Dear Sir / Madam,

Greetings from Telecommunication Engineering Centre (TEC), Department of Telecommunications.

It is my pleasure to inform that TEC has initiated work on a "Technical Report on Direct Broadcasting to Mobile Handheld Devices" and invites your valuable feedback on the same. The updated draft of this technical report is attached herewith.

This draft report outlines the technical prospects for broadcasting Digital Terrestrial TV to Mobile devices (DTT2M), commonly known as Direct to Mobile (D2M). It explores how D2M can introduce new services and elevate the viewing experience for consumers. Furthermore, the report delves into the key features, benefits, and implications of these approaches, reshaping the landscape of mobile entertainment and connectivity. It delves into the underlying technologies and architectures enabling seamless delivery of digital TV content to devices like smartphones and tablets, poised to revolutionize multimedia access and experience in the digital era. Moreover, this draft scrutinizes potential challenges and future prospects for D2M, analyzing its impact on consumer behavior, media industries, and the broader digital ecosystem.

I would request to you to furnish valuable comments/ inputs to dircb2.tec-dot@gov.in with copy to avinash.70@gov.in preferably by 15th January, 2024.

This issues with the approval of DDG (C&B), TEC, DoT.

Director (C&B) TEC

Technical Report On
Direct Broadcasting to Mobile Handheld Devices

ISO 9001:2015

दूरसंचार अभियांत्रिकी केंद्र
खुर्शीदलाल भवन, जनपथ, नई दिल्ली–110001, भारत
TELECOMMUNICATION ENGINEERING CENTRE
KHURSHIDLAL BHAWAN, JANPATH, NEW DELHI–110001, INDIA
www.tec.gov.in

Table of Content

Abstract

The emergence of various new technologies has brought about new opportunities and challenges for terrestrial broadcasting. In this report, we analyse the opportunities for broadcasting **Digital Terrestrial TV to Mobile devices (DTT2M)** also popularly known as **Direct to Mobile (D2M).** This approach includes the ability to offer new services and enhances the viewing experience for consumers. In this report, we explore the key features, benefits, and implications of such approaches in reshaping the landscape of mobile entertainment and connectivity. While DTT2M/D2M services can be delivered in a broadcast (delivering one-to-many linear content using broadcast spectrum) or unicast (delivering one-to-one or one-to-many linear content on the cellular spectrum) manner, this report focuses on the broadcast technologies that operate in UHF or a particular band. This report discusses the underlying technologies and architectures that enable seamless digital TV content delivery to mobile devices such as smartphones and tablets, and how these approaches are poised to revolutionize the way of access and experience multimedia in the digital age. Additionally, this report examines the potential challenges and future prospects for D2M, considering its impact on consumer behavior, media industries, and the overall digital ecosystem.

1.0 Introduction

Television broadcasting in India started on September 15, 1959, with experimental transmission of terrestrial TV signals. A regular TV broadcast service was started in Delhi in 1965 under the aegis of the All India Radio (AIR) and extended to other cities in the 70s. In 1976, TV broadcasting was separated from the AIR with the formation of Doordarshan (DD). Initially, it was only Terrestrial TV broadcasting under the exclusive domain of Prasar Bharati and was mainly being done in analog mode of transmission. Based on information available in Prasar Bharati, the Analogue TV Transmitters used to serve about 88% of Indian population. The major expansion of the terrestrial TV services took place before the Asian Games in Delhi in 1982 when color transmission was introduced and a large number of transmitters were set up throughout the country.

Subsequently, analog terrestrial TV broadcasting has been phased out across the globe due to poor quality of reception, inefficient use of spectrum, limited frequency capacity and obsolescence of analog technologies. The 31st March 2022 is marked an important milestone in the history of India's broadcasting landscape as the national broadcaster, Doordarshan, phased out the last set of obsolete Analogue Terrestrial TV transmitters. This event is ushering the country into a new era of digital reforms and keeping in sync with the rapid technological advancements. The constrained posed by the analogue terrestrial television platform by availability of limited frequency capacity needed a new & more efficient digital terrestrial TV (DTT) transmission system to meet the demands of the future and to allow for the launch of new services.

In this digitization journey of Doordarshan, in 2017, the Telecom Regulatory Authority of India (TRAI) had recommended the introduction of digital terrestrial transmission broadcast services in a phased manner. Accordingly, the digitalization of Doordarshan's Terrestrial TV Transmitters was started in 63 cities. Further, Doordarshan is planned to install DTT Transmitters at 630 locations all across the county in the future.

DTT channels can be received on Mobile TV by using DVB-T2 Dongles in USB-on the go (OTG) enabled Smart Phones, Tablets/laptops etc. The channels can also be viewed on Fixed TV Sets by using Indoor/Outdoor antenna on integrated digital TV (iDTV) Sets or using DTT Set Top Boxes. Doordarshan provided DD National, DD News, DD Bharati, DD Sports, and DD Regional/DD Kisan channels. They were relayed from DTT transmitters installed in 16 cities. With the offering of 4G services in India, and the corresponding 5G launch, the subscribers migrated to view OTT content on smartphones (without the need of an external dongle) and the DVB-T2 service had to be shut down in 2022 due to lack of viewership.

Subsequently, there are discussions on the offering of direct to mobile (D2M)/ Digital Terrestrial Television to Mobile (DTT2M) services that allow to broadcast video and other forms of multimedia content directly to mobile phones, without needing an active internet connection.

The following is a conceptual diagram of such service:

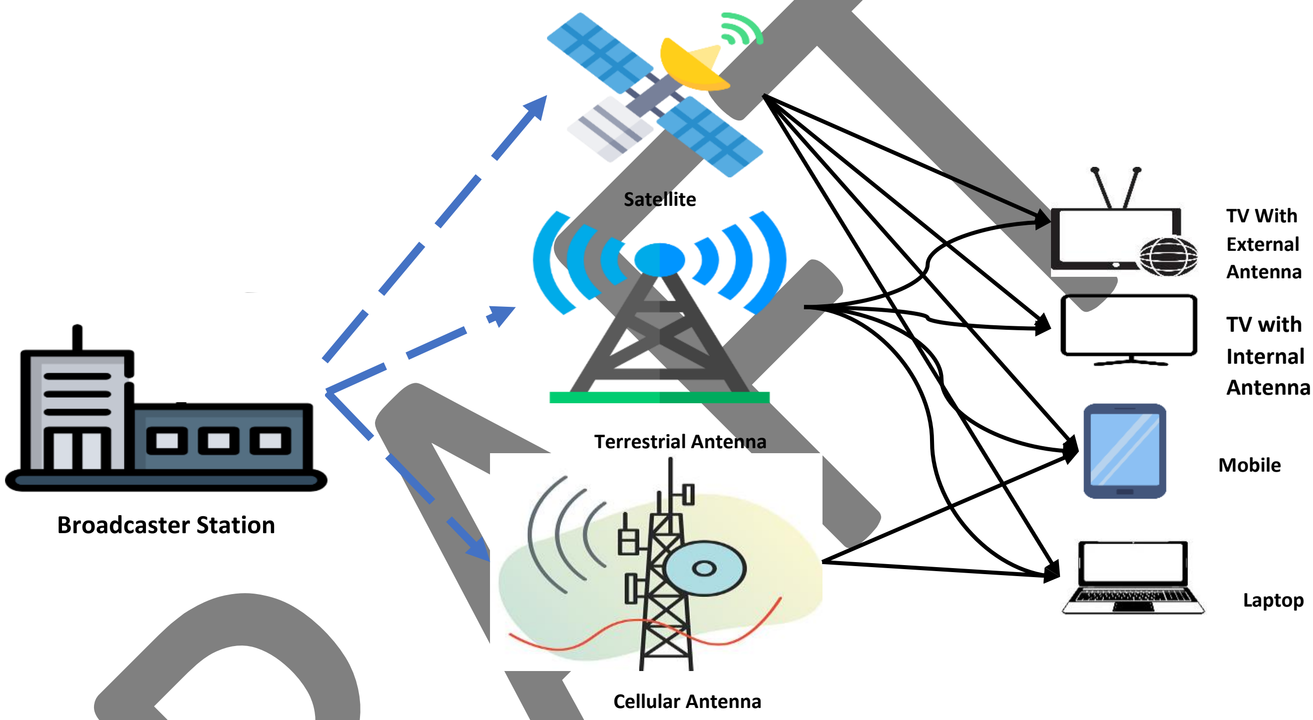

Figure 1: Direct to Mobile (D2M/DTT2M)

The implementation of D2M/DTT2M is to be considered keeping in view the international experiences, investment requirements, and present broadcasting scenario of the country where terrestrial transmission is provided only by public broadcaster and many alternate delivery platforms are available to consumers to access TV broadcasting services. This report tries to summarize the candidate technologies for DoT to help make that determination.

2.0 What is "Broadcasting "?

As recommended by ITU-R, "Broadcasting is a form of Radio communication in which transmissions are intended for direct reception by the general public; these may include sound transmissions, television transmissions and other types of transmission. *[1]*
According to TRAI, "Broadcasting means distribution of audio and video signals to a widely dispersed audience". Broadcasting as a mass communication media is a powerful tool to inform and educate the masses in a vast country like India. *[2]*

According to TRAI, "Broadcasting services" means the dissemination of any form of communication like signs, signals, writing, pictures, images and sounds of all kinds by transmission of electromagnetic waves through space or through cables intended to be received by the general public either directly or indirectly and all its grammatical variations and cognate expressions shall be construed accordingly; *[3]*

2.1 Methods of Broadcasting

I. **Terrestrial Broadcast** refers to a Broadcast that is transmitted via free-to-air or subscription-based wireless transmission, whether in analogue or digital form. Terrestrial television or over-the-air television (OTA) is a type of television broadcasting in which the signal transmission occurs via radio waves from the terrestrial (Earth-based) transmitter of a TV station to a TV receiver having an antenna. For the avoidance of doubt, it does not include Broadcast via a cable service or by satellite. Terrestrial broadcasting can provide wider coverage, especially in remote areas using conventional HPHT networks.

According to TRAI, "Terrestrial Broadcasting means the dissemination of any form of communication like signs, signals, writing, pictures, images, video and sounds of all kinds by transmission of electro-magnetic waves through space using Earth based transmitters intended to be received by the general public." [3]

II. **Cable television** is a system of delivering television programming to consumers via radio frequency (RF) signals transmitted through coaxial cables, or in more recent systems, light pulses through fiber-optic cables.

III. **Satellite broadcasting** is the distribution of multimedia content or broadcast signals originating from TV or radio stations or through a satellite network. Direct-to-home (DTH) Broadcasting Service refers to the distribution of multi-channel TV programs by using a satellite system.

IV. **IPTV broadcasting** stands for internet protocol television broadcasting and uses the technology that delivers live television programs over the internet instead of antennas, satellite dishes, or fiber-optic cables.

According to the ITU-T definition [ITU-T Y.1910], IPTV is defined as multimedia services such as television/video/audio/text/graphics/data delivered over IP based networks managed to provide the required level of quality of service and experience, security, interactivity and reliability. *[4]*

Department of Telecommunication DOT, defines IPTV as, "An IPTV (Internet Protocol Television) service (or technology) is the new convergence service (or technology) of the telecommunications and broadcasting through QoS controlled Broadband Convergence IP Network including wire and wireless for the managed, controlled and secured delivery of a considerable number of multimedia contents such as Video, Audio , data and applications processed by platform to a customer via Television, PDA Cellular, and Mobile TV terminal with STB module or similar device". *[5]*

Definition of IPTV as defined by the Authority (TRAI) under clause 2 (la) of : THE TELECOMMUNICATION (BROADCASTING AND CABLE SERVICES) INTERCONNECTION REGULATIONS, 2004: "Internet Protocol television service" Page 2 of 13 means delivery of multiple Channel TV programmes in addressable mode by using Internet Protocol over a close network of one or more service providers". *[5]*

V. **5G standalone broadcast** is a dedicated broadcast-only network (i.e., independent of cellular networks) that can address the emerging needs of broadcasters and content providers, giving them access to broader audiences via efficient content delivery to both fixed and mobile devices. 5G Broadcast is based on the 3GPP Further evolved Multimedia Broadcast Multicast Service (FeMBMS) broadcast standard. The transmission of a single data stream is done through a high-tower high-power transmitter. All mobile devices within the coverage area of this transmitter can receive the programs distributed via this data stream. Since the signal is distributed only once to all receiving devices, there is no excessive network utilization based on the number of receiving devices per cell and, therefore the quality of the programmes will not be reduced due to many devices. Another important key feature of FeMBMS is the reception of content without the need of an internet connection. However, adapted chipsets are required in mobile devices which enable the broadcast reception from HTHPs (high-tower high-power) with SDO (standalone downlink only) technology.

