国　　　际　　　电　　　信　　　联　　　盟

ITU-R

国际电联无线电通信部门

ITU-R　BT 2140-1 报告

(05/2009)

地面广播从模拟到数字的转换

BT 系列

广播业务

(电视)

国际电信联盟

前言

无线电通信部门的作用是确保所有无线电通信业务，包括卫星业务，合理、公平、有效和经济地使用无线电频谱，并开展没有频率范围限制的研究，在此基础上通过建议书。

无线电通信部门制定规章制度和政策的职能由世界和区域无线电通信大会以及无线电通信全会完成，并得到各研究组的支持。

知识产权政策（IPR）

ITU-R的知识产权政策在ITU-R第1号决议附件1引用的“ITU-T/ITU-R/ISO/IEC共同专利政策”中做了说明。专利持有者提交专利和许可声明所需表格可从http://www.itu.int/ITU-R/go/patents/en获得，该网址也提供了“ITU-T/ITU-R/ISO/IEC共同专利政策实施指南”以及ITU-R专利信息数据库。

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系列	标题
BO	卫星传输
BR	用于制作、存档和播放的记录：用于电视的胶片
BS	广播业务（声音）
BT	**广播业务（电视）**
F	固定业务
M	移动、无线电测定、业余无线电以及相关卫星业务
P	无线电波传播
RA	射电天文
RS	遥感系统
S	卫星固定业务
SA	空间应用和气象
SF	卫星固定和固定业务系统之间频率共用和协调
SM	频谱管理

注： 本ITU-R报告英文版已由研究组按ITU-R第1号决议规定的程序批准。

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ITU-R BT.2140-1 报告

地面广播从模拟到数字的转换

(2008-2009)

主席的说明

根据ITU-R 6E工作组（WP 6E）第6E/39/30-01-2004号文件附件17补正1的主席报告后附的决定，ITU-R WP 6E要求一个小组就模拟向数字广播转换问题准备报告。

该组举行了九次会议，并准备了最终报告草案。前三次会议，第一次于2004年1月13日在欧广联日内瓦总内部，第二次于2004年2月26-27日在米兰，第三次在2004年4月WP 6E会议期间召开。根据这三次会议的结果，该组定义并通过了报告内容草案。后六次会议分别于2004年7月7-9日在罗马、2004年10月在WP 6E会议期间、2005年3月3-4日在威尼斯、2005年6月27-28日在罗马、2006年8月在首尔、2007年1月17-18日在罗马以及2007年12月3-6日在罗马。在最后一次会议上，该组结束其工作，并向2008年5月召开的WP 6E会议提交最终报告。

本报告旨在为那些处于模拟向数字地面广播过渡过程中的国家提供帮助。本报告考察了这一过程发生的原因和涉及的技术，提供了有关数字地面声音和电视广播技术及系统过渡的总体描述。报告简要描述了实现这一转换的现有选项以及遵循的路径。

报告分为两部分。*第1部分*处理数字转换相关主要问题，提出主要问题和可能解决方案。*第2部分*就第1部分涉及的重要问题提供更详细信息。

与会名单

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第1章

1 引言

1.1 报告要旨

世界各国目前正处于从模拟向数字地面广播的切换的不同阶段。世界各地使用的数字系统情况见ITU-R BS.1114-5建议书（声音）和ITU-R BT.1306-3建议书（电视）。

本报告试图提供世界各地数字系统切换情况的概况，其内容将定期更新。

2006年，由第一区（除蒙古外）120个主管部门及第三区的伊朗出席的国际电联区域无线电通信大会（RRC-06）通过了缔约协定（GE06协定），该协定包括一份数字声音和电视广播业务频率《规划》。该《规划》基于数字声音T-DAB系统和数字电视DVB-T系统。这是一个基于掩模概念的长期规划，定义了保护和干涉标准，以使该《规划》可以进一步演进。[1]

1.2 概述

过渡或者说是从模拟向数字技术“切换”过程可以采取多种路径，从过渡的速度、涉及的参与方以及政府介入的程度而言，每一种方案都有其优缺点。通常根据广播体制的不同，不同国家会采取不同的切换方式。正如电视和无线电广播在现代经济、社会和政治生活中发挥的多重作用一样，切换过程也将出现多重技术过渡方案。第2部分附录1（案例研究）将介绍不同国家从模拟向数字系统转换过程中已有或计划采取的不同方案。

切换进程对广播产业价值链各个部分都将产生影响：从内容制作到传输到接收，各部分都需要技术升级，以实现对数字广播的支持。最大的挑战在于替换或升级数量巨大的正在使用的模拟接收机。这可以采用综合数字接收机方案，也可以采用“机顶盒”方案，其中要注意对天线、卫星接收器、线缆等进行必要的改造。

虽然广播数字化的最终推动力来自市场驱动和用户需求，但技术发展对于这一变革的促进作用也不可小视。和其他许多产业一样，新技术发展和应用对于广播产业变革产生的推动作用与商业需求相比不相上下。

1.3 因何数字化？ — 技术角度考虑

数字化最大好处在于可以实现频道性能的更全面控制。模拟无线电通信频道总体性能很大程度上取决于频道自身特性。香农定律所述的 “开销”利用范围（Shannon, C. E. [1949] 《信息论》，伊力诺依大学出版社）是有限的。相对比而言，数字系统总体性能主要由转换过程（模拟向数字，以及反之）的质量来决定，前提条件是不能超过频道容量。在此情况下，可以更大程度地利用“香农开销”，特别是在使用误差控制技术之后。实际效果来看，模拟系统性能趋向于随着频道性能的恶化而恶化，而数字系统则能一直保持转换过程确定的质量，除非整个系统瘫痪。不幸的是，这意味着在接近最终频道容量情况下，数字系统频道性能的主观效果将变差。

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[1] GE06协定第5.1.3条：

“5.1.3 《规划》中遵守《无线电规则》规定在广播业务或*其他主地面业务*中传输的数字记载也可通过报送与《规划》中其他记载不同特征的方式进行通报，前提条件是在上述通报指配中的任意4 kHz上的峰值功率密度不应超过《规划》中数字记载的任一4 kHz内的谱能量密度。此类使用不应要求比上述数字记载更多的保护。”

数字系统最重要功能是将数据压缩在更小的空间内，随之带来的后果是信号输出的延迟。在广播领域，这意味着可以通过压缩编码技术，在更窄频道带宽内传输相对更高质量的伴音和图像。带来好处是可以在一定程度上实现质量（主要由压缩率来决定）和频谱占用之间的自由控制。

这两个因素共同作用的结果便是允许数字广播机构可以在一个模拟频道带宽频谱内传输各种组合的高清（HDTV）和标清（SDTV）节目及附加数据，而每个频道发射机功率仅相当于模拟频道的五分之一。数字电视系统的主要卖点是其能够为受众和受众提供更多业务、更多选择以及更高技术质量。

此外，数字系统还能提供其他好处。首先，由于增加附属数据业务相对容易，从而可以实现自动或半自动调谐、多角度摄像机、有条件接收以及附加（或甚至完全无关）数据流业务。第二，数字广播技术可提供可信“单频率网络”。这反过来可以更有效地利用现有频带，从而为受众带来更多选择。与数字广播技术相关的另一个技术方案是在移动接收终端上采用这些技术。

1.4 因何数字化？ — 商业和监管方面的考虑

如前所述，数字广播在商业方面的最大优势在于其能提供更多更广的业务和应用选择。对于广播机构而言，其吸引力在于能够在不增加频谱（在转换期结束后）、发射功率较低情况下实现这些特性。新商业机遇将出现。更为一致（如果不是更好的话）的主观质量对于提供商和用户而言都是好事情，同样，比如车载无线电自动重新调谐等辅助业务也是如此。

在监管机构可以向用户征收频谱使用费的环境下，更多频道可以生成更多收入，或者说可以向更多用户征收更低额度费用。一些监管机构甚至可能更积极推动尽快关闭模拟系统（当然是在尽可能不对听众和观众产生影响情况下），以便为其他用户腾出更多频谱。

当然，也有一些商业方面的障碍。对于任一广播机构而言，重新部署设备需要成本，而且这不太可能通过获取更多利润的方式加以抵消（广告或补贴）。在此进程中，重要的一点是要说服受众投资新的接收机或机顶盒。这一点再怎么强调也不为过，为此，有必要或者提供高质量节目，或威胁停止模拟业务。后者可以通过主管部门或政府命令方式，也可以通过广播机构商业决定方式实现。在一些情况下，广播机构（以及新进入者）之间要进行频谱划分交易。在此环境下，更多频道的存在起码在短期将降低现有频谱划分的价值，从而打乱商业平衡。

1.5 如何数字化？— 技术和监管方面的考虑

数字和模拟广播传输系统之间几乎不可能兼容。虽然这可能造成一些转换方面的问题，但总体而言是有利的，因为数字系统根据其自身技术和财政驱动力量优化而成，而不必因与现有低级技术兼容做出妥协。熟知的NTSC、PAL和SECAM模拟彩色TV制式主要考虑之一是它们与现有黑白传输之间的后向兼容。

任何技术转换或“切换”策略都必须能工作在一定的商业和监管规则之下。商业考虑将在下一节详细探讨，但简而言之，任何转换策略都将需要在较高比例受众能通过一种或其他传输手段（卫星、有线或地面广播）接收数字业务之前，继续保持现有节目流的模拟传输。通常而言，这意味着在转换期内，同一节目的数字和模拟版本要同时播出（即并播）。为此，可以采用且实际上已经采用了多种技术策略。

最简单方法是为新节目划分一个新的频带。如时机成熟，在过渡进程中，旧的频谱可以被收回。在必要情况下，经认真规划和对于设备的特别设计，最终有可能将数字业务重新转回原有频带。欧洲

就是采用这种方法引入了Eureka 147 DAB。仅从技术上说，该系统甚至可以允许在不同国家使用不同的频带。

由于数字系统在频带和功率方面的要求都比较低，因此有可能在其他业务已经占用的频带传输数字业务。通常来说，这将导致现有模拟业务一定程度的质量衰减（增加了干扰），但这仍在可容忍范围内，原因是：

– 可能造成的影响较小；
– 影响是暂时性的，数字业务正常化之后就没有影响了；
– 这对于转换进程而言非常关键。

一个例证是英国采取这种方法在UHF第4、第5频带引入了数字地面电视业务。这种方法的有效性有赖于现有频带的拥塞程度。

如果数字传输可以占用与模拟信号相同的频谱且具有同样的干扰特性，则可以简单将现有模拟业务替换为数字业务，或使用现有的未被使用的频谱划分。在大多数频带内，很少有未被使用的频谱划分，因此这一策略取决于是否有广播机构同时在不同频道（或甚至是不同平台）传输相同的内容，并且愿意冒险让一些（较少数量）受众重新调谐至另外频率。这一策略目前以调幅方式用于HF、MF和LF波段，以便进行DRM传输试验。在HF波段，可以通过各种非正式协调机构进行频道协调。但是，问题仍在于HF波段的低频带过分拥挤以及不易获得合适的发射机。

另外一个方法是美国IBOC体制下采用的方法，即将数字信号与模拟信号同时适配入同一频道。采取这一方法的前提条件是要求频道安排允许这么做，且必须采取特殊措施，以防止出现不可接受的同频道和邻频道干扰。

如果有新的频谱可用，且数字传输不能与模拟传输同时进行，则可能必须采取“一夜之间”切换方式。这种方式对于各方都将成本很高。

1.6 如何数字化？— 商业方面的考虑

似乎不太可能有或将会有来自受众的压力希望引入数字业务。受众是否采用数字方式取决是否有以下潜在收益：

– 能否提供更多的业务和应用，
– 能否提供诸如首映影片或首映体育节目等加价（有条件接收 — 付费）业务和应用，
– 能否提供宽屏、高清晰和环绕声等高级功能，
– 能否提供更高的伴音和图像质量，
– 能否提供与节目相关的数据、元数据或甚至是独立的业务如网页等，
– 能否提供更便捷的接收，特别是有关专业资料的接收，以及
– 能否提供更便捷的节目选择，比如在不同LF、MF和HF发射机或电子节目导航之间的自动转换。

这些因素必须能够抵消掉可预见的新增设备和可能的注册成本。因此，必须能够为受众提供有吸引力的业务和应用，而且是在其可支付的范围之内。对业界而言，必须能制作出更多更具吸引力的节目内容和价格适中的接收设备。

接收设备的价格是由很多因素决定的，但其中最重要的是广播机构或监管机构是否对其成本给予补贴，以促进销售和推动业务的开展。在英国，作为其诱人注册方案的一部分，DVB-S接收机是“免

费发放”的。任一切换策略都必须认识到，用户社群一般可根据用户对于新技术的投资兴趣划分为三类。“最先尝试者”趋向于那些热衷技术发展且仅仅是出于希望最早尝试新机器的动机而做出投资决定的人群。这类人群通常愿意为新设备支付高昂价格。在产品周期的最初阶段，制造商依赖这批人群为其抵消新消费设备的高昂研发成本。最先尝试者之后是“主流”用户。这些用户将更多考虑价格因素，并且将在真正购买新接收机之前对新业务/应用和做出改变所需成本之间进行比较。这些人群清楚他们将做出的改变，但是真正要买新机器还是要等机器价格下降（这是不可避免的）到他们能够接受的水平为止。第三类人群是“不情愿”人群，他们坚信他们不需要做出任何改变，或者他们对于那些他们不知道发展情况的任何事物都没有任何一丁点的兴趣。这些人群只有在其绝对必须改变的时候（可能是由于模拟服务被取消的情况下）或者价格下降到不成为重要因素且数字传输已经成为标准的时候，他们才能做出改变。

很清楚的一点是，简单市场模式正在被补贴以及威胁停止模拟服务等因素所扭曲。取消服务的威胁是（市场）驱动力之一，在使用时候必须格外小心。公共业务广播机构以及为大部分广播产业提供资金的广告商将发现他们被置于不利之地，因为如果在计划“切断”服务之前，原有受众很大一部分不能接收新服务的话，那么他们与既有受众之间的联系将被“斩断”。在受众数量未降低到其传输成本不经济之前，广播机构也不愿意关闭其服务。

这里可以说清楚一件事情。持续进行的技术研发和不断扩大的消费用户数量意味着接收机生产成本将会下降。这反过来将会降低购买价格。集成技术领域的持续发展意味着越来越复杂的系统能够置于很小的硅片之上。多功能和单功能接收机都能使用相同的芯片，从而使得生产成本将更多地依赖于生产量的大小，而非功能的多少。纯模拟接收机发展停滞不前，这意味着终有一天它们的成本将会比功能更强大的数字机器还要贵。从这一点来说，向数字切换的动力是不可阻挡的。

虽然在部署新设备方面，广播机构相比于受众而言更容易被说服，但这一过程绝非不需要付出成本。如果转换过程需要在现实时间和预算框架内完成，则必须尽一切可能使用现有模拟设施。如果要在现有频带内部署业务，因为较低频带使用的发射机和天线一般来说都非常昂贵且难以更换，因此通常可以将其改装用于数字传输，这的确是件好事。目前在欧洲广播的DRM传输大多数采用经改装的模拟发射机。虽然这些发射机一般不能工作在数字传输最佳状态，但考虑到设计上的截然不同，通过采用这一策略，可以使现有设施在转换期内继续用于模拟业务的同时用于数字业务。此外，同一节目以模拟和数字两种形式同时进行制作和传输，这一成本也不能忽略。

1.7 国际电联的活动

国际电联将继续在频谱使用监管和广播技术等方面发挥关键作用。在频谱政策框架内，一些主管部门之间已就切换过程中的频谱问题进行了探讨。最高目标是要在保护广播服务的同时，鼓励频谱的有效和灵活使用。这里面涉及很多问题，其中重要一点是要讨论划分给地面广播服务的频谱的经济价值，以及设定这一价值过程中的透明性问题。对于制定共同服务关闭日期或者禁止出售模拟接收机等层面的问题，国际电联不会介入。但是，它将对各国数字广播市场及政策进行监测。

国际电联三个部门在各自职能范围之内负责有关广播问题的活动和研究（见第1部分第2章第 2.1节）。特别要提及的是主要研究该问题的无线电通信第6研究组。由于不同媒体之间融合的爆炸性发展、数字技术的引入并考虑到第6研究组所采用的将广播业务视为端对端链接的研究方式，第6研究组非常适合在研究新兴业务和应用方面扮演重要角色。这些业务和应用涉及多媒体内容的新分配方式，包括通过无线向便携及手持接收机发布内容。

1.8 无线电通信第6研究组的职能范围和未来发展

1.8.1 简介

关于在端对端基础上研究广播业务的必要性，无线电通信全会（2000年伊斯坦布尔和2007年日内瓦）已认识到广播业务必须在端对端基础上进行研究。的确，第6研究组“广播业务”的职能范围清楚地表明“考虑到无线电通信广播包括从节目内容制作到向大众传播等问题，该研究组将研究涉及内容制作和无线电通信等问题，包括节目的国际交换以及业务总体质量”。在实际操作上，广播业务是基于一个很长的使用不同技术和执行不同功能但密切相关的技术操作链路，因此每一操作都将对链路下一个环节的操作产生较大影响。

以上考虑的目的是提供对于广播链路的复杂结构的一些较深入审视，以便进一步解释为什么必须在单一机构内研究广播业务。单一机构收集广播链路中各个链接上所需的所有不同专业知识，同时要记住当前研究这些问题的目的是出台一系列经协调一致的ITU-R建议书。这些建议书指明了广播机构如何以最可靠方式并且在最小资源开支范围内（如通过频谱的有效使用）向最终用户（家庭收听者/收视者）提供最佳可能的媒体（音频、视频和数据）质量。

1.8.2 数字广播链

图1显示了一个数字广播链的非常简化的基础框图。它包括四个主要的概念性部件，即内容制作部分，传送部分，接收部分以及呈现部分。

制作部分包括三个主要概念性功能，即：制作、后期制作和录制。

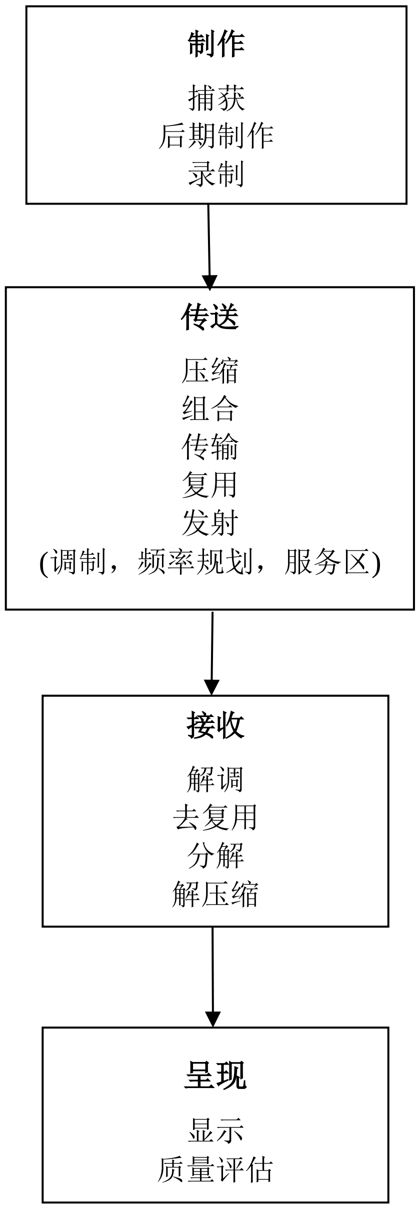
制作包括作为节目组成部分的各种媒体的获取（节目影像以及各种附带的音频部分）以及将其从感官刺激的初始状态转换为数字信号等方面工作。该部分包括将来自各种音视频材料的信号进行混合和排序。它特别需要包括色彩学在内的人类对于音视频刺激的精神感知方面的专业知识以及音频和视频信号采样方面的专业知识。

录制包括音视频节目后期使用所需的录制、重放和存档等工作。以下情况需进行这一工作：制作部分生成的节目材料需要重新混合或重新排序，或需要与不同时期生成的节目材料进行综合。它也包括节目存档，目前这一工作尤为广播机构所青睐，因为它可能有助于开发其存录节目资产的功效，比如重新用于播出，或在国内或国际节目市场进行销售。这方面的研究需要对现有录制技术的深度掌握，包括现代无磁带录制（在光盘、固态存储器和计算机类型存储器上的录制）以及此类节目信号的接入管理及利用方面的知识。

后期制作包括将所获取的节目信号变为最终节目形态所需的所有技术操作。它包括在节目中插入组成元素，比如音乐和对话合成，抠图或色彩调整，节目配音，在演播室片段中添加档案材料，多媒体和交互应用相关元素的开发等。由于一段一段连续播放的图像和伴音信号后期处理出现的累计效应可能影响图像或伴音的最终质量，因此该研究特别需要有关各种后期不同处理方式之间交互影响的类型及深度方面的专业知识。

图1

广播链概念性框图



传送部分包括四个主要概念性功能，即：压缩、组合、复用和发射。

压缩包括为降低每一节目成分（视频和音频信号等）比特率所需的操作，压缩的目的在于使这些数据在发射频道中所需比特率尽量小，因为这对于将图像和伴音以预定质量传输至最终用户来说至关重要。这一研究特别需要对于比特率压缩机制及其对于节目材料感官质量的影响方面具备深入了解。

组合是指将各种不同的节目组成部分（视频信号、音频信号、多媒体和交互应用信号等）组合在一起，以便将其组成一个结构合理的单一的串行数据流，该数据流也承载节目管理必须的附加信息，如知识产权信息、有条件接收信息、版权保护信息等。如下所述，该研究需要对音视频同步保持等将各种不同数字流平滑复用至单一流方面知识的较强了解。

复用是指将各种不同节目流组合进入单一数据流，该数据流速率与复用流承载的传送节目的传输频道数据容量相匹配。它也加入必要的数据，以保护这些节目信号不受传输频道引入的误码的影响。在这一阶段可以最佳利用统计复用，从而最大限度地利用发射频道的比特率容量。

发射是指将复用数据流调制在频道载波上，以便将其在预设的传输频道上广播出去。它也研究频率规划、发射天线的位置和设计及其发射功率。该研究需要对于相关频谱问题的深入掌握，以便在覆盖预设服务区的同时能够遵循对于其他发射机或受其他发射机辐射影响方面的强制要求。

广播链的接收部分所做的操作与传送部分正好相反，即：解调、去复用、分解以及解压缩。

解调在用户端对接收机接收到的调制信号进行操作，恢复调制比特流，并尽可能纠正传输频道引入的误码。

去复用是指对复用比特流进行操作，从中解出复用的各种不同的节目流。

分解是指对前述功能中去复用出来的节目流进行操作，从中恢复出包含选定节目的组成部分（视频信号、各种不同音频信号以及数据）的压缩信号。

解压缩是指对包含特定节目的压缩信号进行操作，从中恢复出未压缩格式信号。

呈现部分是指对解压缩后的信号进行操作，对其进行处理，使得原始音频和视频节目材料可以恰当地显示在最终用户设备（收音机或电视机）上。该研究要求将最初用于捕获节目的设备特性与用户显示设备特性之间相互匹配。由于新型显示设备的出现，这一工作变得愈加具有挑战性。

1.8.3 未来展望

无线电通信第6研究组在其活动之初便掌握了广播的多方面特性，并及时和高效地处理了这一挑战。

第6研究组根据其职能范围在以下领域开展端对端研究：

– 节目材料的制作（节目材料重新封装所需的所有功能，以便将其在互联网、移动电话等更高级应用上传输）；

– 节目材料和相关元数据的数字信号压缩、组合。

– 类似于影院形式的大厅集体观赏电视节目的制作（基本完成）；

– 通过地面广播和卫星广播业务进行节目材料的分配；

– 通过交互式广播和“网络广播”等新型、新兴媒体的节目分配；

– 最终用户对于广播业务的接收；

– 向最终用户提供最佳可能质量的图像和伴音；

– 在广播链最末端进行感观视频和音频质量的主观评定和客观测量，甚至可以通过在线方式进行。

实际上，以上描述的广播链不仅适用于传统广播，也适用于交互式广播，不论其通过无线还是通过有线电视、光纤或者卫星。通过与国际电联其他两个部门的合作，目前正在加强有关回传频道和数字传输协议的确定方面的研究，以便挖掘所需的交互功能。

随着当前数字技术如潮水般不断发展，我们目睹了各种媒体融合的爆炸性发展，无线电通信第6研究组成功采取的有关广播业务端对端链条式研究方式，可能鼓励其扩展研究范围，深入至有关电视节目材料的重新封装领域，以便将电视节目传输至新的广播手段，如通过无线方式将电视节目传输至固定、便携或手持接收机，或甚至将这些节目通过“网络播放”或“线缆播放”方式传输至有线连接。

第2章

2 广播技术概述

2.1 简介

本章介绍国际电联有关模拟和数字广播系统的活动和研究。

国际电联三个部门在其职能范围内负责有关广播问题的活动和研究。

2.1.1 ITU-R

无线电通信第1研究组 — 频谱管理

– ITU-R SM.1047建议书 — 国家频谱管理

– ITU-R SM.2012报告 — 频谱管理的经济问题及其增补

– 手册 — 2005版国家频谱管理

– 手册 — 2005版频谱管理计算机辅助技术

– 手册 — 2002版频谱监测*。

无线电通信第3研究组 — 无线电波传播

– ITU-R P.1546建议书 — 30 MHz至3 000 MHz频带地面业务点到面预测方法。该建议书修订版本替换了之前ITU-R P.370和ITU-R P.529建议书，后者是包含地面移动和广播业务系统场强预测所用传播曲线的两个主要建议书。

– ITU-R 手册 — VHF/UHF波段地面陆地移动无线电波传播（2002）。

无线电通信第6研究组 — 广播业务

– 主要涉及负责地面广播标准和规划参数的6A工作组（前6E工作组）的活动。WP 6A建立了一个报告人组，负责就数字广播技术和标准、数字地面系统与现有模拟网络之间的互操作性，以及从模拟地面技术向数字技术过渡的方法等提交报告。

– 6/8任务组为2006年区域无线电通信信大会（RRC-06）准备了一份报告，更新了1961年斯德哥尔摩规划和1989年日内瓦规划（见第1部分第4章）。

2.1.2 ITU-T

SG 9 — 综合宽带有线网络和电视及声音传输

这是有关综合宽带有线和电视网络问题的牵头研究组，负责研究以下问题：

– 如何利用综合宽带网络等主要用于将电视和声音节目传输至家庭的有线和混合网络，使其也能用于承载声音或其他时间要求严格的业务，视频点播，交互式业务等；

– 如何将电信系统用于电视、音频节目和类似数据业务的馈给、一次分配和二次分配。

ITU-T第9研究组负责研究综合宽带有线网络和电视、声音传输问题，见以下课题及其相关建议书：

课题 *6/9* — 传输至家庭的数字有线系统有条件接收方法及实践

课题 *12/9* — 采用网际协议（IP）和/或分组数据协议通过有线电视网络传输高级多媒体数字业务及应用

课题 *13/9* — 通过有线电视网络传输声音和视频IP应用

第9研究组负责与第6研究组就广播事务进行协调。

SG 15：负责光及其他传输网络的ITU-T第15研究组涵盖以下课题及相关建议书：

课题 *1/15* — 接入网络传输

该课题负责维护并定期更新一份完整的标准概述，网址如下：

http://www.itu.int/ITU-T/studygroups/com15/index.asp

SG 16 — 多媒体业务，系统和终端 。

2.1.3 ITU-D

ITU-D第2研究组和无线电通信第1研究组就有关落实WTDC-98 题为“各国，特别是发展中国家，对频谱管理的参与”的第9号决议问题启动了具体合作，并起草了在此方面通过的第一份报告。WTDC-02通过了第9号决议的修订版，并要求相应研究工作应与ITU-D有关“频率费计算”的第21/1号课题一并开展。WTDC-06确认了同样决定，目前工作正在开展之中。我们也注意到第21/1号课题已纳入WTDC-06第9号决议内。

ITU-D第11-2/2号决定（地面数字声音和电视广播技术及系统的审查，包括成本效益分析，数字地面系统与现有模拟网络的互操作性，从模拟地面技术向数字技术的过渡方式等）研究这一问题。这里要提及的是，ITU-D第2研究组有关课题9-2/2（ITU-T和ITU-R研究组有关发展中国家的研究课题）提供了有关特别关注发展中国家的课题及主要研究问题的概述及已批准的建议书和手册的详细内容。

本报告特别考虑了课题11-1/2的主要观点。

2.1.4 区域无线电通信大会（RRC）

根据2000年开展的有关举行区域无线电通信大会（RRC）以及在174-230 MHz（VHF波段）和470-862 MHz（UHF波段）进行未来广播业务规划的磋商，全权代表大会通过了第117号决议（2002年，马拉喀什），决定在区域无线电通信大会上对上述频带进行地面广播和声音广播的区域规划。

理事会在其2003年会议上修订了第1185号决议，以考虑全权代表大会（2002年，马拉喀什）做出的决定，并起草了RRC两次会议的议程。根据理事会第1185号决议（2003年修订），在RRC-04（2004年5月）期间起草了一份报告。该报告作为RRC第一次大会的工作基础，促进了第二次会议之前有关规划工作的进行，并充当各国主管部门提交要求的表格。大会第一次会议于2004年5月28日在日内瓦举行。大会第二次也是最后一次会议于2006年5月15日至6月16日在日内瓦举行。会议结果见第1部分第4章第4.1.2节。

2.1.5 世界无线电通信大会（WRC-07）

WRC-07决定为IMT以同为主要业务形式有条件划分一些频带（790/806-862 MHz），这些频带之前是以主要业务形式划分给广播业务的（见WRC-07最后文件，第五条，频率划分表）。

2.2 模拟广播技术和系统

建立在尼古拉 • 特斯拉发明基础之上的无线电通信和广播业务，是伴随着十九世纪末马可尼传输的出现而诞生的。自二十世纪最初十年以来，广播科学理论得到了快速发展。

与我们想象不一样的是，有关无线电频率信号处理的第一个标准是数字类型的（开-关）。用于有线电报的标准被用于无线电传输，称为“无线电报”。无线电广播模拟系统及技术的发展必须等到“二极管”和“三极管”技术的出现。“频率调制”和“相位调制”系统（ITU-R BS.467和ITU-R BS.1194建议书）逐步补足了1930年附近创建的“幅度调制”（ITU-R BS.598建议书）不足之处。1940年左右，随着对电视系统的大量研究，出现了综合模拟、幅度调制和频率调制的视频和音频电视系统技术和标准。不同组合导致ITU-R于1960年左右通过了三种不同类型的标准：PAL、SECAM及NTSC制式（ITU-R BT.470建议书）。电子管领域高级技术的发展以及“四极管”、“五级管”、“速调管”的实现，使得轻巧和高效发射机和接收机设备成为现实。这促进了无线电和电视模拟系统的大规模发展。同时，固态三极管，“晶体管”这一新技术的发明以及所有其他固态组件为新一代系统的研发特别是用于接收设备和计算机芯片等方面发展开辟了道路。

1960年左右出现的卫星技术一开始起步于模拟系统，但很快转向数字技术。

新技术使得其他数据传输成为可能，这促进了广播和电信在总体方面可能的融合。

2.3 模拟和数字系统规划考虑

2.3.1 背景

在国际层面，国际电联负责制定广播标准。有关研究在ITU-R SG 1（频谱问题）、SG 6（射频标准和规划参数）以及ITU-D SG 2等相关研究组开展。

ITU-R数字标准化工作开始于1960年左右，有关卫星模拟系统的第一次规划（WARC-77）开辟了数字系统发展之路。

广播和计算机在1980年左右的技术融合促进了数字系统的研究，并创建了数字技术。卫星系统使用的小功率线性放大器（转发器）导致了对卫星发射所用模拟系统的改进。所有从发射机（Tx）到接收机（Rx）的链路全部变为数字化。WRC-2000大会为国际电联第一区和第三区创建了全数字广播规划。

考虑到频谱节约、附加业务、不同类型业务以及更高质量服务等方面因素，第一区的区域无线通信大会RRC对地面模拟广播进行了重新修订， 将其更改为数字化。这届大会的第一部分于2004年5月召开（RRC-04），起草了规划程序和参数；大会第二部分（RRC-06）于2006年5月在日内瓦召开，起草了最终频率规划。

2000年，声音广播创建了不同频率数字系统（DAB、DRM和IBOC）。数字无线电接收质量的改进使得某些广播频带对商业广播机构而言更具有吸引力。ITU-R标准规定，DRM系统频率范围低于30 MHz，而IBOC系统用于中波波段（ITU-R BS.1514建议书）。由于所有新标准均基于数字技术，因此以前出现的声音广播和电视广播之间的界限正在消失。如今，所有数字标准如ATSC、DVB-T、ISDB-T、DVB-H、ISDB-TSB、T-DMB以及ChinaDTV等均可用于声音、电视和数据信号的广播。这意味着只需要一个数字接收机或机顶盒，就可以接收电视内容，数据或无线电业务。在本文件随后部分，将以传统方式分析各个不同标准，或用于声音广播方式或用于电视广播方式。

数字技术，即使目前看来是成熟的，也有赖于低成本接收机的具备。而这一设施背后必须有大量节目发射的支持。

转换期显然是数字系统最终应用的主要问题。

模拟向数字系统转换过程中另一个非常重要的问题是规划。

2006年之前国际电联通过的所有规划主要都是模拟规划，这是为了满足一些主管部门不断增长的频道和播放时间需求。这一需求增长导致了现有频谱之间干扰的增加。应注意的是，接收机特性改良也改进了频谱效率。

数字技术不仅增加了频道容量的交易质量，也为有效使用现有容量提供了可能。来自商业广播机构不断增长的频道容量需求意味着这两个潜力都需要挖掘。随着商业运营机构额外业务增长需求，目前情况导致对频谱更多的需求。这一需求可以通过数字系统来满足，后者可以提供更高的接收质量和更先进的频谱利用率。数字系统的启动变得非常重要。一个很好的例子是日内瓦06规划（覆盖国际电联120个成员国），该规划满足了第一区（除蒙古外）以及第三区一个国家（伊朗）不断增长的频道需求。

转换期间有关模拟和数字系统额外频谱的需求应考虑在内。

这里也要说明的是，随着数字技术的引入，频谱使用效率将得以提高。

2.3.2 与其他主业务共用广播频带

在规划和使用现有广播频率时，我们必须记住，广播绝非独占这些频率，应考虑共用情况。

无线电频谱使用基于国际电联《无线电规则》（RR），其序言如是表述：

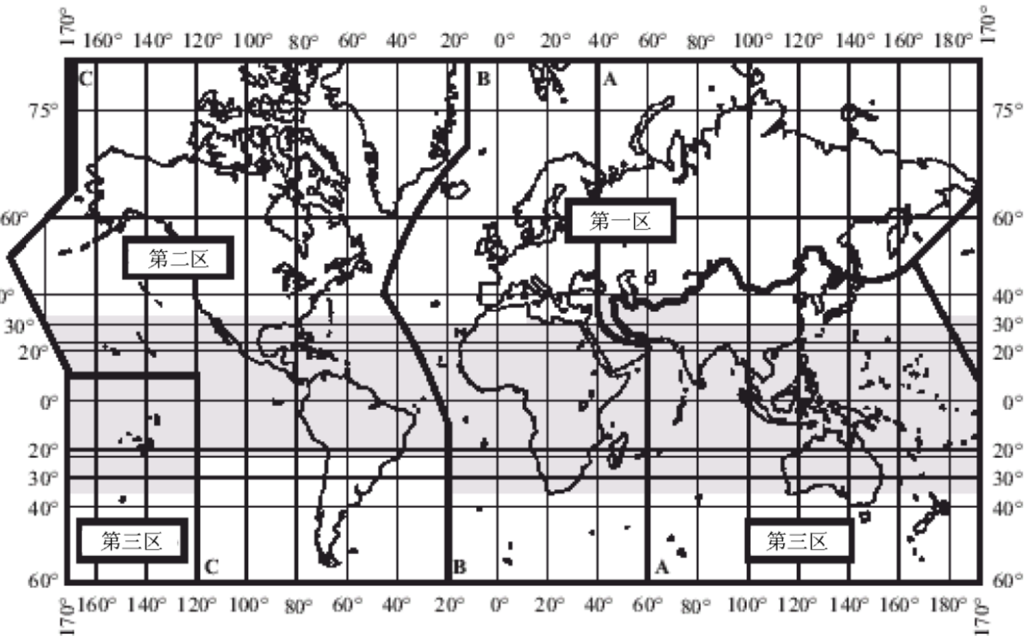
> “在使用无线电业务的频带时，各成员应牢记，无线电频率和对地静止卫星轨道是有限的自然资源，必须根据《无线电规则》的规定合理而有效地节省使用，以使各国或国家集团可以在考虑发展中国家和具有特定地理位置的国家的特殊需要的同时，公平地使用无限的频率和对地静止轨道（《组织法》第196款）。”

《无线电规则》第4条也表述：

> “各成员国承诺，在给电台指配频率时。如果这些频率有可能对其他国家的电台所经营业务造成有害干扰，则必须按照频率划分表及本规则的其他规定进行指配。”

《无线电规则》第5条给出了自9 kHz至275 GHz的《频率划分表》。对于频率划分，世界分为如下图所示三个区域：

图 2



其中，在《频率划分表》框图中，一个频带被列为划分给多个业务，或者是全球性质的或者是区域性质的，此类业务可能具有两类，主要业务或次要业务。主要业务以大写字母或仿宋体字打印在《频率划分表》内（如**广播**（BROADCASTING）），而次要业务则为正常宋体字或正常字母（如固定（Fixed））。

次要业务站点：

− 不应对主要业务站点已经指配的或将要指配的频率造成干扰；

− 不能对主业务站点已经指配或将要指配的频率引起的有害干扰要求保护；

− 但是，能够向同类或其他次要业务站点就未来可能指配的频率造成的有害干扰要求保护。

从《频率划分表》可见，在不同区域，各种业务的主次状态不尽相同。

另外，在《频率划分表》的脚注中，该区域主管部门可以在其国内具有与该区域不同的频率划分情况。

在国际频率规划中，应考虑来自其他主要业务的干扰或对其他主要业务产生的干扰。对于数字广播规划来说，这要困难得多。

在转换阶段，广播信号与其他现有的非广播主要业务在相同频带的共存问题是各主管部门需要解决的最重要问题，为此，需要考虑《WRC-07最后文件》。

2.4 数字广播技术及系统

2.4.1 数字基础知识

数字广播系统赖以维系的基本技术有很多种。其中较为重要的几种将在下文简要介绍。

2.4.2 背景

“雷达”和“激光器”技术发明对于数字系统非常重要，即使对于那些在这些发明之前开发出来的数字系统，也必须等到这两种技术发明之后才能推广。

目前市场上能够提供的配备30 nm晶体管、频率在20 GHz或以上、具备更高容量静态存储器、允许软件和算法的较快和功能强大的计算机技术，促进了模拟系统的更换。

这些新技术也促进了广播和电信的融合。

在一些国际电联成员国，数字声音和电视广播仍然处于发展期，当前难点更多在于监管和经济问题而非技术方面问题，不过，新的等待启动的项目仍层出不穷。

在欧洲，几乎所有欧盟成员国都采取了促进数字电视发展的政策。部分欧盟成员国也在数字声音广播方面采取了相同举措。

2.4.2.1 PCM和采样

大多数数字信号的表示和处理基于脉冲编码调制（PCM）。PCM发明于1930年代，可将模拟波用一个成为比特流的数字字符串表示。这些数字的最简单形式是“1”和“0”（开/关控制键），代表二进制数。该技术相比较于（当时）传统模拟传输来说，如果频道质量足以分辨“1”和“0”，则可以用很明确的精度恢复原始信号。数字系统通过对数字的处理实现对信号的处理。随着IT产业出现的越来越强大和快速的数字处理设备，可以考虑更为高级的信号处理方式。

PCM处理包括两个基本元素。

第一是“采样”。模拟信号用一系列离散的采样来表示。虽然模拟信号必须足够频繁地采样才能够允许精确恢复原始信号，但采样率高过必要也不会带来更多改善。奈奎斯特-香农采样定律规定了最小采样率为大于模拟信号最高频率分量的两倍。低于这个频率的采样将导致出现混频现象，就像大多数人在“西部”片中看到的马车轮子向后倒转的现象。在这个例子中，采样频率即相机的帧频率不足以分辨轮子相邻轮辐的位置。该效应被用于示波器对于快速移动物体的检测。

第二个是“数字化”。每一单独采样必须采用数模转换器转换为（通常是）二进制数字。考虑到转换器本身具备的足够质量和精确度，这一转换可以实现任意精度。高精度的代价是较长串的二进制数字，反过来如果需要“实时传输”的话则需要较宽的带宽。整体系统噪声指标由数模转换过程的精度所确定。模拟数量的任一数字化表示都有一个小于或等于其二进制数字最低位一半的误差。该噪声分量被称为量化噪声，且随着数字采样比特数的增加而明显降低。

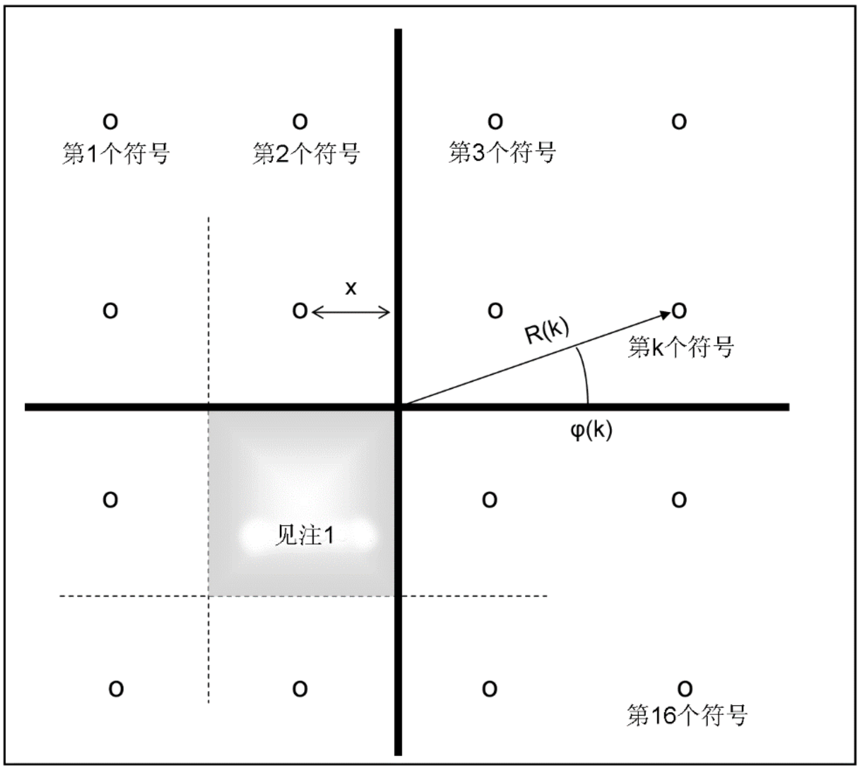
2.4.2.2 比特、符号、QAM和IP

虽然数字表示大多数情况下采用二进制数字，但在一个可以承载模拟信号的频道中，简单地传输“1”和“2”未免显得浪费。频道容量通常也可以通过使用中间电平加以更好利用。比如，通过使用四电平，“0”、“⅓”、“⅔”和“1”，每一电平可以代表2个二进制数位；分别是“00”、“01”、“10”和“11”。每个离散电平或“符号”现在承载了高过一倍的信息量。根据频道的噪声情况，可以分辨出更多的电平，从而可以用一个符号承载更多的信息。在采用载波或副载波的系统中，载波相位可类似地离散变化。这称为相移键控（PSK），通常情况下，180º相移称为B（二相）PSK，90º称为Q（四相）PSK。

四相幅度调制（QAM）是指对载波的幅度和相位同时进行调制。每一符号被定义为一个独特的幅度和相位组合，对这些组合进行选择，以使潜在干扰（噪声）最小化，从而防止出现该符号与另外一个与其幅度和相位最相近的符号发生混淆的现象。虽然可以使用任意集合的符号，但在广播应用上，最常用的是具有64（26）个独立符号的64-QAM和具有16（24）个独立符号的16-QAM；4-QAM是QPSK的一个变化形式。64-QAM每个符号承载6个二进制数，而16-QAM承载4个。

通常，N-QAM可用数理方式描述。可以理解为在一个复平面上平均分摊N个点。通常称之为“星座图”。

图 3



16-QAM星座图

注 *1*：星座图中每个点占用一个小框，其大小（2x × 2x）由信号幅度决定。如果幅度和相位噪声叠加效应能够将符号移入相邻框内，则由于该符号与邻近符号发生混淆，从而不可能进行准确解码。

2.4.2.3 时分和频分复用

通常情况下有必要在一个频道中传输一个以上的比特流。一种方法是频分复用（FDM），将每个比特流放入不同副载波中，并将所有副载波叠加在一起传输。这是一个熟知的技术，已经在很长时间以来用于模拟信号复用中。该方法要求频道总带宽要能容纳各个分量带宽的总和。

时分复用（TDM）只能用于数字系统，它将一个流的比特（或比特组）与来自其他流的比特顺序排列。其最简单的形式是，流1的比特跟随在流2的比特之后，然后是流3的比特，以此类推，直到再轮到填补流1的比特。明显的是，这一交叉复用结构越复杂，时间控制和数据恢复处理越复杂。而且，很清楚的是，在每秒内频道通过的比特流量必须大于或等于比特流所有分量的比特率的总和。

时间和频率交叉复用和误码纠错是需要考虑的其他两个重要技术。

2.4.2.4 编码正交频分复用（COFDM）

编码正交频分复用（COFDM）大量使用于数字地面广播系统。数字广播早期实验显示，多径接收效应在城市地区可能引起严重问题。对于一个信号，接收方可能收到与直接版本幅度相类似的延迟版本，而此延迟版本的延迟时差正好可能造成与相邻（或甚至隔离度更高的）符号的混淆，从而出现相互干扰。解决方案是降低有效比特率，并增加缓冲间隔（即所谓“保护间隔”），从而允许反射效应稳定下来。与全速传输比特流不一样，这一方式将频道分为很多子流（基本上与TDM相反），每个流具有相对较低的码率，且各自调制在不同子载波上；一个明显的例子是频分复用。因为每个子载波的码率都相对较小，因此可以将数量很大的子载波紧密排布并适配入频道带宽内。在COFDM系统中，每个载波实际上承载一个N-QAM，其中的N在广播应用中通常是4、16或64。

通常而言，FDM方案中的每一子载波在解调制之前通过滤波从复用信号中抽取出来。这意味着在调制子载波之间要有一定程度的隔离或“保护带宽”。子载波频率经精心选定可以呈数学上的正交关系。这意味着它们之间可以相互较近，或甚至相互覆盖。正交特性意味着在一整段符号期内相邻子载波的入侵效应可以被基本降低为零；（仅）在相邻子载波未调制的情况下确实为零。很简单，当欲收子载波变为基带信号时，符号长度内应具有相邻子载波的整套周期。

不可避免的是，任一无线电传输频道都将受到均匀或选择性衰落的影响。好在频道带宽能够足以将前者效应最小化，但选择性衰落会偶然造成一个或一组复用相邻频道的丢失。交叉复用意味着接收到的信号中的误差能够分摊，从而对大量采样的影响较小，而对较少采样的影响则较大。编码或严格来说是纠错编码用于COFDM中，用于将选择性衰落和偶然“丢失”问题对于整体接收信号的影响降低到最小限度。

COFDM综合了几乎所有前述各项技术，给出了一个既高效又可靠的调制方案。

2.5 数字声音广播

数字声音广播（DSB）已在世界各地很多地方以各种不同数字系统实现应用：DRM、DAB、IBOC及ISDB-T_{SB} 。美国引入的是数字混合系统（卫星和地面）：XM radio和Sirius。这些系统的商业模式隐含着注册问题。在世界其他地区，自无线电广播出现以来收音机业务就一直是免费的。主要问题在于要在业务引入期内，将成千上万的通常很便宜的模拟接收机更换为相比较而言更为昂贵的数字接收机。

大多数消费者意识不到数字收音机的好处，并且认为模拟收音机物有所值。虽然数字收音机的价格正在下降，但一般消费者判断增加的成本值不值，还在于数字收音机质量的提高和附加值方面的差距或者最起码提供给消费者的信息方面存在差距是不是足够重要。而且，即使真的关闭了模拟收音信号，相比较于电视而言，也不太可能挤出多少频谱，最可能的是这些频谱被不断增长的无线电广播业务所消化吸收。

对于“独立”数字无线电业务而言，情况则微妙得多；这是因为，这些业务并非与数字电视业务捆绑，也非自互联网上接收。与美国以及世界其他地区不同，至今欧洲尚未开通数字卫星无线电业务。数字地面无线电广播于1995年开通，基于Eureka-147 数字声音广播（DAB）标准。但在市场上几乎没有数字接收机，因此也没有多少听众，不过情况从2002年开始有所改善，特别是在英国。

如前所述，主要问题是将成千上万的通常是很便宜的模拟接收机替换为相对很昂贵的数字接收机。大多数消费者意识不到数字收音机问题，并且认为模拟收音机物有所值。数字收音机的附加值，或者最起码为消费者提供的信息方面，尚不足以证明大多数消费者支出的额外成本是必要的，虽然机器的价格在不断下降。此外，在欧洲，由于付费无线电节目有限，因此对接收机给予补贴也非常困难。而且，即使真的关闭了模拟收音信号，相比较于电视而言，也不太可能挤出多少频谱，最可能的是这些频谱被不断增长的无线电广播业务所消化吸收。

无线电业务从主要依赖模拟技术应用向基于数字技术方向的过渡，在过去20年中一直在不断演进之中，开始是伴随性能算法而出现，继而是计算性能和引入数字声音广播所需的数字信号处理（DSP）设备的演进，首先是在演播室，然后是在一次和二次馈给网络，最后是以可支付价格在消费者范围内。（根据摩尔定律，计算性能每18个月翻番，因此加速了数字技术的引入进程）。应用于调制方案的数字技术提供了透明频道。声音广播链的各个部分的质量必须都接近完美；最弱部分将成为瓶颈，从而决定最终质量。因此，数字技术将从演播室开始到馈给网络直至调幅和调频发射机等馈送模拟发射机，当然最后将传送至馈送数字广播发射机（DAB、DRM等）。

模拟声音广播向数字过渡的主要优势在于：

a) 更好的声音接收质量

由于CD播放机和MP3播放机等新组件和设备的出现，公众期待获得更好的音频质量，甚至是希望提供数据广播业务功能。

1990年代末，欧洲国家开发了一种基于OFDM技术、采用T-DAB音频编码器等“当今最新”技术的新的广播业务。T-DAB因此成为DTM、IBOC等全球其他系统的基础。最新数字标准采用了基于MPEG4的音频压缩标准。以DRM为例，该技术包括三个不同音频压缩方案（算法）：用于多功能声音的AAC+，用于高质量话音编码的CELP，以及用于甚低码率话音编码的HVXC。三种算法都是MPEG4的组成部分。对于相同音频质量而言，在码率方面，第一种音频压缩算法比最后一种算法差近四倍。

b) 更诱人的新内容/节目

随着数字技术和高效率音视频压缩技术的出现，与模拟系统相比，可以提供更多节目（内容），同时可以提供更高质量的具有数据显示（节目指南，交通信息）功能的声音业务（如在AM波段下的FM业务，以及在立体声和多声道环绕声系统（如5.1系统）下的T-DAB CD质量）。并且数字声音系统能提供静止图片功能。如需视频和/或数据功能，则听众必须购买专用接收机。

听众从众多新节目中获益，这要归功于所采用的高效数字技术：从1 bit/Hz/s至4 bit/Hz/s 。

c) 便携性，移动性

用户希望在相同功能前提下，相比模拟系统（AM，FM）而言具有更强的便携性和移动接收性能。

d) 高效性

数字技术的引入使得以下成为可能：

– 在所划分频道内频率效率得以改进（更多的节目），同时可以在无干扰情况下使用相邻频道；

– 对于某些覆盖区域而言，能够在大幅度降低辐射功率情况下获得更好的音频质量：比如，对于DRM系统，只需要80 kW而非250 kW峰值功率。

2.5.1 数字声音广播系统描述

在地面声音广播方面已经开发了多种不同系统。本报告考虑以下系统：

– DRM — 世界数字广播 — （系统A，ITU-R BS.1514建议书）。

– IBOC — 带内同频（系统B，ITU-R BS.1514建议书和系统C，ITU-R BS.1114建议书）。

– ISDB-T_{SB} — 综合业务数字地面广播 —（系统F，ITU-R BS.1114建议书）。

– T-DAB — 地面数字声音广播 — （系统A，ITU-R BS.1114建议书）。

（有关以上系统的具体信息详见第2部分。）

2.5.1.1 DRM

DRM国际集团研发的地面世界数字广播（DRM）（数字系统A，ITU-R BS.1514建议书）设计用于为车辆、便携和固定接收机提供高质量数字卫星广播服务。其设计操作于任何低于30 MHz以下的地面频率。系统允许开发本地业务（26 MHz频带MW和/或SW），国内业务（高功率LW、MW、在SW波段的NVIS，甚至是从位于目标区域较短距离发射站发射的SW）以及最终是用于长途和超长途业务（SW）的国际业务。

