GEORGIA: Communications Policy & Regulation Development (Extension)

Digital Broadcasting Switchover, Implementation Support

Technical Requirements

[16 Apr 2014]

J. Kanervisto Consulting

in conjunction with:

Digita Oy

J. Kanervisto Consulting

Contact points;

Mr. Tauno Aijala
email: jukka.kanervisto@nic.fi

Mr. Kari Risberg
email: kari.risberg@digita.fi

Organised by the European Bank for Reconstruction and Development

J. Kanervisto Consulting: Tammelan metsätie, FI-08680 Lohja, Finland
Tel. +358 50 543 7241, Fax: +358 19 335 202. email: jukka.kanervisto@nic.fi

Contents

1 Site survey based Requirements

1.1 Report Overview

Information of the existing infrastructure on the transmitting sites has been gathered by site surveys performed by auditing TRC (Teleradio center) experts. TRC has a good general knowledge of their infrastructure and according to their response site survey was not mandatory for every site. Specific site survey form was used for gathering information during site surveys (Appendix1). Seven sites were surveyed and documents have been received from TRC.

This report is based on the results of inspection and auditing of the two sites and the summary information of seven site surveys performed by TRC .

1.2 Findings and suggested actions

1.2.1 Location

All sites can be accessed by car. In case of site location over 2000 meter altitude, special transmitter type is needed for ensure adequate cooling.

1.2.2 Antennas

- Existing antennas are not suitable for digital transmitting because of power capacity and channel limitations of old antennas and therefore, new antennas are required for most of the sites.
- According to the information provided by TRC, there is space for new antennas on tower/mast at every site. In some cases space can be limited and top antenna installation is not possible. This might cause some limitations for radiation pattern. Mechanical strength of the mast can also limit the size of the potential antenna types.
- Towers/masts have sufficient space for new coaxial feeder lines.

1.2.3 Buildings

1.2.3.1 Space

There is enough free space for new digital equipment and hence transmitters, mask filters and distribution equipment for the state mux can be installed in existing buildings.

1.2.3.2 Ventilation and air conditioning

There is no centralized ventilation and cooling system in site buildings. New air conditioning / ventilation system is needed for most of the sites. Liquid cooled transmitters are recommended for high power stations (transmitter power > 900W). Heat exchangers for liquid cooled transmitters are possible to install outside the building. Depending on the site, some cover might be needed for heat exchangers.

1.2.4 Power supply

1.2.4.1 Main electric supply

According to the information from TRC, main transformers and main distribution boards have enough capacity for new transmitters. Condition and safety of existing main supply must be checked before connecting more electric load to the system. Replacement of the existing system might be necessary in some cases.

1.2.4.2 Sub distribution board

Existing distribution boards are possible to extend and use for new digital equipment at many site locations. However, it is highly recommended to install new sub distribution boards for having improved reliability and safety

1.2.4.3 UPS

Sites have not free Uninterruptible Power Supply (UPS) capacity for new digital equipment. UPS supply is needed for following devices:

- Head End
- Distribution devices
- Exciter and control units of transmitter. UPS can be integrated into transmitter or provided as an external unit.

1.2.4.4 Emergency power supply

Only some of the sites have a backup generator. These generators don't have free capacity for new digital transmitter.

It is mandatory to have backup generator to provide required capacity level. Generator could be installed in suitable room or be an external unit outside of building.

1.3 Project specific Deliverable

Vendors' proposals should include budgetary quotation of at least the following list of measuring equipment for the project:

- Handheld Spectrum Analyzer with at least 3Mhz-3Ghz frequency range and VSWR measuring bridge.
- Handheld Spectrum Analyzer with at least 10Mhz-18Ghz frequency range
- TV Analyzer for the analysis of DVB-T2 broadcasting signal
- High Frequency Radiation Meter - with at least up to 30Ghz frequency range

2 Transmitter System Requirements

2.1 Description of transmitters

2.1.1 Introduction

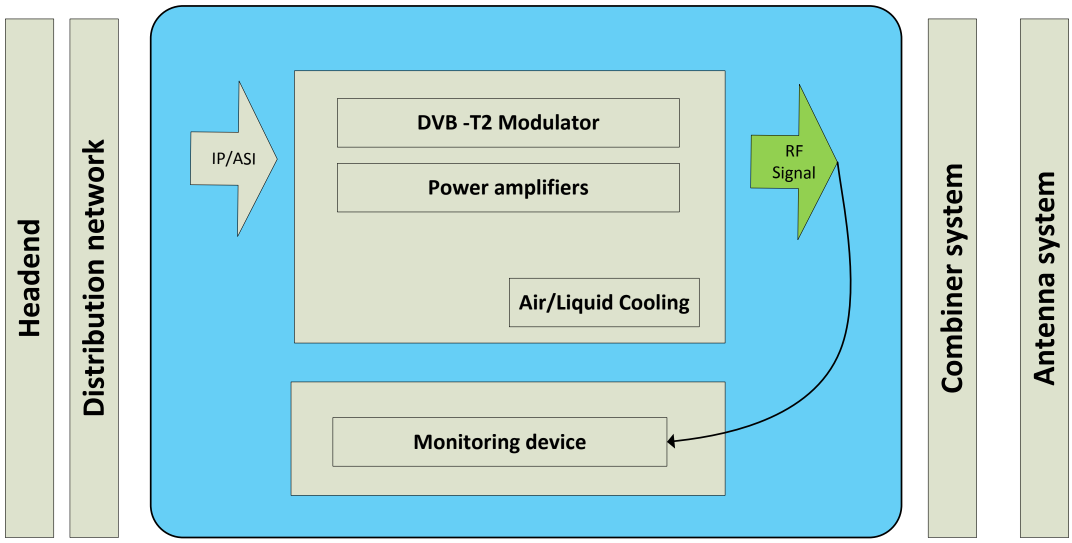
Transmitter and transmitter system defines equipment used for Digital Terrestrial Television broadcasting in Georgia.

State mux Parameters: 256 - QAM (NON rotated), 32kE, CR 2/3, CI 1/8

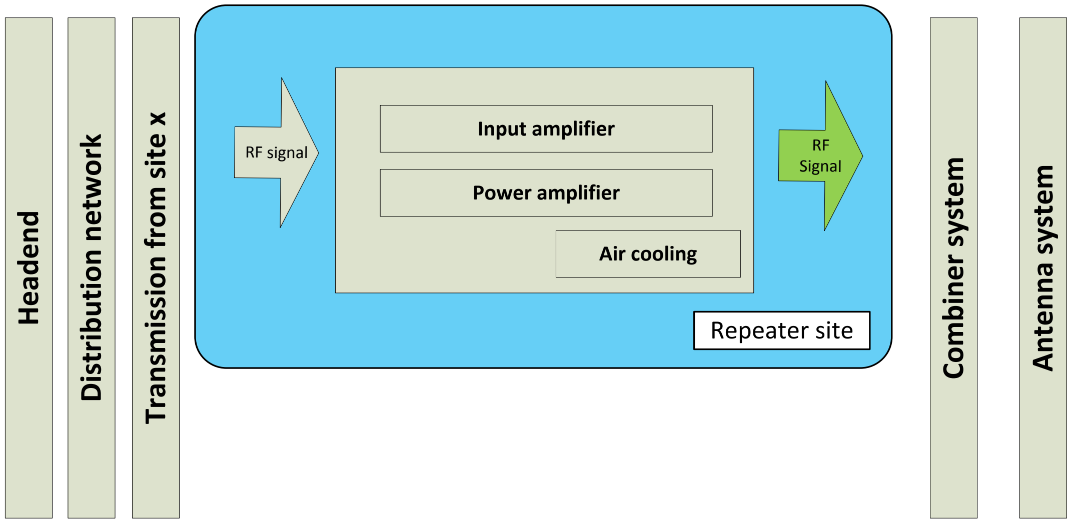
Transmitter system will receive signal from distribution network which is either IP or ASI signal. T2-MI format generated in T2-gateway is received by transmitters which are not repeaters. Input signal is converted to RF frequency and coupled to transmitting antenna via mask filter and feeder lines (rigid or semi rigid). In case of a repeater site, transmitter system input signal is RF signal which is down converted, amplified and up converted to transmitting frequency.

State mux will have its own transmitter system consisting of cooling and monitoring solution (GPS receiver or synchronization from distribution network are added if needed).

Remote control should be made available as mandatory. Transmission Network Operation Centre will be in Tele Radio Center (TRC) which will manage and monitor the entire network 24/7/365.



Picture 1: Block diagram of transmitter system in main site



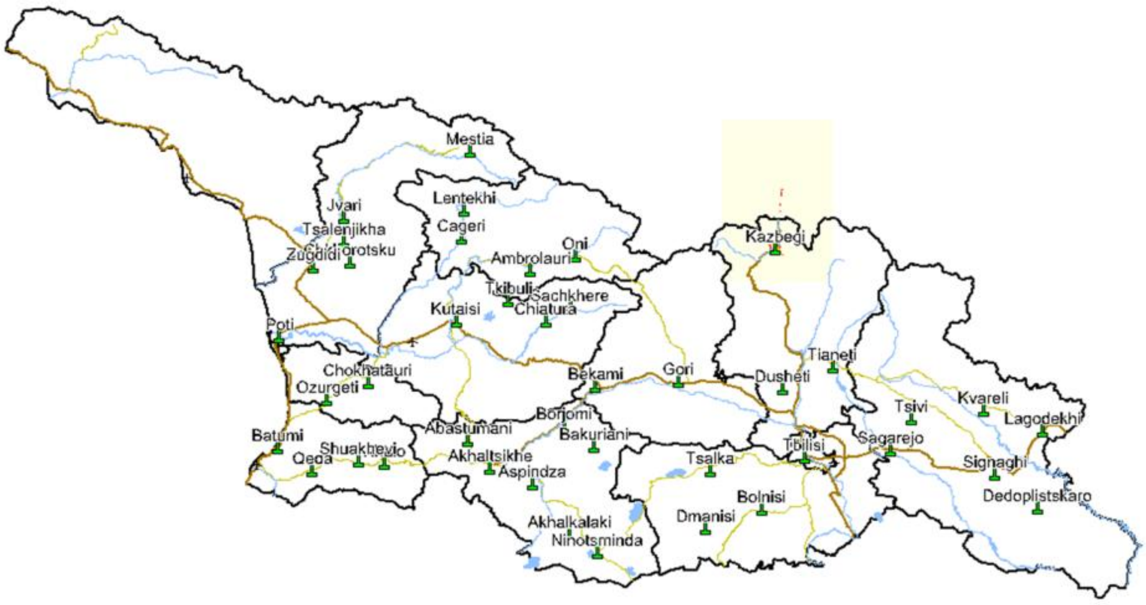
Picture 2: Block diagram of transmitter system in repeater site

Transmitter system related device is T2 gateway where modulation parameters will be defined as well as in transmitter itself. Network parameters for Digital Terrestrial Television are defined in rules of operation (RoO) which will guide T2 gateway parameter settings.

Main parameters	Network Parameters used in Georgia (RoO)	GW parameter checked and designed according to RoO
FFT Size	32k	x
Bandwidth	8 MHz	x
Extended Bandwidth Mode	Yes	x
Pilot Pattern	PP2	-
Modulation	256-QAM	x
Code Rate	2/3	x
FEC Type	64800	x
Rotated QAM	No	x
Data Rate Mbit/s	33,34	x
Number of PLP's	3	x
PLP mode	High efficiency (HEM)	x
ISSY	Long	x

2.1.2 DTT Concept in Georgia for transmitter design

Sites have been categorized in 4 different classes.
Sites in category 1 are required to have redundancy in transmitter configuration (Dual drive).
Sites in category 2 - 4 are required to have redundancy from spare part allocation and individual sites can have redundant configuration in case of being difficult to reach from maintenance point of view.



Picture 3: Transmitter stations in Georgia

2.1.3 Definitions

2.1.3.1 Transmitter structure/configuration

Transmitter configuration must be determined for each station. Configuration data must indicate cooling solution, redundancy and output power. Number of power amplifiers (PA) and modulators, cooling solution and redundancy should be gathered to one table for entire network according to 2. Power level calculation_CONFIDENTIAL.xlsx

2.1.3.2 Cooling solution

Transmitter can be cooled either by Air or Liquid. Liquid cooled transmitters cooling system are required to be built with pipes (10 – 30 m of no less than 40mm diameter pipe) or with flexible hoses (10 – 30 m of no less than 40mm diameter hose) and heat exchanger outside the building. Air cooled transmitters cooling are required to be built with air ducting channels (200 -300 mm diameter steel pipe) for guiding hot air out of the room. With lower output powers, depending on equipment installation space cooling capacity, dissipated heat can be also left to the room itself.

2.1.3.3 Monitoring

Monitoring solution for main sites is for RF output signal at station level. Implementation methods are static or scanning, meaning that static monitoring device will monitor only one (1) transmitter when scanning monitoring device can monitor several transmitters.

2.1.3.4 Synchronization

Transmitter system needs to be synchronized for SFN networks. Transmitter system input interface for synchronization is 1 PPS (pulse per second). Synchronization information can be obtained from distribution network with Network equipment or from separate devices.

2.1.3.5 Redundancy

Transmitter system redundancy can be active and/or passive stand-by. Active stand-by means for example that the final output power is generated with two (2) active transmitters and in case of failure, active transmitter will raise the power to the level of final output power level. Active redundancy can be internally implemented inside the functional unit (eq. PA); number of PA's are selected so that in case of failure output power is decreased to a certain level. Passive stand-by is recommended for redundancy. Passive stand-by can be passive transmitter that will automatically turn on (correct frequency and output power) in case of failure (N+1 or 1+1), number of modulators (single or dual drive) selected so that in case of failure transmission breaks can be avoided and cooling solution designed so that in case of failure transmission breaks should be avoided. External influences (electricity break) should be minimized by having UPS for logical units (eq. modulator, transmitter control unit).

Item	System	Functions	Redundancy Level
1	Modulator	Convert signal to RF frequency with single unit	**SD**
2	Modulator	Convert signal to RF frequency with 2 units (automatic switching between units in case of failure)	**DD**
3	Tx system	Convert signal to RF frequency with output power x kW	**Single tx**
4	Tx system	Convert signal to RF frequency with output power x kW (automatic switching between transmitters in case of failure)	**N+1, 1+1**

Different implementation methods regarding transmitter systems can be presented. Offered solution must fulfil requirements of determined DTT service implementation concept in Georgia.

2.1.3.6 Equipment Communication

Transmitter system in main sites must support remote control and monitoring via IP-connection. Device communication and alarm messages will be gathered to Transmission Network Operation Centre via SNMP messages. Equipment must have SNMP agent for sending and receiving the management information between the device and SNMP management system.

- SNMPv1 and SNMPV2c must be completely implemented
- It must be possible to change the SNMP parameters (e.g. community strings, trap destinations, IP ports) remotely via non-proprietary protocols and applications. Access is password-protected only.
- The physical interface of the equipment is Ethernet (10BaseT, 100BaseT with RJ45 connectors).

2.1.3.7 Transmitter types

Block diagram of transmitter types that can be used in Georgia. Configurations of chosen transmitters have to be presented according to 1.3.1.

2.1.3.8 Combiner/Filter design

- Mask filter is needed for the State MUX to fulfil DVB spectrum mask which is mandatory.
- Patch panel is not mandatory.

2.1.3.9 Environmental requirements

For high altitude locations (>2000m) transmitter system needs to be designed with increased power capacity since altitude will effect heat dissipation.

2.1.3.10 List of standards

To ensure interoperability, DVB-T2 gateway and transmitter system devices must conform to standards outlined by International Electro technical Commission (“IEC”), European Telecommunication Standard Institute (“ETSI”) and Digital Video Broadcasting (“DVB”) as detailed below.

Sources	Signal Type	Standards
DVB-T2 Gateway	DVB-T2 MI	• DVB A136: Digital Video Broadcasting: Modulator Interface (T2-MI) for a Second Generation Digital Terrestrial Television Broadcast System
Transmitter Network	DVB-T2 Transmission	• ETSI EN 302 755: Digital Video Broadcasting: Frame Structure Channel Coding and Modulation for a Second Generation Digital Terrestrial Television Broadcast System • ETSI TR 101 290: Digital Video Broadcasting: Measurement Guidelines for DVB Systems

2.2 Technical list of the needed transmitters (powers, redundancy, cooling…)

Designed reference network, transmitter configurations are given for each site in excel format Power level calculation_CONFIDENTIAL.xlsx

Site list	Transmitter information							
Site name	**transmitter redundancy**	**Cooling (Air / Liquid)**	**Voltage (3-phase / 1-phase)**	**UPS for transmitter**	**Site categorization**	**Energy consumption (kW) per mux**	**Needed tx power (kW) per mux**	**Frequency (CH) State MUX**
1. Kutaisi	DD	Liquid	3	x	1	7,43	2,60	34
2. Tbilisi	DD	Liquid	3	x	1	5,43	1,90	23
3. Gori	DD	Liquid	3	x	1	3,72	1,30	34
4. Akhalkalaki	DD	Liquid	3	x	1	3,72	1,30	34
5. Batumi	DD	Liquid	3	x	1	3,72	1,30	23
6. Kvareli	DD	Liquid	3	x	1	3,72	1,30	23
7. Dmanisi	DD	Liquid	3	x	1	3,33	0,90	39
8. Akhaltsikhe	DD	Liquid	3	x	1	2,22	0,60	34
9. Poti	DD	Liquid	3	x	1	2,22	0,60	23
10. Zugdidi	DD	Liquid	3	x	1	2,22	0,60	23
11. Bolnisi	SD	Air	1	x	4	1,50	0,30	39
12. Dedoplistskaro	SD	Air	1	x	4	1,50	0,30	30
13. Chiatura	SD	Air	1	x	3	1,00	0,20	34
14. Borjomi	SD	Air	1	x	3	1,00	0,20	34
15. Bekami	SD	Air	1	x	3	1,00	0,20	34
16. Sachkhere	SD	Air	1	x	4	1,00	0,20	34
17. Ozurgeti	SD	Air	1	x	3	1,00	0,20	23
18. Chokhatauri	SD	Air	1	x	4	1,00	0,20	34
19. Shuakhevi	SD	Air	1	x	4	1,00	0,20	34
20. Khulo	SD	Air	1	x	4	1,00	0,20	34
21. Chkhorotsku	SD	Air	1	x	4	1,00	0,20	34
22. Tsalenjikha	SD	Air	1	x	4	1,00	0,20	23
23. Jvari	SD	Air	1	x	4	1,00	0,20	23
24. Mestia	SD	Air	1	x	4	1,00	0,20	34

25. Lentekhi	SD	Air	1	x	4	1,00	0,20	34
26. Lagodekhi	SD	Air	1	x	4	1,00	0,20	27
27. Signaghi	SD	Air	1	x	4	1,00	0,20	27
28. Cageri	SD	Air	1	x	4	1,00	0,20	34
29. Tsivi	SD	Air	1	x	3	1,00	0,20	23
30. Tsalka	SD	Air	1	x	4	1,00	0,20	39
31. Dusheti	SD	Air	1	x	4	1,00	0,20	34
32. Oni	SD	Air	1	x	4	1,00	0,20	34
33. Ambrolauri	SD	Air	1	x	4	1,00	0,20	34
34. Kazbegi	SD	Air	1	x	4	1,00	0,20	31
35. Tianeti	SD	Air	1	x	4	1,00	0,20	23
36. Tkibuli	SD	Air	1	x	3	1,00	0,20	34
37. Bakuriani	SD	Air	1	x	4	0,25	0,05	34
38. Qeda	SD	Air	1	x	4	1,00	0,20	23
39. Abastumani	SD	Air	1	x	4	0,25	0,05	34
40. Aspindza	SD	Air	1	x	4	0,25	0,05	34
41. Ninotsminda	SD	Air	1	x	4	0,25	0,05	34
42. Sagarejo	SD	Air	1	x	3	0,25	0,05	23
repeater sites 1-60	SD	Air	1		4	0,20	0,04	

2.3 Technical data, which is to be mentioned in the proposals of the vendors;

Proposals of the vendors should include the following documents:

- General conditions for DVB-T2 transmitters,
- General conditions for DVB-T2 repeaters
- Interconnection (SNMP).
- Maintenance and repair Agreement

2.3.1 General conditions for DVB-T2 transmitters:

- Technical requirements (connectors for RF and Data, Exchangeability of modules etc)
- Transmitter reserve systems (configuration of reserve system, operational 13ehaviour etc)
- Documentation (Technical offer documents, Service documents etc)
- Life cycle / Reliability (The delivery item must be procured in such a way that it meets the requirements of these technical specifications for a useful life period of 15 years)
- Structural conditions (cable routing, accessibility, transmitter configuration etc)
- Software (settings, log file, messaging, update procedure etc)
- Cooling (dissipated thermal power, air volume m^3, redundancy configurations etc)
- Power supply (Voltage, Current, Frequency, power factor, load of phases, ups etc)
- Operation and attendance (operating temperature, humidity, cooling air temp, mains voltage variation etc)
- Switch-on and operating 13ehaviour (short mains break, restart after mains failure, transmitter self-protection etc)
- Remote control (local and remote mode, implemented SNMP protocol)
- Maintenance (corrective maintenance procedures, preventive maintenance procedures)
- Reference standard list which product should fulfil (DIN, EN standards, directives etc)

2.3.2 General conditions for DVB-T2 repeaters:

- Technical requirements (connectors for RF and Data, Exchangeability of modules etc)
- Transmitter reserve systems (configuration of reserve system, operational 13ehaviour etc)
- Documentation (Technical offer documents, Service documents etc)

- Life cycle / Reliability (The delivery item must be procured in such a way that it meets the requirements of these technical specifications for a useful life period of 15 years)
- Structural conditions (accessibility, configurations repeater/ transposer / retransmitter, echo cancellation etc)
- Software (settings, log file, messaging, update procedure etc)
- Cooling (dissipated thermal power, air volume m^3 etc)
- Power supply (Voltage, Current, Frequency, power factor, load of phases, ups etc)
- Operation and attendance (operating temperature, humidity, cooling air temp, mains voltage variation etc)
- Switch-on and operating 14ehaviour (short mains break, restart after mains failure, transmitter self-protection etc)
- Remote control (local and remote mode, implemented SNMP protocol)
- Maintenance (corrective maintenance procedures, preventive maintenance procedures)
- Reference standard list which product should fulfil (DIN, EN standards, directives etc)

2.3.3 General conditions for interconnection (SNMP):

- Protocols and definitions (connectors, network protocol, transport protocol, SNMP agent etc)
- Network connection configuration (auto/half/full-duplex, data rate etc)
- IP configurations (address, subnet mask, dhcp etc)
- SNMP agent configuration and operating 14ehaviour
- List of commands (list of wanted messages from transmitter eq. on/off, faults etc)

2.3.4 Maintenance and repair agreement

(named here transmitter service level agreement) sections which should be agreed:

- General Terms and Conditions for Services
- Service Level Overview (what is included free of charge or specified as separate service for technical support, logistic, parts, updates etc)
- Price list
- Processes (repair time, warranty, TAT, assistance cost from suppliers expert etc)
- Logistics
- list of service providers (where repair will be done, local support/presence, contact persons etc)

2.4 Efficiency (energy consumption and electricity capacity)

Analog transmitters have approx. 20% efficiency and new digital transmitter have efficiency up to 35% in power class above > 0,7 kW. In lower power classes, digital transmitter's efficiency decrease to 20% when analog transmitters remain at static 5 – 10% level. Energy consumption has been calculated based on the above mentioned information for each power level.