Further, Digital terrestrial television (DTTV or DTT, or DTTB with "broadcasting") is a technology for terrestrial television in which land-based (terrestrial) television stations broadcast television content by radio waves to televisions in consumers' residences in a digital format. Digital Terrestrial Television to Mobile (DTT2M) /direct to mobile (D2M) devices refer to the distribution of multi-channel DTT programs to a Mobile device (smartphone or tablet) using a terrestrial system. DTT technologies enable efficient use of the TV spectrum and provide better quality of service. To take advantage of the new opportunities presented by D2M, terrestrial broadcasters will need to change their business models. This may require new partnerships and collaborations with other industry players, as well as new revenue streams, such as advertising and sponsorships.

2.2 Benefits of Digital Terrestrial Television

Digital terrestrial television (DTT) is a technology that allows land-based television stations to broadcast their content in a digital format through radio waves. DTT has many benefits over the previous analog television, such as:

- It provides more efficient use of limited radio spectrum bandwidth, which means more television channels can be transmitted on the same frequency.
- It offers better quality images and sounds, with less interference, ghosting, and snowing.
- It supports different digital TV standards, such as standard definition (SDTV), high definition (HDTV), and ultra-high definition (UHDTV).
- It enables the reception of signals on mobile and portable devices, such as smartphones, tablets, and laptops.
- It reduces the operating costs for broadcasters, after the initial upgrade costs.
- It creates opportunities for local content production, job creation and creativity.

3.0 Features of DTT2M/D2M

D2M have the following features and functionalities:

i. **Mobile-Centric Content Delivery:**
D2M is designed with mobile devices as the primary target platform. It focuses on delivering content optimized for the screen sizes, resolutions, and the capabilities of smartphones and tablets. Low frequencies may not be good for the size of the devices as the antenna needs to be large.

ii. **Seamless Content Delivery:**
D2M allows users to access multimedia content seamlessly and instantaneously, eliminating buffering or waiting times associated with traditional downloading or streaming methods. It will require a dedicated infrastructure and massive investments.

iii. **Over-the-Air Transmission:**
D2M utilizes over-the-air (OTA) transmission to deliver content directly to mobile devices. This approach eliminates the need for continuous internet connectivity, making it ideal for on-the-go entertainment.

iv. **Hybrid Broadcast/Broadband Integration:**
D2M has the ability to combine OTA broadcast with broadband internet delivery, resulting in a hybrid approach that enhances content delivery and ensures consistent user experiences. Integrating terrestrial broadcasting with other broadcasting technologies, such as satellite broadcasting and IP-based streaming, can result in a more flexible and versatile distribution system.

v. **Real-Time and On-Demand Content:**
D2M allows users to access both live, real-time events and on-demand content, providing flexibility and variety in content consumption.

vi. **Interactive Services:**
D2M enables interactive features such as interactive advertisements, datacasting, interactive applications, and additional information alongside the main content.

vii. **Energy Efficiency:**
D2M employs energy-saving technologies to optimize power consumption in both the broadcasting infrastructure and mobile devices.

viii. **Advanced Error Correction and Robustness:**
D2M uses advanced error correction techniques and robust transmission

methods to ensure reliable reception, even in areas with weaker signals or high mobility scenarios.

ix. **Targeted Advertising:**
D2M can deliver targeted advertisements to specific user segments based on location, preferences, and demographics.

x. **Multilingual Support:**
D2M supports multiple audio tracks and subtitles, allowing for the delivery of content in different languages to cater to a diverse audience.

xi. **Emergency Alert System (EAS):**
D2M can integrate with emergency alert systems to deliver critical information and public safety alerts directly to mobile users. It is also available in cellular network.

xii. **Scalability and Future-Readiness:**
D2M is designed to be scalable and adaptable to future technological advancements, ensuring compatibility with evolving mobile devices and networks.

xiii. **Content Protection and Security:**
D2M includes measures for content protection and digital rights management to safeguard intellectual property and prevent unauthorized access.

4.0 Technology options for DTT2M/D2M

4.1 GPP 5G Broadcast

The 3rd Generation Partnership Project (3GPP) stands as a collaborative force in the realm of telecommunications standards, with a rich background dating back to its establishment in 1998. Conceived through the joint efforts of leading standardization bodies like ETSI, ARIB, TTC, ATIS, TTA, TSDSI, and CCSA, 3GPP was formed to unify the global landscape of mobile communication systems. Over the years, 3GPP's regular releases have introduced a tapestry of advancements, encompassing enhanced data rates, spectral efficiency, multimedia capabilities, and the broader horizon of the Internet of Things. Beyond the realm of mobile phones, 3GPP's standards ripple across industries, facilitating smart cities, connected vehicles, critical communications, and a diverse spectrum of applications that define the interconnected modern world. Through its global standardization efforts, 3GPP continues to foster innovation, compatibility, and a seamless mobile experience that transcends borders and empowers societies. Unicast and multicast are two different methods of data transmission in 5G broadcasting. Thus 3GPP introduced two different solutions which may enable the DTT2M service across releases;

Unicast is a one-to-one communication method, where data is sent from one device to another. This is the most common method of data transmission in 5G, and is used for things like streaming video, downloading files, and making phone calls. Unicast solution (LTE Broadcast)/ (Evolved multimedia broadcast multicast services [eMBMS]) is for operation on the mobile operator's cellular spectrum.

Multicast is a one-to-many communication method, where data is sent from one device to a group of devices. This is used for things like broadcasting live TV, sending emergency alerts, and delivering updates to a fleet of devices. A broadcast/multicast solution (5G Broadcast)/(Further evolved multimedia broadcast multicast services [FeMBMS]) is for operation on the broadcast UHF spectrum.

4.1.1 5G broadcast (eMBMS):

Unicast mode of 5G broadcasting is a way of delivering multimedia content to individual devices over a cellular network. It is also known as one-to-one communication, as each device receives a dedicated channel or stream from the source node. It is based on the 3GPP Release 14 specification. Unicast mode is suitable for on-demand and personalized services, such as video-on-demand, social media, and web browsing. LTE Broadcast, also known as evolved Multimedia Broadcast Multicast Service (eMBMS), is a feature of the 4G LTE standard that allows operators to allocate a portion of their spectrum for the multicast delivery of content. LTE Broadcast can improve the user experience by reducing buffering, congestion, and latency, and can also reduce the cost and complexity of content delivery for operators and service providers. However, unicast mode can also be inefficient and costly when delivering identical content to a large number of devices, such as live sports, concerts, or emergency alerts. In such cases, the multicast-broadcast mode of 5G broadcasting can offer better performance and scalability.

For broadcast transmission across multiple cells, it defines transmission via single-frequency network configurations. The specification is referred to as Evolved Multimedia Broadcast Multicast Services (eMBMS) when transmissions are delivered through an LTE (Long Term Evolution) network. eMBMS is also known as LTE Broadcast.

Target applications include mobile TV and radio broadcasting, live streaming video services, as well as file delivery and emergency alerts.

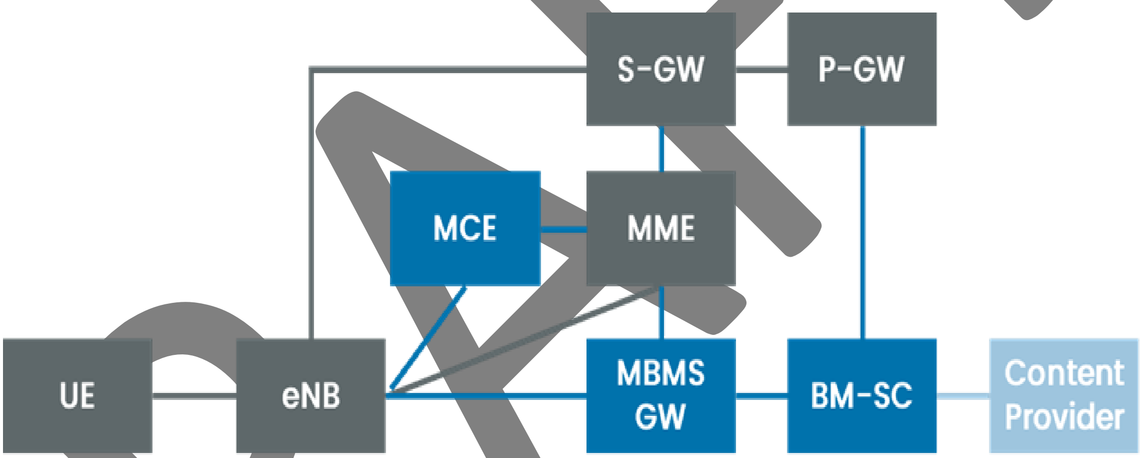

Figure 2: eMBMS Architecture

[Source: https://www.3gpp.org/technologies/broadcast-multicast1

eMBMS introduced the concept of the MBMS Single Frequency Network (MBSFN) to deliver the broadcast/multicast service. MBSFN is a transmission technique where identical waveforms are transmitted at the same time via a group of cells covering a geographic area. Single Cell Point to Multipoint (SC-PTM) can be used to adjust the broadcast/multicast area with the granularity of a single cell and to dynamically use radio resources of each cell.

eMBMS also offered major enhancements compared to MBMS. For example, the eMBMS enhanced service continuity by specifying relevant signaling and mechanisms in both single and multi-frequency scenarios. New features such as MBMS operation on demand was specified, which enables the operator to move multiple unicast services into one broadcast service given a certain threshold, rather than waiting for the explicit eMBMS session start by the operator and UEs' request

4.1.2 5G Broadcast (FeMBMS)

5G Broadcast is a technology that leverages the 5G New Radio (NR) standard to enable multicast transmission of content over 5G networks. It is based on the 3GPP Release 16 specification, which defines a new mode of operation called FeMBMS (Further evolved Multimedia Broadcast Multicast Service). Unlike LTE Broadcast, which requires a dedicated spectrum allocation, 5G Broadcast can use any available spectrum, including the low, mid, and high bands. 5G Broadcast can also support higher data rates, wider coverage, and more flexible configuration options than LTE Broadcast.

Release 16 5G Broadcast (then called enhanced TV) builds on the new end-to-end system and radio access design in Release 14, and meets all the major 5G broadcast requirements defined in TR 38.913. It can be deployed in existing UHF spectrum (i.e., 470 to 698 MHz) that broadcasters already own or have access to, and its design allows the reuse of existing cellular modem building blocks, thereby allowing for entry into mobile handsets. 5G Broadcast reuses the 4G/5G building blocks, the technology currently commoditized. Such commonality and a standards-based implementation are key to facilitate the mass market adoption of technology into industry verticals. This ensures wider stakeholder participation and the creation of an ecosystem that is critical for bringing down the cost to consumers at a global level. The 3GPP 5G Broadcast technology is already on that path. The technology is designed to reuse 3GPP silicon to optimize on cost and performance. The integration with the 3GPP stack also allows for advanced features such as emergency notifications, interactive, broadcast, etc. The 3GPP standards continue to evolve and will add more features as the requirements and use cases arise.

5G Broadcast defines two modes of broadcast communication: *5G standalone broadcast* and *mixed-mode multicast*.

5G standalone broadcast is a dedicated broadcast-only network that can address the needs of broadcasters and content providers, giving them access to broader audiences via efficient content delivery to both fixed and mobile devices. It can be deployed in existing UHF spectrum and reuse existing cellular modem building blocks. 5G standalone broadcast supports receive-only mode, downlink-only, dedicated broadcast spectrum, and more.