DRM系统是一个可靠同时具有较高频谱和功耗效率的声音和数据广播系统。它采用高级数字技术，从音频源信号中去除冗余的以及感官上认为不相关的信息，然后在发射信号上施加密切控制的冗余码，以便用于误码纠错。被发射信息然后扩散至频率和时域，甚至是工作在严重多径传播（天波传播）环境下包括静止、便携和移动状态的接收机上都能获得高质量信号。频谱有效利用度接近4 bit/Hz/s。DRM允许在国际电联频道（9或10 kHz）内广播多达四个不同业务。由于采用了OFDM调制方案，该技术具有频率再利用特性，通过将发射机全部同步工作在相同辐射频率（SFN）上，可以实现广播网络的扩展，这一扩展实际上没有限制。根据传播频道特征，DRM标准包括不同的调制模式，包括从耐震模式C到高效率模式A（在一个10 kHz频道内高达37 kbit/s）。DRM标准允许使用不同类型的并播模式，包括作为妥协版本的允许在同一RF频道内同时用模拟和数字方式广播同一内容的模拟和数字单频道并播模式（SCS），也包括多频道并播模式（MCS）,在这一模式下，可以在两个相邻频道上或者非相邻频道或者采用频率组合方式以模拟和数字方式广播相同内容。例如，在MW上广播模拟内容，同时在SW上广播数字信号。

近期，DRM集团决定将DRM标准扩展应用于VHF波段（波段I和II），扩展标准的具体规范将在若干年后发布。

有关DRM的更详细信息见第2部分第1.1节。

2.5.1.2 IBOC DSB

带内同频数字声音广播（IBOC DSB）系统（仅用于美国）工作于MW和VHF波段II（ITU-R BS.1514和ITU-R BS.1114建议书），也称为HD Radio™系统，该系统设计工作于三种模式：“混合”、“扩展混合”以及“全数字”。操作模式取决于广播的频率、频谱当前使用情况以及广播机构的业务需求。混合操作模式允许在当前模拟信号频道内同时传输模拟和数字格式的相同节目材料。扩展混合模式也支持并播，但允许广播机构在现有模拟信号附近增加数字载波，以便为高级声音和数据业务获取更多数字容量。全数字模式是指在去除现有模拟信号之后或在目前尚未用于模拟广播的相同频道之内的操作，能提供更强功能。

IBOC DSB系统由四个基本部分组成：编解码器，负责对音频信号进行编码和解码；FEC编码和交织，负责通过冗余和多样方式提供更高可靠性；调制解调器，负责将信号进行调制和解调制；以及混频器，负责将数字信号平滑转换为现有模拟信号（对于混频和扩展混频操作），或转换至备份数字信号（对于全数字操作）。

IBOC DSB系统为广播机构和听众提供了若干益处。在VHF和MF中，系统能提供增强的声音质量。VHF广播能提供接近CD质量的声音，而MF广播能提供接近VHF质量的声音。系统还允许广播机构提供多播功能，这使得广播机构可以在现有模拟节目并播基础上，再引入多达七个频道的新数字音频业务。IBOC DSB可提供节目相关数据，并将此列为基本功能。这将允许接收机显示音乐家、曲名信息和其他滚动数据。系统还允许广播机构提供高级数据业务，如交通和天气信息，导航系统更新，股市指数，音频存储和重放，以及电子节目指南等。

有关IBOC DSB的更详细信息见第2部分第1.3节。

2.5.1.3 ISDB-T_{SB}

综合业务数字广播-地面声音广播ISDB-TSB系统（在ITU-R BS.1114建议书附件3中也称为数字系统F）设计用以提供高质量声音和数据广播，具有高可靠度，甚至可以用于移动接收环境。系统也设计用以提供灵活、可扩展和一致的地面网络多媒体广播，并符合ITU-R BS.774建议书规定的系统要求。

ISDB-TSB系统是一个可靠系统，采用OFDM调制、2维频率-时间交叉复用以及串联误码纠错。系统采用的OFDM调制称为BST-OFDM（频带分段传输OFDM）。系统与数字地面电视广播ISDB-T系统在物理层具有一致性。一个OFDM块（称为OFDM分段）的带宽大约为500 kHz。系统包括一个或多个OFDM分段，因此系统带宽大约为500 kHz或1.5 MHz。

ISDB-TSB系统的传输参数很多，如载波调制方案，内部纠错码编码速率，以及时间交织长度。载波中的一部分被分配用以控制载波，这些载波发送有关传输参数的信息。这些控制载波称为TMCC载波。

ISDB-TSB系统可使用高压缩率音频编码方式，如MPEG-2第II层，AC-3和MPEG-2 AAC。该系统也采用MPEG-2系统。它与其他许多采用MPEG-2系统的系统如ISDB-S、ISDB-T、DVB-S和DVB-T具有一致性或互操作性。

有关ISDB-TSB 的更详细信息见第2部分第1.4节。

2.5.1.4 T-DAB

地面声音广播（T-DAB）是在Eureka 147项目之内开发的，（ITU-R BS.1114建议书的数字系统A）设计用以为车载、便携和固定接收机提供高质量、多业务数字无线电广播接收。它设计工作于3 000 MHz以下任一频率的地面、卫星、混合（卫星和地面）以及有线广播传输。系统也设计为一种灵活、多功能综合业务数字广播（ISDB）系统，能够支持很多源及频道编码选项，声音-节目相关数据和独立数据传输业务，符合ITU-R BO.789和ITU-R BS.774建议书有关灵活和多样业务及系统的要求。

T-DAB系统是一个可靠的，同时具有很高频谱和能源效率的声音和数据广播系统。它采用高级数字技术，从声音源信号中去除冗余和感官不相关信息，然后在传输信号中加入密切控制的冗余信息用于纠错。然后，传输信息被扩散至频率和时间域，从而即使在恶劣多径传输环境下（不论是静止还是移动）也可以在接收机中获得高质量信号，

有效的频谱利用是通过对多重节目信号进行交叉复用实现的，而频率再利用的特点之一是允许广播网络通过利用新增全部同步并工作在统一发射频率（SFN）的发射机进行扩展，这一扩展实际上可以是无限制的。

有关T-DAB的更详细信息见第2部分第1.2节。

2.6 数字地面电视广播

2.6.1 介绍

数字电视于1994年引入美国，1996年引入欧洲和日本，起初是卫星电视，随后很快发展为有线和地面网络，其技术基础为高级电视系统委员会（ATSC）、数字视频广播（“DVB”）以及综合业务数字广播（ISDB）规范。

2002年，欧盟家庭平均普及率预计为3200万（21%）：卫星：2150万（13.9）；有线810万（5.2%）；地面260万（1.7%）。卫星电视数字化占市场主导地位。

随着数字电视的到来，公众管理机构必须考虑未来发展问题，并就模拟向数字电视的转换做好准备，使其尽可能平滑转换。美国计划于2009年2月终止模拟电视广播。日本计划于2011年7月终止模拟电视广播。韩国计划于2012年12月开展模拟向数字转换工作。一些欧洲国家已经决定采取截止期做法，模拟电视广播将于该截止期之后终止，欧洲范围内已经就2012年截止期问题达成一致。巴西计划于2016年终止模拟电视广播。

因此，政府监管机构有必要研究开放数字电视业务带来的潜在政治含义、新增业务、市场（潜在观众和金融流量）、频道可用度等问题，当然还包括此类业务与现有模拟网络的技术整合问题。

这一过渡进程的第一阶段是要建立一个监管框架（法律或条例），以管理数字电视的引入，规定允许的复用数量（每个复用有几个广播频道，一个复用占用量相当于一个模拟频道）以及业务类型。

从主要依靠模拟技术应用的电视业务向基于数字技术过渡的进程已经进行了近三十年。这种电视业务的过渡是电视、电信和计算机技术和科学通过共享数字技术而走向融合过程的自然扩展。

分别处于相机和接收机两端的电视系统的输入和输出信号本质上是模拟的。因此，自然要问“因何数字化？”这个问题。

因为在模拟信号中，信号衰减是累积的，由于衰减特性的存在，使得恢复图像信号这一工作非常困难，而数字脉冲序列的再生能力理论上能够使数字信号不受外界干扰源的影响。数字比特流能够在一个单独频道内交叉复用。这一交叉过程使得可以在传输视频和相关音频信号的同时发射、传输、存储和处理附加信号。而且，基于冗余还原的压缩技术可以用于数字视频和音频业务，这使得能够在现有广播频道内传输HDTV业务、多标准业务或HDTV与SDTV复合业务。

随着1990年代第二代和第三代分量和合成数字磁带记录器、交换机、动画图片和特效机以及有关串行数字信号接口的出现，加速了全数字制作设备发展进程。数字制作和数字磁带记录器推动了广播机构多代编辑从采用模拟技术的五代后期编辑向采用数字技术的数十代方向发展。数字技术的应用将相机设置时间从几个小时缩短为几乎瞬时完成。数字图书馆系统将存放录制媒体的场所向用户透明开放。计算机对整个进程的控制深入到节目制作和分配设备，确保了控制的精确性和功能的可重复性。

数字广播技术首先用于演播室和发射站之间的传输，可以通过卫星或地面链路实现。

由此可见，数字地面电视广播（DTTB）有如下优势：

与模拟电视相比，除了能提供更多频道外，数字地面电视（DTT）优势还在于能鼓励收视者为接收节目而购买或租借解码器：

a) *更高的画面和伴音质量* — DTT发展背后的动力在于能向消费者传输高清电视（HDTV）。具有高质量环绕声的HDTV是地面广播、卫星和有线等所有传输平台聚焦的重点。HDTV也可以过蓝光技术通过光盘传输。

b) *诱人心动的新节目* — 要吸引人，必须能够实实在在地有足够能力抓住观众。三类频道最有可能引起收视者兴趣：通用频道，这需要采用革新或差异化方式将其与现有频道分开；更为主题化的频道，能足够包容且吸引较大范围的目标观众；以及本地或区域频道，这主要呼应收视者切身所处地理环境关注的社会经济和政治问题。

c) *便携性* — 从绝对意义上讲，这是一个理想的技术方案：通过将天线集成在或连接在机器上，即使利用一个便携机，也可以在户外或者在屋内任意地方接收电视。但从广播基础设施方面讲，这将会使成本很高，因为主发射机必须另外增加中继器才能为DTT覆盖范围内所有收视者提供便携接收功能。

d) *互动性* — DTT也可为收视者提供互动业务和应用，换句话说，能提供电视用户和业务提供商之间对话功能，比如，提供信息和交易服务如电视购物，赌博和银行交易等。技术融合最终应能使电视为多种功能的指引者或存放器。然而，互联网在一些国家相对滞后的发展速度表明，有一部分人不愿意使用此类业务。而且，一些人认为电视遥控器并非浏览互动节目或业务的最为用户友好的工具，但在对连接和反映时间做出改进之前，可能还需要一些时间。

e) *移动性* — 地面广播相比较与其他形式的广播来说，最明显的优势在于能为汽车、卡车、公交车和列车提供移动接收。

切换最难之处就在于地面电视，原因是多方面的，包括在一些地区缺乏频谱，广域覆盖的成本，相对有限的网络容量，已经在位的竞争电视提供商，以及商业上出现的差错等。

不过，各国之间在市场变量方面差异很大，比如各电视网络（地面，有线和卫星）普及率和商业模式（免费空中传输相对于收费电视）等方面，但各国在数字广播过渡政策方面也有差异。目前看来，数字电视主要在卫星付费电视方面发展，而免费空中传输方面只占总数字电视收视率的不到20%。付费电视驱动力依次为多频道，高质量节目，以及运营商对于机顶盒的补贴。

2.6.2 数字电视广播系统描述

围绕地面广播，已经开发了多种数字电视系统。相关系统为：

– ATSC DTV — 高级电视制式委员会 — （系统A）。

– ATSC-M/H — 移动和手持高级电视系统委员会。

– ChinaDTV — （GB 20600-2006：“数字电视地面广播系统帧结构，频道编码和调制”）。

– DVB-H — 数字电视广播 — 手持。

– DVB-T — 数字视频广播—地面—（系统 B）。

– ISDB-T — 综合业务数字地面广播-（系统 C）。

– T-DMB兼容T-DAB（ITU-R BT.1833建议书、ETSI TS 102 427和ETSI TS 102 428）。

– ISDB-T_{SB} — 综合业务数字广播—地面声音广播 —（ITU-R BT.1833建议书的多媒体系统F）。

– FLO — 单一前向链路（ITU-R BT.1833建议书，多媒体系统M，TIA-1099）。

有关系统A、B、C的详细信息见ITU-R BT.1306建议书和ITU-R BT.2035报告 — 数字地面电视广播系统评估指南和技术。ITU-R BT.1833 — 用于手持接收机移动接收的多媒体和数据应用广播，将T-DMB定义为多媒体系统"A"，ISDB-T 一部分定义为多媒体系统"C"，ISDB-TSB定义为多媒体系统"F"，DVB-H 定义为多媒体系统"H"，以及单一前向链路（FLO）定义为多媒体系统"M"。

更多细节见第2部分。

2.6.2.1 ATSC

ATSC数字电视标准设计目的在于在一个6 MHz地面电视广播频道内最大化传输高质量视频和音频以及附加数据。该设计促进实现了数字高清电视（HDTV）和多声道环绕声，以及提供多频道标清和数据广播以及互动业务的能力。

地面广播的8-VSB调制模式设计目的在于提高频谱效率，在低接收机信噪比（C/N）门限要求情况下实现数据吞吐量的最大化，既能抵御同频道干扰也能抵御邻频道干扰，且传输误码率要低。8-VSB特点是能够在既包含模拟又包含数字电视信号的拥挤频谱环境下使用DTV频道。8-VSB较低的功率要求使得ATSC DTV站点能在模拟站点因干扰问题而不能工作的频道上生存。8-VSB的频谱效率和功率要求特性对于地面广播传输从模拟向数字转换非常重要，因为在转换期内不会分配新的频谱。

ATSC系统采用MPEG-2 传输流语法，用于数字广播系统视频、音频和数据信号的分组和复用。ATSC标准A/65定义的程序和系统信息协议（PSIP）是一个很小的表格集合，设计用于工作在数字电视地面广播每一传输流（TS）之内。其目的在于描述为某一具体TS承载的所有虚拟频道（频道数量不直接受限于真实射频频道频率）的系统和事件层级的信息。另外，模拟频道以及来自其他传输流的数字频道的信息也可能纳入在内。

ATSC采用MPEG-2视频流语法（高层级基本型）用于视频编码。表1列出了ATSC数字电视标准允许的压缩格式。这里要注意的是，60.00 Hz和59.94（60x1000/1001）Hz图片速率都是允许的。此外，还允许图片速率在30 Hz和24 Hz的双速率。

表 1

压缩格式

垂直线	像素	纵横比	图片速率
1080	1920	16:9	60I, 30P, 24P
720	1280	16:9	60P, 30P, 24P
480	704	16:9和4:3	60P, 60I, 30P, 24P
480	640	4:3	60P, 60I, 30P, 24P

ATSC A/52B定义的ATSC标准-数字音频压缩（AC-3）用于音频压缩。A/52B标准也定义了可提供附加编码工具和功能的增强AC-3（E-AC-3）。

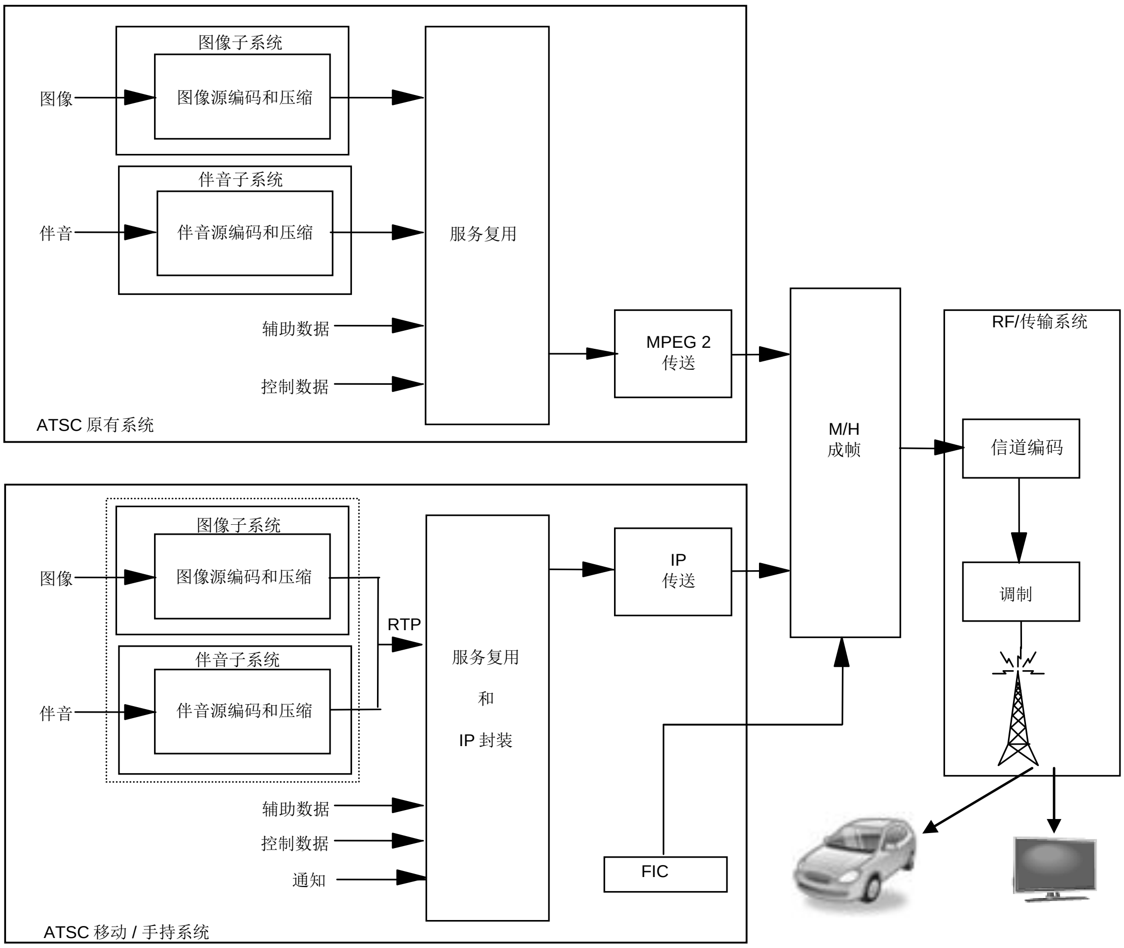
ATSC开发了一整套数据广播标准，其中，ACAP标准用于交互式电视业务。

ATSC-M/H

ATSC-M/H（A/153）利用~19.39 Mbit/s ATSC 8-VSB有效负载的一部分提供移动/步行/手持广播业务，而剩下部分依然可以用于HD和/或多SD电视业务。M/H系统是双流系统，ATSC业务用于现有数字电视业务，M/H业务用于一个或多个移动，步行和手持业务。

ATSC移动/手持业务（M/H）按ATSC A/53描述的那样如同一个标准ATSC广播业务一样，共用同一射频频道。M/H使用总共19.4 Mbit/s的带宽的一部分，通过IP方式传输。M/H系统总体情况见图4。

图 4



有关ATSC更详细信息见第2部分第1.5节。

2.6.2.2 ChinaDTV

中国DTTB国家标准，“数字电视地面广播系统帧结构，信道编码和调制”由中国标准化主管部门于2006年8月18日发布，并于2007年8月1日起生效。ChinaDTV系统设计上内置有灵活功能，能够适应多种接收环境：它既能处理固定接收也能处理移动接收，同时支持在模拟电视频道附近的临近频道内的应用，以及相同节目的单频网络框架。

ChinaDTV系统在PN顺序帧头和符号保护间隔插入（可以取得快速和有效的频道预测和均衡）、低密度奇偶校验编码（LDPC）以及系统信息扩频传输等方面进行了特别设计。系统支持从4.813 Mbit/s至32.486 Mbit/s的数据速率，可应用于标清电视（SDTV）和高清电视（HDTV）。而且，系统还针对中国目前正在使用的8 MHz频道间隔进行了设计。

它提供灵活的业务变化特性，可以实现64-QAM、32-QAM、16-QAM、4-QAM、4-QAM-NR的星座映射, 具有FEC 编码LDPC（7488, 3008），（7488，4512），（7488, 6016），帧头部长度 PN420、PN595、PN945，以及两种类型的卷积交叉复用可能性，根据需要还可提供其他更多选项。可以使用4-QAM-NR、4-QAM甚至16-QAM以及更高阶调制方式实现移动接收，这已经大量实验室测量和不同频道环境的现场试验中得以证实。

系统在不同环境下都具有较强抗破坏能力，能抵抗坡面或楼宇回声或来自远距离发射机或SFN之内的同频道信号干扰。该功能对于中国目前拥挤频谱环境下进行的数字电视业务规划工作，将起到改善频谱利用效率方面的作用。

ChinaDTV系统包括能量扩散随机化处理、信道编码、交织、星座映射、帧结构、帧信息处理、UHF和VHF波段数字电视频带8 MHz基带信号及射频信号理等。

目前，一系列相关数字地面电视规范正在研发之中，奥林匹克城市正在建设若干发射站，HDTV节目已于2007年10月在北京开通。

2.6.2.3 DVB-H

音视频和电信业务的融合早已开始进行，大多数电信业者希望可以在xDSL上传输电视。毫无疑问，在这一发展过程中，很快将会有用户希望获得相应的业务环境。8-15年的机会窗口预计将会给相关业务带来收益（8年是大多数国家从现在到关闭模拟电视并播的大致时间框架，而1-15年是新的、正在研究相关指标要求的所谓“4G”的新兴无线电系统普及的时间，且假定3G需要10年时间才能获得收支平衡）。机会来自这样一个事实，即联合DVB-T/H的蜂窝系统将潜在具备预期的部分4G功能。

作为商业提供移动融合业务的基础，DVB-T/DVB-H标准、无线电通信网络（GSM/GPRS，UMTS）及地面DVB广播网络概念等起到了重要作用。

在新商业和监管环境下，由于业界对投资短期回报的希冀，各国际工作组如DVB和3GPP的长期活动步伐已经减慢。该项目将充当近期趋势与最新技术发展之间的桥梁，特别是通过支持DVB-H标准（对于DVB-T很重要，因为DVB-T目前正在受到ISDB-T在移动和功耗问题上的挑战）使得DVB能够保持其在播放标准工具箱方面的全球控制地位。

欧洲议会经济与科学政策局开展了有关移动电视方面的研究（2007年10月）。

有关DVB-H方面更详细信息见第2部分第1.7节。

2.6.2.4 DVB-T

数字地面电视广播（DVB-T）系统设计主要目的在于具备内置灵活度，以便能用于所有频道：不仅可以处理无干扰频道也可以处理交织规划频道（即相邻于模拟传输的频道），甚至是不同发射机（SFN）共用一个频道进行相同节目操作。

多载波（DVB-T）系统设计初衷是为了用于欧洲8 MHz UHF频道间隔，并已被改造用于7和6 MHz频道。根据其编码和调制参数的不同，可以实现20到30 Mbit/s的数据速率，以便通过广播频道传输高质量数字电视。同样的，如需更高可靠度，也可降低数据的速率。

它也允许实现业务灵活度，可以通过屋顶天线接收，也可根据需要实现手持接收。四相键控（QPSK）和高阶调制也可实现移动接收，这已经大量实验室测量和不同频道条件下现场试验所证实。

系统设计时也考虑了可靠性问题，以抵御延时信号（可能是来自坡面或楼宇的回音，也可能是来自SFN远距离发射机的信号）的干扰。对于欧洲正在发生的拥挤频谱条件下进行的数字电视业务规划来说，该功能将有助于频谱利用效率的改善。

DVB-T系统具有很多可选参数，这使得它能够适应大范围C/N值和频道行为，允许固定、便携或移动接收，在可用比特率上具有开销功能。参数范围允许广播机构根据预测的应用选择合适的模式。在数字业务与模拟业务交织情况下（例如，与模拟信号相邻的频道），可以选择一个可靠性较强且有效负载较高的模式。如果数字电视广播可以使用无干扰频道，则可采用可靠性较低而有效负载最大的模式。

有关DVB-T更详细信息见第1部第1.6节。

2.6.2.5 ISDB-T

综合业务数字地面广播（ISDB-T）（用于日本）设计用以提供可靠的高质量视频、声音和数据广播，不仅用于固定接收机，也可用于便携/移动接收机。系统也为多媒体广播提供了灵活性，扩展性和一致性/互操作性。系统较为可靠，原因是采用了正交频分复用（OFDM）调制，二维（时域和频域）交叉复用，以及串联纠错编码。

ISFB-T系统采用具有频带隔离的OFDM调制，后者也称为频带分段传输OFDM（BST-OFDM）。ISDB-T 系统包括13个OFDM分段。每个分段的带宽为B/14 MHz（B表示地面电视频道带宽：根据不同地区，分别为6、7或8 MHz），因此一个分段占用带宽为6/14 MHz（428.57 kHz）、7/14 MHz（500 kHz）或8/14 MHz（571.29 kHz）。系统具有很多传输参数，可以选择载波调制方案，内部纠错码编码速率，交织时长等。每个分段被分配给一个层，可为其单独选择一整套传输参数。

系统最高支持三层的层级传输（A、B和C层）。在这些层中，每一层的传输参数都可以改变。特别的，该层级传输的中心段可通过手持接收机接收（称为“一段”）。由于每个OFDM段都具有共同结构，一个一段接收机可以“部分”接收ISDB-T信号中心段传输的节目（部分接收这一称法主要是指接收机只能接收一部分传输带宽）。系统具有三种传输模式（模式1，2和3），各自具有不同载波间隔，以处理多种情况，如由网络配置和移动接收中发生的多普勒频移等因素确定的可变保护时间长度等。

系统采用MPEG-2视频编码和MPEG-2高级音频编码（AAC）。另外，它采用MPEG-2系统用于数据流的封装。因此，各种不同形式的数字内容，如语音，文字，静止图片和其他数据都能同时传输。它与其他使用MPEG-2系统的系统，如ISDB-S、ISDB-C和ISDB-TSB等具有一致性和互操作性。

有关ISDB-T的更详细信息见第2部分第1.8节。

2.6.2.6 T-DMB

在移动多媒体广播业务方面，韩国开发了一个视频标准，称为地面数字多媒体广播（T-DMB），该标准完全后向兼容于T-DAB。地面数字多媒体广播（T-DMB）设计用于为移动环境中的用户提供视频服务，可后向兼容于数字声音广播（DSB）系统A。MPEG-4 AVC已知具有高达两倍于MPEG-4 第2部分视觉（ISO/IEC 14496-2）的压缩效率。MPEG-4 BSAC已知具有与MPEG-4 AAC（高级音频编码）相同的压缩效率，其特点是具有细粒度升级性这一附加功能。场景二进制格式（BIFS）与可以平滑实现不同类型互动业务多媒体对象的MPEG-4 同步层（SL）一起，为各种多媒体对象提供了灵活组建功能。对于音频业务，ITU-R BS.1114建议书所述的DSB系统A采用MUSICAM，而T-DMB采用MPEG-4 BSAC或MPEG-4 AAC 以及MUSICAM，以提供具有静止图片和文本的丰富业务。

有关更详细信息见ITU-R BT 2049报告及第2部分第1.9.1节。

2.6.2.7 单一前向链路（FLO）

单一前向链路（FLO）是一种移动数据广播技术，设计用以提供手机广播多媒体内容移动接收，以解决手持终端的物理缺陷，包括功率消耗，内存，移动性和形状因素限制等。FLO的业务元素包括实时广播视频和音频流的接收；多媒体业务的接收，以及相同载波广域和本地内容等。FLO系统设计用以提供通过IP实现接收控制、注册管理和交互式业务。

2.6.2.8 ISDB-T_{SB}

ISDB-TSB 系统在ITU-R BT.1833建议书中被称为多媒体系统“F”，设计用以提供可灵活设置的视频、高质量音频和数据业务。此外，通过对富文本格式的支持，在手持接收机多媒体广播接收中提供内容和业务灵活性。

更详细信息见第2.5.1.3节。

2.7 总结

表2

标准	频道	频带	调制	适用标准
ATSC	6 MHz	UHF/VHF	8-VSB	A/52,A/53, A/65, A/153
ChinaDTV	8 MHz	UHF/VHF	OFDM	GB 20600-2006
DVB-T	6、7及8 MHz	UHF/VHF	OFDM	EN 300 744
DVB-H	5、6、7及8 MHz	UHF/VHF	OFDM	EN 302 304
ISDB-T	6、7及8 MHz	UHF/VHF	分段OFDM	ARIB STD-B31
T-DMB	1.75 MHz	VHF/1.5 GHz	OFDM	ETSI TS 102 427及ETSI TS 102 428
FLO	5、6、7及8 MHz	UHF/VHF	OFDM	TIA 1099
ISDB-T_{SB}	0.43、0.50、0.57 MHz 1.29、1.50、1.71 MHz	UHF/VHF	分段OFDM	ARIB STD-B29

2.8 对于潜在数字声音和电视广播系统的评估

近期，世界不同地区已经提出了若干数字广播系统。

当前部署的所有系统都取决于是否具备高压缩码率高效编码系统，而这一编码系统在数字内容转变为与现有空中频道特性一致的数值时必不可少。

对于电视广播而言，即使近期已出现一些更为新型的、也可能更有效率的编码标准，但这并不能阻碍各个层面的MPEG标准在全球范围内获得采纳。

目前现有各种数字传输系统是在不同时期提出的，较新系统吸取了之前系统的优势和劣势。

在寻找数字广播真正“杀手级应用”过程中，最重要的一点是要求数字标准能适应可能的高级广播业务。对于数字电视广播，这包括互动性、数据播放、可携带性以及移动接收等。

2.8.1 对于具体地面数字声音和电视广播的评估

现有数字电视和声音广播标准大致可分为两类：

– 单载波编码（如美国标准ATSC-DTT使用的8-VSB）

  8-VSB系统基于对需传输数字信息进行的单一幅度（8级）编码。调制信号随后通过奈奎斯特滤波器处理，以降低传输带宽。

– 多载波（COFDM的各种演进形式），基于DVB-T、DAB（欧洲和参加RRC-06会议的国家采用此模式）、ISDB-T（日本采用）以及其他编码。

COFDM方式建立在对工作频道内大量载波进行数据分割的基础之上。然后对各载波相关数字信息进行幅度和相位（如QPSK、16-QAM、64-QAM）编码。同时传输的、对应于不同载波的数字数据组成一个OFDM符号。

基于COFDM的编码允许通过物理频道传输包含若干可由接收机选择和提取的内容的复用信号。

而且，分置于许多载波中的信号通过整个频道带宽进行传输，同时引入错误恢复系统以保证数据的完整性，这样就使得COFDM系统可以像DVB-T一样被考虑作为SFN网络的实施方案，而在SFN中，相同频率被用以在相邻覆盖区域内传输，对于因发射机操作在同一频率而引起的信号之间同频率干扰所引起的衰落，可以通过COFDM系统特色功能得以恢复。商业SFN网络（在DVB-T中）已在澳大利亚和西班牙等地部署。

由于对于干扰具有同样高的防护能力，这使得COFDM数字广播系统也适用于移动接收。特别适合这一用途的是近期发布的载于ITU-R BT.1833建议书中的手持接收标准。在该标准中，特别考虑了电池寿命保护、误码纠错机制等问题，以增强系统的可靠性。

ATSC已经开发了ATSC-M/H系统，该系统能够允许广播机构使用其现有DTV频道向移动和手持设备提供服务，而同时仍能保持其与大众性的DTV接收机的后向兼容特性。

有关更多细节，见第2部分第1章。

2.8.2 混合系统

一些卫星系统采用XM radio、Sirius等地面组件以改善其业务质量。更多信息见ITU-R BO.1130和ITU-R BS.1547建议书有关数字系统E部分内容。其他系统也可能采用类似方法。

第3章

3 数字广播的应用和部署

传统上，广播和电信是分开考虑的，从而形成了各自纵向的市场格局。数字融合意味着相同数字内容可以在任意此类网络中传输，这潜在地在各个价值链层面创建了新的横向市场，如内容，业务提供，网络操作和终端，从而开辟了极富希望的新商业机遇。人们也第一次有机会选择固定、便携和移动等各种类型传输平台以合理价格接收各种多媒体业务。

从模拟向数字广播的切换，也即转换，是一个具有社会和经济含义的复杂过程，远远超出纯技术过渡本身。数字广播发展是有积极意义的，因其同时改善了业务范围和质量，这主要归功于数字压缩技术。这不仅改善了频谱使用效率，而且改善了网络负荷。

声音和数字电视切换应是一个包含各种网络、商业模式和业务的包容性进程，包括免费的空中电视，更高质量的图片或数据和交互式业务。模拟业务的关闭应只在数字广播已取得大致普及之后才能进行，要认真考虑以上各种可能性，以确保社会成本的最小化。政策干预应在第一时间在国内层面开展，要考虑所在广播区域成员国之间的市场和政策差异。不过，ITU也有其用武之地，特别是有关内部市场问题上。ITU可能做的贡献主要包括：基准线，设备标准，消费者信息，协调和促进增值业务接入等。

业界正在开展有关促使数字融合成为现实的技术研发工作。数字融合允许内容和业务提供商通过多种传输方式传输其产品。相对应的，消费者可以通过各种多媒体内容终端接收服务，还可以通过单一终端接收多种服务。这将使得传统广播与电子通信领域之间的界限更为模糊，从而对媒体传输领域产生深远影响。因此，应认真拟定监管条款，以反映这些变革。

3.1 监管考虑

监管应允许通过各种类型传输网络提供多媒体业务，而且应为各方提供一个在新横向市场公平竞争的环境，并纠正市场的缺陷。为促进这一进程，现有的政治和监管架构应加以修正。

频谱政策（包括并考虑诸如划分、指配和开放等项目）有必要为所有竞争者提供一个协调、开放、透明和非歧视的准入，并提供足够并恰当的传输容量。为促进全球业务和传输的发展以及设备制造的互操作性和经济规模性，应鼓励全球协调一致的频谱使用方式，而同时要有一定灵活度，以免妨碍有关通过频谱管理和执照发放等方式在促进竞争和技术进步方面所做的努力。

电信和广播网络至今仍在独立的、垂直导向的标准和监管环境下向前发展。广播一直就是无线电和电视，而电信就是话音。近期，数据通信已在其IT标签之下发展起来。随着数字化进程的发展，电信、电视和无线电业务以及数据通信之间的界限将消失。结果便是，未来传输结构如果依靠其传输的业务类型来分辨的话将会变得非常困难。相应的，对于监管领域，需要确定新的定义。

新监管环境也应允许通过各种类型传输网络（广播和移动）提供多媒体业务。实际上，如果对于内容传输的类型不加以限定，网络用途将得以扩展并变得更加灵活。用途扩展将增加新建网络的投资，并促进技术的进步。

3.2 广播频谱的有效利用

模拟向数字广播的过渡已经在一些国家开始实施，并有望在未来几年在全球铺开。在模拟和数字并播的实际持续期即模拟传输终止期问题上，各国有不同规定（许多欧洲国家已表示将2010年设定为数字电视的目标时间）。

这一转换过程包括诸多要素：

– 数字电视的开启，

– 模拟电视的关闭，以及

– 如何处理模拟电视频谱的再利用（“重新划分”）问题。

这方面的进展将为新业务带来新的容量，比如在传输相同内容所需带宽问题上，数字方式只需模拟方式的一小部分。因此，利用现有无线电频谱可以解决更多数字电视节目的提供问题。而且，新类型数字业务和内容可以通过这一数字广播频谱提供，这是指数字技术引入期更多的是指模拟广播关闭之后，只有到那个时候才能显著增加广播电视（视频）节目的数量。因此，在固定、便携和移动环境下，额外电视和无线电广播以及其他交互式业务，比如IP数据广播和交互业务，将有很大发展机会。

未来全数字化的好处只有在模拟广播关闭之后才能实现。关键问题是要确保诸多不同业务提供商提供的诸多不同业务能够到位，并确保开放性和中立性，以便为业务创新、技术革新和活力竞争铺平道路，造福消费者和整体经济。

3.3 声音和电视广播业务要求

3.3.1 网络方面

数字地面广播在便携、移动、综合接收机和机顶盒接收方面的优势全面证明了最大化地面覆盖的必要性。在许多国家，大多数家庭通过地面方式接收模拟广播。对于那些只想接收免费数字空中业务的家庭，很可能将通过地面方式接收这些业务。现有地面模拟网络基础设施完全能用于这一目的。

单频网络（SFN）概念能在有限地理区域提供服务方面有效节约频谱。

不过，对于DVB-T，由于有了2K和8K模式以及若干保护间隔，系统可以提供有效的SFN规划工具，用于包括移动接收在内的多项用途。众所周知的是，在广播世界里，通过使用直放站或中继器，发射机也可以轻松实现接收性能的增强，并能同时完全兼容未来升级要求，具备更轻便和移动的接收可能。这意味着可以在合理成本上实现网络移动和便携接收方面的扩展和修正。

用户正在快速向移动生活方式转变。2G，3G和未来技术已经教会我们如何在我们日常通信中使用移动蜂窝技术。通过DVB-T/H并同时利用2G/3G作为回传频道接收移动广播数据播放业务，消费者将能接收新型内容业务，并将获得更强的交互功能。DVB-T/H和蜂窝网络技术的相互利用将为消费者提供与位置无关的个性化服务。

3.3.2 接收机方面

主要可能有四类接收机：

1 采用屋顶天线或固定室内天线的用于固定接收的固定数字电视机和机顶盒。

2 便携电视或收音机。

3 车载终端和移动手持终端，可能集成2G/3G蜂窝功能。

4 移动/便携宽带无线系统。

第3和第4类，也即手持和便携终端，将采用电池操作，因此必须关注低功率消耗问题。从而，必须特别考虑创建满足此类要求的无线电环境，同时也要满足从终端和射频角度看的用户友好性和方便性。特别地，在电视方面，对当前环境的主要考虑是在全部UHF波段内置入数字频道，从而使高功率模拟频道与数字频道相邻。这使得终端射频组件必须具有非常高的线性度，这需要消耗过多的能源。为便携/移动数字数据广播和宽带无线保留一个一致的频谱将大大缓解这一状况。

3.4 有关系统互操作性方面的问题

关于更为复杂如应用编程接口（API）等方面的功能问题，必须鼓励具有互操作性和开放性的互动电视业务方案。成员国将决定是否有必要采用某种标准以改进互操作性和用户的自由选择权利。的确，在市场驱动的切换方案中，这两个标准很可能推动消费者采纳数字广播，从而减少公共干预的必要性。

新技术引入和业务融合对系统互操作性起到了促进作用。

有关更多信息见第2部分。

3.5 数字声音广播设备要素

3.5.1 发射机

非线性声音发射机不能被改装或重新用于数字系统。为此，所有此类发射机将不得不在转换期内被替换掉。根据截止日期的不同，可能需安装一些能够进行并播的发射机。从广播机构角度来看，需要考虑经济问题。

用于LF、MF和HF波段的新近建成的发射机可用于数字操作。

3.5.2 传输天线

在转换期内，在MF、HF、VHF波段内使用的宽带天线从技术/经济角度来看不成问题，因为不需要技术干预。

用于MF、HF、VHF频带的窄带天线将对数字载波带来相应衰减和相位转动，从而带来质量上的相应下降。在此情况下，根据天线功率和所用系统类型，需采取相应技术/经济干预措施。

对于LF发射，实际困难在于天线带宽以及相应的经济和技术问题。

3.5.3 接收机

用户希望一个价格适中、易于使用的终端，既能接收数字声音广播业务，又能接收模拟广播业务。

第一台消费类数字终端于2003年底出现在市场上。

关于数字市场问题，意大利等国对于工作在VHF和部分L波段（1452 至1492 MHz）终端感兴趣。

预期近期业界主要精力将集中在便携和移动/手持接收机上，前提条件是需要具备必需的频谱。

而且，有必要考虑的是，这种类型的终端需要集成哪些网络和业务平台，而从历史上来看，这两者是独立发展的。

实际上，需要着重考虑的有以下几个问题：

– 电信网络重点在于个人无线和有线交互式通信。

– 宽带网络向普通消费受众传输单向节目。

数据网络满足了商业和家庭用户日益增长的互联网流量和文件下载方面的需求。

在模拟向数字系统转换过程中，用于LF、MF、HF、VHF、UHF波段接收的宽带天线从技术/经济角度看不构成问题，因为不需要采取技术干预措施。

用于LF、MF、HF、VHF、UHF波段接收的窄带天线在数字载波上产生相应的衰减和相位转动，带来相应的质量恶化。

3.6 数字电视广播设备要素

就电视广播而言，数字电视标准方面的工作可被视为已经完成了。现在，必须认真考虑的是不同传输系统要素之间的互操作性和传输系统与市场现有机顶盒（STB）之间的兼容性问题。

3.6.1 发射机

除了用合适数字调制器更换现有模拟调制器以便将模拟设备转换为数字设备外，还需特别认真考虑以下几个问题：

– 系统工作于“共用放大”模式的能力，即放大整个信号而非其单独载波（比如音频和视频载波）。

– 具有较低交叉调制的系统线性度（在数字领域表述为阈值电平）。

– 参照频率源产生的稳定性和相位噪声。

– 系统控制逻辑电路与将数字系统转变过程中要求加入的新要素之间的接口能力。

近期，大部分新推出的模拟设备（大部分用于VHF和UHF波段电视应用）具有所谓“数字可用”特色，以显示其可以转换为数字设备。不管怎么说，这一操作的实际可行性以及潜在的成本必须个案具体分析。

3.6.2 传输天线

用于电视广播的VHF和UHF天线系统通常很适合用于在同一频道增加数字信号的操作。在此情况下，就射频带宽来说不会出现更多问题，因为频道带宽与模拟广播相同。对于数字系统与先前模拟系统不使用同一操作频道或者当一个新数字频道加入现有模拟操作频道后的情形，可能需对天线进行重新调谐，但不需更换其任一组件。虽然很多天线组件都具有宽带特性，但在相同频带内（VHF或UHF IV或UHF V）对操作频率的任一改动都意味着需对天线进行调谐。在很多情况下，通过调谐输入特性就可以解决大多数不兼容问题，这通常可以通过购买特定调谐设备并检查馈线相位来实现。在其他情况下，需要对天线进行重新设计，以符合新的操作条件。

对于DAB业务，由于是在完全不同频率上进行的传输（VHF和L波段），因此需要全新的天线。在VHF波段，由于操作频道带宽比电视使用带宽窄，因此VHF波段设计用于电视广播的天线系统也不一定适合在同一频率上进行DAB广播。

3.6.3 接收机

旧电视模拟接收机可以通过增加符合标准的机顶盒得以继续保留。因此，电视机方面的转换可以逐步进行。

目前在市场上已有多种标准的综合数字电视机。

3.6.3.1 分配网络

对于社区接收来说，需要新建一个分配网络。

3.6.3.2 接收天线

通常而言不需对天线进行改装。但是，在一些情况下，根据所采用的规划标准和所需覆盖的业务区域，可能有必要进行一些改装。

3.7 数据广播

这涉及向计算机或其他数字设备直接传送多媒体内容问题。可以通过在接收设备上安装一个数据卡，以便将其转换为计算机或其他数字设备能使用的格式。互联网的使用和网际协议的采用，对全球多媒体广播市场起到了革命性的影响。目前，欧洲、美国和日本正在多媒体广播方面开发各种标准，国际电联也在开展相关标准化工作。

对于数字广播技术的益处，很明显从模拟向数字的转换将随着时间的过渡在全球展开。这些技术成功的核心要素是具备更高带宽、更便宜接收机、更有效全球频谱利用率以及解决与现有模拟网络之间的互操作问题。

在模拟向数字广播转换之前，有必要找到对应的市场。市场和消费者在技术和业务中寻找可用点和质量。但是，已经证明的是，数字无线电和电视与模拟比较而言，优势很明显。这些优势包括：

- 更高质量的图像和声音
- 更吸引人的新节目
- 便携性
- 交互性
- 新业务
- 较低的发射机辐射功率。

这些因素增强了未来数字市场的可行性。数字技术为新的高级业务提供了发展机遇，正如现今已经证明的互联网促成了风险企业（电子商务）一样，正在出现很多公司，它们将满足不断变化和复杂的消费者需求。参与方也必须将消费者作为重心，并准备随时为消费者和技术用户服务。

相关问题在于复用、数据比特率、视频比特率和音频比特率以及由此带来的对算法、软件和压缩的不同选择或使用。以上问题也可能受传播类型的影响（如等离子传播）。

3.8 移动接收广播业务

无线电第6研究组开发了手持接收机移动接收多媒体系统，见ITU-R BT.1833建议书 – 手持接收机移动接收多媒体和数据应用广播

3.9 接口问题

3.9.1 移动环境下免费接收接口

基于对静止（模拟）地面广播系统业务质量（QoS）的多年经验，移动广播业务未来用户将不只需要更高级的QoS（更清晰的电视图片，更高级的声音质量），同时还要求消除移动环境中由于多径反射和多普勒频移所带来的对广播数据流BER的严重影响。

因此，有必要注意到，这些系统将不只是传统意义上的接收宽带内容，而是要能提供无误码下载所购买的源代码甚至是可执行代码，当然这些内容必须完整无缺地传送至目标客户。

要在现实中减弱此类干扰并非易事，不过一些新标准/规范中已有了新的解决方案。

3.9.2 最终用户环境下干扰造成的影响

音频或视频接收机通常受人为噪声和/或其他业务造成的本地干扰影响。如果能减弱这类干扰，则可以提高系统的效率。

计算机，移动电话和/或家用设备（电动剃须刀，微波炉等）是对固定或便携音频和视频接收机产生较大干扰的主要设备。

无线电第6研究组正在研究电力线传输（PLT） 所致干扰效应。为减弱该效应，各主管部门必须考虑定义和实施相关保护限值的可能性。

第4章

4 转换问题

通常而言，有关数字广播业务的频谱、技术、法律要求和义务等推动了数字广播的部署。

4.1 频谱可用性

4.1.1 有关数字广播方面的考虑

4.1.1.1 技术融合

随着数字技术和数字广播技术的引入，数字广播、计算和其他电信系统之间的差别显得越来越小。因此，这些应用之间的技术融合变得成为可能。

不同技术为声音、电视、附加业务等不同类型业务如提供了不同发展机遇。

数字业务原则上能提供改进的质量和/或在同一频率带宽内提供更多的节目，广播机构有可能在提供广播之外额外提供新的具有吸引力的业务。

而另一方面，移动电话业务技术能提供类似于广播的业务，当然质量有限，但是可以提供便携接收。

4.1.1.2 义务

在一些国家，传统上对一些网络要求有传输某些频道的义务。一些广播机构认为将其义务扩展至数字网络将有助于向数字技术的切换，因为这样用户就会发觉他们原来的模拟广播业务能够出现在数字系统中。但是，网络运营机构担心这些措施的所占比重，以及相关补偿措施的不到位。不过不论在何种情况下，都可以清楚定义这些义务。

4.1.1.3 版权

作为通用原则，数字传输以及模拟传输（并播）版权保护业务需要缴纳额外的版权费，即使在收视人数只有很少增加或不增加的情况下亦是如此。此类需求可能被视为将对数字业务的提供或扩展产生不利影响。应鼓励版权持有者，包括其代表，就通过旨在以过渡为目的的相同传输方式进行模拟和数字并播传输问题提出适当的报价。未来版权许可也应促进业务和数据的调整和丰富，以改善特殊要求用户的接收效果。

数字广播的发展也可能受到某些电视节目只能供该国居民观看这一规定的限制。虽然技术上说要接收此类节目是可能的，但在一些国家，由于版权的地理属性，这可能无法获得版权持有者的同意。

4.1.1.4 数字广播业务的多样化

数字广播将吸引不同类型的消费者，如果能提供多种模拟业务不存在或仅部分存在的业务，比如：

- 固定，便携和移动接收；
- 更高质量的音频和图片，包括宽屏和高清电视；
- 数据和交互式业务，即“信息社会业务”；
- 更多的节目，并因而有可能促进节目的多样化和区域化及本地化发展；

此类数字业务多样化将有助于进一步扩展数字电视的优势，使其给人的印象将不再仅仅是多频道和高级付费业务。而这些作为数字电视市场启动以来的占主导地位的业务，对于同时存在较多频道模拟电视的地区来说通常并不能成为转换的动力。数字业务的最大多样化将帮助确保其与模拟之间的差异，并吸引具有其他类型数字电视业务需求的人群和市场。

公众监管机构可以从各个方面鼓励电视网络提供增值内容。

首先，确保能提供越来越多的政府信息。大多数此类信息对于市民来说非常有价值，并经常是以较低价格提供的。此项工作可以建立在已开展的电子政务工作基础之上，并应确保信息能够以可接收格式显示在电视上。成员国在此方面的举措非常关键，相关成本将会因规模效应而得以降低。这意味着可采用互操作和横向的方案，尽可能实现"平台无关"性，以便于主管部门之间信息的交流。

其次，不同主管部门在电子内容，电子政府，远程教育，电子医疗保健等方面的举措可以促进数字广播网络增值内容提供（不论是否与政府有关）方面的公私伙伴关系。

第三，可以通过实施有关第三方接入电子通信网络和设施的国家和国际规制条款来刺激业务竞争。相关业务可包括传统广播节目，也可包括交互业务，如允许用户之间互动的信息服务，从而通过直接网络效应促进业务的发展。

最后一点，宽屏和高清晰格式将刺激消费者购买数字电视。

4.1.1.5 频谱管理

地面广播频谱的有限提供对于切换来说既是重要的理由，也是挑战。

各地区频谱情况各不相同。在频谱过分拥挤的地区，并播难度更大，因此尽早关闭模拟业务的压力更大。

频谱管理传统而言是由国家政府紧密控制的。此外，一种高程度频谱国际协调在国际电联进行。这些国际论坛关注以下两个主要问题：

– 避免跨界干扰；
– 通过协调某项特定用途频带的使用，促进通信业务和设备在全球和/或区域范围的普及。

在频谱管理中，有必要区分"划分"，"分配"和"指配"问题。相关资料见《无线电规则》第1.16、第1.17和第1.18款。

划分指的是在具体频带内传输的业务类型（地面移动，卫星固定，射电天文或其他业务），有关这些业务的协调问题已大致在国际层面协商一致。尽管如此，不同业务之间的区别仍可能不断受到市场和技术发展的挑战，比如数字融合问题，需要更多更为灵活的频谱划分方案。该问题影响有关转换问题的讨论，当然实际上影响的远非仅仅切换问题。频率指配指的是许可某个站点使用具体频率的权利。

切换工作的现实开展和模拟系统关闭时间问题非常重要。在第一区和一些第三区国家，模拟业务在一个国家的提供可能制约另外一个国家对相同频率的使用。不同国家政府不同优先重点之间的引发的问题对于广播信号来说尤为突出，因为广播信号功率大，使用的发射频率低（VHF和UHF波段），因而通常传播距离较远。因此这些国家的切换进度及其所带来的益处，可能受到邻国较慢过渡进度的影响。

有关协调问题的技术讨论已在国际电联进行了多年。特别的，覆盖整个欧洲广播区域、非洲和相邻国家的两次国际电联区域无线电通信大会的召开，审议了当前地面广播频率协调规划（"1961年斯德哥尔摩规划"和日内瓦89版及其随后更新），为促进数字转换并为关闭后的情况做了准备。第一次会议召开于2004年，第二次会议召开于2006年。这些政府间磋商的焦点在技术方面，做出的决定不一定非得基于共同的政治目标，所得的成果也可能不一定有利于市场的发展。根据具体技术标准选定的协调机制也可能导致对其他方案的排斥，从而可能降低市场的竞争和消费者的福利。

从这个意义上说，有必要就频谱管理和切换制定政策导向，以实现内部市场目标，解决所述的三方面问题：指配机制；过渡的组织和时间框架。这将有助于解释转换所真正涉及的厉害关系，特别是谁、在何时以及以何种方式受益。

4.1.2 广播规划总体考虑

如前所述，总的趋势是引入数字技术替换模拟广播。但是，因为目前正在使用的很大数量的广播接收机以及此类接收机的较长预期寿命，很清楚的一点是，从模拟向数字广播的变更将不会在所有国家很快发生。实际上，可以预测到的是这一变更将在大多数国家在很多年内完成。因此，要避免对广播接收产生有害干扰，就有必要非常仔细地考虑全模拟状况和全数字状况之间的转换期问题。

就转换而言，必须强调的是，需要考虑两个分开的阶段。第一阶段是当数字传输引入广播频带，而后者正在被仍在运营的模拟传输或多或少占用着。第二阶段是当模拟传输被关闭，从而可以引入额外的数字传输。在这两个阶段的规划考虑可能大不相同，但在目前，能获得的足够信息还只是局限于研究第一阶段的各种不同措施。