Power class kW	Analog power consumption (kW)	Digital power consumption (kW)
2	10	5,7
1	5	2,8
0,5	3,3	1,6
0,2	2	1
0,05	1	0,33

From this table it can be seen that electricity capacity of main transformer should be in the right category since there are existing analog transmitters on site. However simulcast period before analog switch off (ASO) has to be taken into consideration, capacity of main transformer and fuse category must be re-calculated in actual implementation.

2.4.1 Electricity modification with new equipment

New main switchboards, electricity cables, fuses and installation material for the State MUX

- < 2,5 kW liquid cooled transmitter
- < 0,5 kW air cooled transmitter
- < 0,2 kW air cooled transmitter
- < 0,05 kW air cooled transmitter and repeaters

In low power class <0,05kW current switchboard does not need to be renewed before analog switch off.

2.4.2 Electricity modification with existing equipment

Electricity cabling can be done from existing switchboards (<u>if there is enough capacity</u>). In this case the need to invest to new cables and fuses should be taken into account. Use of old switchboards needs more communication with station personnel and possible service breaks to existing transmissions in installation situation might be required.

Use of existing switchboards , new electricity cables, fuses and installation material per State MUX:

- < 2,5 kW liquid cooled transmitter: cables, fuses
- < 0,5 kW air cooled transmitter: cables, fuses
- < 0,2 kW air cooled transmitter: cables, fuses
- < 0,05 kW air cooled transmitter and repeater: cables, fuses

2.4.3 Back-up generator

Back-up generator is designed for situations when main electricity distribution network is temporarily out of operation. Increase of needed electrical capacity is quite marginal when DTT network is implemented to Georgia. New back-up generators depend on what is the needed power (kW) level at each location.

2.4.4 Cooling

Cooling capacity of the transmitter(s) room should be based on air ventilation plan (how much transmitter can dissipate thermal heat to the room itself -> which gives the value of much thermal energy should be guided outside the building). Air ventilation value is x m^3/min, flow rate.

For air cooled transmitters dissipated thermal heat to the room can be calculated (average):

Power class kW	**0,05**	**0,2**	**0,5**	**1**	**1,5**	**2,5**
Energy consumption	0,33	1	1,67	2,86	4,29	7,14
Dissipated heat (kW)	0,28	0,8	1,17	1,86	2,79	4,64

Regarding air flow rate some kind of basic rules can be used (depends on air pressure, transmitter)

- 10 kW thermal heat equal to 20 m^3/min.
- 30 kW thermal heat equal to 50 m^3/min.

2.4.5 Cooling solutions

When designing the practical implementation of transmitter systems you choose either air or liquid cooled type and calculate necessary cost for infrastructure modification.

If air cooled is chosen, transmitter installation room has to have enough air cooling capacity -> ducting of hot air outside the room need fans and multiple air ducts. In case of chosing liquid cooled, heat exchanger will be installed outside and transmitter room does not need “transmitter based” air ventilation.

2.4.6 Cooling related modification for liquid cooled sites

For liquid cooled sites there are only small needs to modify the existing infrastructure. Heat exchanger should be installed in the north side of building (free sheltered space should be available) and space for holes for cooling liquid pipes/hoses must be available in interior and exterior walls.

2.4.7 Cooling related modification for air cooled sites

For air cooled sites, air ducting should be built and needed modifications depend on power levels and number of transmitters in the same room.

2.5 Transmitter System Deliverable

2.5.1 Supplier of the transmitter system is expected to provide

a) Technical support (years)____

b) Spare part repairs (years)____

c) Local presence / regional office with technical support__________________________________

2.5.2 Provide Total Cost of Ownership calculation as per table below

For the reference, please indicate Electricity price in Georgia for kW

Supplier	Transmitter Type	Power Class kW	Price (€)	Total Efficiency [1]% (inc. cooling)	Delivery time weeks	Active PVC	Energy Consumption per Year kW	OPEX per year
	Model x							
	Model y							
	Model z							

2.5.3 Budgetary cost estimation of the spare parts

Spare Part	Supplier	Price
Modulator		
Power Amplifier		
Control Unit		

2.5.4 Budgetary cost estimation of the transmitter system

Transmitter Site Types	TX Power Class (kW)	Transmitter including cooling	Monitoring Receiver	Combiners / Filters	Rigid lines / coaxial[2] cables	Installation work	Infrastructure[3]	CAPEX Transmitter system
Site 1	Model x							
Site 2	Model y							
Repeater site	Model z							

[1] Efficiency (total efficiency including cooling) is based on actual measurements, i.e. average based on measurements from channel 21, 35 and 48.

[2] To be mentioned how many meters is approximately between transmitter output (mask filter) and antenna feeder input. Simple way could be 10 m.

[3] To be mentioned what infrastructure work is assumed to be taken into consideration, eq. electricity and/or air ventilation. Simple way could be reference to sections 2.4.4,2.4.5, 2.4.6,2.4.7 and 2.4.8 which is quite obvious. Vendor may answer that it is assumed no work Is needed and make reference to 1.2

3 Antenna System Requirements

3.1 Introduction

The antenna system design is made in close co-operation with coverage planning and transmitter design. Coverage planning states the wanted radiated power (ERP) in order to reach the wanted coverage (geographical area and population). Transmitter power and antenna system gain is together optimized in order to reach the most cost effective solution for the needed ERP. Each antenna is custom designed, taking into account the specific needs for the area.

3.2 Design philosophy

3.2.1 Existing antennas used for analogue TV

The DVB-T2 networks in Georgia will need new antenna system(s), feeders, and band pass (mask) filter(s). The existing analog TV stations / networks operate in both VHF I, VHF III, as well as UHF IV/V bands and in most cases have dedicated antennas only for one channel. The antennas can most probably not handle extra power and the combiner system would become very complex if the digital TV multiplexes would be added to the existing antenna system. Therefore it is recommended to install one or two new antenna systems for the DVB-T2 networks on each main transmitter site and gap filler site.

3.2.2 Reliability of antenna system

For the most critical sites some redundancy should be planned, options include reserve antenna, half power mode antenna and 2 feeders. For most transmitter sites in Georgia, the effective radiated power (ERP) is relatively small (below 1 kW), and therefore no half power mode is needed and one feeder cable is enough. Reserve antennas are used in order to minimize transmission break periods due to antenna system faults (malfunction of antenna, power divider, cable, lightning, etc.), or installation or maintenance works in mast (check EMF, electromagnetic fields, limits for workers if antenna needs to be unused during the work).

3.2.3 Antenna radiation patterns

The polarization planned to be used in Georgia is horizontal.

Antenna patterns are designed to target the most important areas, and ensure that the TV coverage is good enough with respect to both area and population and restricted with power limitations given by national (and indirectly international) authorities.

So far the needed radiated powers in Georgia are so low that radiation restrictions will most probably be given only for one site, Dmanisi. This transmission site lies relatively close to the Armenian border and transmissions from Dmanisi might interfere the Armenian networks. Directional requirements can be stated by GNCC (indirectly by the regulatory authorities of the neighbouring countries: Armenia, Azerbaijan, Iran, Russia, Turkey).

For high altitude sites the antenna should be tilted (either mechanically or electrically) in order to aim the radiation towards the population and not over the horizon. If the site is very close to residential area care should be taken to ensure no vertical pattern minimums cause problems on the reception side.

3.2.4 Environmental constraints

Some transmitter sites have special climatic conditions that affect the antenna design. On high altitudes these can include ice load or falling ice. The tower model (square, triangular or round) as well as diameter and space available sets limits on what size and type of antenna can be installed. Mast load (wind load, icing, etc.) limitations are not taken into account during this phase of planning, because this would require a total picture of mast capacity and information on each aerial system and feeder cable in the mast as well as details about the mast structure.

3.3 Antenna types

3.3.1 Top-mount omnidirectional antennas

Small and medium power omnidirectional super turnstile antennas can be easily mounted on the top of a mast and it has small wind load. There are different options available regarding handling power and number of bays, which directly affects the vertical radiation pattern.

In case of having also another antenna at the transmitter site care needs to be taken to create the radiation pattern similar as the one of the super turnstile antenna. The other antenna has to be built using antenna panels since more than one super turnstile antenna cannot fit on a mast. If two channels used on the transmitter site are neighbouring channels it is extremely important to create similar radiation patterns, otherwise the reception will suffer as the difference between received signal strength can be over 30 dB if nulls in the vertical radiation pattern are placed at very different points.

3.3.2 Broadband panel arrays

Panel array antennas are built using different number of panels and power dividers for different configurations. Each antenna can have customized horizontal as well as vertical radiation patterns, null fill and beam tilt, and power handling capability.

Directive (D) antenna patterns are created using 1-3 panels per bay and non-directive (ND) radiation patterns are created using four or more panels per bay. If the mast diameter is very large more than 4 panels are needed per bay.

3.4 Technical list of the needed antennas

Designed reference network, antenna systems are given for each site in excel format.

					Antenna system including combiner												
Site name	Nominal power (kW)	Needed tx power (kW) per mux	ERP power (dB)	ERP power (kW)	Feeder cable length (m)	Antennin polarization	Combiner/Filter type	Combiner/Filter loss (dB)	RF power after combiner system (kW)	Feeder type	Feeder loss 8dB)	Antenni gain(dBd)	Antenna system total G	Antenna type (ST = superturnstile, panel)	Directivity [ND/D]	nr of bays,	nr of panels / bay
1. Kutaisi	2.3	2.600	42.7	18.75	140	H	Mask Filter	0.6	2.600	3 1/8	2.10	11.0	8.58	panel	ND	2	4
2. Tbilisi	2.3	1.902	40.6	11.54	130	H	CIB Combiner	0.6	1.902	1 5/8	2.60	11.0	7.83	panel	ND	4	5
3. Gori	1.15	1.301	36.5	4.438	185	H	CIB Combiner	0.6	1.301	1 5/8	3.70	9.5	5.33	panel	ND	3	5
4. Akhalkalaki	1.15	1.301	37.7	5.84	120	H	Mask Filter	0.6	1.301	1 5/8	2.40	9.5	6.52	panel	ND	3	4
5. Batumi	1.15	1.301	38.6	7.2	70	H	Mask Filter	0.6	1.301	1 5/8	1.40	9.5	7.43	panel	D	2	3
6. Kvareli	1.15	1.301	36.5	4.489	100	H	Mask Filter	0.6	1.301	1 5/8	2.00	8.0	5.38	panel	ND	2	4
7. Dmanisi	1.15	0.900	35.0	3.135	180	H	Mask Filter	0.6	0.900	1 5/8	3.60	9.5	5.42	panel	D	2	3
8. Akhaltsikhe	0.6	0.600	36.2	4.133	100	H	Mask Filter	0.6	0.600	1 5/8	2.00	11.0	8.38	panel	D	3	3
9. Poti	0.6	0.601	34.1	2.58	130	H	Mask Filter	0.6	0.601	1 5/8	2.60	9.5	6.33	panel	D	2	3
10. Zugdidi	0.6	0.600	33.6	2.304	75	H	Mask Filter	0.6	0.600	1 5/8	1.50	8.0	5.84	panel	ND	2	4
11. Bolnisi	0.2	0.200	31.9	1.555	85	H	Mask Filter	0.6	0.200	1 5/8	1.70	9.5	7.15	panel	D	2	3
12. Dedoplistskaro	0.3	0.300	36.1	4.043	250	H	CIB Combiner	0.6	0.300	3 1/8	3.75	13.7	11.30	panel	ND	6	6
13. Chiatura	0.2	0.200	27.5	0.567	120	H	Mask Filter	0.6	0.200	1 5/8	2.40	7.5	4.52	ST	ND		
14. Borjomi	0.2	0.200	29.9	0.983	50	H	Mask Filter	0.6	0.200	7/8	1.50	9.5	6.92	panel	D	1	3
15. Bekami	0.2	0.200	27.1	0.514	45	H	Mask Filter	0.6	0.200	7/8	1.35	6.5	4.10	panel	D	1	3
16. Sachkhere	0.2	0.200	28.1	0.643	60	H	Mask Filter	0.6	0.200	7/8	1.80	8.0	5.07	panel	D	1	2

17. Ozurgeti	0.2	0.200	25.3	0.338	40	H	Mask Filter	0.6	0.200	7/8	1.20	4.5	2.28	ST	ND		
18. Chokhatauri	0.2	0.200	24.6	0.287	60	H	Mask Filter	0.6	0.200	7/8	1.80	4.5	1.57	ST	ND		
19. Shuakhevi	0.2	0.200	25.1	0.322	60	H	Mask Filter	0.6	0.200	7/8	1.80	5.00	2.07	panel	ND	1	4
20. Khulo	0.2	0.200	27.5	0.558	35	H	Mask Filter	0.6	0.200	7/8	1.05	6.50	4.46	panel	D	1	3
21. Chkhorotsku	0.2	0.200	24.6	0.287	60	H	Mask Filter	0.6	0.200	7/8	1.80	4.50	1.57	ST	ND		
22. Tsalenjikha	0.2	0.200	29.0	0.788	35	H	Mask Filter	0.6	0.200	7/8	1.05	8.00	5.96	panel	D	1	4
23. Jvari	0.2	0.200	24.9	0.311	50	H	Mask Filter	0.6	0.200	7/8	1.50	4.50	1.92	ST	ND		
24. Mestia	0.2	0.200	26.1	0.411	30	H	Mask Filter	0.6	0.200	7/8	0.90	5.00	3.13	panel	ND	1	4
25. Lentekhi	0.2	0.200	29.1	0.82	30	H	Mask Filter	0.6	0.200	7/8	0.90	8.00	6.13	panel	D	1	2
26. Lagodekhi	0.2	0.200	25.3	0.338	40	H	Mask Filter	0.6	0.200	7/8	1.20	4.50	2.28	ST	ND		
27. Signaghi	0.2	0.200	28.3	0.675	40	H	Mask Filter	0.6	0.200	7/8	1.20	7.50	5.28	ST	ND		
28. Cageri	0.2	0.200	26.6	0.455	60	H	Mask Filter	0.6	0.200	7/8	1.80	6.50	3.57	panel	D	1	3
29. Tsivi	0.2	0.200	27.8	0.606	25	H	Mask Filter	0.6	0.200	7/8	0.75	6.50	4.81	panel	D	1	3
30. Tsalka	0.2	0.200	27.4	0.549	65	H	Mask Filter	0.6	0.200	7/8	1.95	7.50	4.39	ST	ND		
31. Dusheti	0.2	0.200	25.8	0.382	25	H	Mask Filter	0.6	0.200	7/8	0.75	4.50	2.81	ST	ND		
32. Oni	0.2	0.200	25.3	0.338	40	H	Mask Filter	0.6	0.200	7/8	1.20	4.50	2.28	ST	ND		
33. Ambrolauri	0.2	0.200	24.1	0.258	45	H	Mask Filter	0.6	0.200	7/8	1.35	3.50	1.10	panel	ND	1	4
34. Kazbegi	0.2	0.200	27.5	0.558	35	H	Mask Filter	0.6	0.200	7/8	1.05	6.50	4.46	panel	D	1	1
35. Tianeti	0.2	0.200	25.1	0.324	45	H	Mask Filter	0.6	0.200	7/8	1.35	4.50	2.10	ST	ND		
36. Tkibuli	0.2	0.200	24.6	0.287	60	H	Mask Filter	0.6	0.200	7/8	1.80	4.50	1.57	ST	ND		
37. Bakuriani	0.05	0.050	18.5	0.07	35	H	Mask Filter	0.6	0.050	7/8	1.05	3.50	1.46	panel	D	1	3
38. Qeda	0.05	0.050	27.3	0.536	40	H	Mask Filter	0.6	0.050	7/8	1.20	6.50	4.28	panel	D	1	3
39. Abastumani	0.05	0.050	19.4	0.087	50	H	Mask Filter	0.6	0.050	7/8	1.50	5.00	2.42	panel	D	1	2
40. Aspindza	0.05	0.050	22.8	0.19	40	H	Mask Filter	0.6	0.050	7/8	1.20	8.00	5.78	panel	D	1	3
41. Ninotsminda	0.05	0.050	21.5	0.14	35	H	Mask Filter	0.6	0.050	7/8	1.05	6.50	4.46	panel	D	1	3
42. Sagarejo	0.05	0.050	23.1	0.205	30	H	Mask Filter	0.6	0.050	7/8	0.90	8.00	6.13	panel	D	1	2
repeater site x	0.05	0.050	20.0	0.1	30	H	Mask Filter	0.6	0.050	7/8	0.90	5.00	4.00	panel	D	2-3	2

** For the sites Tbilisi, Gori and Dedoplistskaro is expedient to use existing 75 ohm 120mm feeder, so it is recommended to use full UHF band (IV; V) CIB combiners and impedance transformers 50/75.

3.5 Antenna System Deliverable

3.5.1 Supplier of the antenna system is expected to provide

a) Technical support (years)____

b) Spare part repairs (years)____

c) Local presence / regional office with technical support__________________________

3.5.2 Provide data as per table below

Site list & basic info						Network Plan input			Filter system			Antenna System											
Site name	Latitude	Longitude	Antenna height m)	Antenna Polarization	MUX frequency / frequencies	Max power handling capability	Wanted ERP[4]	Directivity (ND/D)[5]	Filter/Combiner type	Filter loss (dB)	RF power after combiner system (kW)	Feeder type	Feeder cable length (m)	Feeder loss (dB)	Antenna type (S/T = superturnstile, panel)	Directivity (ND/D)	Number of bays	Number of panel / bay	Antenna gain (dB)	Antenna system total G	Delivery time	Installation work	CAPEX

3.5.3 Budgetary cost estimation of the spare parts

Spare Part	Supplier	Price

[4] From network plan, alternatively optimized plan by vendor

[5] power limitations from coordination or special coverage wish based on site position

4 Radio Network Requirements

4.1 Protection of Analog TV in UHF band

Present analog TV in Georgia uses frequencies in the VHF-I, VHF-III and UHF bands. According to GE06 agreement analog TV stations will be protected until June 16th 2015. After the transition period has ended, countries may continue to operate analogue broadcasting stations, provided that these stations do not cause unacceptable interference and do not claim protection.

The GNCC decides how the frequencies are used in Georgia, taking into account international agreements and regulations. Below is a general presentation of the TV and radio frequency ranges:

Frequency range	Frequency	Service until June 16th 2015	Service after June 17th 2015
VHF-I	47-68 MHz	Analog TV	To be decided by the GNCC
VHF-II	87.5-108 MHz	FM radio	FM radio
VHF-III	174-230 MHz	Analog TV	Digital TV
UHF without 700 -band	470 -694 MHz	Analog and Digital TV	Digital TV
700-band	694-790 MHz	Analog and Digital TV	Mobile broadband

The DVB in Georgia will start using only UHF frequencies, and this frequency analysis is concentrating only for the time period before analog switch off (ASO). Therefore the frequency and interference analysis in this document is limited to UHF bands only for the state nationwide MUX.

Database of existing analog UHF TV was formed in order to analyse which frequencies are the best for the time when analog and digital TV co-exist.

The GNCC frequency license database was cross-checked with international ITU-R BRIFIC frequency database, and such analog frequencies were used in the analysis, which GNCC confirmed to be in use. Analog networks and frequencies are listed in table *Georgian analog TV stations in UHF*, in the last pages of the Radio Network Planning section.

Analog GBP networks are using mostly VHF frequencies, therefore adding DVB to UHF does not affect to their existing services very much.

4.2 Digital TV stations

The frequency plan for DVB has been made for 42 main sites[6], seven multiplexes[7], however the document will define criteria for the State MUX only.

