This report aims to give a brief overview of the technical challenges found in providing mobile television services. It also gives a short introduction to some of the existing industrial standards which contains a mobile television services. Furthermore a closer look at DBV-H is provided. It is one of the likely candidates to provide such a service in Europe.
**Contents**

The vision of Mobile television .......................................................................................................................... 3

Challenges connected to mobile television ........................................................................................................ 4
  Spectrum is a scarce resource .......................................................................................................................... 4

Technologies for mobile television .................................................................................................................. 5
  Cellular networks ........................................................................................................................................... 5
  Digital TV Broadcast ..................................................................................................................................... 5
  Digital Audio Broadcast and Digital Multimedia Broadcast ........................................................................ 6

DVB-T infrastructure and transmission system ................................................................................................. 7

DVB-H: An extension providing services for handheld devices ........................................................................... 8
  Time-slicing .................................................................................................................................................... 9
  MPE-FEC ...................................................................................................................................................... 10
  4K transmission mode .................................................................................................................................. 10
  In-depth interleaver for 2K and 4K modes ....................................................................................................... 11
  Transmission Parameter signaling (TPS) bits ................................................................................................. 11

Field Trials and Commercial Interests ........................................................................................................... 11

Market demand for Mobile Television ............................................................................................................... 12

Conclusion ..................................................................................................................................................... 13

Bibliography .................................................................................................................................................... 14
The vision of Mobile television

Mobile TV promises a future where it is possible to watch TV on small devices in a ubiquities manner. In this world every mobile phone, PDA, netbook and maybe even notebook users will be able to watch television whenever and wherever they are. You will be able to watch the news while waiting for the train to arrive at the station or during your daily shuttle between work and home. You will be able to interact with the TV shows in a new manner. All of this is possible with technologies known today and may be a part of our everyday life in a not so distant future.

There are several technologies aiming to provide this kind of services and they all have their pros and cons. Mobile TV possesses some new challenges that normal broadcast television does not have. First of all it is important that you will be able to receive it while being on the move i.e. traveling in a car or a train. Another problem is that the signal will be received on different kind of devices with varying sizes. Especially important are mobile phones in this view as the trend has dictated that smaller is better. Other difficulties include Digital Rights Management (DRM), interoperability between network equipment from different vendors but more importantly between all kinds of handsets available to the end user.

This report aims to give a short introduction to the challenges that this emerging field holds. Different technologies will be reviewed very shortly and there will be given a more thorough introduction to one major technology named DVB-H. DVB-H is likely one of the more important technologies for the European market and is related to DVB-T which is used to broadcast digital television in Europe.
Challenges connected to mobile television
What defines mobiles television is extremely simple: The ability to watch television on often handheld devices anywhere at any time. Even though the vision is simple the implementation of the technology which shall make this reality can hardly be called simple. Different sectors have each tried to come up with a solution for this challenge. These challenges include broadcasting, on-demand services and especially delivery method. The delivery of a mobile television services differs from normal terrestrial broadcasting in several ways. Other challenges such as creating content targeting the new platform that utilizes some of new possibilities or other things related to the commercial model i.e. digital rights management used will not be covered in this report. Only technologies related to the actual transmission will be discussed and file formats and compression techniques will only be mentioned when they are specified in the standards.

First of all the small form factor of the intended devices makes it difficult to use standard antenna designs. Secondly, the devices all have a limited battery capacity, so all the electronics should have very low power consumptions. Even though the processing power of the handheld devices today are comparable to PCs few years back, it is not enough for complicated encoding and decoding tasks, or format and frame rate conversions. Even though today’s cell phones are capable of data speeds of more than 5 Mbps the networks are not prepared for broadcasting huge amount of video data. The small form factor also limits the size of the screen which makes them less suitable to receive ordinary television broadcast.

Mobile TV is therefore about adjusting these services to the challenges of the platform and trying to utilize already existing technologies and network infrastructure. DVB-H, which will be explained in more detail later, uses most of the existing terrestrial broadcast network with a few adjustments to cater for mobile nature of the service. The mobility requirement of the service also introduces new problems such as Doppler effects on the received signal and rapid varying radio conditions that the ordinary broadcast networks does not suffer from.