在筹备区域无线电通信大会第一次会议（RRC-04）过程中，任务组6/8提出了一份包括若干规划方案的输入文件。

区域无线电通信大会第二次会议（RRC-06）制定了第一区和第三区部分国家有关波段III（VHF）、波段IV和V（UHF）电视系统的数字地面广播DVB-T规划，以及有关波段III（VHF）的数字地面声音广播T-DAB规划，这被称为日内瓦-06规划。相关文本可在互联网上获取：http://www.itu.int/ITU-R/conferences/rrc/rrc-06/plan_process/index.html。

4.2 广播规划原则

4.2.1 总体考虑

在斯德哥尔摩和日内瓦大会期间，地面模拟广播业务规划是基于《无线电规则》第1.18款定义的“指配”概念：

> “由某一主管部门对给某一无线电台在规定条件下使用某一射频或无线电频率的许可。”

就采用指配规划方法制定规划这一点来说，一个指配包括一个（单独）发射机站点（以精度和纬度规定），具有给定的有效辐射功率（e.r.p.），有效天线高度，发射机辐射模式等。这些参数一经选定，就可以确保在一个与发射机站点相关的区域（通常是其周围）以可接受的程度接收（或覆盖）一个希望获得的节目。但是，指配的预期覆盖在制定规划时未明确加以考虑，且原则上讲，这一点也唯有等规划完成之后才能确定。

随着更多注意力集中在要求规划实现对已知覆盖区域的保护，并且随着数字技术为规划方式提供了更多的潜力，指配规划这一概念已经到了必须重新审视的地步。这已经演变成了一个更为相关也更为灵活的概念，称为“分配规划”。在《无线电规则》第1.17款中，一个分配定义为：

> “经有权的大会批准，在一份议定的频率分配规划中，关于一个指定的频道可供一个或数个主管部门在规定条件下，在一个或数个经指明的国家或地理区域内用于地面或空间无线电通信业务的记载。”

但是，为了避免出现主管部门在其自身领土之外的权力问题，就地面广播业务规划而言，该定义可理解为：

“经有权的大会批准，在一份议定的频率分配规划中，关于一个指定的频道可供一个主管部门在规定条件下，在其领土内或在其领土内的地理区域内用于地面广播业务的记载。”

4.2.2 分配区域的覆盖

分配规划可以用于确保那些希望被保护不受干扰的地区在制定规划时可以被考虑在内。分配区域的覆盖可通过以下方式获得：

– 一个包括一组发射机的单频网络（SFN），其精确站点位置和其他技术特性在规划确定时知晓，因发射机基础设施已经确定。在此情况下，网络的干扰潜力可用组成SFN的指配集合来表示。

– 一个位于预先确定站址的具有已知特性的单一发射机。干扰潜力用指配表示。

– 一个包括一组发射机的单频网络（SFN），其中发射机的精确站点位置和其他技术特性在规划确定时尚未确定。在此情况下，网络的干扰潜力必须用参照网络来表示。

– 如果需要覆盖一小块区域但尚未就发射机站址的选择或其他特性做出决定，则干扰潜力可用单一发射机来表示。

见ITU-R SM.1050-1建议书。

4.2.3 划分测试点

一旦一个划分的覆盖区域已经确定，就必须通过测试点方式明确定义其边界。这些测试点起到以下作用：

首先，划分测试点将定义划分的地理位置、形状及其大小，即“划分边界”：

– 为此，测试点将在适当情况下，用一套经议定的国家边界和海岸线集合，以精度和纬度的度、分和秒来表示。

– 一个划分区域将用规定的测试点（将作为每个多边形的顶点）定义的多边形（或多个多边形）表示。因为只有有限数量的测试点可供使用，因此多边形（或多个多边形）之间的配对以及与其的覆盖可能不精确；因此，测试点的选择必须很仔细，以足够精确地描绘出划分区域。

– 给定多边形的测试点应加以排序，以便在相邻点之间画直线时，要能够形成一个封闭的多边形（不要出现边之间的相互交切），并能包含预期的覆盖区。这意味着多边形序列中的第一个测试点和最后一个测试点的坐标必须相同（也即它们代表相同的物理点），从而使多边形能够“闭合”。

第二，如果划分干扰潜力是以参照网络而非真实指配来表示，则在规划计算时，应采用与划分相关的测试点作为干扰源位置。按此方法，可以解决划分干扰潜力问题。

第三，在规划计算中，将为划分测试点计算由于其他划分或指配引起的干扰电平。为此，它们之间应有“合理”间隔。这意味着它们与预期覆盖区域之间应有“良好”距离，这里面主要考虑是任何位于多边形（即覆盖区域）内的潜在干扰都不应高过测试点；如果间隔太大，则不能满足这一点。而在另外一方面，间隔过小可能“超过必要”，且只能导致表面的计算。

4.2.4 HF波段数字声音广播

WRC 03决定通过在HF波段广播业务鼓励引入世界数字广播（DRM），要求其保护率符合第543号决议（WRC-03）的要求。

非正式协调组和广播联盟就HF波段实施DRM传输的不同方式问题进行了多次讨论。目前，根据现行规则《无线电规则》第12条，还没有任何一种方法能带来实际益处。

因此，DRM传输的引入采用了第12条规定的非正式协调程序。这给予了广播机构在规划DRM传输时的最大灵活度，因为它们能够根据现行的广为人知的程序，自由选择任何新的频率。任何对于现有模拟传输的非预期干扰将采用这些非正式协调程序解决。而且，它允许广播机构将部分传输中的现有模拟频率改变为数字调制。

由于数字传输数量的不断增长，未来可能需要考虑其他策略。

4.3 业务质量

为确保广播传输的质量，其中一个很重要工作是要监测目标覆盖区域内的传输信号。对于模拟业务，这通常是通过使用高质量信号接收机来实现的。信号强度可从校准的仪表中读出，从而对信号质量做出主观评测。历史上，这一评估方法的实施是通过目标区域内的某人将接收机调谐至所需的业务，然后进行实时观看和/或收听。近来，这一手工方法已经被替代为通过使用无人遥控或定时接收机来接收信号，并记录信号强度以及接收信号的采样。通过使用数字传输系统，使得对于接收的监测变为全自动。

4.4 频谱使用的经济方面问题

更多信息可参考ITU-R SM.2012报告- 频谱管理经济方面的问题，以及WTDC-06第9号决议 – ITU-R和ITU-D有关频谱管理的联合组。

也见第2部分。

4.5 医疗，安全和其他法律方面的考虑

在从模拟向数字广播转换过程中，必须充分考虑确保发射系统符合所有现行有关电磁辐射危害限制和医疗以及职工及普通大众安全问题的标准和建议书。

ITU-R BS.1698建议书包含需要仔细考虑的问题。在第2部分，对于该建议书重要部分做出了概述。

4.6 模拟数字切换

4.6.1 模拟和数字业务并播

4.6.1.1 并播的优缺点

有若干种可能的并播方式。在本报告中，我们只考虑以下方式：

– 单频道并播：有单独一个频道承载相同内容的模拟和数字信号；

– 多频道并播：用两个（可能相邻）频道并播相同内容的模拟和数字信号。可用下例扩展多频道并播概念：MW波段用于模拟信号，HF用于数字内容，或反之。

第2部分给出了DRM并播的一个例子。

4.6.1.2 单频网络（SFN）的优缺点

主要优点在于仅适用一个射频频道在整个覆盖区域内传送相同内容。主要缺点在于要求内容要完全相同，而且将不再可能提供本地或区域业务。

4.6.1.3 频谱可用度

在一些广播频带拥挤的国家，转换工作可能非常困难。应由国家主管部门寻求解决办法。

4.6.2 部署数字广播的可能机制

如果要在HF,MF和LF波段进行AM广播，看来所有现有频率都已被占用了。因此可能方法是将原先用于模拟传输的相同频率再额外用于数字传输。但要注意对其他站点的干扰或其他站点对现有业务的干扰不应超过现有频率规划的限值。对于DRM系统，该值为–7 dB，这对于临时使用应该说是比较合适的限值。

在决定何时转向数字系统这一问题上，最重要的一点是能够实现数字信号解码的接收机是否具备。为此，需要一段转换期，在此时间内，将采用模拟和数字技术同时发射信号。

当数字接收机数量超过所有接收机或所有听众的 95%时，模拟也就可以关闭了。

对于T-DAB引入问题，情况要简单得多。对于此类数字声音广播业务，一些国家预计使用波段III（大多数为第12频道）和波段L（c/a 1.5 GHz）的一些电视频道。

在转换期内，模拟传输将保留在FM波段（在大多数欧洲国家，从87.5 MHz 至 108 MHz）。在此阶段之后，该波段也可用于数字传输。

数字地面电视可能是更为困难的问题。在大多数西欧国家，所有现有电视频道被用于模拟传输。在一些国家，在61-69频道有一些免费频道，因为这些频带中一部分被用于其他业务。

另外一个可能性是使用在模拟电视规划时被列为限制使用的频道，这些频道称做规划限制（在美国称为“TABO”频道）。

不过，区域和区域之间关于规划区域的策略也大不相同，甚至国家与国家之间也是如此。

总体而言，在用数字传输替换现有模拟传输方面，对于相同覆盖区域相同业务质量，数字辐射功率要小一些。

4.6.3 切换综述

在无线电和电视领域（通常为“广播”），“切换”指的是从模拟向数字广播的过渡进程，从数字系统的引入作为开端，以模拟广播的关闭作为结束。就进程的速度、时间、涉及的相关方以及政府介入程度而言，有多种可能路径。

各个国家采取其自己切换路径，这一路径通常受其本地广播机构的影响。

理想化情况下，最终关闭模拟广播应该是在数字系统已经取得了广泛的普及且只有很少量模拟家庭用户存在。否则，如果很多家庭被简单地剥夺了接收电视和无线电业务的权利，将会引起社会的倒退；或者如果为避免出现这一现象而实施了昂贵的或歪曲的公众政策措施，则会影响经济的发展。

切换不仅仅是一种技术的过渡。考虑到电视和无线电在当今社会中的地位，其影响不仅是经济的也是社会和政治的。切换影响广播价值链的各个部分，即：内容制作，传输和接收。所有各部分都要求技术升级，以支持数字广播。主要挑战在于接收端：要替换或升级巨大数量的模拟接收设施。这可

以通过综合数字电视机或无线电接收机，或连接在模拟电视机上的“机顶盒”来实现。而且，连接点（天线，碟型天线，线缆）必须也做出改装。

对于电视和无线电来说，切换的情况大不相同。数字电视市场普及率相对高得多。模拟和数字电视通过形式各异的网络提供，包括有线，卫星和地面（通过VHF和UHF波段）。数字音视频内容也可通过互联网以及目前尚少使用的数字用户线（“DSL”）实现。各个网络都具有各自强项和弱项。因此电视的切换是一个“多网络”或“多平台”进程，数字电视与数字地面电视不是一个同步的过程。不过，这方面的争论一般集中在地面电视上，因为目前模拟地面电视所用的频谱可能被回收，且传统上政府在此领域有一定介入。

数字电视也不等同于交互式电视。前者主要是指通信网络的类型，这是本文的焦点所在；而后者则指的是能够通过网络提供的具体业务。在实践中，网络和业务的部署是相互关联的。最后一点是，数字电视不仅仅是付费电视；一些成员国也提供免费空中数字电视。

至于数字广播的好处，一些是与切换进程本身相关的，另外一些则仅在最后才能实现，也就是说要等到模拟广播的关闭。所有益处均因为相比较模拟信号而言，在数字系统下可以对数字数据进行更有效的处理和压缩以及对网络容量更有效的利用。这些益处可在多方面加以利用。首先，它可以促进提供新的或改善的广播业务：附加节目；节目相关的增强功能；更高质量的图片和音频；数据和交互式业务，包括“信息社会”和互联网业务。第二，它促进了市场的竞争和创新，这主要归功于价值链不同层面可能出现的新的进入者，比如新的广播机构或交互应用开发商。

此外，切换还意味着为某些市场参与者带来具体益处：降低传输成本；增加数字接收机销售；更便捷地存储和处理内容。实际上，对于不同相关方，或者就本地和网络而言，益处和困难都是不一样的。

不论在任何情况下，就短期而言，切换涉及显著成本，难度较大，需要：在价值链所有部分引入技术升级，并重新考虑频谱机制和方法；开发有吸引力的业务以推动需求，如果没有需求，则整个进程将会变得在经济和政治上不可维系；以及要克服怀疑主义甚至是来自业界参与者和市民的抵制。他们可能看到在改变广播部门现状方面的风险。

目前，向数字广播的过渡已经受到信息通信部门的影响，而后者的特点是资金有限。这将消除加速切换以释放频谱方面的压力。而且，市场对于互动电视和融合业务的接受也需要时间，消费者是否愿意为这些业务买单也还不一定。

总而言之，进展要比预期的慢，一些国家对于切换目标也表示了怀疑。电视和无线电广播机构将终有一天实现完全数字化，但很难知道何时以及用何种方式。在一些欧盟国家，转换可能是一个很长的过程，其成果尚未可知。比如，频谱在何种程度上得以回收并被更有效率地进行重新划分问题将取决于政治和市场环境。

第1部分
附录1

案例研究

国家案例研究概述

本附录给出一些国家有关数字地面电视广播（DTTB）发展措施和当前状况的概述。

以下文字为不同国家所采取行动的总结。

更多信息见第2部分。

1 澳大利亚

澳大利亚由一个范围广泛的网络PAL-B模拟网络提供服务，近期由DVB-T数字网络提供服务（8 k载波模式，64QAM，2/3或3/4 FEC）。地面电视广播传输站点工作在VHF和UHF，频率间隔为7 MHz，目前并播模拟和数字信号。在引入数字电视时，澳大利亚已经在大多数地区规划了七个数字电视网络，其中五个用于替换现有的模拟网了，两个为新增数字网络。数字电视业务于2001年1月1日在主要大城市开始，现在已经逐步在区域性地区部署。

澳大利亚发射机部署的特点是大部分人口接收少数几个高功率、典型覆盖区域达150 km"主站"发射机的信号。对于数字业务，那些主站发射机的辐射功率电平在VHF波段达100 kW e.r.p，在UHF 频道高达1250 kW e.r.p。除了高功率主站业务外，也采用了大量中继站用于未能覆盖地区的业务。这些中继器既可以采用多频网络（MFN），也可以采用单频网络（SFN）。

HDTV是澳大利亚数字地面电视的一大特色，已经成为数字电视启动的重要驱动力。澳大利亚政府致力于确保数字电视尽可能价格适中。虽然广播机构被要求为拥有HDTV电视机的用户提供最起码数量的高清电视节目，他们同时也被要求提供SDTV格式的电视节目。SDTV格式节目的传输不仅为收视者提供了接收数字广播附加功能的机会，也为消费者提供了获取数字业务的较为便宜的转换途径。

澳大利亚政府已经宣布将2013年12月31日确定为关闭最后一台模拟发射机的日期。

2 巴西

首先，有必要注意到该国未按DTTB标准规定进行频道规划，因为该国仍在考虑现有各DTTB标准的特点。DTTB可以通过使用UHF（14至69频道）频带来替换现有模拟电视。DTTB站点将与现有模拟站点具有相似的业务区域。现有模拟频道和新的数字频道的并行广播是转换阶段采用的方法。

2006年6月，巴西政府通过发布第5820号法令，决定将ISDB-T数字电视标准（ITU-R BT.1306建议书的系统C）作为地面电视的基础。数字编码采用ITU-T H.264建议书（MPEG-4/AVC），数字编码为创新系统协调国际应用程序接口 — 具有本地中间件开发的API。

为保证数字转换的进行，截止2006年12月，国家电信机构（Agência Nacional de Telecomunicações – Anatel）提供了1893条数字频道。这一工作仍在继续，到2013年将有6100多条数字频道。假定每条模拟频道都必须有其对应的数字频道，则在"并播"阶段，肯定能提供包括模拟和数字在内的12200条频道。

2007年12月2日，巴西DTT系统在圣保罗开始商用，到2008年第二季度，该城市已有10条商用广播线路。虽然在2007年5月就进行了测试传输，但巴西政府还是决定将12月2日确定为正式系统的开启日期。

巴西数字传输系统提供了诸如高清和标清图片，数据传输，交互通信，便携和移动业务等重要特色，这些业务具备了更好服务收视者的必备技术灵活特性。

巴西监管机构认为保留免费和开放电视模式对于DTTB的成功以及为整个巴西社会带来福祉方面来说至关重要。

2007年，巴西5645万户家庭中有85%以上具有电视机，只能接收免费空中电视业务。这说明了免费电视模式对巴西来说具有重要意义。

3 保加利亚

除偏远农村地区外，不允许在超过一年以上时间内进行模拟和数字地面广播的并播。

两阶段数字电视地面广播将确保数字转换的逐步进行。

六个取得许可证的国家级DVB-T和DVB-H MFN/SFN网络运营机构必须确保在所有15个划分区域内实现人口的完全覆盖：前三个于2012年12月前，其他三个于2015年6月之前。

二十七个区域性SFN网络必须确保在所有15个划分区域内实现人口的90-95%覆盖：前十二个SFN于2010年1月前，其他十五个于2012年12月之前。

有关数字地面HDTV广播的许可申请应于2011年12月之前提交，许可证可能很快就发放。

鼓励互动业务和应用。

所有模拟电视地面传输将于2012年12月之前完成关闭工作。

数字地面电视广播的转换应于2015年6月结束，并将建立实际数字红利。

4 加拿大

加拿大于1997年采纳ATSC标准。第一个商用DTT站点于2003年在多伦多正式启用。目前，该国约有20多个DTT站点，分别向多伦多、蒙特利尔、温哥华和渥太华等主要市场提供广播服务。加拿大无线电-电视和电信委员会（CRTC）将2011年8月31日设定为加拿大模拟电视关闭日期。其结果便是各主要电视网络积极开展了数字转换工作，以符合CRTC的截止时限要求。

通信研究中心（CRC）正在利用STN（单品网络）和数字同频中继器（DOCR）等分布传输网络开展传输测试工作。该项测试的目的在于确定是否能克服因地形所致覆盖问题，并探索DTT业务用于行走和移动接收领域的可能性。

5 德国

2002年11月1日正式启动了DTTB，截止2008年底，已全部实现采用DVB-T标准的数字传输。商业模式是免费空中电视模式。该国频道规划基于根据ITU-R日内瓦2006年协定（GE-06）制定的国家频率

权利框架，主要采用“室外便携”（日内瓦规划的RPC-2加上高功率发射机每个城市的一个或若干指配）。该业务概念可使占德国总面积一半以上的人口聚居地实现室内接收，通常以标清（SD）质量提供二十多个数字节目。在这些聚居地以外，可以以“室外便携”或使用指向天线来接收DVB-T。在HDTV方面，已经开展了测试传输。同时也开展了有关DVB-T复用内声音无线电节目传输的实验。

市场上有各种类型的接收机，从用于计算机和笔记本电脑USB插口形式的手持和车载接收小型便携电视机（屏幕尺寸通常在直径5至7英寸之间）到用于静止接收的机顶盒和电视机（通常具有平面显示）。2008年5月，集成DVB-T接收机的移动电话首次亮相市场。此外，目前在车载导航系统上也配备了DVB-T接收机。

关闭工作自2003年8月在柏林-勃兰登堡开展。截止2003年底，在柏林和勃兰登堡联邦成员国内已经有六百万人可以以SD画质接收26个数字频道。这是世界上首次进行的对地面模拟广播的关闭。这一成功可以部分归功于政府，因其规定业务将完全免费，并且规定仅在2003年向最贫穷家庭提供免费解码器。而其他任何情况下购买DVB-T都将不能获得补贴。截止2007年底，德国人口85%以上（6800万人）已经能够接收数字地面电视。在该日期之前，已经售出了900万台接收机。DVB-T在德国的成功归因于公众能够免费接收大量德语节目。2008年，柏林-勃兰登堡16.8%的家庭使用DVB-T。

在其他大城市，DVB-T传输开始于2004年。德国方式的关键一点是数字广播业务是一个区域一个区域逐步开展的，最初是宣布6个月的很短转换时期，随后不再提供任何并播期。截止2008年底，已经完全实现了切换过程（比最初计划的时间提前了两年）。

业务开始启动以来至2008年底，预计大约售出了1500万台DVB-T接收机。尽管如此，对于德国90%家庭用户而言，其主要的电视业务（起居室大屏幕）仍然依赖有线电视或卫星传输。

6 几内亚

卫星广播的发展减慢了地面电视从模拟向数字广播过渡的进程。但是，DTTB的启动仍在考虑之内。已经考察了两种方法，或者是关闭模拟系统然后建设一个全新的数字网络，或者是采用混合系统（模拟和数字）。后一种方案对于发展中国家来说显得更为适当。在频道规划和平台问题上，DVB-T被视为相对较低廉且在转换期内对于发展中国家而言更具优势的一种标准。这使得相邻国家之间可以进行更富有成效的区域协商，以便就引入数字广播设备涉及的相关技术实施问题协调一致。

7 意大利

2003年开始计划建设DTTB业务。该国频道规划基于欧洲标准DVB-T。目前正在运营的有六个国家级复用，传输电视频道超过42个。过去几年，每年都有几十个本地数字频道出现。综合而言，就数字信号覆盖来说，当前数字电视普及率超过70%。就模式而言，免费电视与系统启动一年后引入的付费收视业务并存。截止2006年底，400万意大利家庭用户安装了机顶盒。这意味着20%意大利家庭用户通过数字电视机顶盒收视数字电视。

广播机构已提供了很多如数字电文、新闻消息、天气预报、观众投票以及EPG之类 基于MHP的交互业务。而且，政府（包括中央和地方政府）正在提供实验性的“电视政府”（通过电视机的交互功能提供电子政务业务）业务，目标旨在帮助缩小数字鸿沟。

模拟广播的关闭时间最可能是在2012年。国家切换计划由意大利主管部门提交。撒丁岛于2008年10月31日成功实现模拟系统的关闭。下一个全数字地区将是瓦莱达奥斯塔地区，其模拟系统将于2009年春季关闭。

8 日本

地面电视广播是日本基础性媒体，拥有4800万家庭用户和1亿台电视机。地面广播机构已经设置了许多中继站，以便为山地半岛地区提供最大程度的覆盖；发射站点超过2000个。由于现有模拟中继站对UHF频道的大量使用，如果模拟站点不过渡，则不可能指配数字频道。结果是，很多模拟电视频道被迫转移至其他UHF频道。因此，地面电视广播数字化对于日本来说极端重要。

该国数字电视广播（DTTB）频道规划基于ISDB-T规划标准。

自2003年12月在三个主要大城市地区东京，名古屋和大阪开始DTTB以来，业务覆盖不断扩展；截止2007年12月，90%以上家庭已经被覆盖。至2011年，将建设小型中继站，并到那时将完成全数字过渡进程。根据其规章规定，模拟广播将于2011年关闭。

ISDB-T是日本DTTB传输系统，提供层级式传输特性。这使得可以将部分频带划分给固定接收（主要是HDTV），而将剩余部分划分给手持接收（称为"一段"）。

例如，1080i格式制作的纯HDTV节目大约占NHK通用频道所有节目的90%以上。而且，所有广播机构都在提供承载各种生活资讯和附加节目信息的数据广播业务。

车载HDTV接收机自2005年即已上市，截止2008年8月，车载电视接收机出货量已达1800万台。

使用ISDB-T信号中心段的手持接收机一段业务开始于2006年4月。一段接收机自2006年上市，截止2008年8月，一段接收机数量已达400万个。

9 墨西哥

在墨西哥，音频和电视广播是公众活动，因此，有必要以最好的技术提供这些业务，以造福大众。为此，1999年建立了数字广播技术咨询委员会（下称委员会），供业界和政府在协商一致基础上分析和评估其他国家发展及实施的转换进程。2000年，委员会以此类协议方式确定了承诺；并开展了数字无线电和广播技术实验运营。

此外，委员会参加了无线电通信第6研究组的各项会议，这些会议为评估国际电联数字标准发展程度提供了必要的技术信息。而且，委员会还与数字电视技术开发机构举行会议，以便从源头了解标准的强项和弱势所在，并了解在转换过程中设备提供及成本等情况。

委员会认为其已掌握核心要素，可以建议采纳**"数字地面（DTT）标准及其转换政策"**；相应协定发布于2004年7月2日。协定规定：采用ATSC A/53标准；对于所涉各方而言，转换进程都具有法律确定性；用于评估进展的进程后续客观条件，以及目的，目标，要求，条件和义务。

由于地面数字电视转换政策涉及特许权、被许可者、制造者、广告商以及一般而言的电视观众，成本较大，因此这是一个长期过程。因此，在制定转换方案是需要考虑以下因素：灵活和渐变的DTT站点安装过程；有待复审的这一过程中的开发期，以及基于人口密度的最小目标。

2006年4月1日，声音和电视广播监管机构致函联邦电信委员会，后者特别关注DTT转换的监管和控制问题。在此期间，该国10个主要城市建立了35个数字发射站。

10 俄罗斯联邦

目前，有5个DVB-T 发射机正在工作，另一个将在近期启动。所有这些发射机都处于试验阶段，并被用于观察DVB-T和模拟（SECAM-K）电视广播之间的兼容性，但也有人建议用其提供全功能DVB-T业务。

俄罗斯联邦在从模拟向数字电视的转换的最初阶段就认为，用数字信号取代模拟信号的同时要保持现有的信号分解标准。此类信号不仅可以被彩色电视机还原，也可被具有特殊机顶盒的黑白电视机所还原。

俄罗斯要求在数字电视引入之前必须进行试验广播。为此，在莫斯科– 32, 34 TVch；圣彼得堡 – 34 TVch；下诺夫哥德堡– 50 TVch；弗拉迪沃斯托克– 51 TVch；车里雅宾斯克– 30 TVch等地区进行了试验广播。

广播采用DVB-T标准。目前，开展了有关液晶显示移动电视接收机互动接收研究，回传频道计划通过GSM网络实现。

为进一步推广数字电视广播，在欧洲广播区域内以及在170 ºE以东地区开展了DVB-T频率指配规划工作，目前，已经就指配给DVB-T站点的规划频率与其他主管部门进行了协调，在规划（斯德哥尔摩，1961年）中纳入了37个频率指配，在MIFT中纳入了4个频率指配。

此外，已经就DVB-T站点24个频率指配进行了协调，近期将被纳入规划（斯德哥尔摩，1961年）及扩展规划区领土的现有和计划电视站点《列表》之内。

基于MHP的互动业务是可能的，但是作为尚未全国普及的电话和电信系统普及率是一个需要深入考虑的关键问题。

11 坦桑尼亚

坦桑尼亚位于国际电联第一区内，坦桑尼亚通信监管机构（TCRA）（在国际电联代表坦桑尼亚）是通信、广播和邮政部门监管机构。TCRA代表该国出席了RRC-04和RRC-06会议，这两个会议生成了两份公开磋商文件，随后开展了旨在处理如何部署、管理和监管数字地面广播的研讨会、年度会议和论坛。磋商就坦桑尼亚新广播前景制定了初步框架，即引入名为复用运营机构（MUX）的信号传输机构。它提议在初初步许可框架之下，设立两个商业复用运营机构和一个公众业务复用运营机构。

TCRA采取的措施中，值得注意的是其引入的具有四个主要许可证的融合许可框架（CLF）：

1 网络设施

2 网络业务

3 内容业务

4 应用业务

为处理复杂的涉及融合和数字化等在内的许可问题，建立了国家技术委员会以处理向全数字广播的过渡并制定路线图，在监管机构内部建立数字广播临时工作组（WGDB），由广播、频谱管理、ICT发展和立法领域的专家组成，以处理以下问题：考虑MUX的许可问题，国家数字广播规划和并播期限，移动电视、IPTV等其他业务的许可问题，就提供STB问题考虑并通过一个立场文件，并编辑数字广播最后文件。

2008年4月，TCRA宣布了一份招标书（EOI），对能够提供积极响应的数字复用业务的提供进行预评估。有关修订2003版坦桑尼亚ICT政策和其他适用法律的工作正在由政府主导平稳进行。在初期数字规划之后，能够为部署全国范围内DTT提供频道，初期提出了四个阶段，并将于近期予以更新。

12 美国

美国大力推进采用ATSC数字电视（DTV）部署DTV。根据FCC要求，10个最大城市的29个站点于1998年11月自愿启动DTT业务，比FCC制定的截止日期提前六个月。六个月后（1999年5月），前10位市场中的附属于四个最大广播网络的所有站点都被要求提供服务，并且在又过六个月后（1999年11月），这一要求被扩展至四个最大网络位于所有30个最大城市的所有附属站点。要求所有商业广播机构于2002年5月开通业务，所有非商业广播机构于2003年5月。在2006年初，美国国会制定了法律，要求广播机构于2007年2月17日之前停止其模拟传输。该法律条款规定向电视收视者购买用于在现有模拟电视接收机上收视DTT信号的数模转换机顶盒给予高达15亿美元的补贴。FCC规则要求逐步将ATSC接收功能纳入电视机内，一开始是2004年要求的最大号电视机，然后是2007年7月要求的所有13英寸以上电视机。2005年11月，FCC对规则进行了修订，要求在2007年3月1日之前完成这一工作，不分尺寸，所有电视机都必须达到这一要求。从而，自2007年3月1日开始，美国销售的每一电视机都具有ATSC DTT接收和解码功能。美国消费者电子协会预测美国2007年之前每年将售出3400万台ATSC DTT接收机，而到2009年，总计将有1.52亿台ATSC接收机。广播机构和制造商正在计划利用ATSC-M/H系统部署移动和手持业务。

13 韩国

韩国于2001年开始数字地面电视广播，于2002年开始数字卫星广播，并于2005年开始地面多媒体广播。自2002年起，有线电视也开始提供数字节目。

13.1 固定接收数字电视

韩国于1997年采用ATSC系统用于UHF波段的模拟电视广播的数字传输，以获得6 MHz带宽高清质量，并于1999年和2000年开展了现场试验工作。目前在全国安装有160个ATSC发射机，2006年覆盖范围约占其领土的92%。为数字电视站点寻找频率并非一件易事，因为UHF波段早已被模拟电视所占用。为便于频率指配，设计了均衡数字同频中继器和分布式翻译器，以便ATSC系统能使用相同频率。

13.2 T-DMB移动接收

对于多媒体广播业务，韩国开发了地面数字多媒体广播（T-DMB）。首尔市区及其附近地区在第III频带开展了T-DMB试验业务，现场测试结果显示具有良好的移动接收质量。现场测试结果提交了2004年4月的WP 6M会议，并被纳入ITU-R BT.2049报告（也见6E/186号文件）。2005年12月，韩国在首尔市区启动了T-DMB商业服务，并于2007年3月将该业务扩展至全国。

14 委内瑞拉

该国将通过国家监管机构—国家电信委员会（CONATEL）的支持引入DTTB业务。这一引入过程分为若干不同阶段：可行性研究，论坛和操作表，试验和标准通过。这一过程正在发展之中。已经开展了试验工作，但对于具体频道规划或具体标准等问题尚没有清晰的导向性意见。

15 OCDE

OCDE信息、计算机和通信政策委员会2003年出版的题为“融合对于电子通信监管的影响”的文件的主要部分是有关广播在电子通信中的定位问题（文件DSTI/ICCP/TISP（2003）5）。

16 欧盟

欧洲（芬兰，法国，西班牙，瑞典和英国）有关数字视频广播频谱问题的相关信息见ITU-D有关课题11-1/2的报告。

第1部分
附录2

词汇表（缩略语）

AAC	高级语音调制
AFS	可选频率交换
AM	幅度调制
ATSC	高级电视制式委员会
ATSC-DTT	高级电视制式委员会 – 数字电视传输
ATSC M/H	高级电视制式委员会 移动/手持
BER	误码率
BPF	带通滤波器
BST	频带分段传输
CA	条件接收
CELP	编码激励线性预测
COFDM	编码正交频分复用
DAB	数字声音广播
DC	直流
DCP	分布和通信协议
DDC	数字下变频
ChinaDTV	中国地面数字电视
*x*DSL	*x*数字用户线
DRM	世界数字广播
DSB	数字声音广播
DVB	数字电视广播
DVB-H	数字电视广播- 手持
DVB-T	数字电视广播-地面
ETSI	欧洲电信标准协会
FAC	快速接入频道
FDM	频分复用
FEC	前向纠错
FLO	单一前向链路
FM	频率调制
GPRS	通用分组无线业务
GPS	全球定位系统
GSM	全球移动通信系统
HF	高频
HVXC	谐波向量激励编码
IBOC	带内同频

IDS	iDAB数据业务
IEC	国际电工委员会
IP	网际协议
IPR	知识产权
IRD	综合接收解码器
ISDB	综合业务数字广播
ISDB-T	综合业务数字广播-地面
ISDB-T_{SB}	综合业务数字广播-地面声音广播
ISDN	综合业务数字网络
ITU-D	国际电信联盟电信发展部门
ITU-R	国际电信联盟无线电通信部门
ITU-T	国际电信联盟电信标准化部门
LAN	局域网
LF	低频
LMDS	本地多点分配系统
LW	长波
MCI	调制器控制接口
MCS	多频道并播
MDI	复用分配接口
MER	调制误码率
MHP	多媒体家庭平台
MLC	多级别编码
MLDS	多媒体本地分配系统
MF	中频
MFN	多频网络
MMDS	多频道多点分配系统
MPEG	移动图像专家组
MSC	主要业务频道
MUX	复用器
MW	中波
NTP	网络时间协议
NTSC	国家电视系统委员会
NVIS	近垂直入射天波
NVOD	准视频点播
OCDE	经济和社会发展组织
OFDM	正交频分复用
PC	个人计算机
PDA	个人数字助理
PFT	保护、分片和传输

PSTN	公众交换电话网络
QAM	四幅调制
QoSAM	数字调幅波段业务质量
QPSK	四相键移
RA	ITU-R无线电通信全会
RBDS	无线电广播数据系统
RDS	无线电数据系统
RF	射频
RFP	射频相位
RRB	国际电联无线电规则委员会
RSCI	接收机状态和控制接口
RT	远程终端
SBR	频带复制
SCE	业务元素编码器
SCS	单频道并播
SDC	业务描述频道
SDI	业务分配接口
SFN	单频道网络
SNR	信噪比
SOHO	小企业或家庭企业
SW	短波
T-DAB	地面数字声音广播
T-DMB	地面数字多媒体广播
TMCC	传输和复用配置接口
UEP	差错非均匀保护
UDP	用户数据报协议
UMTS	通用移动电信系统
USB	通用串行总线
VOD	视频点播
VSAT	甚小口径终端
VSB	残留边带
WAN	广域网
WARC	世界无线电行政大会
WLL	无线本地环路
WRC	世界无线电通信大会
WTDC	世界电信发展大会

Part 2

Contents

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Chapter 1

1.1 DRM

1.1.1 Features of the system design for the markets to be served by the Digital Radio Mondiale (DRM) system

The DRM system, is a flexible digital sound broadcasting (DSB) system for use in the terrestrial broadcasting bands below 30 MHz. (Recommendation ITU-R BS.1514)

It is important to recognize that the consumer radio receiver of the near future will need to be capable of decoding any or all of several terrestrial transmissions; that is, narrow-band digital (for <30 MHz RF), wider band digital (for >30 MHz RF), and analogue for the LF, MF, HF bands and the VHF/FM band. The DRM system will be an important component within the receiver. It is unlikely that a consumer radio receiver designed to receive terrestrial transmissions with a digital capability would exclude the analogue capability.

In the consumer radio receiver, the DRM system will provide the capability to receive digital radio (sound, program related data, other data, and still pictures) in all the broadcasting bands below 30 MHz. It can function in an independent manner, but, as stated above, will more likely be part of a more comprehensive receiver – much like the majority of today's receivers that include AM and FM band analogue reception capability.

The DRM system is designed to be used in either 9 or 10 kHz channels or multiples of these channel bandwidths. Differences in detail on how much of the available bit stream for these channels is used for audio, for error protection and correction, and for data depend on the allocated band (LF, MF, or HF) and on the intended use (for example, ground wave, short distance sky wave or long distance sky wave). In other words, there are modal trade-offs available so that the system can match the diverse needs of broadcasters worldwide. As indicated in the next section, when regulatory procedures are in place to use channels of greater bandwidth than 9/10 kHz, the DRM system's audio quality and total bit stream capability can be greatly improved.

The DRM system employs advanced audio coding (AAC), supplemented by spectral band replication (SBR) as its main digital encoding. SBR improves perceived audio quality by a technique of higher baseband frequency enhancement using information from the lower frequencies as cues. OFDM/QAM is used for the channel coding and modulation, along with time interleaving and forward error correction (FEC) using multi-level coding (MLC) based on a convolutional code. Pilot reference symbols are used to derive channel equalization information at the receiver. The combination of these techniques results in higher quality sound with more robust reception within the intended coverage area when compared with that of currently used AM.

The system performs well under severe propagation conditions, such as those encountered under long distance multipath HF sky-wave propagation, as well as under easier to cope with MF groundwave propagation. In the latter case, maximum use is made of the AAC and SBR source coding algorithms, leading to much higher quality audio than that achieved by AM, since a minimal amount of error correction has to be employed. For many HF propagation conditions, the necessity to achieve a high degree of robustness reduces the audio quality compared to MF digital; nevertheless, the audio quality is still better than current AM quality.

The design permits the use of the DRM system within a single frequency network (SFN).

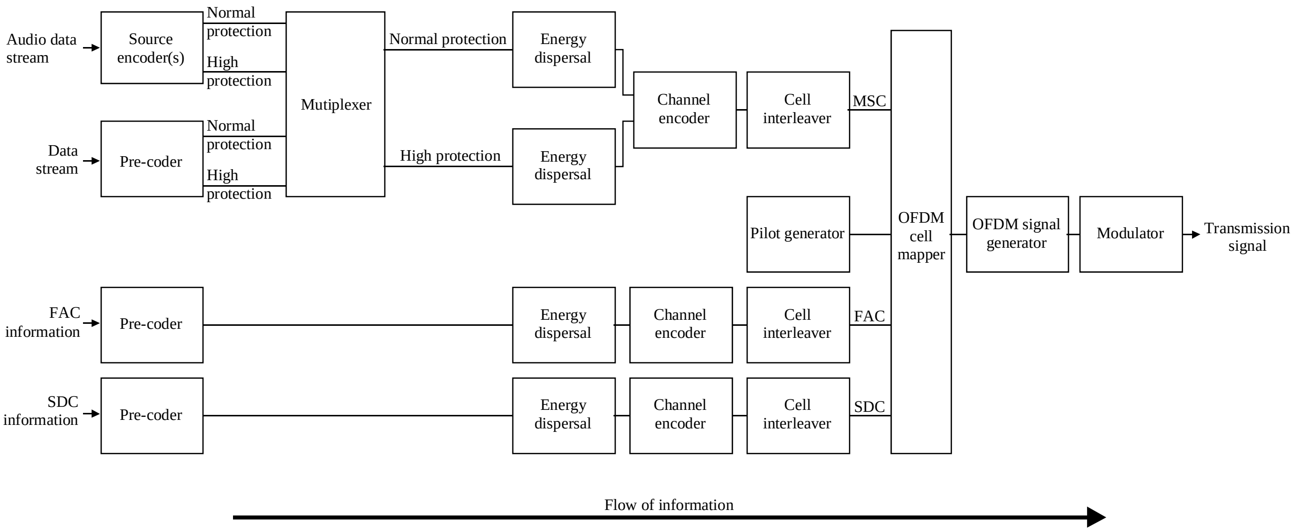
It also provides the capability for automatic frequency switching, which is of particular value for broadcasters who send the same signals at different transmission frequencies. For example, this is done routinely by large HF broadcasting organizations using AM to increase the probability of at least one good signal in the intended reception area. The DRM system can enable a suitable receiver to select the best frequency for a programme automatically without any effort on the part of the listener.

1.1.2 Brief description of the DRM system

1.1.2.1 Overall design

FIGURE 1

Block diagram of input to a transmitter



MSC: main service channel

1514-01

Figure 1 describes the general flow of the different classes of information (audio, data, etc.) from encoding on the left of the Figure to a DRM system transmitter exciter on the right. Although a receiver diagram is not included as a figure, it would represent the inverse of this diagram.

On the left are two classes of input information:

– the encoded audio and data that are combined in the main service multiplexer;

– information channels that bypass the multiplexer that are known as fast access channel (FAC) and service description channel (SDC)

The audio source encoder and the data pre-coders ensure the adaptation of the input streams onto an appropriate digital format. Their output may comprise two parts requiring two different levels of protection within the subsequent channel encoder.

The multiplex combines the protection levels of all data and audio services.

The energy dispersal provides a deterministic, selective complementing of bits in order to reduce the possibility that systematic patterns result in unwanted regularity in the transmitted signal.

The channel encoder adds redundant information as a means for error correction and defines the mapping of the digital encoded information into QAM cells. The system has the capability, if a broadcaster desires, to convey two categories of “bits”, with one category more heavily protected than the other.

Cell interleaving spreads consecutive QAM cells onto a sequence of cells, quasi-randomly separated in time and frequency, in order to provide an additional element of robustness in the transmission of the audio in time-frequency dispersive channels.

The pilot generator injects information that permits a receiver to derive channel equalization information, thereby allowing for coherent demodulation of the signal.

The OFDM cell mapper collects the different classes of cells and places them on a time-frequency grid.

The OFDM signal generator transforms each ensemble of cells with the same time index to a time domain representation of the signal, containing a plurality of carriers. The complete time-domain OFDM symbol is then obtained from this time domain representation by inserting a guard interval –a cyclic repetition of a portion of the signal.

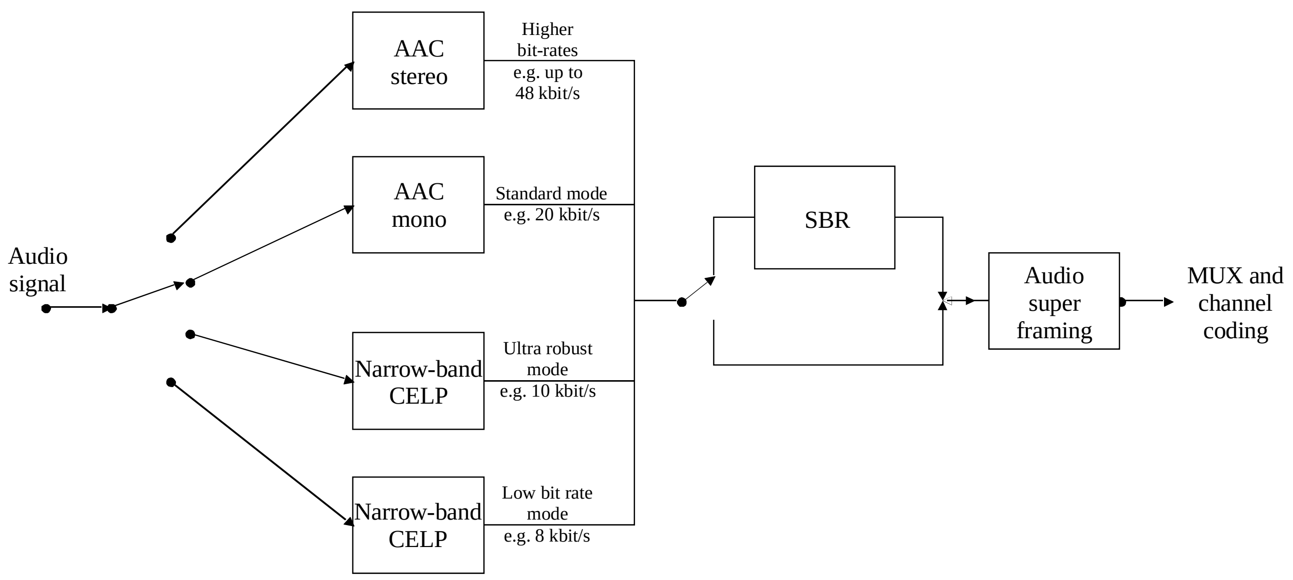
The modulator converts the digital representation of the OFDM signal into the analogue signal that will be transmitted via a transmitter/antenna over the air. This operation involves frequency up-conversion, digital-to-analogue conversion, and filtering so that the emitted signal complies with ITU-R spectral requirements.

With a non-linear high-powered transmitter, the signal is first split into its amplitude and phase components (this can advantageously be done in the digital domain), and then recombined (by the action of the transmitter itself) prior to final emission.

1.1.2.2 Audio source coding

FIGURE 2

Source coding overview



CELP: code excited linear prediction

1514-02

The source coding options available for the DRM system are depicted in Fig. 2. All of these options, with the exception of the one at the top of the figure (AAC stereo), are designed to be used within the current 9/10 kHz channels for sound broadcasting below 30 MHz. The CELP option provides relatively low bit-rate speech encoding and the AAC option employs a subset of standardized MPEG-4 for low bit rates (that is, up to 48 kbit/s). These options can be enhanced by a bandwidth-enhancement tool, such as the SBR depicted in the figure. Representative output bit rates are noted in the figure. All of this is selectable by the broadcaster.

Special care is taken so that the encoded audio can be compressed into audio superframes of constant time length (400 ms). Multiplexing and unequal error protection (UEP) of audio/speech services is effected by means of the multiplex and channel coding components.

As an example of the structure, consider the path in Fig. 2 of AAC mono plus SBR. For this, there are the following properties:

Frame length:	40 ms
AAC sampling rate:	24 kHz
SBR sampling rate:	48 kHz
AAC frequency range:	0-6.0 kHz
SBR frequency range:	6.0-15.2 kHz
SBR average bit rate:	2 kbit/s per channel.

In this case, there is a basic audio signal 6 kHz wide, which provides audio quality better than standard AM, plus the enhancement using the SBR technique that extends this to 15.2 kHz. All of this consumes approximately 22 kbit/s. The bitstream per frame contains a fraction of highly protected AAC and SBR data of fixed size, plus the majority of AAC and SBR data, less protected, of variable size. The fixed-time-length audio superframe of 400 ms is composed of several of these frames.

1.1.2.3 Multiplex, including special channels

As noted in Fig. 1, the DRM system total multiplex consists of three channels: the MSC, the FAC and the SDC. The MSC contains the services, audio and data. The FAC provides information on the signal bandwidth and other such parameters and is also used to allow service selection information for fast scanning. The SDC gives information to a receiver on how to decode the MSC, how to find alternate sources of the same data, and gives attributes to the services within the multiplex.

The MSC multiplex may contain up to four services, any one of which can be audio or data. The gross bit rate of the MSC is dependent upon the channel bandwidth and transmission mode being used. In all cases, it is divided into 400 ms frames.

The FAC's structure is also built around a 400 ms frame. The channel parameters are included in every FAC frame. The service parameters are carried in successive FAC frames, one service per frame. The names of the FAC channel parameters are: base/enhancement flag, identity, spectrum occupancy, interleaver depth flag, modulation mode, number of services, reconfiguration index, and reserved for future use. These use a total of 20 bits. The service parameters within the FAC are: service identifier, short identifier, CA (conditional access) indication, language, audio/data flag, and reserved for future use. These use a total of 44 bits. (Details on these parameters, including field size, are given in the system specification.)

The SDC's frame periodicity is 1 200 ms. Without detailing the use for each of the many elements within the SDC's fields, the names of them are: multiplex description, label, conditional access, frequency information, frequency schedule information, application information, announcement support and switching, coverage region identification, time and date information, audio information, FAC copy information, and linkage data. As well as conveying this data, the fact that the SDC is inserted periodically into the waveform is exploited to enable seamless switching between alternate frequencies.

1.1.2.4 Channel coding and modulation

The coding/modulation scheme used is a variety of coded orthogonal FDM (COFDM) which combines OFDM with MLC based on convolutional coding. These two main components are supplemented by cell interleaving and the provision of pilot cells for instantaneous channel estimation, which together mitigate the effects of short-term fading, whether selective or flat.

Taken together, this combination provides excellent transmission and signal protection possibilities in the narrow 9/10 kHz channels in the long-wave, medium-wave and short-wave broadcasting frequency bands. And it can also be effectively used at these broadcasting frequencies for wider channel bandwidths in the event that these are permitted from a regulatory standpoint in the future.

For OFDM, the transmitted signal is composed of a succession of symbols, each including a guard interval – a cyclic prefix which provides robustness against delay spread. Orthogonality refers to the fact that, in the case of the design of the DRM system, each symbol contains approximately 200 subcarriers spaced across the 9/10 kHz in such a way that their signals do not interfere with each other (are orthogonal). The precise number of subcarriers, and other parameter considerations, are a function of the mode used: ground wave, sky wave, and highly robust transmissions.

QAM is used for the modulation that is impressed upon each of the various subcarriers to convey the information. Two primary QAM constellations are used: 64-QAM and 16-QAM. A QPSK mode is also incorporated for highly robust signalling (but not for the MSC).

The interleaver time span for HF transmission is in the range of 2.4 s to cope with time- and frequency-selective fading. Owing to less difficult propagation conditions, a shortened interleaver with 0.8 s time span can be applied for LF and MF frequencies.

The multi-level convolutional coding scheme will use code rates in the range between 0.5 and 0.8, with the lower rate being associated with the difficult HF propagation conditions.

1.1.3 Transmitter considerations

The DRM system exciter can be used to impress signals on both linear and non-linear transmitters. It is expected that high-powered non-linear transmitters will be the normal way of serving the broadcasters. This is similar to current practice which exists for double-sideband amplitude modulation.

Because of this need, over the past few years, using the DRM system and other prototypes, effort has been spent to determine how these non-linear transmitters can be used with narrow-band digital signals. The results have been encouraging, as can be seen from recent DRM system field tests.

Briefly, the incoming signal to a Class C (non-linear amplification) transmitter needs to be split into its amplitude and phase components prior to final amplification. The former is passed via the anode circuitry, the latter through the grid circuitry. These are then combined with the appropriate time synchronization to form the output of the transmitter.

Measurements of the output spectra show the following: the energy of the digital signal is more or less evenly spread across the 9/10 kHz assigned channel; the shoulders are steep, and drop rapidly to 40 dB or so below the spectral density level within the assigned 9/10 kHz channel, and the power spectral density levels continue to decrease at a lower rate beyond ±4.5/5.0 kHz from the central frequency of the assigned channel.

1.1.4 Over the air

The digital phase/amplitude information on the RF signal is corrupted to different degrees as the RF signal propagates. Some of the HF channels provide challenging situations of fairly rapid flat fading, multipath interference that produces frequency-selective fading and large path delay spreads in time, and ionospherically induced high levels of Doppler shifts and Doppler spreads.

The error protection and error correction incorporated in the DRM system design mitigates these effects to a great degree. This permits the receiver to accurately decode the transmitted digital information.

1.1.5 Selecting, demodulation and decoding of a DRM system signal at a receiver

A receiver must be able to detect which particular DRM system mode is being transmitted, and handle it appropriately. This is done by way of the use of many of the field entries within the FAC and SDC.

Once the appropriate mode is identified (and is repeatedly verified), the demodulation process is the inverse of that shown in the upper half of Fig. 1, the diagram of the transmitter blocks.

Similarly, the receiver is also informed what services are present, and, for example, how source decoding of an audio service should be performed.

1.1.6 Ongoing case study in Italy since 2006: DRM daytime MW Tests for frequencies below 1 MHz

The transmission site located near Milan was used to provide for an initial field test on frequency (693 kHz). The DRM signal is being broadcast by a station in Siziano, located 20 kilometres south of Milan. The same site is used to broadcast RAI’s regular analogue MW signals.

The analogue transmitter (working on 200 kW at 900 kHz) was combined with the digital transmitter (working on 34 kW at 693 kHz) and radiated by the same antenna structure.

On the basis of acquired data for the DRM transmission we can reach the following conclusions.

The whole north-west part of Italy is completely covered with a signal strength with a level greater than the minimum one indicated in Recommendation ITU-R BS.1698 for the adopted configuration transmission parameters (38,6 dBμV/m). Moreover minimum SNR of 14,1 dB was exceeded in each measurement point, also in deep valleys. The extension of coverage area can be identified with national border (Sestriere, Ceresole Reale, Domodossola and Bormio). On the east direction the DRM signal is available up to Trieste on which seacoast the field strength is 48,5 dBμV/m with a SNR of 21,7 dB. Due to particular topography and poor ground conductivity the Brennero valley was covered only before the town of Trento. In south-east direction DRM is available up to just before Ancona. In south direction DRM reaches all Liguria coast, and a part of Tuscany coast up to Grosseto town. The cities of Genova, Savona, La Spezia and Livorno are also covered.

The whole coverage results are indicated on Map 1. The inner contour shows the coverage area in which both commercial and professional receivers were able to decode DRM signal. The outer contour shows the coverage area in which only professional receiver was able to decode DRM signal.

MAP 1

Measured coverage area

The service area shown on Map 2 is computed on the basis of 45 dBµV/m for towns below 1,000 living persons and of 53 dBµV/m for towns with more than 1 000 living persons.

At the moment, about 150 static measurement points were verified.

