economic Aspects of Spectrum Management*

Bhutan Ministry of Information and Communications *Draft Broadcasting Policy* (www.moic.gov.bt)

Bhutan Ministry of Information and Communications *Special Report 2007 on Communications and Transport*

Australian Government, *Radiocommunications Act 1992*

9 Annex A An Introduction to Digital Television

Source ITU Report pages 24 and 25

2.6.1 Introduction

Digital TV was introduced in 1994 in the United States of America and in 1996 in Europe and Japan, first on satellite and soon after on cable and terrestrial networks, based on the Advanced Television Systems Committee (ATSC), Digital Video Broadcasting ('DVB') and Integrated Services Digital Broadcasting (ISDB) specifications.

The EU average household penetration was estimated in 2002 at 32 million (21%): satellite: 21.5 million (13.9%); cable 8.1 (5.2%); terrestrial 2.6 (1.7%). Digitization of satellite TV is marketed.

With the advent of digital television, the public authorities must consider the future and make preparations for the transition from analogue to digital television to be as smooth as possible. The United States is scheduled to cease analogue television broadcasting in February of 2009. Japan is scheduled to cease analogue television broadcasting in July of 2011. Korea plans to make the transition from analogue to digital in December 2012. Some European countries have already decided to impose a cut-off date by which analogue television broadcasting will cease, with an EU-wide deadline already agreed for the year 2012. Brazil is scheduled to cease analogue television broadcasting in 2016.

There is therefore a need for government authorities to study the policy implications, proposed services, market (potential audience and financial volume), availability of channels for introducing digital television service and, of course, the technical integration of such a service in the existing analogue network.

The first stage in such a migration requires that a regulatory framework (law or ordinance) be set up to govern the introduction of digital television, specifying the number of multiplexes authorized (several broadcast channels per multiplex, one multiplex occupying the equivalent of an analogue channel) and the types of service.

The migration from a television service dependent primarily on the application of analogue technologies to one that is based on digital technologies has been evolving over the past thirty years. This television service migration is part of a natural outgrowth of the convergence of the television, telecommunications and computer arts and sciences through the shared use of digital technology.

The input and output signals of television systems, at the camera and at the receiver, respectively, are inherently analogue. Thus, the question "Why digital?" is a natural one.

While signal degradations in the analogue signal are cumulative and the characteristics of the degradations make them difficult to distinguish from the video signal, the ability to regenerate a digital pulse train exactly renders the digital signals theoretically immune to impairments from external sources. Digital bit streams can be interleaved within a single channel. This interleaving process allows for the emission, transmission, storage or processing of ancillary signals along with the video and associated audio. Further, compression techniques based on redundancy reduction can be applied to digitized video and audio services allowing the possibility of transmitting one HDTV service, multiple standard services or combinations of HDTV and SDTV in an existing broadcasting channel.

The arrival of the second and third generation component and composite digital video tape recorders, switchers, animated graphics and special effects machines and agreement on a serial digital signal interface by 1990 have sped up the move to implementation of the all-digital production facility. Digital production and use of digital tape recorders moved the broadcaster's practice on multi-generation editing from five generations of post-production editing using analogue technology to tens of generations using digital technology. The application of digital techniques has reduced camera set-up time from hours to near-instantaneous. Digital library systems made the location of recorded media transparent to the user. Computer control of the entire process penetrated deeply into the programme generation and distribution facility, bringing with it precise control and function repeatability.

The first use of digital broadcasting technologies has been for distribution between the studio and the transmitting sites either via satellite or terrestrial links.