Frequency selection has been made to minimize interference for analog networks, and conformity with GE06 allotment plan with neighbouring countries has also been checked. There are several ways to plan DVB network, Digita has used power levels, sites and antenna heights listed in the table *DVB frequencies for Georgia State MUX before ASO* in the last pages of the Radio Network Planning section. The table includes also the selected frequencies, which is also the result of the analysis.

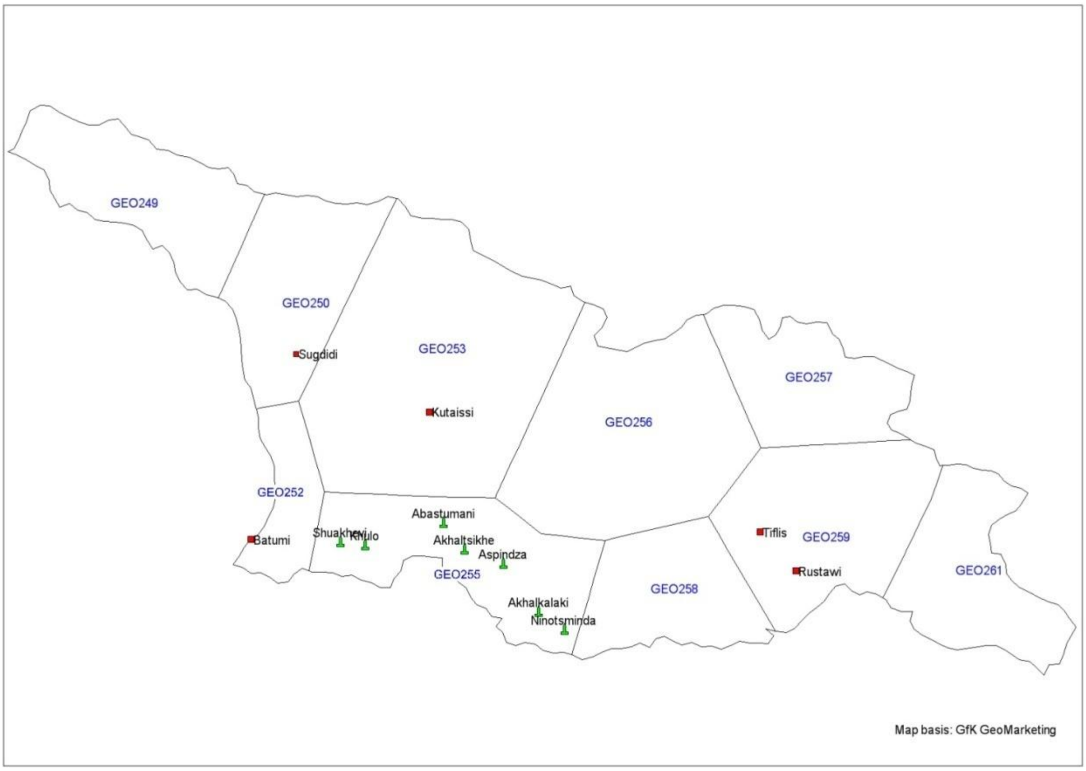
Site information is based on the coordinates given by Georgian project partners (TRC), and this information is used in planning tool. Site height is retrieved from the ground height model based on these coordinates.

Georgia has been divided into 10 allotment areas for the RRC04/06 digital TV frequency planning conference, which made GE06 agreement. These allotment areas are depicted below, with sites of the allotment area GEO255 as an example:

[6] It is to be taken into acoount that due to a mountaineous terrain full coverage is expected to be provided by 42 main and 60 gap filler sites in Georgia

[7] Within the famework of EBRD technical support, Digita performed Radio Frequency planning for seven MUX platforms, out of which one is a State MUX, licences for five MUX platforms are available via an open contest held by GNCC; and set of frequencies equivalent to the last MUX platform are reserved

GE06 allotment areas for Georgia
Main DVB-sites of the allotment area GEO255 shown



4.2.1 DVB-T/T2 parameters used in the planning

DVB-T2 parameters were selected to give reliable coverage, fulfil the demand for the number of TV services and enable large SFN areas.

FFT Size	32KE
Bandwidth	8 MHz
Pilot Pattern	PP2
Modulation	256QAM
Guard interval	1/8
Code Rate	2/3
Minimum FS for Fixed For Portable Indoor	48/54 dB(uV/m) * 66/75 dB(uV/m) **

***** Given field strength criteria is for fixed rooftop reception (10 m height) on the average UHF frequency 634 MHz with variability corrections for 70% and 95% of locations. Frequency dependent correction factor 20log(f/634) will be added according to selected frequency. In the equation f is central frequency of the channel in MHz.

****** Given field strength criteria is for portable indoor reception (calculated 1.5 m height outside the building, taking entry penetration loss into account, etc. according to ITU recommendations on the average UHF frequency 634 MHz with variability corrections for 70% and 95% of locations. Frequency dependent correction factor 20log(f/634) will be added according to selected frequency. In the equation f is central frequency of the channel in MHz.

4.2.2 Frequency selection process

The possible interference caused by each DVB frequency candidate of each allotment areas was calculated. Frequency candidates were compared and the best two frequencies were selected.

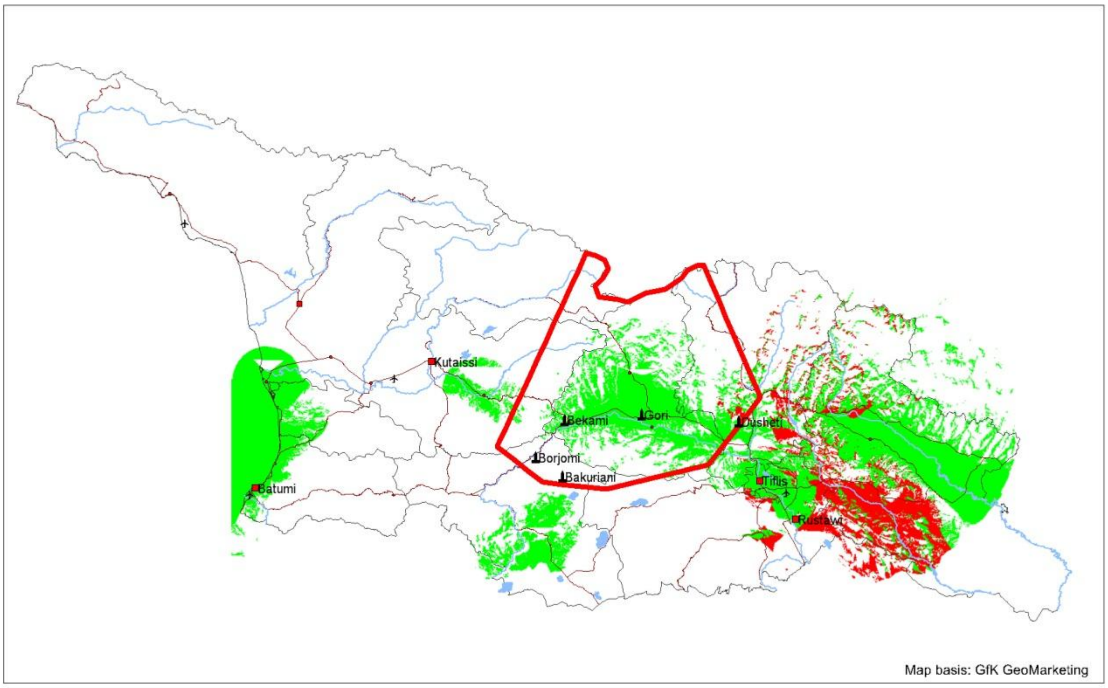
The frequency band below (694 MHz) was preferred solution, but if possible interference indication for analog TV was detected, then channels on 700 MHz band were also analysed. The 700 MHz band is assumed to be given to mobile services after analog switch off and therefore this is only temporary solution for DVB.

In this frequency plan the time after ASO has not been optimized, because analog TV reserves frequencies. It would be possible to modify the whole plan and enlarge the SFN areas after ASO, but this will require frequency changes for the DVB transmitters.

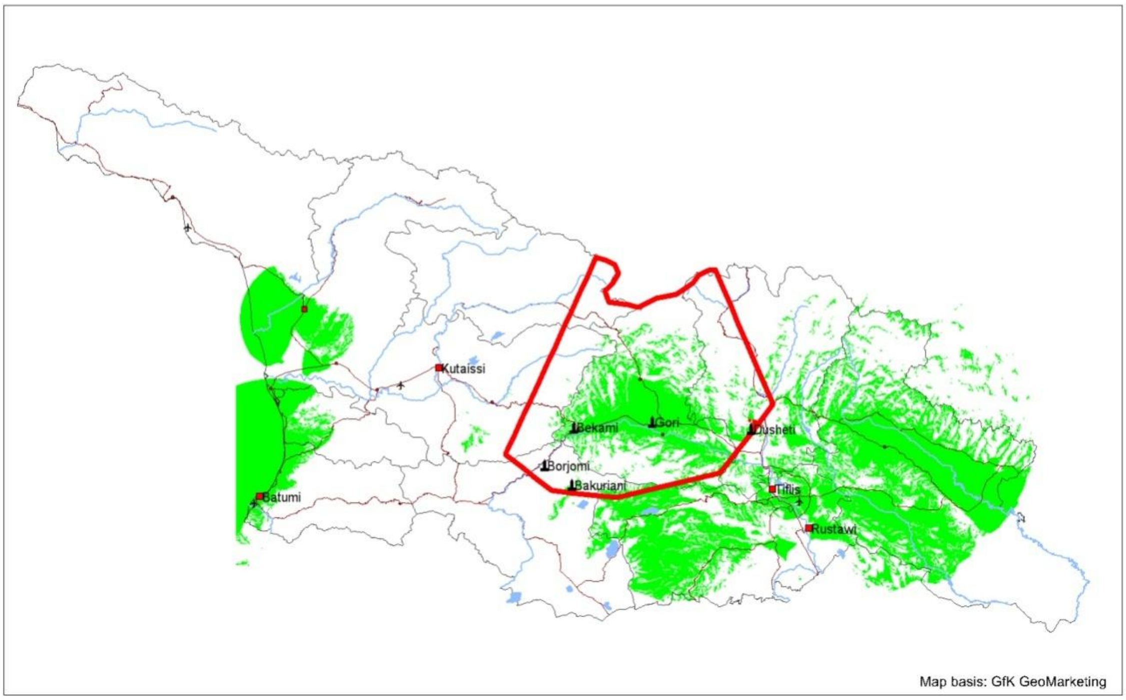
Network planning tool was used to find the worst possible analog victims of the DVB frequency on test, and these analog coverage areas in UHF frequency band were calculated. Then DVB transmitters were added, and full interference analysis for these analog TV stations was calculated.

As an example of the frequency selection process, candidate frequencies for allotment area GEO256 are presented as maps. The result shown in green colour unaffected analog coverage areas and possible interference is seen in red area:

Possible interference for existing analog TV in red, calculated with ITU-R P.1546
Allotment GEO256 DVB transmitters on channel 43 is not recommended solution before ASO



Possible interference for existing analog TV in red, calculated with ITU-R P.1546
Allotment GEO256 DVB transmitters on channel 42 is recommended solution before ASO



4.2.3 Recommended UHF-channels for the State MUX before analog switch off

Allotment	Recommended UHF ch	
	State MUX	
GEO250	23	
GEO252	60	in 700 MHz band
GEO253	50	in 700 MHz band
GEO255	47	
GEO256	47	
GEO257	31	
GEO258	59	in 700 MHz band
GEO259	23	
GEO261	27	

4.3 Coverage areas of DVB

After selecting DVB frequencies, it was possible to calculate interference limited coverage areas. All the existing analog networks in UHF and the State DVB MUX were taken into account in the calculation.

4.3.1 Mapping data and models used

- Wave propagation model is based on ITU-R rec. P.526-9
- Except for portable indoor calculations wave propagation model used: ITU-R P.1546-2 terrain with TCA
- Receiving antenna height: 10 m (fixed) and 1.5 m (portable)
- Usage of digital terrain model with 100m resolution
- Background vector map: GfK GeoMarketing

- Coordinate system of the maps WGS-84 UTM zone 38N, central meridian East 45
- Wanted summation procedure: T-Log-Normal
- Interfering summation procedure: T-Log-Normal

4.3.2 Propagation prediction method

ITU recommendation P.526 has been agreed with the GNCC to be used for the planning, because this site-specific prediction model is analysing the whole terrain profile, and giving more information of the real coverage area than “site general” propagation model, such as ITU-R rec. P. 1546.

In analog era field strength predictions has been made usually for 50% of locations and 50% of time for wanted signal. This is related to the way the analog reception is degrading when signal is either interfered or low in level. DVB signal is more critical when signal quality is in the reception limit, and the reception is perfect until the QEF point (quasi error free) is reached, after that reception is not possible at all. Therefore field strength is calculated using location variability of 95% or 70%, adding some safety margin to the calculations. In interference calculations 1% and 50% of time has been used with corresponding protection ratios.

Even after very detailed coverage calculation there can be places where DVB reception is not possible, even though coverage predictions are not revealing these. This may happen, because there is no perfect calculation model nor mapping data existing, all the results are still predictions, and there are some, even small, uncertainties left in any case. Normally these problematic areas pointed out by feedback of TV viewers have to be measured, when the network is in operation, in order to make sure that the said problem is in the network, not in the receiving end system of the TV viewers. The license terms for the DVB networks will be made to include well defined obligations for coverage, the network have to make denser by adding more transmitters if shadowed areas severe enough will be found.

4.3.3 Portable indoor coverage for Tbilisi area

Indoor reception is including more uncertainties than fixed rooftop reception. Exact coverage calculation would require detailed model of each building, including building materials and their parameters relevant for radio wave propagation, and the suitable calculation model. Even if such building and calculation models would exist, detailed calculations for each household would be so time-consuming, that it would not be feasible.

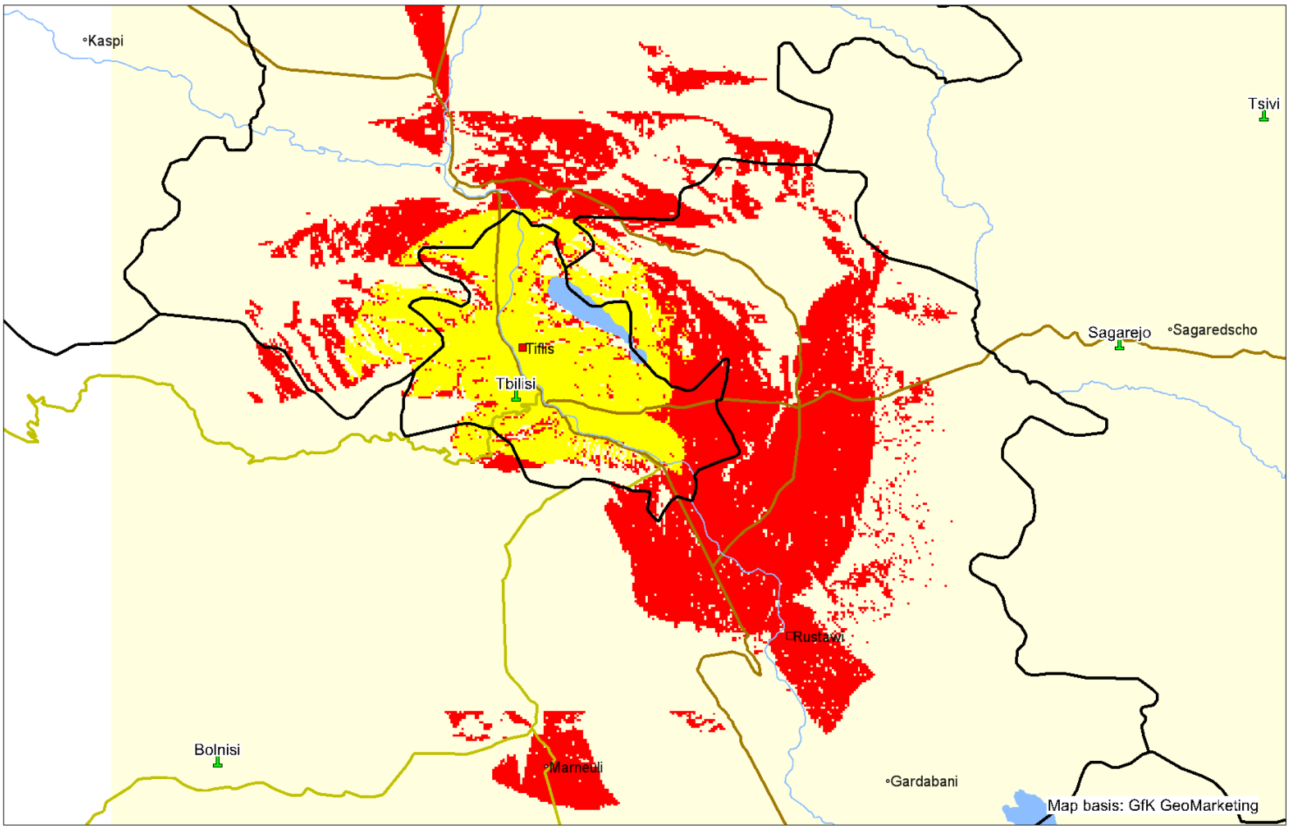
Indoor antennas are used to receive TV broadcasts in good conditions eq. near the transmitting station and good field strengths for stationary reception. Special care needs to be taken to placing the indoor antenna inside the building so that wall and window attenuation is minimized. Moving around antenna to find the best possible reception point is advised. Generally it is hard to get a good signal if tall structures / neighbouring buildings exist close to the reception point. Tinted glass windows, which are common for increasing cooling or heating isolation, have a higher attenuation than regular windows and may therefore add challenges for indoor reception.

When active receiving antenna or separate receiving amplifier is used, it should be noted that when electrical amplification is applied, both interfering noise and the useful digital TV signal is increased, and C/N is not improved. Active receiving amplification is at its best when C/N is good but signal level is low. In practice, indoor coverage of broadcast network will never reach 100% of households within city or any larger area.

In case of portable reception the receiving antenna is assumed as a non-directional antenna in 1.5 m above ground level. The coverage predictions were done on a receiving antenna height of 1.5 m above ground level. The correction factors like receiving antenna gain or penetration loss applied as recommended by the ITU.

State MUX Coverage Tbilisi Portable Indoor Reception (receiver antenna height 1.5 m)

Interference limited coverage DVB-T2 70/95 % location propability in red/yellow ITU-R rec. 1546



Georgian analog TV stations in UHF					21st December 2013			Page1/2
TX-Name	**Freq.**	**Ch.**	**ERP kW**	**Longit.**	**Latit.**	**Ant.H.**	**Ground Height**	**Network**
Abastumani	575.2500	34	0.25	042E52 08.000	41N55 19.000	30	1059	Spektri
AKHALKALAKI	583.2500	35	0.5	043E25 34.000	41N20 52.000	40	1812	GPB2
AKHALKALAKI	599.2500	37	1.0	043E25 34.000	41N21 52.000	55	1739	I Stereo
AKHALKALAKI	615.2500	39	2.0	043E25 34.000	41N20 52.000	65	1812	Rustavi 2
AKHALKALAKI	519.2500	27	0.5	043E25 34.000	41N20 52.000	75	1812	Teleimedi
Akhaltsikhe	479.2500	22	0.1	042E57 29.000	41N37 49.000	55	1327	GPB2
Akhaltsikhe	551.2500	31	0.2	042E57 25.000	41N37 48.000	52	1338	Rustavi 2
Akhaltsikhe	511.2500	26	1.0	042E57 25.000	41N37 49.000	50	1338	Spektri
Akhaltsikhe	495.2500	24	0.5	042E57 29.000	41N37 49.000	55	1327	Teleimedi
Aspindza	487.2500	23	0.25	043E16 37.000	41N33 00.000	30	1418	Spektri
Bakuriani	575.2500	34	0.05	043E33 10.000	41N44 07.000	25	2077	Rustavi 2
BATUMI	599.2500	37	3.0	041E43 19.000	41N41 07.000	42	267	Ajara
BATUMI	567.2500	33	1.0	041E42 55.000	41N41 38.000	55	181	Civil Education Fund
Batumi	727.2500	53	1.0	041E42 55.000	41N41 38.000	110	181	I Stereo
Batumi	639.2500	42	3.0	041E42 55.000	41N41 38.000	50	181	Rustavi 2
BATUMI	495.2500	24	0.1	041E42 55.000	41N41 38.000	30	181	Telearkhi 25
BATUMI	519.2500	27	0.5	041E42 55.000	41N41 38.000	50	181	Teleimedi
Bolnisi	615.2500	39	2.0	044E32 16.000	41N25 50.000	40	678	I Stereo
Bolnisi	687.2500	48	0.5	044E32 16.000	41N25 50.000	35	600	Rustavi 2
Bolnisi	711.2500	51	0.5	044E32 07.000	41N28 11.000	20	781	Rustavi 2
Borjomi	559.2500	32	0.25	043E23 05.000	41N50 08.000	25	874	Spektri
Borjomi	471.2500	21	0.2	043E23 05.000	41N50 08.000	30	874	Teleimedi
Chiatura	503.2500	25	0.5	043E14 48.000	42N16 56.000	90	648	Teleimedi
Chkhorotsku	679.2500	47	0.5	042E06 11.000	42N31 46.000	50	287	Ghia Abkhazetisatvis
Chkhorotsku	567.2500	33	0.1	042E06 11.000	42N31 46.000	40	287	Rustavi 2
Chokhatauri	559.2500	32	0.1	042E15 00.000	42N01 00.000	38	162	Rustavi 2
Chokhatauri	503.2500	25	0.2	042E15 00.000	42N01 00.000	50	162	Teleimedi
DEDOPLIS TSKARO	615.2500	39	2.0	046E08 16.000	41N27 48.000	65	834	Rustavi 2
DEDOPLIS TSKARO	479.2500	22	1.0	046E08 16.000	41N27 48.000	195	834	Teleimedi
DMANISI	479.2500	22	20.0	044E12 51.000	41N22 48.000	230	1814	GPB2
DMANISI	575.2500	34	1.0	044E12 51.000	41N22 48.000	230	1814	Rustavi 2
DMANISI	503.2500	25	1.0	044E12 51.000	41N22 48.000	70	1814	Teleimedi
GORI	711.2500	51	0.5	044E02 56.000	42N01 55.000	175	883	Civil Education Fund
GORI	591.2500	36	3.0	044E02 51.000	42N01 56.000	165	865	I Stereo
GORI	759.2500	57	3.0	044E02 51.000	42N01 56.000	160	865	Rustavi 2
GORI	615.2500	39	1.0	044E02 56.000	42N01 55.000	200	883	Teleimedi
KEDA	559.2500	32	0.1	041E56 30.000	41N35 48.000	25	232	Rustavi 2
Khashuri	503.2500	25	0.2	043E33 37.000	42N00 08.000	37	812	Teleimedi
Kumisi	495.2500	24	0.01	044E46 51.394	41N37 03.575	20	591	GPB2
KUTAISI	591.2500	36	3.0	042E44 12.000	42N16 49.000	95	351	Ajara
Kutaisi	663.2500	45	0.5	042E44 10.000	42N16 49.000	115	351	Civil Education Fund
KUTAISI	487.2500	23	3.0	042E44 12.000	42N16 49.000	60	351	I Stereo
Kutaisi	551.2500	31	0.5	042E44 10.000	42N16 49.000	100	351	Rioni
KUTAISI	567.2500	33	5.0	042E44 10.000	42N16 50.000	95	336	Teleimedi
KVARELI	631.2500	41	1.0	045E49 42.000	41N54 23.000	50	327	Rustavi 2
KVARELI	567.2500	33	1.0	045E49 38.000	41N54 23.000	50	326	Teleimedi
LAGODEKHI	679.2500	47	3.0	046E10 14.000	41N48 45.000	30	487	Ajara