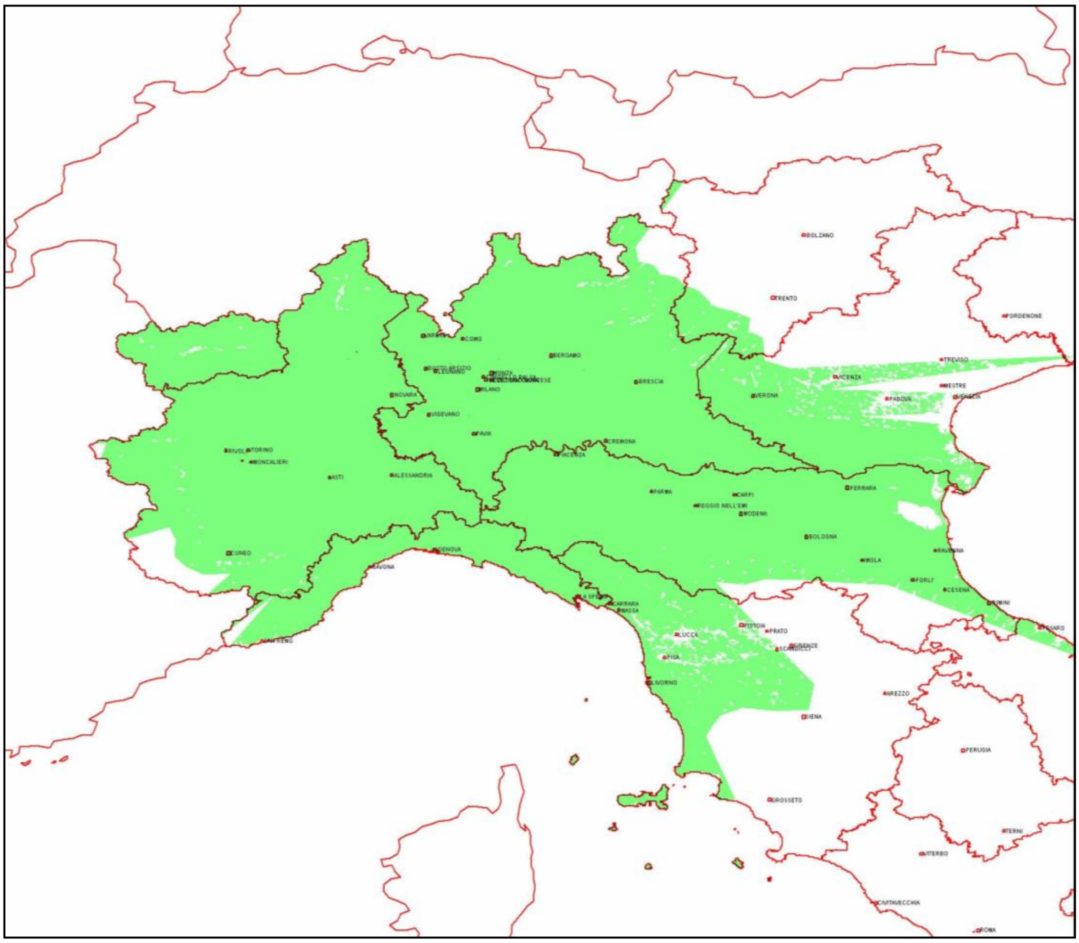
Some data analysis was done in order to identify locations where reception was not available because of local particular situations:

– in the centre town of Turin, 125 km far from the transmitter, in 1 of 12 measurement points the performance of DRM signal has been damaged by an electric feeder for public transport. At that point was recorded a SNR of 13,4 dB with a signal strength of 52,1 dBµV/m and no audio decoding;

– northern from Milan, at the beginning of Valtellina valley (93 km far from the transmitter) some topographical situations and poor ground conductivity cause low signal strength (35,7 dBµV/m) and SNR (8,5 dB). Travelling along the valley route the signal and SNR come back to increase up to Bormio city, 170 km far from the transmitter.

MAP 2

Predicted coverage area (according to Recommendation ITU-R P.368-7)



During day time no discernable broadcasting interference situations were recorded in the whole predicted and measured coverage area.

As can be easily noted, measured and predicted area match quite well.

1.2 T-DAB general

The multi-carrier T-DAB system as adopted by the majority of countries in Europe and also in some countries outside the European continent, has been designed with a bandwidth of about 1.5 MHz. Frequency blocks have been fit in to the 7 MHz VHF channel scheme. A mean rate of about 1.15 Mbit/s is available for the delivery of high quality CD-like sound services in conjunction with text, data and images, for fixed, portable and mobile receivers.

1.2.1 Frequency bands

1.2.1.1 General

The Plan to be established by the second session of Regional Radio Conference (RRC-06) should contain assignments and/or allotments for digital broadcasting stations in the following bands:

– Band III (174 to 230 MHz);

– Bands IV and V (470 to 862 MHz).

The European countries after evaluating the other possible options have finally adopted the T-DAB system for Band III.

1.2.1.2 Frequencies for sound channels in the planning area

It is to be noted that whilst the frequency band from 174 to 216 MHz is primarily used for terrestrial analogue television, there are also some T-DAB allotments in this band. The frequency band 216-230 MHz (240 MHz in some countries) is mainly allocated to T-DAB in European countries; nevertheless there is still widespread use of part of this band for television.

Ultimately, a flexible approach will be required as regards the use of T-DAB, or DVB-T, in specific channels in Band III because of the different situations and time-frames all over the planning area, or even within one country. Sharing criteria and clear procedures for both kinds of use are therefore required.

1.2.2 T-DAB in Band III

Band III is seen as the optimum solution for a T-DAB band to provide a terrestrial T-DAB service.

The band does not suffer from a number of the anomalous propagation characteristics which are a problem in Band I such as sporadic E and F2 layer propagation. Man-made noise is significantly lower in Band III than in Band I, and Band III frequencies are still sufficiently low that the Doppler shift created by moving vehicles at motorway speeds will not create a problem for operation in Mode 1 of the digital system A specification.

This is made possible by a rugged system design that allows seamless and fade-free reception even in highly disruptive conditions, largely dominated by multipath propagation.

It has to be noted that Band II was also considered for T-DAB, but this turned out not to be viable due to the congested situation in many areas.

1.2.3 Location of transmitters

It should be noted that in the case of an SFN the separation distance between transmitters influences the choice of guard interval, which in turn determines the size of the network. The separation distance and the effective height influence the effective radiated power. In the implementation of T-DAB existing transmitting site infrastructures have been used where possible, with the addition of some new supplementary sites. The latter have been adopted in order to fulfil the SFN requirements.

1.3 IBOC

1.3.1 IBOC Overview

The IBOC system was designed for regions where limited spectrum prevents the allocation of new spectrum for digital broadcasting. The IBOC system allows broadcasters to simultaneously transmit an analogue and digital signal without the need for additional spectrum for the digital signal. The IBOC system takes advantage of unused portions of the spectrum on either side of the analogue carrier (as defined by the service frequency allocation “mask”) and implements frequency re-use by including digital carriers in quadrature to the existing analogue carrier. In either case, the analogue signals are in close proximity to the digital signals and great care must be taken to prevent unwanted interference between them.

The IBOC system offers a number of advantages for broadcasters, consumers and regulators. The IBOC system replicates the existing coverage patterns of each radio station thereby retaining the existing economic value of the station. Broadcasters can convert to digital broadcasts with a modest investment and retain the vast majority of their existing physical plant. In addition, the introduction of the digital signal in the existing channel allows the broadcaster to retain the station’s existing dial position. Because the system supports simulcast of the analogue and digital signals, consumers are able to upgrade to digital over an extended period and taking into account normal equipment replacement cycles. Regulators benefit because there is no need for spectrum allocations or licensing of new stations.

The IBOC system offers the following features:

- CD quality audio in the VHF-band and VHF quality audio in the MF band.
- Digital coverage equivalent to existing analogue coverage. In areas where the digital signal is lost, the system automatically blends to the analogue back-up signal to ensure digital coverage is never less than existing analogue coverage.
- Advanced coding technologies and time diversity between the analogue and digital signals ensure a robust signal.

− The VHF system has demonstrated significant robustness in the presence of severe multipath, and the MF system has demonstrated significant robustness in the presence of impulse noise.

− The VHF system offers options for introducing new audio and data services ranging from 1 to 300 kbit/s depending on the mode of operation.

The IBOC system has been tested in North and South America, Europe and Asia. It is currently in operation in approximately 1 800 stations throughout the United States of America. This has added more than 900 new multicast audio streams using existing VHF stations. The system has been used for demonstrations, testing and/or ongoing operations in Brazil, China, France, Indonesia, Mexico, the Philippines, Switzerland, Ukraine, Vietnam.

The IBOC system has been standardized by the National Radio Systems Committee (NRSC), a standards setting organization sponsored by the National Association of Broadcasters and the Consumer Electronics Association in the United States. The current version of the standard, NRSC-5-B is available from the NRSC at www.nrscstandards.org.

Currently, there are commercially available IBOC receivers in most market segments. OEM receivers are available in the United States as standard equipment or a factory installed option for many major auto manufacturers. More than sixty models of aftermarket automobile receivers, tabletop receivers, home HiFi receivers and car converter products are available from national and local retailers throughout the United States. As the cost of components and the power consumption levels are reduced in the near future, it is anticipated that mobile receivers will become available.

1.3.2 The IBOC System Technical Design

The IBOC system is designed to permit a smooth evolution from current analog modulation to a fully digital system. This system can deliver digital audio and data services to mobile, portable, and fixed receivers from terrestrial transmitters in the existing Medium Frequency (MF) and Very High Frequency (VHF) radio bands. The system is designed to allow broadcasters to continue to transmit analog MF and VHF simultaneously with new, higher-quality and more robust digital signals, allowing broadcasters and their listeners to convert from analog to digital radio while maintaining each station’s current frequency allocation.

The IBOC system allows a broadcast station to offer multiple services. A service can be thought of as a logical grouping of application data identified by the IBOC system. Services are grouped into one of two categories:

1 Core Services:

a) Main Program Service (both Audio (MPA) and Data (PAD))

b) Station Information Service (SIS)

2 Advanced Application Services (AAS)

The flow of service content through the IBOC broadcast system is as follows:

a) Service content enters the IBOC broadcast system via Service Interfaces;

b) Content is assembled for transport using a specific protocol;

c) It is routed over logical channels via the Channel Multiplex.

It is waveform modulated via the Waveform / Transmission System for over-the-air transmission.

The system employs coding to reduce the sampled audio signal bit rate and baseband signal processing to increase the robustness of the signal in the transmission channel. This allows a high quality audio signal plus ancillary data to be transmitted in band segments and at low levels which do not interfere with the existing analog signals.

1.3.2.1 Services

1.3.2.1.1 Main Program Service (MPS)

The Main Program Service is a direct extension of traditional analog radio. MPS allows the transmission of existing analog radio-programming in both analog and digital formats. This allows for a smooth transition from analog to digital radio.

Radio receivers that are not IBOC enabled can continue to receive the traditional analog radio signal, while IBOC receivers can receive both digital and analog signals via the same frequency band. In addition to digital audio, MPS includes digital data related to the audio programming. This is also referred to as Program Associated Data (PAD).

1.3.2.1.2 Station Information Service (SIS)

The Station Information Service provides the necessary radio station control and identification information, such as station call sign identification, time and location reference information. SIS can be considered a built-in service that is readily available on all IBOC stations. SIS is a required IBOC service and is provided dedicated bandwidth.

1.3.2.1.3 Supplemental Program Service (SPS)

The Supplemental Program Service allows broadcasters to introduce up to seven new digital audio channels depending on the throughput devoted to the SPS. The SPS includes support for Program Associated Data for each program stream.

1.3.2.1.4 Advanced Application Services (AAS)

AAS is a complete framework in which new applications may be built. In addition to allowing multiple data applications to share the Waveform / Transmission medium, AAS provides a common transport mechanism as well as a unified Application Programming Interface (API). On the transmission side, broadcasters utilize the common AAS interface to insert service(s) into their signal; receiver manufacturers utilize the AAS 'toolkit' to efficiently access these new services for the end-user. AAS includes separate audio programming such as reading services and other secondary audio and data services.

1.3.3 System components

1.3.3.1 Codec

The IBOC DSB system uses the HDC codec supplemented by SBR. This delivers high quality "FM-like" stereo audio within the bandwidth constraints imposed on operations below 30 MHz. To further enhance the robustness of the digital audio beyond that provided by FEC and interleaving, special error concealment techniques are employed by the audio codecs to mask the effects of errors in the input bit-stream. Furthermore, the audio codec bit-stream format provides the flexibility of allowing future enhancements to the basic audio coding techniques.

1.3.3.2 Modulation techniques

The IBOC DSB system uses QAM. QAM has a bandwidth efficiency that is sufficient for transmission of "FM-like" stereo audio quality as well as providing adequate coverage areas in the available bandwidth.

The system also uses a multi-carrier approach called OFDM. OFDM is a scheme in which many QAM carriers can be frequency-division multiplexed in an orthogonal fashion such that there is no interference among the carriers. When combined with FEC coding and interleaving, the digital signal's robustness is further enhanced. The OFDM structure naturally supports FEC coding techniques that maximize performance in the non-uniform interference environment.

1.3.3.3 FEC coding and interleaving

FEC coding and interleaving in the transmission system greatly improve the reliability of the transmitted information by carefully adding redundant information that is used by the receiver to correct errors occurring in the transmission path. Advanced FEC coding techniques have been specifically designed based on detailed interference studies to exploit the non-uniform nature of the interference in these bands. Also, special interleaving techniques have been designed to spread burst errors over time and frequency to assist the FEC decoder in its decision-making process.

A major problem confronting systems operating below 30 MHz is the existence of grounded conductive structures that can cause rapid changes in amplitude and phase that are not uniformly distributed across the band. To correct for this, the IBOC DSB system uses equalization techniques to ensure that the phase and amplitude of the OFDM digital carriers are sufficiently maintained to ensure proper recovery of the digital information. The combination of advanced FEC coding, channel equalization, and optimal interleaving techniques allows the IBOC DSB system to deliver reliable reception of digital audio in a mobile environment.

1.3.3.4 Blend

The IBOC DSB system employs time diversity between two independent transmissions of the same audio source to provide robust reception during outages typical of a mobile environment. In the hybrid system the analogue signal serves as the backup signal, while in the all-digital system a separate digital audio stream serves as the backup signal. The IBOC DSB system provides this capability by delaying the backup transmission by a fixed time offset of several seconds relative to the main audio transmission. This delay proves useful for the implementation of a blend function. During tuning, blend allows transition from the instantly acquired back-up signal to the main signal after it has been acquired. Once acquired, blend allows transition to the back-up signal when the main signal is corrupted. When a signal outage occurs, the receiver blends seamlessly to the backup audio that, by virtue of its time diversity with the main signal, does not experience the same outage.

Digital systems depend on an interleaver to spread errors across time and reduce outages. Generally longer interleavers provide greater robustness at the expense of acquisition time. The blend feature provides a means of quickly acquiring the back-up signal upon tuning or re-acquisition without compromising full performance.

1.3.4 Operating modes

1.3.4.1 Hybrid MF mode

In the hybrid waveform, the digital signal is transmitted in sidebands on either side of the analogue host signal as well as beneath the analogue host signal as shown in Fig. 3. The power level of each OFDM subcarrier is fixed relative to the main carrier as indicated in Fig. 3. The OFDM carriers, or digital carriers, extend approximately ±14.7 kHz from the AM carrier. The digital carriers directly beneath the analogue signal spectrum are modulated in a manner to avoid interference with the analogue signal. These carriers are grouped in pairs, with a pair consisting of two carriers that are equidistant in frequency from the AM carrier. Each pair is termed a complementary pair and the entire group of carriers is called the complementary carriers. For each pair, the modulation applied to one carrier is the negative conjugate of the modulation applied to the other carrier. This places the sum of the carriers in quadrature to the AM carrier, thereby minimizing the interference to the analogue signal when detected by an envelope detector. Placing the complementary carriers in quadrature to the analogue signal also permits demodulation of the complementary carriers in the presence of the high level AM carrier and analogue signal. The price paid for placing the complementary carriers in quadrature with the AM carriers is that the information content on the complementary carriers is only half of that for independent digital carriers.

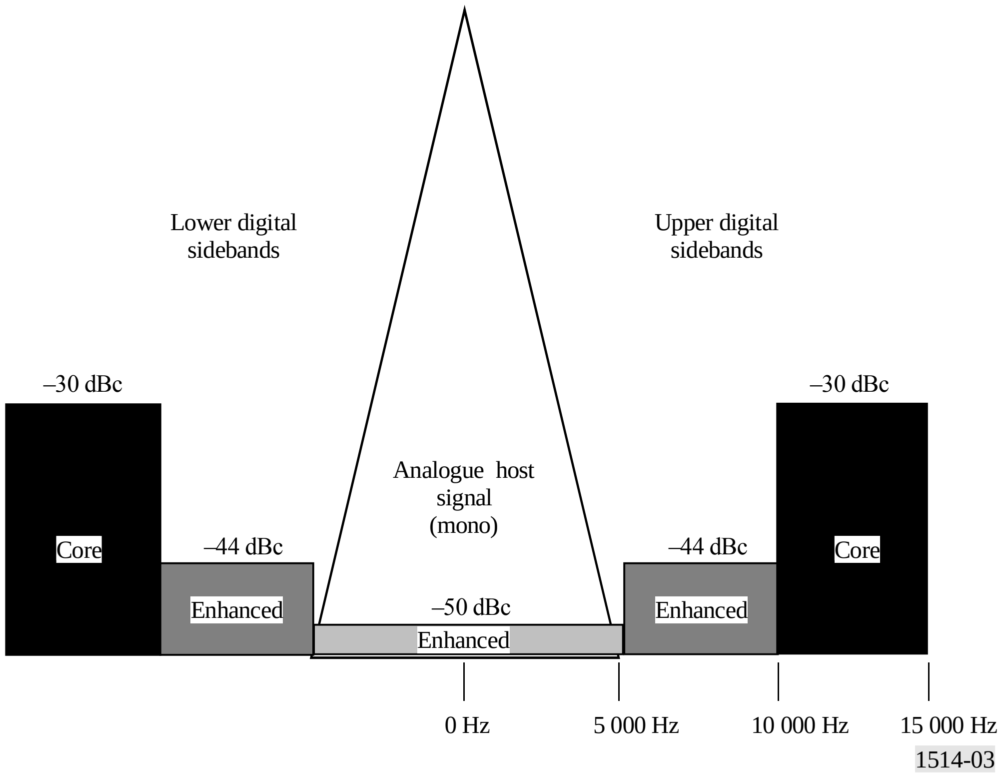
The hybrid mode is designed for stations operating at MF in areas where it is necessary to provide for a rational transition from analogue to digital. The hybrid mode makes it possible to introduce the digital services without causing harmful interference to the existing host analogue signal.

To maximize the reception of the digital audio, the IBOC DSB system uses a layered codec where the compressed audio is split into two separate information streams: core and enhanced. The core stream provides the basic audio information whereas the enhanced stream provides higher quality and stereo information. The FEC coding and placement of the audio streams on the OFDM carriers is designed to provide a very robust core stream and a less robust enhancement stream. For the hybrid system the core information is placed on high-powered carriers ±10 to 15 kHz from the analogue carrier while the enhanced information is placed on the OFDM carriers from 0 to ±10 kHz.

To protect the core audio stream from interference and channel impairments the IBOC DSB system uses a form of channel coding with the special ability to puncture the original code in various overlapping partitions (i.e., main, backup, lower sideband and upper sideband). Each of the four overlapping partitions survives independently as a good code. The lower and upper sideband partitions allow the IBOC DSB system to operate even in the presence of a strong interferer on either the lower or upper adjacent, while the main and backup partitions allow the IBOC DSB system to be acquired quickly and be robust to short-term outages such as those caused by grounded conductive structures.

FIGURE 3

Hybrid MF IBOC DSB power spectral density



In the hybrid system the core audio throughput is approximately 20 kbit/s while the enhanced audio throughput adds approximately 16 kbit/s.

1.3.4.2 All-digital MF mode

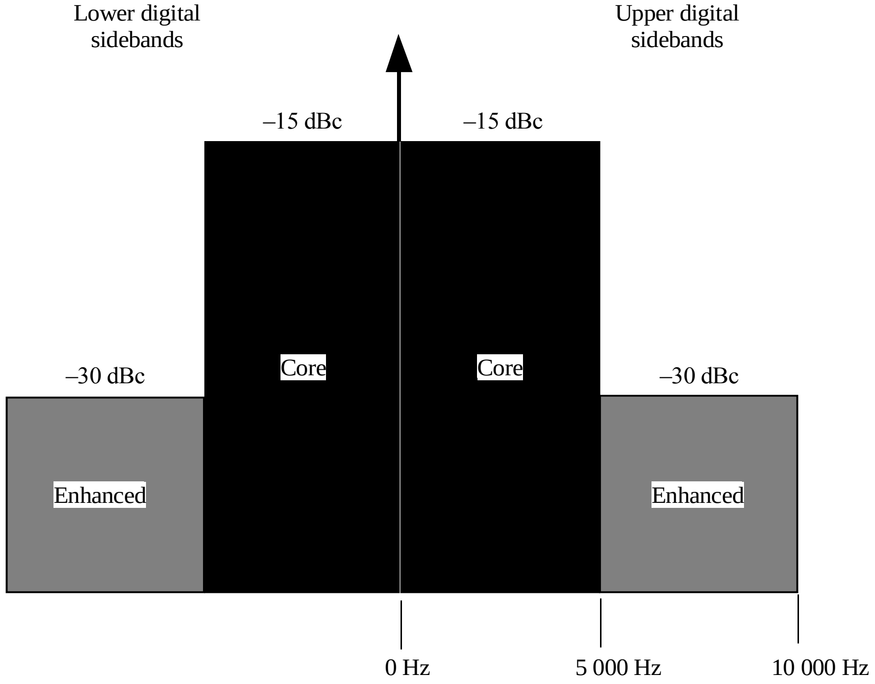
The all-digital mode allows for enhanced digital performance after deletion of the existing analogue signal. Broadcasters may choose to implement the all-digital mode in areas where there are no existing analogue stations that need to be protected or after a sufficient period of operations in the hybrid mode for significant penetration of digital receivers in the market place.

As shown in Fig. 4, the principal difference between the hybrid mode and the all-digital mode is deletion of the analogue signal and the increase in power of the carriers that were previously under the analogue signal. The additional power in the all-digital waveform increases robustness, and the "stepped" waveform is optimized for performance under strong adjacent channel interference.

The same layered codec and FEC methods, with identical rates (i.e. ~20 kbit/s for the core audio and ~16 kbit/s for the enhanced audio), are used in the all-digital system as is used in the hybrid system. This simplifies the design of a receiver having to support both systems.

FIGURE 4

All-digital MF IBOC DSB power spectral density



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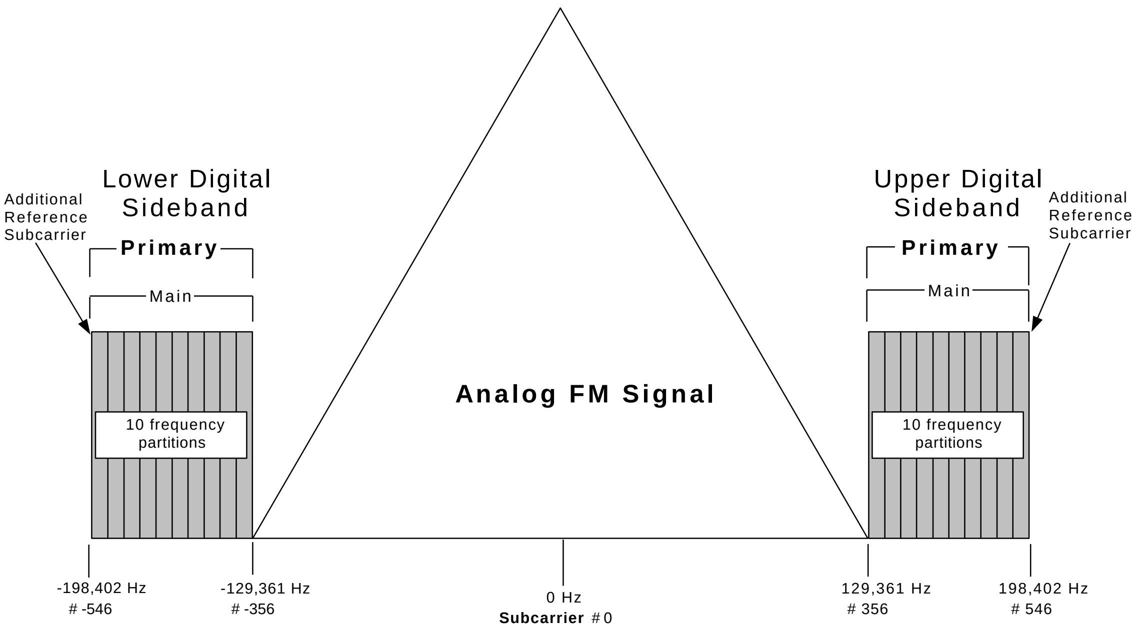
1.3.4.3 Hybrid VHF mode

The digital signal is transmitted in sidebands on either side of the analogue FM signal. Each sideband is comprised of ten frequency partitions, which are allocated among subcarriers 356 through 545, or –356 through –545. Subcarriers 546 and –546, also included in the sidebands, are additional reference subcarriers. The amplitude of the subcarrier within the sidebands is uniformly scaled by an *amplitude scale factor*.

FIGURE 5

Spectrum of the hybrid waveform–service mode
(The level of the digital subcarriers is such that the total power of these carriers is 20 dB below the nominal power of the FM analogue carrier)

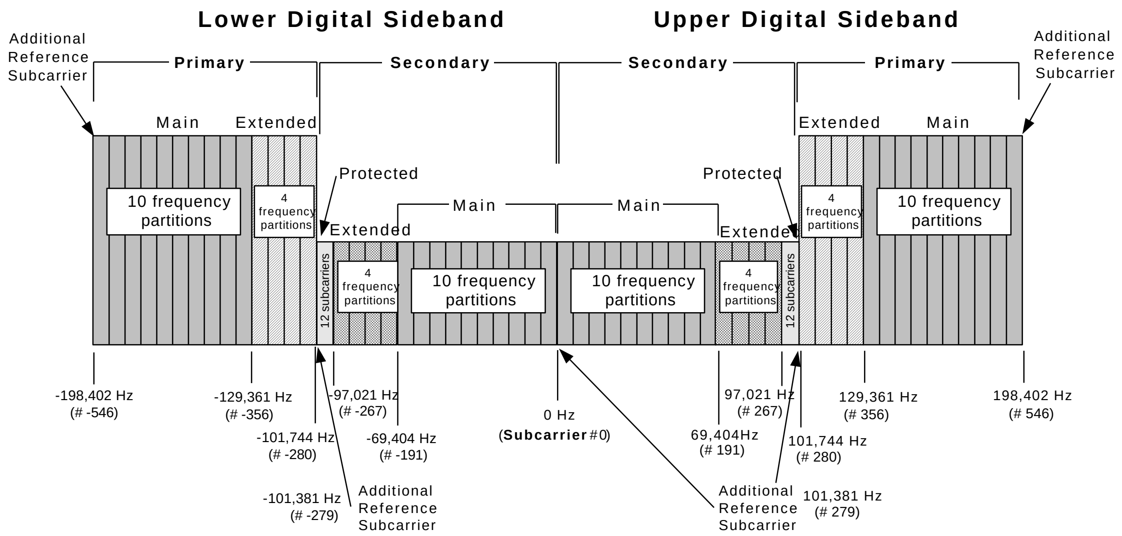


1.3.4.4 All Digital VHF mode

The All Digital waveform is constructed by removing the analogue signal, fully expanding the bandwidth of the primary digital sidebands, and adding lower-power secondary sidebands in the spectrum vacated by the analogue signal. The spectrum of the All Digital waveform is shown in Fig. 6.

FIGURE 6

Spectrum of the all digital waveform
(The level of the digital subcarriers is such that the total power of these carriers is no more than 10 dB below the nominal power of the FM analogue carrier that it replaces)



1.3.5 Generation of the signal

1.3.5.1 Transmission Subsystems

A basic block diagram representation of the system is shown in Fig. 7. It represents the IBOC digital radio system as three major subsystems.

− Audio source coding and compression

− Transport and Service Multiplex

− RF/Transmission.

1.3.5.1.1 Audio Source Coding and Compression

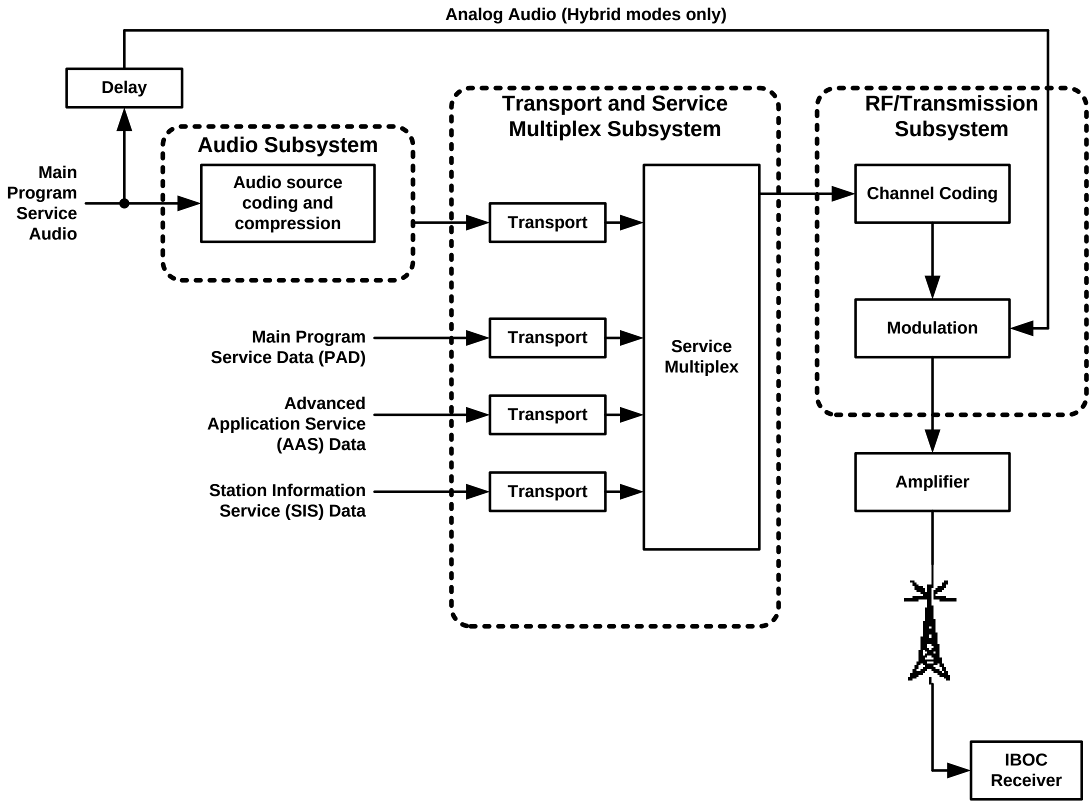
The Audio subsystem performs the source coding and compression of the sampled digitized Main Program Service (MPS) audio program material. “Source coding and compression” refers to the bit rate reduction methods, also known as data compression, appropriate for application to the audio digital data stream. In hybrid modes the MPS audio is also analog modulated directly onto the carrier for reception by conventional analog receivers. Several categories of data may also be transmitted on the digital signal including station identification, messages related to the audio program material, and general data services.

1.3.5.1.2 Transport and Service Multiplex

“Transport and service multiplex” refers to the means of dividing the digital data stream into “packets” of information, the means of uniquely identifying each packet or packet type (data or audio), and the appropriate methods of multiplexing audio data stream packets and data stream packets into a single information stream. The transport protocols have been developed specifically to support data and audio transmission in the MF and VHF radio bands.

FIGURE 7

IBOC digital radio broadcasting model

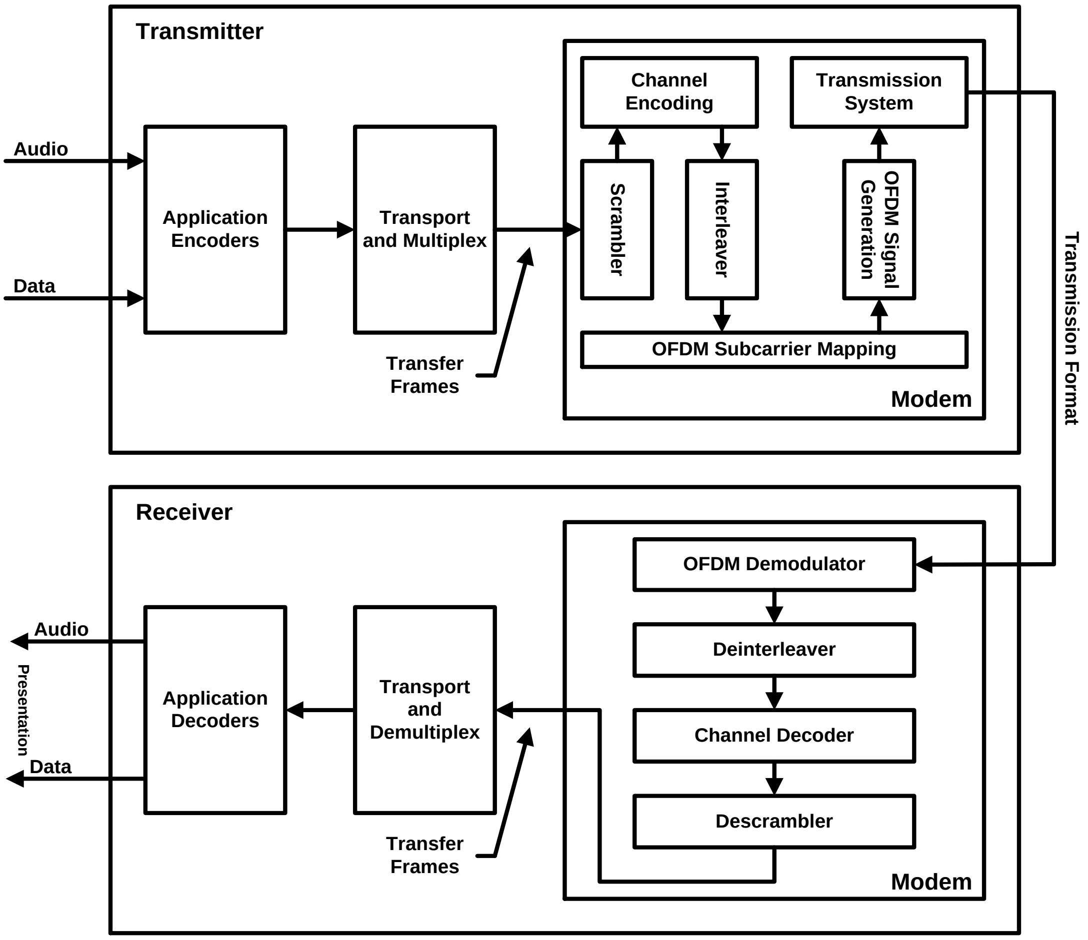


1.3.5.1.3 RF/Transmission System

"RF/Transmission" refers to channel coding and modulation. The channel coder takes the multiplexed bit stream and applies coding and interleaving that can be used by the receiver to reconstruct the data from the received signal which, because of transmission impairments, may not accurately represent the transmitted signal. The processed bit stream is modulated onto the OFDM subcarriers which are transformed to time domain pulses, concatenated, and up-converted to the VHF band.

FIGURE 8

RF/Transmission function in context of overall system



1.3.6 Reception of the signal

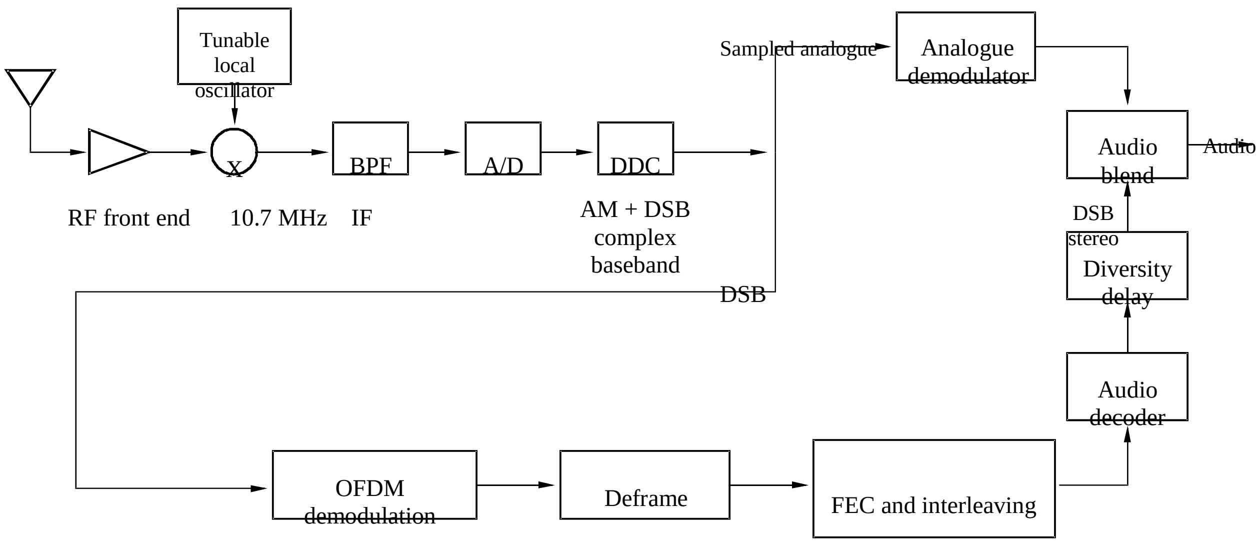
A functional block diagram of an MF IBOC receiver is presented in Fig. 9. The signal is received by a conventional RF front end and converted to IF, in a manner similar to existing analogue receivers. Unlike typical analogue receivers, however, the signal is filtered, A/D converted at IF, and digitally down converted to baseband in-phase and quadrature signal components. The hybrid signal is then split into analogue and DSB components. The analogue component is then demodulated to produce a digitally sampled audio signal. The DSB signal is synchronized and demodulated into symbols. These symbols are deframed for subsequent deinterleaving and FEC decoding. The resulting bit stream is processed by the audio decoder to produce the digital stereo DSB output. This DSB audio signal is delayed by the same amount of time as the analogue signal was delayed at the transmitter. The audio blend function blends the digital signal to the analogue signal if the digital signal is corrupted and is also used to quickly acquire the signal during tuning or reacquisition.

Noise blanking is an integral part of the IBOC receiver and is used to improve digital and analogue reception. Receivers use tuned circuits to filter out adjacent channels and intermodulation products. These tuned circuits tend to “ring”, or stretch out short pulses into longer interruptions. A noise blanker senses the impulse and turns off the RF stages for the short duration of the pulse, effectively limiting the effects on the analogue “listenability,” of ringing. Short pulses have a minimal effect on the digital data stream and increases “listenability of the analogue signal” (see Note 1).

NOTE 1 – The data paths and the noise blanker circuit are not shown for simplicity.

FIGURE 9

Hybrid MF IBOC typical receiver block diagram



BPF: band pass filter
DDC: digital down conversion

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1.4 ISDB-T$_{SB}$

1.4.1 Features of ISDB-T$_{SB}$

1.4.1.1 Ruggedness of ISDB-T$_{SB}$

The ISDB-T$_{SB}$ system uses OFDM modulation, two-dimensional frequency-time interleaving and concatenated error correction codes. OFDM is a multi-carrier modulation method, and it is a multipath-proof modulation method, especially adding a guard interval in the time domain. The transmitted information is spread in both the frequency and time domains by interleaving, and then the information is corrected by the Viterbi and Reed-Solomon (RS) decoder. Therefore a high quality signal is obtained in the receiver, even when working in conditions of severe multipath propagation, whether stationary or mobile.

1.4.1.2 Wide variety of transmission

The ISDB-T$_{SB}$ system adopts BST-OFDM, and consists of one or three OFDM-segments. That is single-segment transmission and triple-segment transmission. A bandwidth of OFDM-segment is defined in one of three ways depending on the reference channel raster of 6, 7 or 8 MHz. The bandwidth is a fourteenth of the reference channel bandwidth (6, 7 or 8 MHz), that is, 429 kHz (6/14 MHz), 500 kHz (7/14 MHz), 571 kHz (8/14 MHz). The bandwidth of OFDM-segment should be selected in compliance with the frequency situation in each country.

The bandwidth of single-segment is around 500 kHz, therefore the bandwidth of single-segment transmission and triple-segment transmission is approximately 500 kHz and 1.5 MHz.

The ISDB-T$_{SB}$ system has three alternative transmission modes which allow the use of a wide range of transmitting frequencies, and four alternative guard interval lengths for the design of the distance between SFN transmitters. These transmission modes have been designed to cope with Doppler spread and delay spread, for mobile reception in presence of multipath echoes.

1.4.1.3 Flexibility

A multiplex structure of the ISDB-T_{SB} system is fully compliant with MPEG-2 systems architecture. Therefore various digital contents such as sound, text, still picture and data can be transmitted simultaneously.

In addition, according to the broadcaster's purpose, they can select the carrier modulation method, error correction coding rate, length of time interleaving, etc. of the system. There are four kinds of carrier modulation method of DQPSK, QPSK, 16-QAM and 64-QAM, five kinds of coding rate of 1/2, 2/3, 3/4, 5/6 and 7/8, and five kinds of time interleaving length from 0 to approximately 1 s. The TMCC carrier transmits the information to the receiver indicating the kind of modulation method and coding rate that are used in the system.

1.4.1.4 Flexibility Commonality and interoperability

The ISDB-T_{SB} system uses BST-OFDM modulation and adopts MPEG-2 systems. Therefore the system has commonality with the ISDB-T system for digital terrestrial television broadcasting (DTTB) in the physical layer, and has commonality with the systems such as ISDB-T, ISDB-S, DVB-T and DVB-S which adopt MPEG-2 Systems in the transport layer.

1.4.1.5 Efficient transmission and source coding

The ISDB-T_{SB} system uses a highly-spectrum efficient modulation method of OFDM. Also, it permits frequency reuse broadcasting networks to be extended using additional transmitters all operating on the same radiated frequency.

In addition, the channels of independent broadcasters can be transmitted together without guardbands from the same transmitter as long as the frequency and bit synchronization are kept the same between the channels.

The ISDB-T_{SB} system can adopt MPEG-2 AAC. Near CD quality can be realized at a bit rate of 144 kbit/s for stereo.

1.4.1.6 Independency of broadcasters

The ISDB-T_{SB} system is a narrow-band system for transmission of one sound programme at least. Therefore broadcasters can have their own RF channel in which they can select transmission parameters independently.

1.4.1.7 Low-power consumption

Almost all devices can be made small and light weight by developing LSI chips. The most important aspect of efforts to reduce battery size is that the power consumption of a device must be low. The slower the system clock, the lower the power consumption. Therefore, a narrow-band, low bit rate system like single-segment transmission can allow for the receiver to be both portable and lightweight.

1.4.1.8 Hierarchical transmission and partial reception

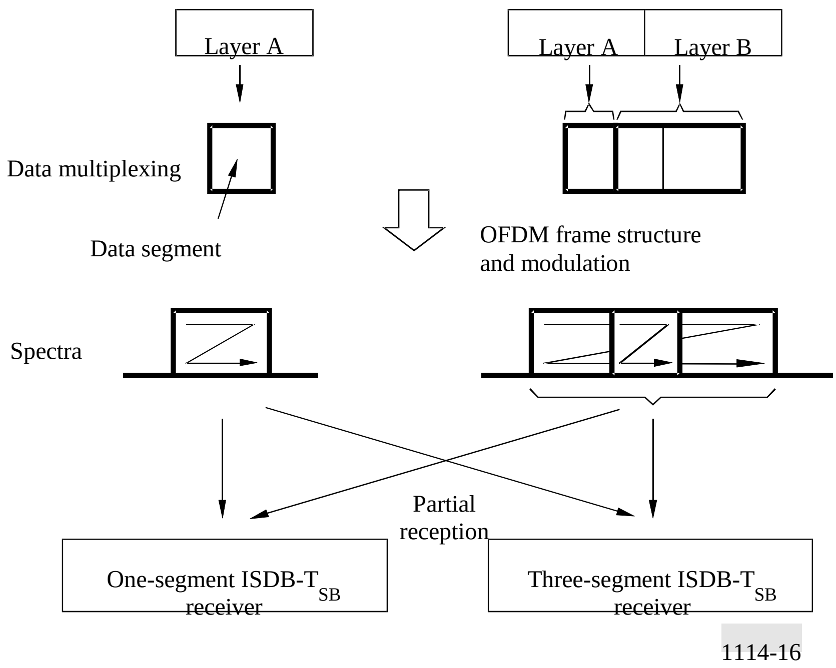
In the triple-segment transmission, both one layer transmission and hierarchical transmission can be achieved. There are two layers of A and B in the hierarchical transmission. The transmission parameters of carrier modulation scheme, coding rates of the inner code and a length of the time interleaving can be changed in the different layers.

The centre segment of hierarchical transmission is able to be received by single-segment receiver. Owing to the common structure of an OFDM segment, a single-segment receiver can partially receive a centre segment of full-band ISDB-T signal whenever an independent program is transmitted in the centre segment.

Figure 10 shows an example of hierarchical transmission and partial reception.

FIGURE 10

Example diagram of hierarchical transmission and partial reception



1.4.2 Transmission parameters

The ISDB-T$_{SB}$ system can be assigned to 6 MHz, 7 MHz or 8 MHz channel raster. Segment bandwidth is defined to be a fourteenth of channel bandwidth, therefore that is 429 kHz (6/14 MHz), 500 kHz (7/14 MHz) or 571 kHz (8/14 MHz). However, the segment bandwidth should be selected in compliance with the frequency situation in each country.

The transmission parameters for the ISDB-T$_{SB}$ system are shown in Table 1.

TABLE 1

Transmission parameters for the ISDB-T$_{SB}$

Mode		**Mode 1**	**Mode 2**	**Mode 3**
Total number of segments(1) ($N_s = n_d + n_c$)		1, 3		
Reference channel raster (BWf) (MHz)		6, 7, 8		
Segment bandwidth (BWs) (kHz)		$BWf \times 1\,000/14$		
Used bandwidth (BWu) (kHz)		$BWs \times N_s + C_s$		
Number of segments for differential modulation		n_d		
Number of segments for coherent modulation		n_c		
Carrier spacing (C_s) (kHz)		$BWs/108$	$BWs/216$	$BWs/432$
Number of carriers	Total	$108 \times N_s + 1$	$216 \times N_s + 1$	$432 \times N_s + 1$
	Data	$96 \times N_s$	$192 \times N_s$	$384 \times N_s$
	SP(2)	$9 \times n_c$	$18 \times n_c$	$36 \times n_c$
	CP(2)	$n_d + 1$	$n_d + 1$	$n_d + 1$
	TMCC(3)	$n_c + 5 \times n_d$	$2 \times n_c + 10 \times n_d$	$4 \times n_c + 20 \times n_d$
	AC1(4)	$2 \times N_s$	$4 + N_s$	$8 \times N_s$
	AC2(4)	$4 \times n_d$	$9 \times n_d$	$19 \times n_d$

TABLE 1 (*end*)

Mode	Mode 1	Mode 2	Mode 3	Mode
Carrier modulation	DQPSK, QPSK, 16-QAM, 64-QAM			
Number of symbol per frame	204			
Useful symbol duration (T_u) (μs)	1 000/C_s			
Guard interval duration (T_g)	1/4, 1/8, 1/16 or 1/32 of T_u			
Total symbol duration (T_s)	$T_u + T_g$			
Frame duration (T_f)	$T_s \times 204$			
FFT samples (F_s)	256 ($N_s = 1$) 512 ($N_s = 3$)	512 ($N_s = 1$) 1024 ($N_s = 3$)	1024 ($N_s = 1$) 2048 ($N_s = 3$)	
FFT sample clock (F_{sc}) (MHz)	$F_{sc} = F_s/T_u$			
Inner code	Convolutional code (Coding rate = 1/2, 2/3, 3/4, 5/6, 7/8) (Mother code = 1/2)			
Outer code	(204,188) RS code			
Time interleave parameter (I)	0, 4, 8, 16, 32	0, 2, 4, 8, 16	0, 1, 2, 4, 8	
Length of time interleaving	$I \times 95 \times T_s$			

FFT: fast Fourier transform.

(1) The ISDB-T_{SB} system uses 1 or 3 segments for sound services, while any number of segments may be used for other services such as television services. (Compare with System C of Recommendation ITU-R BT.1306.)

(2) SP (scattered pilot), and CP (continual pilot) can be used for frequency synchronization and channel estimation. The number of CP includes CPs on all segments and a CP for higher edge of whole bandwidth.

(3) TMCC carries information on transmission parameters.

(4) AC (auxiliary channel) carries ancillary information for network operation.

1.4.3 Source coding

The multiplex structure of the ISDB-T_{SB} system is fully compliant with MPEG-2 systems architecture, therefore MPEG-2 transport stream packets (TSPs) containing compressed digital audio signal can be transmitted. Digital audio compression methods such as MPEG-2 Layer II audio specified in ISO/IEC 13818-3, AC-3 (Digital Audio Compression Standard specified in ATSC Document A/52) and MPEG-2 AAC specified in ISO/IEC 13818-7 can be applied to the ISDB-T_{SB} system.

1.4.4 Multiplexing

The multiplex of the ISDB-T_{SB} system is compatible with MPEG-2 TS ISO/IEC 13818-1. In addition, multiplex frame and TMCC descriptors are defined for hierarchical transmission with single TS.

Considering maximum interoperation among a number of digital broadcasting systems, e.g. ISDB-S recommended in Recommendation ITU-R BO.1408, ISDB-T recommended in Recommendation ITU-R BT.1306 (System C) and broadcasting-satellite service (sound) system using the 2.6 GHz band recommended in Recommendation ITU-R BO.1130 (System E), these systems can exchange broadcasting data streams with other broadcasting systems through this interface.

1.4.4.1 Multiplex frame

To achieve hierarchical transmission using the BST-OFDM scheme, the ISDB-T_{SB} system defines a multiplex frame of TS within the scope of MPEG-2 systems. In the multiplex frame, the TS is a continual stream of 204-byte RS-TSP composed of 188-byte TSP and 16 bytes of null data or RS parity.

The duration of the multiplex frame is adjusted to that of the OFDM frame by counting RS-TSPs using a clock that is two times faster than the inverse FFT (IFFT) sampling clock in the case of single-segment transmission. In the case of the triple-segment transmission the duration of the multiple frame is adjusted to that of the OFDM frame by counting RS-TSPs using a clock that is four times faster than the IFFT sampling clock.

1.4.5 Channel coding

This section describes the channel coding block, which receives the packets arranged in the multiplex frame and passes the channel-coded blocks forward to the OFDM modulation block.

1.4.5.1 Functional block diagram of channel coding

Figure 11 shows the functional block diagram of channel coding of the ISDB-T$_{SB}$ system.

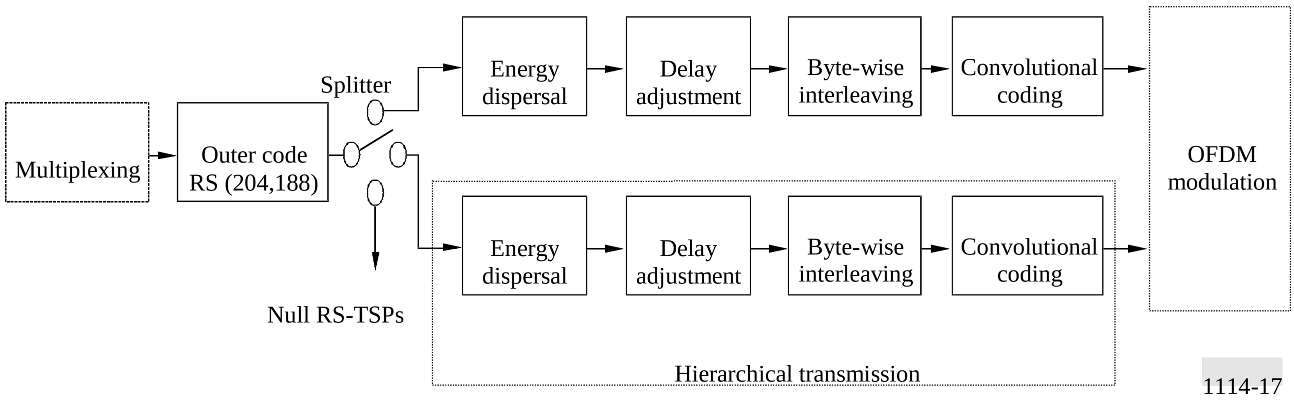
The duration of the multiplex frame coincides with the OFDM frame by counting the bytes in the multiplex frame using a faster clock than IFFT-sampling rate described in the previous section.