As well as more channels than analogue television, digital television terrestrial (DTT) offers advantages likely to encourage viewers to buy or rent a decoder in order to receive it. Consequently, the advantages of the digital terrestrial television broadcasting (DTTB) are as follows::

a) ***Better Images and Sound*** *− A driving force behind the development of DTT was the ability to transmit high definition television (HDTV) to consumers. HDTV with high quality surround sound is the major focus of all delivery platforms including terrestrial broadcasting, satellite and cable. HDTV is also being delivered on disk using Blue-ray technology.*

b) ***Attractive New Programmes*** *− the attraction must be real and sufficient to capture audiences. Three types of channel are likely to arouse viewers' interest: general channels which either innovate or differentiate themselves from existing ones; more thematic channels, sufficiently encompassing and likely to appeal to a fairly broad target audience; and local or regional channels, which respond to the social, economic, and political concerns of viewers in their immediate geographic environment.*

c) ***Portability*** − *In the absolute, this is the ideal technical solution: by means of an antenna integrated within or connected to the set, television can be received outdoors as well as anywhere in the house, even on a pocket set. In terms of broadcasting infrastructure, however, it will be costly, as the main transmitters will need additional relays in order to provide all viewers in the DTT coverage area with portable reception.*

d) ***Interactivity*** − *DTT is also presented as offering viewers interactive services and applications – in other words, as allowing a dialogue between the television user and a service provider, for example provision of information, transaction services such as television shopping, gambling and banking. Ultimately, technological convergence should enable television to be the vector or the receptacle of multiple functions. However, the relatively slow take-up rate of the Internet in some countries where it is available shows that part of the population is reluctant to use such services. Their development may also be restricted by the narrow capacities of the available frequencies. Furthermore, some people are of the opinion that the television remote control is probably not the most user-friendly tool for navigating within an interactive programme or service, and it will be some time before there is any improvement in connection and response times.*

e) ***Mobility*** − *One of the most obvious advantages of terrestrial broadcasting compared with other means of broadcasting is the capability to provide mobile reception for cars, trucks, buses and trains.*

The most difficult switchover case is with terrestrial TV due to such factors as lack of spectrum in certain areas, cost of achieving wide coverage, relatively limited network capacity, competing TV offers already in place, and business mistakes.

However, there are significant national differences, notably in relation to market variables like penetration of individual TV networks (terrestrial, cable and satellite) and business models (free-to-air versus pay-TV), but there are also differences between national policies regarding the migration to digital broadcasting. So far, digital TV has mainly grown on the back of satellite pay-TV, with free-to-air still accounting for less than 20% of total digital TV viewing. In turn, pay-TV has been driven by multi-channel and premium programming, together with operators' subsidies for set-top-boxes.

10 Annex B Digital Migration and Spectrum Management

Extract from ITU Report on Digital Television Migration: Chapter 4: Spectrum Management

(ITU Report Sections 4.1.1.5-4.2.3 Pages 39-40

4.1.1.5 Spectrum Management

Limited availability of terrestrial broadcasting spectrum is both an important justification and challenge for switchover.

The spectrum situation varies from one region to another. In areas where spectrum is over-crowded simulcasting is more challenging and there is greater pressure analogue services to be switched off early.

Spectrum management has traditionally been closely controlled by national governments. In addition, a high degree of international co-ordination of spectrum management takes place within the ITU. These international fora focus on two major issues:

- avoidance of cross-border interference;
- promoting the availability of communication services and equipment on a global and/or regional scale by fostering the harmonisation of the frequency bands used for specific purposes.

In spectrum management it is necessary to distinguish "allocation", "allotment" and "assignment" issues. See respectively Nos. 1.16, 1.17 and 1.18 of the RR.

Allocation refers to the types of services delivered over specific spectrum bands (terrestrial mobile, fixed satellite, radio astronomy or other), on which harmonisation decisions are largely agreed at international level. Nevertheless, the distinction between different services may be increasingly challenged by market and technological developments, notably associated with digital convergence, calling for more flexible approaches to spectrum allocation. This issue affects, but actually goes well beyond, the switchover debate. Frequency assignment refers to granting of rights to use specific frequencies to a station.

The actual organisation of switchover and the timing of analogue switch-off are important factors. In Region 1 and some countries in Region 3 the provision of analogue services in one country could constrain the use of the same frequency bands in another. This tension between the priorities of different national governments is particularly acute for broadcasting signals because of the long distances they typically travel, due to their high power and their use of low transmitting frequencies (VHF and UHF bands). So switchover progress in these countries, and all its attendant benefits, may be held up by slower migration in neighbour countries.