Georgian analog TV stations in UHF					21st December 2013			Page2/2
TX-Name	**Freq.**	**Ch.**	**ERP kW**	**Longit.**	**Latit.**	**Ant.H.**	**Ground Height**	**Network**
MARNEULI	511.2500	26	0.1	044E47 18.000	41N29 30.000	35	497	GPB 1
MARNEULI	647.2500	43	0.1	044E48 00.000	41N28 00.000	40	397	Kvemo Kartli TV-Radio Company
MARNEULI	727.2500	53	0.5	044E47 18.000	41N29 30.000	40	497	Rustavi 2
MARNEULI	471.2500	21	0.5	044E47 18.000	41N29 31.000	55	497	Teleimedi
Martvili	687.2500	48	0.5	042E21 59.000	42N27 21.000	20	415	GPB 1
Martvili	471.2500	21	0.2	042E21 59.000	42N27 21.000	23	415	Teleimedi
Ozurgeti	471.2500	21	0.1	042E02 02.000	41N55 26.000	30	107	Guria
Ozurgeti	607.2500	38	0.1	042E02 02.000	41N55 26.000	25	107	Rustavi 2
Ozurgeti	487.2500	23	0.2	042E02 02.000	41N55 26.000	40	107	Teleimedi
POTI	527.2500	28	5.0	041E42 28.000	42N11 07.000	130	1	GPB2
POTI	583.2500	35	0.25	041E41 00.000	42N09 00.000	30	2	Metskhre Talgha
POTI	479.2500	22	0.5	041E41 00.000	42N09 00.000	40	2	Rustavi 2
POTI	503.2500	25	1.0	041E42 28.000	42N11 07.000	130	1	Teleimedi
Sachkhere	623.2500	40	0.5	043E24 23.000	42N20 57.000	30	687	Civil Education Fund
Sachkhere	543.2500	30	0.1	043E24 16.000	42N20 56.000	35	718	GPB2
Sachkhere	479.2500	22	0.5	043E24 16.000	42N20 56.000	40	718	I Stereo
Sachkhere	527.2500	28	0.1	043E24 16.000	42N20 56.000	35	718	Rustavi 2
SAGAREJO	575.2500	34	0.1	045E17 17.000	41N43 41.000	20	824	Tvali
Senaki	719.2500	52	0.5	042E03 27.000	42N17 24.000	35	340	Civil Education Fund
Senaki	527.2500	28	0.5	042E03 27.000	42N17 24.000	25	340	I Stereo
Senaki	543.2500	30	0.2	042E03 27.000	42N17 24.000	30	340	Samegrelo
SIGHNAGHI	711.2500	51	0.5	045E53 28.000	41N37 04.000	20	984	Rustavi 2
TBILISI	567.2500	33	1.0	044E47 09.000	41N41 44.000	70	746	Civil Education Fund
TBILISI	503.2500	25	1.0	044E47 09.000	41N41 44.000	210	746	Evrika
TBILISI	623.2500	40	10.0	044E47 09.000	41N41 44.000	250	746	I Stereo
TBILISI	527.2500	28	5.0	044E47 09.000	41N41 44.000	200	545	Kavkasia
TBILISI	663.2500	45	2.0	044E47 09.000	41N41 44.000	120	746	MZE
TBILISI	583.2500	35	2.0	044E47 09.000	41N41 44.000	100	746	Pik
TBILISI	543.2500	30	2.0	044E47 09.000	41N41 44.000	83	746	Teleimedi
TELAVI	631.2500	41	1.0	045E24 35.000	41N52 13.000	40	1784	Rustavi 2
TELAVI	647.2500	43	1.0	045E24 39.000	41N52 18.000	30	1788	Teleimedi
Tkibuli	471.2500	21	1.0	043E02 12.000	42N22 36.000	70	1178	Teleimedi
TSALENJIKHA	607.2500	38	0.1	042E03 45.000	42N37 00.000	35	276	Ghia Abkhazetisatvis
TSALENJIKHA	519.2500	27	0.1	042E03 45.000	42N37 00.000	30	276	GPB2
TSALENJIKHA	471.2500	21	0.1	042E03 45.000	42N37 00.000	30	276	Rustavi 2
Tsalka	471.2500	21	0.1	044E14 19.000	41N38 06.000	40	1947	Rustavi 2
Tsalka	535.2500	29	0.25	044E14 19.000	41N38 06.000	45	1947	Spektri
Zestaphoni	655.2500	44	0.05	043E03 48.000	42N03 37.000	25	474	JLC Kvetenadze and Company
Zestaphoni	615.2500	39	0.2	043E03 48.000	42N03 37.000	20	474	Teleimedi
Zugdidi	567.2500	33	0.1	041E53 07.000	42N30 07.000	35	120	GPB2
Zugdidi	599.2500	37	1.0	041E53 09.000	42N30 08.000	30	129	I Stereo
ZUGDIDI	615.2500	39	0.1	041E53 09.000	42N30 08.000	55	129	Odishi
Zugdidi	519.2500	27	0.1	041E53 07.000	42N30 07.000	35	120	Rustavi 2
Zugdidi	471.2500	21	0.2	041E53 07.000	42N30 07.000	50	120	Samegrelo
Zugdidi	631.2500	41	0.5	041E53 07.000	42N30 07.000	70	120	Teleimedi

DVB frequencies for Georgia State MUX before ASO							March 25th 2014	
TX-Name	Freq.	Ch.	ERP [kW]	Longit.	Latit.	Ant.H. above ground level [m]	Ground height [m] (based on coordinates & digital terrain model	Network
ABASTUMANI	682,00	47	0,087	042E49 28.160	41N45 11.070	30	1552	State MUX
AKHALKALAKI	682,00	47	5,000	043E25 33.950	41N20 51.900	60	1812	State MUX
AKHALTSIKHE	682,00	47	4,133	042E57 25.070	41N37 48.480	60	1338	State MUX
AMBROLAURI	706,00	50	0,258	043E09 51.790	42N30 50.090	20	782	State MUX
ASPINDZA	682,00	47	0,190	043E12 10.140	41N34 05.580	30	1588	State MUX
BAKURIANI	682,00	47	0,070	043E33 13.340	41N44 08.560	25	2129	State MUX
BATUMI	786,00	60	5,000	041E42 55.290	41N41 37.620	46	174	State MUX
BEKAMI	682,00	47	0,514	043E33 39.300	42N00 08.350	32	809	State MUX
BOLNISI	778,00	59	1,555	044E32 17.390	41N28 00.760	30	744	State MUX
BORJOMI	682,00	47	0,983	043E23 00.580	41N49 26.500	20	1320	State MUX
CAGERI	706,00	50	0,455	042E45 25.950	42N38 57.940	30	745	State MUX
CHIATURA	706,00	50	0,567	043E15 39.850	42N17 16.090	70	633	State MUX
CHKHOROTSKU	706,00	50	0,287	042E06 11.390	42N31 45.910	35	287	State MUX
CHOKHATAURI	706,00	50	0,287	042E13 49.450	41N59 38.130	30	198	State MUX
DEDOPLISTSKARO	522,00	27	4,043	046E08 10.820	41N28 00.810	90	912	State MUX
DMANISI	778,00	59	3,135	044E12 52.630	41N22 39.820	60	1882	State MUX
DUSHETI	682,00	47	0,382	044E39 23.750	42N00 07.120	30	1214	State MUX
GORI	682,00	47	4,438	044E02 50.990	42N01 56.100	166	865	State MUX
JVARI	490,00	23	0,311	042E03 23.810	42N43 31.320	25	486	State MUX
KAZBEGI	554,00	31	0,558	044E36 42.950	42N37 31.340	20	1769	State MUX
KHULO	682,00	47	0,558	042E20 34.270	41N38 23.270	25	1478	State MUX
KUTAISI	706,00	50	5,000	042E44 11.450	42N16 48.900	100	351	State MUX
KVARELI	490,00	23	4,489	045E49 41.440	41N54 23.190	40	326	State MUX
LAGODEKHI	522,00	27	0,338	046E10 16.870	41N48 42.610	25	481	State MUX
LENTEKHI	706,00	50	0,820	042E45 53.460	42N46 31.100	12	1716	State MUX
MESTIA	706,00	50	0,411	042E47 39.630	43N02 07.740	18	2185	State MUX
NINOTSMINDA	682,00	47	0,140	043E35 19.020	41N16 01.360	30	1932	State MUX
ONI	706,00	50	0,338	043E25 44.680	42N34 46.130	25	811	State MUX
OZURGETI	786,00	60	0,338	041E59 34.700	41N54 49.420	25	182	State MUX
POTI	786,00	60	2,580	041E42 03.090	42N11 16.300	120	1	State MUX
QEDA	786,00	60	0,536	041E55 22.870	41N35 54.820	25	496	State MUX
SACHKHERE	706,00	50	0,643	043E24 15.550	42N20 55.580	20	718	State MUX
SAGAREJO	490,00	23	0,205	045E17 17.000	41N43 40.700	25	824	State MUX
SHUAKHEVI	682,00	47	0,322	042E11 23.820	41N38 57.480	22	1401	State MUX
SIGNAGHI	522,00	27	0,675	045E53 27.700	41N37 15.000	25	1002	State MUX
TBILISI	490,00	23	5,000	044E47 06.440	41N41 44.750	120	748	State MUX
TIANETI	490,00	23	0,324	044E56 54.700	42N06 07.300	20	1201	State MUX
TKIBULI	706,00	50	0,287	043E02 20.060	42N22 26.890	40	1286	State MUX
TSALENJIKHA	490,00	23	0,788	042E03 45.230	42N37 00.030	20	276	State MUX
TSALKA	778,00	59	0,549	044E14 19.110	41N38 05.980	50	1947	State MUX
TSIVI	490,00	23	0,606	045E24 35.450	41N52 13.230	12	1784	State MUX
ZUGDIDI	490,00	23	2,300	041E53 09.440	42N30 07.800	60	129	State MUX

4.4 Digital TV channel multiplexes after ASO

Frequency planning target for State MUX in UHF band was to have SFN areas as large as possible.

4.4.1 UHF-frequency plan

The target of the frequency plan presented in the table "*UHF Frequency plan for the State MUX before and after ASO"* was to have simulcast with analogue and digital state television and be able to perform analogue switch off with more or less no breaks in digital TV transmission. The nationwide State MUX has 42 main transmitter stations (same as the goal for the time before ASO) and 60 gap filler stations. No regional content was wished for the multiplex.

After ASO (analog switch off), the temporary set of frequencies / channels used for digital TV during simulcast will have to be changed to permanent set of frequencies. According to the plan, there are 12 channels, used for either State MUX or MUX1[8] before ASO will remain at the same transmitter station after ASO (e.g. Tbilisi ch 23 will be used for State MUX both before and after ASO. The channels that will remain at the transmitter station after ASO are marked with blue in the table below.

All channels above 48 (channels in the 700 MHz band) will be used for mobile services after ASO, and are marked with red in the table below.

Number of adjacent digital channels on the same site has been minimized to give more freedom in transmitter antenna selection for different multiplexes.

Simulcast period have not been considered for the frequency changes needed in the two multiplexes State MUX and MUX1. Having State MUX and MUX1 on air before ASO, makes it possible to have analog and digital simulcast of several channels. But when the analog channels are switched off, the majority of UHF channels used for State MUX and MUX1 will be changed.

Table. UHF Frequency plan for two MUXes before ASO and seven MUXes after ASO. UHF channels in the 700 MHz band are coloured red. UHF channels that remain at the same site after ASO are coloured blue. UHF channels that are not used for MUX4, 5 and 7 are coloured grey.

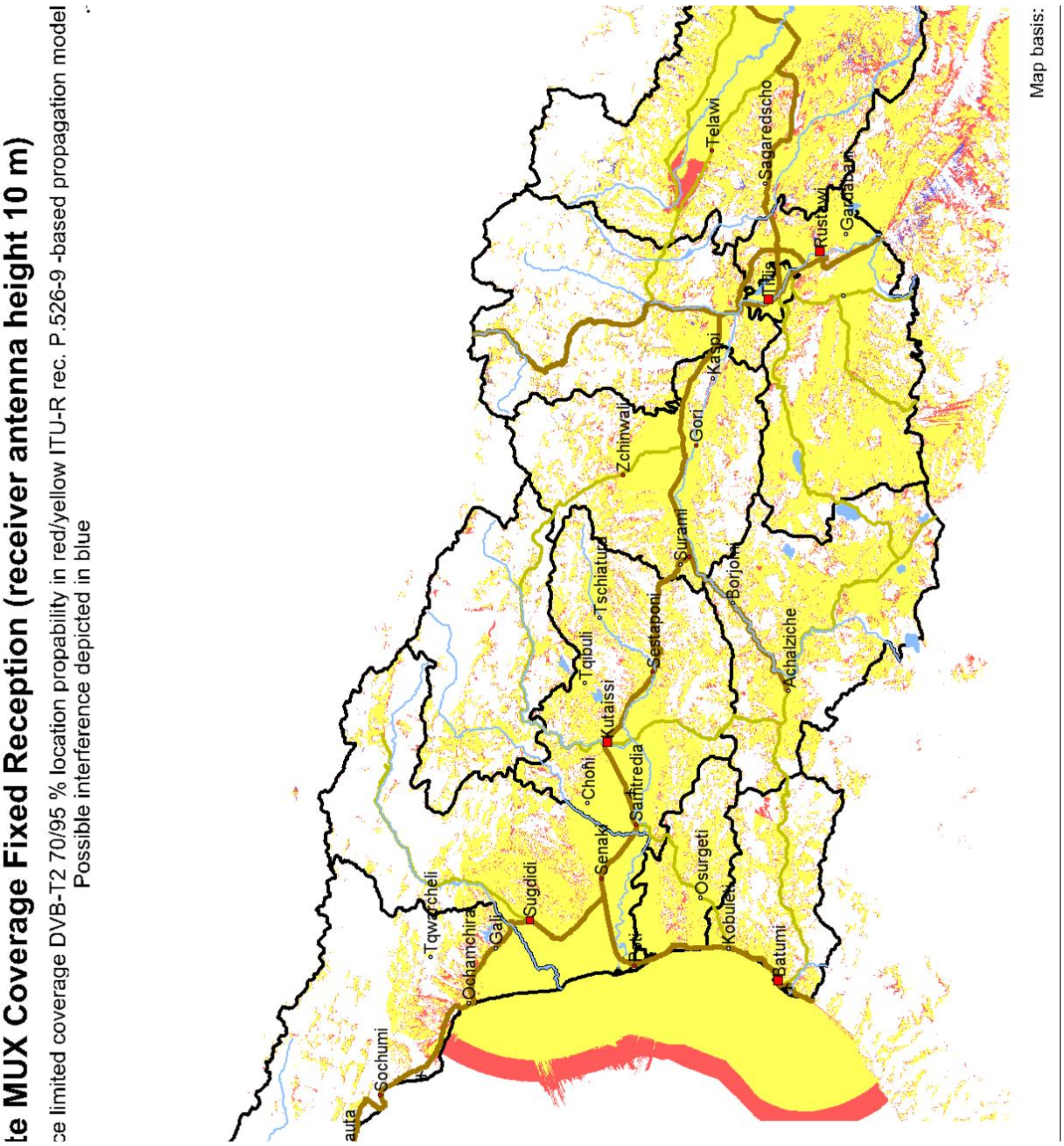
[8] MUX 1 is one out of five commercial multiplex platforms owned by a separate commercial MUX Operator(s), the licences for which have been assigned by GNCC

Allotment	Site	before ASO		after ASO						
		State MUX	1	State MUX	1	2	3	4	5	7
		public broadcaster	Regional /local insertions Fre-to-air	public broadcaster	Regional / local insertions	mational Free-to-air	comertialPay-TV	comertialPay-TV	comertialPay-TV	Resereved regional insertions
GE0250	Jvari	23	51	23	40	36	38	30	33	29
GE0250	Tsalenjikha	23	51	23	28	36	38	30	33	29
GE0250	Zugdidi	23	15	23	26	36	38	30	33	29
GE0252	Batumi	60	58	23	30	36	38	27	33	48
GE0252	Ozurgeti	60	58	23	29	36	38	27	33	48
GE0252	Poti	60	58	23	43	40	38	27	33	26
GE0252	Qeda	60	58	23	29	36	38	27	33	40
GE0253	Ambrolauri	50	58	34	25	21	44	32	41	48
GE0253	Cageri	50	58	34	46	21	44	32	41	48
GE0253	Chiatura	50	58	34	39	21	44	32	41	24
GE0253	Chkhorotsku	50	58	34	46	21	44	32	41	25
GE0253	Chokhatauri	50	58	34	39	21	44	32	41	48
GE0253	Kutaisi	50	58	34	47	21	44	32	41	24
GE0253	Lentekhi	50	58	34	39	21	44	32	41	48
GE0253	Mestia	50	58	34	47	21	44	32	41	25
GE0253	Oni	50	58	34	39	21	44	32	41	48
GE0253	Sachkhere	50	58	34	26	21	44	32	41	24
GE0253	Tkibuli	50	58	34	46	21	44	32	41	24
GE0255	Abastumani	47	53	34	29	21	38	32	41	25
GE0255	Akhalkalaki	47	53	34	29	21	38	32	41	25
GE0255	Akhaltsikhe	47	53	34	30	21	38	32	41	25
GE0255	Aspindza	47	53	34	29	21	38	32	41	25
GE0255	Khulo	47	53	34	30	21	38	32	41	24
GE0255	Ninotsminda	47	53	34	29	21	38	32	41	25
GE0255	Shuakhevi	47	53	34	43	21	38	32	41	24
GE0256	Bakuriani	47	42	34	30	21	38	28	26	23
GE0256	Bekami	47	42	34	42	21	38	28	26	30
GE0256	Borjomi	47	42	34	40	21	38	28	26	46
GE0256	Dusheti	47	42	34	30	21	38	28	26	23
GE0256	Gori	47	42	34	43	21	38	28	26	24
GE0257	Kazbegi	31	53	31	39	27	44	36	41	33
GE0258	Bolnisi	59	51	39	31	27	44	36	33	35
GE0258	Dmanisi	59	51	39	41	27	44	36	33	35
GE0258	Tsalka	59	51	39	31	27	44	36	33	35
GE0259	Kvareli	23	57	23	40	21	38	28	26	31
GE0259	Sagarejo	23	57	23	40	21	38	28	26	48
GE0259	Tbilisi	23	57	23	46	21	38	28	26	48
GE0259	Tianeti	23	57	23	40	21	38	28	26	30
GE0259	Tsivi	23	57	23	42	21	38	28	26	31
GE0261	Dedoplistskar	27	29	30	25	47	45	43	22	35
GE0261	Lagodekhi	27	29	27	29	47	45	43	22	35

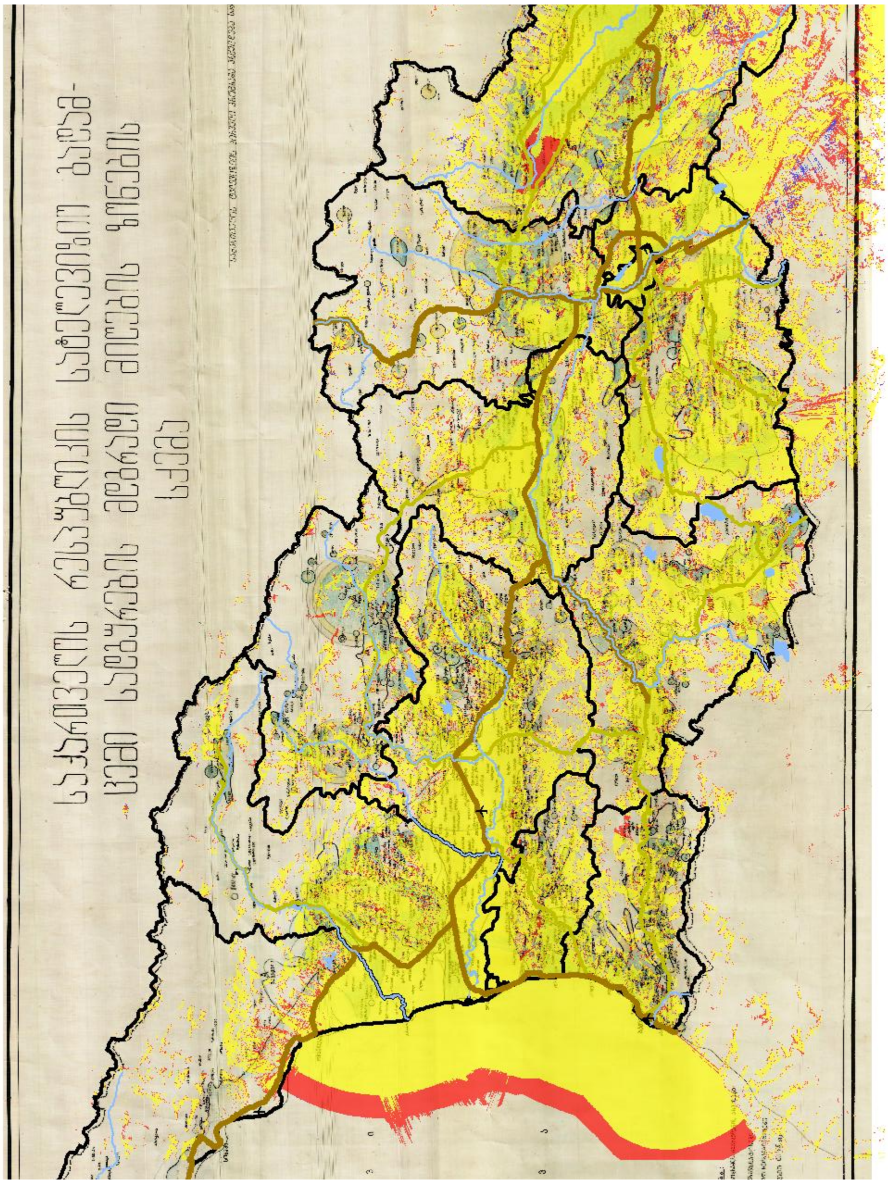
4.4.2 Coverage prediction of UHF State MUX

Full coverage map of State MUX is presented in the following two pages, first on vector map, then handmade GPB analog TV coverage map as a supporting background.