At the interface between the multiplex block and the outer coding block, the head byte of the multiplex frame (corresponding to the sync-byte of TSP) is regarded as the head byte of the OFDM frame. In bit-wise description, the most significant bit of the head byte is regarded as the synchronization bit of OFDM frame.

For the triple-segment layered transmission, the RS-TSP stream is divided into two layers in accordance with the transmission-control information. In each layer, coding rate of the inner error correction code, carrier-modulation scheme, and time-interleaving length can be specified independently.

FIGURE 11

Channel coding diagram



1.4.5.2 Outer coding

RS (204,188) shortened code is applied to each MPEG-2 TSP to generate an error protected TSP that is RS-TSP. The RS (208,188) code can correct up to eight random erroneous bytes in a received 204-byte word.

Field generator polynomial: $p(x) = x^8 + x^4 + x^3 + x^2 + 1$

Code generator polynomial: $g(x) = (x - \lambda^0)(x - \lambda^1)(x - \lambda^2)(x - \lambda^3) \cdots (x - \lambda^{15})$

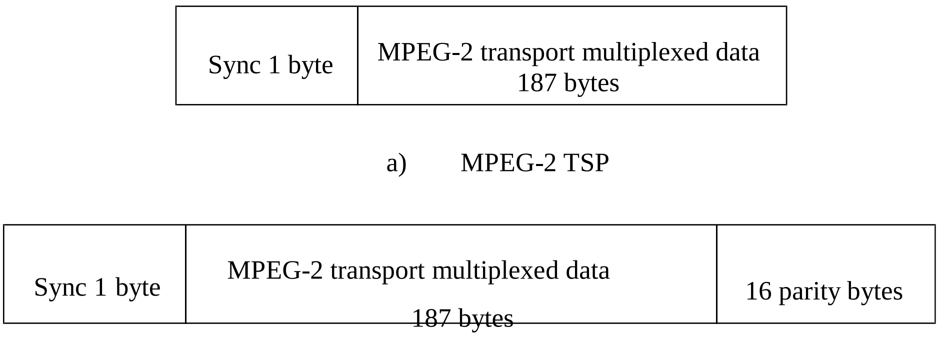
where $\lambda = 02_h$.

It should be noted that null TSPs from the multiplexer are also coded to RS (204,188) packets.

MPEG-2 TSP and RS-TSP (RS error protected TSP) are shown in Fig. 12. RS error protected TSP is also called transmission TSP.

FIGURE 12

MPEG-2 TSP and RS-TSP (transmission TSP)



b) RS-TSP (transmission TSP), RS (204,188) error protected TSP

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1.4.5.3 Energy dispersal

In order to ensure adequate binary transitions, the data from the splitter is randomized with pseudo-random binary sequence (PRBS).

The polynomial for the PRBS generator shall be:

$$g(x) = x^{15} + x^{14} + 1$$

1.4.6 Delay adjustment

In the byte-wise interleaving, the delay caused in the interleaving process differs from stream to stream of different layer depending on its properties (i.e. modulation and channel coding). In order to compensate for the delay difference including de-interleaving in the receiver, the delay adjustment is carried out prior to the byte-wise interleaving on the transmission side.

1.4.6.1 Byte-wise interleaving (inter-code interleaving)

Convolutional byte-wise interleaving with length of $I = 12$ is applied to the 204-byte error protected and randomized packets. The interleaving may be composed of $I = 12$ branches, cyclically connected to the input byte-stream by the input switch. Each branch j shall be a first-in first-out (FIFO) shift register, with length of $j \times 17$ bytes. The cells of the FIFO shall contain 1 byte, and the input and output switches shall be synchronized.

The de-interleaving is similar, in principle, to the interleaving, but the branch indices are reversed. Total delay caused by interleaving and de-interleaving is 17 × 11 × 12 bytes (corresponding to 11 TSPs).

1.4.6.2 Inner coding (convolutional codes)

The ISDB-T$_{SB}$ system shall allow for a range of punctured convolutional codes, based on a mother convolutional code of rate 1/2 with 64 states. Coding rates of the codes are 1/2, 2/3, 3/4, 5/6 and 7/8. This will allow selection of the most appropriate property of error correction for a given service or data rate in the ISDB-T$_{SB}$ services including mobile services. The generator polynomials of the mother code are $G_1 = 171_{oct}$ for X output and $G_2 = 133_{oct}$ for Y output.

1.4.7 Modulation

Configuration of the modulation block is shown in Figs. 13 and 14. After bit-wise interleaving, data of each layer are mapped to the complex domain.

FIGURE 13

Modulation block diagram

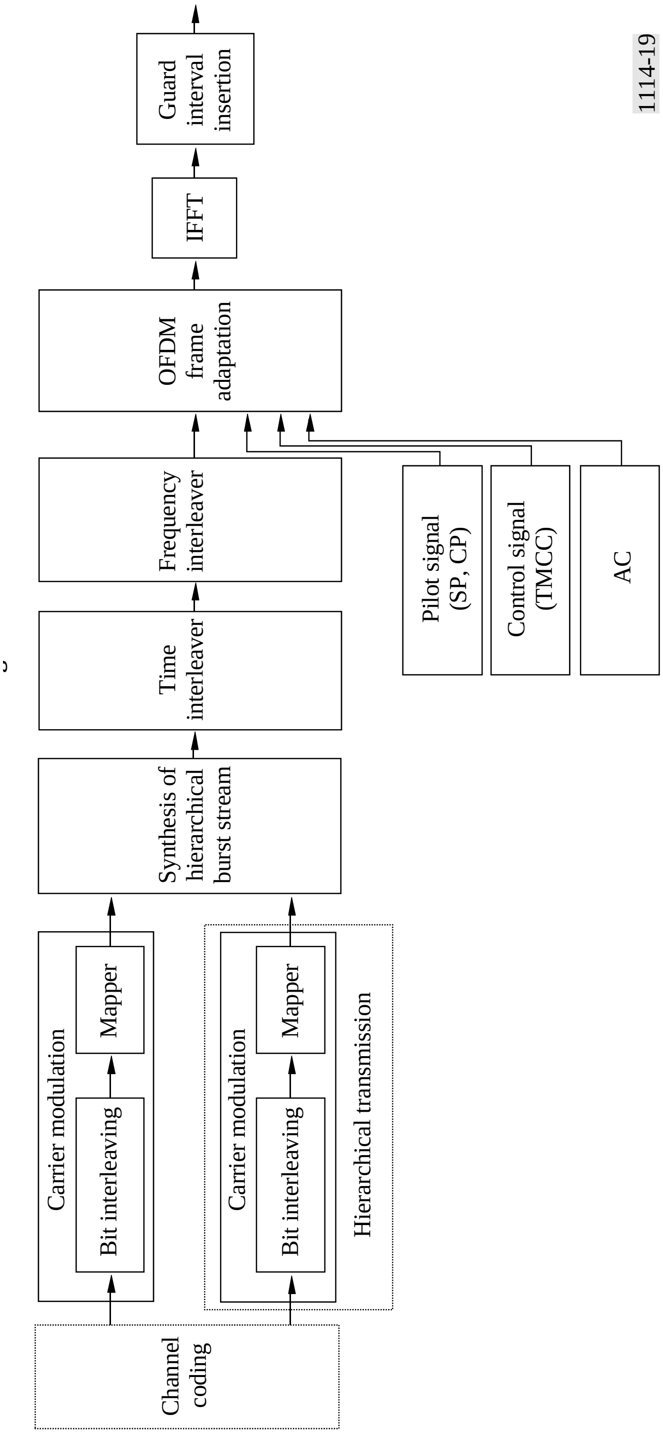
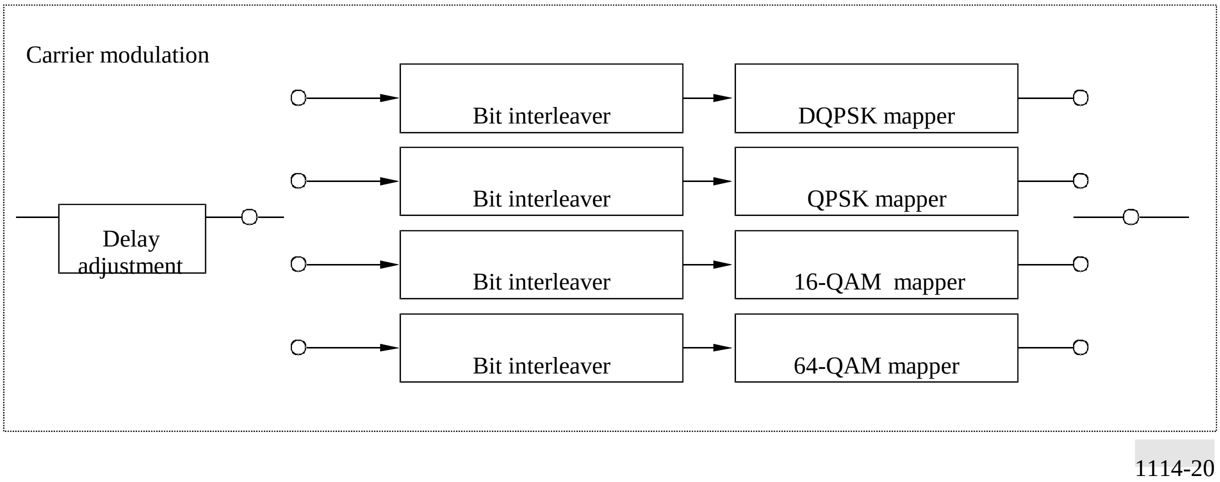


FIGURE 14

Configuration of carrier modulation block



1.4.7.1 Delay adjustment for bit interleave

Bit interleave causes the delay of 120 complex data ($I + jQ$) as described in the next section. By adding proper delay, total delay in transmitter and receiver is adjusted to the amount of two OFDM symbols.

1.4.7.2 Bit interleaving and mapping

One of the carrier modulation schemes among DQPSK, QPSK, 16-QAM and 64-QAM is selectable for this System. The serial bit-sequence at the output of the inner coder is converted into a 2-bit parallel sequence to undergo π/4-shift DQPSK mapping or QPSK mapping, by which n bits of I-axis and Q-axis data are delivered. The number n may depend on the hardware implementation. In the case of 16-QAM, the sequence is converted into a 4-bit parallel sequence. In 64-QAM, it is converted into a 6-bit parallel sequence. After the serial-to-parallel conversion, bit-interleaving is carried out by inserting maximum 120-bit delay.

1.4.7.3 Data segment

Data segment is defined as a table of addresses for complex data, on which rate conversion, time interleaving, and frequency interleaving shall be executed. The data segment corresponds to the data portion of OFDM segment.

1.4.7.4 Synthesis of layer-data streams

After being channel-coded and mapped, complex data of each layer are inputted every one symbol to pre-assigned data-segments.

The data stored in all data segments are cyclically read with the IFFT-sample clock; then rate conversions and synthesis of layer data streams are carried out.

1.4.7.5 Time interleaving

After synthesis, symbol-wise time interleaving is carried out. The length of time-interleaving is changeable from 0 to approximately 1 s, and shall be specified for each layer.

1.4.7.6 Frequency interleaving

Frequency interleaving consists of inter-segment frequency interleaving, intra-segment carrier rotation, and intra-segment carrier randomization. Inter-segment frequency interleaving is taken among the segments having the same modulation scheme. Inter-segment frequency interleaving can be carried out only for triple-segment transmission. After carrier rotation, carrier randomization is performed depending on the randomization table.

1.4.7.7 OFDM segment-frame structure

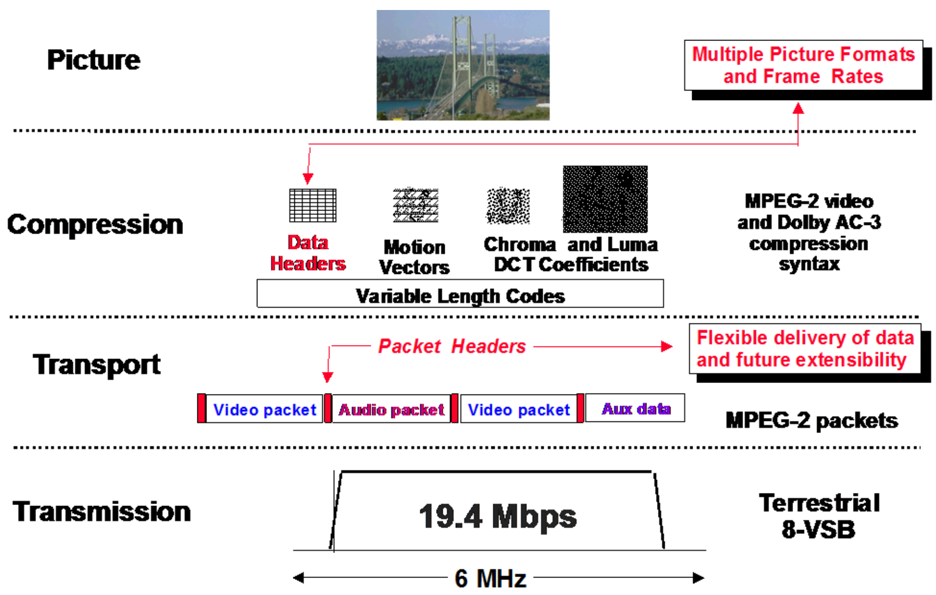
Data segments are arranged into OFDM segment-frame every 204 symbols by adding pilots such as CP, SP, TMCC and AC. The modulation phase of CP is fixed at every OFDM symbol. SP is inserted in every 12 carriers and in every 4 OFDM symbols in the case of coherent modulation method. The TMCC carrier carries transmission parameters such as carrier modulation, coding rate and time interleaving for the receiver control. The AC carrier carries the ancillary information.

1.5 ATSC

1.5.1 Overview of the ATSC Digital Television System

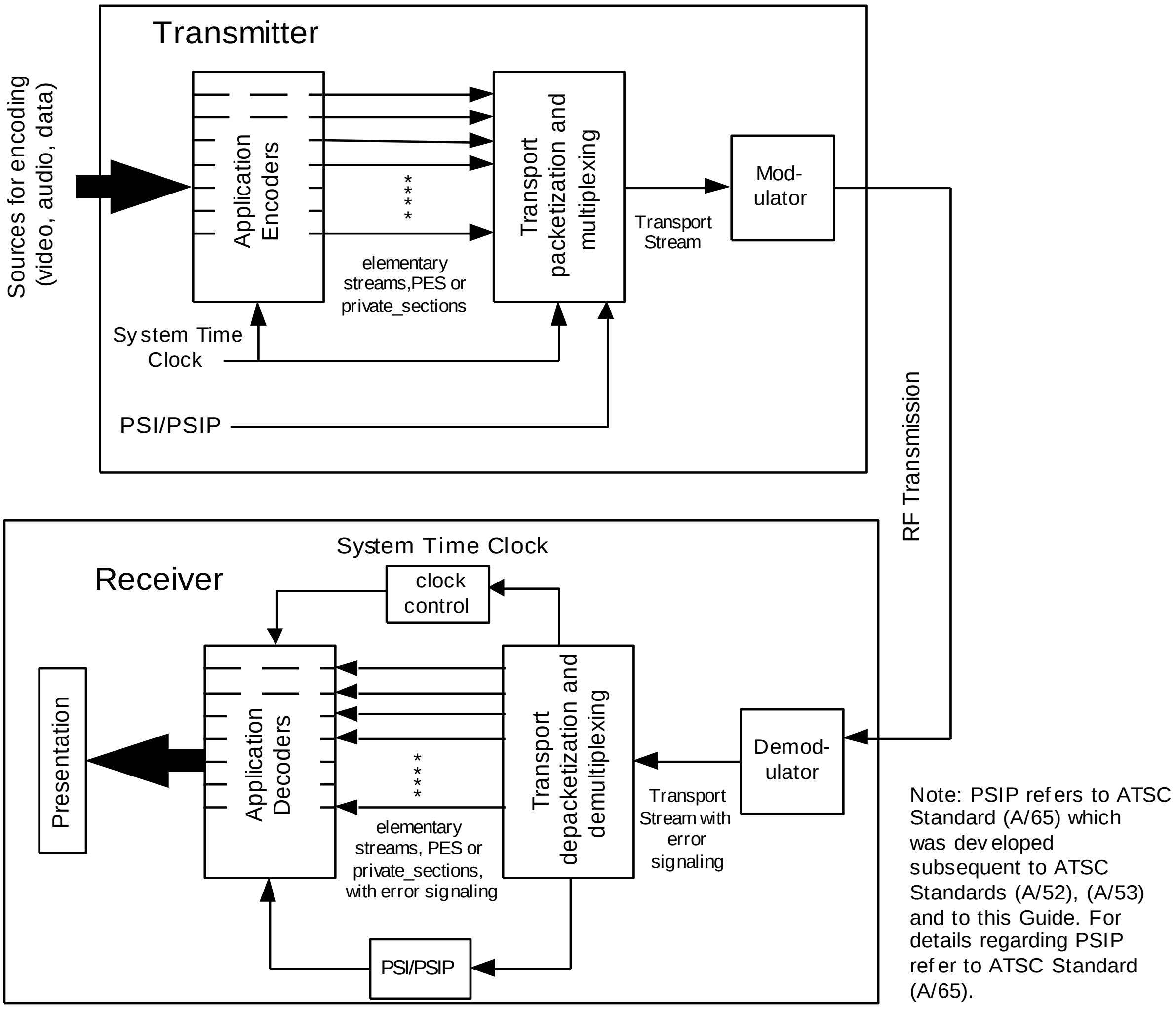
The ATSC Digital Television (DTV) standard ushered in a new era in television broadcasting. The impact of DTV is more significant than simply moving from an analog system to a digital system. Rather, DTV permits a level of flexibility wholly unattainable with analog broadcasting. The ATSC Digital Television Standard describes a system designed to transmit high quality video and audio and ancillary data within a single 6 MHz terrestrial television broadcast channel. The design emphasis on quality resulted in the advent of digital HDTV and multi channel surround-sound. The ATSC system pioneered a layered architecture that separates picture formats, compression coding, data transport and digital transmission as shown in Fig. 15.

FIGURE 15



A block diagram of the system is provided in Fig. 16.

FIGURE 16



1.5.1.1 Video Formats

The source video formats for the ATSC standard were carefully selected for their interoperability characteristics with film (wide aspect ratio and 24 fps), computers (square pixels and progressive scanning), and legacy television systems (480 lines and ITU-601 sampling), as illustrated in Fig. 3. In addition, the HDTV formats and the square pixel SDTV format are related by simple 3:2 ratios, allowing high quality, yet economical conversion among these formats. ATSC system.

1.5.1.2 Video Compression

The ATSC DTV Standard specifies the MPEG-2 video stream syntax (Main Profile at High Level) for the coding of video. The ATSC DTV Standard defines the video formats for HDTV and SDTV (Table 2).

TABLE 2

Digital Television Standard Video Formats*

Vertical lines	Pixels	Aspect ratio	Picture rate
1080	1920	16:9	60I, 30P, 24P
720	1280	16:9	60P, 30P, 24P
480	704	16:9 and 4:3	60P, 60I, 30P, 24P
480	640	4:3	60P, 60I, 30P, 24P

*Note that both 60.00 Hz and 59.94 (60x1000/1001) Hz picture rates are allowed. Dual rates are allowed also at the picture rates of 30 Hz and 24 Hz.

ATSC consumer receivers are designed to decode all HDTV and SDTV streams providing program service providers with maximum flexibility.

ATSC also provides the ability to utilize Advanced Video Coding (AVC) within an ATSC DTV transmission. Part 1 of ATSC A/72, "Video System and Characteristics of AVC in the ATSC Digital Television System," and "Part 2 "AVC Video Transport Subsystem Characteristics". The standard details the methodology to utilize Advanced Video Coding (AVC) within an ATSC DTV transmission. AVC which was developed by the ITU-T Video Coding Experts Group together with the ISO/IEC Moving Picture Experts Group is also known as H.264 and MPEG-4 Part 10. The A/72 Standard defines constraints with respect to AVC, compression format restraints, low delay and still picture modes, and bit stream specifications.

1.5.1.3 Audio Compression

The ATSC DTV Standard utilizes "Digital Audio Compression (AC-3)" for the coding of audio as based upon the ATSC A/52 Standard.

1.5.1.4 Transport

Transport defines the methodology of dividing each bit stream into "packets" of information. The ATSC system employs the MPEG-2 transport stream syntax for the packetization and multiplexing of video, audio, and data signals for digital broadcasting systems.

The ATSC A/65 Program and System Information Protocol (PSIP) describes the information at the system and event levels for all virtual channels (channel numbers are not tied directly to the actual RF channel frequency) carried in a particular TS. Additionally, information for analog channels as well as digital channels from other Transport Streams may be incorporated.

There are two main categories of information in the ATSC PSIP Standard (A65), system information and program data. System information allows navigation and access of the channels within the DTV transport stream, and the program data provides necessary information for efficient browsing and event selection. Some tables announce future events and some are used to locate the digital streams that make up an event. The PSIP data are carried via a collection of hierarchically arranged tables, repeated in the packet stream at frequent intervals.

1.5.1.5 RF Transmission

"RF Transmission" refers to channel coding and modulation. The channel coder takes the packetized digital bit stream, reformats it and adds additional information that assists the receiver in extracting the original data from the received signal, which due to transmission impairments may contain errors. In order to protect against both burst and random errors, the packet data is interleaved before transmission and Reed-Solomon [isn't a reference needed?] forward error correcting codes are added. The modulation (or physical layer) uses the digital bit stream information to modulate a carrier for the transmitted signal. The basic modulation system offers two modes: an 8-VSB mode and a 16-VSB mode. The 8-VSB mode was designed for spectral efficiency, maximizing the data throughput with a low receiver carrier-to-noise (*C*/*N*) threshold requirement, high immunity to both co-channel and adjacent channel interference, and high robustness to transmission errors. The attributes of 8-VSB allow DTV channels to co-exist in a crowded spectrum environment that contains both analog and digital television signals. In addition, the lower power requirements (typically, 12 dB lower than analog NTSC) of 8-VSB allow ATSC DTV stations to exist on channels where analog stations cannot due to interference constraints. The spectral efficiency and power requirement characteristics of 8-VSB are essential to the conversion of terrestrial broadcast transmission from analog to digital since new spectrum is not allotted during the transition phase.

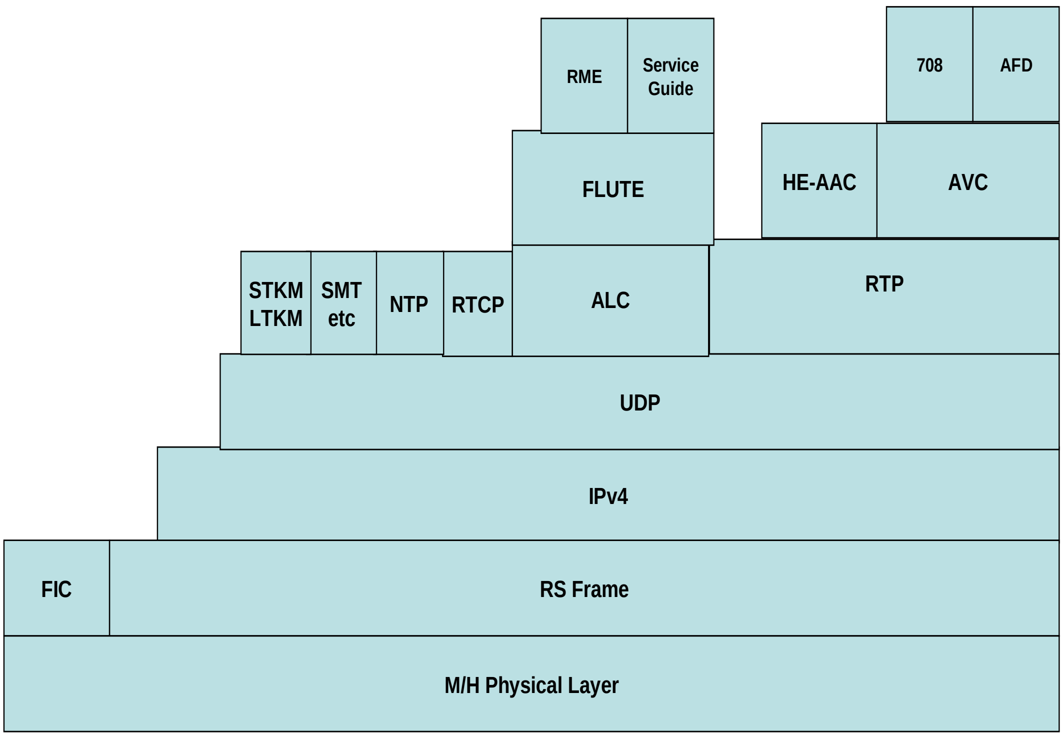
1.5.2 ATSC-M/H System Overview

The ATSC Mobile/Handheld service (M/H) shares the same RF channel as a standard ATSC broadcast service described in ATSC A/53. M/H is enabled by using a portion of the total available 19.4 Mbit/s bandwidth and utilizing delivery over IP transport. A block diagram representation of the broadcast system is shown in Fig. 17.

Central to the M/H system are additions to the physical layer of the ATSC transmission system that are easily decodable under high Doppler rate conditions. Extra training sequences and forward error correction (FEC) are added to assist reception of the enhanced stream(s). Consideration has also been given to the many system details that make such a signal compatible with legacy ATSC receivers, particularly audio decoder buffer constraints; but also such constraints as MPEG transport packet header standards, requirements for legacy PSIP carriage, etc. These changes do not alter the emitted spectral characteristics. The ATSC-M/H system broadcast protocol stack is illustrated in Fig. 17.

FIGURE 17

ATSC-M/H broadcast protocol stack



1.5.2.1 Description of A/153 Parts

The following sections provide an over view of the Parts that make up the ATSC-M/H system.

1.5.2.1.1 *Part 2 - RF/ Transmission*

M/H data is partitioned into Ensembles, each of which contains one or more services. Each Ensemble uses an independent RS Frame (an FEC structure), and furthermore, each Ensemble may be coded to a different level of error protection depending on the application. M/H encoding includes FEC at both the packet and trellis levels, plus the insertion of long and regularly spaced training sequences into the M/H data. Robust and reliable control data is also inserted for use by M/H receivers. The M/H system provides bursted transmission of the M/H data, which allows the M/H receiver to cycle power in the tuner and demodulator for energy saving.

1.5.2.1.2 *Part 3 - Service Multiplex and Transport Subsystem*

In the ATSC-M/H physical layer system, the M/H data is transferred by a time-slicing mechanism to improve the receiver's power management capacity. Each M/H Frame time interval is divided into 5 sub-intervals of equal length, called M/H Subframes. Each M/H Subframe is in turn divided into 4 sub-divisions of length 48.4 ms, the time it takes to transmit one VSB frame. These VSB frame time intervals are in turn divided into 4 M/H Slots each (for a total of 16 M/H Slots in each M/H Subframe).

The M/H data to be transmitted is packaged into a set of consecutive RS Frames, where this set of RS Frames logically forms an M/H Ensemble. The data from each RS Frame to be transmitted during a single M/H Frame is split up into chunks called M/H Groups, and the M/H Groups are organized into M/H Parades, where an M/H Parade carries the M/H Groups from up to two RS Frames but not less than one. The number of M/H Groups belonging to an M/H Parade is always a multiple of 5, and the M/H Groups in the M/H Parade go into M/H Slots that are equally divided among the M/H Subframes of the M/H Frame.

The RS Frame is the basic data delivery unit, into which the IP datagrams are encapsulated. While an M/H Parade always carries a Primary RS Frame, it may carry an additional Secondary RS Frame as output of the baseband process. The number of RS Frames and the size of each RS Frame are determined by the transmission mode of the M/H physical layer subsystem. Typically, the size of the Primary RS Frame is bigger than the size of Secondary RS Frame, when they are carried in one M/H Parade.

The Fast Information Channel (FIC) is a separate data channel from the data channel delivered through RS Frames. The main purpose of the FIC is to efficiently deliver essential information for rapid M/H Service acquisition. This information primarily includes binding information between M/H Services and the M/H Ensembles carrying them, plus version information for the M/H Service Signaling Channel of each M/H Ensemble.

In ATSC-M/H, an "M/H Service" is similar in general concept to a virtual channel as defined in ATSC A/65C [10]. An M/H Service is a package of IP streams transmitted through M/H Multiplex, which forms a sequence of programs under the control of a broadcaster which can be broadcast as part of a schedule. Typical examples of M/H Services include TV services and audio services. Collections of M/H Services are structured into M/H Ensembles, each of which consists of a set of consecutive RS Frames.

In general, there are two types of files that might be delivered using the methods described in this standard. The first of these is content files, such as music or video files. The second type of file that may be transmitted is a portion of the service guide. This includes long- and short-term keys for service protection, logos, and SDP files. In either case, the delivery mechanisms are the same and it is up to the terminal to resolve the purpose of the files.

1.5.2.1.3 *Part 4 - Announcement*

In an M/H system, the Services available on that system (or another system) are announced via the Announcement subsystem. Services are announced using a Service Guide. A Service Guide is a special M/H Service that is declared in the Service Signaling subsystem. An M/H receiver determines available Service Guides by reading the Guide Access Table for M/H (GAT-MH). This table lists the Service Guides present in the M/H broadcast, gives information about the service provider for each guide, and gives access information for each guide.

The ATSC-M/H Service Guide is an OMA BCAST Service Guide, with constraints and extensions as specified in this standard. A Service Guide is delivered using one or more IP streams. The main stream delivers the

Announcement Channel, and zero or more streams are used to deliver the guide data. If separate streams are not provided, guide data is carried in the Announcement Channel stream.

1.5.2.1.4 *Part 5 - Application Framework*

The primary objective for the M/H platform is to deliver a set of audio and/or video services from a transmission site to mobile or portable devices. The Application Framework for enables the broadcaster of the audio-visual service to author supplemental content to define and control various additional elements to be used in conjunction with the M/H audio-visual service. It enables one to define auxiliary (graphical) components, layout for the service, transitions between layouts and composition of audio-visual components with auxiliary data components. Furthermore, it enables the broadcaster to send remote events to modify the presentation and to control presentation timeline. The Application Framework further enables coherent rendering of the service and its layout over a variety of device classes and platforms, rendering of action buttons and input fields, and event handling and scripting associated with such buttons and fields.

1.5.2.1.5 *Part 6 - Service Protection*

Service Protection refers to the protection of content, be that files or streams, during its delivery to a receiver. Service Protection assumes no responsibility for content after it has been delivered to the receiver. It is intended for subscription management. It is an access control mechanism, only.

The ATSC-M/H Service Protection system is based on the OMA BCAST DRM Profile. It consists of the following components:

- Key provisioning
- Layer 1 registration
- Long-Term Key Message (LTKM), including the use of Broadcast Rights Objects (BCROs) to deliver LTKMs
- Short-Term Key Messages (STKM)
- Traffic encryption.

The system relies on the following encryption standards:

- Advanced Encryption Standard (AES)
- Secure Internet Protocol (IPsec)
- Traffic Encryption Key (TEK)

In the OMA BCAST DRM Profile there are two modes for Service Protection—interactive and broadcast-only mode. In interactive mode, the receiver supports an interaction channel to communicate with a service provider, to receive Service and/or Content Protection rights. In broadcast-only mode, the receiver does not use an interaction channel to communicate with a service provider. Requests are made by the user through some out-of-band mechanism to the service provider, such as calling a service provider phone number or accessing the service provider website.

1.5.2.1.6 *Part 7 - AVC and SVC Video System*

The M/H system uses MPEG-4 AVC and SVC video coding as described in ISO/IEC 14496 Part 10, with certain constraints.

1.5.3.1.7 *Part 8 - HE AAC Audio System*

The M/H system uses MPEG-4 HE AAC v2 audio coding as described in ISO/IEC 14496 Part 3, with certain constraints. HE AAC v2 is used to code mono or stereo audio. HE AAC v2 is the combination of three audio coding tools, MPEG-4 AAC, Spectral Band Replication (SBR) and Parametric Stereo (PS).

1.5.3 *System Configuration Signaling*

Recognizing that the mobile sector of the economy is subject to rapid technology change, the needs for continued viability of the system in the face of change were formalized. As there are many technological elements of the system, they were grouped into functional units called elementary subsystems.

1.6 DVB-T

1.6.1 DVB-T variants

The DVB-T standard allows for different levels of modulation and different code rates to be used to trade bit rate versus ruggedness. As some variants can be selected as representative of the much larger set of all variants, it will be necessary to select such a sub-set for the planning Conference. This sub-set is useful to avoid too many options that would otherwise need to be displayed.

The non-hierarchical variants are chosen as being typical of some expressed requirements and are close to others; for the DVB-T example, it is to be expected that channel requirements for a variant with a code rate of 2/3 will be similar to those for a variant with a code rate of 3/4, for the same modulation.

A2: QPSK, 2/3: this variant provides a low data capacity of only 6 to 8 Mbit/s but it does provide a very rugged service.

B2: 16-QAM, 2/3: the data capacity is moderate at 13 Mbit/s to 16 Mbit/s and this variant may be of interest for providing reasonably rugged services especially for portable or mobile reception.

C2: 64-QAM, 2/3: this variant has a high data capacity, 20 Mbit/s to 24 Mbit/s but provides less rugged services and is particularly sensitive to self-interference effects in large area SFNs.

1.6.2 Hierarchical variant

Hierarchical DVB-T system variants mean that the MPEG-2 bit stream is divided into two parts: the high priority stream and the low priority stream. The high priority stream is the rugged part of the hierarchical system and uses QPSK modulation and an appropriate code rate to provide the necessary protection against noise and interference. Because of the type of modulation, the data capacity is low (about 5 to 6 Mbit/s). However, the *C*/*I* ratio is worse than that for a non-hierarchical QPSK system although the data capacity is the same as that of a QPSK system of the same code rate.

The low priority stream is the more fragile part of the hierarchical system and may be either 16-QAM or 64-QAM. Not much consideration has been given to a low priority stream using 16-QAM because the data capacity of the low priority stream is about the same as that of the high priority stream. A low priority stream using 64-QAM provides about twice the capacity of the high priority QPSK stream. Its exact capacity relative to that of the high priority stream depends on the relative code rate of the two streams.

The hierarchical system variants could be used in several ways. One example would be for a combination of fixed and mobile services in the same area, where the high priority stream gives robust mobile coverage and the low priority stream provides fixed antenna reception.

1.6.3 Guard interval

OFDM, as used in DVB-T, exhibits relatively long symbol periods due to its multi-carrier nature. This long symbol period provides a degree of protection against inter-symbol interference caused by multipath propagation. This protection can, however, be greatly enhanced by use of a guard interval. The guard interval is a cyclic extension of the symbol. In simplistic terms, a section of the start of the symbol is simply added to the end of the symbol.

For MFNs, small guard intervals are used while for SFNs, larger guard intervals are required. There is a trade-off between the length of the guard interval and the data capacity. For a given DVB-T variant, a larger guard interval length implies a lower data capacity.

1.6.4 DVB-T in Band III

There are indications that the use of Band III (174-230 MHz) is being considered for DVB-T in some countries. Band III propagation is particularly suitable for portable and mobile reception, because of the uniform field strength distribution that can be achieved in that band, together with the possibility of achieving large area coverage with lower power than would be needed using UHF frequencies. However, in some parts of the planning area (eastern Mediterranean area and Gulf area) the situation is different due to propagation anomalies such as ducting and super-refraction.

A challenge to be faced within Band III is the existence of several channelling arrangements, including the use of 7 MHz and 8 MHz bandwidth channels. Any possible move to a uniform channel raster presents a long-term challenge due to the existing complex non-uniform situation.

The following advantages have led to an increased interest in DVB-T in VHF Band III:

– coverage for large areas is achieved with fewer transmitters than are required at UHF;

– mobile reception (reduction of Doppler effect).

At VHF, propagation conditions are different from UHF; therefore suitable networks may also be different. Furthermore the Doppler shift for mobile reception is less at VHF than at UHF due to the lower frequencies. This is a clear advantage for VHF when administrations consider deploying mobile DVB-T.

1.7 DVB-H

1.7.1 Building and validating an open and scalable network architecture

The interworking points between the different domains and actors will also be identified with the objective of defining interworking units whenever required. System engineering rules will be articulated in order to cope with scalability issues. This in particular requires identifying the parameters that are key when scaling up the system. This is crucial to allow the successful progressive introduction of open systems with distributed management functions.

Field trials that include testing of an open operational architecture composed of several broadcast cells will give final input on the viability of the overall system. The novelty will consist in having an open demonstrator addressing the complete/commercial-like architecture. Roaming will be tested between different partners' sites, for instance. Feedback from a panel of users will determine whether the services have sufficiently user-friendly interfaces and will qualify the technical and commercial viability of the services.

Technology development in the project is articulated around three domains that intend to make particularly innovative contributions on:

− content, services and applications,

− user devices,

− networks.

1.7.2 Content, services and applications

The business motivation in this area is to increase content/service creation productivity because of the increasingly diverse means of accessing services in terms of networks and terminals. This productivity is enhanced only at the expense of making common as many steps as possible in the content/service creation process.

In content generation and production, the migration from the more or less autonomous production workflows of separate departments to workflows where content is created in a multitude of formats to be transmitted via a number of platforms and channels to different terminals will be planned. Content will be produced, generated and edited from a number of sources. A central server architecture connected to a content management system will be implemented allowing for quick, cost-efficient and automated content editing. A mechanism will be established for ensuring that user privacy and security is kept in a common digital environment.

1.7.3 User devices

The main user-device-related objective is to pave the way for the commercial introduction of end-user devices able to provide intuitive access to mobile/portable broadcast and broadband services in collaborating networks. The eEurope 2005 action plan recognizes that the development of such terminals is crucial to social inclusion.

1.7.4 Networks

Assuming that national regulations will evolve according to EC recommendations, the opportunity exists to deploy new networks specifically targeting broadcast-based mobile and indoor reception, with better geographical granularity (i.e. smaller cells). This will lead to the definition and field validation of deployment rules for a cellularized DVB-T/H system. Because of the potential co-location of low power DVB-T/H transmitters with 2G/3G base stations, co-existence rules will be defined, depending on the identified interference scenarios.

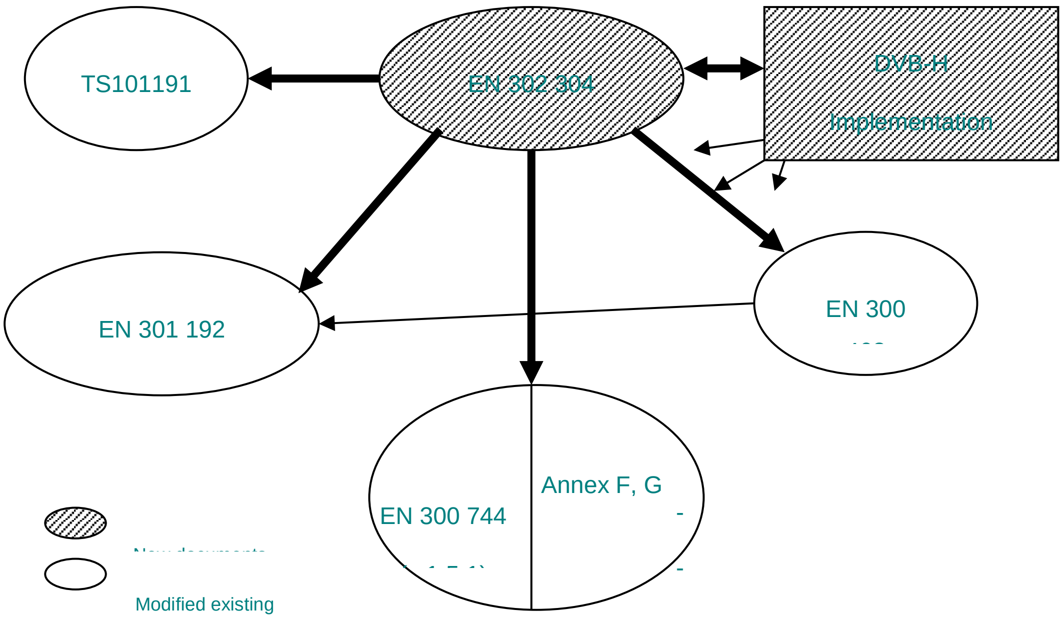
Digital Video Broadcasting Handheld (DVB-H) is a new standard for digital terrestrial TV broadcasting to handheld portable/mobile terminals.

It has been standardised in 2004 by ETSI EN 302 304: “Digital Video Broadcasting (DVB); Transmission System for Handheld Terminals” (DVB H).

The introduction of DVB-H implied to modify slightly few DVB standards. DVB-T has been improved with the introduction of a 4 K carriers mode, a depth interleaver, new time stamps (TPS) and a 5 MHz RF bandwidth. Some people are thinking to introduce 1,5, 3 and 4,5 MHz RF bandwidth in order to fit with the frequency grid in the L band in region 1 and 3 (RRC). 5 MHz RF channel is used in USA in the L band.

FIGURE 18

DVB-H standards family



The main objective is to deliver various content (video and audio) compressed with MPEG4 encapsulated in IP bursts. One of the main challenges was to reduce the power consumption of the handheld devices (mobile phones, PDA or portable PC) and to allow the reception in various conditions.

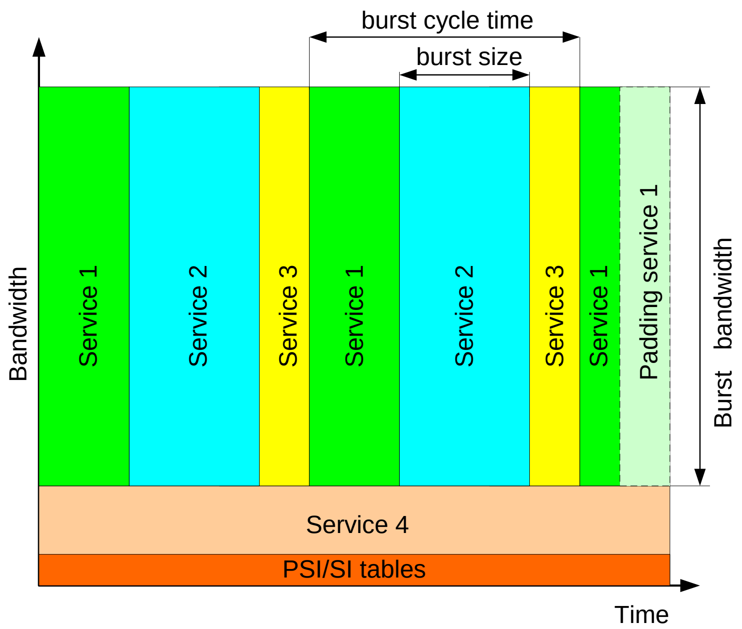
In the future, it could be large power transmitter in order to cover a great number of users at once (one to many) with a dedicated format of content and even to be able to deliver interactive services in small cells with low power transmitters compatible with GSM or UMTS cells.

There are two options in term of frequency usage:

– UHF for large coverage areas, from one DVB-H service up to a full channel filled with DVB-H services (see figure hereafter which shows a DVB-T service + several DVB-H services in the same channel. The DVB-T transport stream (service 4) has a constant bitrate the other services (1, 2 and 3) are DVB-H IP bursts) .

– L bands for small coverage areas with full channel filled with DVB-H services.

FIGURE 19



In one 8 MHz channel, it is possible to broadcast up to 50 different programs with an average of 400 kbits/s MPEG4 streams.

The definition of the image is fitting with the size of the display of the handheld device which means (CIF or QVGA).

DVB-H benefits of the advantages of OFDM modulation scheme combined with IP slicing.

In term of usage, DVB-H is a relevant example of converging technology: Convergence between Broadcasting and Telecommunication. However, the introduction of that technology has to be managed carefully in term of frequency allocation and/or sharing.

1.8 ISDB-T

1.8.1 ISDB-T Transmission Parameters

ISDB-T consists of 13 OFDM segments. One OFDM segment corresponds to a frequency spectrum having a bandwidth of B/14 MHz (B means the bandwidth of a terrestrial TV channel: 6, 7 or 8 MHz), so one segment occupies bandwidth 6/14 MHz (428.57 kHz), 7/14 MHz (500 kHz) or 8/14 MHz (571.29 kHz). Television broadcasting employs 13 segments with a transmission bandwidth of about 5.6MHz, 6.5 MHz or 7.4 MHz.

ISDB-T has three transmission modes having different carrier intervals in order to deal with a variety of conditions such as the variable guard interval as determined by the network configuration and the Doppler shift occurring in mobile reception. In Mode 1, one segment consists of 108 carriers, while Modes 2 and 3 feature two times and four times that number of carriers, respectively. Table 2 lists the basic parameters of each mode in ISDB-T system.

A digital signal is transmitted in sets of symbols. The active symbol duration is the reciprocal of the carrier spacing – this condition prevents carriers in the band from interfering with each other. The guard interval is a time-redundant section of information that adds a copy of the latter portion of a symbol to the symbol's "front porch" with the aim of absorbing interference from multi-path-delayed waves. Accordingly, increasing the guard-interval duration in the signal decreases the information bit rate. An OFDM frame consists of 204 symbols with guard intervals attached regardless of the transmission mode. The time interleaving duration in real time depends on the parameters set at the digital-signal stage and on the guard-interval duration, and consequently the values shown in Table 3 for these parameters are approximate.

The error-correction scheme uses concatenated codes, namely, Reed-Solomon (204,188) code for the outer code and convolutional code for the inner code. The information bit rate takes on various values depending on the selected modulation scheme, inner-code coding rate, and guard-interval ratio. The range shown in Table 2 reflects the minimum and maximum values for 13 segments.

TABLE 3

Basic parameter of ISDB-T system

Transmission parameter	Mode 1	Mode 2	Mode 3
Number of segments	13		
Bandwidth	5.57 MHz (6M*) 6.50 MHz (7M*) 7.43 MHz (8M*)	5.57 MHz (6M*) 6.50 MHz (7M*) 7.43 MHz (8M*)	5.57 MHz (6M*) 6.50 MHz (7M*) 7.43 MHz (8M*)
Carrier spacing	3.968 kHz (6M*) 4.629 kHz (7M*) 5.271 kHz (8M*)	1.948 kHz (6M*) 2.361 kHz (7M*) 2.645 kHz (8M*)	0.992 kHz (6M*) 1.157 kHz (7M*) 1.322 kHz (8M*)
Number of carriers	1405	2809	5617
Active symbol duration	252 μs (6M*) 216 μs (7M*) 189 μs (8M*)	504 μs (6M*) 432 μs (7M*) 378 μs (8M*)	1008 μs (6M*) 864 μs (7M*) 756 μs (8M*)
Guard interval duration	1/4, 1/8, 1/16, 1/32 of active symbol duration		
Carrier modulation	QPSK, 16-QAM, 64-QAM, DQPSK		
Number of symbols per frame	204		
Time interleaving duration	0, 0.1s, 0.2s, 0.4s		
Inner code	Convolutional coding (1/2, 2/3, 3/4, 5/6, 7/8)		
Outer code	RS(204,188)		
Information bit rate	3.65-23.2 Mbit/s (6M*) 4.26-27.1 Mbit/s (7M*) 4.87-31.0 Mbit/s (8M*)		
Hierarchical transmission	Maximum 3 levels (Layer A, B, C)		

* Bandwidth of a terrestrial TV channel.

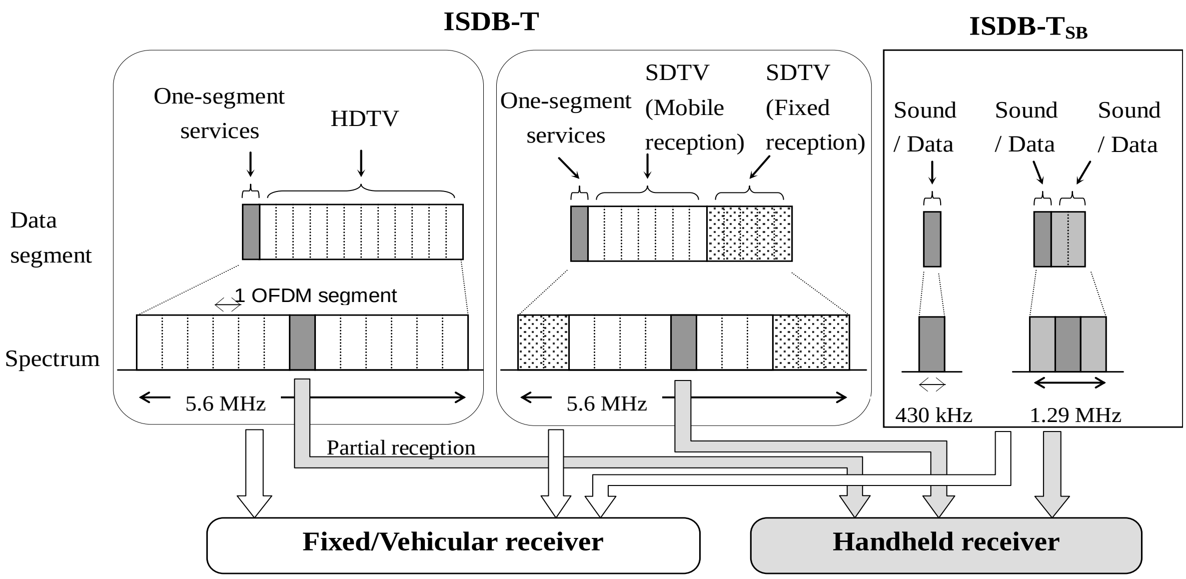
1.8.2 Hierarchical Transmission

A mixture of fixed-reception programs and handheld reception programs is made possible through hierarchical transmission achievable by band division within a channel. "Hierarchical transmission" means that the three elements of channel coding, namely, the modulation scheme, the coding rate of convolutional error-correcting code, and the time interleaving duration, can be independently selected. Time and frequency interleaving are each performed in their respective hierarchical data segment.

As described above, the smallest hierarchical unit in a frequency spectrum is one OFDM segment. Referring to Fig. 20, one television channel consists of 13 OFDM segments, and up to three hierarchical layers (Layers A, B, and C) can be set with regard to these segments. If the OFDM signal is transmitted using only one layer, the layer is A. If the signal is transmitted using two layers, the center "rugged" layer is A and the outer layer is B. If the signal is transmitted using three layers, the center “rugged” layer is A, the middle layer is B, and the outer layer is C. Taking the channel-selection operation of the receiver into account, a frequency spectrum segmented in this way must follow a rule for arranging segments. In addition, one layer can be set for the single center segment as a partial-reception segment for handheld receivers of one-segment services. In this case, the center segment is Layer A. Using the entire band in this way is called ISDB-T. Audio broadcasts and one-segment services feature a basic one-segment format as well as a three-segment expanded format, both referred to as ISDB-T_{SB}.

FIGURE 20

ISDB-T service examples and transmission signals

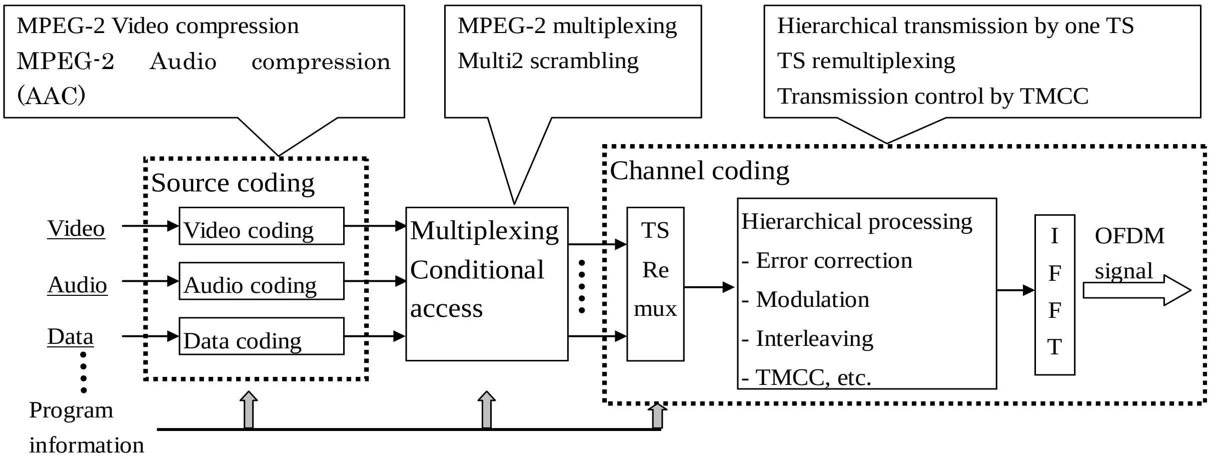


1.8.3 Outline of ISDB-T

Figure 21 shows ISDB-T system configuration. This system uses MPEG-2 Video coding and MPEG-2 advanced audio coding (AAC) for source coding. Moreover, it adopts MPEG-2 Systems for encapsulating data streams. Therefore, various digital content such as sound, text, still pictures, and other data can be transmitted simultaneously. For channel coding, transmission parameters may be individually set for each layer, making for flexible channel composition. Furthermore, to achieve an interface between multiple MPEG-2 Transport Streams (TSs) and the Channel coding, these TSs are re-multiplexed into a single TS. In addition, transmission control information, such as channel segment configuration, transmission parameters, etc., are sent to the receiver in the form of a transmission multiplexing configuration control (TMCC) signal.