As the receivers will mainly be mobile telephones it is possible to take advantage of many of the existing capabilities. Most mobile handsets already contain hardware or software to process and show video and audio. Most telephones today also have the capabilities to connect to the internet and thereby supports many IP based or related protocols. This connection can also act as a return channel allowing for bidirectional services.

Spectrum is a scarce resource
Another challenge comes from the limited radio spectrum available. Today most of the suitable spectrum has been allocated to other functions or has to be licensed, which is very costly as it is a scarce resource. Therefore many of the emerging technologies try to reuse the spectrum of other networks i.e. the VHF and UHF band designated for terrestrial television broadcast. Others try to extend existing technologies so that the service can be deployed on the existing spectral allocation or spectrum the companies have already acquired a license for.

In many countries the old analogue broadcast network is being converted to digital broadcasting. This frees up spectrum on the existing terrestrial broadcast band. One transmission channel can often carry between 4 or 6 digital channels in place of one analogue, but during the transition period simulcast of both standards are often employed thus actually occupying more spectral resources.
The spectrum used of course depends on the technology employed to provide the mobile television service. Mobile phones are designed to work at frequency bands around 800-, 1800- and 1900 MHz. The use of other frequency bands will typically require another antenna on the device. Higher frequency bands are characterized by higher Doppler frequency shifts and higher path losses. Lower frequency bands require larger antennas and therefore possess difficulties of designing antennas with a high gain (1 pp. 283-308).

Technologies for mobile television

The industry has come together to make several different standards for how to solve all these challenges. The reasons for all standards shall be found in the many different stakeholders coming from diverse backgrounds. Some standards originated from the people behind the mobile networks, others from the companies behind the television broadcast. Many standards are conceived out of interest of reusing an already existing standard and in this manner employ already existing technology and network infrastructure.

Cellular networks

Mobile networks has had access to the internet and streaming of video for a long time, but this has been limited by low bit rates and unicast methods limiting the number of simultaneous users. As the bit rate have increased with the introduction of shared high speed channels there have been a considerably effort to standardize the file formats used and introducing broadcast and multicast features. The 3GPP has now provided an extension of the regular cellular networks called Multimedia Broadcast and Multicast Service (MBMS) in which it is specified how to provide broadcast services as mobile TV to the customers.

TDtv is another technology for broadcasting television on the mobile network made by IPWireless. Instead of using the common bandwidth of 3G networks the TDtv technology is based on the UMTS TD-CDMA air interface. The signals are send out in a fashion so that an unlimited number of users can view live TV without affecting the voice and data bandwidth of the regular UMTS network. In this way it is possible to deliver up to 50 TV channels at 128 kbps or 15 high-speed channels at 384 kbps over a 5MHz unpaired spectrum.

China has developed a new standard that because of the sheer size of the country should be mentioned. China Multimedia Mobile Broadcasting (CMMB) might be compared to the European DVB-SH standard, which can be described as a physical layer for delivering multimedia services to handheld devices through a hybrid satellite/terrestrial downlink and a conventional mobile uplink as UMTS or GPRS.

Digital TV Broadcast

Meanwhile the efforts in the mobile industry the broadcast networks began to look into how they could provide mobile television through the existing infrastructure for terrestrial broadcast networks. Most of these networks in Europe, the United States of America, Japan and other countries are in the process of preparing their networks to digital TV signals. This process makes it possible to carry many more channels on the same spectrum and dedicate a part of the gained capacity to mobile TV services.

Mobile TV over the existing terrestrial broadcast networks work much like FM radio on mobile phones in that they have a separate TV receiver built in hence it does not use the capacity of the mobile networks.
The handsets contain a built-in tuner and demodulator for the TV signals. This means the service is not dependent on coverage of the mobile network. The European TV broadcasting industry chose to build upon the existing standards as they already provide very good performance under many of the use cases a mobile service requires. The existing DVB-T standard was enhanced with some additional features like time-slicing, MPE-FEC and a new transmission mode which was defined to give the network operators more flexibility when designing and building their nets. This new standard was named DVB-H, Digital Video Broadcasting – Handheld.