The comparison with analog map should not be considered in detail, because the way analog map has been drawn, is not fully taking into account the mountains. But when looking at large scale, overall comparison could be useful. It should also be remembered, that the digital plan includes only 42 main transmitting sites, while GPB analog map consists of both main sites and many gapfillers.



e MUX Coverage Fixed Reception (receiver antenna height 10 m)
e limited coverage DVB-T2 70/95 % location propability in red/yellow ITU-R rec. P.526-9 -based propagation mo
nwide analog terrestrial TV coverage map as background given by the GNCC



Map ba

4.5 Radio Network Deliverable

The vendor is expected to provide own Radio Network design if an alternative planning methodology is used
.

Coverage

- Coverage maps (interference limited)
  - Service coverage and capacity tradeoff
  - SFN plan**

- Site information (coordinates, antenna heights)
- Planning parameters & calculation methodology
  - Planning tool used
  - Radiowave propagation model
  - Quality of ground-height model and maps

References

- DVB-T2 networks planned (and built) by vendor

5 Head End Design Requirements

5.1 Introduction

The Digital Terrestrial Television Head End will aggregate Broadcasters standard and high definition channels using MPEG4 encoding and statistical multiplexing for efficient Multiple Program Transport Stream ("MPTS") generation for service delivery. The Head End will provide Program Specific Information ("PSI") and System Information ("SI") services and HbbTV1.5 play out facilities to support interactive services offered by the Service operator.

5.2 System and service requirements

The Head End will receive uncompressed baseband HD and SD signals from the respective Broadcasters premises together with scheduled data information for the Electronic Program Guide (EPG). The HD services will be delivered in HD-Serial Digital Interface ("HD-SDI") format, which conforms to SMPTE292M standard at a nominal data rate of 1.485 Gbps and SD services using the SD-SDI, which conforms to SMPTE259M standard at a nominal data rate of 270 Mbps. The scheduled data will be delivered in XML format. The contribution network will deliver main and backup signals to both the Head End and the State Mux. The State Mux will have additional feed to Digital Recovery Head End to ensure system availability. At the Head end, baseband signals will be monitored before feeding the MPEG4 encoders. The encoder outputs will be then multiplexed and fed to the T2 Gateways for encapsulation into T2-MI format before transmitting over the distribution network. Schedule data from the Broadcasters will feed the PSI/SI generator and the HbbTV playout Server for the platform EPG.

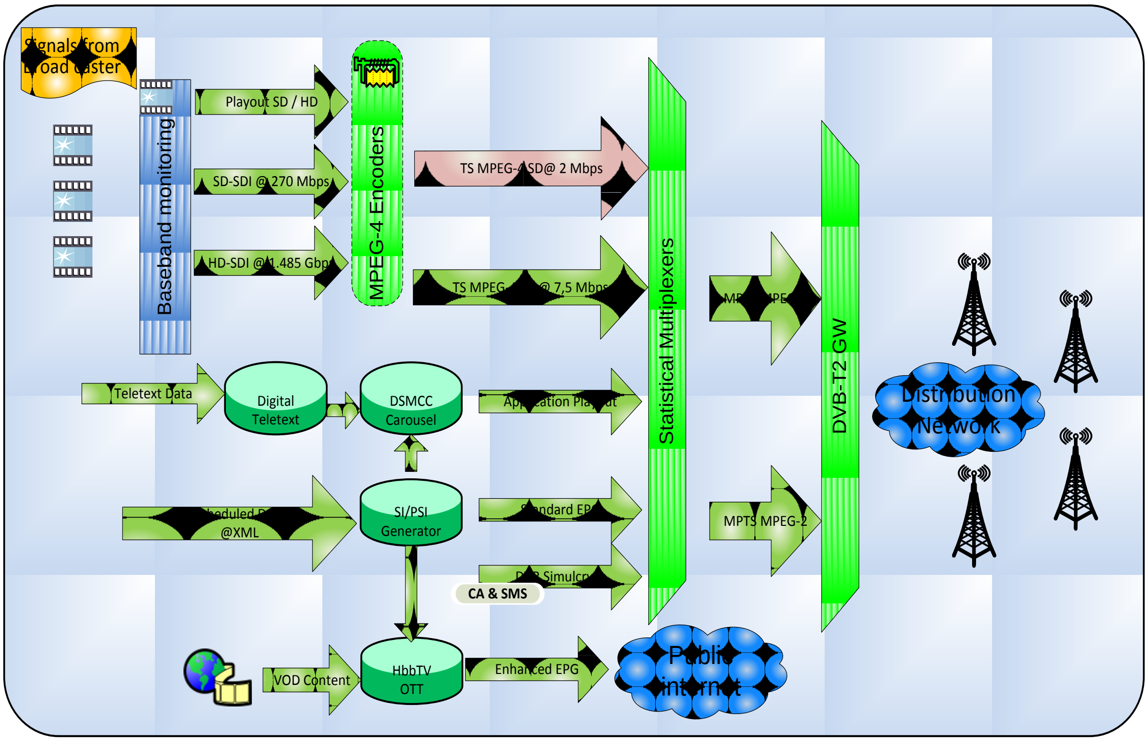


Figure 1. Overview of DVB-T2 Head end.

Each Broadcaster sends SD-SDI or HD-SDI signals and Program information for Event Information Table (EIT) to the Head end via the contribution network. Uncompressed baseband signals can be filtered in frame synchronizers and audio on automatic leveler to maintain quality of service before feeding the MPEG-4 encoder farm. Scheduled data via XML will be processed in the PSI/SI Generator to update the platform's EPG.

Components of the Head End are baseband monitoring, MPEG-4 Encoder platform, Statistical multiplexing, DVB-T2 GW technology, conditional access systems, subtitling systems, PSI/SI generation, DSMCC carousels, management system transport stream and baseband analyzers.

5.2.1 Provide data for optimal bit-rates used in markets

The total number of services (programs) to be carried is 15 standard definition programs (SD) or 4 high definition programs (HD) in the multiplex.

Regarding the HD format, the EBU Technical Report 005 (Information Paper on HDTV Formats) compares two most common formats 720p/50 and 1080i/25. Whilst the EBU report recommended 720p/50, improvements in display technology mean that this is no longer necessarily the case for optimal perceived picture quality and 1080i/25 has emerged as the de-facto industry production standard format for HD services worldwide.

Table 1 below shows the recommended data rate per program according to the EBU paper. The SD programs as well as the HD programs should be considered with the source coding method H.264/AVC.

Format	Source coding	Video data rate (Mbit/s)	Program associated data (Mbit/s)	Total data rate for one program (Mbit/s)
SD – 576i/50	H.264/AVC	1.8	0.85	2.65
HD - 720p/50	H.264/AVC	7.0	0.85	7.85
HD - 1080i/25	H.264/AVC	7.5	0.85	8.35
HD - 1080p/50	H.264/AVC	10.0	0.85	10.85

Table 1: Data rate (Source: EBU Strategic Program on Spectrum Management, July 2012)

GPB proposes to adopt the 576i/50 format for SD services and 1080i/25 format for HD services based on the information above. The encoding equipment will also support 720p/50 if a broadcast channel wishes to select this format. 720p/50 is recommended if source material is sports and source signal 720p/50.

The data rate as per Table 1 above acts as a guideline for broadcasters to adopt. Table 2 below shows examples of actual bitrates used by broadcasters based on their content genre and the amount of motion in the material. (High motion content requires more capacity to prevent picture degradation).

	Optimal Bit Rates per channel (Mbps)							
DVB-T2 Standards	Average Bitrate		Sports		News		Movies	
Operator, Country (Compression)	HD	SD	HD	SD	HD	SD	HD	SD
DIGITA, Finland (H.264)	6.0-6.5	N.A	7.3-7.9	N.A	5.2-5.6	N.A	5.5-5.9	N.A
Teracom, Sweden (H.264)	6.0-6.5	1.2-1.6	7.3-7.9	1.5-1.8	5.2-5.6	1-1.3	5.5-5.9	1.1-1.4
Norkring, Norway (H.264)	6.0-6.5	1.2-1.6	7.3-7.9	1.5-1.8	5.2-5.6	1-1.3	5.5-5.9	1.1-1.4
Kordia, New Zealand (H.264)	8.0-9.0	2.0-3.0	-	-	-	-	-	-
Arqiva, UK (H.264)	7.0-8.0	2.0-3.0	-	-	-	-	-	-
Georgia (Proposed) (H.264)	6.5-7.5	1.4-2.2	7.0-8.0	1.6-2.4	5.2-5.6	1.2-1.6	5.5-5.9	1.4-1.8

Table2: Georgia Proposed Data Rate vs. Global Operators Data Rate

Table 2 above shows the actual bit rates used by different operators using H.264/AVC encoding on DVB-T2 services. The average bitrate used ranges between 6.0-9.0 Mbps for HD and 1.2-3.0 Mbps for SD. GPB is proposing an average bitrate of 6.5-8.0 Mbps and 1.2-1.6 Mbps for HD and SD services respectively.

The total average bitrate proposed for HD services will be 8.0 Mbit/s. HD service will consist of one video and several audio components, plus optional audio, subtitling, and HbbTV components. Typically 7.5 Mbit/s as an average bitrate for the HD video component provides excellent video quality, especially when the service is statistical multiplexed with other services, allowing dynamic allocation of video bitrate depending upon content within the statistical multiplexing group.

The total average bitrate proposed for SD services will be 2.15 Mbit/s. SD services may consist of one video and several audio components, plus optional subtitling and HbbTV components. Typically 1.7 Mbit/s as an average bitrate for SD video components provides good video quality when statistically multiplexed with other services as described above.

Table 3 below shows the typical percentage gain in efficiency depending on the number of programs per multiplex, and shows that with 10 services in one multiplex, a gain of approximately 25% can be achieved, offering better perceived picture quality than would be possible using constant bit rate.

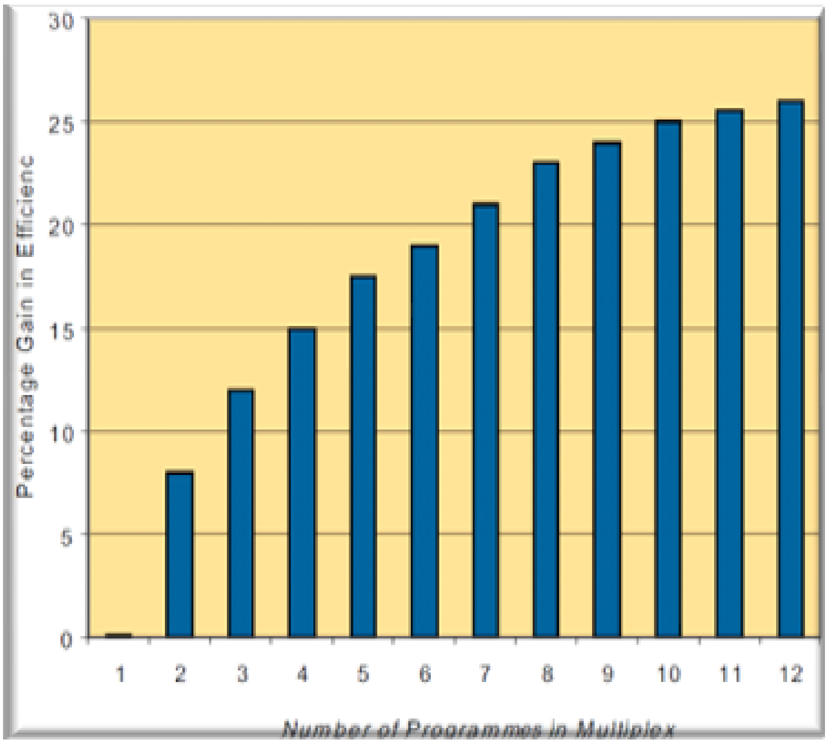


Table 3: Typical Statistical Multiplexer Gain

The multiplex will also carry PSI/SI (including the EPG schedule data). In the multiplex, 1.0 Mbit/s should be allocated for this purpose. PSI/SI will be cross-carried to ensure that the EPG schedule data for all multiplexes is available for receivers all the time. In addition, a small amount of bit rate will be allocated to provide 'headroom' and also for the DVB-SSU over-the-air receiver software download service.

5.2.2 H.264 Encoders and Multiplexers

Encoders and Multiplexers are statistically controlled. Variable bit rate ("VBR") encoding allows for more channels to be multiplexed and still maintain high quality picture for each channel. MUX capacity will also be used for the DVB-PSI/SI tables as they are used for the location of EPG, CA, NIT for automatic tuning of receivers upon selection and others.

5.2.3 Digital Subtitling Transmission Systems

DVB Subtitling is subtitle bitmap image picture that is compressed and sent as a DVB transport stream along the channel as separate data PID. Because the subtitle is image broadcasters gets full control of the appearance of the subtitles, as well as full support for all languages.

In DVB subtitling subtitling viewers can choose not to display the subtitles or display different languages.

5.2.4 Electronic Program Guide ("EPG")

The EPG is an essential feature on a converged Digital Terrestrial TV platform environment. It serves as a guide to viewers allowing them to search and preview the programs offered by all the broadcasters.

EPG information shall be available up to 7 days ahead (today + seven days) Compared to the Analogue service, DTT offers many more channels and hence viewers will need an EPG to help them find and 'discover' content.

DVB-SI-based EPG will be used: The EPG data is broadcasted as tables conforming to the DVB-SI specifications. Receivers can decode this data and display it in a visual presentation designed by the receiver manufacturer.

5.2.5 Master Sync clock and Frequency generator

The Head End, distribution network and transmitters will need to have exact timing information. Since the satellite's GPS signal can be disturbed, GPS-independent timing and synchronization should be considered alternatively.

GPS-independent timing and synchronization will be installed in the Head End and distributed by distribution network to transmitters and DVB-T2 SFN adapters.

5.2.6 Emergency Information System ("EIS")

Network provider will develop the EIS. This application will be broadcasted and signalled at all times from the Head end. Under instruction from the appropriate emergency services coordination authorities, the EIS application will be activated to display appropriate textual or graphical information simultaneously across the country. The EIS alerts can be configured to interrupt normal viewing and provide the viewer with critical information during national emergencies.

The EIS will be able to provide the following functions in the event of a disaster:

- Interrupt normal programming
- Provide audio alert or a message
- Display text information
- Display graphical information

5.2.7 Conditional Access System ("CAS")

The Smart Card system provides additional security features like chipset pairing, three-layered card issuing system and multi-layered encryption. Usually CAS system is communicating with Multiplexers where scrambling is done.

5.2.8 Subscriber Management System ("SMS")

Subscriber Management System (SMS) is an entry level Subscriber Management System enabling the pay TV operators to manage their viewers:

- Access to end user data
- Administration of customers subscriptions: create, modify and delete channel packages

The system should build on an architecture that can be easily integrated to third party systems, such as billing systems, through specific interfaces to import or export data.

5.2.9 24/7 Logging System

24/7 logging and archiving of the transport stream output of the multiplexers. All SD and HD channels with EPG information will be analyzed with ETR 290 Priority 1, 2 and 3. All analyzed content can be recalled for analysis and using as availability reports for referring to the SLA.

5.2.10 Redundancy availability requirement

In order to achieve 99.97 % service availability, each main components in the Head end needs to be for either (N+M) or (1+1) redundancy scheme with no single point of failure. This approach provides enhanced services protection for high value services and minimal interruption from real life failure conditions. The Head end electrical power designs meet Uptime Institute Tier III specifications and the entire IP network is configured for automatic failover to a secondary core switches when the primary network fails.

The following table describes the redundancy provisions designed for specific system components.

Item	System	Functions	Redundancy Level
1	H.264 Encoders	Encode signals to H.264 single program transport stream	**N+M**
2	Multiplexers	Stat Mux to multiple transport program stream ("MPTS")	**1+1**
4	DVB-T2 Gateway	MPTS is modulated into T2-MI format before sending to distribution network	**1+1**
5	Network Switches	IP backbone of the LAN infrastructure	**1+1**

Table 5: Redundancy Provisions

5.3 Management of the equipment

Management system will continually monitor network operators every device within a local system, and provides automated failure detection, redundant switching and configuration of the fail-over components.

- Encoders and multiplexers profiles can be scheduled.
- Alarm overview from all devices in one view.
- Automatic switchover to spare units
- Availability monitoring for SLA Reporting

5.3.1 SNMP management

Simple Network Management Protocol (SNMP) is a standard protocol for monitoring and management devices with IP connection.

The most important alarms, status information and controls from all equipment are collected to by SNMP server and it's the primary tool for network supervisors. The SNMP server stores the wanted incidents to the management databases for statistical and SLA purposes.

Equipment should have SNMP agent for sending and receiving the management information between the device and SNMP management system. Devices must support and comply with standards.

- SNMPv1
- SNMPv2c
- SNMPv3
- MIB-2 (RFC1213 and RFC1573)
- The physical interface of the equipment is Ethernet (10BaseT, 100BaseT with RJ45 connectors).

Both get and set SNMP community strings must be changeable, and maximum length of strings must exceed 16 characters.

5.3.2 Traps

SNMP agent should send the on-going trap within 1 to 2 seconds, when an alarm comes up or the status of the equipment changes. The agent should also send the same off going trap, when the alarm goes off or the status changes back to original state within same time interval. These off going traps should also be sent after 'RESET' command, if the status of alarm and equipment changes.

Agent must have at least two configurable trap destinations. The agent should send the on and off going traps only once, when the status changes.

Administrator should have possibility to configure, which traps are sent to the management system, through SNMP and local console.
Enterprise specific traps should be sent with the enterprise object ID and equipment object ID (OID).

Each alarm should be sent as a unique trap with on/off status. Status of the trap must be readable via SNMP GET, from some status branch of the MIB.

5.3.3 Commands

It should be possible to read the status of the performed command with the command OID.

In addition to this all alarm and status changes that the command creates, should be sent as individual traps as specified in the previous paragraphs.

5.3.4 The System's Own Management System

If the system has its own management system, the integration to Management/Monitoring server is recommended to be implemented through SNMP.

5.4 Technical description of the required system

5.4.1 Encoder requirements

- Video encoding support
    - H.264 HD 4:2:0 8 bit 1-20 Mbit/s
        - 1920/1440 x 1080i 25
        - 1280/960 x 720p 50
    - MPEG-4 SD 4:2:0 8 bit 0.5-10 Mbit/s
        - 720/704x576i
- 3G/HD/SD-SDI, video input support
- (DPI) Digital Program Insertion SCTE 104 / 35 support
- Audio Encoding support
    - Up to 4 stereo pairs
    - MPEG-1 Layer II encoding per channel
    - AAC or HE-AAC encoding per channel
    - AC-3 pass-through support
    - AC-3 and E-AC3 support
    - Embedded (SDI) and AES-EBU audio input support
- MPEG-2 TS support with 188 packet size
- VANC data extraction and support for generic VANC (SMPTE 2038)
- Dual Power Supply support
- IPv4 support
- Automatic Redundancy to backup encoder.