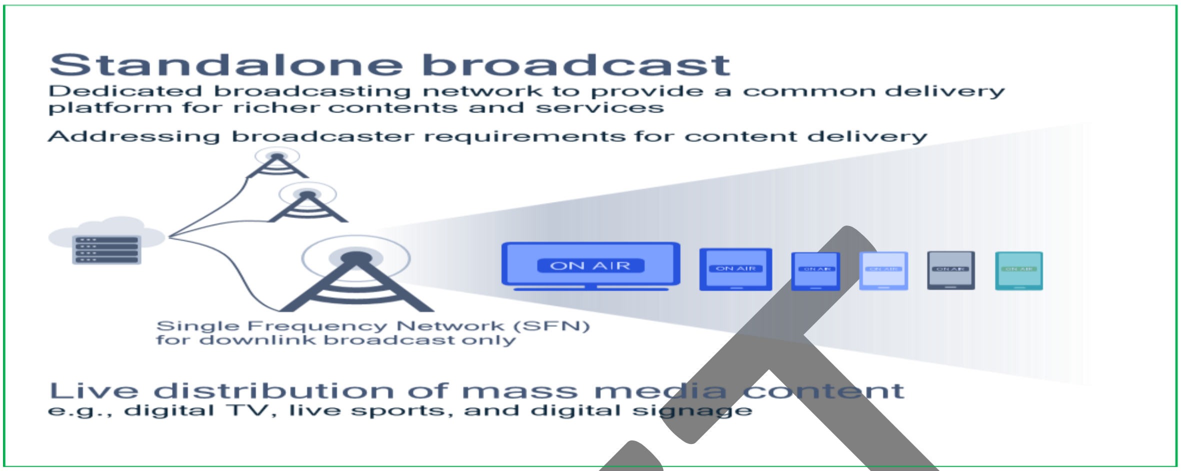

Figure 3: Standalone Broadcast mode DTT2M solutions from 3GPP

[Source: Qualcomm]

Mixed-mode multicast is a low-power network that supports dynamic mode switching between unicast and broadcast to more efficiently deliver identical content. It can support broader 5G use cases, such as efficient eMBB delivery, SW/FW update, IoT, V2X, and public safety. There are good chances of NR-Mixed mode being standardized in Rel-17

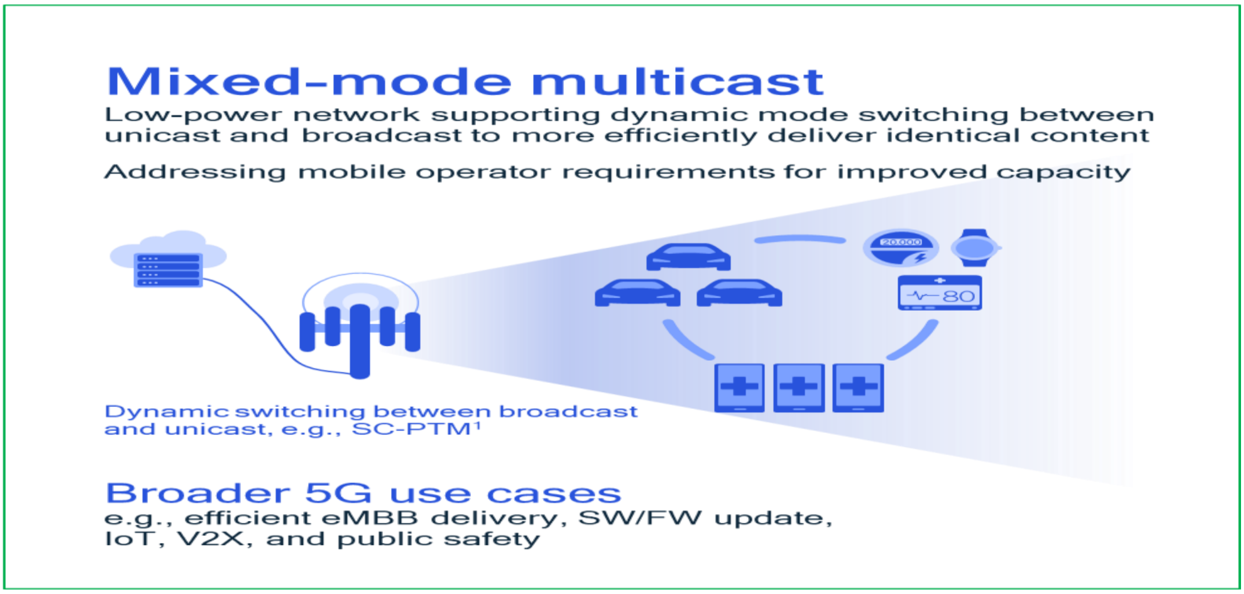

Figure 4: Mixed mode DTT2M solutions from 3GPP

[Source: Qualcomm]

The 5G broadcast technology brings new opportunities for the broader cellular and broadcast ecosystem. Built on the 3GPP Rel-16 feature-set, the 5G Broadcast solution operates within the UHF spectrum on a Receive-Only Mode (ROM), Free-To-Air (FTA) and without the need for a SIM card (SIM-free reception). The specs corresponding to 5G Broadcast have already been transposed by TSDSI and subsequently adopted into national standards by the TEC. 3GPP has defined 5G Broadcast (LTE-based 5G Terrestrial

Broadcast) as the terrestrial broadcast system to address new use cases and application. The TSDSI TR 6015 titled Service Delivery using 5G Broadcast for TV, Radio, IPTV and File-casting provides more details on this technology.

4.1.2.1 Architecture of Broadcasting over 5G:

The general architecture for a 5G Broadcast System is provided in figure 3. The principal actors in the system are as follows:

i. A 5G Broadcast TV/Radio Content Service Provider runs a head-end providing linear television and radio services.
ii. A 5G Broadcast TV/Radio Service Application runs on devices that include a 5G Broadcast Receiver.
iii. A 5G Broadcast System operator runs a 5G Broadcast System with 5G Broadcast Transmitters for use by devices including 5G Broadcast Receivers.
iv. A 5G Broadcast TV/Radio Content Service Provider makes services available using the 5G Broadcast System.
v. A 5G Broadcast TV/Radio Service Application is able to consume the service by communicating with the 5G Broadcast Receiver through a dedicated set of 5G Broadcast Client APIs.

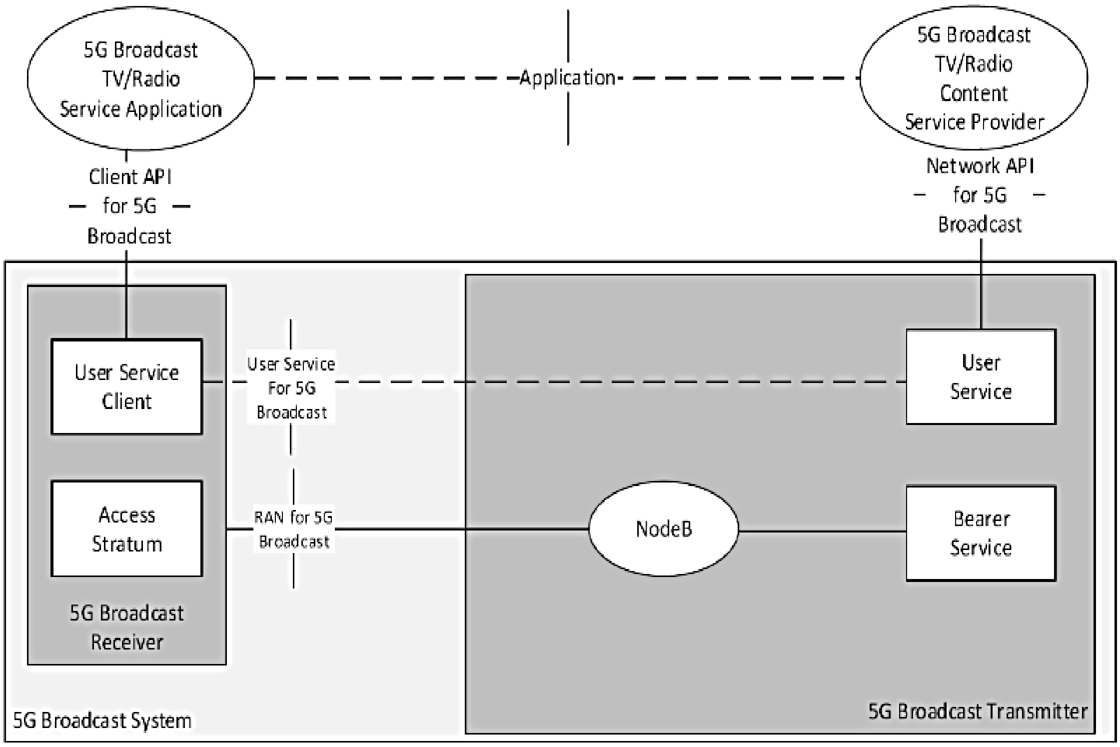

Figure 5: Reference architecture for 5G Broadcast System

Source: ETSI TS 103 720

4.1.2.2 Benefits of 5G Broadcast:

Following is a comprehensive list of benefits enabling new use cases for the multiple stakeholders' Indian market:

- Distribute public and commercial linear TV, radio services as well as live content, FTA or encrypted, to 3GPP-compatible devices such as smartphones, smart TVs or in-car infotainment systems. The main aim of 5G Broadcast is complemented existing cable-provided services namely in the areas where cable connections is not well established
- Enabling personalized media offers by delivering linear broadcast content along with catch-up or on-demand services using the same family of standards (3GPP). With such option, 5G Broadcast is aiming at brining both broadband and broadcast closer. A concrete example of this is to give the possibility to MNOs to (partially) use the existing Broadcasting resources (i.e. frequencies and infrastructure) and create new business incentives between the broadband and broadcast worlds while creating an India-specific model (referring to 5G).
- Enable broadcast distribution of linear TV and radio services integrated into existing media applications with 3GPP-defined APIs.
- Enable seamless integration with Public Safety broadcast services (like emergency broadcast messages) with integrated text/multimedia and possibility of add-on interactivity via broadband connectivity
- Flexibility of deployment with high-power high-tower (HPHT), low-power low-tower (LPLT) and medium-power medium-tower (MPMT) depending on the scenario, application, and geography under consideration.
- 5G Broadcast is a broadcasting technology designed with hardware reuse of cellular modems in mind.
- Features needed for broadcasters (high-power deployments, operation without SIM card, support of UHF spectrum, support of fixed reception) are supported by 5G Broadcast.
- Integration with the 3GPP stack allows for advanced features such as emergency notifications, interactive broadcast, etc.
- The 5G Broadcast system, apart from its ease of integration in handsets, inherits features of cellular systems such as support of multiple antennas, carrier aggregation, etc.
- New band definition work underway in 3GPP for introducing 6/7/8MHz channel bandwidth. This is a Rel-18 independent WID.
- The 5G Broadcast system has seen continuous evolution during the last few releases and may be further enhanced if new use cases / requirements arise.

4.1.2.3 5G Broadcast standard references:

- ETSI TS 103 720: 5G Broadcast System for linear TV and radio services; LTE-based 5G terrestrial broadcast systems – a profile of 3GPP specification containing the necessary parts to deploy 5G broadcast developed by the EBU
- 3GPP TR 36.976: Overall description of LTE-based 5G broadcast (Release 16) – the overall description of enhanced TV (enTV) for 5G broadcast
- Various 3GPP specifications of the 5G PHY supporting broadcast together with unicast in TS 36.211/TEC 25601:2020 , TS 36.212/ TEC 25002:2020, TS 36.213 TEC 25069: 2020. The Telecom Engineering Center (TEC) has adopted them into Indian standards
- TSDSI TR 6015: Service Delivery using 5G Broadcast for TV, Radio, IPTV and File-casting.

4.1.2.4 Salient features of 5G Broadcasting:

a. **Frequency Bands:** 5G broadcast services are defined band agnostically and can be delivered over various frequency bands, including sub-6 GHz and millimeter-wave (mm Wave) bands. The choice of frequency band depends on the specific use case, network architecture, and local regulations. 5G Broadcast services are designed to be delivered over the UHF bands.

b. **Modulation Schemes:** 5G broadcast services can use various modulation schemes, such as 16-QAM, 64-QAM, and 256-QAM, to encode the multimedia content for transmission over the network.

c. **Core Network Architecture:** The core network architecture for Terrestrial Broadcasting in 5G Era services includes a broadcast/multicast service center (BM-SC), which is responsible for managing the delivery of broadcast/multicast content over the network.

d. **Media Delivery Methods:** 5G broadcast services can use various media delivery methods, such as File Delivery over Unidirectional Transport (FLUTE), MPEG-2 Transport Stream (TS), and MPEG-DASH, to deliver multimedia content to end- users.

e. **Latency:** 5G broadcast services are designed to have low latency, typically between 10 and 100 milliseconds, to enable real-time multimedia experiences such as live streaming of sports events or concerts.

f. **Quality of Service (QoS):** Terrestrial Broadcasting in 5G Era services support various QoS levels, including best-effort and guaranteed bit rate, to ensure that the multimedia content is delivered with the appropriate level of quality and reliability.

g. **Security:** Terrestrial broadcasting in 5G Era services is designed with various security features, such as encryption and authentication, to ensure the privacy and integrity of the multimedia content and the network.