[Image: DTT broadcasting systems Countries using DVB-T are shown in blue; Taken from the Wikipedia article on DVB-T on the 3rd of December 2009 - Creative Commons Attribution-ShareAlike License.]

There exist other digital broadcast standards that are widely deployed. As seen from Figure 1. These are primarily used outside Europe. North America and Korea are using the ATSC standard and Japan uses the ISDB-T standard. ATSC has shown to be limited in a number of ways that makes in unsuitable for mobile television. In Japan they are using the Integrated Services Digital Broadcasting (ISDB) standards. ISDB-Terrestrial includes services targeted handheld devices and is similar to DVB-H in that it uses the existing terrestrial broadcasting infrastructure. Another major standard is Digital Terrestrial Multimedia Broadcast (DTMB, formerly known as DMB-T/H) which is used in China. It also specifies a service for mobile television.

**Digital Audio Broadcast and Digital Multimedia Broadcast**

Digital Audio Broadcast (DAB) is a replacement for the traditional analogue FM radio transmission. DAB makes high quality stereo audio and data possible either through a terrestrial broadcast network or from satellites. The reception of DAB services is possible even in fast moving cars and trains and therefore already includes some mobility features. Furthermore many countries have already allocated spectrum to the DAB services so extending the standards to also include multimedia services was seen as a fast way to introduce mobile TV. The development of what is now known as DMB was primarily driven by Korea where it has seen wide deployment through satellite with terrestrial repeaters.

Only a few of the many technologies capable of delivering mobile television services have been mentioned here. Others include but is not limited to WiMAX and proprietary technologies such as MediaFlo (FLO).
Most of these services have not attracted wide attention or is limited to a few countries and is therefore not described in more detail here in this report (1 pp. 175-286).

**DVB-T infrastructure and transmission system**

To provide a better understanding for the following section about DVB-H, a short summary of the existing Digital Video Broadcasting — Terrestrial (DVB-T) system is provided here. A schema of a DVB-T transmitter can be seen in Figure 2.

![DVB-T transmitter schema](image)

**Figure 2 — Overview of a DVB-T transmitter; Taken from the Wikipedia article on DVB-T on the 3rd of December 2009 - Creative Commons Attribution-ShareAlike License.**

The compressed video, audio and data streams are multiplexed into a MPEG program stream (MPEG-PS). Several MPEG-PS are multiplexed together in a MPEG Transport Stream (MPEG-TS). This is the basic stream transmitted to the receivers and the set top boxes at the end user (STB).

Two different MPEG-TSs can be combined using a technique called Hierarchal Transmission. This allows the transmitting both a Standard definition (SD) and a high definition (HD) on a single carrier. The SD signal has higher noise resilience than the HD signal, and if the STB cannot decode the HD signal and it may then switch to the SD signal.

The next step is the MUX adaption and energy dispersal, here the MPEG-PS data packets are identified and the byte sequence is decorrelated through a scrambling process called energy dispersal. The external encoder adds a first layer of error correction using a Reed-Solomon RS (204, 188) code to the data stream. The external interleaver is used to changes the bit streams so that it becomes less sensitive to long sequences of errors. The internal encoder adds another error correction mechanism through a punctured convolutional code; also known as Forward Error Correction (FEC). Another interleaver is used to rearrange the data again this time using a block interleaving thus providing another level of protection against burst errors.
The data is then mapped into a stream of complex symbols in the base band of the modulation technique used. The three allowed schemes are QPSK, 16-QAM and 64-QAM. The symbols are then arranged into frames and super frames by the frame adoption layer. Pilot and TPS bits are then added to the blocks for channel synchronization and signaling.

Now the signal is modulated using an OFDM modulation scheme and one of the specified transmission modes, these will be described in more detail later. Guard intervals are inserted into the signal. Finally, the signal is converted from a digital representation to an analogue signal and transmitted from the antenna in the desired 5 – 8 MHz channels by the Radio Frontend.

The bit rate of the final data streams depends on the modulation scheme used, the FEC coding rate and the guard interval used. Table 1 shows the achievable bit rates in different configurations (2).