5.4.2 Multiplexer requirements

- Statistical multiplexing
- MPEG-2 TS support with 188 packet size
- Dual Power Supply support
- IPv4 support
- ASI (Asynchronous Serial Interface) Input / Output
- Automatic Redundancy to backup multiplexer.

5.4.3 Regional content insertion requirements

- DVB-T2 MI decrypter
- SFN syncronization
- PLP re-inserter
- PSI/SI generator for regional channel

5.4.4 (PSI) Program Specific Information requirements

Refer to Rules of operation specification

- (PAT) Program Association Table
- (PMT) Program Map Table
- (CAT) Conditional Access Table
- (NIT) Network Information Table

5.4.5 (SI) Service Information requirements

- (SDT) Service Descriptor Table
- Cross-Carriage of SI information between multiplexers

5.4.6 (EIT) Event Information Table

- Schedule up to 14 days information
- Now and next schedules
- Actual and other schedules
- Multilanguage support

5.4.7 DSM-CC carousel requirements

- Over The Air (“OTA”) Downloads

5.4.8 Digital Teletext and Subtitling Transmission System

- Multilanguage support
- DVB subtitlting
- Teletext subtitling

5.4.9 Sync clock and Frequency generator

- 1PPS
- 10 MHz
- NTP time

5.4.10 Baseband monitoring

- Audio level monitoring
- Subtitling monitoring
- HD/SD SDI monitoring.
- Waveform monitoring

Visual monitoring of all channels *“Mosaic picture”*

5.4.11 Transport stream monitoring

Output of muxes should be monitored at transport stream level according ETR 290 specification priority’s 1, 2 and 3

5.4.12 Emergency Information System

In case of emergency there should be a possibility to put emergency information banner and warning sound on every channel that will give Information intended to protect life, health and safety.

5.5 Architecture drawings of the system

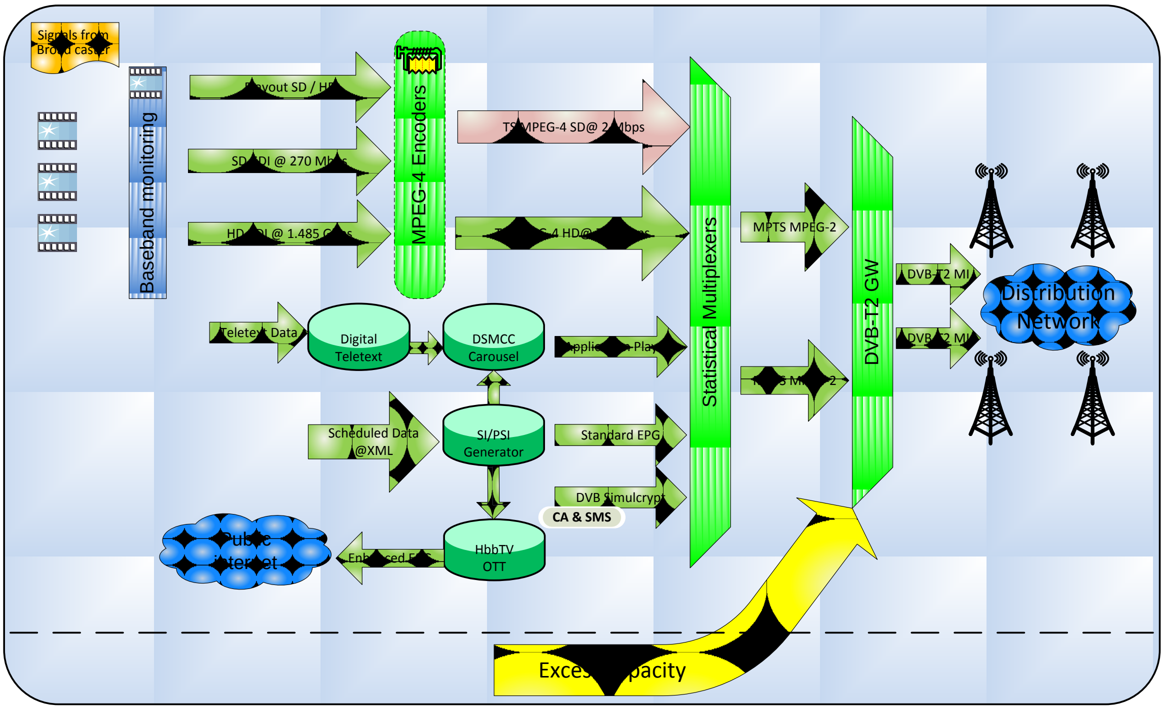


Figure 2. Example head end overview

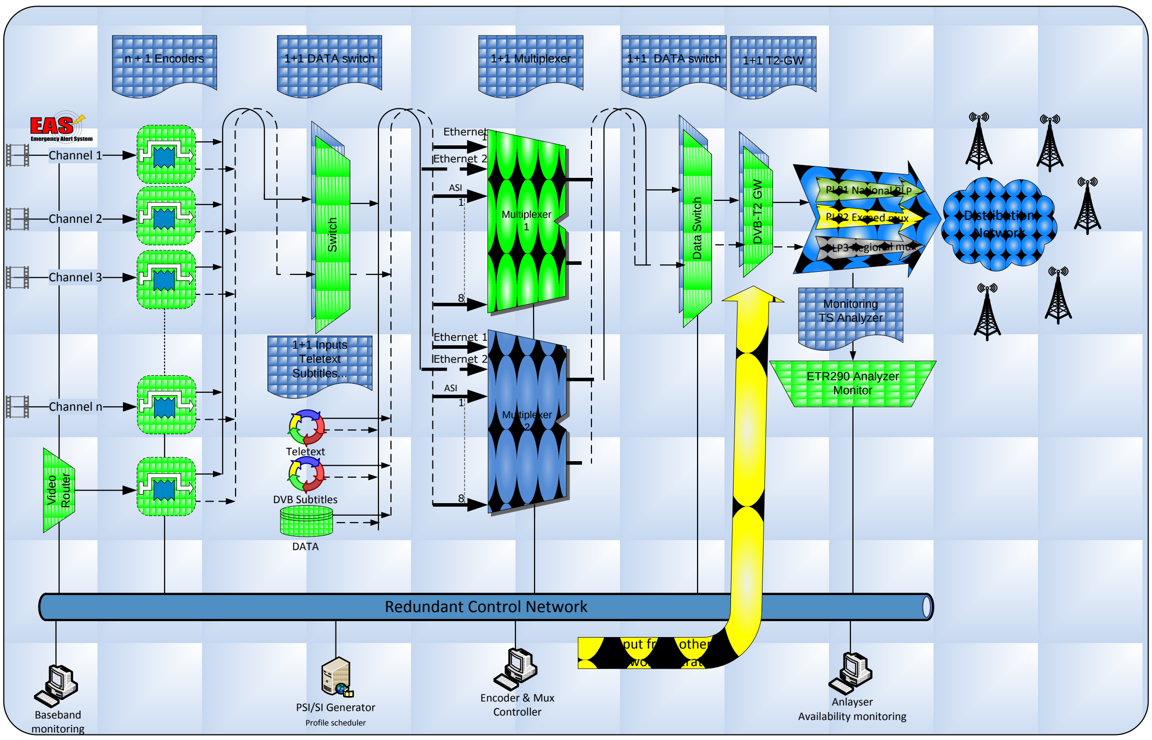


Figure 3. Example of head end architecture

5.6 List of standards the system must fulfil.

Digital Terrestrial Television Industry Technical Standards

To ensure interoperability, the encoders, multiplexers, carousel, DVB-T2 gateway, transmission network and the receiver devices must conform to standards outlined by International Organization of Standard (“ISO’), International Electro technical Commission (“IEC”), European Telecommunication Standard Institute (“ETSI”) and Digital Video Broadcasting (“DVB”) as detailed below.

Sources	Signal Type	Standards
Encoders **Multiplexers/ Re-Multiplexers**	INPUT MPEG-4/H.264 Video Encoding	• SMPTE 259 • SMPTE 274 • SMPTE 296 • SMPTE 334-1 Closed Captions • SMPTE 2016-3 AFD and Bar Data • SMPTE-2031 Teletext • OP47 Teletext Subtitles • SCTE35 Digital Program Insertion Cueing • SCTE104
	MPEG-4 AAC and AC-3 Audio Encoding	• ISO/IEC 13818-2: Generic coding of moving pictures and associated audio information: Video • ETSI TS 101 154: Digital Video Broadcasting Specifications for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream • ETSI EN 300 468: Digital Video Broadcasting Specifications for Service Information (SI) in DVB System • ISO/IEC 14496-10 SD& HD: Coding of Audio Visual Objects – Advanced Video Coding (AVC) • ETSI TS 102 366: Digital Audio Compression (AC-3, Enhanced AC-3) Standard • ISO/IEC 14496-3: Coding of Audio Visual Objects – Audio

Sources	Signal Type	Standards
	MPEG-2 Multiple Program Transport Stream	• SCTE30 Digital Program Insertion Splicing API • ISO/IEC 13818-1: Generic coding of moving pictures and associated audio information: Systems • ISO/IEC 13818-2: Generic coding of moving pictures and associated audio information: Video • ISO/IEC 13818-3: Generic coding of moving pictures and associated audio information: Audio • ETSI TS 101 154: Digital Video Broadcasting Specifications for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream • ETSI ETR 289: Digital Video Broadcasting – Support for use of Scrambling and Conditional Access (CA) within Digital Broadcasting System • ETSI EN302 755: Digital Video Broadcasting- Frame Structure channel Coding and Modulation for a Second Generation Digital Terrestrial Television Broadcasting System (DVB-T2) • ISO/IEC 14496-10 SD& HD: Coding of Audio Visual Objects – Advanced Video Coding (AVC)
		• ISO/IEC 6937: Coded Graphic Character Set for Text Communication – Latin Alphabet • ETSI EN 300 468: Digital Video Broadcasting Specifications for Service Information (SI) in DVB System • ETSI TR 101 290: Digital Video Broadcasting: Measurement Guidelines for DVB Systems • ETSI TR 101 211: Digital Video Broadcasting: Guidelines on Implementation and Usage of Service Information • ETSI TR 101 891: Guidelines for the implementation and usage of the DVB Asynchronous Serial Interface (ASI) • ETSI TS 102 323: Digital Video Broadcasting: Carriage and Signalling of TV-Anytime information in DVB Transport Streams • TR 102 035 Implementation Guidelines of the DVB Simulcrypt Standard
Subtitling	DVB Subtitles	• ETSI EN 300 743: Digital Video Broadcasting: Subtitling System
DSM CC	HbbTV Applications	• ISO/IEC 13818-6: Generic Coding of Moving Pictures and Associated Audio Information- Extension for DSM-CC • ETSI EN 301 192: Digital Video Broadcasting: DVB Specifications for Data Broadcasting • ETSI TR 101 202: Digital Video Broadcasting: Implementation Guidelines for Data Broadcasting
DVB-T2 Gateway	DVB-T2 MI	• DVB A136: Digital Video Broadcasting: Modulator Interface (T2-MI) for a Second Generation Digital Terrestrial Television Broadcast System
Transmitter Network	DVB-T2 Transmission	• ETSI EN 302 755: Digital Video Broadcasting: Frame Structure Channel Coding and Modulation for a Second Generation Digital Terrestrial Television Broadcast System • ETSI TR 101 290: Digital Video Broadcasting: Measurement Guidelines for DVB Systems

5.7 Quantitative estimation of this system

Georgia Public Broadcaster Head end for State Mux

Equipment	Description
Multiplexer	Multiplexer 1+1 with 2 TS outputs, with one TS licence
Encoders	Encoder 15 SD, software upgradeable to HD, +3 spare (1 mux will fit 15 SD (h.264) channels, each HD channel will reduce the amount of SD channels by 4 pcs.), SD/HD-SDI Video router for automatic switchover
Switches	Control and Data Switches
Monitoring	Baseband, Mosaic and Transport Stream ETR290 Level 1,2 and 3 monitoring
DVB-T2 GW	DVB-T2 GW 1+1
Misc.	Racks wirings installations FAT and SAT

5.8 HeadEnd Design Deliverable

5.8.1 Overall description of the Head end system and equipment

- Multiplexing, encoding and DVB-T2 GW
- Encryption system
- Management
- PSI/SI system
- Monitoring

5.8.2 Description of system architecture and redundancy and preferred SLA

5.8.3 Detailed Description of equipment and interfaces for system

- Multiplexing, encoding and DVB-T2 GW
- Encryption system
- Management
- PSI/SI system
- Monitoring

5.8.4 List of all the equipment and cost (CAPEX / OPEX)

Supplier	Equipment Type	Amount (units)	CAPEX price Euro / unit	CAPEX price Euro total	OPEX per year Euro Total	Total Efficiency %	Energy Consumption per Year kW	Dimensions (rack units U)	Delivery Time weeks

5.8.5 Supplier of the system is expected to provide

a) Technical support (years)____

b) Spare part repairs (years)____

c) Local presence / regional office with technical support____________________________

6 Distribution Network Design Requirements

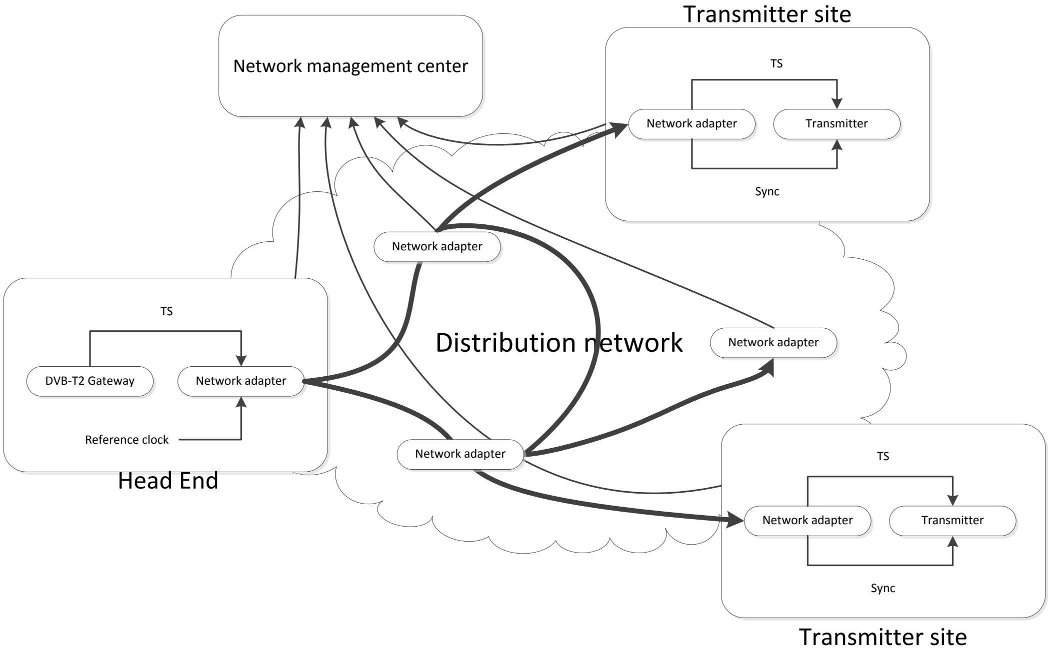
6.1 Overview

The distribution network needs to be designed to transport the TS (transport stream) signal to the main 42 DVB-T2 transmitter sites. TS signal is received from the Head-End.

Distribution network needs to transport one TS signal having a bit rate of no less than 35 Mbit/s. In addition to this distribution network needs to have capacity for additional services such as monitoring and also capacity for additional TS signals needs to be reserved. Distribution network needs to have STM-1 capacity or similar Ethernet capacity depending on technology being used.

The required design philosophy and technology criteria for the distribution network are clarified in this document.

A principle of the distribution network is presented below.



Picture 1 Principle of the distribution network

6.2 Design Philosophy

6.2.1 Reliable Network and Proven Platform

The distribution network needs to have high availability to transport the TS signal reliably from the Head End to each main transmitter station. Distribution network needs to have redundancy and needs to have short restoration time in case of failure. The platform must be based on reliable and proven technology.

6.2.2 Platform must be flexible and be ready for future expansion

The platform needs to be able to handle not only a TS signal but also other signals.

- Management data: The distribution network needs to provide control and monitoring (Network Management) of all equipment remote from the network monitoring center.
- Clocking signals: The distribution network should also provide an accurate time signal to transmitters.

6.2.3 Operation and management of the network

Network operator should be able to operate and manage all the network layers of the distribution network.

6.2.4 Rapid deployment

A nationwide infrastructure of the distribution network must be deployed in a short time.

6.3 Design Criteria

6.3.1 Network Availability

Total availability of the DTT service needs to be high. This means availability of the distribution network from the Head-End to each main transmitter station needs to be even higher.

6.3.2 Terrestrial based vs. Satellite based Distribution Network

A terrestrial based distribution network using a ring topology is preferred based on pros and cons comparison given below. Physical transport media could be microwave radio links or leased lines. Satellite based distribution network using DVB-S2 satellite transmission could provide backup for the terrestrial distribution network.

6.3.2.1 Pros and cons of satellite and terrestrial distribution

- Terrestrial pros:
  - Multi-service for increased ROI: DTT, Mobile TV, Radio, Contribution services etc.
  - Cost-effective local insertion of local content and ads
  - Inherent management connectivity
  - Less sensitive
  - Easy to have redundancy
  - Possible to have GPS independent solution for SFN

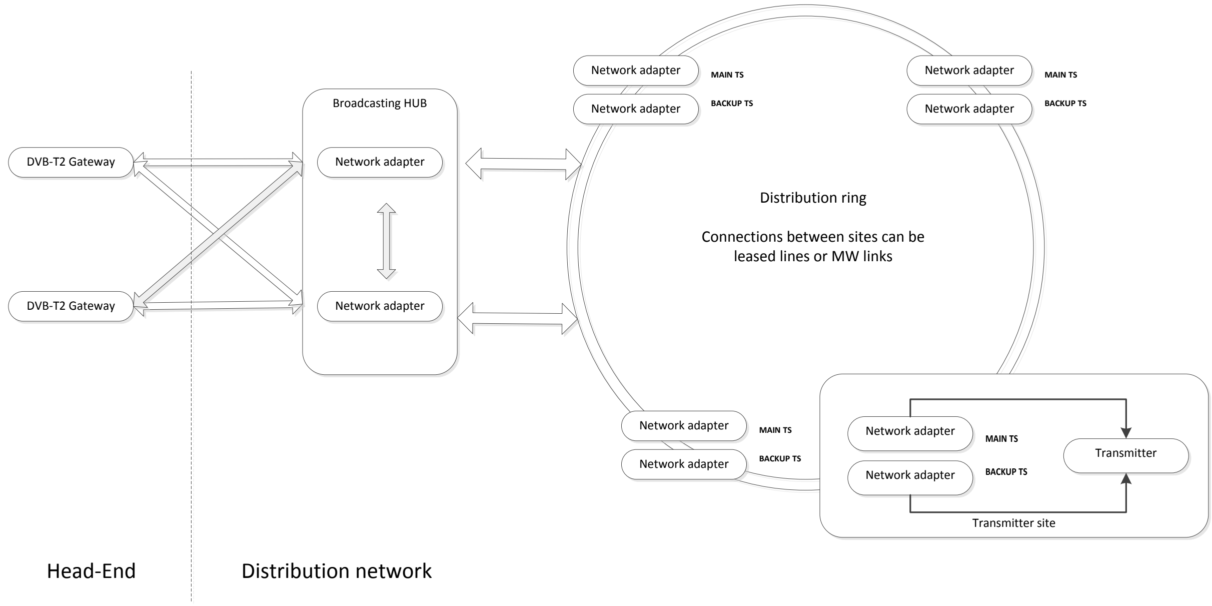
- Terrestrial cons:
  - Investment in the beginning
  - May need new microwave towers/masts

- Satellite pros:
  - Rapid national coverage
  - Flat fee regardless of size of deployment

- Satellite cons:
  - Expensive in long run
  - Sensitive to disturbance
  - WiMax interference in C-band
  - Rain fade in Ku-band (N&P regions)
  - No return channel, needs other network for management
  - No multi-service

6.3.3 Network Topology

To meet the criteria of the high network availability the ring topology is preferred. A star or tree topology can be used to connect remote sites to the ring. A 1+1 protection is preferred for physical transport media if star or tree topology is being used.



Picture 2: An example of ring topology in distribution network

6.3.4 Physical transport media

A total capacity of ~35 Mbit/s is required to transport one TS signal in the distribution network. I addition to this the distribution network needs to be able to transport additional TS signals. This could be achieved with STM-1 signal or with similar Ethernet capacity depending on technology being used. In addition to this the distribution network needs to deliver capacity also for the management and monitoring network.

Dedicated microwave radio links for DTT distribution network is preferred as a physical transport media. Rebroadcasting is not an option for main transport of backup method if SFN is being used.

6.3.4.1 Microwave radio links

The link budget of the microwave radio link connections and equipment protection needs to be designed to meet the availability criteria of the network. Below is given guidelines for mw radio link system.