4.1.3 Deployment/Trial/Test Beds scenario in various countries:

The Deployment/Trial/Test Beds scenario in various countries is given in the table below:-

Table 1: Deployment/Trial/Test Beds scenario in various countries

Country	Cities	Trial name	TMMB system (Terrestrial Multimedia Mobile Broadcasting)	Frequency range used	Date
China	Beijing, Shanghai	5G NR MBS Trial in Beijing and in Shanghai	5G new radio (NR) multicast and broadcast system (MBS)	758-768 MHz	October 2020/November 2021
	Nanjing	5G NR MBS Trial in Nanjing	5G new radio (NR) multicast and broadcast system (MBS)	Within the 700 MHz range	October 2021
Switzerland France Germany Italy Austria	Geneva Paris Stuttgart Turin Vienna	5G Broadcast of the Eurovision Song Contest 2022	LTE-based 5G Terrestrial Broadcast	600 MHz	April/May 2022
Germany	Stuttgart, Heilbronn	5G Media2Go	FeMBMS (Release 14) LTE-based 5G Terrestrial Broadcast LTE Unicast	622-630 MHz	October 2020/ September 2022
	Hamburg	5G Broadcast in Hamburg	LTE-based 5G Terrestrial Broadcast	574-582 MHz	October 2021/ December 2023
Austria	Vienna	Vienna field trials	FeMBMS (Release 14) LTE-based 5G Terrestrial Broadcast	734-744 MHz 662-672 MHz 638-642 MHz	2020/2021 – Phase 1 2021/2023 – Phase 2
Italy	Aosta Valley	LTE-based 5G Broadcast trial in Aosta Valley	LTE-based 5G Terrestrial Broadcast	726-734 MHz	November 2021/ June 2022
Denmark	Copenhagen	LTE based 5G Terrestrial Broadcast field trials in Denmark	LTE-based 5G Terrestrial Broadcast	617-622 MHz	June/July 2022
Spain	Barcelona	5G-B trial during MWC in 2020, 2022 and 2023	FeMBMS (Release 14) FeMBMS (Release 16), eMBMS (Release 12)	750-755 MHz 617-627 MHz 617- 622 MHz	[Feb.] 2020/[Feb.] 2022/[Feb.] 2023

Italy	Turin and Palermo	Rai Way Trial of 5G Broadcast network and services in the 700 MHz band in the cities of Turin and Palermo	FeMBMS (Release 16) and seamless switching broadband/broadcast	743-748 MHz (SDL-B2)	July 2022/July 2023
Italy	Lissone (Monza-Brianza)	EI-Towers 5G-B field Trial in Lissone (MB)	FeMBMS (Release 16)	738-743 MHz (SDL-B1)	March 2023
USA	Boston	Transmit LTE-based 5G Broadcast over a licensed ATSC 3.0 TV broadcast facility	FeMBMS (Release 16)	UHF TV band	Ongoing
China	Chengdu	5G broadcast pilot project	FeMBMS (Release 16)	630-638 MHz	Ongoing
Brazil	Rio	5G Broadcast streaming demonstration	FeMBMS (Release 16)	UHF TV band	February 2023
Switzerland	Geneva	5G Broadcast based hybrid content distribution	FeMBMS (Release 16)	UHF TV band	April 2023

[Source: Qualcomm]

4.2 ATSC 3.0

ATSC 3.0, also known as NextGen TV, ATSC 3.0 is US based, is a cutting-edge digital television broadcasting standard that combines ATSC 1.0 features with most recent digital modulation techniques that are also used for DVB-T2. Developed by the Advanced Television Systems Committee (ATSC), ATSC 3.0 was created to address the evolving landscape of media consumption and technological advancements in the digital age. The transition from analog to digital broadcasting was facilitated by ATSC 1.0, revolutionizing television with improved picture and sound quality. However, the rapid progress of technology and changing viewer habits necessitated a more versatile and feature-rich standard, leading to the development of ATSC 3.0.

ATSC 3.0 introduces a host of transformative features. It enables broadcasters to deliver Ultra High Definition (UHD) and High Dynamic Range (HDR) content, offering viewers a captivating visual experience that was previously unattainable. The standard's enhanced audio capabilities enable efficient delivery of rich and lifelike soundscapes and personalised audio experiences to consumers and includes accessibility features that deliver a far richer experience for hearing and visually impaired audiences.

One of ATSC 3.0's ground-breaking aspects is its interactivity. ATSC 3.0 relies on internet based feedback channel i.e. interactivity needs availability of internet. The NR MBS design consist of the uplink channel to make richer interactivity experience. Viewers can now engage with content through interactive features, opening doors to personalized experiences, engaging advertisements, and more. Moreover, the standard embraces datacasting, allowing broadcasters to transmit non-broadcast data over the airwaves, enhancing emergency alerts, software updates, and targeted advertising.

ATSC 3.0 harmoniously merges traditional broadcasting with broadband internet, resulting in hybrid services that offer a seamless blend of linear television and internet-based content. This adaptability caters to various devices, from conventional TVs to mobile devices, ensuring a consistent and versatile viewer experience.

4.2.1 Features of ATSC 3.0

- **i.** Mobile Reception: ATSC 3.0 supports mobile reception, allowing users to receive multimedia content directly on their smartphones and tablets.
- **ii.** Ultra High Definition (UHD) Video: ATSC 3.0 enables the transmission of the UHD video content, providing a superior visual experience on mobile devices.
- **iii.** High Dynamic Range (HDR): The standard supports delivery of highest-quality & accurate HDR video, enhancing color depth and brightness for a more immersive viewing experience on mobile screens.
- **iv.** Immersive Audio: ATSC 3.0 supports object-based audio, delivering immersive, personalized and accessible sound experiences on mobile devices.
- **v.** Interactive Content: ATSC 3.0 allows for the delivery of interactive content, including interactive advertisements and additional information alongside the main broadcast. ATSC 3.0 relies on internet based feedback channel i.e. interactivity needs availability of internet. The NR MBS design consists of the uplink channel to make richer interactivity experience.
- **vi.** Robust Error Correction: The standard includes advanced error correction techniques, ensuring reliable reception even in challenging mobile environments.
- **vii.** Broadcast Internet Integration: ATSC 3.0 integrates broadcast and broadband networks, enabling hybrid services that combine OTA and internet-based content.
- **viii.** Scalability: The standard is designed to be scalable to various screen sizes and resolutions, ensuring a consistent user experience across different mobile devices.
- **ix.** Personalized Content Delivery: ATSC 3.0 enables personalized content

recommendations based on user preferences, enhancing content discovery on mobile devices.

x. Advanced Emergency Alerts: The standard enhances emergency alert systems with geo-targeted and multimedia alerts for public safety on mobile devices.

xi. Energy Efficiency: ATSC 3.0 incorporates energy-saving technologies, optimizing power consumption in both broadcasting stations and mobile devices.

xii. Adaptive Bitrate Streaming: The standard supports adaptive bitrate streaming, adjusting the video quality based on network conditions for smooth playback on mobile devices.

xiii. Mobile App Integration: ATSC 3.0 allows integration with mobile apps, enabling interactive features and complementary content on mobile devices.

xiv. Mobile Data Offloading: The standard supports mobile data offloading, would reduce mobile network congestion by delivering content through broadcast channels. Note that the broadcast offload to non- 3GPP network feature is still under discussion, and normative architecture work is yet to begin in 3GPP.

[Offloading broadcast traffic would demand interworking with 3GPP or other mobile broadband standards. S1-222349 WID and S1-222350 proposals are yet to initiate any normative architecture and protocols work in 3GPP.]

xv. Real-time Broadcast: ATSC 3.0 ensures real-time delivery of live events and broadcasts, enabling users to watch sports, news, and other events on their mobile devices in real-time

4.2.2 Architecture of ATSC 3.0

The architecture of ATSC 3.0 is structured in layers to ensure efficient and seamless content delivery to mobile devices, offering users an immersive multimedia experience on their smartphones and tablets. At its foundation is the Physical Layer (PHY), responsible for transmitting and receiving data through the airwaves using OFDM modulation. The Link Layer (LL) manages the connection between transmitting and receiving devices, overseeing link adaptation and resource allocation. Above this, the Protocol Layer (PL) handles data packets, error correction, and retransmission protocols to ensure dependable data delivery.

The following is the block diagram of ATSC 3.0

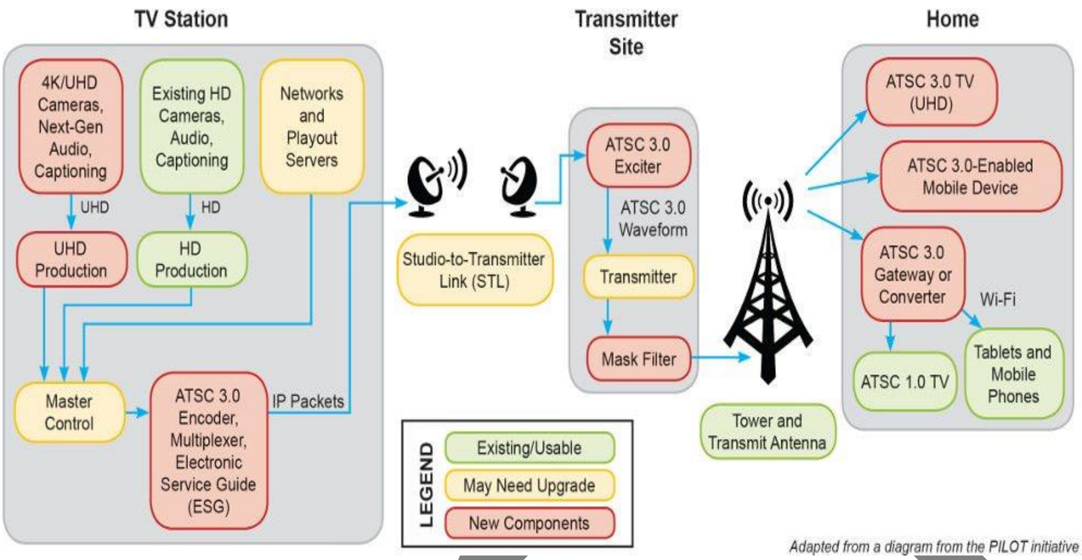

Figure 6: Block diagram of ATSC3.0

[Source: https://www.atsc.org/atsc-documents/type/3-0-standards/]

The Management and Protocols Layer (MPL) takes charge of service discovery, signaling, and the management of various protocols. The Presentation Layer (PLS) decodes and presents multimedia content, offering audio, video, and more. The Application Framework (AF) lays the groundwork for interactive applications and services, while the Application Layer (AL) manages interactive content delivery, personalized recommendations, and user interactions.

Enabling the integration of broadcast and internet-based services, the Broadcast Internet Protocol (BIP) facilitates the delivery of IP-based content over broadcast channels. Service Layer Multiplexing combines diverse services like audio, video, and data into a unified transport stream, and Service Protection and Security handle content encryption and digital rights management for secure delivery.

The Broadcast Internet Integration layer manages the harmonious integration of broadcast and broadband networks, facilitating hybrid services. The Emergency Alert System (EAS) ensures efficient delivery of emergency alerts to mobile devices, enhancing user safety. The Electronic Service Guide (ESG) provides interactive access to program schedules and information, enriching user engagement. The Interactive Application Execution Environment executes interactive applications on receiver devices, enhancing interactivity.

Serving as a communication hub, Middleware manages interactions between the different layers and components of the ATSC 3.0 system. Altogether, these layers create a comprehensive architecture that optimizes content delivery, interactivity, security, and integration, offering a robust platform for delivering multimedia content seamlessly to mobile devices.