FIGURE 21

ISDB-T system configuration



1.9 T-DMB

1.9.1 T-DMB General

Terrestrial Digital Multimedia Broadcasting (T-DMB) system, is the extended system compatible with Digital Sound Broadcasting System A, which enables video services by using T-DAB networks for handheld receivers in mobile environment. This system uses frequency bands of band III and L-band, which T-DAB networks are in operation.

T-DMB provides multimedia services including video, audio, and interactive data. For audio services it uses MUSICAM as specified in DSB System A and for video services MPEG-4 standards. ITU-T H.264 | MPEG-4 AVC standard is used for video, MPEG-4 ER-BSAC or MPEG-4 HE AAC for the associated audio, and MPEG-4 BIFS and MPEG-4 SL for interactive data. Outer channel coding of Reed-Solomon code applies to guarantee the good performance of video reception.

Field test results and the summary of T-DMB specification are included in the Report ITU-R BT.2049. The specification of T-DMB was standardized by ETSI in 2005. ETSI TS 102 427 and ETSI TS 102 428 describe error protection mechanism and the A/V codec of the T-DMB system, respectively. A variety of receivers are in the market: PC (laptop) type, vehicular type, and PDA type as well as mobile phone.

1.9.2 System architecture

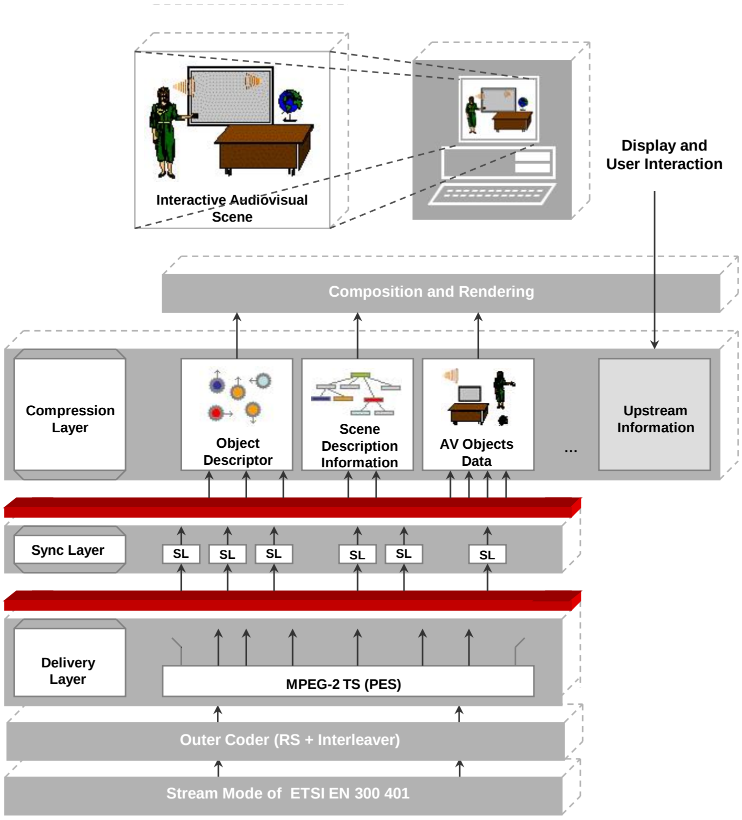
The system for the T-DMB video services has the architecture that transmits MPEG-4 contents encapsulated using “MPEG-4 over MPEG-2 TS” specification as illustrated in Fig. 21.

Video service is delivered through the stream mode of DSB System A transmission mechanism. In order to maintain bit error rates extremely low, this service uses the error protection mechanism described in ETSI TS 102 427. This video service is composed of three layers: contents compression layer, synchronization layer, and transport layer. In the contents compression layer in ETSI TS 102 428, ITU-T H.264 | ISO/IEC 14496-10 AVC is employed for video compression, ISO/IEC 14496-3 ER-BSAC/HE-AAC for audio compression, and ISO/IEC 14496-11 BIFS for auxiliary interactive data services.

To synchronize audio-visual contents both temporally and spatially, ISO/IEC 14496-1 SL is employed in the synchronization layer. In the transport layer specified in ETSI TS 102 428, some appropriate restrictions are employed for the multiplexing of compressed audiovisual data.

FIGURE 22

Conceptual architecture for the video services

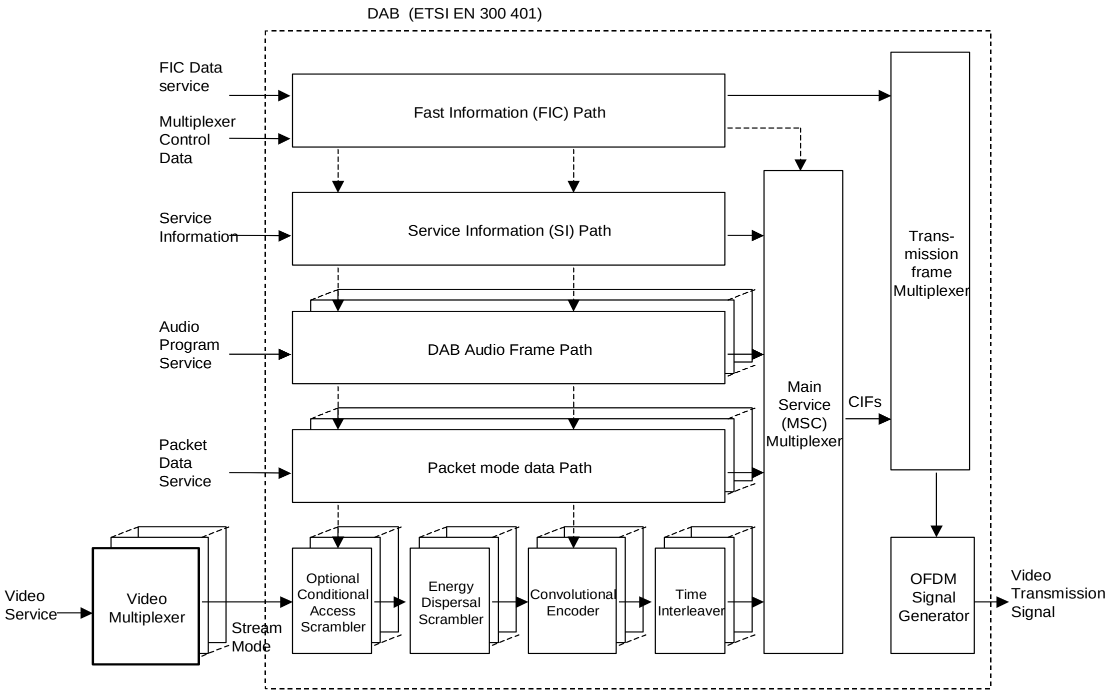


1.9.3 Video service transmission architecture

The conceptual transmission architecture for video services is shown in Fig. 23. The video, audio, and auxiliary data information for a video service are multiplexed into an MPEG-2 TS and further outer-coded by the video multiplexer. It is transmitted by using the stream mode specified in DSB System A.

FIGURE 23

Conceptual transmission architecture for the video services

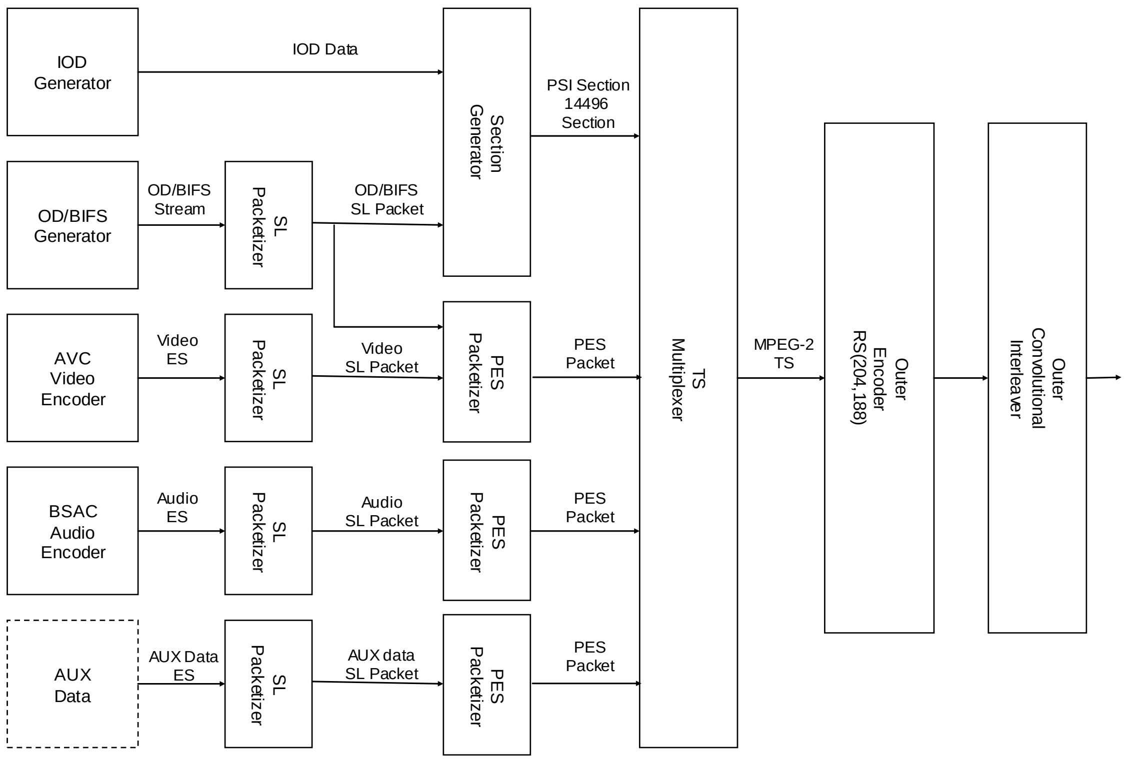


1.9.4 Video multiplexer architecture

The conceptual architecture of the video multiplexer for a video service is shown in Fig. 24.

FIGURE 24

Architecture of the video multiplexer



1.9.5 T-DMB specifications

The list of specifications for T-DMB is shown in Table 4.

TABLE 4

T-DMB specifications

Physical Layer	Recommendation ITU-R BS.1114 System A
Encapsulation and protocols for transmission of content	ETSI EN 300 401 ETSI TS 102 427 ISO/IEC 13818-1 ISO/IEC 14496-1 ETSI TR 101 497 ETSI TS 101 759 ETSI ES 201 735 ETSI TS 101 499 ETSI TS 101 498-1 ETSI TS 101 498-2
Multimedia Content Format	ETSI EN 301 234 ISO/IEC 14496-11
Audio Coding	MPEG-2 Layer II MPEG 4 ER BSAC/MPEG 4 HE-AAC ETSI TS 102 428
Video Coding	ITU-T Rec. H.264 / MPEG-4 AVC ETSI TS 102 428

1.10 LMDS (Local Multipoint Distribution System)

Since the very preliminary applications of digital terrestrial broadcasting, interactive and multimedia applications seemed bound to play an important role in the take-off of the new broadcasting standard. Later on, the availability of MHP standard and of MHP-compatible set-top boxes definitely opened the doors to interactive and multimedia applications.

Interactive and multimedia terrestrial TV became a key part of the service in Finland, where are operational in MHP standard since 2002 and interactivity is currently tested also on the Digital Terrestrial TV networks of Spain, Germany, and Singapore **(other countries are invited to send a contribution on this)**. With the current launch of Digital Terrestrial Television in Italy, multimedia applications are getting a considerable interest, also for what concerns interaction with public administration (T-government) and education.

Some countries have started a field trial of IP over digital TV broadcasting.

1.10.1 Use of LMDS systems

1.10.1.1 The LMDS technology approaching the market of multimedia delivery

LMDS at 42 GHz is now a mature technology in terrestrial digital video broadcasting with the capability to have a great amount of band to offer services to the customers. For example multichannel LMDS and MPEG2 compression coding system - allowing multiple digital time-shifted programs inside the same 33 MHz video channel - permit NVOD (Near Video On Demand) services, without any "return connection" between the customer and the Service Provider.

Services with a low interactivity level like Video on Demand (VOD), Games or Home Shopping applications, can be achieved over LMDS with telephone return channel: most of the commercial DVB Set Top Boxes (decoders) already include internal telephone modem. Also Internet access with telephone return channel is achievable, deserving some LMDS down-link channels to deliver Internet traffic.

(All sub-sections describe the situation in European Union. Other administrations are invited to provide further information on their own scenarios.)

LMDS technology is rapidly evolving and the introduction of higher levels of interactivity, will move applications from pure entertainment to Wireless Local Loop (WLL) services. In-band return channels offer attractive independence from PSTN (Public Switching Telephone Network) for Service Providers. Interactivity is pushing LMDS and WLL applications into a merge whose continuous technology evolution will contribute extending profitable business penetration.

Some WLL services promise profitable commercial businesses for Small Business or Home Business (SOHO) subscribers; in particular high speed Internet surfing seems to be a valuable service for most of the users.

1.10.2 Some key factors in the technology

The choice of the complete system architecture requires a deep analysis of communication scenarios, network scenarios and traffic characteristics. The required capacity of a network depends on a large number of parameters, including the number of users, the applications they use, the protocol efficiency and the frequency re-use strategy. Access protocols must be able to cope with traffic loading near saturation.

1.10.3 Technological trends and objective constraints

Technology improvements, especially in the millimetre component field, will contribute to extend interactive LMDS services into large commercial business but, on the other hand, millimeter-wave Remote Terminal (RT) transceiver architecture must be maintained as simple as possible in order to be cost effective. Available throughput rate per customer must be traded-off with RT architecture complexity, Base Stations content feeding, modulation schemes, RT output power and return path link budget.

The design of application oriented LMDS network services in real environments appears to be an issue to be solved on a case by case basis. Besides automatic design procedures can help in the design producing an optimised network topology and architecture, cost and infrastructure implications must be carefully evaluated for each situation.

The main arguments in favour of the LMDS technology are increased data rates available to the user, the possibility to deliver both general content services and to customise dedicated services within well delimited geographical areas. Moreover it’s considerable the opportunity for the operators to expand their network over a few years in terms of number of customers and services offered.

One of the most important factors affecting the success of Broadband Wireless Access Operators is the initial amount of spectrum licensed per Operator by the Administration. Another important factor is the availability of additional spectrum to meet demand as Broadband Wireless Access systems rollout. In fact, whilst a modest amount spectrum may be available in the short term, it will not be sufficient in a long term perspective where an increasing number of competitors and services will face the market.

1.10.4 Target market foreseen for LMDS

Due to the propagation limitation, line of sight users are mandatory. The target market for Broadband Wireless Access systems could be a single or multi-tenant building within the coverage area of the cell with clear line of sight to the base station, and sufficient traffic volume to economically support the cost of the network infrastructure. There is also the need of a wired building in order to allow the distribution of forward and return channel, needed if a high interactivity level is requested, to each user from the RF terminal on the rooftop.

1.11 Forward Link Only (FLO)

1.11.1 Introduction

Video and other rich multimedia services on a cellular phone have been primarily delivered via existing 3G wireless networks. Until recently this delivery was primarily via unicast wireless networks, although the availability of multicast methods within the existing unicast networks is increasing. The broadcast-multicast mechanisms of these 3G networks are basically added onto the existing unicast physical layer. For simultaneous wide distribution of content, typically beyond a few users per sector, it is generally accepted as economically advantageous to transition to broadcast-multicast delivery.

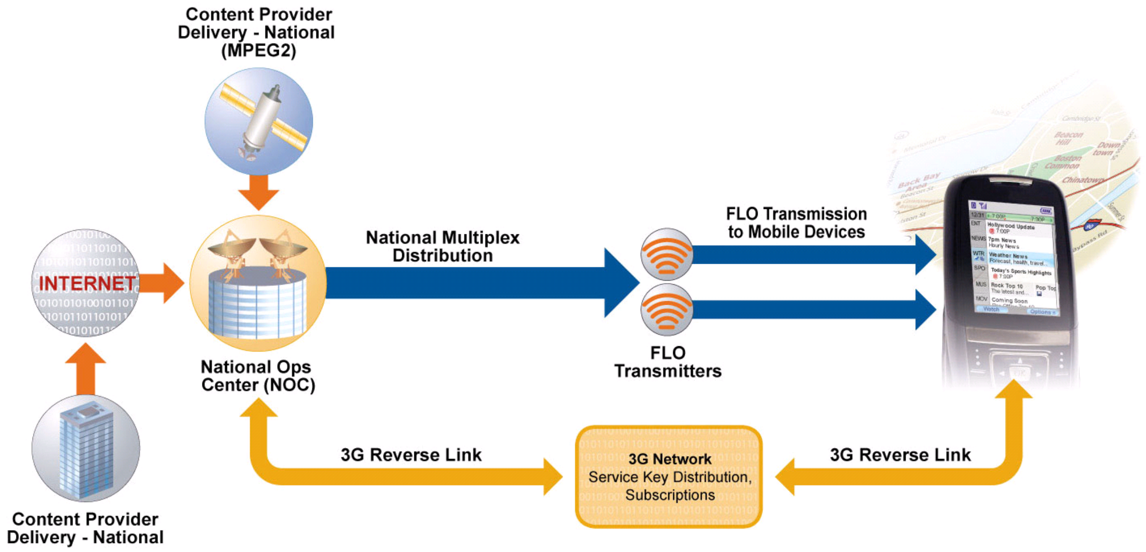
While the cost reduction that can be achieved by a broadcast mode within a unicast framework can be significant, even greater efficiencies can be achieved by a dedicated broadcast-multicast overlay. This is the underlying philosophy behind the Forward Link Only technology for broadcasting of multimedia data to handheld mobile devices.

1.11.2 Forward Link Only system architecture

A Forward Link Only system is comprised of four sub-systems namely Network Operation Centre (NOC – which consists of a National Operation Centre and one or more Local Operation Centres), Forward Link Only Transmitters, IMT-2000 networks, and Forward Link Only-enabled devices. Figure 25 shown below is a schematic diagram of an example of Forward Link Only system architecture.

FIGURE 25

Forward Link Only system architecture example



1.11.3 Forward Link Only system overview

1.11.3.1 Content acquisition and distribution

In a Forward Link Only network, content that is representative of a linear real-time channel is received directly from content providers, typically in MPEG-2 format, utilizing off-the-shelf infrastructure equipment. Non real-time content is received by a content server, typically via an IP link. The content is then reformatted into Forward Link Only packet streams and redistributed over a single or multiple frequency network (SFN or MFN). The transport mechanism for the distribution of this content to the Forward Link Only transmitter may be via satellite, fibre, etc. At one or more locations in the target market, the content is received and the Forward Link Only packets are converted to Forward Link Only waveforms and radiated out to the devices in the market using Forward Link Only transmitters. If any local content is provided, it would have been combined with the wide area content and radiated out as well. Only users of the service may receive the content. The content may be stored on the mobile device for future viewing, in accordance to a service programme guide, or delivered in real-time for live streaming to the user device given a linear feed of content. Content may consist of high quality video (QVGA) and audio (MPEG-4 HE-AAC)[2] as well as IP data streams. An IMT-2000 cellular network or reverse communication channel is required to provide interactivity and facilitate user authorization to the service.

1.11.3.2 Multimedia and data applications services

A reasonable Forward Link Only-based programming line-up for 25 frames-per-second QVGA video, with stereo audio, in a single 8 MHz bandwidth frequency allocation, includes 25 to 27 real-time streaming video channels of wide area content including some real-time streaming video channels of local market specific content. The allocation between local and wide area content is flexible and can be varied during the course of

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[2] High Efficiency AAC (HE AAC) audio profile is specified in "ISO/IEC 14496-3:2001/AMD 1:2003" and is accessible through the ISO/IEC website. The performance of the HE-AAC profile coder is documented in the publicly available formal verification test report WG 11 (MPEG) N 6009.

the programming day, if desired. In addition to wide area and local content, a large number of IP data channels can be included in the service delivery.

1.11.3.3 Power consumption optimization

The Forward Link Only technology simultaneously optimizes power consumption, frequency diversity, and time diversity. The Forward Link Only air interface employs time division multiplexing (TDM) to transmit each content stream at specific intervals within the Forward Link Only waveform. The mobile device accesses overhead information to determine which time intervals a desired content stream is transmitted. The mobile device receiver circuitry powers up only during the time periods in which the desired content stream is transmitted and is powered down otherwise.

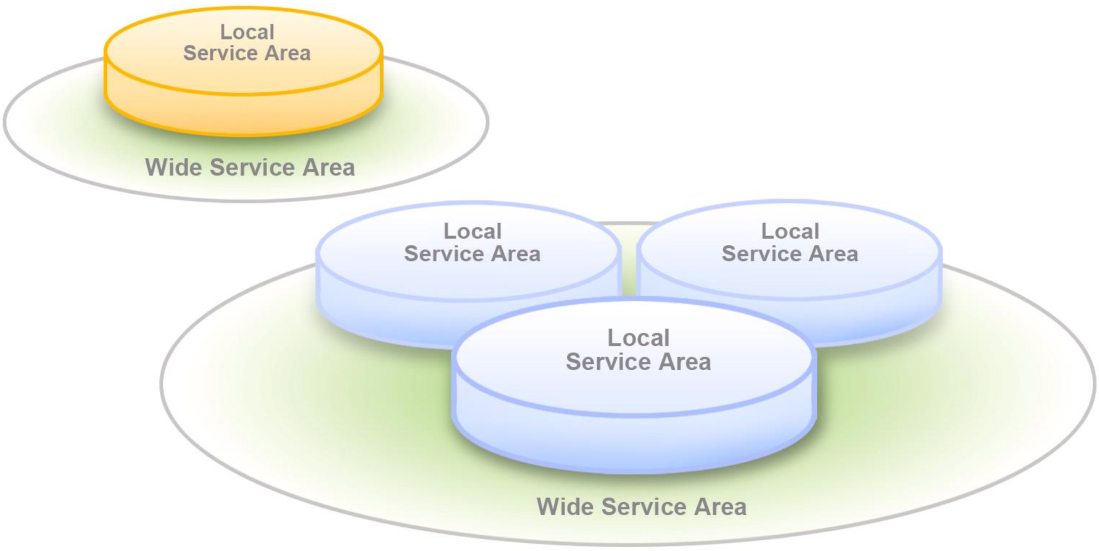
Mobile users can channel surf with the same ease as they would with digital satellite or cable systems at home.

1.11.3.4 Wide and local area content

As shown in Fig. 26, Forward Link Only supports the co-existence of local and wide area coverage within a single Radio Frequency (RF) channel. When utilizing a SFN, it eliminates the need for complex handoffs for coverage areas. The content that is of common interest to all the receivers in a wide area network is synchronously transmitted by all of the transmitters. Content of regional or local interest can be carried in a specific market.

FIGURE 26

Hierarchy of local and wide area SFNs



1.11.3.5 Layered modulation

To provide the best possible quality of service, Forward Link Only technology supports the use of layered modulation. With layered modulation, the Forward Link Only data stream is divided into a base layer that all users can decode, and an enhancement layer that users with a higher signal to noise ratio (SNR) can also decode. The majority of locations will be able to receive both layers of the signal. The base layer has superior coverage as compared to non-layered mode of similar total capacity. The combined use of layered modulation and source coding allows for graceful degradation of service and the ability to receive in locations or speeds that could not otherwise have reception. For the end user, this efficiency means that a Forward Link Only network can provide a better coverage with good quality services, especially video, which requires significantly more bandwidth than other multimedia services.

1.11.4 FLO Specification

Standardizing of the Forward Link Only technology has been achieved in the Telecommunications Industry Association (TIA) as Standard TIA-1099 and is further coordinated through the FLO Forum, www.floforum.org.

Other informative references related to the Multimedia system “M” performance include:

– TIA-1102: Minimum Performance Specification for Terrestrial Mobile Multimedia Multicast Forward Link Only Devices.

– TIA-1103: Minimum Performance Specification for Terrestrial Mobile Multimedia Multicast Forward Link Only Transmitters.

– TIA-1104: Test Application Protocol for Terrestrial Mobile Multimedia Multicast Forward Link Only Transmitters and Devices.

Chapter 2

2.1 Aspects related to interoperability of systems

2.1.1 Digital reception

Ensuring that most users are equipped with digital receivers is the main challenge for switchover and a pre-condition for switch-off. Finding a solution for all receivers in the home, not just the main receiver, just adds to the challenge. The two basic options are digital converters or set-top-boxes connected to analogue receivers, and integrated digital receivers. Moreover, additional reception facilities such as cabling, antennas, dishes, etc are often necessary.

There must be a large range of digital reception solutions to suit various user segments. This means choice of functionality, price and commercial formulas. Equipment cost is not a major barrier to the consumer of pay-TV services since some pay-TV operators subsidise it, having already deployed millions of set-top-boxes. However, pay-TV will not achieve the widespread penetration of digital TV only. Now the main challenge concerns the creation of "horizontal" markets for unsubsidized receivers supporting free-to-air digital TV services, where consumers pay the full cost from day on Co-existence of the two business models is important for wide-spread digital TV market penetration.

Availability of cheap receivers is essential to minimize entry barriers for consumers. Most of them must be equipped before the switch-off can take place. Equipment costs should not be much higher than in analogue and services at least comparable, thus offering a cheap entry point to digital TV. This is the way the market seems to go now. Of course consumers should also have options to buy expensive equipment supporting sophisticated services. Service and equipment diversity also contributes to wide-spread digital TV market penetration.

2.1.2 Encouragement to deployment of digital receivers

Free movement of goods within the internal market requires that national authorities do not impose administrative constraints for commercializing digital broadcasting equipment and compulsory technical requirements.

Some ITU Member States envisage public subsidies for digital equipment through schemes aimed at the whole population or just specific groups. The risk with the first scheme is discouraging purchases, including purchases of more sophisticated equipment than the one subsidized. The risk with the second scheme is trading of devices between subsidized and unsubsidized population groups.

Several other forms of incentives have been considered by some Member States, roe instance temporary and digressive reduction of the license fee for homes with digital equipment to encourage fast digital migration, etc. Some Member States allow a reduced rate of VAT on pay-per-view and subscription broadcasting services. The financial implication and parties affected are different, so each option should be carefully analyzed and implemented.

2.1.3 Consumer information on digital equipment and switchover

Consumer information is crucial to drive digital equipment sales in a market-led approach to switchover. Consumers should be empowered to plan their own migration rather than being forced and thus deprived by this process. They should be well informed of the timing and consequences of switchover so as to take their own decisions on services and equipment from a wide range of choices. They must be aware of what various devices can offer, what are the prospects of analogue equipment obsolescence and the possibilities for upgrading. Information and labelling should also be available in accessible formats for consumers with disabilities.

Informing consumers is the responsibility of equipment manufacturers, retailers and service providers, who need to co-ordinate their action and send clear messages whilst respecting competition law. Labelling schemes for analogue and digital equipment, with explanatory notices and/ or logos, based on voluntary industry commitment, would be particularly useful. The goal would be to send consumers positive and negative signals about, respectively, digital-compliant and analogue-only receiver equipment. This information should mirror national switchover policies, including indicative national or regional switch-off dates. Especially as an analogue switch-off date approaches in a particular Member State, its consumers should be clearly warned about the risks of equipment obsolescence.

Policy intervention in this area has been proposed in some ITU countries. However, Member States cannot impose *de jure* or *de facto* compulsory labelling schemes without prior notification. Notification enables a compatibility assessment of such measures with internal market rules to be undertaken. Where necessary, a certain degree of harmonization could be envisaged so that the approach to labelling would be common whilst tailoring its implementation to local circumstances, such as national switch-off dates. Labelling specifications could be approved by consumer and standardization bodies.

2.1.4 Integrated digital television receivers

The prohibition of selling analogue-only television receivers according to a staggered calendar was approved and is now fully implemented in the United States. It is being debated in some EU Member States. All EU countries would have to implement the obligation more or less simultaneously to preserve homogeneity within the internal market. This would have greater impact in countries where digital penetration remains low and strain the principle of subsidiarity traditionally applied in broadcasting policy.

Another potential drawback of compulsory integrated digital receivers would be the extra cost for consumers which, depending on the exact technical requirements, could however be partly offset by economies of scale. The impact would be greater in those countries where digital TV is less developed. Concerns can be also raised as to the technological neutrality of the measure. If only one type of digital tuner were to be mandated, this would presumably favour the dominant analogue TV network, often terrestrial.

2.1.5 Digital connectivity

Currently, digital TV signals are almost always displayed on analogue TV sets connected to a digital set-top-box, which decodes those signals, through the analogue ‘SCART’ socket or connector. That means digital signals are converted into analogue signals before being displayed. This is acceptable for today’s television receivers, based on cathode ray tubes and small screen sizes. However, the quality penalty is more perceptible on big screens using new digital display technologies. Moreover, the lack of systematically implemented and enabled digital connectors prevents the transfer of digital information between digital TV receivers and other digital devices in the home. But digital connectivity raises copyright security concerns, in particular that insufficiently protected digital content could be illegally copied or distributed. The possibilities for implementing digital connectors should be further explored as an incentive to consumer equipment switchover. A number of options exist to interconnect digital TV equipment, fulfilling different requirements but it is still unclear which way the market will go.

2.1.6 Access for users with special needs

Access to digital broadcasting should include citizens with special needs, notably people with disabilities and older persons. However, while digital broadcasting offers greater possibilities than analogue in this area, these are not yet supported by digital equipment on the market. Harmonized approaches can reduce costs through economies of scale, thus facilitating the marketing of relevant functionalities.

2.1.7 Removal of obstacles to the reception of digital broadcasting

Infrastructure competition stimulates market development, increasing consumer choice, quality of service and price competition. This may be constrained in some areas by legal, administrative or contractual restrictions on the deployment of infrastructure or reception facilities. Authorities will need to arbitrate between promoting digital broadcasting and the fundamental freedom to receive information and services, therefore facilitating network competition, and other policy objectives on town planning, environmental protection or other areas. With that proviso, national authorities should encourage network competition. By way of example, some Member States have already adopted measures in support of this objective, for instance by requiring the provision of multi-network reception facilities in new apartment blocks, facilitating their installation in existing blocks (for instance by reducing the required threshold of tenants’ votes), or by removing restrictive clauses in property or renting contracts. Co-ordination between national and local authorities is important since local authorities are often responsible for the practical implementation of this type of measure.

2.1.8 Effects on citizens

In all transition periods there are a lot of actors, but the past has shown the principal actors are the users. The decision of the users is in all cases oriented by market forces that, driven politically by Administrations and Manufacturers with the support of Broadcasters, can promote the opinion for change to oldest analogical systems and buy the new digital equipment. What is very important and urgent is the coordination among the different actors. In fact if the users are ready to buy new equipment and the manufacturers have produced the equipment, is very important to have a "frequency planning" program prepared by Administrations and, at the same time, a sufficient number of programs emitted, with interesting contents attract the attention of users and promote the change.

The users are moving fast towards a mobile 2G/3G lifestyle and future technologies have taught us to use mobile technology in our everyday communication. By receiving mobile broadcasting services in conjunction with 2G/3G as a return channel, consumers will be able to receive a new kind of content service and have increased interactivity. Joint utilization of digital broadcasting and existing and new cellular/cellular-type network technologies will provide consumers with location-independent and personalized services. Additionally, the delivery of digital media content via several distribution channels strengthens the availability of information society services, as they could be provided in various manners, via different network transmission methods. The use of more extensive and diverse communication networks promotes the availability of additional services and the development of content and receivers at affordable prices. This will mean information society services, including public services, can be made more accessible and cheaper than ever for all citizens by combining the usage of different types of distribution communication networks or by offering them via one communication network.

For digital television and radio the crucial conditions for success require a public that is informed on the facilities and benefits offered by the new digital services, including technical enhancements, additional programmes and services. The public must be aware of the additional service opportunities digital broadcasting and consumer electronics will offer. (For example, initiatives in this direction (i.e. to raise the public's awareness) are already ongoing in some European countries.) In addition, geographical access to digital services should be maximized and the new services should be accessible on the shortest time-scale.

Open access to public services of the information society should be encouraged, and directly developed whenever possible. This will support and speed up the implementation and success of digital broadcasting and additional datacast services. The lifetime of consumer products is in general expected typically to be from 5 to 10 years, and in some instances more. This requires stable systems, open access and the possibility of upgrading. This can only be assured when there are common, widely adopted standards jointly agreed among market players.

2.2 Mobile services

2.2.1 Sound

Mobile sound service consists of traditional Audio programs. The small devices and low price are requested. One important problem is Long battery lives.

Compared to stationary reception of broadcasting, the portable broadcast receiver is introducing this new user requirement, which can only be met, if the broadcasting link system allows for low power consumption of the receiving handheld terminals.

This has been taken into account through different means in some of the standards/specifications, which have already been elaborated on a regional/national basis.

2.2.2 Mobile TV

Mobile TV services consist of traditional TV programs or TV-like programs. TV type of services presented to mobile handheld devices with small screens is predicted to be designed different from content offered to large screen receiving terminals in a stationary broadcasting environment.

Instead of users watching a two-hour movie on the smaller screen of a handheld terminal, a more typical usage scenario would be to watch news flashes, sports features, music videos, weather forecasts, stock exchange reports and other such content, which is suitable for "ad hoc" consumption during smaller time slots.

2.2.3 Enhanced mobile TV

Online TV shopping, chat, gaming and quiz plus voting are examples of functionalities, which may be introduced as enhancements to the mobile TV to allow a true interactive mobile broadcasting experience.

2.2.3.1 The Electronic Service Guide (ESG)

Especially in the mobile environment it is important for the user to be able to navigate through the various broadcast service offerings in an easy and formalized way. Electronic Service Guide (ESG) contains information of the available services and how those can be accessed. The concept of the ESG has been found to be a well-accepted way for the user on the move to discover, select, and purchase the broadcasted services he/she is interested in.

2.2.3.2 Data

The mobile TV programs may be supplemented by auxiliary data associated with the basic service. Such information could be part of the broadcast or can be accessed on demand via the interactivity link.

The additional background information may include links to the service provider’s web pages, video clips, sound tracks, games, etc.

In Table 5, an overview of currently known mobile broadcasting transmission mechanisms is provided. The technical characteristics shown are subject to change and are by no means exhaustive but provided for comparison only.

TABLE 5

Mobile digital broadcasting transport mechanisms

Standard or Spec.	**Modulation**	**Transport stream**	**RF channel (MUX) size (MHz)**	**Int. Broadcast bands**	**Terminal power reduction methodology**	**Regional national origin**
DVB-H	QPSK or 16-QAM COFDM	IP/MPE-FEC/ MPEG2 TS	8	IV and V	Time slicing	Region 1 (Europe)
ISDB-T	QPSK or 16-QAM COFDM	MPEG2 TS	0.433	IV and V	Bandwidth shrinking	Region 3 (Japan)
T-DMB	DQPSK COFDM	MPEG2 TS	1.75	III and 1.5 GHz	Optimised narrow bandwidth	Region 3 (Rep. of Korea)

2.2.3.3 Implementation of interactivity

It is therefore natural for the mobile user community to expect interactivity as a basic characteristic of future mobile broadcasting services, an expectation that several ongoing trials have confirmed.

2.2.3.4 The interaction channel implementation

2.2.3.4.1 Digital mobile telephony

As the major part of the world standards of digital mobile telephony including IMT-2000 offer two-way data services, one approach to implement interactivity seem to be the incorporation of such mobile technology in the user terminals.

Apart from offering the user all state-of-the-art mobile telephone services, this way of implementation of interactivity with the broadcasting service offerings provide immediately a reliable control link for all such broadcasting services. It allows the user to respond and interact with the broadcasting system and to receive control codes through a secure environment.

This approach may also take advantage of the global roaming characteristics of many mobile technologies as well as of the wide-area coverage characteristics of mobile telephone technology throughout the world.

2.2.3.4.2 Interaction channel making use of the broadcast spectrum

This approach has been studied in the past, but major difficulties with global circulation of user equipment capable of transmitting into the broadcast spectrum have so far been a substantial hurdle. The development of a new two-way data transport standard may also delay the progress.

2.2.3.4.3 Summary of interaction channel methodologies

TABLE 6

Interaction channel methodologies for interactive mobile broadcasting systems

Methodology	Reference standards/ Specifications	Carrier service	Link peak bit rate (bps)
Mobile telephony	IMT-2000	HSDPA (Device Category 10) HSUPA (E-DCH)	14 Mbit/s 3.84 Mbit/s
	Global system for mobile communications (GSM)	GPRS (Device Category 10) EGPRS	85.6 kbit/s 236.8 kbit/s
	Other		
Broadcasting in-band	NA	NA	NA

Chapter 3

3.1 Report of TG 6/8

The report of TG 6/8, in Chapter 3 - Planning principle, methods and approach, § 3.4.2.3 to the first session of the RRC gave considerable information about four planning scenarios which were intended to indicate that any general planning philosophy wish expressed by an administration could be satisfied. There is, of course, no intention to imply that the detailed requirements submitted by administrations can all be satisfied. In fact, it is extremely unlikely that all requirements can be satisfied because there are natural limitations on the capacity of the available spectrum and it is to be expected that the initial requirements from administrations will exceed that natural capacity. Compromises will therefore need to be made by administrations in order to achieve a satisfactory plan.

The planning scenarios in the TG report are intended to respond to a wider range of planning options than are likely to be required by administrations. This is necessary if there is to be certainty that all general planning philosophies can be dealt with. However, it means that only very limited attention needs to be given to planning scenario 1 which seems unlikely to be needed in practice as it can be replaced by planning scenario 2 with no loss of generality.

This is because the intention of planning scenario 1, which was to allow for the case where an analogue station remains operational for an indefinite period, can be achieved by planning scenario 2, which allowed for continued protection of an analogue station with a subsequent change to digital operation in the same channel at the end of a transition period. If an administration does decide not to convert an existing analogue station to digital operation, it just means that the transition period for that station is extended indefinitely.

It may also be the case that scenario 4, which allowed for the planning of digital stations with no constraints imposed by reuse of existing analogue channels, is unlikely to be of general value. This is because if there is no reuse of existing (or planned) channels, it becomes almost impossible to ensure protection of both analogue and digital stations during the transition period, especially in the case where the administrations of neighbouring countries have different timetables for effecting the transition from analogue to digital.

However, there is one situation in which the application of scenario 4 could become very important. This is where there is part of the spectrum in which there is no current analogue broadcasting, and preferably no planned analogue broadcasting either. Under these circumstances, the channels for digital broadcasting stations can be planned to make fully efficient use of the spectrum. The latter is not possible in the case where there is considerable reuse of the channels of the existing analogue stations, as the optimum distance spacing between a pair of analogue stations and that between the same pair of stations operating digitally may be different. This necessarily introduces some inefficiency in the use of the spectrum. On the other hand, reuse of channels makes it possible to plan for a transition from analogue to digital with a reasonable hope of controlling interference levels and the possibility for viewers and broadcasters to make use of the existing infrastructure to a large extent.

It will have been noted that in the limited discussion of the two planning scenarios above, there is an assumption that different scenarios can be adopted by different administrations and also in different parts of the planning area. The adoption of different scenarios can be considered at an even more detailed level, that is at the level of individual broadcasting stations. One example would be where an administration considers that a particular analogue station needs to be maintained in operation for a long period while some other analogue station (or stations) can be changed to digital operation in the very short term. The converse is also true. An administration can decide that for some specific reason, and there can be many such reasons, an analogue station should be changed to digital operation as early as possible while other stations can be left as analogue for a much longer time.

3.2 UMTS/GSM and DVB-T Convergence

The ad hoc group DVB-UMTS/GPRS/GSM has classified the co-operation of DVB-T and UMTS/GSM/GPRS for commercial applications in different scenarios. This classification typically uses the broadcast channel for the down-load (unidirectional way), and the telecommunication channel (PSTN, xDSL, GSM, GPRS, UMTS, and…) for the up/down-load (unidirectional/bi-directional way). Particularly are addressed the user view for services built on Telco/Broadcast convergence.

There are many scenarios that can be considered for a co-coordinated use of UMTS/GPRS/GSM and DVB networks. These range from the simple sharing of content to the sharing of spectrum. A basic assumption for a co-operation of mobile network is that terminals are able to access both networks (DVB and UMTS/GPRS/GSM). Such a co-operation of both networks will improve the capabilities and varieties of services, the economics for the user and, hopefully, the ease of handling. It combines the network service modes of both network and thus enables new solutions for applications. Of course, there will still be services, which need only one network. Some applications like interactive TV can use also separate terminals, e.g. a set top box (IRD) of a UMTS/GPRS/GSM mobile terminal. Furthermore, the co-operation of networks enables the use of the UMTS/GPRS/GSM operator's services like customer relationship management and billing for all services.

Initially, the work of DVB-UMTS/GPRS/GSM group has focused on the provision of services using the DVB-T and UMTS/GPRS/GSM platforms. The specifications will be developed in different stages, corresponding to the availability of present hardware and software products and the development time required for new solutions mainly:

a) Interactive Broadcast services (video, data); use of UMTS/GPRS/GSM as a return channel for interactive TV. UMTS shall be able to substitute GSM as a return channel for these services for dial in access and further for Internet based access.

b) Integration at the terminal level. No definitive co-operation of networks is required. The specification covers only the terminal, which is able to switch between the two networks and related services. The user has the choice to select the service of DVB or UMTS/GPRS/GSM to get requested information.

c) Integration at terminal and network levels. Co-operation of networks with applications using both co-operating network resources. Terminals are firstly portable PCs, PDAs etc combined with a UMTS/GPRS/GSM "modem" for interactive services, which run on a co-operative software platform, e.g. in a domestic or car environment. The mobile handset and the broadcast receiver can connect (for example) into the PC via USB ports. The data allocation in the DVB Transport Stream can be used for IP data carousel play out and multicasting/unicasting; UMTS/GPRS/GSM will operate as an interaction channel for Internet services.

d) Mobile operation: full mobility and range of co-operative services within a single handset (terminal). Delivery of DVB content and services over UMTS/GPRS/GSM will be supported. Content can be delivered via IP over the DVB-T platform, in all or part of the multiplex or (suitably re-purposed) over UMTS/GPRS/GSM.

The co-operation platform will incorporate all functions that enable inter-working between legacy domains (broadcast, cellular), or new functions that are not available in any legacy domain.

3.3 DRM simulcast

Simulcast is an option of particular interest to broadcasters who have to continue to satisfy existing analogue listeners for several years to come, but wish to introduce DRM services as soon as possible. In many cases these broadcasters are restricted in the ways in which the digital service can be introduced. For example they may have a single MF assignments and no prospect of receiving an additional frequency assignment to start a digital only version of their service. They may also be keen to avoid having to make a short-term investment in an additional transmitter and/or antenna and site to start a digital service on a new frequency.

These broadcasters would like to be able to transmit simultaneously both the existing analogue service and a new DRM service, with the same content, whilst using the existing transmitter and antenna. This option is probably most applicable to broadcasters with LF or MF assignments, where there is generally less freedom to use new frequencies, although there may be similar SW applications where NVIS is used for domestic radio coverage. In an ideal world these broadcasters would like to be able to transmit a service using single channel simulcast (SCS), so that both the analogue and digital signals are contained wholly within the assigned 9 or 10 kHz channel.

Strictly the term simulcast can be taken to describe the simultaneous transmission of more than one signal carrying the same programme content. In this context it often describes the simultaneous transmission of analogue and digital versions of the same programme from the same transmitter and therefore from a common location. However, it could also mean that only the antenna is common, as well as that both transmitter and antenna are common to the two services. In some cases it could be more economic to add a new lower powered transmitter for the DRM service, feeding the same antenna, rather than making extensive modifications to an older less suitable transmitter, currently carrying the analogue service.

DRM supports a number of different simulcast options. Currently the supported simulcast modes require the use of additional spectrum outside an assigned 9 or 10 kHz channel (Multi-Channel or Multi-frequency Simulcast, MCS). The DRM signal can be located in the next adjacent upper or lower channel and can occupy a half or whole channel depending on the bandwidth option chosen. Significant testing, both in the laboratory and in the field, has been carried out to determine the optimum level of DRM signal needed to provide a good quality DRM service, whilst avoiding significant impact on the continuing analogue service. The conclusion is that a satisfactory compromise can be obtained when the DRM power level is around
14-16 dBs below the adjacent analogue signal. In an ideal world it would also be possible to transmit both an analogue and a digital signal within the same channel (9 or 10 kHz) so that the analogue service could be received, without interference from the digital signal, on any analogue receiver. At the same time the digital service could be received in high quality audio on a digital receiver. However, although promising proposals for a SCS option are currently being evaluated, certain compromises will almost certainly need to be made. Amongst these are likely to be a reduced digital service data rate, which will adversely impact on audio quality, and a reduced service area compared to the analogue service if interference to the analogue service is to be avoided. In the case of the analogue service there is likely to be some impact on the background noise level due to the presence of the digital signal, and the impact is likely to be dependent on the design of the analogue receiver. Nevertheless, there is optimism that most of these problems will be overcome, or significantly reduced, as a result of the ongoing development work.

Even if single channel simulcast may prove a difficult goal to achieve, the other options mentioned above, which require wider bandwidths, can already be implemented. These options will still allow some reduction in transmission equipment investment by allowing the use of the existing antenna and/or transmitter that already carries the current analogue service.

3.4 Service planning

3.4.1 DRM overview

Planning procedures within the AM broadcasting bands below 30 MHz need to be considered in two parts. Within the AM bands contained in the LF and MF part of this spectrum, there are pre-existing regional plans which lay down the fixed assignments or allotments to be used for transmissions by each member country of the ITU. In the HF bands, planning is done on a much more flexible basis, which takes into account the diurnal, seasonal and solar variations in propagation when the allocation of spectrum is determined. In the case of MF and LF spectrum two agreements are in force, the Geneva 1975 Agreement, which covers ITU Regions 1 and 3 and employs a 9 kHz frequency grid, and the Rio Agreements of 1981 and 1988, which cover Region 2 and employ a 10 kHz frequency grid. In the case of HF planning, all three regions use the same frequency grid of 10 kHz and planning, for most countries, is carried out through the auspices of the informal HFCC/ASBU/ABU-HFCC coordination process, with the resultant twice-yearly plan being registered at the ITU by administrations.

3.4.1.1 Regions 1 and 3 – LF and MF planning

Within these two Regions only Region 1 currently has assignments for and uses the LF band. Therefore the majority of assignments for both regions are in the MF band. Under the existing GE75 Plan, existing assignments are listed with their power, antenna details and transmitter location. Any change to this situation, for a particular assignment, requires a recalculation of the transmission parameters to ensure that the protection ratios for other assignments in the Plan, which might be adversely affected by the change, do not deteriorate by more than 0.5 dB. This is also the means by which new assignments have been and can be introduced into the Plan. In September 2002 the ITU Radiocommunication Bureau published Circular Letter CCR/20 under which the RRB with Rules of Procedure to provide the possibility to introduce DRM transmissions into the MF band in Regions 1 and 3 and the LF band in Region 1. Until this issue is agreed by a competent conference the following course of action may be taken by administrations on a provisional basis.

In the case of existing assignments already within the GE75 Plan the ITU-R Letter allows these to be converted to DRM assignments on the basis that they operate with an average DRM power at least 7 dB below that of the currently assigned analogue DSB service carrier power.

In the case of new assignments, which it is proposed should be introduced under the existing GE75 Plan, planning is carried out as if it were to be a new analogue DSB Assignment. If such a new analogue assignment is allowable within the plan, then it may be introduced as a DRM service, provided it is operated at an average power level at least 7 dB below the allowable new analogue assignment.

In both the above cases it is important to note that only DRM Modes A and B using 9 kHz bandwidth are approved for use under this change in the Rules of Procedure.

3.4.1.2 Region 2 – MF planning

The introduction of DRM services in the MF band in Region 2, within the confines of the Rio 1981 (R81) Agreement, is much more problematical. This is due to a stipulation to the effect that § 4.2 of Annex 2 to this Agreement imposes on the classes of emission, other than A3E (that is DSB with full carrier), the condition of being receivable by receivers employing envelope detectors. The later Rio 1988 (R88) Plan, which extends the allowable extent of the MF band in this Region, does not impose such a similar condition. However the ITU RRB did not currently feel able to make a determination for a draft change in the Rules of Procedure for either agreement and so DRM services are not currently envisaged as feasible within the MF band in Region 2. This does not entirely preclude the use of DRM transmissions in this band should an Administration wish to authorise its use within its territory on a non-interference and non-protected basis.

The RRB discussed in its determination the question of whether simulcast systems might be allowable under the R81 plan, as they were receivable on a receiver employing an envelope detector. However the Board expressed concern about the bandwidth requirements of such systems, as they generally required between 20 and 30 kHz of spectrum to accommodate both the analogue DSB signal and the digital counterpart.

Except for a single channel simulcast version of the DRM system (see § 3.3), which was not specified at the time of the RRB's determination, all other DRM simulcast proposals involve the use of between 20 and 30 kHz of spectrum. In some Region 2 territories such a system option would be potentially allowable within the terms of locally applied spectrum masks with which broadcast services in the MF band must comply. These spectrum masks are generally more relaxed than the ITU–R transmission spectrum mask and envisage lowered but significant levels of energy being radiated up to 10 or 15 kHz away from the assigned channel centre frequency. In such cases the DRM hierarchical transmission modes could be operated in conjunction with an analogue DSB signal to occupy a total of 20 or 30 kHz of spectrum. The analogue signal, at full assigned power, could occupy 10 kHz of spectrum with the base and enhancement DRM transmissions occupying 5 or 10 kHz of spectrum immediately above and below the analogue signal.

3.4.1.3 Regions 1, 2, and 3 – HF bands

Due to the diurnal (day/night-time), seasonal and sun spot related variations in propagation which take place in the SW bands, planning requires that frequency schedules are generally valid for only a six month period. For the majority of international SW broadcasters and operators this requires that intended transmissions are coordinated informally through the HFCC/ASBU/ABU-HFC in order to reduce the potential for interference to a minimum. This procedure is equally being observed for the introduction of DRM transmissions into these bands. Under current coordination procedures DRM transmissions may be introduced under similar principles to that in the MF bands. That is the service is first coordinated as if it were an analogue DSB service and then a DRM transmission substituted with a power level at least 7dB lower than the allowable analogue transmission. The provisional protection ratios adopted during WRC03, for the protection of analogue DSB transmissions from DRM transmissions, show small variations according to DRM mode and modulation. However, in all cases, these variations are smaller than the precision of the propagation prediction tools and can be discounted for the purposes of coordination.

3.4.1.4 The 26 MHz SW/HF band

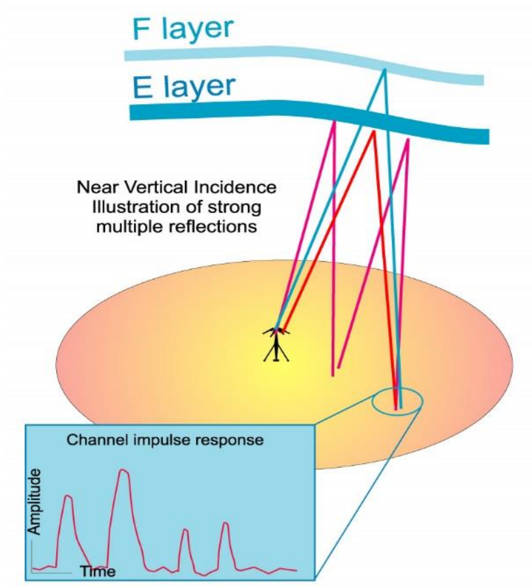
The 26 MHz broadcasting band allocation is seldom used for traditional short-wave broadcasting. This is due to the frequency being too high for reliable sky-wave propagation during most of the 11-year sunspot cycle in most parts of the world. To a lesser degree, the same is true for the 21 and 19 MHz bands. These bands, particularly the 26 MHz one, could easily be used for DRM broadcasting to a more local audience. Tests in Europe have produced very encouraging results. In the UK tests were part of a local single frequency network of 3 transmitting stations for which the power used was only 10 watts per transmitter. Another test using a single 100-200 W transmitter at a high altitude site close to Geneva showed excellent coverage and quality around the city.

For the line-of-sight services, which are proposed within these bands, Modes A, or B are likely to offer the optimum results. It may sometimes be possible, in some countries and with regulatory approval, to employ the wideband 20 kHz option to improve the audio quality still further. To obtain the best performance from this type of service, it is likely that it will need to be planned in a similar way to an FM service. That is with the antenna at a high level, with respect to the coverage area, and with average powers in the range of 100 to 200 W. It must be recognised, however, that for a period of the sunspot cycle around its maximum, significant interference may be experienced to the local service area. This interference is most likely to be caused by high power international 26 MHz transmissions, as conditions will then make these possible. There may also be interference from other, more local, low powered transmissions, if efforts are not made to minimise sky-wave radiation from them.