- For long hops (over 20km) a low frequency is preferred f e.g. 6L, 6U, 7,3 or 7,6 GHz
- For frequencies over 18 GHz a rain fading is dominant cause of outage, not possible to use for long hops
- A 1+1 equipment and frequency protection must be used to meet the availability criteria
- Propagation model and availability calculations: ITU R P-530.13 Propagation data and prediction methods required for the design of terrestrial line-of-sight systems

6.3.4.2 Microwave repeaters

The landscape is very mountainous so new masts and active repeaters need to be used for some of the mw radio link connections. The repeater set includes

- Mast
- Active repeater
- Solar cells
- Batteries
- Antennas

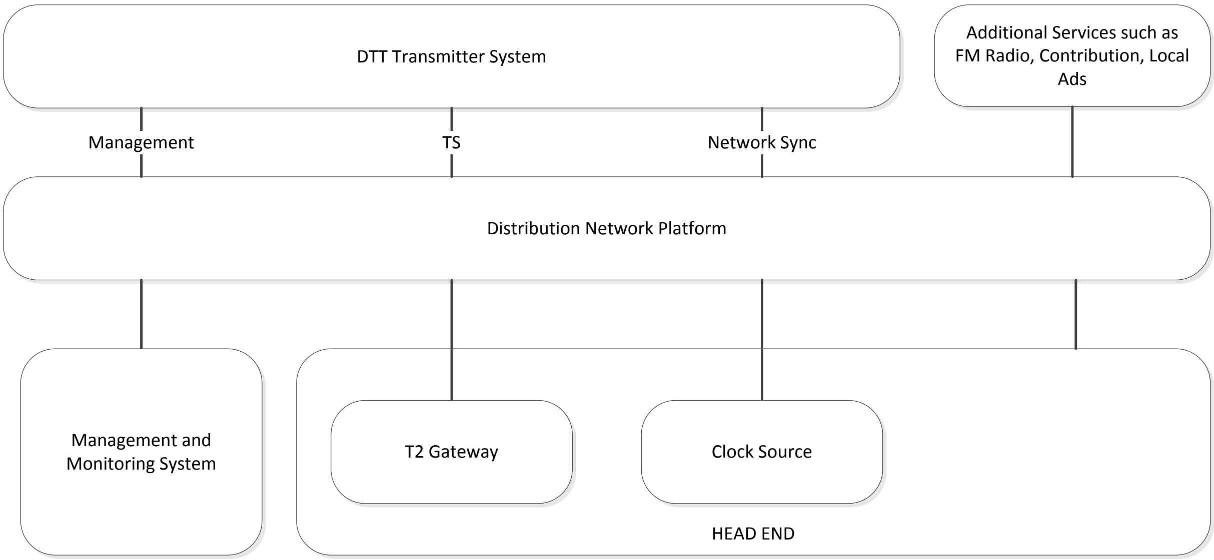
New masts may situate in rural areas where no roads or electricity exists.

6.3.5 Network synchronization and timing

A GPS or GLONASS free synchronization for the distribution network is preferred if SFN is being used. The distribution network needs to transport the clocking signals required by the DTT SFN service. An accurate clock source is needed (e.g. rubidium). Also a NTP service is needed for management network.

6.3.6 Distribution Platform

The proposed platform that will power the distribution network must be based on reliable and proven technology. The platform needs to be able to handle not only transport streams but also other signals such clocking signals and signals for the network management. This is illustrated in picture below.



Picture 3 Distribution platform

6.3.6.1 Possible Technologies for Distribution Platform

Platform could be based on one of the following technologies

- Baseband
- IP/MPLS Internet Protocol / Multi-Protocol Label Switching
- SDH Synchronous Digital Hierarchy
- DTM Dynamic Synchronous Transfer Mode

6.3.6.2 Pros and cons of different platform technologies

- Baseband pros
    - Simple network architecture
- Baseband cons
    - Fiber needed
    - Expensive
    - Network not dynamic
    - Changes slow and complicated

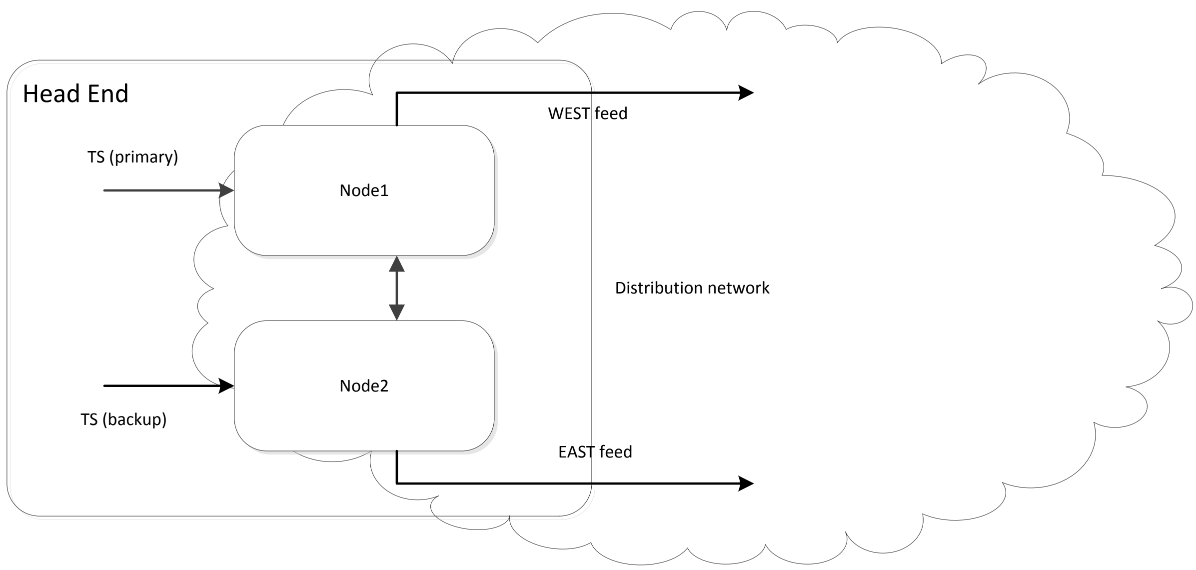
- IP/MPLS NGN pros
    - Flexible
- IP/MPLS NGN cons
    - Complicated network architecture
    - High level operational skills needed
    - Network management system complicated and expensive

- SDH pros
    - Simple
    - Easy to manage
- SDH cons
    - Legacy technology

- DTM Dynamic synchronous Transfer Mode pros
    - Future proof
    - Dynamic
    - Easy to manage
    - Both SDH and Ethernet connections can be utilized
    - Possible to distribute GPS free Sync signal for SFN network
- DTM Dynamic synchronous Transfer Mode cons
    - Expensive

6.3.6.3 Distribution network architecture at the Head End

Distribution network need to be able to receive transport streams from two different Gateways which could be located at the different sites.



Picture 4 an example of distribution network configuration at the Head End

6.3.6.4 Interface

Platform needs to support Ethernet and STM-1 interfaces.

6.3.6.5 Disaster recovery mechanism for Head End

Platform needs to provide disaster recovery mechanism at the Head End. Malfunction or failure at the power supply of a one distribution platform node at the Head End should not have an effect on distribution of TS signals.

6.3.6.6 Multicast / Broadcast

Platform needs to be able to transport TS signals as multicast / broadcast traffic in order to optimize network capacity. The platform needs to be able to form an optimal multicast / broadcast distribution tree over any type of network topology.

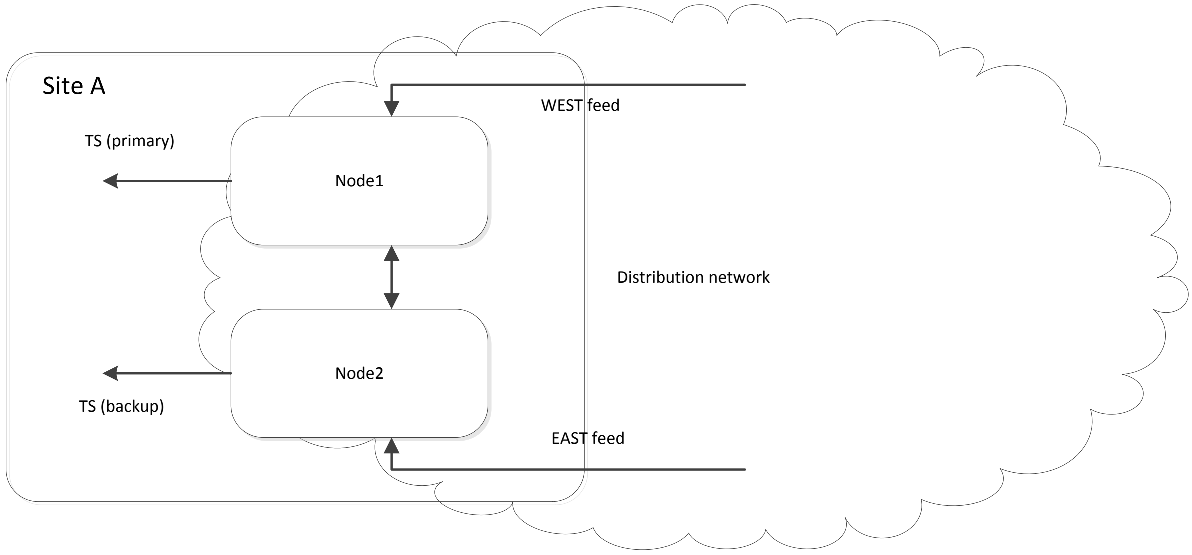
6.3.6.7 Rerouting and recovery in case of failures

Platform needs to support an automatic rerouting in case of failure.

6.3.7 Architecture at the Transmitter sites

6.3.7.1 Ring connected sites

For the ring connected sites the transport streams need to be received from two different microwave links from different far end sites. Malfunction or failure at the power supply of a one platform node at the ring connected transmitter site should have no effect on distribution signal to the transmitters of the whole distribution network.



Picture 5: An example of distribution network configuration at the ring connected site

6.3.7.2 Distant sites

Star or tree topology can be used to connect distant sites to main distribution ring. MW links used for this need to have 1+1 redundancy.

6.3.8 Management network and monitoring

Distribution network needs to provide capacity for a separate management network which is being used to monitor, manage and operate all the equipment in DTT service.

A minimum configuration for each transmitter site is one IP router and switch capable of OSPF protocol.

SNMP is preferred for monitoring purposes.

All devices should support IP based monitor and management and SNMP alarm handling.

6.3.8.1 Parameters to be monitored in distribution network

- MW links
    - TX and RX power
    - Input signal
    - Node down
    - Feedline pressure
        - waveguide or coax low pressure sensor, protects against wet feeds
- Repeaters
    - Amplifier:
        - Current and RF power output monitored
        - Node down

- Power equipment:
    - battery voltage
    - battery temp
    - ac chargers
    - ac mains

- Feedline pressure
    - waveguide or coax low pressure sensor, protects against wet feeds

- Security
    - open door alarm,
    - inputs for site perimeter alarm
    - inputs for solar panel, battery or antenna security wire lo

- Platform
    - Node down
    - Signal error at lower level

6.4 Proposed distribution network

6.4.1 Topology

Digita proposes to use availability criteria 99,99% – 99,999 % for planning each radio link connection depending on topology. All the MW links have 1+1 configuration (including hardware protection and frequency and space diversity) for redundancy and for high availability. In this way together with ring topology high availability is achieved for DTT service distribution.

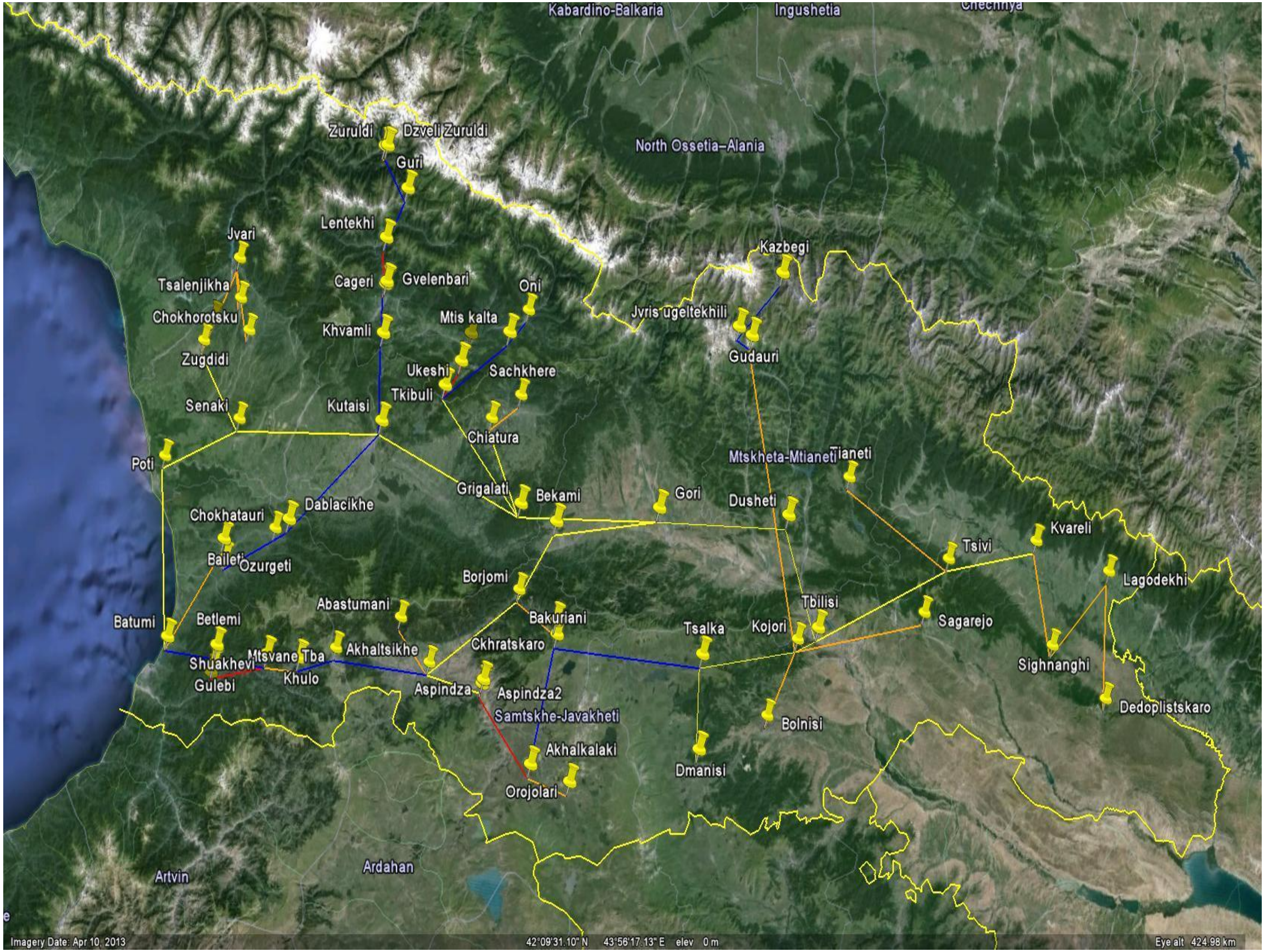
In the example topology described below MW radio link connections are planned by using only masts operated by TRC only.Not all the masts are reachable by line of sight connection. This means that MW repeaters have to be used.

Picture 6 An example network topology

Yellow lines describe high priority links with 1+1 backup system
Blue - powered by solar panels
Red - passive links

Please note: original kmz file for Google Earth you can download here:

http://bin.ge/dl/118327/Georgia-MW--Google-.kmz.html


Kabardino-Balkaria
Ingushetia
Chechnya
North Ossetia–Alania
Zuruldi
Dzveli Zuruldi
Guri
Lentekhi
Jvari
Cageri
Gvelenbari
Oni
Tsalenjikha
Chokhorotsku
Khvamli
Mtis kalta
Zugdidi
Ukeshi
Sachkhere
Tkibuli
Senaki
Kutaisi
Chiatura
Kazbegi
Jvris ugeltekhili
Gudauri
Mtskheta-Mtianeti
Tianeti
Poti
Grigalati
Bekami
Gori
Dusheti
Chokhatauri
Dablacikhe
Baileti
Ozurgeti
Borjomi
Kvareli
Tsivi
Lagodekhi
Abastumani
Bakuriani
Tbilisi
Sagarejo
Batumi
Betlemi
Tsalka
Kojori
Akhaltsikhe
Ckhratskaro
Shuakhevi
Mtsvane Tba
Khulo
Gulebi
Aspindza
Aspindza2
Samtskhe-Javakheti
Sighnanghi
Dedoplistskaro
Bolnisi
Akhalkalaki
Dmanisi
Orojolari
Artvin
Ardahan
Imagery Date: Apr 10, 2013
42°09'31.10" N 43°56'17.13" E elev 0 m
Eye alt 424.98 km

6.4.1.1 Number of MW link connections

Annex of GNCC Decision from March 6, 2014, No 121/13

N	Site A	Geographical Coordinates	Site B	Geographical Coordinates	A Tx. MHz	B Tx. MHz	Frequency Band MHz	Channel Number according to ITU plan	Difference between Tx/Rx MHz	Polarization V/H	Distance between the two sites km	Antenna height m	
												A	B
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Tbilisi	41°41'44.75"N 44°47'6.44"E	Dusheti	42°0'7.12"N 44°39'23.75"E	6375.140	6123.100	29.650	ch7	252.040	H	36	80	12
2	Tbilisi	41°41'44.75"N 44°47'6.44"E	Kojori	41°40'13.93"N 44°41'17.36"E	22386.000	23394.000	28.000	ch21	1008.000	V	9	80	12
3	Tbilisi	41°41'44.75"N 44°47'6.44"E	Tsivi	41°52'13.23"N 45°24'35.45"E	7355.500	7194.500	28.000	ch3	161.000	V	55	165	10
4	Tsivi	41°52'13.23"N 45°24'35.45"E	Kvareli	41°54'23.19"N 45°49'41.44"E	6375.140	6123.100	29.650	ch7	252.040	H	35	7	7
5	Tsivi	41°52'13.23"N 45°24'35.45"E	Tianeti	42° 6'7.30"N 44°56'54.70"E	6375.140	6123.100	29.650	ch7	252.040	V	46	7	25
6	Kvareli	41°54'23.19"N 45°49'41.44"E	Sighnaghi	41°37'15.00"N 45°53'27.70"E	6123.100	6375.140	29.650	ch7	252.040	V	32	7	25
7	Sighnaghi	41°37'15.00"N 45°53'27.70"E	Lagodekhi	41°48'42.61"N 46°10'16.87"E	6375.140	6123.100	29.500	ch7	252.040	H	32	25	7
8	Lagodekhi	41°48'42.61"N 46°10'16.87"E	Dedoplistskaro	41°28'0.81"N 46°8'10.82"E	6123.100	6375.140	29.500	ch7	252.040	V	39	7	7
9	Kojori	41°40'13.93"N 44°41'17.36"E	Sagarejo	41°43'40.70"N 45°17'17.00"E	6375.140	6123.100	29.650	ch7	252.040	H	46	80	10
10	Kojori	41°40'13.93"N 44°41'17.36"E	Tsalka	41°38'5.98"N 44°14'19.11"E	6375.000	6109.000	28.000	ch7	266.000	H	38	12	25
11	Kojori	41°40'13.93"N 44°41'17.36"E	Bolnisi	41°28'0.76"N 44°32'17.39"E	6375.000	6109.000	28.000	ch7	266.000	V	26	12	7
12	Kojori	41°40'13.93"N 44°41'17.36"E	Gudauri	42°29'22.55"N 44°30'2.78"E	6375.000	6109.000	28.000	ch7	266.000	H	93	12	10
13	Tsalka	41°38'5.98"N 44°14'19.11"E	Dmanisi	41°22'39.82"N 44°12'52.63"E	8363.000	8482.000	28.000	ch6	119.000	V	30	7	7
14	Tsalka	41°38'5.98"N 44°14'19.11"E	Tskhratskaro	41°41'51.65"N 43°33'25.86"E	6375.140	6123.100	29.650	ch7	252.040	H	57	7	10

15	Tskhratskaro	41°41'51.65"N 43°33'25.86"E	Akhalkalaki	41°20'51.90"N 43°25'33.95"E	6123.100	6375.140	29.650	ch7	252.040	V	40	10	7
16	Gudauri	42°29'22.55"N 44°30'2.78"E	Jvris Ugheltekhili	42°30'53.82"N 44°26'22.85"E	6109.000	6375.000	28.000	ch1	1010.000	V	6	10	10
17	Jvris Ugheltekhili	42°30'53.82"N 44°26'22.85"E	Kazbegi (Sno)	42°37'31.63"N 44°36'46.83"E	6375.000	6109.000	28.000	ch7	266.000	V	13	10	10
18	Dusheti	42°0'7.12"N 44°39'23.75"E	Gori	42° 1'57.12"N 44° 2'50.89"E	7512.000	7694.000	28.000	ch4	182.000	V	52	10	15
19	Gori	42° 1'57.12"N 44° 2'50.89"E	Grigalati	42° 3'10.30"N 43°23'39.22"E	7694.000	7512.000	28.000	ch4	182.000	H	54	50	25
20	Gori	42° 1'57.12"N 44° 2'50.89"E	Bekami	42° 0'8.81"N 43°33'40.06"E	7201.500	7362.500	28.000	ch13	161.000	V	41	7	7
21	Bekami	42° 0'8.81"N 43°33'40.06"E	Borjomi	41°49'27.20"N 43°23'0.33"E	7738.500	7577.500	28.000	ch21	161.000	H	26	7	7
22	Borjomi	41°49'27.20"N 43°23'0.33"E	Bakuriani	41°44'9.58"N 43°33'13.61"E	7577.500	7738.500	28.000	ch21	161.000	V	18	7	7
23	Borjomi	41°49'27.20"N 43°23'0.33"E	Akhaltsikhe	41°37'48.46"N 42°57'25.44"E	7577.500	7738.500	28.000	ch21	161.000	H	42	7	7
24	Akhaltsikhe	41°37'48.46"N 42°57'25.44"E	Abastumani	41°45'11.43"N 42°49'28.04"E	7424.500	7263.500	28.000	ch1	161.000	V	19	10	40
25	Akhaltsikhe	41°37'48.46"N 42°57'25.44"E	Mtsvane Tba	41°40'13.05"N 42°31'2.43"E	7738.500	7577.500	28.000	ch21	161.000	H	37	10	7
26	Mtsvane Tba	41°40'13.05"N 42°31'2.43"E	Khulo	41°38'23.60"N 42°20'35.50"E	7577.500	7738.500	28.000	ch21	161.000	V	15	7	10
27	Akhaltsikhe	41°37'48.46"N 42°57'25.44"E	Aspindza	41°34'43.95"N 43°12'35.47"E	7424.500	7263.500	28.000	ch1	161.000	H	22	50	35
28	Akhalkalaki	41°20'51.01"N 43°25'33.52"E	Orojolari (Ninotsminda)	41°17'53.29"N 43°36'28.60"E	7424.500	7263.500	28.000	ch1	161.000	V	16.2	7	7
29	Aspindza	41°34'43.95"N 43°12'35.47"E	Aspindza 2	41°34'4.24"N 43°12'10.39"E	7263.500	7424.500	28.000	ch1	161.000	H	1.4	7	7
30	Aspindza 2	41°34'4.24"N 43°12'10.39"E	Akhalkalaki	41°20'51.01"N 43°25'33.52"E	7263.500	7424.500	28.000	ch1	161.000	H	31	7	30
31	Grigalati	42° 3'10.30"N 43°23'39.22"E	Kutaisi	42°16'48.21"N 42°44'11.73"E	7327.500	7166.500	28.000	ch2	161.000	V	60	25	25