4.2.3 Deployment/Trials/Test beds scenario in various countries

Table 2: Deployment/Trials/Test beds scenario in various countries

Country	Cities	Trial name	TMMB system (Terrestrial Multimedia Mobile Broadcasting)	Frequency range used	Date
USA	Texas, New York, Alabama, Michigan, Colorado, Ohio	Currently in the process of deploying ATSC 3.0 for D2M. Some broadcasters Sinclair Broadcast Group, Nexstar Media Group, and Tegna have launched the network.		UHF	2023
Canada	Toronto	Broadcast-Broadband Convergence B^{2}C Lab, Humber College [first and only ATSC 3.0 experimental broadcasting license in Canada]	Lab has deployed a custom multiple transmitter/antenna ATSC 3.0 over-the-air test bed covering the Toronto area.	UHF	
South Korea	PyeongChang	launched ATSC 3.0 in 2017 to deliver better video and audio quality to OTA viewers in its largest urban areas, to promote its 4K capabilities. Some trial attempts were made to deliver two streams; one for fixed TV and the other for mobile. But now, only fixed TV stream is available and no D2M is commercially launched.		700 MHz	2017/2018

Brazil	Rio	"TV 3.0" project It aims to improve the quality of television broadcasting in Brazil using ATSC 3.0 technologies. TV 3.0 in Brazil is still under early development now and ATSC3.0 is being only studied/verified as one of candidate PHY technologies.	FeMBMS (Release 16)	UHF TV band	February 2023
Mexico		Mexico is also planning to deploy ATSC 3.0 for D2M. The government has issued a tender for the deployment of ATSC 3.0 D2M services, and the first services are expected to launch in 2023. Mexico is focused on distance education use cases for ATSC 3.0 D2M. The government is working with universities to develop D2M services that can be used for distance learning.		UHF	2023
Jamaica	Througho ut the country	Television Jamaica limited (TVJ) launched ATSC 3.0 digital TV transmission services in 2022.		UHF	2022

Source: 1. https://humber.ca/research/b2c-lab
2. https://www.atsc.org/nextgen-tv/deployments/
3. https://nabpilot.org/jamaica-the-latest-to-adopt-atsc-3-0/#:~:text=ATSC%203.0%20is%20the%20most,their%20new%20digital%20broadcast%20standard
4. https://www.broadcastandcablesat.co.in/deployments-atsc-nextgen-tv/
5. https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2019/ITU-TRAI-International-Training-on-Emerging-Trends-in-Broadcasting/Sung_Ik_Park_Speech.pdf
6. https://www.atsc.org/news/road-to-atsc-3-0-broadcaster-headway-in-south-korea/

4.3 DVB-T2 system

Digital Video Broadcasting - Terrestrial 2 (DVB-T2) is a European technology and is an advanced digital television broadcasting standard that represents a significant evolution from its predecessor, DVB-T. Developed by the Digital Video Broadcasting Project (DVB), DVB-T2 was designed to address the growing demand for higher-quality video, improved spectrum efficiency, and enhanced transmission robustness in terrestrial broadcasting.

DVB-T2 builds upon the success of DVB-T, which played a crucial role in the global transition from analog to digital television broadcasting. DVB-T revolutionized television by providing better image quality, more channels, and interactive features. However, as technology continued to progress, the need for even more efficient and advanced broadcasting capabilities became evident.

DVB-T2 has been adopted by numerous countries as their preferred digital television broadcasting standard. Its enhanced capabilities and improved efficiency make it well-suited to the demands of modern broadcasting, offering viewers an enriched and immersive television experience while allowing broadcasters to deliver a broader range of content and services.

4.3.1 Basic Features of DVB-T2

i. Efficient Spectrum Usage: DVB-T2 uses advanced modulation and coding techniques, including COFDM (Coded Orthogonal Frequency Division Multiplexing), to maximize the utilization of available spectrum.

ii. High Definition (HD) Video: Supports the transmission of high-quality HD video content.

iii. Robust Reception: DVB-T2 employs sophisticated error correction and diversity techniques to improve reception in challenging signal conditions.

iv. Adaptive Bitrate Streaming: Enables adaptive bitrate streaming to adjust video quality based on network conditions for smoother playback.

v. Interactive Services: Provides support for interactive services like electronic program guides (EPG) and datacasting.

vi. Multimedia Subtitling and Audio: Supports multiple audio tracks and subtitles for multimedia content.

vii. Hybrid Broadcast/Broadband Integration: Can be integrated with broadband networks for hybrid services.

viii. Low Power Consumption: Enables energy-efficient transmission for reduced power consumption.

ix. Multiple PLPs (Physical Layer Pipes): Allows multiple services to be multiplexed and transmitted in parallel.

x. Time Slicing and MISO: Supports time slicing and multiple-input, single-output (MISO) techniques for improved reception.

xi. Enhanced Guard Interval: Provides better resistance to multipath interference.
xii. Hierarchical Modulation: Allows for different data rates for different reception environments.
xiii. Dynamic Single Frequency Network (SFN) Configuration: Supports adaptive SFN configurations for optimized coverage.
xiv. Regionalization and Local Services: Facilitates regional content delivery and localized services.
xv. Encryption and Conditional Access: Enables content protection and conditional access systems for secure broadcasting.

4.3.2 Conceptual Architecture of DVB-T2

The conceptual architecture of DVB-T2 for potential direct-to-mobile delivery is a creative adaptation that envisions a specialized approach beyond standard implementation. At its core, the architecture comprises distinct layers to facilitate seamless data transmission and reception. The Physical Layer (PHY) forms the foundation, utilizing DVB-T2 modulation (COFDM) for transmitting and receiving data over the airwaves. The Link Layer (LL) manages the connection between transmitting and receiving devices, incorporating error correction and diversity techniques to enhance reliability. The Protocol Layer (PL) oversees data packet management, error correction, and retransmission protocols, ensuring dependable data delivery.

An essential component is the Adaptation Layer, serving as an interface where content intended for mobile devices is extracted or transcoded from the DVB-T2 stream. This allows for efficient delivery of content tailored for mobile consumption. Additionally, the architecture includes Mobile Data Offloading, enabling mobile network operators to directly provide popular content to mobile devices, thereby alleviating traffic from cellular networks. The Interactive Application Framework establishes the groundwork for interactive applications and services, while Mobile App Integration offers the potential for mobile apps to access supplementary interactive content and services. Middleware plays a pivotal role in managing communication between the various layers and system components. Content Protection and Security handle critical tasks, including content encryption and digital rights management, ensuring secure and protected content delivery.

The architecture also features Service Layer Multiplexing, consolidating diverse services like audio, video, and data into a unified transport stream. The Electronic Program Guide (EPG) offers users interactive access to program schedules and information. The Interactive Application Execution Environment executes interactive applications on receiving devices, enriching the user experience. Broadcast Internet Integration manages the harmonious integration of broadcast and broadband networks, enabling hybrid services that combine both mediums. The Emergency Alert System (EAS) ensures the efficient distribution of emergency alerts to mobile devices. Finally, Mobile Reception empowers DVB-T2-equipped mobile devices to capture and decode transmitted signals, bringing the envisioned direct-to-mobile content delivery to fruition.

4.3.3 DVB-T2 deployment scenario

This has basically died, and there is no business case. Doordarshan started Digital terrestrial Television services in 16 cities of India from 2016. DTT channels can be received on Mobile TV also using DVB-T2 Dongles in OTG enabled smart phones and tablets, Tablets/laptops etc. The channels can also be viewed on Fixed TV Sets using Indoor/Outdoor antenna on integrated digital TV (iDTV) Sets or using DTT Set Top Boxes. Doordarshan was offering DD National, DD News, DD Bharati, DD Sports, DD Regional/DD Kisan channels were relayed from DTT transmitters installed in 16 cities. With the offering of 4G services in India, and the corresponding 5G launch, the subscribers migrated to view OTT content on smartphones (without the need of an external dongle) and the DVB-T2 service had to be shut down in 2022 due to lack of viewership.

4.4 ISDB-T systems family

Integrated Services Digital Broadcasting - Terrestrial (ISDB-T) is a digital television broadcasting standard that originated in Japan and has since been adopted by several countries in Latin America and other regions. Developed by the Japanese government and industry, ISDB-T represents a significant advancement over analog broadcasting, offering improved image and sound quality.

ISDB-T has played a vital role in the digitalization of television broadcasting, particularly in the countries where it has been adopted. Its capabilities have contributed to the improved broadcasting quality, expanded services, and greater access to information and entertainment for viewers.

ISDB-T is designed to provide high-quality digital broadcasting signals with better resistance to interference compared to analog TV signals. It uses advanced modulation techniques and error correction to ensure that the transmitted signal is received accurately by the receiver.

4.4.1 Basic Features of ISDB-T

i. Mobile Reception: ISDB-T supports mobile reception through its Terrestrial Mobile Multimedia Broadcasting (ISDB-Tmm) mode, enabling users to receive multimedia content directly on their handheld devices.

ii. High-Quality Video and Audio**:** Currently deployed ISDB-T e.g. in Brazil delivers high-quality video and audio content to mobile devices, using video codecs like MPEG-2 and MPEG-4 AVC (H.264), and audio codecs such as MPEG-2 AAC or MPEG-4 HE-AAC.

iii. Interactive Services: ISDB-T allows for interactive services, enabling the delivery of additional data and applications alongside the main broadcast. This includes interactive applications, datacasting, and other interactive content.

iv. Robust Error Correction: ISDB-T employs robust error correction techniques to ensure reliable reception, especially in areas with weaker signals or high mobility scenarios.

v. Data Rate Adaptation: The standard supports adaptive data rate based on available bandwidth and content requirements, optimizing the transmission for different network conditions.

vi. Modulation: Orthogonal Frequency Division Multiplexing (OFDM): ISDB-T uses OFDM modulation, which efficiently utilizes the available spectrum and provides resistance against multipath propagation.

vii. Service Layer Multiplexing: ISDB-T allows multiple services, including audio, video, and data, to be combined into a single transport stream, giving users the option to select the desired service.

viii. Hybrid Broadcast/Broadband Integration: ISDB-T can integrate terrestrial broadcast and broadband networks, enabling hybrid services that combine OTA and internet-based content.

ix. Emergency Alert System: ISDB-T includes an emergency alert system to deliver critical information to mobile users during emergencies.

x. Interactive Electronic Program Guide (EPG): Users can access an interactive EPG to browse program schedules and access additional information about the content being broadcasted.

xi. Multilingual Audio and Subtitles: ISDB-T supports multilingual audio and subtitles, allowing users to choose their preferred language for audio and text.

xii. Personalized Content Delivery: ISDB-T enables the personalized content delivery, tailoring content recommendations based on user preferences.

xiii. Energy Efficiency: The standard incorporates energy-saving technologies, optimizing power consumption in both broadcasting stations and mobile devices.

xiv. Parental Control: ISDB-T includes parental control features to restrict access to certain content based on age or content ratings.

xv. Real-time Broadcast: ISDB-T ensures real-time delivery of live events and broadcasts, enabling users to watch sports, news, and other events as they happen.

4.4.2 Architecture of ISDB-T

The ISDB-T architecture is composed of multiple interconnected layers, each with specific functions to ensure seamless digital broadcast operations. At its foundation, the Physical Layer (PHY) employs OFDM modulation to transmit and receive data over the airwaves. Above this, the Data Link Layer handles the link establishment and management to facilitate efficient data transfer. The Transport Layer comes into play, responsible for packetization and error correction to ensure dependable data transmission. The Service Layer Multiplexing combines audio, video, and data services into a unified transport stream, while the Presentation Layer decodes and presents audio and video content. The Application Layer manages interactive services, datacasting, and applications, supported by the Interactive Application Framework that provides the basis for interactive applications. These applications are executed by the Interactive Application (IA) Execution Environment on receiver devices, and their data is combined with audio and video through the IA Composition Engine. Ensuring synchronization of audio and video streams is the role of Media Synchronization. Middleware manages communication between different system layers and components, while Content Protection and Security handle encryption and digital rights management. The Network Layer oversees hybrid broadcast/broadband integration, and the Emergency Alert System (EAS) is in place for delivering crucial alerts to mobile devices. Finally, the Electronic Program Guide (EPG) offers users interactive access to program schedules and information. Together, these elements form the comprehensive ISDB-T architecture, enabling a rich and secure digital broadcast experience.