Technical discussions on co-ordination issues have been taking place for some years in the ITU. In particular, a two-session ITU Regional Radiocommunication Conference, covering the whole European Broadcasting Area, Africa and contiguous countries, was held place to review the current frequency co-ordination planning for terrestrial broadcasting (the '1961 Stockholm plan' and Geneva 89 and their subsequent updates), so as to facilitate the digital transition and prepare the post-switch-off scenario. The first session was held in 2004 and the second session in 2006. These inter-governmental negotiations have a technical focus and decisions are not necessarily based on shared policy goals, with outcomes which may not be in line with market developments. The selection of co-ordination mechanisms according to specific technical criteria may also lead to the exclusion of other alternatives, possibly reducing market competition and consumers' welfare.

In this context, it seems justified to develop policy orientations on spectrum management and switchover to achieve the goals of the internal market, addressing in particular the three aspects mentioned: assignment mechanisms; organisation and time scales of the migration. This would help

clarify the real stakes of the switchover, in particular who will benefit from it, when and how. That would provide certainty for all those involved, help establish their respective responsibilities.

4.1.2 General considerations on broadcasting planning

As explained before, there is a general trend for introduction of digital techniques to replace analogue broadcasting. However, because of the very large numbers of broadcasting receivers in use and the long life expected for such receivers, it is clear that a changeover from analogue to digital broadcasting will not take place very rapidly in all countries. Indeed, the changeover can be expected to take many years in most countries. It is therefore necessary to consider very carefully how the changeover can be managed to ensure the end result is successful. It is also necessary to consider very carefully the transition period between an all-analogue situation and an all-digital situation if harmful interference to broadcasting reception is to be avoided.
In the context of transition, it must be stressed that there are two separate phases to be considered. The first phase occurs when digital transmissions are introduced into broadcasting bands, which are already occupied, more or less completely, by analogue transmissions which remain in operation. The second phase occurs when the analogue transmissions are switched off allowing the opportunity to introduce additional digital transmissions. Planning considerations during these two phases are likely to be very different but, at present, sufficient information is only available to allow detailed examination of different approaches for the first phase.
In preparation for the first session of Regional Radiocommunication Conference (RRC-04) the Task Group 6/8 produced an input document containing several planning scenarios.
The second session of the Regional Radiocommunication Conference (RRC-06) established digital terrestrial broadcasting DVB-T plan for television systems in Band III (VHF), Bands IV and V (UHF), and digital terrestrial sound broadcasting T-DAB plan in Band III (VHF) in Region 1 and certain Countries in Region 3, known as Geneva-06 Plan. This text can be accessed via internet at http://www.itu.int/ITU-R/conferences/rrc/rrc-06/plan_process/index.html.

4.2 Broadcasting planning principles

4.2.1 General considerations

The planning of terrestrial analogue broadcasting services during the Stockholm and Geneva Conferences was based on the concept of an ‘assignment’ defined in No. 1.18 of the RR as:

> *“Authorization given by an administration for a radio station to use a radio frequency or radio frequency channel under specified conditions.”*

In the context of producing a plan using an assignment planning approach, an assignment consists of a (single) transmitter site (specified in terms of longitude and latitude), with given effective radiated power (e.r.p.), effective antenna height, transmitter radiation pattern, etc. These parameters are chosen to ensure acceptable reception (or coverage) of an intended program in an area associated with, and usually surrounding, the transmitter location. However, the desired coverage of the assignment is not explicitly taken into account during the development of the plan and, in principle, cannot be determined until the plan had been finalised.
As more attention is now being placed on the need for a plan to achieve protection of a known coverage area and as digital techniques offer greater potential for planning approaches, the concept of assignment planning has come under close examination This has evolved into a related but more flexible concept termed ‘allotment planning’. An allotment is defined in No. 1.17 of the RR as:

> *“Entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by one or more administrations for a terrestrial or space radiocommunication service in one or more identified countries or geographical area and*

under specified conditions."