<table>
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<tr>
<th>Modulation</th>
<th>Coding rate</th>
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<th>1/8</th>
<th>1/16</th>
<th>1/32</th>
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<tr>
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<td>9.676</td>
<td>10.246</td>
<td>10.556</td>
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<tr>
<td>16-QAM</td>
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<td>11.059</td>
<td>11.709</td>
<td>12.064</td>
</tr>
<tr>
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<td>15.612</td>
<td>16.086</td>
</tr>
<tr>
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</table>

Table 1 – Available bitrates (Mbit/s) for a DVB-T system in 8 MHz channels; Taken from the Wikipedia article on DVB-T on the 3rd of December 2009 - Creative Commons Attribution-ShareAlike License.

DVB-H: An extension providing services for handheld devices

DVB-H is designed to provide digital media services to mobile devices. It is build upon the existing Digital Terrestrial TV broadcast network. It reuses most elements of the existing network and can coexist on the same network as DVB-T. The handheld specifications of the DVB standard have been designed almost exclusively to provide TV services for mobile devices including the following:

- Broadcast nature, reaching potentially unlimited users
- Should be delivered at sufficient power to reach users inside buildings
- Receiving TV service of choice while conserving battery power
- Use the broadcast spectrum freed up by digitalizing terrestrial TV networks
- Cater for rapid varying radio conditions through robust coding and error correction
- Requiring minimal investment in infrastructure through using already existing DVB-T infrastructure
The physical layer is exactly the same as the one used in DVB-T with a few adjustments to cater for the challenges connected to mobile users. Twenty to forty channels (depending on the bit rate) can be broadcasted through a DVB-H service or up to 11 Mbps in one DVB-H multiplex (1 pp. 217-244)

Services used in mobile devices usually require very low bit rates. It has been estimated that with the use of advanced video compressing algorithms such as MPEG-4 the maximum bit rate will be in the range of few hundred kilobytes per second (KB/s). One likely bit rate is 384 KB/s coming from the 3GPP standards. There may be requirements for file downloading so there must be room for flexibility. Time-slicing is introduced as a way of reducing power consumptions of the receiving devices.

**Time-slicing**

Normally in a DVB-T a number of data channels are multiplexed together in a sequential way. In DVB-H these data channels are time sliced together. This is a requirement in DVB-H and one of the things that differentiate the two standards. Because of the high data rates in each channel the receiver has to be active all the time. Therefore time-slicing is used to reduce power consumption on the receiving handset and also enables smooth and seamless handover between cells. Time-slicing is in its essence a form of Time division multiplexing se the Figure 3.

![Diagram of time-slicing](image)

**Figure 3** – The time slicing principle: example of a service multiplex in a common DVB-T/H channel, including time-sliced DVB-H services; Taken from the Wikipedia article on DVB-H on the 3rd of December 2009 - Creative Commons Attribution-ShareAlike License.

Time-slicing involves that data is transmitted using bursts at a much higher bit rate compared to what would have been required of a traditional continuous transmission. The time before the next burst (delta-t) is included within the burst. Between two bursts no data for the specific channel is broadcasted. Note that the transmitter does not interrupt the transmission; the following data just belongs to another channel. Time-slicing thus enables the receiver to only stay active during the bursts of the selected channel. This keeps the power consumption low as the receiver can be in power off mode for up to 95% of the time.
depending on the number of channels multiplexed. To achieve such high power savings the burst bit rate must be at least ten times as high as the constant bit rate of the underlying service (1 pp. 217-244).

During the idle periods between two bursts a receiver can listen for neighboring cells in the area. Furthermore the off-time between the bursts can be used to make a handover to another cell. Using this method it is possible to accomplish an almost optimal and seamless service handover. Note that in a single frequency network (SFN) there is only a need to do a handover when switching network as all the transmitters form a single cell. Non-time-sliced services as DVB-T can be multiplex together with DVB-H services see figure 2.

**MPE-FEC**

The small form factor of many of the devices and the mobile nature of these devices affects the receiving condition; Lower gain from the antenna and rapid changing radio conditions. Even though the Coded Orthogonal Frequency Division Multiplexing (COFDM) used for transmission is very robust it cannot cater for the aforementioned challenges. Therefore another level of error correction is introduced at the link-layer in DVB-H to increase the Carrier-To-Noise (C/N) ratio and the Doppler performance.