4.4.3 Advanced ISDB-T

Japan Broadcasting Corporation (NHK) has been conducting research and development on large-capacity transmission technologies for next-generation digital terrestrial television broadcasting (DTTB) system. In this work, a transmission system inherited Integrated Services Digital Broadcasting-Terrestrial (ISDB-T) has been developed, which can provide both fixed reception service and mobile reception service. The transmission system was developed with the aim of providing 4K/8K UHDTV broadcasting for fixed reception and HDTV broadcasting for mobile reception in one channel (6 MHz bandwidth).

Advanced ISDB-T is the next leap of ISDB-T to enable offering of far beyond the existing services, such as provision of UltraHD based service on both broadcast and Integrated Broadcast-Broadband. This system is a tentative scheme to reply for Brazil TV3.0 project. Advanced ISDB-T is based on the candidate technologies for the next-generation DTTB standard in Japan, which is expected to be standardized around 2023.

4.4.3.1 Basic features of Advanced ISDB-T

i. Advanced ISDB-T is an evolution of the current ISDB-T standard, which is adopted in Brazil and other countries.

ii. Advanced ISDB-T aims to provide various and flexible services with high efficiency, such as UltraHD, interactive, and mobile services.

iii. Advanced ISDB-T is compatible with the current ISDB-T system and can cover the requirements for both Brazil and Japan.

iv. Compared to the current ISDB-T standard, the transmission capacity of the advanced ISDB-T can be increased by approximately 10 Mbps with the same required carrier-to-noise ratio (CNR), and the required CNR can be improved by approximately 7 dB with the same transmission capacity.

v. The transmission capacity can be further increased by using a MIMO technology, which enables the transmission of two independent signals using two antennas in both transmitter and receiver sides.

vi. The advanced ISDB-T can transmit one UltraHD 4K service by using high efficiency video coding (HEVC) in a single 6-MHz channel for fixed single-input single-output (SISO) reception. For versatile video coding (VVC), it is expected that an UltraHD 8K service can be transmitted by using the MIMO system

4.4.3.2 Architecture of Advanced ISDB-T

The architecture of advanced ISDB-T, the next generation digital TV system that is being developed in Japan, is based on the current ISDB-T standard, which is adopted in Brazil and other countries. Advanced ISDB-T aims to provide various and flexible services with high efficiency, such as UltraHD, interactive, and mobile services.

Advanced ISDB-T can transmit up to three layers (layers A, B, and C) with different transmission capacities and robustness. Each layer can be used for different types of services, such as fixed, mobile, or interactive services. Advanced ISDB-T uses IP and HTML5 application environment to enable rich and complex services, such as emergency warnings, social network services, and e-commerce. IP and HTML5 also allow for easy integration of broadcast and broadband services. Advanced ISDB-T employs state-of-the-art technologies, such as low-density parity-check (LDPC) codes, 2×2 multiple-input multiple-output (MIMO) transmission, and scalable video coding (SVC). These technologies improve the spectrum efficiency, transmission rate, and quality of the system. Advanced ISDB-T is compatible with the current ISDB-T system and can cover the requirements for both Brazil and Japan.

4.4.4 ISDB-T deployment Scenario

ISDB-T is still under development and target country is only Japan, Philippines and Latin America. Device ecosystem will be challenging since it is not worldwide targeted technology. *[Source: https://www.dibeg.org/techp/what/]*

"Editor's note: Inputs solicited"

4.5 DTMB-A systems

The Digital Terrestrial Multimedia Broadcast - Audio (DTMB-A) system is a digital broadcasting technology developed by China to provide advanced audio services within its digital television framework. It is an extension of the Digital Terrestrial Multimedia Broadcast (DTMB) standard, which was adopted as the national digital television standard in China.

The DTMB-A system builds upon the foundation of DTMB, which itself is based on the European DVB-T (Digital Video Broadcasting - Terrestrial) standard. DTMB was chosen as China's digital television standard due to its ability to deliver efficient and robust terrestrial broadcasting in a diverse geographical and population landscape.

DTMB-A specifically focuses on enhancing audio services by delivering high-quality and immersive sound experiences to viewers. This system aims to improve audio quality, support multiple audio channels, and provide compatibility with various audio codecs. It complements the video capabilities of the DTMB standard with advanced audio features, catering to the evolving preferences of modern audiences.

4.5.1 Basic Features of DTMB-A

- **i.** High spectral efficiency: DTMB-A Direct to Mobile can achieve a spectral efficiency of up to 5 bits/Hz, which is much higher than traditional terrestrial TV broadcasting standards. This allows for more channels to be broadcast in the same bandwidth, or for existing channels to be broadcast with higher quality.
- **ii.** Low latency: DTMB-A Direct to Mobile has a latency of less than 100 milliseconds, which is comparable to cable and satellite TV. This makes it suitable for applications such as live streaming and gaming.
- **iii.** Robustness to interference: DTMB-A Direct to Mobile is robust to interference from other radio signals, such as Wi-Fi and cellular networks. This makes it reliable even in crowded urban areas.
- **iv.** Support for mobile reception: DTMB-A Direct to Mobile can be received on mobile devices, such as smartphones and tablets. This allows users to watch TV anywhere they have a good signal.
- **v.** Low power consumption: DTMB-A Direct to Mobile receivers have a low power consumption, which makes them suitable for battery-powered devices.
- **vi.** Support for high definition (HD) and ultra-high definition (UHD) video: DTMB-A Direct to Mobile can support HD and UHD video, with resolutions up to 4K. This provides a high-quality viewing experience.
- **vii.** Support for multiple audio languages: DTMB-A Direct to Mobile can support multiple audio languages, making it suitable for a global audience.
- **viii.** Support for closed captions: DTMB-A Direct to Mobile can support closed captions, which is helpful for people who are hard of hearing or deaf.
- **ix.** Support for interactive applications: DTMB-A Direct to Mobile can support interactive applications, such as voting, quizzes, and games. This makes it a more engaging viewing experience.

x. Support for data broadcasting: DTMB-A Direct to Mobile can be used to broadcast data, such as news, weather, and traffic information. This can be used to provide users with up-to-date information.
xi. Support for future technologies: DTMB-A Direct to Mobile is designed to be future-proof, and can support new technologies as they become available.
xii. Open standard: DTMB-A Direct to Mobile is an open standard, which means that it is not controlled by any one company. This makes it more affordable and accessible to broadcasters and consumers.
xiii. Support for global adoption: DTMB-A Direct to Mobile is being adopted by countries around the world, which makes it a more viable option for broadcasters and consumers.
xiv. Government support: DTMB-A Direct to Mobile is supported by governments in many countries, which helps to ensure its widespread adoption.
xv. Industry support: DTMB-A Direct to Mobile is supported by a number of industry organizations, which helps to promote its development and adoption.

4.5.2 Architecture of DTMB-A

The architecture of DTMB-A (Digital Terrestrial Multimedia Broadcast - Direct to Mobile) encompasses several key components to enable efficient and robust content delivery. At its core is the Physical Layer, which employs OFDM (Orthogonal Frequency Division Multiplexing) modulation, dividing the bandwidth into narrowband channels to enhance efficiency and resistance to interference. The Medium Access Control Layer manages resource access using TDMA (Time Division Multiple Access), ensuring the fair allocation of radio resources among users. The Packet Layer encapsulates data into packets, integrating error correction coding to safeguard against transmission errors.

Facilitating multimedia content delivery, the Application Layer supports diverse services like television, radio, and data broadcasting. The Conditional Access Module (CAM) handles encryption and decryption to prevent unauthorized content access. Receivers equipped with OFDM demodulators, MAC decoders, packet decoders, and application layer decoders process the DTMB-A signal, while transmitters with modulators and encoders broadcast the signal. Signaling channels exchange system configuration, content, and user location details.
Networking capabilities include single-hop, multi-hop, and mesh networks, supporting various services. Security measures encompass encryption, authentication, and authorization to safeguard the content. Engineered for performance, DTMB-A ensures reliability and quality of service even in challenging environments. Its cost-effectiveness stems from the use of affordable components and adaptability to different settings.

Scalability allows DTMB-A to accommodate numerous users and services through easy expansion. The system's future-proof design enables seamless integration of new technologies and services. With its international adoption by multiple countries, DTMB-A emerges as a practical option for broadcasters and consumers alike, fostering a globally recognized solution for multimedia content delivery.

4.5.3 DTMB-A deployment scenario

At present, DTMB/DTMB-A standard have successfully deployed and put into operation in mainland China, Hong Kong, Macao as well as other countries and regions, such as Laos, Cuba. Cambodia, East Timor and Pakistan. DTMB/DTMB-A mobile transmission system was applied successfully during the Beijing Olympic Games. *[Source: http://www.dtnel.org/2020/dtvnews_0106/1947.html]*

"Editor's note: Inputs solicited"

5.0 Direct to handset Satellite

Direct to handset satellite is a technology that allows smartphones and other mobile devices to connect directly to satellites without any additional equipment. This technology can provide coverage in remote and underserved areas, as well as enable rich and complex services, such as emergency warnings, social network services, and e-commerce. Some of the companies that are developing or planning to use this technology are Apple, Huawei, Starlink, Lynk, and Iridium.

According to a report by GSMA Intelligence, the direct satellite-to-device market is the single biggest opportunity in satellite communications history, predicting revenue generation of $60 billion with up to 350 million subscribers by 2030. The report also states that the main differentiator from GEO and LEO constellations (such as Starlink, OneWeb and Amazon's Kuiper) that need a dish or other large receiving equipment is that connectivity is provided direct to someone's mobile phone, or any standard mobile device. This allows users to be 'mobile' while using the service.

One of the challenges for this technology is the regulatory framework, which needs to be flexible enough to allow for the smartphones of the present, because satellite direct-to-handset connectivity is an industry development that is here to stay. Traditional licensing, focused on satellites serving many identical terminals, will need to be adapted for a smartphone market with a multiplicity of vendors, as well as users that switch providers.

The idea is not to make consumers choose between a cellular or a satellite phone, but to turn their phone into a satellite terminal. This can be done either by including satellite-capable hardware into modern cell phones, as exemplified by Apple and Huawei, or by designing cellular-capable hardware into satellites, which is what Starlink and Lynk are doing. Either way, partnerships, not competition, between the mobile and the satellite industries mean that smartphones will progressively have integrated satellite connectivity. So much so that the 3GPP release 17 standardized unique cooperation between 5G and non-terrestrial networks, including satellites, to provide a seamless transition between the two.

5.1 Advantages of Direct to Handset Satellite

i. Some of the advantages of direct to handset satellite are:
ii. It can provide global and ubiquitous connectivity, regardless of terrestrial infrastructure or geographical barriers.
iii. It can offer high-speed and low-latency communication, especially with low-earth orbit (LEO) satellites that are closer to the earth than geostationary orbit (GEO) satellites.
iv. It can enhance the resilience and security of communication, especially in disaster situations or hostile environments.
v. It can create new opportunities and markets for satellite operators, mobile network operators, handset manufacturers, and service providers.

5.2 Disadvantages of Direct to Handset Satellite

i. Some of the disadvantages of direct to handset satellite are:
ii. It can be expensive and complex to design, launch, and operate satellites, as well as to develop and integrate compatible handsets and chipsets.
iii. It can face regulatory and spectrum challenges, as different countries may have different rules and requirements for satellite communication and licensing.
iv. It can suffer from signal interference and attenuation, especially in urban areas or bad weather conditions.
v. It can have environmental and social impacts, such as space debris, light pollution, and the digital divide.

Bureau of Indian Standards (BIS) /Indian Govt. has mandated free to air (FTA) satellite tuner based on DVB S/S2 standard (IS 18112:2022). The document describes a baseline profile, based on open standards for DTV, it states that using TV and Radio with built in Satellite tuner (DVB-S&DVB-S2) would enable users to access the free to air multichannel by connecting to an appropriate dish antenna.

6.0 Broadcasting via Converged Gateway Node

TEC, New Delhi has released a standard i.e. Generic Requirement (GR) on "Converged Gateway Node for Delivering Broadcast Content to Portable Devices through Wireless LAN" (TEC 57040:2023) which provides a readily solution to enable the dissemination of broadcast content to portable devices. This solution is based on the concept of a converged access node which receives the linear television and other signals through the conventional modes such as satellite, cable, or terrestrial and then distributes them using Wi-Fi or other WLAN. The end users can view the television or other audiovisual content on their portable devices without consuming mobile/internet data and without requiring any additional hardware or plugin, etc.