However, in order to avoid difficulties with regard to the competence of administrations in territories other than their own, in the context of planning for terrestrial broadcasting services, this definition can be taken to mean:

> *"Entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by an administration for a terrestrial broadcasting service within its own territory, or geographic areas within its territory, and under specific conditions."*

4.2.2 Coverage of an allotment area

Allotment planning may be used to ensure that the area which is intended to be protected against interference is taken into account during the development of a plan. The coverage of an allotment may be achieved by using:

- A single frequency network (SFN) consisting of a group of transmitters whose precise site locations and other technical characteristics are known at the time when the plan is made because the transmitter infrastructure has already been determined. In this case, the interference potential of the network can be represented by the set of assignments forming the SFN.
- A single transmitter with known characteristics at a pre-determined site. The interference potential is represented by the assignment.
- A single frequency network (SFN) consisting of a group of transmitters whose precise site locations and other technical characteristics have not been determined at the time when the plan is made. In this case, the interference potential of the network must be represented by means of a reference network.
- In the case where a small area is to be covered but where there have been no decisions regarding the choice of transmitter site or other characteristics, the interference potential may be represented by a single transmitter.

See Recommendation ITU-R SM.1050-1.

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4.2.3 Allotment test points

Once the coverage area for an allotment has been decided, its boundary must be explicitly defined by means of test points. These test points will serve several purposes.

First of all, the allotment test points will define the geographical position, shape, and size of the allotment, that is, the 'allotment boundary':

- For this purpose, the test points are to be specified using, where appropriate, an agreed set of national boundaries and coastlines (as contained in the ITU IDWM), in terms of degrees, minutes, and seconds of longitude and latitude.
- An allotment area will be represented by the polygon (or polygons) defined by the specified test points (which will be the vertices of each polygon). Because only a limited number of test points can be usefully treated, the match between the polygon (or polygons) and the desired coverage may not be exact; therefore the choice of test points must be made carefully to demarcate the allotment area to a sufficient degree of accuracy.
- The test points for a given polygon should be ordered so that, when straight lines are drawn between consecutive points, a closed polygon is formed with no sides intersecting and containing the intended coverage area. This means that the coordinates of the first test point

and the last test point in the sequence for the polygon must be identical (i.e., they represent the same physical point) so that the polygon 'closes'.

Secondly, for calculations during planning in those cases where the interference potential of the allotment is represented by means of reference networks rather than by actual assignments, the test points will be used for the locations of the source of the interference that is associated with the allotment. In this way the interference potential of the allotment can be assessed.

Thirdly, for calculations during planning, the interference level due to other allotments or assignments will be calculated for the allotment test points. For this reason they should be 'reasonably' spaced. This means that they should give a 'good' approximation to the intended coverage area, the idea being that any potential interference within the polygon (i.e., the coverage area) will be no more than that occurring at the test points; too large a spacing may not assure this aim. On the other hand, too small a spacing may be 'overkill' and only lead to superfluous calculations.

11 Annex.C. Minimum Signal Levels Planning of Digital Television Reception

Power Levels for Digital Television Reception

Source: Australian Communications and Media Authority Broadcasting Planning Handbook 2007.[28]

Planned minimum field strength figures for Analogue television

(50% of locations, 50% of the time, measured at 10 metres above ground level – see guideline 9)

TV Transmission Band	*Frequency Range (MHz)*	*Planned Minimum Field Strength (dBµV/m)*
I	45 - 70	50
II	85 - 108	50
III	137 - 230	50
IV	520 - 582	62
V	582 - 820	67

Planned minimum field strength figures for digital television

(50% of locations, 50% of the time, measured at 10 metres above ground level – see guideline 9)

TV Transmission Band	*Frequency Range (MHz)*	*Planned Minimum Field Strength (dBµV/m)*
III	174 - 230	44
IV	520 - 582	50
V	582 - 820	54

See ITU Recommendation *ITU-R BT.1368-8*[*] *Planning criteria for digital terrestrial television services in the VHF/UHF bands* for a more comprehensive analysis of the protection requirements for different operating parameters.