The audio and video data is delivered through IP datacasting. This means that the data is encapsulated in IP packets. The data protection is then achieved by using Forward Error Correction (FEC) at the MPE level. By adding additional parity bits to the data in a separate MPE-FEC section, error free decoding can be done under very bad radio conditions. The exact number of bits and thereby the overhead of MPE-FEC is flexible. A parity overhead of 25% may provide the same Carrier-to-noise ratio as a receiver with antenna diversity (2). The lower throughput because of the overhead can be compensated by using slightly weaker transmission code while overall providing better performance than normal DVB-T transmission. The MPE-FEC scheme should allow high-speed single antenna DVB-T reception using 8K/16-QAM or even 8K/64-QAM signals. MPE-FEC also improves the performance under narrow noise condition. The use of MPE-FEC is specified as optional in the DVB-H standard.

**4K transmission mode**

Traditional DVB-T uses an orthogonal frequency-division multiplexing (OFDM) modulation scheme. The data is modulated on to a large number of closely spaced orthogonal sub carriers. These parallel data streams are then modulated with a conventional modulation technique such as quadrature amplitude modulation (QAM). In DVB-T two such modes for transmission are defined one using 2048 carriers (2K) and a second using 8192 carriers (8K).

DVB-H introduces a new transmission mode using 4096 carries (4K) to improve network planning flexibility at the cost of SFN cell size and mobility tradeoffs. This new mode is also largely compatible with the existing architecture and hardware. The 2K mode is known to provide better mobile reception performance than the 8K mode owing to the larger inter-carrier spacing. On the other hand the symbol time is very short in the 2K mode. The duration of the guard time is consequently very short too, and therefore only suitable for small SFN cells. This makes it difficult to build spectral efficient network. The 4K mode therefore allows for medium SFN cells and a better use of spectral resources. Furthermore the 4K mode allows for reasonable simpler receiver electronics and thereby lower power consumption (4). The emitted spectrum of the 4K mode is the same as for the two other modes thus no change to existing transmitter filters are necessary (3).
In-depth interleaver for 2K and 4K modes
Noise coming from narrow sources will be averaged out on 8192 sub-carries at demodulation in the 8K mode. In 2K and 4K modes this noise is averaged out on fewer carriers thus the noise power on a given sub-carrier is therefore doubled in 4K mode and quadrupled for the 2K mode. Using the 8K symbol interleaver for the other modes makes the signal more noise resilient. If one subcarrier is affected by noise then the receiver in the 2K mode will still have 3 out 4 symbols without noise and 1 out 2 in 4K mode. This gives the 2K and 4K modes almost the same impulse noise immunity as the 8K mode.

Transmission Parameter signaling (TPS) bits
One of the problems in DVB-H is the time to switch TV channels on the handheld device because the receiver is powered off in large periods. To enable faster switching between DVB-H channels the signaling stream of DVB-T is used to carry information about the DVB-H service also. This additional information makes the DVB-H receiver aware of the entire transmission stream thus making the retuning to a newly selected channel faster.

There are 68 TPS bits whereof only 23 is used for regular DVB-T services, the remaining bits are reserved for future use. DVB-H uses new combinations of the existing TPS bits to signal information about the new transfer 4K mode and in-depth interleaving. Moreover some of the previously unused bits are employed to signal if there is at least one time-sliced DVB-H service available in the transmission channel, and if any of these services utilizes MPE-FEC. The new signaling bits are backward compatible with existing DVB-T receivers as they are programmed to ignore the formerly unused bits. The otherwise optional identification bits of the TPS bits in the cells are made obligatory in the DVB-H standard (4).

Field Trials and Commercial Interests
Many trials and experiments have proven the concept and technology work in real setups. During the FIFA World Cup in Germany 2006 several large scale DVB-H trials were executed. Live broadcast of the matches and ongoing news and results were sent out to millions of people in Europe. Several commercial services have since then been launch throughout the world. In Europe Italy, Switzerland and Austria are among the countries that have mobile television services available for the citizens (5).