6.1 A conceptual diagram of the Converged Gateway Node for delivering broadcast content is as below;

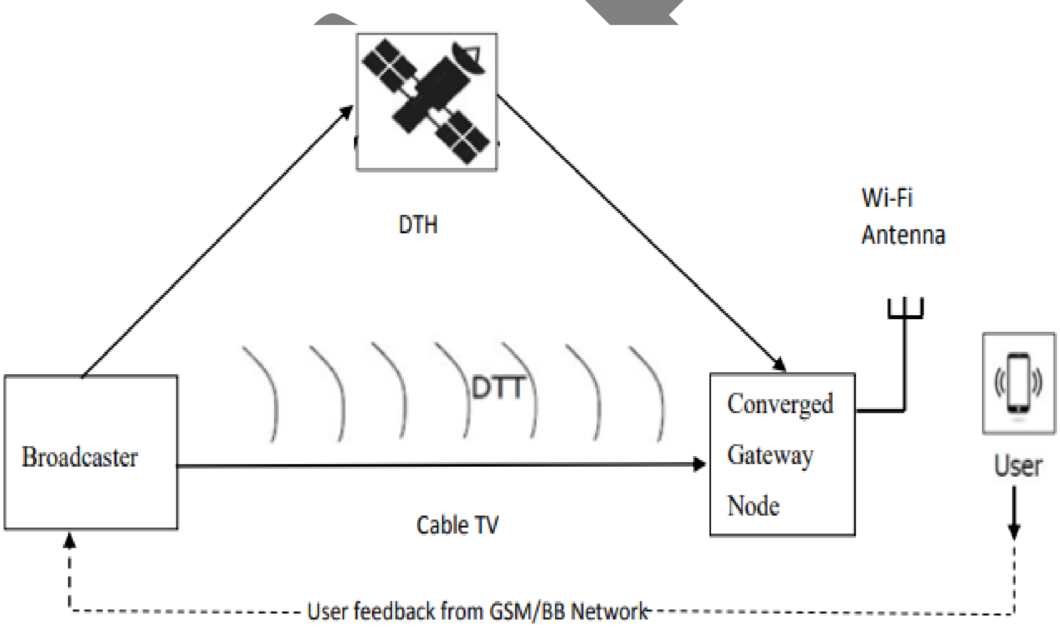

Figure 7 - Conceptual diagram

[Source: TEC GR(TEC 57040:2023)]

In the Converged Gateway Node, Digital Terrestrial/Satellite/Cable content is received, demodulated, decoded, and finally selectively streamed in appropriate formats over the WLAN/Wi-Fi. A local content server can also be hosted for various offline services. The content is consumed by end-users using browsers on smartphones and laptops by accessing a web portal through the WLAN/Wi-Fi. Additionally, the end-user can switch to regular OTT services if the access point has been connected to the internet backhaul.

6.2 A functional block diagram of the Converged Gateway Node is as below;

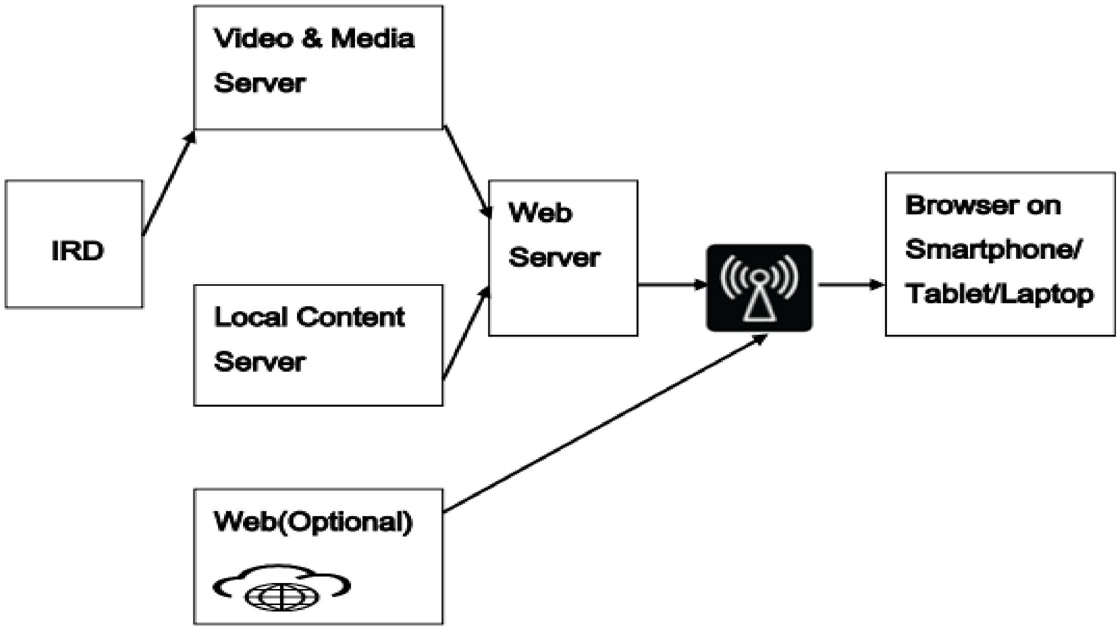

Figure 8 - Functional block diagram

[Source: TEC GR (TEC 57040:2023)]

The blocks are briefly explained below:

i. **IRD (Integrated Receiver Decoder)**
A dish antenna on the ground at the gateway location receives the down linked signals from the satellite. Terrestrial signals are similarly received via a smaller antenna. A device at the antenna amplifies these signals and converts them to a suitable band for consumption by demodulation devices. A demodulation device is tuned only to a particular frequency and can only receive a certain number of channels. So ideally one would need a great number of these devices to cater to all satellite and terrestrial channels. This device further converts the signals to baseband signals containing multiple DTV or Radio channels and are streamed out.

ii. **Video and Media Server**
To ensure that the audio/video content is consumed by the end user without having to rely on any kind of specialized software or plugin. Having to install third party plugins or players is not only an inconvenience but also a risk factor for the user. Streams generated in the previous step are not playable by any industry standard browser. This requirement is addressed by the Video & Media Server which transcodes the UDP stream into a stream that can be made HTML compatible with the browser. Also,

it ingests a stream and breaks it down to files that can be hosted over HTML using a web server.

iii. Self-Learning Web Server

The function of a web server is two-fold:-

a) To act as an HTML/Web server for serving the audio/video content to the end user's browser

b) To learn from the user viewership statistics and come up with a list of "n" number of channels as the most watched/desired channels. The channels are thus selectively streamed initially for a period followed by a self-learning algorithm that determines the most desired/watched channels at a given location. After the algorithm converges to a decisive list over time, the channels are finalized. This brings down the cost in terms of reliance on the number of demodulating devices. As mentioned in the "IRD" section, the number of such devices can ideally be a lot but the same is not desired and that purpose is solved by the algorithm inside the web server business logic layer.

iv. Local Content Server

A local content server can be hosted for various offline services. The content is consumed by end-users using browsers on smartphones and laptops by accessing a web portal through the WLAN/Wi-Fi.

v. End-User Browser

End-user experience is at the heart of any solution or product. The smart phone/laptop/tab user who wants to consume content doesn't have to install any special app or plugin which is both unsafe and inconvenient. After connecting to the Wi-Fi, the user would access the web portal using an appropriate link. In the browsers, the user shall be able to find the list of channels decided by the algorithm in the previous step. The user shall be able to play the content of these channels directly in the browser by pressing the channel name.

6.3 This solution is technology agnostic and support DVB-S/S2) / DVB-C) /DVB-T/T2 RF input stream. It can also support other technologies as mentioned above like ATSC 3.0, 5G Broadcast or any other emerging technology. The Converged Gateway Node can be used in various scenarios such as Bharat Net in rural areas. Wi-Fi access points through the PM-WANI can also deploy Converged Gateway Node so that the broadcast channels are also available to users without using internet data. It can be deployed for inflight in moving vehicles (like State Road Transport Buses / City Buses/ Trains/ Taxis/Cars, etc.)

7.0 Comparison between Technical Features

A Comparison between Technical Features of Broadcasting Technologies available for D2M as mentioned above is given below:-

Characteristics	**ATSC 3.0**	**5G Broadcast**	**DVB-T/T2**	**DTMB-A**	**ISDB-T**
Net data rates in Mbps (depending on BW and MCS)	0.93 – 77.2	0.66-61.7	7.5 – 50.5	4.81 – 32.48	3.65 – 23.23
SFN/MFN	Supported	Supported	Supported	Supported	Supported
Spectrum	UHF		UHF	UHF	UHF
Transmission parameter Signaling	Bootstrap, Preamble symbol, L1 signaling	Carrier Acquisition subframe (CAS), Multicast Channel(MCH) for both control and user plane	Preamble symbol P1	Service Channel signaling is Carried by control channel in the super frame	TMCC Pilot carriers
Technology status	Deployed	In deployment (planned)	Deployed	Not Deployed	Japan has launched “One-seg” (brand-name of D2M) using ISDB-T almost 10 years ago.
Targeted regions/ Countries	US, KR, Jamaica	Worldwide	EMEA, Columbia, Australia, Malaysia, Indonesia	China	Japan, Latin America (exl. Columbia), Philippines
Transport Layer	IP based	IP based	MPEG-2 based	MPEG based	MPEG-2 based
Ecosystem readiness (Infrastructure/ End user devices) – Fixed	*R/*R	*R/*R	*R/*R	*R/*R	*R/*R
Ecosystem readiness (Infrastructure/ End user devices) – Mobile	*R/**NR	*R/*R	*R/**NR	*R/**NR	*R/**NR

Table 3: Comparison between Technical Features of Broadcasting Technologies available for D2M

***RReady. Readiness is assessed based on the available market offerings and accessibility.*
***NR → Not Ready. Non-readiness is defined by the ecosystem willingness or readiness to support in relation to support of the standard based on the expected Bill of Materials (BoM) for the stakeholders.*

8.0 Receiver Requirements for D2M

Signals can be received on any device like fixed TV receiver, handheld terminal etc. This report focuses on mainly mobile handheld devices such as Mobiles and Tablets.

i. **Frequency bands:** D2M terrestrial broadcasting may likely use specific frequency bands allocated for broadcasting services. Receivers must be capable of tuning into these frequencies to receive the broadcasting signals. For operation in India, the receiver must be capable of operating in the Indian UHF band (470-582 MHz)

ii. **Antenna compatibility:** Receivers should have antennas designed to receive signals in the frequency bands used for D2M. These antennas may be integrated into the device or be external, depending on the application. The antenna gain may be severely limiting the system efficiency.

iii. **Decoding capabilities:** D2M terrestrial broadcasting might use different codecs and compression techniques. Receivers need to support the relevant codecs to decode the audio and video content accurately.

iv. **Error correction and resilience:** Broadcasting systems require robust error correction and resilience mechanisms to handle transmission errors. Receivers should be equipped to handle and correct errors in the received signals to ensure a seamless viewing or listening experience.

v. **Low latency:** To support real-time or near-real-time services like live broadcasting, receivers should have low latency to minimize delays between the transmission and reception of the content.

vi. **Security features:** Broadcasting services may require content protection mechanisms to (e.g., DRM) to prevent unauthorized access or content piracy. Receivers should support these security features to ensure content is only accessible by authorized users.

vii. **Interoperability:** To ensure compatibility with various broadcasting networks and services, receivers should adhere to globally harmonized industry standards and specifications.

viii. **Software update capability:** As technology evolves, it's essential for receivers to have the ability to receive software updates to stay current with the latest features, bug fixes, and security patches.

ix. **RF tuner:** The requirement of a receiver regarding RF tuner is to select and amplify a specific channel or frequency of the many signals picked up by an antenna, and convert it to a fixed frequency that is suitable for further processing, usually by an intermediate frequency (IF) amplifier. The RF tuner should be able to reject the unwanted stations and improve the signal to noise ratio. The RF tuner should also be compatible with the broadcasting standards used for the transmission, such as 3GPP 5G Broadcast, ATSC 3.0, DTMB-A, DVB-T2, and ISDB-T.

x. **Conditional Access/Authorization:** It should have the capability of the conditional access facility.