[*] The material and terms used in this Recommendation in no way modify/replace/supersede those used in the GE06 Agreement.

Note the approximate 6dB difference between Analogue and Digital figures and in particular the difference of 6 dB between Band III VHF and Band IV UHF which essentially suggest that the power levels for Band III UHF should be retained for Band IV UHF to achieve roughly equivalent coverage.

12 Annex D: Draft Terms of Reference for Digital Television Working Committee

The Working Party is required to make recommendations to the [Government/MOIC] on all aspects of the introduction of digital television to Bhutan

The Working Committee should provide a preliminary report by [date] covering questions upon which it needs endorsement or guidance to allow it to complete its work and should complete its final report and recommendations by [date]

In undertaking its task the Working Committee should consider:

a. The preferred approach to the strategic policy questions set out in Section 3.1 of this ITU Digital Broadcasting Migration Bhutan Report;

b. The number and type of television services that may be required/practical in Bhutan over the next 5-10 year time period including multi-channel, HDTV, and other services using this technology;

c. An assessment of the costs of digital conversion for all stakeholders (Government, Broadcasters, Infrastructure, Consumers) including both capital and ongoing operating costs;

d. How when and why digital television should be introduced into Bhutan;

e. How and when competitive services should be introduced into Bhutan, including ways in which such services might be introduced in an equitable manner;

f. Whether digital television should be introduced using a multi-service per transmitter channel basis or as a simple multi-program single licence per transmitter solution;

g. The system standards to be adopted in Bhutan for digital television;

h. Review the existing legislation and regulations and determine what changes and additions need to be made to implement the recommendations of the Committee;

i. Develop detailed spectrum and channel plans for implementation of digital television including recommendations on the channel plans to apply post analogue switch-off;

j. Determine arrangements for establishing the necessary standards in Bhutan to implement the recommended approach (eg technical standards, and associated service specifications);

Strategic Policy Questions (from Section 3.1)

a. Why consider migration to digital?

b. What are the national and public policy objectives to be advanced through digital migration? What are the major enabling factors (eg content, new types of services, specialist channels such as education and information services...)?

c. To what extent should IPTV and Internet services (which may be used to rebroadcast or allow replay of broadcast programmes) be considered in the framework?

d. What expected future changes in needs or services should be considered in formulation of the strategy so that they can be enabled easily at the appropriate time?

e. What form of digital television is needed to deliver these objectives (eg. multi-channel, HDTV, mobile television, associated data services....)? How will this change over time? Should provision be made in the migration framework to enable such evolution in the future?

f. What is a realistic timeframe for migration given economic capacity of Bhutan, the need to ensure most people can receive services intended for them, the cost of professional and consumer equipment, the resources including technical capacity to implement the migration and to create or acquire any new content needed to assist in the process?

g. Should future extension of services to those places without any television be implemented a digital only services? At what point would this be a sensible strategy (assuming 100% coverage in analogue is not achieved by the time migration commences)?

h. To what extent should broadcasters have freedom to use the data stream (eg can they use the allocated data stream for additional services? Will they be required to hold separate licences for each service? What types of licence would be appropriate?

i. Will new services be considered in the strategy (television, data, and other types of services?

j. How would any new broadcasters be accommodated (eg digital only new services, new services commencing on analogue and migrating to digital...)?

k. What technical standards should be adopted that will best serve the needs of Bhutan, be cost effective and sustainable?

l. What is the preferred video display standard? Should this be mandated or can it be left to the broadcasters to decide what best meets their needs?

m. What particular factors should be considered in reaching a decision on the technical standard?

n. How will consumer migration to digital be accomplished (simulcast, subsidy, new programmes...)?