3.4.1.5 Near vertical incidence sky-wave (NVIS)

This type of propagation is typically used for in-country SW coverage in tropical zones. The "near vertical" geometry causes multiple reflections between ground and the reflecting ionospheric layers. The result is illustrated in Fig. 27, where several significant reflections are seen to arrive at the receiver antenna. It has been observed during transmissions that at certain times of day, such as dawn and dusk, these reflections can have similar energy and be spread over a period of several milliseconds. In order to prevent destructive interference it is important to ensure that these reflections arrive inside the guard interval otherwise the system will fail.

FIGURE 27



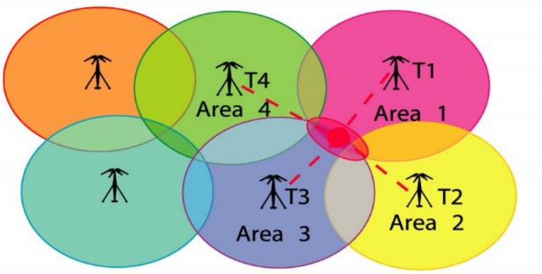
At the same time as these multiple impulses are observed they can also be subject to high values of Doppler spread. This is due to the constant movement of the reflecting layers and is more significant compared to long path reflections, due to the fact that for NVIS the movement represents a greater proportion of the ground to ionospheric distance. The result of the conjunction of these two phenomena is simultaneously high values of delay and Doppler spread. This can only be overcome by the use of a long guard interval in conjunction with wider frequency spacing for the OFDM carriers. However, because the signal strength can be quite high due to the short paths, signal to noise ratio is often not the limiting factor in NVIS and so
64-QAM may be useable for the MSC. Even so, due to the frequent need to use Mode D because of its higher resistance to Doppler and delay spread, the usable data rate of this mode, in a 10 kHz channel, will be quite

low. This low data rate may force the use of CELP+SBR audio coding, rather than AAC, unless it is possible to use the 20 kHz wideband option. In this case AAC+SBR becomes possible providing near mono FM, or even stereo quality in good conditions.

3.4.1.6 Single Frequency Networks (SFNs)

Although analogue synchronous networks are often used to provide extended coverage, there will always be problems with mutual interference in at least some parts of the overlap areas. This usually requires the use of additional frequencies to supplement coverage in these areas. With careful design, this problem can be all but eliminated in the case of a DRM SFN. Figure 28 shows a much-simplified arrangement for a DRM SFN, using 6 transmitters. In the area of overlap between areas 1 to 4 it can be seen that signals may be received from all four transmitters at the same time. Provided these signals all arrive within the guard interval they will reinforce each other and reception should be improved in this area over that obtainable from any one transmitter. It is important to note that the transmitted signals must be identical for reinforcement, rather than interference, to occurrence.

FIGURE 28



Care will need to be taken however to ensure that the network continues to work effectively after dark. Then sky-wave propagation may allow more distant transmitters in the network to contribute signal into the local service area of parts of the SFN. If the propagation path is of sufficient length, and the signal strength is high enough, it may cause interference due to the sky-wave signal being delayed by more than the guard interval. Preventative measures to be taken could include ensuring that sky-wave radiation is minimised by suitable antenna design and changing to a more robust transmission mode, with a longer guard interval, during times of sky-wave propagation.

SFN operation is, in principle, possible using two or more MF or SW transmitters providing service entirely using sky-wave propagation. However the technical requirements are quite onerous, since each of the signals must be timed to arrive simultaneously over the whole of the coverage area. Otherwise they will cause mutual interference rather than reinforcement. This may require real-time monitoring of signals received at several points in the intended coverage area.

Without this, predicting the propagation transition time from transmitter to receivers in the coverage area may prove difficult to achieve sufficiently accurately in advance.

3.4.1.7 Coverage planning

At the time of writing there are no planning tools available which have been specifically designed to calculate coverage and availability for DRM transmissions. However a number of DRM Members plan to rectify this situation by setting up a new project to design software planning tools which takes into account the additional propagation parameter needs of the DRM system. For the moment though, it remains necessary to make a calculation of field strength in the target coverage area based on an analogue DSB transmission. This can then be related to the required signal strength for a DRM transmission using a particular combination of robustness Mode, MSC constellation and code rate to provide the necessary SNR for service. For ground-wave services, this method can be expected to provide results close to observed measurements, as the path is simple, and little, if any, multi-path is introduced to cause signal distortions.

For sky-wave services the prediction is much more complex, as the resultant service will depend not only upon the delivered signal strength but on the level of Doppler and Delay spread to which the signal will be subject. Most software based prediction tools either do not estimate these parameters or, if they do, do not produce reliable results. Nevertheless, for the time being, the existing analogue prediction tools will continue to be used, as they are all that is available. However, it is anticipated that new tools will be developed in the near future, which will aim to provide an estimate of these additional propagation parameters. These tools will be designed to recommend the combination of transmission parameters that best meet the needs of a broadcaster for a specific transmission path and target zone.

In general the average power requirements of a DRM transmission will be less than that of the equivalent analogue transmission. In part this is due to the fact that a DRM transmission will have a higher peak to mean ratio than an analogue DSB signal.

A simple analogue DSB signal will consist of a single carrier at zero modulation whilst at 100% modulation there will be the addition of two sidebands which together will increase the power output of the transmitter to 1.5 times the carrier power. The use of power saving, where the carrier level depends on the modulation level, will modify this relationship, so that the average power output and consumption of the transmitter will be lowered compared to the absence of such a system. Because the DRM signal has a peak to mean power ratio of approximately 10 dB the transmitter must be operated in a backed off condition in order to avoid the digital signal being clipped within the various stages of the transmitter. Should excessive signal clipping occur within the transmitter, it would cause the generation of in channel intermodulation products. These products would cause inter-symbol interference and this can impact adversely on the receiver performance.

3.4.1.8 DRM reception monitoring

An important part of assuring the quality of any radio transmission comes from monitoring the transmitted signals within the target coverage area. In the case of analogue services, this has generally been accomplished by using a high quality receiver for signal reception. The signal strength is then read from a calibrated meter, whilst making a subjective assessment of the audio quality. Such an assessment has historically been made by someone in the target area tuning a receiver to the required service and then listening to it in real time. More recently, this manual method has been supplemented by using unmanned remotely controlled or scheduled receivers to receive the signals and record the signal strength, together with a sample of the audio. The move to using a digital transmission system enables the monitoring of reception to be completely automated. To this end DRM has developed a specification and protocol for the control interface (RSCI). If manufacturers of professional receivers use this specification it will ensure that an operator can use monitoring receivers of more than one manufacturer to build a monitoring network, but use the same software to control and download data from all these receivers. Furthermore this opens the possibility for several operators or broadcasters to share the same receivers, if they so wish.

Because a DRM transmission uses digital coding it facilitates the recording of data that can characterise the reception quality. This information can include not only the signal strength and audio quality, which can be assessed from the audio bit error rate, but also continuous parameters describing the quality and nature of the transmission channel. Over time the accumulation of this information should lead to an improved understanding of the propagation behaviour of the ionosphere.

Data acquired by the monitoring receiver can be stored locally and downloaded from the reception site on a regular basis, to provide evidence of the performance of a particular transmission, or accessed in near real time. In either case the most likely method of transmitting this information back to the broadcaster will be by means of the Internet, or if that is not available, by directly dialling the receiver using a telephone line and modem connection.

In some cases it may be possible to permanently connect to the monitoring receiver(s) either via the Internet, using broadband, or a local network connection or, perhaps, via VSAT terminals. In any of these cases it becomes possible to acquire information about the quality of the service in the target coverage area on a near real-time basis. In this case, by providing a real time method for collating and analysing the reception data, it becomes possible to optimise the transmission parameters of the service(s) in real time. This optimisation process requires the employment of a computer system, which amalgamates the reception data from a number of monitoring receivers in the coverage area. Based on this data, the analysis and prediction algorithm within the computer makes near real-time adjustments to transmission parameters, such as the transmission Mode, MSC modulation and code-rate, to achieve a pre-defined quality of service.

A validation of that concept has been done in the framework of the QoSAM project in 2003 and 2004.

3.5 Market impact

3.5.1 Market complexity; plurality of scenarios and stakeholders

There is no single switchover pattern or formula. Experiences vary according to the local circumstances and from one network to another. Consequently, the general analysis provided here could only be a simplification. The switchover debate tends to focus on terrestrial TV for two reasons: greater difficulties for a market-led digitisation than other networks; and higher political stakes and government involvement, mainly because of the pressure to recover spectrum, and a wide-spread perception associating terrestrial with universal free-to-air broadcasting services.

Switchover is a complex and long process involving many variables and affecting more or less directly many parties, namely: users/ consumers, industry and public authorities. Each group can be further subdivided into smaller segments. For instance, users can be categorised according to their attitude towards digital TV: current or potential pay-TV subscribers, assuming that all pay-TV will be digital sooner or later; current or potential free-to-air digital TV viewers, who have bought or are ready to buy a digital receiver; viewers who will be always reluctant to adopt any form of digital TV, pay or free-to-air, for various reasons. The switchover strategies adopted will obviously determine, and be determined by, the respective percentage of each user category. In particular, the extent to which market forces alone can achieve digitisation will depend on the number and resilience of consumers reluctant to migrate to digital TV.

Switchover also concerns many industry players, such as content creators, service providers, network operators or equipment manufacturers. Some were already active in the analogue broadcasting market, others look for new business opportunities. Likewise, various departments in national and international administrations are interested in switchover insofar as it affects the achievement of policy objectives.

3.5.2 The case for public intervention

A key question is whether public authorities should intervene to accelerate switchover and/ or otherwise influence the process. That would be justified under *two premises*: first, the extent to which general interests are at stake; that is, how far there are potential benefits and/ or problems for the society as a whole, rather than just for certain groups or individuals. Secondly, market failure; that is, market forces alone fail to deliver in terms of collective welfare. In other words, market players’ behaviour does not fully internalise switchover costs. Assessing the existence and intensity of both premises is largely a matter of political judgement by the competent authority, which, in the case of broadcasting, tends to be national and/ or regional authorities. In any case, such judgement should not be arbitrary but supported by sound market analysis.

As to general interests, potential benefits from digitisation can be oriented towards various policy goals: social, cultural, political, economic, etc. Usually there are trade-offs to make between them. For instance, part of the spectrum released by analogue switch-off could be redistributed in order to transfer this resource to operators who would use it to support different services or ‘reinvested’ in broadcasting to improve and extend the service.

The broadcasting sector is not comparable to any other sector, as it plays a central role in modern democratic societies, notably in the development and transmission of social values. Broadcasting offers a unique combination of features. Its widespread penetration provides almost complete coverage of the population across different broadcasting networks; provision of substantial quantities of news and current affairs together with cultural programming mean that it both influences and reflects public opinion and socio-cultural values. Switchover may affect these general interests. It will be important to ensure the continuing availability of a variety of television services, without discrimination and on the basis of equal opportunities, to all parts of the population. In particular, this is a pre-condition for public service broadcasters to fulfil their special obligations.

The likelihood of market failure is linked to the complexity of the environment where switchover takes place, and the interactions between the main parties involved. All have interests to defend and seek to influence the main variables: introduction or not of digital terrestrial TV, speed of the migration and switch-off timing, convenience and type of public intervention. However, coordinated action from the main stakeholders, rather than confrontation of individual strategies, is likely to lead to the collective optimum: a swift and efficient switch-off, with the minimum negative social and economic implications.

At least in the case of terrestrial television and radio, a series of structural failures hinder market co-operation and slow down switchover, notably (free riding) behaviour, oligopoly situations and ‘chicken and egg’ deadlocks. More specifically, the parties benefiting the most from switchover (equipment manufacturers or potential beneficiaries of released spectrum, including new broadcasters) may be different from those likely to bear the costs (final users or current broadcasters). So the latter have little incentive to internalise the costs and contribute to the switchover. Overcoming this kind of situation would require setting up co-ordination mechanisms to share benefits and costs between all parties involved, ideally with little or no public intervention. In this regard, public authorities, especially those responsible for competition law, must make careful judgements as to the right balance between market competition and cooperation between relevant parties. Those judgements must be based on clear understanding of both market dynamics and policy goals pursued.

3.5.2.1 Modalities

If the need for public intervention is established, decisions must be taken about its modalities, within a coherent switchover strategy. Any intervention should be transparent and proportionate as to the policy objectives pursued, market obstacles, and implementing details. This would provide certainty for all parties to prepare themselves and would limit the scope for arbitrary or discriminatory measures.

Five principles and guidelines for regulatory action can be established. Regulation should:

− Be based on clearly defined policy objectives.

− Be the minimum necessary to meet those objectives.

− Further enhance legal certainty in a dynamic market.

− Aim to be technologically neutral.

− Be enforced as closely as possible to the activities being regulated.

A key area in national switchover strategies is the approach to digital broadcasting licensing and regulatory obligations attached thereto. This involves policy choices on network competition versus complementarity, number of operators, roll-out calendar and map, etc. Otherwise, there is a variety of possible intervention instruments and measures to encourage switchover, ranging from encouragement measures, like information campaigns, to compulsory ones, like analogue turn-off dates, or mandatory standards for equipment including digital tuners. They can also vary according to the parties targeted (consumers, equipment manufacturers, broadcasters, potential users of released spectrum, others). The impact of the planned measures should be evaluated through prospective economic analysis to ensure that the expected cost and benefits are fairly distributed; public policy should not lead to situations where some parties will be forced to bear most switchover costs whilst others will enjoy the benefits.

Timing is a key element of any intervention on switchover. Premature or late action can be useless and even counterproductive insofar as it introduces market distortion. Timely intervention requires good knowledge of market status and evolution, and therefore regular monitoring and analysis. In principle, an early switch-off is likely to be more controversial, but a more distant date may reduce any beneficial impact. In this connection, three main phases can be identified in TV switchover: the take-up phase driven by pay-TV, where sooner or later operators convert subscribers to digital; the consolidation phase, starting now in the countries where digital TV is the most advanced, where some consumers decide to equip themselves with digital devices to receive free-to-air digital TV; the closure phase, where users still not interested in any type of digital TV are forced to adopt it, with or without public support for the acquisition of a digital receiver.

Public intervention can support digital TV penetration in all three phases but stronger measures should be confined to the closure stage, after industry has made all possible efforts to increase consumer uptake. This requires that authorities ensure a favourable and predictable regulatory environment, and intensify their action when the market cannot deliver further. That may be the case when it is considered that digital broadcasting is not progressing quickly enough to achieve policy targets.

3.5.2.2 Risks

Broadcasting has a stronger tradition of policy intervention than other information and communication sectors like telecommunications, where the impact of liberalisation has been greater. This is justified by the political and social relevance of broadcasting content, which calls for the enforcement of minimum quality and pluralism requirements. Policy intervention is even greater in the case of terrestrial broadcasting because of its heavy use of spectrum, a scarce public resource, and the already-cited perception associating terrestrial with universal free-to-air TV services.

However, the contexts surrounding the introduction of analogue and digital broadcasting are very different. When analogue broadcasting was introduced, only the terrestrial option existed; there was no competition and the market was entirely shaped by regulatory intervention. Now, there are various types of networks, high market competition and faster technological change. Under these circumstances, the transition to digital broadcasting represents a big industrial challenge that must be led by the market. Intervention from public authorities to facilitate and supervise the process could be justified insofar as general interests are at stake.

The risks from both public intervention or absence of it must be assessed. Non-intervention can result in market failure and jeopardise general interest goals in the sense explained above. As to the risk from public intervention, it includes policy-driven approaches captured by industrial parties seeking to offset commercial risk, thus reducing competition and pressure to innovate. This could result in perverse effects, like ‘moral hazard’ or market inaction, and ultimately slow the switchover process down. In practice, these parties may exaggerate the advantages from digital broadcasting, mixing private and collective benefits. Then, they might persuade authorities to support them (legally, financially or otherwise) in the name of general interests to gain a competitive edge over rivals. If not transparently justified, this could distort the market.

Moreover, public intervention, or the simple announcement of it, that turns out to be inappropriate for any reason (disproportionate, discriminatory, untimely, etc) can be counterproductive. It can create additional obstacles to digital broadcasting uptake, by stimulating an appetite for more public intervention than would have been necessary otherwise. For instance, if a government announces too early that digital receivers will be offered to all remaining analogue users shortly before analogue switch-off, there will be little incentive for those users to buy receivers. Also, untimely imposition of technical standards that are immature or require costly implementation may discourage investment. Finally, all intervention by national authorities must be compatible with existing law.

3.5.2.3 Policy orientations

As explained, market forces must drive the switchover process focusing on users. The challenge is to stimulate demand so that it is a service-led process rather than a simple infrastructure change with no perceived added-value for citizens. Consequently, the various consumer segments must be offered packages of services and equipment that are attractive to them; that is, stimulating, user-friendly and affordable. This is primarily a task for market players.

There is however also scope for policy intervention considering the social and industrial general interest at stake, and that some key elements of the process are the responsibility of public authorities. Such intervention must be conducted in the first instance by national and/ or regional authorities, which are the most directly responsible for broadcasting content policy and licensing.

3.6 General strategy and co-ordination

3.6.1 Transparent strategy and monitoring

As indicated, policy transparency improves certainty for market players (including consumers), encourages co-ordinated action, and ultimately facilitates the switchover. Therefore will be important calls upon Member States to publish by end 2003 their intentions regarding a possible switchover. This could cover, in particular, the way they organise and monitor the process, stakeholders' involvement, and policy instruments intended to promote switchover.

At ITU level, comparison of national experiences and regular monitoring would provide useful information on policy and market status. This would help identifying possible actions to develop internal market synergies.

3.6.2 Regulation allowing for business autonomy and co-operation

Developing digital broadcasting markets is a complex process requiring significant investment from many players to: roll-out networks, develop enabling technologies, sell terminals, offer compelling services, and encourage user uptake. Industry must have incentives to invest and autonomy to search for winning formulas. This requires a stable regulatory environment, including licensing terms for service operators with a duration that enables an appropriate return on investment, taking into account the additional costs caused by the transition and with the possibility of licence renewal so as to provide an adequate incentive. Licensing terms should also facilitate provision of sufficient network capacity to support a variety of services.

However, authorities should monitor market evolution, consult with industry, and be ready to review or flexibly interpret conditions relevant to switchover where justified, for example conditions concerning the calendar for roll-out and territorial coverage, technical choices on transmission and terminals, ownership thresholds, price caps, taxes, simulcast extent and timing, or obligations to provide certain programming. Authorities may have trade-offs to make between a faster switchover and other policy objectives, for instance regarding the degree of pluralism, and they need to consider the impact of policy choices on market competition. The challenge is to find the right balance between different policy objectives while respecting legal requirements, in order to maximise collective welfare. For instance, as argued below, co-ordination and cooperation between different industries is important for switchover. While various public policy objectives can be taken into consideration in this context, competent authorities must ensure maximum transparency regarding such objectives and the necessary means to achieve them. This should go beyond vague references to the goal of digital switchover and/or the Information Society.

Co-ordinated and synchronised action may be necessary to achieve critical mass. Co-operation between industry players at various levels of the value-chain must be therefore facilitated, especially in the initial market stages, which imply trial and error testing. This can be organised through joint investment and risk sharing schemes for technological research, launch of new equipment and services, and promotion. Authorities may contribute through financing or regulation, as is done in some Member States for both digital TV and radio.

Co-ordination is particularly relevant in horizontal markets, such as free-to-air broadcasting. Unlike pay broadcasting, no dominant party controls the value-chain and 'free-riding' behaviour can result in collective business failure. Sharing responsibility for commercial promotion and consumer after-sale service, notably in face of difficulties with signal reception or receiver equipment, is particularly important.

In the case of digital radio, apart from favourable regulatory frameworks in the Member States, it appears that synchronised implementation across the ITU Member States is important to increase market synergies.

3.6.3 Proportionate and technologically neutral regulation

In terms of political feasibility, switch-off in a given territory can only take place when nearly all households receive digital services. In order to promote the fast and efficient achievement of this objective, all transmission networks should be taken into account (primarily cable, satellite or terrestrial). This approach recognises that network competition contributes to the roll-out process. This implies a regulatory level playing field. In principle, each network should compete on its own strengths. Any public support for one particular option cannot be excluded but should be justified by well-defined general interests, and implemented in a proportionate way. Otherwise it would appear discriminatory and could jeopardise investments in other networks. In particular, each individual network should not necessarily enjoy the same position in the digital landscape as in the analogue landscape. The objective should be to achieve a fast and efficient switchover.

Efficiency should include preserving the general interest missions of broadcasting, while limiting public expense.

Finally, any public financial support to digital broadcasting needs to be compatible with State aids rules and in line with national laws.

3.7 Problems related to the interoperability of systems

In Europe the scenario is as follows.

3.7.1 Digital reception

Ensuring that most users are equipped with digital receivers is the main challenge for switchover and a pre-condition for switch-off. Finding a solution for all receivers in the home, not just the main receiver, just adds to the challenge. The two basic options are digital converters or set-top-boxes connected to analogue receivers, and integrated digital receivers. Moreover, additional reception facilities such as cabling, antennas, dishes, etc are often necessary.

There must be a large range of digital reception solutions to suit various user segments. This means choice of functionality, price and commercial formulas. Equipment cost is not a major barrier to the consumer of pay-TV services since some pay-TV operators subsidise it, having already deployed millions of set-top-boxes. However, pay-TV will not achieve the widespread penetration of digital TV only. Now the main challenge concerns the creation of ‘horizontal’ markets for unsubsidised receivers supporting free-to-air digital TV services, where consumers pay the full cost from day one. Co-existence of the two business models is important for wide-spread digital TV market penetration.

Availability of cheap receivers is essential to minimise entry barriers for consumers. Most of them must be equipped before the switch-off can take place. Equipment costs should not be much higher than in analogue and services at least comparable, thus offering a cheap entry point to digital TV. This is the way the market seems to go now. Of course consumers should also have options to buy expensive equipment supporting sophisticated services. Service and equipment diversity also contributes to wide-spread digital TV market penetration.

3.7.2 Encouragement to deployment of digital receivers

Free movement of goods within the internal market requires that national authorities do not impose administrative constraints for commercialising digital broadcasting equipment and compulsory technical requirements.

Some ITU Member States envisage public subsidies for digital equipment through schemes aimed at the whole population or just specific groups. The risk with the first scheme is discouraging purchases, including purchases of more sophisticated equipment than the one subsidised. The risk with the second scheme is trading of devices between subsidised and unsubsidised population groups.

Several other forms of incentives have been considered by some Member States, for instance temporary and digressive reduction of the licence fee for homes with digital equipment to encourage fast digital migration, etc. Some Member States allow a reduced rate of VAT on pay-per-view and subscription broadcasting services. The financial implications and parties affected are different, so each option should be carefully analysed and implemented.

3.7.3 Consumer information on digital equipment and switchover

Consumer information is crucial to drive digital equipment sales in a market-led approach to switchover. Consumers should be empowered to plan their own migration rather than being forced and thus deprived by this process. They should be well-informed of the timing and consequences of switchover so as to take their own decisions on services and equipment from a wide range of choices. They must be aware of what various devices can offer, what are the prospects of analogue equipment obsolescence and the possibilities for upgrading. Information and labelling should also be available in accessible formats for consumers with disabilities.

Informing consumers is the responsibility of equipment manufacturers, retailers and service providers, who need to co-ordinate their action and send clear messages whilst respecting competition law. Labelling schemes for analogue and digital equipment, with explanatory notices and/ or logos, based on voluntary industry commitment, would be particularly useful. The goal would be to send consumers positive and negative signals about, respectively, digital-compliant and analogue-only receiver equipment. This information should mirror national switchover policies, including indicative national or regional switch-off dates. Especially as an analogue switch-off date approaches in a particular Member State, its consumers should be clearly warned about the risks of equipment obsolescence.

Policy intervention in this area has been proposed in some EU and third countries. However, Member States cannot impose *de jure* or *de facto* compulsory labelling schemes without prior notification. Notification enables a compatibility assessment of such measures with internal market rules to be undertaken. Where necessary, a certain degree of harmonisation could be envisaged so that the approach to labelling would be common whilst tailoring its implementation to local circumstances, such as national switch-off dates. Labelling specifications could be approved by consumer and standardisation bodies.

3.7.4 Integrated digital television receivers

The prohibition of selling analogue-only television receivers according to a staggered calendar has been completely implemented in the United States and debated in some EU Member States. All countries would have to implement the obligation more or less simultaneously to preserve homogeneity within the internal market. This would have greater impact in countries where digital penetration remains low and strain the principle of subsidiarity traditionally applied in broadcasting policy.

Although a potential drawback of compulsory integrated digital receivers would be the extra cost for consumers but the increase is likely to be minimal because of economies of scale.

3.7.5 Digital connectivity

Digital connectivity raises copyright security concerns, in particular that insufficiently protected digital content could be illegally copied or distributed. A number of options exist to interconnect digital TV equipment, fulfilling different requirements but it is still unclear which way the market will go in the long term as home networking strategies are implemented.

3.7.6 Interoperability of services

Regarding more sophisticated functionalities such as *Application Programme Interfaces* (API), interoperable and open solutions for interactive TV services must be encouraged. The Member States will decide whether it is necessary to mandate certain standards to improve interoperability and freedom of choice for users. Indeed, these two criteria will likely contribute to consumer uptake of digital broadcasting in a market-led switchover scenario, thus minimising the need for public intervention.

3.7.7 Access for users with special needs

Access to digital broadcasting should include citizens with special needs, notably people with disabilities and older persons. However, while digital broadcasting offers greater possibilities than analogue in this area, these are not yet supported by digital equipment in some markets. Harmonised approaches can reduce costs through economies of scale, thus facilitating the marketing of relevant functionalities.

3.7.8 Removal of obstacles to the reception of digital broadcasting

Infrastructure competition stimulates market development, increasing consumer choice, quality of service and price competition. This may be constrained in some areas by legal, administrative or contractual restrictions on the deployment of infrastructure or reception facilities. Authorities will need to arbitrate between promoting digital broadcasting and the fundamental freedom to receive information and services, therefore facilitating network competition, and other policy objectives on town planning, environmental protection or other areas. With that proviso, national authorities should encourage network competition. By way of example, some Member States have already adopted measures in support of this objective, for instance by requiring the provision of multi-network reception facilities in new apartment blocks, facilitating their installation in existing blocks (for instance by reducing the required threshold of tenants' votes), or by removing restrictive clauses in property or renting contracts. Co-ordination between national and local authorities is important since local authorities are often responsible for the practical implementation of this type of measure.

3.8 Precautions to control the direct health effects of RF radiation

Recommendation ITU-R BS.1698 contains the precautions to be taken into account. Two groups of people are considered in terms of the precautions that can reasonably be taken. The first group is employees at, or regular official visitors to, transmitting stations. Whilst this group may be at a more frequent risk, the extent to which control measures can be applied is much greater than that for the second group, being members of the general public.

3.8.1 Employee (occupational) precautionary measures

3.8.1.1 Physical measures

Some form of protective barrier must be provided to restrict access to any area where either the basic biological limits are exceeded or contact with exposed RF conductors is possible. Access to such areas must only be possible with the use of a key or some form of tool. Mechanical or electrical interlocking should be provided to enclosures where access for maintenance is needed. Screening of equipment should be sufficiently effective to reduce the level of RF radiation.

Other physical measures such as warning lights or signs should also be used in addition to, but not instead of, protective barriers.

The risk of shock or burns from RF voltages induced on conducting objects, such as fences and support structures, should be minimized by efficient and properly maintained RF earthing arrangements. Particular attention should be paid to the earthing of any temporary cables or wire ropes, such as winch bonds, etc.

Where such objects need to be handled in a RF field, additional protection from shocks or burns should be provided by the wearing of heavy-duty gloves and through effective labelling.

3.8.1.2 Operational procedures

RF radiation risk assessments must be carried out by suitably trained and experienced staff at regular intervals and also when any significant changes are made to a transmitting station. The initial objective must include the identification of the following:

- The areas where people may be exposed to “derived” or “investigation” levels.
- The different groups of people, e.g. employees, site sharers, general public etc., who may be exposed.
- The consequences of fault conditions, such as leakage from RF flanges, antenna misalignment or operational errors.

An initial check on the RF radiation levels can be done by calculation or mathematical modelling, but some sample measurements should also be carried out for verification purposes. In most cases, however, measurements will be needed to determine RF radiation levels more accurately. The actual quantities to be measured (E field, H field, power flux-density, induced current) should be determined based on the specific circumstances. These include station frequencies, field region (near/far field) being measured and whether it is proposed to check compliance with basic restrictions (SAR) or only “derived/investigation” levels. These circumstances will also largely determine whether the three individual field components should be measured separately or whether an isotropic instrument should be used. RF radiation surveys should then be carried out by staff trained in the use of such instruments, following prescribed measurement procedures, and recording results in a specified format.

A nominated competent person should be made responsible for the identification and provision of suitable types within any organization or company. Such measuring instruments must always be used in accordance with manufacturers’ instructions and be subject to regular functional testing and calibration. Labels showing expiry dates must be fixed to instruments following such tests or calibration. Records of calibration should be kept, including whether adjustments and/or repairs were needed on each occasion. This information should then be used to determine the interval between calibrations.

Systems of work should be implemented that not only ensure that RF radiation limits are not exceeded, but also minimize exposure in terms of time and number of employees. Maintenance work, in areas subject to access restrictions due to high RF radiation levels, should be planned around scheduled transmission breaks or radiation pattern changes where possible. However, there should always be a balance between exposure to RF radiation and other risks, such as working on masts at night, even when floodlit. Where necessary, transmitters should be switched to reduced power or turned off to allow safe access for maintenance or repair work.

Prohibited areas on transmitting stations must be clearly defined and marked, and "permit to work" systems should be implemented. Appropriate arrangements should be put in place for any systems, antennas, combiners or areas shared by other organizations. All staff who regularly work in areas with high levels of RF radiation should be issued with some form of personal alarm or RF hazard meter.

Records must be kept of exposure above specified RF radiation levels. Companies or organizations responsible for operating transmitting stations should monitor the health of staff who regularly work in areas with high levels of RF radiation and take part in epidemiological surveys, where appropriate.

Details of general policies and procedures relating to RF radiation safety should be included in written safety instructions and given to all appropriate staff. In addition, local instructions for each transmitting station should be issued to ensure compliance with such policies and procedures.

Safety training should also include the nature and effects of RF radiation, the medical aspects and safety standards.

3.8.2 Precautionary measures in relation to the general public

3.8.2.1 Physical measures

Similar considerations apply to the general public, as those detailed in § 3.8.1.1 for employees.

Particular attention should be given to areas where RF radiation limits could be exceeded under fault conditions. Protective barriers should be provided in the form of perimeter fencing, suitably earthed where needed. Additional hazard warning signs will probably be necessary.

3.8.2.2 Operational procedures

Risk assessments, carried out under § 3.8.1.2 above, must take into account the possibility of members of the public having medical implants. A procedure for providing health hazard information to such potential visitors should be adopted with appropriate restricted access procedures. Basic RF safety instructions should be provided for regular site visitors.

The need to carry out RF radiation surveys beyond site boundaries must be considered, in particular where induced voltages in external metallic structures (cranes, bridges, buildings etc.) may cause minor burns or shock. In carrying out such surveys the possibility of the field strength increasing with distance, usually due to rising terrain, should be taken into account. Where necessary, a procedure for monitoring planning applications or other development proposals should be implemented.

An example which illustrates the text above is given in § 3.10 and Figs. 29 and 30 of this Report.

3.9 Precautions to control the indirect RF radiation hazards

Indirect effects of RF radiation, such as ignition hazards to flammable substances, may occur at levels well below the "derived/investigation" levels particularly at MF/HF. This is because flammable substances may be stored on a site having associated conducting structures, such as pipe work, that could act as a fairly efficient receiving antenna. Actual risks are, however, rare, but may include industrial processing plants, fuel storage facilities and petrol filling stations. Detailed evaluation is, however, far from simple. The general procedure recommended below is, therefore, based on progressive elimination. The detailed precautions adopted will however need to take account of any national standards or legislation in the country concerned.

An initial assessment should be carried out, based on practical, worst case estimates, of the minimum separation needed between a particular type of transmitter and a conducting structure to avoid such a hazard. The first step in doing this is to determine the minimum field strength that might present an ignition hazard for the particular transmitter frequencies in use. This is a function of the type of flammable substance and the perimeter of any loop formed by metallic structures, usually pipe work, and can most easily be determined from tables or graphs. The vulnerable area should then be determined from this minimum field strength by calculation, mathematical modelling or from tables/graphs.

If the vulnerable area, as determined above, contains any such sites on which flammable substances are stored, or if any are being planned, a more detailed assessment should then be made. This should be based on the actual dimensions of any metallic structures, the gas category of the flammable substance(s) being stored and the measured field strength. This detailed assessment should be carried out by calculation of the extractable power from the metallic structure to determine whether this exceeds the minimum ignition energy of the flammable substance. Should this be the case, then the extractable power should be measured and any necessary modifications to the structure and/or other safeguards implemented.

In a similar category to ignition hazards, is the possible detonation of explosive materials. This will very rarely be encountered but detailed guidance is available from national standards, such as BS 6657 in the United Kingdom. Other indirect effects that should be considered include interference to the safety systems of vehicles, machines, cranes etc. close to, or within the boundaries of, transmitting stations. The immunity of these systems is covered by electromagnetic compatibility (EMC) regulations and CISPR.

Where necessary, precautions similar in principle to those described above may need to be applied.

3.10 Field-strength values to be determined

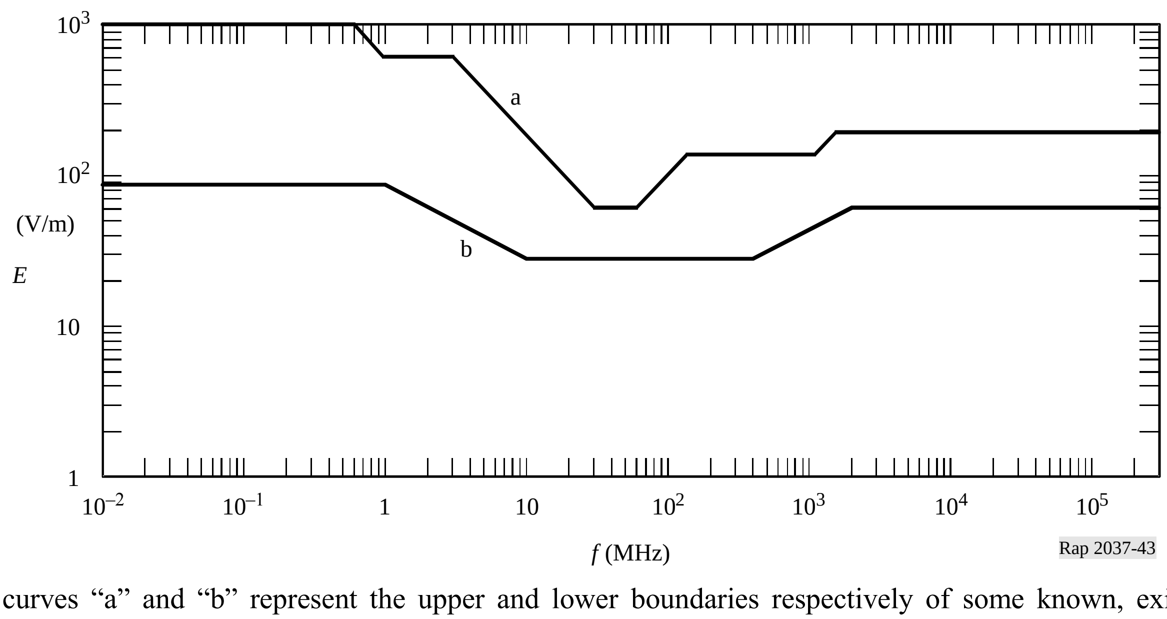
Preliminary, using data given by a number of international and national authorities concerned with the health aspects of EMFs, the range of electrical and magnetic field strengths are shown in Figs. 29 and 30, respectively.

These curves/graphs should not be used as a basis for an administration's regulatory requirements. They represent a composite view of the limits currently depicted and are certain to evolve over time. As such, they are merely illustrative of the methodology that could be applied to develop useful standards within an administration.

Also, it must be recognized that results of independent studies of the subject are not entirely consistent and as a result the interpretation of the results by responsible authorities has in the past and will continue in the future to result in differing requirements in different countries.

FIGURE 29

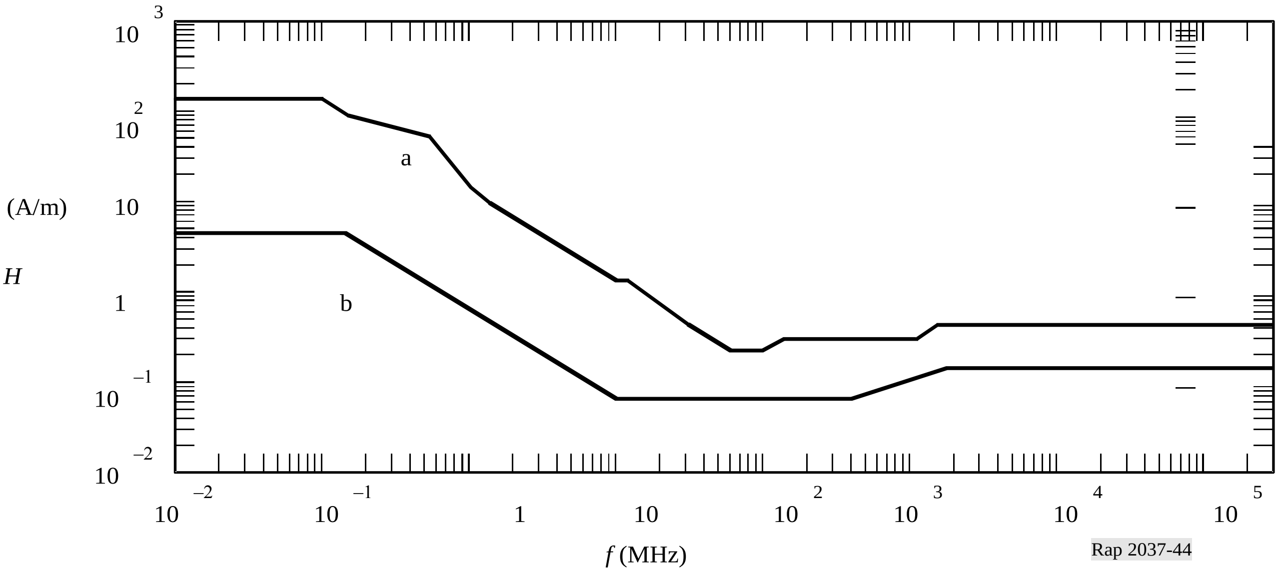
The range of the electrical field strengths derived from the tables given by international and national authorities concerned with the health aspects of EMFs



The curves "a" and "b" represent the upper and lower boundaries respectively of some known, existing recommendations for RF exposures levels (presented in this section, as example). All curves from authorities making such recommendation lie between these boundaries, and any curve between curves "a" and "b" should allow adequate broadcasting services.

FIGURE 30

The range of the magnetic field strengths derived from the tables given by international and national authorities concerned with the health aspects of EMFs



The curves "a" and "b" represent the upper and lower boundaries respectively of some known, existing recommendations for RF exposures levels (presented here, as example). All curves from authorities making such recommendation lie between these boundaries, and any curve between curves "a" and "b" should allow adequate broadcasting services.

The differences between the suggested maximum levels at the same frequency (Figs. 29 and 30) depend on different conditions considered by the various sources suggesting the limits.

3.11 Additional evaluation methods

3.11.1 Dosimetry

The application of dosimetric concepts enables the link to be established between external (i.e. outside the body) field strengths and internal quantities of electric field strength, induced current density and the energy absorption rate in tissues. The development of experimental and numerical dosimetry has been complementary. Both approaches necessitate approximations to the simulation of human exposure; however the development of tissue equivalent materials and minimally disturbing probes in the experimental domain and the use of anatomically realistic models for computational purposes have improved the understanding of the interaction of RF fields with the body.

Whereas current density is the quantity most clearly related to the biological effects at low frequencies, it is the specific energy absorption rate (SAR), which becomes the more significant quantity as frequencies increase towards wavelengths comparable to the human body dimensions.

In most exposure situations the SAR can only be inferred from measured field strengths in the environment using dosimetric models. At frequencies below 100 MHz non-invasive techniques have been used to measure induced current, and in extended uniform fields, external electric field strengths have been related to induced current as a function of frequency. In the body resonance region, exposures of practical significance arise in the reactive near field where coupling of the incident field with the body is difficult to establish owing to non-uniformity of the field and changing alignment between field and body. In addition, localized increases in current density and SAR may arise in parts of the body as a consequence of the restricted geometrical cross-section of the more conductive tissues.

Dosimetric quantities can be calculated by use of suitable numeric procedures and calculational models of the human body. On the other hand such quantities can be measured using suitable physical models (phantoms).

3.11.2 Specific Absorption Rate (SAR) measurement

The Specific Absorption Rate, SAR (W/kg), is the basic limit quantity of most RF exposure regulations and standards. SAR is a measure of the rate of electromagnetic energy dissipated per unit mass of tissue.

The Specific Absorption Rate (SAR) may be specified as the value normalized over the whole body mass (sometimes referred to as the "whole body averaged SAR") or the localized value over a small volume of tissue ("localized SAR").

SAR can be ascertained from the internal quantities in three ways, as indicated by the following equation:

$$\text{SAR} = \frac{\sigma E^2}{\rho} = C_i \frac{\mathrm{d}T}{\mathrm{d}t} = \frac{J^2}{\sigma\rho}$$

where:

- E: value of the internal electric field strength in the body tissue (V m^{-1})
- σ : conductivity of body tissue (S m^{-1})
- ρ : density of body tissue (kg m^{-3})
- C_i : heat capacity of body tissue (J kg^{-1} °C^{-1})
- $\mathrm{d}T/\mathrm{d}t$: time derivative of temperature in body tissue (C s^{-1})
- J: value of the induced current density in the body tissue (A m^2).

The local SAR in an incremental mass (dm) is defined as the time derivative of the incremental absorbed energy (dW) divided by the mass:

$$\text{SAR} = \mathrm{d}/\mathrm{d}t\ (\mathrm{dW}/\mathrm{dm})$$

This quantity value is important from two standpoints; the resulting non-uniform distribution of energy absorption when exposed to a uniform plane wave, and the localized energy absorption arising from non-uniform fields in close proximity to a source of exposure.

Exposure regulations or standards contain derived electric and magnetic field limits. The underlying dosimetric concept assures that compliance with the (external) derived levels will assure compliance with the basic SAR limits. However, external or internal SAR measurements can also be used to show compliance. For partial-body near-field exposure conditions, the external electromagnetic fields may be difficult to measure, or may exceed the derived limits although the local SAR is below the basic limits. In these cases internal SAR measurements in body models have to be conducted. The most important methods to measure SAR will be described below.

3.11.3 Electric field measurement

The SAR is also proportional to the squared RMS electric field strength E (V/m) inside the exposed tissue:

$$\text{SAR} = \sigma E^2/\rho$$

where σ (S/m) is the conductivity and ρ (kg/m^3) is the mass density of the tissue material at the position of interest. Using an isotropic electric field probe, the local SAR inside an irradiated body model can be determined. By moving the probe and repeating the electric field measurements in the whole body or in a part of the body, the SAR distribution and the whole body or partial-body averaged SAR values can be determined. A single electric field measurement takes only a few seconds, which means that three-dimensional SAR distributions can be determined with high spatial resolution and with a reasonable measurement time (typically less than an hour).

3.11.4 Temperature measurement

The SAR is proportional to initial rate of temperature rise $\mathrm{d}T/\mathrm{d}t$ (C/s) in the tissue of an exposed object:

$$\text{SAR} = c\ \Delta T/\Delta t$$

where c is the specific heat capacity of the tissue material (J/kgC). Using certain temperature probes, the local SAR inside an irradiated body model can be determined. One or more probes are used to determine the temperature rise ΔT during a short exposure time Δt (typically less than 30 s to prevent heat transfer). The initial rate of temperature rise is approximated by $\Delta T/\Delta t$, and the local SAR value is calculated for each measurement position. By repeating the temperature measurements in the whole body or in a part of the body, the SAR distribution and the whole-body or partial-body averaged SAR values can be determined.

Three-dimensional SAR-distribution measurements are very time consuming due to the large number of measurement points. To achieve a reasonable measurement time the number of points has to be limited. This means that it is very difficult to measure strongly non-uniform SAR distributions accurately. The accuracy of temperature measurements may also be affected by thermal conduction and convection during measurements, or between measurements.

3.11.5 Calorimetric measurement

The whole-body average SAR can be determined using calorimetric methods. In a normal calorimetric measurement, a full-size or scaled body model at thermal equilibrium is irradiated for a period of time. A calorimeter is then used to measure the heat flow from the body, until the model is at thermal equilibrium again. The obtained total absorbed energy is then divided by the exposure time and the mass of the body model, which gives the whole-body SAR. The calorimetric twin-well technique uses two calorimeters and two identical body models. One of the models is irradiated, and the other one is used as a thermal reference. This means that the measurement can be performed under less well-controlled thermal conditions than a normal calorimetric measurement.

Calorimetric measurements give rather accurate determinations of whole-body SAR, but do not give any information about the internal SAR distribution. To get accurate results a sufficient amount of energy deposition is required. The total time of a measurement, which is determined by the time to reach thermal equilibrium after exposure, may be up to several hours. Partial body SAR can be measured by using partial-body phantoms and small calorimeters.

3.11.6 Body current measurement

Measurement devices for body current may be carried out in two categories:

– Measurement devices for body to ground current.

– Measurement devices for contact current.

3.11.6.1 Induced body currents

Internal body currents are induced in persons occur from partial or whole-body exposure of the body to RF fields in the absence of contact with objects other than the ground.

The two principal techniques used for measuring body currents include clamp-on type (solenoidal) current transformers for measuring current flowing in the limbs, and parallel plate systems that permit the measurement of currents flowing to ground through the feet.

Clamp-on current transformer instruments have been developed that can be worn.

The meter unit is mounted either directly on the transformer or connected through a fibre-optic link to provide a display of the current flowing in a limb around which the current transformer is clamped. Current sensing in these units may be accomplished using either narrow-band techniques, e.g., spectrum analysers or tuned receivers (which offer the advantage of being able to determine the frequency distribution of the induced current in multi-source environments, or broadband techniques using diode detection or thermal conversion.

Instruments have been designed to provide true r.m.s. indications in the presence of multiple frequencies and/or amplitude-modulated waveforms.

The upper frequency response of current transformers is usually limited to about 100 MHz however air cored transformers (as opposed to ferrite-cored), have been used to extend the upper frequency response of these instruments. Whilst air-cored transformers are lighter and therefore useful for longer term measurements, they are significantly less sensitive than ferrite cored devices.

An alternative to the clamp-on device is the parallel plate system. In this instrument, the body current flows through the feet to a conductive top plate, through some form of current sensor mounted between the plates, and thereby to ground. The current flowing between the top and bottom plates may be determined by measuring the RF voltage drop across a low impedance resistor. Alternatively, a small aperture RF current transformer or a vacuum thermocouple may be used to measure the current flowing through the conductor between the two plates.

Instruments with a flat frequency response between 3 kHz and 100 MHz are available.

There are several issues that should be considered when selecting an instrument for measuring induced current.

Firstly, stand-on meters are subject to the influence of electric-field induced displacement currents from fields terminating on the top plate. Investigations have shown that apparent errors arising in the absence of a person are not material to the operation of the meters when a person is present.

Secondly, the sum of both ankle currents measured with clamp-on type metres tends to be slightly greater than the corresponding value indicated with plate type meters. The magnitude of this effect, which is a function the RF frequency and meter geometry, is not likely to be material. Nonetheless, the more accurate method of assessing limb currents is the current transformer. The precise method of measurement may depend upon the requirements of protection guidelines against which compliance assessments are made.

Thirdly, the ability to measure induced currents in limbs under realistic grounding conditions such as found in practice need to be considered. In particular, the differing degree of electrical contact between the ground and bottom plate of the parallel plate system and the actual ground surface may affect the apparent current flowing to ground (Ref.).

Measurements can be made using antennas designed to be equivalent to a person. This enables a standardized approach to be used and permit current measurements to be made without the need for people to be exposed to potentially hazardous currents and fields.

3.11.7 Contact current measurement

The current measurement device has to be inserted between the hand of the person and the conductive object. The measurement technique may consist of a metallic probe (definite contact area) to be held by hand at one end of the probe while the other end is touched to the conductive object. A clamp-on current sensor (current transformer) can be used to measure the contact current which is flowing into the hand in contact with the conductive object.

Alternative methods are:

− the measurement of the potential difference (voltage drop) across a non-inductive resistor (resistance range of 5-10 Ω) connected in series between the object and the metallic probe holding in hand;

− a thermocouple milliammeter placed directly in series.

The wiring connections and the current meter must be set up in such way that interference and errors due to “pick-up” are minimized.

In the case where excessively high currents are expected an electrical network of resistors and capacitors can simulate the body’s equivalent impedance.

3.11.8 Touch voltage measurement

The touch voltage (no-load-voltage) is measured by means of a suitable voltmeter or oscilloscope for the frequency range under consideration. The measurement devices are connected between the conductive object charged by field induced voltage and reference potential (ground). The input impedance of the voltmeter must not be smaller than 10 $k\Omega$.

3.12 Legal consideration

The legal and health aspects connected with the safety for R.F. services are strategic for the project of one transmitting centre. The values of the field strength should be compatible with the security of neighbouring living people and with the house TV set, telephones, and household appliances. Not only the medical aiding equipment but also the pacemaker, hearing aid systems and other personal aids, may suffer from radio-frequencies interference.

The levels indicated in Fig. 29 of § 3.10 are accepted levels to be maintained at the border of the transmission centre land. The above levels are considered suitable for a radioservice and are to be considered valid also for the quality of a radioservice. Consequently, from the above levels one derives the extension of the controlled area and the location of one transmission centre. Naturally, a transmitter centre located inside a city has much more constraints in comparison with a transmitter centre located in the countryside. Each administration or broadcaster may choose the values of the e.m. reference field (Fig. 29), but, if the value is too low: either the radio services do not have the necessary quality (e.g. because the E.R.P. cannot reach the necessary values), or the necessary land extension is too large with consequent high cost for the construction of the transmission centre.

Currently the sensitivity of the people living near the transmitter centres, is very high for possible problems caused by the radio frequency. For legal consideration one clear indication of the perimeter and extension of the controlled area (where the values of e.m.f. are higher or equal to the values of Fig. 29) should be clearly indicated: one fence, one wall or, at least some appropriate signposting, with indication of e.m.f. value, need to be installed.

From urbanization point of view the construction of residential buildings must be forbidden inside the controlled area. The above aspects connected with the e.m.f. must be treated in the same manner as the ambient ecologic, landscape and panorama problems.

Appendix 1
to Part 2

1 Australia

1.1 Digital terrestrial television broadcasting in Australia

Australia is served by an extensive network of PAL-B analogue, and more recently by DVB-T digital, terrestrial television broadcasting transmitting sites. A feature of the transmitter deployments in Australia is that a very large proportion of the population receives signals from a relatively small number of high power "main station" transmitters that have large coverage areas, typically 100-150 km in diameter. Radiated power levels at main station VHF Band III transmitters can be up to 500 kW e.r.p for analogue and up to 100 kW e.r.p. for digital. The radiated power levels at main station UHF Band IV and V transmitters can be up to 2 000 kW e.r.p for analogue and up to 1 250 kW e.r.p. for digital.

As a consequence of the sparse distribution of terrestrial transmitter sites, analogue main station assignments in Australia were generally planned on the basis of noise-limited reception rather than interference limited reception. This has meant that the so-called analogue taboo channels (e.g. adjacent channels, image channels and local-oscillator channels) are usually unencumbered by other (out-of-area) TV signals. Most of the population of Australia has access to five free-to-air analogue TV services.

In introducing digital television, Australia has planned for seven digital television networks in most areas - a digital network for each of the existing analogue networks plus two new digital networks. Australian digital television services commenced in metropolitan regions on 1 January 2001 and subsequently have been progressively deployed in regional areas. The relevant federal government legislation stipulated a simulcast period of eight years. During the simulcast period, existing analogue television transmissions have continued and an additional digital signal has been brought into service. The digital service is required to carry a standard definition (SDTV) digital version of the programmes being provided on the analogue service.

In December 2007 the Australian government changed the simulcast period, announcing that 31 December 2013 will be the date by which the last analogue transmitter will be switched off.

1.2 DTTB System Selection

The first step in the DTV conversion process was a comparative assessment process that led to the selection of DVB-T (8k carrier mode) as the preferred digital television transmission standard and the determination of system planning parameters such as interference protection ratios and minimum required signal levels. The availability of this information permitted the conduct of a preliminary study of possible DTV channel allocations. The conclusions of this preliminary study showed that it would be possible to allocate a complete TV channel (7 MHz wide in Australia at both VHF and UHF) to each existing analogue service to permit its conversion to DTV as well as provide additional channels for new digital-only services.