Nokia, LG and other mobile phone manufactures have already launched products specific tailored for the mobile television experience with built in DVB-H receivers. Also several of the high end models from the companies have built in DVB-H receivers. As the technology matures and the production costs of the chipset fall even more mobile phones will come with built in DVB-H receivers. Texas Instruments does already offer a single chipset with DVB-H support. By single chipset is meant a single chip for receiving and decoding DVB-H services, the mobile does of course need to have additional chipsets for the GSM and UMTS services.

Interoperability is of course a major concern when developing mobile handset for the television service. The DVB-H standard is fully specified and open so that any DVB-H receiver will be able to decode the signal. The big question is more if the industry can agree on a way to secure digital rights in a way that does not require special software or hardware.
Market demand for Mobile Television

By 2008 several of the commercial launched services had achieved high subscriber numbers. Italy one of the largest mobile network operators in Italy had around 800,000 paying subscribers for their mobile television service, about ten percent of their phone clients. In Switzerland 40,000 people watch short news show made for mobile television every day (7). Japan and South Korea are the leaders in direct mobile television. It is estimated that there are around 20 million cell phones with equipment to receive mobile television in Japan. In South Korea they have around 8.5 million devices. All in all it is estimated that there by the end of 2007 was almost 30 million mobile TV viewers across the globe.

A market research from India done in six major cities in February 2008 tells that 84% percent of the people asked would be interested in mobile television provided it is commonly available and affordable. The report also says that the trend is that the mobile is to remain the multi-purpose device of choice outnumbering other devices such as PDA and digital media players. It predicts that mobile television could reach a penetration level in the range of 6 – 8% and that India will have around 12 million mobile TV subscribers within the first year; Making it a 360 million US dollar market by the end of 2008 (7). A commercial service has been launched in Doordarshan (Delhi) a metropolis with more than 12 million inhabitants.

All of these numbers clearly indicates that there is a market for mobile television services and that the market is growing. New emerging markets around Europe and in the United States will increase the number significantly if they can come up with new services that appeal to the consumers. It is also clear from previous launches that it is not enough just copying the traditional television service. New programs and services specially tailored for the mobile user must be launched simultaneous with the traditional TV programs.
Conclusion

Mobile television is not a service of the future as seen through this report. Today there already exist many different technologies that can provide a mobile television service. Commercial products have already been launched in several markets and are expanding rapidly. So the vision of being able to watch television everywhere is now near reality in several countries.

This report has looked upon many of the challenges that have to be solved before mobile television can be widely deployed throughout the world. Most of the challenges concerning integration the necessary technology in small handheld devices and lowering power consumptions have been solved. One of the big challenges in the future will be finding spectral resources to deploy the service on. This is tried solved by reusing existing spectral allocation and extending already existing technologies where it is feasible.

Several mobile phones from the major manufacturer support mobile television using some of the mentioned technologies. There are still other major challenges remaining to be solved by the industry, namely the one of interoperability. Another big challenge is to provide new content specially tailored for the platforms. Finally, the TV industry and mobile operators will have to come up with a complete new lineup of interactive services to take full advantage of the new medium.

DVB-H is an efficient and easy way to provide mobile television services through the existing digital terrestrial broadcast networks. It can be used and coexist on the existing DVB-T infrastructure with only minor changes to the equipment. The standard has been extended on a few but important areas to better support the mobile television service. Time-slicing are used to allow the handheld devices to stay in power-off mode for most of the time thus reducing power consumption with up to 95%. An additional transmission mode and in-depth interleaving have been added to make the transmission signal more robust and less sensitive to noise in a mobile setting where the radio conditions change rapidly. On top of all this another FEC code has been added to the link layer to further increase the noise resilience of the signal.

DVB-T has been adopted by a large number of countries throughout the world. The deployment of mobile television services is therefore easily achievable in these countries. It has already proven its worth at big events like the FIFA World Cup. Several companies have launched commercial products based on the technology and Market research has shown that there is a real demand for the mobile television service if it can be made commonly available and affordable.
Bibliography