o. What would be considered an appropriate penetration of receivers to consider migration sufficiently advanced to turn off analogue? (eg x% of the current analogue

television penetration? One per household? One per village? Multiple receivers per household?).

p. Will assistance be provided to consumers? What form should that take? At what point would it be announced/decided?

q. Will any assistance be provided to broadcasters and will current assistance through exemption from duties on equipment and software be continued to assist broadcasters achieve the roll-out of digital services in a timely manner?

r. Will any new entrants receive the same assistance as may be contemplated for existing broadcasters (eg BBS)? Would this depend on whether they have to migrate from analogue or commence directly on digital? Would any subsidy apply if they are sharing a common multiplexer and infrastructure?

s. What is the most appropriate spectrum to use for Digital to minimize cost, maximize service delivery etc against potential competing needs for spectrum by other services including other ICT services such as mobile telephone?.

t. What factors will determine the end of analogue transmissions and the end of any simulcast period?

u. What is to happen to the spectrum vacated by analogue transmissions?

v. What other ICT and other services need to be considered in the spectrum and planning decisions? (eg Mobile TV using say DVB-H technology)

w. What role should satellite play in achieving universal coverage of Bhutan and what is the optimal way to achieve this from a technical, cost and user perspective?

x. Assignment of Logical Channel Numbers for Bhutan digital services

13 End Notes

[1] Email from Bhutan Ministry of Information and Communication dated 8 January 2010.
[2] Report ITU-R BT.2140-1..... p 5
[3] Ibid p 5
[4] BIMC Act preamble
[5] MOIC Report Bhutan Media Impact Study 2008 p13 http://www.moic.gov.bt/pdf/mediaimpact_2008.pdf
[6] Advice received from The Bhutan Project Team
[7] Comments from Bhutan Project Team in Teleconference and email exchange Dec 2009
[8] Bhutan Ministry of Information and Communications, Technical Guidelines on Information and Communications Technology (ICT) for Preparation of the Tenth Five Year Plan 2008-2013 , August 2006, www.moic.gov.bt/pdf/tg.pdf
9 Bhutan Ministry of Information and Communication Draft Broadcasting Policy,http://www.moic.gov.bd/pdf/broadcast%20%Policy%20(draft).pdf .
[10] See ITU Report p 6
[11] Media Impact Study 2008, p13 and elsewhere
[12] http://www.digitaltelevision.gov.uk/wswitchover_home.html
[13] Handbook general ref on spectrum Chapter
[14] ITU Handbook Section 3.1 and 3.2 Pages 32-33
[15] ACMA Broadcasting Planning Manual http://www.acma.gov.au/WEB/STANDARD/pc=PC_91711.
[16] DVB Fact Sheet DVB Handheld
[17] ITU Handbook BT2140-1 Pages 25 and 26 A narrative and substantially non-technical description of each of the systems is contained in Part 2 of this ITU Report.
[18] http://www.dvb.org/technology/dvbt2/
[19] Goia, Garazi; British Broadcasting Corporation, *Freeview HD in the UK: on week to launch*. Conference paper Forecast 2009 - EBU, Nov 2009
[20] DVB Consortium, *DVB-T Deployments Worldwide*; http://www.dvb.org/about_dvb/dvb_worldwide/index.xml , 2009
[21] Digital Terrestrial Television Action Group, Geneva, *Digital Television Implementation in Europe*, http://www.digitag.org/DTTMaps/country_homePage.php 2009
[22] SAI Global Australia, www.saiglobal.com
[23] http://www.digitalready.gov.au/publications.aspx
[24] Bhutan Ministry of Information and Communications *Media Impact Study 2008* , p 13
[25] ITU-R Report s1.6 p 7-8
[26] http://www.dvb.org/technology/fact_sheets/ - DVB Open MHP Multimedia Home Platform
[27] Report ITU-R SM.2012-2 *Economic Aspects of Spectrum Management P 7*
[28] ACMA Broadcasting Planning Manual: http://www.acma.gov.au/WEB/STANDARD/pc=PC_91711