32	Grigalati	42° 3'10.30"N 43°23'39.22"E	Chiatura	42°17'15.57"N 43°15'40.46"E	7327.500	7166.500	28.000	ch2	161.000	H	28.5	25	25
33	Grigalati	42° 3'10.30"N 43°23'39.22"E	Tkibuli	42°22'27.53"N 43° 2'20.90"E	7577.500	7738.500	28.000	ch5	154.000	H	46.5	35	50
34	Chiatura	42°17'15.57"N 43°15'40.46"E	Sachkhere	42°20'54.86"N 43°24'4.22"E	18.140	19.150	28.000	ch16	1010.000	V	14	20	10
35	Tkibuli	42°22'27.53"N 43° 2'20.90"E	Mtiskalta	42°30'54.02"N 43°20'55.94"E	7738.500	7577.500	28.000	ch5	154.000	V	31	7	7
36	Tkibuli	42°22'27.53"N 43° 2'20.90"E	Ukeshi (Agara)	42°26'22.30"N 43° 6'59.37"E	8335.000	8454.000	28.000	ch4	119.000	H	11	7	7
37	Mtiskalta	42°30'54.02"N 43°20'55.94"E	Oni	42°34'38.22"N 43°26'27.31"E	7577.500	7738.500	28.000	ch5	154.000	V	10	7	7
38	Ukeshi (Agara)	43°11'15,76"E 42°29'38,75"N	Ambrolauri	42°30'49.70"N 43° 9'52.28"E	8335.000	8454.000	28.000	ch4	119.000	V	8.5	7	7
39	Kutaisi	42°16'48.21"N 42°44'11.73"E	Khvamli	42°31'0.30"N 42°44'44.71"E	8335.000	8454.000	28.000	ch4	119.000	V	26	10	10
40	Kutaisi	42°16'48.21"N 42°44'11.73"E	Senaki	42°17'23.64"N 42° 3'28.45"E	8321.000	8440.000	28.000	ch3	119.000	H	56	15	15
41	Kutaisi	42°16'48.21"N 42°44'11.73"E	Dablatsikhe	42° 0'52.60"N 42°17'42.05"E	8363.000	8482.000	28.000	ch6	119.000	V	42	7	7
42	Dablatsikhe	42° 0'52.60"N 42°17'42.05"E	Chokhatauri	41°59'38.25"N 42°13'49.53"E	18250.000	19260.000	28.000	ch20	1010.000	V	11	7	7
43	Dablatsikhe	42° 0'52.60"N 42°17'42.05"E	Ozurgeti	41°54'49.72"N 41°59'33.58"E	8335.000	8454.000	28.000	ch4	119.000	V	32	5	7
44	Ozurgeti	41°54'49.72"N 41°59'33.58"E	Baileti	41°58'58.77"N 41°57'40.42"E	18250.000	19260.000	28.000	ch20	1010.000	V	8.4	7	10
45	Baileti	41°58'58.77"N 41°57'40.42"E	Batumi	41°41'37.58"N 41°42'54.98"E	8363.000	8482.000	28.000	ch6	119.000	H	38.3	10	10
46	Khvamli	42°31'0.30"N 42°44'44.71"E	Tsageri	42°38'57.71"N 42°45'25.56"E	8454.000	8335.000	28.000	ch4	119.000	V	17	10	7
47	Tsageri	42°38'57.71"N 42°45'25.56"E	Gvelenbari	42°39'19.78"N 42°45'46.60"E	5969.000	6235.000	28.000	ch2	266.000	H	1	7	15
48	Gvelenbari	42°39'19.78"N 42°45'46.60"E	Lentekhi	42°46'28.45"N 42°45'40.57"E	5969.000	6235.000	28.000	ch2	266.000	V	13	15	7
49	Lentekhi	42°46'28.45"N 42°45'40.57"E	Ghuri	42°54'26.48"N 42°51'54.75"E	6235.000	5969.000	28.000	ch2	266.000	H	19	7	7
50	Ghuri	42°54'26.48"N 42°51'54.75"E	Dzv. Zuruldi	43° 1'28.43"N 42°46'7.46"E	5969.000	6235.000	28.000	ch2	266.000	V	17	7	7
51	Dzv.Zuruldi	43° 1'28.43"N 42°46'7.46"E	Mestia	43° 1'30.51"N 42°45'36.56"E	6235.000	5969.000	28.000	ch2	266.000	H	2	7	7

52	Senaki	42°17'23.64"N 42° 3'28.45"E	Zugdidi	42°30'7.89"N 41°53'8.84"E	7619.500	7780.500	28.000	ch3	161.000	V	28	15	30
53	Senaki	42°17'23.64"N 42° 3'28.45"E	Poti	42°11'16.36"N 41°42'4.09"E	7619.500	7780.500	28.000	ch3	161.000	H	32	15	30
54	Zugdidi	42°30'7.89"N 41°53'8.84"E	Kortskheli	42°33'45.63"N 41°56'2.41"E	18250.000	19260.000	28.000	ch20	1010.000	V	8	30	10
55	Kortskheli	42°33'45.63"N 41°56'2.41"E	Jvari	42°43'30.75"N 42° 3'24.10"E	18140.000	19150.000	28.000	ch16	1010.000	V	21	10	7
56	Jvari	42°43'30.75"N 42° 3'24.10"E	Tsalenjikha	42°37'0.46"N 42° 3'45.20"E	18195.000	19205.000	28.000	ch18	1010.000	V	12	10	15
57	Jvari	42°43'30.75"N 42° 3'24.10"E	Chkhorotsku	42°31'46.63"N 42° 6'11.88"E	18250.000	19260.000	28.000	ch20	1010.000	V	22	10	15
58	Poti	42°11'16.36"N 41°42'4.09"E	Batumi	41°41'37.58"N 41°42'54.98"E	7263.500	7424.500	28.000	ch1	161.000	V	55	50	25
59	Batumi	41°41'37.58"N 41°42'54.98"E	Betlemi	41°40'22.43"N 41°57'3.59"E	7424.500	7263.500	28.000	ch1	161.000	V	20	7	7
60	Betlemi	41°40'22.43"N 41°57'3.59"E	Shuakhevi	41°38'57.45"N 42°11'23.76"E	7263.500	7424.500	28.000	ch1	161.000	H	20	7	7
61	Shuakhevi	41°38'57.45"N 42°11'23.76"E	Khulo	41°38'23.60"N 42°20'35.50"E	7424.500	7263.500	28.000	ch1	161.000	V	13	10	10
62	Shuakhevi	41°38'57.45"N 42°11'23.76"E	Gulebi (Keda)	41°37'8.22"N 41°56'1.33"E	7577.500	7738.500	28.000	ch21	161.000	H	22	10	10
63	Gulebi (Keda)	41°37'8.22"N 41°56'1.33"E	Keda	41°35'54.87"N 41°55'23.07"E	7577.500	7738.500	28.000	ch21	161.000	V	2.4	10	10

Table outlines MW connections as per licences assigned to TRC by GNCC. In the table sites marked green are active sites, those marked yellow are passive sites.

6.5 Distribution Network Deliverable

6.5.1 Overall description of the distribution system and equipment

Physical layer
- MW radio link equipment
- Repeater equipment

Platform layer equipment
Management layer equipment
Network synchronization equipment

6.5.2 Description of network architecture, topology and redundancy

Physical level
Platform level
Management layer
Synchronization

6.5.3 Detailed Description of equipment and interfaces for each site

Physical layer
Platform layer
Management layer
Synchronization

6.5.4 Estimation of the service availability at the input of transmitter for each site based on selected topology and equipment

Site Name	Availability %

6.5.5 List of all the equipment for each site and cost (CAPEX / OPEX)

Site Name	Supplier	Equipment Type	Amount (units)	CAPEX price Euro / unit	CAPEX price Euro total	OPEX per year Euro Total	Total Efficiency %	Energy Consumption per Year kW	Dimensions (rack units U)	Delivery Time weeks

6.5.6 Supplier of the system is expected to provide

a) Technical support (years)____

b) Spare part repairs (years)____

c) Local presence / regional office with technical support________________________________

7 Network Management Center Requirements

Network Management Centre (NMC) should be located in the same facility with the Headend devices. NOC should become the centralised control centre for the whole Digital Terrestrial Television (DTT) platform, which monitor and control everything right from the incoming signals from broadcaster to transmitter sites. Network management system (NMS) should be used for automatic monitoring and alarm gathering from all devices in the DTT system. NMS servers and application should be installed to collect data from all equipment including network elements.

The monitor & control capability should include but not limited to the following tasks;

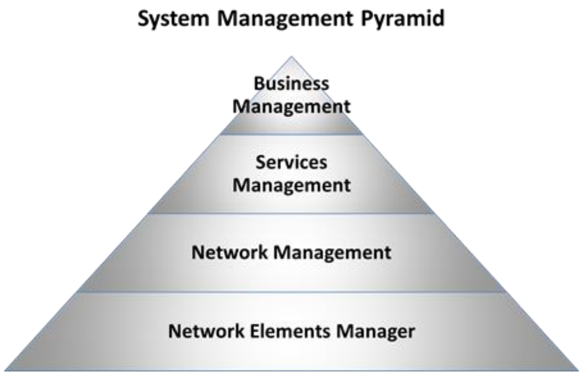
- Incoming signals from broadcasters
- Headend devices
- Distribution network
- Transmitter sites
- Transport Stream analysers

Data Connectivity from DTT Transmitter to NMC

In a managed services environment, it is of paramount importance that a stable connectivity is provided to connect all of the remote devices for the purpose of remote management and monitoring.

7.1 Network Management system

This section gives an example of Transmission Management System (TMS) and the functional hardware and software TMS requirements.



The objective is to manage the Network Operators facilities from as high a level up the `management pyramid' as possible. This pyramid represents the increasing consolidation and abstraction of information as one move from the bottom of the pyramid to the top, the bottom being the `concrete' view of the installed equipment and systems, and the top being the abstract `business' view of the Network Operators transmission facilities.

The bottom layer of the pyramid is the `Network Element Management' layer, and corresponds to the basic surveillance and control, which occurs at the basic equipment and `network element' level. DTT Transmitter is monitored and controlled directly by NMS.

The next higher level, the `Network Management' layer, should be Network Operators minimum objective. At this layer the operator of the TMS will view and manage the DTT transmitter facilities from a network perspective, that is, the interconnection of installed equipment to provide the Network Operators network and transmission infrastructure.

The next layer above the Network Management layer is the `Services Management' layer, and the Network Operators objective should be to perform as much management as possible at this layer. This layer represents the view of the Network Operators facilities as perceived by the broadcasters.

The top layer, the `Business Management' layer, is the corporate interface to the TMS, and is typically represented by the generation of business information such as service outages', broadcaster impact reports', etc. It also represents the point of interconnection between the Network Operators TMS and the Management Systems of other organisations, where broadcasters may have direct (partitioned) access to lower level information maintained by the TMS, and the company may obtain access to information maintained by an external provider's Management System.

24 Hour Monitoring System for Maximising Service Availability

To achieve high service availability, it is important to understand the concept of failure and how it could contribute to the down time.

Anomalies

An anomaly is a discrepancy between the actual and desired characteristics of an item. The desired characteristics may be expressed in the form of specification. An anomaly may or may not affect the ability of an item to perform a required function.

Defect

A defect is a limited interruption in the ability of an item to perform a required function. It may or may not lead to maintenance action depending on the results of additional analysis. Successive anomalies causing a decrease in the ability of an item to perform a required function are considered to be a defect.

Fault

A fault is the inability of an item to perform a required function. The severity of a fault depends on its effect such as;

- The transmission system performance as experienced by the broadcaster
- The probability that subsequent faults will occur, thus resulting in a deteriorated performance as seen by a broadcaster.

According to their importance and consequences to the quality of service provided to broadcasters and to the transmission system technical performance, the faults can be classified as follows;

- Faults which result in complete interruption of service to one or more broadcasters
- Faults which result in partial interruption (for example, degradation of transmission quality) to one or more broadcasters
- Faults which decrease the availability of equipment and/or transmission systems but do not affect broadcasters
- A fault can be either a permanent or an intermittent condition and this may alter the effect of the fault on the transmission system
- The severity of a fault can be determined by measuring downtime, uptime and failure rate of the equipment

As such, service availability shall be calculated based on total down time experienced by broadcasters. The system shall log the total downtime and measures the service availability automatically by the end of every month.

7.2 Service monitoring and Service Level calculation

In the following text an example of Service Level Guarantee ("SLG") is given. SLG should comprise the following components:

a. Service Monitoring
b. Incident Handling
c. Availability
d. Reporting
e. Rebates

The SLG should contain all the obligations of the Network Operator(s) and each of the above mentioned SLG component is further explained as below.

7.2.1 Service Monitoring

a. The DTT network should be supervised from the NMC on a 24/7 basis such that any fault situations can be recorded and rectified around the clock.

b. The monitoring is based on an alarm system that should detect any issues over the network element. On top of that, all transport streams should be monitored automatically with a transport stream analyser that should also generate alarms if any problems are detected on the bit streams coming out of the multiplexer systems.

c. The reference for the bit stream monitoring is the ETSI ETR290 standard for first priority alarms. However, the program contents are NOT monitored actively. An illustration of supervision and monitoring system is shown in the diagram below.

d. The RF monitor receiver and Mpeg4 monitoring are optional and not included in the cost estimation

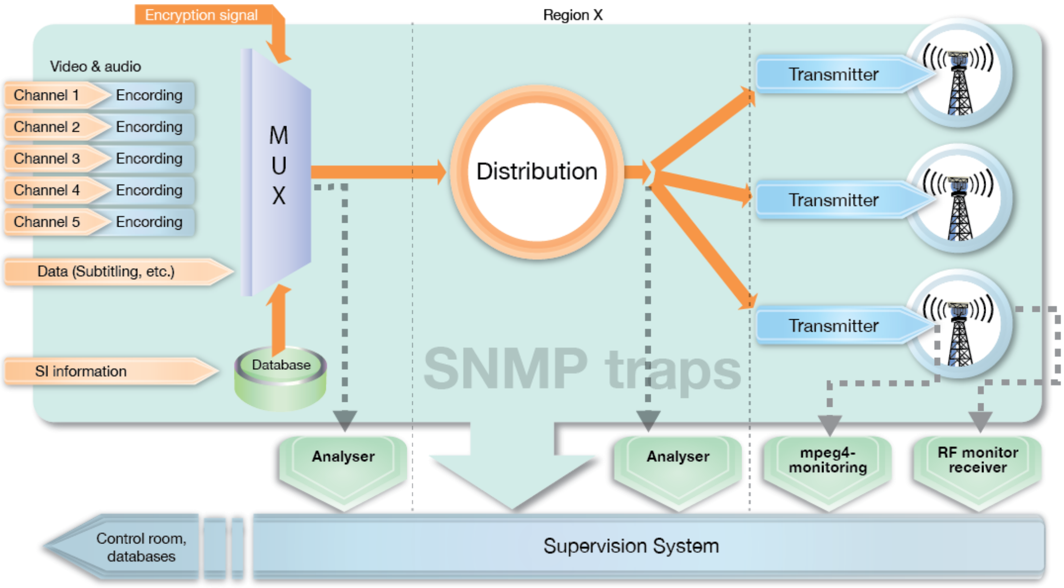


Figure 1: Supervision and Monitoring System Schematic Diagram

7.2.2 Incident Handling

a. All systems and devices are monitored on a 24/7 basis.

b. Broadcasters should be informed immediately in the case of any service interruption and the level of its severity.

c. For incidents that cause service interruption in main transmitter stations, corrective maintenance action should be deployed immediately with a target turnaround time of **not more than 4 hours.**

d. For incidents that cause service interruption in gap filler stations, corrective maintenance action should be deployed immediately between 6:00 am to 10:00 pm. Incidents reported after 10:00 pm should be rectified only after 6:00 am the following day. The target turnaround time should **not be more than 12 hours**.

7.2.3 Availability

a. The service should be disrupted when there is an error in the DVB-T2 data stream. This error is defined under ETSI ETR 101 290 as a Priority 1 Error in the stream.

b. “Unavailability” should be defined as the time between the detection of the error by the Network Operator monitoring system and the error resolution.

c. Errors that last less than 15 seconds or caused by planned maintenance are ignored (*refer to ‘Reporting’ subsection below*).

d. Availability time is calculated separately based on individual program channel and for individual main transmitter station.

e. The formula for calculating actual availability is as follows:
K = **100 x (1-X/8,760)**

Where;
K = Actual Availability %
X = Unavailability Time (hours per year)
8,760 = Total hours in a year

7.2.4 Reporting

a. The NOC should inform the customer by email or by SMS message immediately when an error is recorded. The report should include the following information:
   - Affected Program Channel
   - Affected transmitter site(s)
   - Sphere of influence
   - Error description
   - Start time
   - Estimated time of repair

b. The NOC should also inform the customer immediately when error is resolved. The Network Operator can perform planned maintenance works and changes to the network without affecting the availability if the Network Operator informs customer about the works beforehand.

c. The Network Operator should be obligated to minimise any interruption of services during planned maintenance works.

d. The Network Operator should inform the Broadcasters by email of any work that may cause service interruptions two weeks before proceeding. The customer can suggest an alternative date to be agreed by both parties for the Network Operator to carry out the maintenance work.

e. The Network Operator should provide service availability reports to the customer on a monthly basis.

f. This report should include service availability on a per-channel-per-transmitter station basis as well as the previous month's availability and cumulative availability of the current calendar year as shown in the following figure.

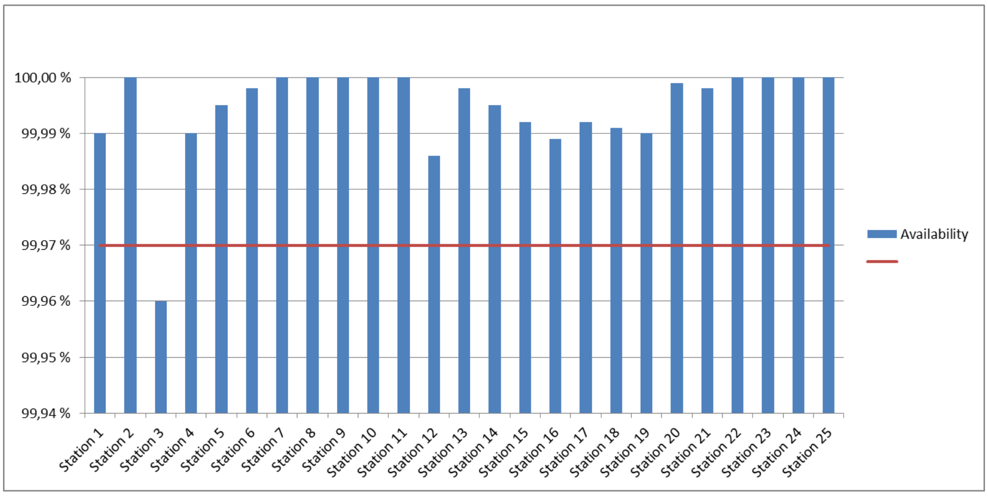


Figure 2: Example of a Cumulative Service Availability Report

7.2.5 Rebate Calculation

If the agreed availability is not reached Network Operator should pay agreed rebate.

7.3 Network Management Centre Deliverable

7.3.1 Overall description of the NMC system and equipment

Monitoring and analyzing
Reporting system and availibility calculation (SLA)
DVB-T2 network management (incident management)

7.3.2 Description of system architecture and redundancy and preferred SLA

Detailed Description of equipment and interfaces for system
Monitoring and analyzing
Reporting system
DVB-T2 network management
Availability calculation and reporting
Incident management
List of all the equipment and cost (CAPEX / OPEX) as per table below

Supplier	Equipment Type	Amount (units)	CAPEX price Euro / unit	CAPEX price Euro total	OPEX per year Euro Total	Total Efficiency %	Energy Consumption per Year kW	Dimensions (rack units U)	Delivery Time weeks

7.3.3 Supplier of the system is expected to provide

a) Technical support (years)____

b) Spare part repairs (years)____

c) Local presence / regional office with technical support____