9.0 Transmitter requirements for D2M

The Followings are some general considerations and potential transmitter requirements.

i. **Transmit power and coverage:** Broadcasting systems need to deliver signals over a wide area to reach a large number of users. Transmitters must have sufficient power output and coverage capabilities to reach the intended audience.

ii. **Antenna design:** Transmitters require well-designed antennas to efficiently radiate the broadcasting signals. Antenna systems should be optimized for the frequency bands used and the desired coverage area.

iii. **Energy efficiency:** Transmitters should be designed with energy efficiency in mind, considering the environmental impact and operational costs.

10.0 Potential Challenges of D2M broadcasting

i. **Limited interactivity:** Terrestrial broadcasting is a one-way communication channel, which means that it does not support interactivity or two-way communication. This limits the ability to offer personalized content or to receive feedback from viewers.

ii. **Regulatory standards (National Standards):** Indian Govt. has mandated FTA satellite tuner based on DVB S/S2 standard (IS 18112:2022). The document describes a baseline profile, based on open standards for DTV, it states that using TV and Radio with built in Satellite tuner (DVB-S&DVB-S2) would enable users to access the free to air multichannel by connecting to an appropriate dish antenna. As DTT2M continues to evolve, regulatory standards which will be appropriate for D2M will be a challenge.

iii. **Fixed infrastructure and Device enablement:** Terrestrial broadcasting networks are based on fixed infrastructure, which means that they cannot be easily adapted to changing needs or user demands. This can make it difficult to keep up with evolving technologies and consumer preferences. To launch the technology on a large scale, it is required to overcome infrastructural challenges as well as making technology available in every corner of the country is not going to be easy. The success of DTT2M is determined by the enablement of DTT2M technology inside mobile form factor devices like smartphones and tablets. In its absence, a repeat of the DVB-T2 failure is eventual.

iv. **Spectrum allocation:** The allocation of spectrum for terrestrial broadcasting networks can be a complex and politically charged issue, with limited spectrum available for broadcasting in some regions. This can limit the expansion of terrestrial broadcasting services and lead to increased competition for available spectrum.

(Editor's note: inputs solicited on Spectrum related issues, present status/use of frequencies identifies for D2M, etc.)

11.0 Conclusion

With rapid technological advancements and an increasingly connected world, mobile devices such as smartphones and tablets have become an integral part of our daily lives. In present scenario, mobile users also desire to receive broadcasting services directly in their smartphones or similar terminal devices. The demand for personalized, on-demand content has led to the emergence of Direct to Mobile (D2M)/ Digital Terrestrial TV delivery to Mobile devices (DTT2M) as a game-changing content delivery approach. In addition, such broadcasting can deliver the content to a large audience simultaneously, without requiring an internet connection. A large number of consumers will still watch TV using DTH and cable TV on fixed television sets, but here we are focused on those consumers who are mobile with handheld devices. It can be used to deliver localized content, such as news, weather updates, and advertisements. Public safety messages using ETWS & CMAS are already functioning on 4G/5G technology and can easily integrate into the DTT2M framework, offering tailored messages for specific areas and languages, including indoor delivery.

This report tries to cover various possible technologies which can be used for the implementation of D2M/DTT2M. It covers the details about 5G Multimedia Broadcast/ Multicast Service (MBMS) based on 3GPP Rel.-18, ATSC 3.0, DVB-T2 system, ISDB-T and DTMB-A etc. The integration of smartphones that support these technologies remains a big challenge. From a network perspective, implementing ATSC 3.0 might necessitate a new nationwide network for indoor coverage, adding complexity. Challenges also exist for technologies like DTMB-A and ISDB-T, which are limited and not in line with other global standards. DVB-T2 faced issues due to a lack of device ecosystem development, leading to its discontinuation in the Doordarshan network in India. Considering these factors, a standard compatible with existing mobile handsets would be desirable for D2M/DTT2M, as it would offer cost-effectiveness and leverages existing ecosystem support.

Appropriate D2M standard will help in offloading broadcasting traffic and is envisaged to promote the design and manufacturing of smartphones and similar terminal devices that can directly receive broadcast signals through integrated broadband cable networks or digital wireless transmission. As of today no mobile devices are available for any of these broadcasting technologies/standards anywhere.
There is consensus now that the success of these approaches relies on the ability to enable this service inside mobile devices, more specifically a smartphone or a tablet. The success of this adoption will further be constrained on how the ecosystem of devices will be created in open-market low-cost smartphones, operating on the Indian UHF band. The spectrum allocated for broadcast in India is in the 470-582 MHz range (14 channels of

8 MHz). Even when the underlying technologies to offer converged services (e.g., DVB-T/T2, ATSC 3.0, 5G Broadcast, etc.) are mature, the ecosystem for devices in this band is yet to be developed.

The ability by which the D2M/DTT2M operator, based on the technology adopted develops the devices ecosystem and then broadcasts to the tens of millions of open market mobile devices will eventually define the success of D2M/DTT2M in India. Scalability is crucial from both device and network perspectives, catering to mass viewership using mobile devices.

Actual deployment scenarios have not been analyzed, so the actual feasibility is unknown and potential shortcomings have not been identified or analyzed. As DTT2M continues to evolve, it is essential to address challenges such as content quality, security, and regulatory considerations. The issues related to the implementation of DTT2M, its potential, viability, business opportunities, spectrum requirements and roadmap for end enablement in end devices (including smart phones and TV's) need to be examined for creating a facilitating environment for digitization of the terrestrial TV broadcasting sector.

"Editor's note: Inputs solicited"

12.0 References

1. RECOMMENDATION ITU-R V.662-2 TERMS AND DEFINITIONS
2. Consumer handbook on broadcasting services by TRAI
3. File NO: 8-26/2004-B&CS
4. https://www.itu.int/dms_pub/itu-t/opb/tut/T-TUT-IPTV-2014-GLOSS-PDF-E.pdf
5. https://www.trai.gov.in/sites/default/files/ALCOA08012019.pdf
6. REPORT ITU-R BT.2295-3 - Digital terrestrial broadcasting systems
7. Evaluation of ATSC 3.0 and 3GPP Rel-17 5G Broadcasting Systems for Mobile Handheld Applications | IEEE Journals & Magazine | IEEE Xplore
8. PowerPoint-Präsentation (itu.int)
9. Scenarios for 5G networks: The COHERENT approach | IEEE Conference Publication | IEEE Xplore
10. Handbook on Digital Terrestrial Television Broadcasting networks and systems implementation (itu.int)
11. 3GPP TR 23.757 – Study on architectural enhancements for 5G multicast-broadcast services – Tec Spec (itecspec.com)
12. ISDB-T System | DiBEG
13. Advanced ISDB-T | DiBEG
14. DVB - The global standard for digital television - Home
15. TS 103 720 - V1.2.1 - 5G Broadcast System for linear TV and radio services; LTE-based 5G terrestrial broadcast system (etsi.org)
16. REPORT ITU-R BT.2295-3 - Digital terrestrial broadcasting systems
17. Driving sustainable telecom connectivity – Cellnex
18. TSDSI TR 6015 V1.0.0, Service Delivery using 5G Broadcast for TV, Radio, IPTV and File-casting, April 2022
19. 3GPP TR 22.816 v14.1.0 "3GPP enhancement for TV service (Release 14)"
20. 3GPP TR 36.976 v16.0.0 "Overall description of Terrestrial Broadcasting"
21. 5G Evolution for Multicast and Broadcast Services in 3GPP Release 17
22. EBU TR 063, 5G BROADCAST NETWORK PLANNING AND EVALUATION
23. EBU TR 064, COMPATIBILITY BETWEEN 5G BROADCAST AND OTHER DTT SYSTEMS IN THE SUB-700 MHZ BAND
24. https://www.dibeg.org/techp/what/]
25. https://humber.ca/research/b2c-lab
26. https://www.atsc.org/nextgen-tv/deployments/
27. https://nabpilot.org/jamaica-the-latest-to-adopt-atsc-3-0/#:~:text=ATSC%203.0%20is%20the%20most,their%20new%20digital%20broadcast%20standard
28. https://www.broadcastandcablesat.co.in/deployments-atsc-nextgen-tv/
29. https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2019/ITU-TRAI-International-Training-on-Emerging-Trends-in-Broadcasting/Sung_Ik_Park_Speech.pdf
30. https://www.atsc.org/news/road-to-atsc-3-0-broadcaster-headway-in-south-korea/
31. https://www.3gpp.org/technologies/broadcast-multicast1

13.0 Abbreviations

1. 3GPP: Third Generation Partnership Project
2. 4G: Fourth Generation (mobile network)
3. 5G: Fifth Generation (mobile network)
4. AC: Antenna compatibility
5. AD: Antenna design
6. AIR: All India Radio
7. APIs: Application Programming Interfaces
8. ARIB: Association of Radio Industries and Businesses (Japan)
9. ATIS: Alliance for Telecommunications Industry Solutions (USA)
10. ATSC: Advanced Television Systems Committee
11. ATSC 1.0: First-generation Advanced Television Systems Committee standard
12. ATSC 3.0: Next-generation Advanced Television Systems Committee standard
13. CA: Conditional Access/Authorization
14. CCSA: China Communications Standards Association
15. CGN: Converged Gateway Node
16. CMAS: Commercial Mobile Alert System
17. COFDM: Coded Orthogonal Frequency Division Multiplexing
18. DC: Decoding capabilities
19. DASH: Dynamic Adaptive Streaming over HTTP (MPEG-DASH)
20. DD: Doordarshan
21. DTH: Direct-to-Home
22. DTT: Digital Terrestrial Television
23. DTT2M: Digital Terrestrial TV to Mobile
24. DTTB: Digital Terrestrial Television Broadcasting
25. DTMB-A: Digital Terrestrial Multimedia Broadcast – Audio
26. DTTV: Digital Terrestrial Television
27. EAS: Emergency Alert System
28. EE: Energy Efficiency
29. EPG: Electronic Program Guide
30. ERC: Error correction and resilience
31. ETSI: European Telecommunications Standards Institute
32. FB: Frequency bands
33. FeMBMS: Further evolved Multimedia Broadcast Multicast Service
34. FI: Fixed infrastructure
35. HDR: High Dynamic Range
36. HEVC: High Efficiency Video Coding
37. HPHT: High-Pressure High-Temperature
38. HDTV: High Definition Television
39. HTTP: Hyper Text Transfer Protocol
40. IA: Interactive Application
41. Io: Interoperability
42. IoT: Internet of Things
43. ISDB-T: Integrated Services Digital Broadcasting – Terrestrial
44. ISDB-Tmm: Terrestrial Mobile Multimedia Broadcasting
45. LI: Limited interactivity

46. LTE: Long-Term Evolution (4G mobile network)
47. MBSFN: MBMS Single Frequency Network
48. MAS: Multilingual Audio and Subtitles
49. MHz: Megahertz
50. MISO: Multiple-Input, Single-Output
51. MNO: Mobile Network Operator
52. MNOs: Mobile Network Operators
53. MPMT: Medium-Power Medium-Tower
54. MPEG-2: Moving Picture Experts Group-2
55. MPEG-2 AAC: Advanced Audio Coding
56. MPEG-4 AVC (H.264): Advanced Video Coding
57. MPEG-4 HE-AAC: High-Efficiency Advanced Audio Coding
58. MPEG-DASH: Moving Picture Experts Group Dynamic Adaptive
59. Streaming over HTTP
60. NR: New Radio (5G standard)
61. NR MBS: New Radio Multicast and Broadcast System
62. OFDM: Orthogonal Frequency Division Multiplexing
63. OTG: On-The-Go
64. OTA: Over-The-Air
65. OTT: Over-The-Top
66. PCD: Personalized Content Delivery
67. PHY: Physical Layer
68. QAM: Quadrature Amplitude Modulation
69. QoS: Quality of Service
70. RAN: Radio Access Network
71. RF: Radio Frequency
72. RFT: RF tuner
73. RS: Regulatory standards
74. RTB: Real-time Broadcast
75. SDO: Standalone Downlink Only
76. SF: Security features
77. SFN: Single Frequency Network
78. TEC: Telecom Engineering Center
79. TPC: Transmit power and coverage
80. TSDSI: Telecommunications Standards Development Society (India)
81. TTC: Telecommunication Technology Committee (Japan)
82. TR: Technical Report
83. TP: Parental Control
84. TV: Television
85. UHD: Ultra High Definition
86. UHF: Ultra High Frequency
87. UHDTV: Ultra-High Definition Television
88. UEs: User Equipment
89. USA: United States of America
90. VOD: Video on Demand

-----------------End of the Report------------------