In 1998 legislation that set the framework for the establishment of DTV services was passed by the Australian Parliament. In that legislation the government determined that each broadcaster would be loaned spectrum to provide a digital service that matched the coverage of the analogue service as closely as possible. Further legislation was also enacted to establish the detail of the regulatory regime to apply to the provision of digital television and datacasting.

1.3 Simulcast of SDTV and HDTV programmes

The Australian government has been committed to ensuring that digital television would be as affordable as possible. Although broadcasters have been required to provide at least a minimum amount of high definition television programming for those who can afford HDTV sets, they have also been required to provide their broadcast in SDTV format. SDTV programming provides viewers with a picture quality that is generally superior to the analogue television service. Currently two additional SDTV digital-only programme streams are transmitted on national broadcaster networks and three more commercial SDTV programme streams could be available from 1 January 2009. The transmission of SDTV format programming not only provides viewers with the ability to access the additional features of digital broadcasting, but also provides consumers with a digital conversion path that is cheaper than the alternative approach of purchasing a HDTV set or a HD set top box.

HDTV is a key feature of digital terrestrial television in Australia. Broadcasters are required to transmit HDTV programmes for a minimum of 1 040 hours per year. The government has not specified any particular technical parameters for HDTV, and broadcasters have been able to adopt and use of theMPEG-2 MP@HL format for transmission (i.e. 576/50p, 720/50p, 1080/50i). However, Australian broadcasters have expressed a preference that programme production and exchange should be based on 1080i line formats.

By requiring both SDTV and HDTV programming, viewers have been given a choice in digital television products but at the same time allowed broadcasters scope to demonstrate the appeal of HDTV.

1.4 Use of Single Frequency Networks (SFNs)

Digital television services have been introduced in Australia, using either a multi-frequency network (MFN) or a single frequency network (SFN) approach. In either case, the digital television service is provided from a network that consists of a high-powered central (or parent) transmitter that may be supported by, or contribute signal to off-air feed, a number of low-powered in-fill or area-extension re-transmitters.

In the MFN case, the re-transmitters operate on a different channel (or channels) from the parent transmitter while, in the SFN case, the re-transmitters may either operate on the same channel as the parent transmitter (if not an off air feed); or on another channel in one or more SFN re-transmission networks, which can be off air feed from the parent[3].

In the later case, the parent transmitter is operated in the MFN mode, albeit with SFN timing information embedded into the signal for use by the SFN re-transmission network(s). In a few cases more than one parent transmitter, together with their re-transmitters operate as an SFN.

1.5 Planning parameters and interference threshold limits

Australia's planning for digital television services takes into account a legislated requirement that "... in SDTV digital mode in that area should achieve the same level of coverage and potential reception quality as is achieved by the transmission of that service in analog mode in the same area". Following this approach, Australia's digital services are typically planned with a maximum e.r.p. of 6 dB less than same band analogue television services.

Planning guidelines in Australia also specify minimum median field strengths (referred to a measurement height of 10 m above local terrain) of 44, 50 and 54 dBμV/m for Band III, IV and V digital television services respectively[4]. To minimise the "cliff-effect", digital television services are planned to achieve the required protection ratio for better than 99% of the time, irrespective of whether the interference is considered to be continuous or tropospheric in nature.

1.6 Comparison of ITU-R and Australian television planning parameters

The following text summarises differences between Australian television planning parameters, including minimum field strengths and protection ratios and the corresponding Recommendation ITU-R BT.1368 parameters for the protection of DVB-T digital television services.

Australian planning for both analogue and digital terrestrial television is based on an assumption of fixed reception using outdoor receiving antennas. Therefore protection ratios relevant to Ricean channels are used where available. The DVB-T mode 64-QAM with 2/3 FEC and a 1/8 guard interval has been adopted as the basis for digital television planning, however to achieve a higher picture quality for the SD/HD simulcast, most broadcasters have selected 64-QAM with 3/4 FEC and 1/16 guard interval.

1.7 Digital television minimum median field strengths

Australian digital television planning is based on provision of minimum median field strength levels of 44, 50 and 54 dBμV/m in Bands III, IV and V respectively. These values are reasonably close to the values that can be derived from the sample calculation value provided in Table 44 of Recommendation ITU-R

[3] In a limited number of cases a parent station may feed several SFNs that may each operate on a different channel.

[4] Refer http://www.acma.gov.au/WEB/STANDARD/pc=PC_91853.

BT.1368-7[5]. The Australian values are, respectively, 0.1, 0.9 or 2.8 dB higher than values that would be derived from the Recommendation. The differences are due to: inclusion of a 1 dB higher receiver noise figure allowance in Bands III and V; use of 6.7 rather than 7.6 MHz for the receiver bandwidth; inclusion of a 1 dB allowance for man-made noise in VHF Band III; different combinations of antenna gain/feeder loss in Bands III and IV; and, use of frequencies at the top rather than the middle of each band as the reference frequency for the calculation. The Australian minimum field strength calculations also include a 1 dB 'Interference Margin' for the support of co-channel, frequency re-use planning.

1.8 Digital television protection ratios

Protection ratios for digital-digital and digital-analogue co-channel and adjacent channel interference from other television broadcasting services were first defined in July 1999. Only minor changes have been made to those original values. The values used in Australian planning are the same as the 64-QAM, 2/3 FEC values set out in Recommendation ITU-R BT.1368-7[6].

The relevant protection ratios are not to be exceeded for more than 1% of the time. That is, the E(50,1) value is used for the interfering field strength.

2 Brazil

The digital terrestrial television broadcasting channel planning and the deployment of the DTTB in Brazil.

2.1 Introduction

This chapter presents the work that has been conducted by the National Telecommunications Agency (Agência Nacional de Telecomunicações - Anatel) related to channel planning regarding the introduction of the Digital Terrestrial Television Broadcasting (DTTB) in Brazil and the stages for its deployment. The text consolidates three contributions (RGQ11-1/2/93-E, 95-E and 185-E) submitted by the Brazilian Administration to the Rapporteur's Group on Question 11-1/2 during the meetings held on September 8th 2003 and May 31st 2004, both in Geneva. The Rapporteur´s Group Meeting of September 2003 "proposed that the contributions of Brazil should be documented on the ITU Web site as a case study on the introduction of digital terrestrial TV broadcasting"(2/REP/012-E). This proposal was approved in the Plenary Session of the Study Group 2 on September 11th 2003. As a result of these decisions, this Annex presents the methodology, the results and the current work Anatel is undertaking on the completion of the DTTB channel planning. In addition, it is important to observe that the country's channel planning is not related to any specific DTTB standard, since it contemplates the particularities of each existing DTTB standards.

2.2 Methodology applied for digital terrestrial television channel planning and its respective results

This section describes the methodology applied by Brazil to prepare its channel planning for the deployment of the DTTB in the country and its results. The applied methodology is independent of the DTTB standard adopted. A working group under the coordination of Anatel and representatives from the Brazilian TV networks has been working on digital terrestrial television channel planning since 1999.

2.2.1 Digital television channel planning strategy

When it comes to coverage, Brazilian TV networks present quite different characteristics among themselves. They can be either regional networks or national networks, which encompass regional networks, or eventually independent full TV station with strict local penetration. Figure 31 indicates the distribution of full TV stations (in stars) and relay stations (in circles) of a particular Brazilian network with distributed generation and national penetration.

The preparation of the Basic Plan for DTTB began in September 1999. Since then, specific premises have been

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5 Australian planning is based on provision of a service at 80% of locations within 200 m by 200 m areas. A 4.5 dB correction factor is applied to convert from a 50% of locations to an 80% locations field strength value.

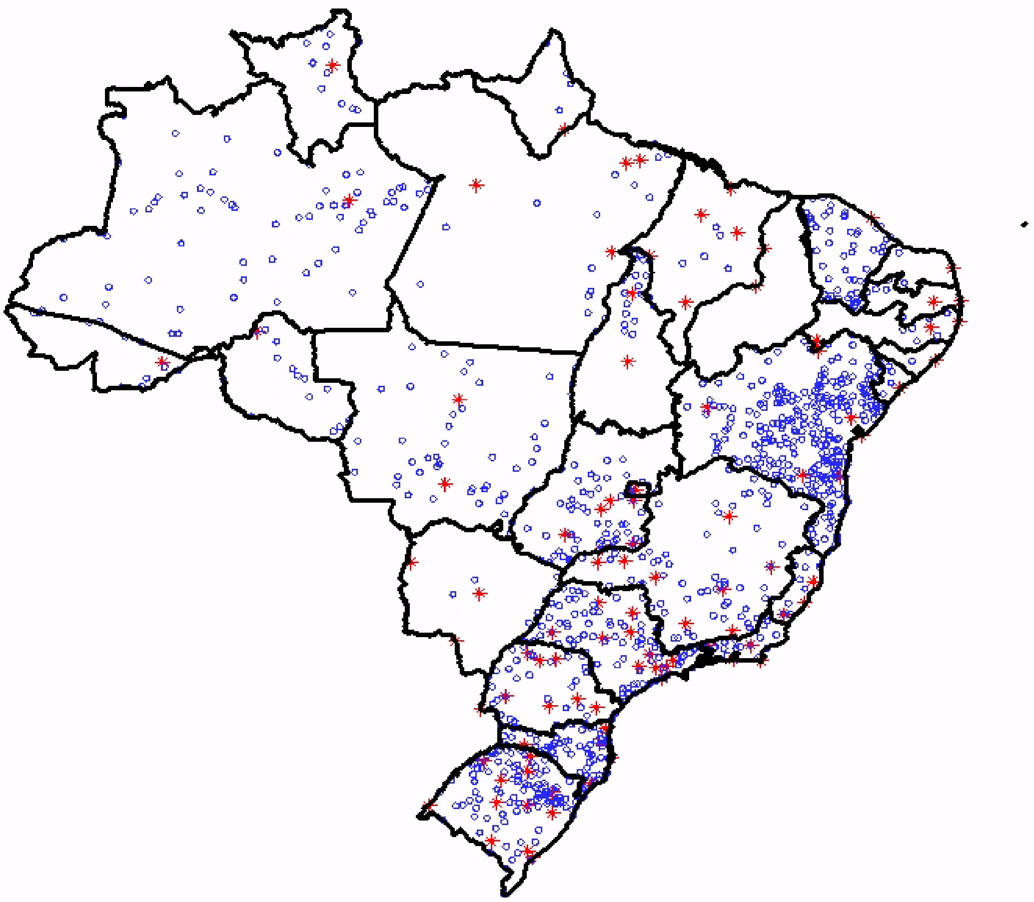
6 The original 1999 values were adopted following protection ratio measurements made in 1998 using the "traditional" wanted-to-wanted protection ratio measurement approach, rather than the more recent *C*/(*I*+*N*) approach that appeared in Recommendation ITU-R BT.1368-1 (and later revisions).

established. They are as follows:

– digital television will replace existing analogue TV by using UHF (channels 14 to 69) frequency bands;
– the main objective of channel planning is to assure that digital television stations will have service areas similar to their corresponding analogue stations service areas;
– during the initial stage called the 'transition period', analogue and digital channels will perform simultaneous broadcast (simulcasting);
– digital television planning will be carried out in three phases: "Phase 1" only for those cities where active full TV stations are in place and, in a later stage; "Phase 2" for those cities whose population is over one hundred thousand inhabitants with only television relay stations; and "Phase 3" for others cities with television relay stations;
– whenever is possible, digital stations will have to operate on the maximum power of its class[7].

FIGURE 31

Network with distributed generation and national penetration (Phases 1 and 2)



[7] Brazilian TV Stations are classified into Special, A, B or C Class according to the ERP (Effective Radiated Power) that they are authorized to transmit by Anatel. The ERP limits for each class are defined in the national technical regulation for television broadcasting.

Because of the preparation for the Basic Plan for Digital Television Channel Distribution (PBTVD[8]), Anatel has suspended, from October 1999 to April 2005, allocation of new analogue channels, and changes of the technical characteristics in the existing channels in regions of Brazil under heavy spectrum usage. From February 2002 to April 2005, the same policy was applied to the remaining regions. After the publication of the PBTVD, item 1.3.3, Anatel resumed activities on the analogue channels allotment plan, proceeding with the inclusion of new analogue channels. It's important to observe that PBTVD will continue to use the frequency band currently allocated to analogue transmission.

2.2.2 Phases of digital television channel planning

The channel plan studies were divided in three phases. The first phase focused on making digital channels available to broadcast simultaneously with a specific and already existing analogue channels, those authorized to provide television service on municipalities where at least one generator station covers.

The second phase focused on the availability of digital channels for simulcasting in municipalities with population above one hundred thousand inhabitants and that are covered only by relay stations. This phase also included a review of the first phase, in order to meet the demand in all municipalities to which authorizations to install new television operating networks were granted after the beginning of the first phase.

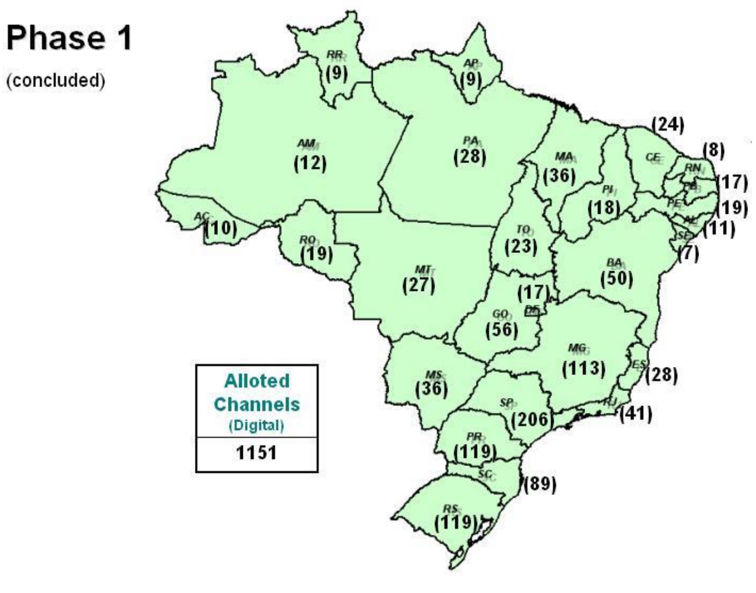
In the year of 2006, Brazilian government initiated the third phase of digital channel planning studies. This phase deadline is June 2011. It includes the allotment of digital channels for the relay stations on the remaining cities and a digital channel revision on the previous phases allotment plan.

2.2.3 Channel planning results

The first phase, concluded in September 2002, made available 1 151 digital channels in 164 municipalities, as presented in Fig. 32.

FIGURE 32

Digital channels available after Phase 1



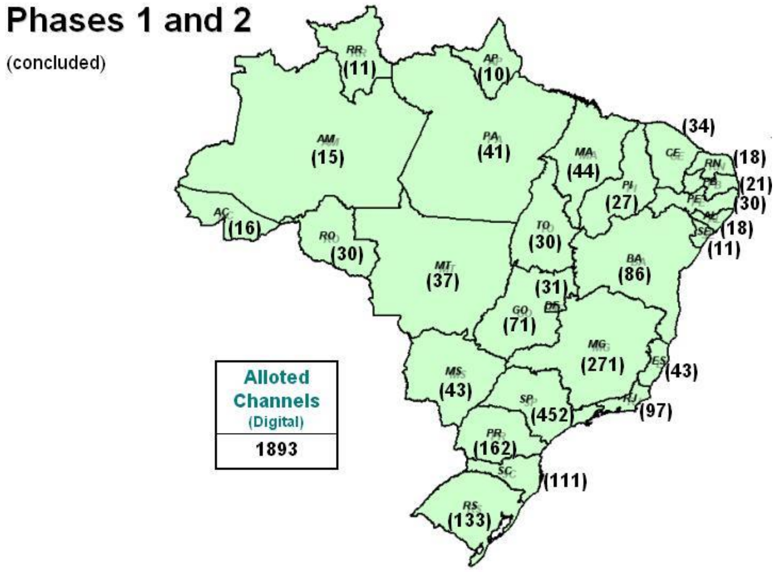
The second phase, concluded in March 2003, made further allocation of 742 digital channels in 132 municipalities. As a result of the conclusion of both Phases 1 and 2, 1893 channels were made available for the introduction of Digital Terrestrial Television Broadcasting (DTTB) in Brazil as presented in Fig. 33.

8 Basic Plan for Digital Television Channel Distribution (PBTVD) is the official name designated for the Digital Television Allotment Plan in Brazil.

FIGURE 33

Results obtained after the conclusion of Phase 2

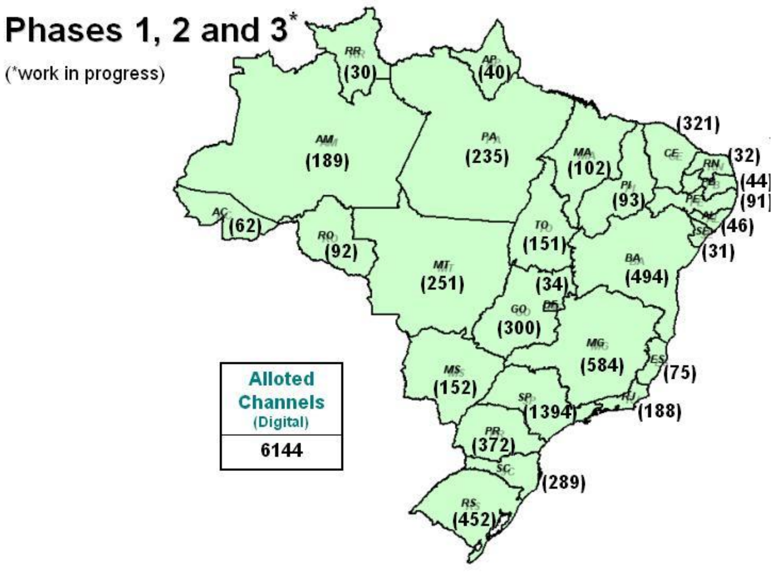
Digital channels



After the conclusion of the third phase, which is currently in progress, it's planned 6 144 digital channels in Brazil, as presented in Fig. 34.

FIGURE 34

Digital channels allotted after the conclusion of Phase 3



The Basic Plan for Digital Television Channel Distribution (PBTVD) has been successful in assuring that the service areas of digital television stations is similar to its related analogue stations. The PBTVD encompasses 296 Brazilian municipalities, whose total population is approximately 110 million inhabitants. These municipalities are either covered by a generator television station service or their population is over one hundred thousand inhabitants and there is, at least, one operating relay station in the city. Only in service analogue channels were taken into account for the channel planning. Therefore, up to August 2008,
2 157 digital channels have been made available by the National Telecommunications Agency (Agência

Nacional de Telecomunicações - Anatel) and there will be more than 6 100 digital channels in Brazil until 2013. Thus, more than 12 200 channels, analogue or digital, will be available during the "simulcast" period from 2013 to 2016.

2.3 Legislation and Regulatory adjustments for the deployment of Digital TV in Brazil

In order to deploy the Brazilian System of Digital TV (SBTVD), adjustments to the legislation and to the regulatory framework were needed. This process had five important stages, as listed below.

2.3.1 Stage 1: Creation of the Brazilian System of Digital Television (SBTVD)

The first stage: the creation of the Brazilian System of Digital TV (SBTVD), was initiated by the Decree 4.901, of 26 of November of 2003, which:

- Established the aims of the Brazilian System of Digital Television (SBTVD).
- Created the Development Committee of the SBTVD with the scope of studying and elaborating a report[9] with proposals for:
  1. The definition of the reference model for the Brazilian system of digital television.
  2. The standard of television to be adopted in the Country.
  3. The form of exploitation of the digital television service
  4. The period and framework of the transition from analogue to digital system.
- Created an Advisory Committee and a Steering Group, which jointly compose the SBTVD, along with the Development Committee.

2.3.2 Stage 2: Digital Technology updates in regulatory documentation

The Stage 2, which was based on digital technology updates in the regulatory framework, was approved by Anatel Resolution N. 398, on April 7th 2005[10]. This Regulatory document presents technical aspects of sounds and images broadcasting and television retransmission, with the purpose of:

- Ensuring the quality of the signal in the coverage area.
- Preventing harmful interferences over currently authorized, and already installed, telecommunication stations.
- Establishing the technical criteria of viability projects designing, especially those regarding to inclusions in channel allotment plans, and modifications on technical installations.

The revision of the technical regulation for television broadcasting also included the procedure for calculation of viability involving channels of Digital TV[11] and the adoption of Recommendation UIT-R P.1546[12].

2.3.3 Stage 3: Creation of Basic Plan for Digital Channel Distribution (PBTVD)

The Stage 3 startup occurred with the publication of Anatel Resolution 407, on June 10th 2005[13]. This document approved the Brazilian Digital Television Channel Allotment Plan, officially named as Basic Plan for Digital Channel Distribution - PBTVD[14], referred to in item 1.2.3, Fig. 33. It also allocated, considering the guidelines discussed on item 1.2.1, 1893 digital television channels in 306 localities. In sum, in 2005, the Basic Plan of Distribution of Television Channels (PBTV) contained a total of 473 generator TV stations (analogue stations), 9845 relay TV stations and 1207 stations in cities where its populations is more than one hundred thousand inhabitants

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[9] http://sbtvd.cpqd.com.br/cmp_tvdigital/divulgacao/anexos/76_146_Modelo_Ref_PD301236A0002A_RT_08_A.pdf

[10] http://www.anatel.gov.br/Portal/documentos/biblioteca/resolucao/2005/res_398_2005.pdf

[11] http://www.anatel.gov.br/Portal/documentos/biblioteca/resolucao/2005/anexo_res_398_2005.pdf

[12] http://www.anatel.gov.br/Portal/documentos/biblioteca/resolucao/2005/anexoii_res_398_2005.pdf.

[13] http://www.anatel.gov.br/Portal/documentos/biblioteca/resolucao/2005/res_407_2005.pdf

[14] http://www.anatel.gov.br/Portal/documentos/biblioteca/resolucao/2005/anexo_res_407_2005.pdf

2.3.4 Stage 4: Definition of the Digital Terrestrial Television system and the transition period guidelines

The Stage 4 started with the Decree No 5,820, on June 29th 2006[15], defining that the SBTVD-T would adopt, as a base, the standard of signals designed by ISDB-T (Integrated Services Digital Broadcasting), also incorporating the technological innovations approved by the Development Committee. Beyond those definitions, the document presented the guidelines for the transition period from analogue to digital TV. The Decree also laid down the following points:

- Creation of the SBTVD Forum[16];
- Made possible:
  - Simultaneous fixed, mobile and portable transmission.
  - Interactivity.
  - High Definition (HDTV) and Standard Definition Television (SDTV).
- Defined the consignation of one digital channel for each existing analogue channel, regarding the transition period. The preference is for the digital channel allocation in the UHF band (channels 14 - 59), rather than in the VHF band - high (channels 7 - 13).
- Deployment sequence, first starting with the TV stations.
- Established that, after signing the assignment contract, the installation projects must be submitted by the broadcasting companies to the Ministry of Communications within 6 months. Afterwards, the digital transmissions should start within 18 months.
- Defined that, after July 1st 2013, only digital technology television channels will be granted by the Ministry of Communication for television broadcasting.
- Defined the date of June 29th 2016 as the switch-off date of analogue transmission.

Creation of 4 (four) digital public channels for the national Government.

2.3.5 Stage 5: Establishment of conditions for assignment contract of the additional channel for the digital and analogue simultaneous transmission

The Ministry of Communication (MC) ordinance Nº 652[17], which has been published on the 10th of October, 2006, initiated Stage 5 by establishing the assignment contract conditions for the additional channel, which shall be used during the digital and analogue simultaneous transmission period (Simulcast). It has also included the schedule for the transition, as defined below:

- The assignment contract will observe the PBTVD.
- The digital channel will have to:

  I Provide the same coverage as its analogue counterpart;

  II Provide efficient management of the analogue and digital transmissions;

  III Prevent interferences.

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15 http://www.planalto.gov.br/ccivil/_Ato2004-2006/2006/Decreto/D5820.htm

16 http://www.forumsbtvd.org.br

17 http://www.mc.gov.br/sites/600/695/00001879.pdf.

FIGURE 35

Transition period in Brazil (analogue to digital television)

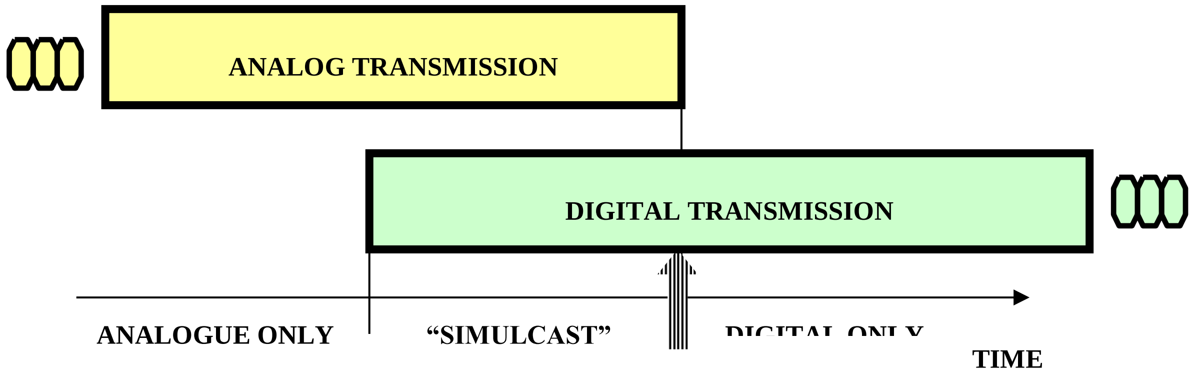

Table 7 presents the planning phases for assignment contracts of additional channels and the schedule for their commercial deployment.[18]

TABLE 7

Schedule for the assignment contract and commercial deployment of Digital TV

Phase of planning (Item 1.2.3)	**Station TV type**	**Cities (Group)**	**Assignment contract schedule**	**Commercial deployment schedule**
Phase 1	TV stations	São Paulo (SP)	Up to 12/29/2006	12/29/2007
Phase 1	TV stations	Belo Horizonte, Brasília, Rio de Janeiro, Salvador e Fortaleza (G1)	Up to 11/30/2007	Up to 01/31/2010
Phase 1	TV stations	Belém, Curitiba, Goiânia, Manaus, Porto Alegre e Recife (G2)	Up to 03/31/2008	Up to 05/31/2010
Phase 1	TV stations	Campo Grande, Cuiabá, João Pessoa, Maceió, Natal, São Luis e Teresina (G3)	Up to 07/31/2008	Up to 09/31/2010
Phase 1	TV stations	Aracaju, Boa Vista, Florianópolis, Macapá, Palmas, Porto Velho, Rio Branco e Vitória (G4)	Up to 11/30/2008	Up to 01/31/2011
Phase 1	TV stations	Other Cities with TV Stations (G5)	Up to 03/31/2009	Up to 05/31/2011
Phase 2	Relay stations	Cities of the Groups SP, G1, G2, G3, G4 (Capitals and Federal District)	Up to 04/30/2009	Up to 06/31/2011
Phases 2 and 3	Relay stations	Other Cities with Relay Stations	Up to 04/30/2011	Up to 06/30/2013

According to the plan, migration priority is given to generator TV stations and, later, to the relay stations located in Capitals and the Federal District. The signing of assignment contracts by relay station operators in the remaining cities will take place at the last stage.

After the assignment contract is signed, the TV Broadcaster may start to test and then commercially deploys the system.

2.4 The Brazilian Digital Television System (SBTVD) Forum

After the release of Presidential Decree 5,820, the role of private organizations in the development of DTT was intensified, mainly because of the SBTVD Forum.

The Forum is a nonprofit entity, whose main objectives are supporting and fostering the development and implementation of best practices to the Brazilian digital television broadcasting success. The most important participants of broadcasting, reception-and-transmission-equipment-manufacturing, and software industries are part of this Forum.

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18 http://www.forumsbtvd.org.br/cronograma.php.

The Forum's main tasks are: to identify and harmonize the system's requirements; to define and manage the technical specifications; to promote and coordinate technical cooperation among television broadcasters, transmission-and-reception-equipment manufacturers, the software industry, and research-and-education institutions; to propose solutions to matters related to intellectual property aspects of the Brazilian DTT system; to propose and develop solutions to matters related to the development of human resources; and to support and promote the Brazilian standard in the country and overseas.

Besides the private sector, federal government representatives also participate in the Forum. And such participation is considered very important, since it allows those representatives to closely follow the discussions taking place, while strengthening the relationship between forum members and public regulators.

2.4.1 Objectives

The Forum of Brazil's Terrestrial Digital TV Broadcasting System was formally instated in December 2006. The Forum's mission is to help and encourage the installation or improvement of the digital sound and image transmission and receiving system in Brazil, promoting standards and quality that meet the demands of the users.

The purpose of this Forum is to propose voluntary or mandatory technical norms, standards, and regulations for Brazil's terrestrial digital television broadcasting system, and, in addition, to promote representation, relations, and integration with other national and international institutions.

2.4.2 Structure and Composition

There are three membership categories: Full Members, Effective Members, and Observers. The full members, who have the right to vote and the obligation to pay annual dues, belong to the following sectors:

a) Broadcasting stations.

b) Manufacturers of receiver or transmitter equipment.

c) Software industry.

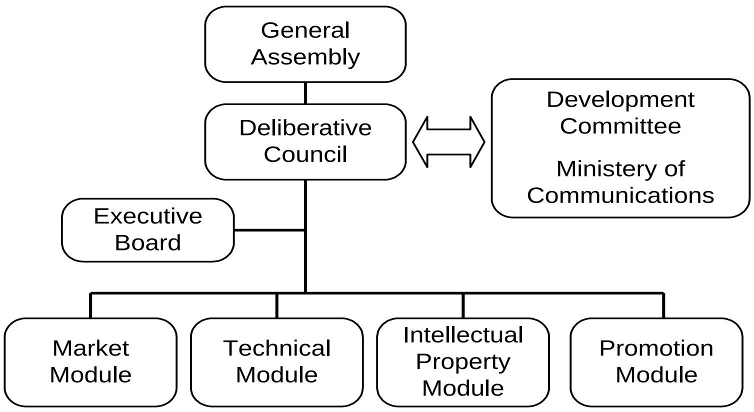
d) Teaching and research institutions that carry out activities directly involving Brazil's digital TV system.

Effective members come from sectors that are different from those mentioned previously, but they must also pay annual dues. The observer members are those who, when formally invited by the Council, accept to enter the Forum, without any voting rights and without the obligation to pay annual dues.

The Deliberative Council is comprised of 13 councilor members elected by the General Assembly. The Council shall be able to draw up general policies of action, strategies, and priorities, adopt the results of the work, and refer them to the Development Committee of the Federal Government.

FIGURE 36

Brazilian digital TV Forum



2.4.3 Modules Assignments

The Forum is comprised of four modules that address different aspects of the Digital TV implementation effort.

2.4.3.1 Market Module

The market module must identify the needs, wishes, and opportunities of the market, defining functional requirements, time limits for availability, and costs, and coordinating the relationship between the various sectors represented in the Forum.

This module checks conformity with the technical specifications and requirements that are drawn up and analyzes and proposes solutions to issues related to planning the implementation of terrestrial digital television.

2.4.3.2 Technical Module

The technical module coordinates the efforts relative to the technical specifications of Brazil's digital TV system and research and development activities, identifies specification needs, and defines the availability of technical solutions referring to the generation, distribution, and receiving of the digital TV system, including high definition, standard definition, mobility, portability, data services, interactivity, content protection, and conditional access.

This module also coordinates the efforts to harmonize technical specifications with other national and international institutions.

2.4.3.3 Intellectual Property Module

The intellectual property module must coordinate efforts in the search of solutions regarding intellectual property, drawing up policies and practices to be adopted among the members and proposing the legal approach to these issues to the competent institutions.

This module also helps and monitors the negotiation of royalties linked to the incorporation of technologies along with their holders and informs the council about the costs involved in the techniques being adopted or incorporated.

2.4.3.4 Promotion Module

The promotion module coordinates efforts to promote, distribute, and disseminate Brazil's system. This module must promote seminars and courses; publish newspapers, bulletins, and other carriers of information. The Promotion Module is also responsible for organizing the common activities of broadcasters and industries aimed at increasing the awareness about the advantages of the Digital TV system.

2.4.4 Outline of the Technical Standards

Standardization activities, performed by the Technical Module, are divided among eight subgroups of specialist volunteer members, which work in the sectors of the broadcasters, consumer electronics, transmitters and software industries and universities. The working groups are organized as in Fig. 37.

The standards for the digital terrestrial television, showed in the Fig. 37, are listed below:[19]

- ABNT NBR 15601:2007 – Transmission system
- ABNT NBR 15602:2007 – Video coding, audio coding and multiplexing
- ABNT NBR 15603:2007 – Multiplexing and service information (SI)
- ABNT NBR 15604:2007 – Receivers
- ABNT NBR 15605:2007 – Security issues (under approval)
- ABNT NBR 15606:2007 – Data coding and transmission specification (partial)
- ABNT NBR 15607:2007 – Interactive channel (partial)
- ABNT NBR 15608:2007 – Operational guidelines
- ABNT NBR 15609:2007 – Middleware test suit (internal working document)
- ABNT NBR 15610:2007 – Tests for receivers (internal working document).

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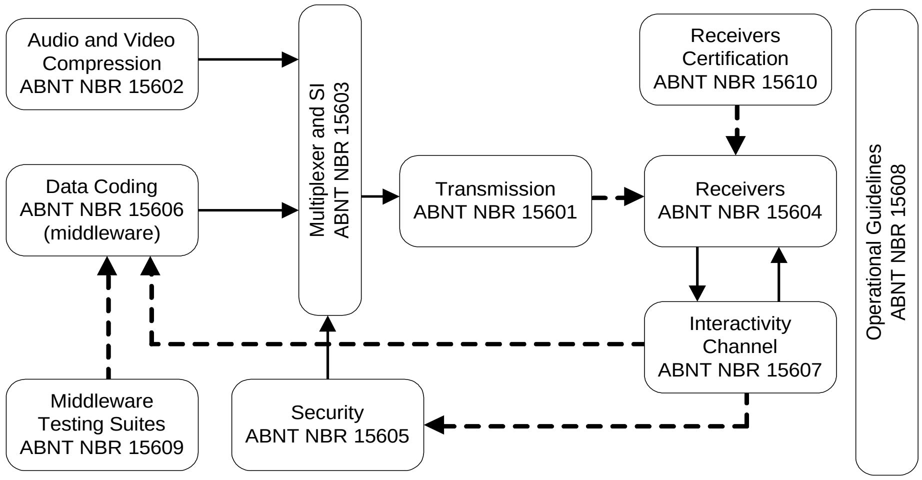
[19] http://www.abnt.org.br/tvdigital/TVDIGITAL.html

FIGURE 37

Brazilian standardization structure



2.5 Current Status of the DTT deployment

On December 2nd, 2007, the first official implementations of the Brazilian DTT system began commercial operations in the city of São Paulo and, by mid-2008, there were already 10 commercial broadcasters operating in this city. Although tests were already being conducted since May, 2007, the government chose the December date as the official date of the system launch.

According to the schedule established by the government, all analog TV broadcasters must also be transmitting digital until 2013. Furthermore, the switch-off of the analog systems is schedule to take place in 2016.However, in 2008, the actual deployment of DTT transmissions in Brazil was moving ahead of the schedule. Stimulated by the increasing interest in the new technology, many broadcasters have been investing earlier than required by law and have been starting digital transmissions sooner than expected. The accelerated implementation was also due to the tax-reduction incentives offered by the government, and to the new applications made possible by the DTT system, such as portable reception.

In the first six months after the official commercial launch, DTT transmissions in Brazil is a reality in São Paulo, Rio de Janeiro, Belo Horizonte and Goiânia, and 10 other cities were scheduled to get digital broadcasting yet in 2008. By the third quarter of this year, DTT signals already covered over 21 million people, and were expected to reach 30 major cities and state capitals by the end of 2009.

The robustness of DTT signals, as well as the superior video and audio quality provided by the technology, represents a big step forward in the technical quality on content access of lower income population. The market penetration of television devices in Brazil and its close relationship with the general population are clues to enable us to devise the huge market that DTT will offer in the next few years.

2.5.1 DTT market in 2008

In the third quarter of 2008, there were already over 30 different DTT receivers available in the market, with functionalities and designs aimed to different economic segments and user preferences. Among those models, there could be found portable reception devices (1-Seg), including portable TVs, computer USB tuners and cell phones. For fixed reception, consumers could choose between standard definition and high definition devices, although all broadcasters have been transmitting in high definition (1080i). There were already over 50 h a week of original HDTV programming, and a growing demand from viewers.

Since the commercial start of DTT in Brazil, consumers were able to see a significant fall in the prices of reception devices, with the proliferation of additional manufacturers and models. As an example, by the third quarter of 2008, portable one-seg receivers for computers could be found for prices around US$ 100, while high-definition fixed-reception set-top devices could be found in the US$ 180 to US$ 300 price range. It was not unusual to find special offers to lower income consumers that split the price of the receiver in up to 12 monthly payments.

By that same time, the industry had already provided many solutions for the high-end DTT market, such as full-HD displays with integrated digital tuners. Many manufacturers offered displays with integrated receivers, with sizes ranging from 32 to 52 inches, for a price to the consumer starting at around US$ 1.500.

Since the beginning of transmissions, market prices for DTT receivers have been falling gradually, as the market moves from the early adopters to the ordinary consumers. That expected movement has been regarded by broadcasters and industry as proof of the successful introduction of DTT. It's a trend that is expected to intensify with the beginning of transmissions in other cities. As of mid-2008, manufacturers have been preparing for Christmas, when a surge in demand for reception devices is expected. The general expectations are that the demand for DTT receivers and integrated TVs will grow steadily over the following years.

2.6 Conclusion

The opinion of the majority of the concerned entities is that the introduction of digital TV in Brazil has been very successful. The better images and sound quality, the portable TV with in-band "one-seg" technology, the future interactivity with the user and the digital convergence are the most evident benefits of the new technology. Nonetheless, keeping terrestrial television a free and open service, providing ways for the social inclusion of a growing number of citizens, as well as offering them an important mean of entertainment, education and cultural integration, at local, regional, and national levels, are not less important objectives for system that has been prepared to serve a vast country such as Brazil, both in territorial and demographic senses.

One of the first steps on the transition process was the development of the Digital Television Channel Plan, that has been conducted by the National Telecommunications Agency (Agência Nacional de Telecomunicações - Anatel) since 1999. At the end of the channel planning process, not later than 2013, it is expected that more than 6 100 digital channels have been assigned. In the full "simulcast" period, from 2013 to 2016, more than 12 200 analogue and digital channels are supposed to be in operation. This fact illustrates the magnitude of the task that has been assigned to Anatel, and that has been so far successfully executed by the Agency.

An important cornerstone of the successful introduction of the digital terrestrial TV in Brazil was the creation of the Brazilian Digital Television System Forum, or SBTVD Forum, in 2006. The Forum, whose members are TV network operators, equipment manufacturers, the software industry, education and research institutions, plus some other invited institutions and individuals, has had an important role in supporting and fostering the development and implementation of digital television in the country. It is also responsible for defining the best practices for the deployment of the system. By working close with the Japanese experts on the ISDB-T standards, the Forum has created a vast knowledge base about the implementation of DTT, and has contributed to the formation of a large number of professionals with competence on the subject.

3 Bulgaria

With due consideration of the complexity and far reaching consequencies of the transition from analogue to digital, relevant Strategic Plan for Introduction of Terrestrial TV Broadcasting (DVB-T) in the Republic of Bulgaria has been elaborated and approved at session of the Council of Ministers of 31 January 2008 (Reference: Protocol No 5 by decision on Agenda item 24). Its main considerations and key aspects are provided herewith.

3.1 Background of country TV broadcasting market

3.1.1 TV Programme licences

As of January 2008, a total of 203 TV programmes have been licensed for delivery to the population of this country by cable television, terrestrial broadcasting and via satellite.

3.1.1.1 The terrestrial broadcasting component ensures analogue delivery of the total of seven TV programmes as follows:

a) Three nation-wide TV programmes, namely:

– “**Channel 1**” of the Bulgarian National Television (BNT) with population coverage of 98,3% achieved by 677 high power main transmitters, relay transmitters and low power fill-in transmitting stations in Frequency Bands II, III, IV and V;
– “**bTV**” with population coverage of 97% achieved by 676 high power main transmitters, relay transmitters and low power fill-in stations in Frequency Bands III, IV and V; and
– “**Nova**” exceeding 70% population coverage achieved by total of 143 transmitters, with comparatively lesser number of high power main transmitters and with a growing network of relay transmitters and low power fill-in transmitting stations, all operating in Frequency Bands IV and V.

b) In addition there are four regional TV programmes licensed to be on air in the towns of Blagoevgrad, Plovdiv, Russe and Varna.

3.1.1.2 Remaining 196 licenses are issued for TV programme delivery via cable or satellite.

3.1.2 Public/Commercial/Temporary licensed operators

Seventeen licenses are issued to public broadcasting operators and 169 licenses to commercial broadcasting operators totalling 186 regular licenses. Furthermore, the said regular licenses are supplemented by additional 42 specific licenses (temporary in nature but still in force) for terrestrial analogue broadcasting.

3.1.3 Cable/Satellite/Terrestrial delivery

It is estimated that predominantly around 63% of the country population is served by cable network delivery, 7% of the population by satellite and about 30% of the population receives TV programming via terrestrial broadcasting channels. While every country town is served via cable TV network delivery only about 28% of the villages of this country are served by cable TV. It is expected that cable TV network delivery would reach its saturation limit at 75% of the population coverage.

The country population having access to terrestrial TV broadcasting only is estimated to be within 10 to 11% range.

3.1.4 Digital terrestrial TV broadcasting

Only one digital terrestrial TV broadcasting operator has been licensed to serve the area of Sofia City since 2004.

3.2 Purpose and mission of the analogue to digital terrestrial TV transition

The said Plan for introduction of digital terrestrial broadcasting aims not only at retaining the number of users who, in spite of having access to cable, terrestrial and satellite delivery, have already chosen to use analogue terrestrial delivery, but also has set the target of increasing the number of digital terrestrial delivery users in nearest future. Indeed the Plan has the objective of creating an enabling competitive environment thus effectively preventing the monopolistic cable and satellite delivery operators’ grasp at the market.

Towards this end, the digital terrestrial broadcasting shall be deployed under certain conditions as follows:

– free of charge delivery to users (not more than one encrypted programme per multiplex be permitted);
– initial number of programmes delivered shall be not less than 15;
– programmes delivered be composed of an attractive-to-viewers blend of national, regional and local origin;
– HDTV programme delivery license applications be allowed by 2011;
– better quality and offer of additional/interactive e-services and applications, in consistency with Directives 2002/21/EC (Framework Directive) and 2002/19/EC (Access Directive) of the European Parliament and the Council of 7 March 2002; and
– mobile outdoor reception predominantly for cars and portable reception inside of buildings expected to be used for the purpose of second and third household receivers.

The said Transition Plan has defined the strategic aspects of:

– population coverage objectives and criteria;
– Multiple Frequency Network (MFN) approach dedicated only to nation-wide coverage, while Single Frequency Network (SFN) approach will be applied explicitly to allotment zones;
– initial build-up of SFN network broadcast coverage of densely populated towns and areas (Island Coverage) within any allotment zone followed by further gradual network extension until the entire allotment zone coverage has been achieved;
– optimization of number of multiplexes within allotment zones;
– granting license or temporary permission to any new analogue terrestrial broadcasting operator applicant will be severely restricted;
– parallel broadcasting of both the analogue and the digital (simulcast) being limited to one year duration upon the expiry of which the concerned analogue broadcasting license/s will be terminated. Thus the reuse of liberated spectrum of analogue broadcasting is provided for further build-up of digital terrestrial TV broadcasting networks as per the Plan;
– establishing criteria for switch-off of analogue TV broadcasting, but not later than end 2012;
– nation-wide coverage by digital terrestrial broadcasting to be completed in all zones by end 2015;
– factual digital dividend definition; and
– timely supply of Set Top Boxes (STB) to the population at affordable prices and risks involved.

3.3 Impact of the digital terrestrial broadcasting Plan of RRC-06 and GE 06 Agreement

RRC-06 and GE 06 Agreement guarantee to the Bulgarian Administration to have at its disposal and use at its discretion 10 nation-wide networks for terrestrial digital TV broadcasting, supplemented by 34 regional networks and by 23 networks dedicated to the regions of Sofia and Varna.

3.4 Transition to digital terrestrial TV broadcasting

The said transition will be executed into two phases as follows:

3.4.1 First phase-start of the transition

3.4.1.1 Three nation-wide digital terrestrial TV networks

Three nation wide MFN/SFN networks, all DVB-T, will be licensed to operators for deployment in allotment zones of Burgas, Plovdiv, Ruse, Sofia, Stara Zagora, Varna and Vidin by June 2008.

Licensed operators shall start “Island Coverage” broadcast within said allotment zones as from January 2009 and they must achieve at least 75% population coverage within said allotment zones by December 2012.

Exactly one year later, after the simulcast expiry, new licenses will be granted to operators with obligation to start “Island Coverage” broadcast within allotment zones of Blagoevgrad, Kurdzhali, Pleven, Smolyan and Shumen and they must achieve at least 75% population coverage by December 2011.

Furthermore, relevant licensees must ensure full population coverage inclusively for the above-mentioned twelve allotment zones by December 2012.

3.4.1.2 Twelve regional digital terrestrial TV networks

Twelve regional SFN networks will be licensed to operators within allotment zones of Burgas, Plovdiv, Sofia and Varna (three SFN networks each) by June 2008. Licensees shall start “Island Coverage” broadcast within said allotment zones by January 2009 followed by ensuring of full population coverage for the said four allotment zones by January 2010.

3.4.2 Second phase of the transition

3.4.2.1 Additional three nation-wide digital terrestrial TV networks

Furthermore, three nation-wide MFN/SFN networks, two of them DVB-T plus one DVB-H, will be licensed to operators for deployment in the allotment zones of Burgas, Plovdiv, Ruse, Sofia, Stara Zagora, Varna and Vidin by July 2010.

Licensed operators shall start “Island Coverage” broadcast within said allotment zones as from January 2011 and they must ensure at least 75% population coverage of said allotment zones by December 2013.

Exactly one year later, after the simulcast expiry, new licenses will be granted to operators by July 2011 with obligations to start “Island Coverage” broadcast within the allotment zones of Blagoevgrad, Kurdzhali, Pleven, Smolyan by January 2012, being followed by obligations to ensure at least 75% population coverage by July 2014.

Furthermore, relevant licensees must ensure full population coverage inclusively for the above-mentioned twelve allotment zones by July 2015.

3.4.2.2 Additional fifteen regional digital terrestrial TV networks

Fifteen regional SFN networks will be licensed to operators for deployment in the allotment zones of Blagoevgrad, Burgas, Kardzhali, Pleven, Plovdiv, Ruse, Smolyan, Sofia, Sofia-City, Stara Zagora, Strandzha, Shumen, Varna, Varna-City and Vidin by July 2010.

These licensees will be obliged to start “Island Coverage” broadcast within said allotment zones as from January 2011 and they will be required to ensure 90-95% of population coverage in the above-mentioned allotment areas by December 2012.

3.4.3 Allotment zones

Figure 38 defines the distribution of allotment zones on the map of Bulgaria as per RRC-06.

3.4.4 HDTV

Subject to license application/s for digital terrestrial HDTV broadcasting network/s being submitted latest by December 2011 to competent regulatory authorities, or upon initiative of competent regulatory authority, license/s may be granted to relevant operator/s for deployment and operation of digital High Definition TV terrestrial broadcasting network/s.

3.4.5 One Year Simulcast Limitation

The period of parallel broadcasting of both analogue and digital terrestrial TV broadcasting (simulcast) is limited to one year after the start up of digital terrestrial broadcasting within relevant “Island”. Upon expiry of this one-year period all analogue terrestrial TV broadcasting transmitters within the “Island” territory coverage will be switched-off as a principle, however exceptions may be granted spectrum permitting, in particular for remote rural areas.

Appropriate measures will be taken to ensure adequate spectrum allocation/s in order to guarantee the practical implementation of this key requirement.

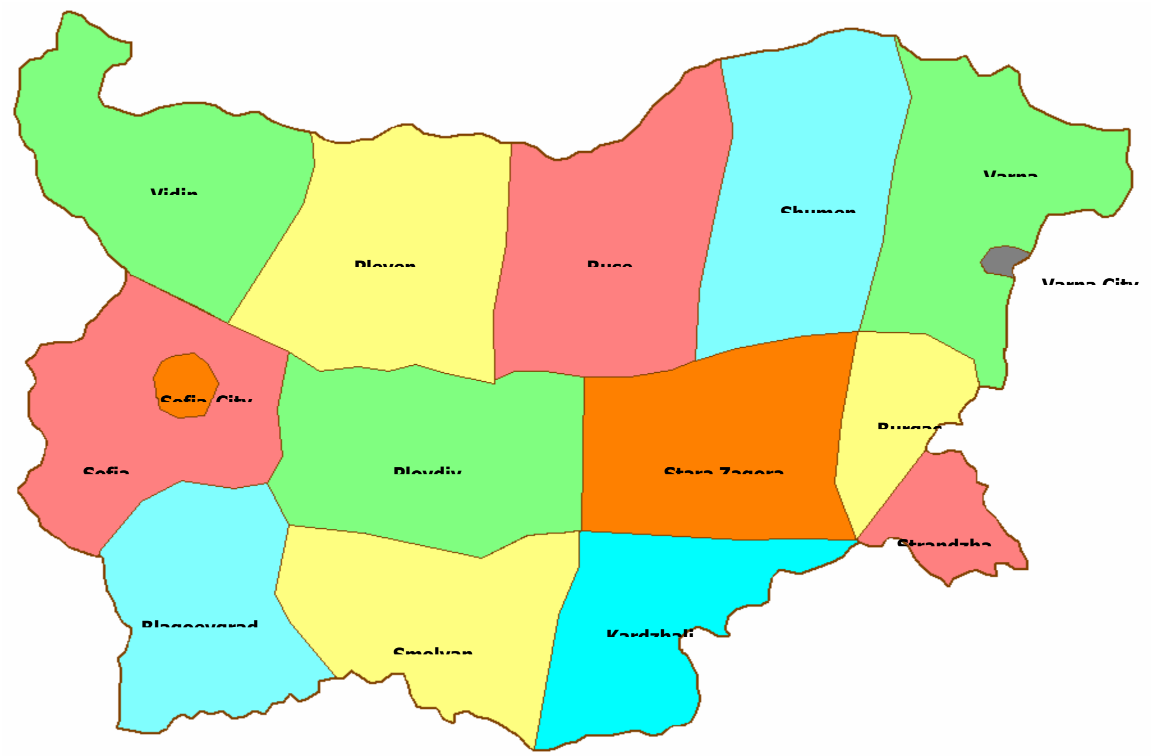
3.4.6 “Must carry” obligation

The Electronic Communications Law, May 2007, Article 47(2).1 stipulates that any digital terrestrial broadcasting network, be it radio or television, must carry two Bulgarian programmes. It is within the purview of the Electronic Media Council (EMC), empowered by this Law, to decide on the programme allocation within any network. Furthermore, it is the EMC who decides on the network to broadcast the programme/s of Bulgarian National Television, but within the said limitation of two Bulgarian programmes per network.

Taking into account the existing spectrum constraints, the Second Phase of the Transition Plan (see § 2.4.2) may be implemented only on condition that relevant spectrum indeed be liberated by the already licensed operators for analogue terrestrial digital TV broadcasting with nation-wide coverage networks. In this regard and in order to ensure that the above-mentioned requirement of the Electronic Communications Law will be met, either the said licensed operators must have new licenses granted for nation-wide network coverage of digital terrestrial TV broadcasting during the First Phase of Transition (see § 4.1), or alternatively, in consistency with the decision of the EMC on the network assigned to carry the programme/s of Bulgarian National Television (BNT) a "must carry" obligation be imposed on relevant operator/s, being licensed as First Three Nation-wide digital terrestrial TV Broadcaster during the First Phase of Transition to carry obligatorily the programme/s of Bulgarian National Television.

FIGURE 38

Allotment zones for the Republic of Bulgaria defined by RRC-06



3.4.7 Analogue switch-off

Switch-off of any analogue TV terrestrial broadcasting transmission in the country will be imposed by December 2012 at the latest.

3.4.8 Digital dividend

The switchover from analogue to digital broadcasting will create new distribution networks and expand the potential for wireless innovation and services. The digital dividend accruing from efficiencies in spectrum usage will allow more channels to be carried with variety of fast data transmission rates and lead to greater convergence of services.

The inherent consistency of data flows over long distances and flexibility offered by digital terrestrial broadcasting will support mobile reception of video, internet and multimedia data, making applications, services and information accessible and usable anywhere and at any time. Along with the introduction of innovations such as Handheld TV Broadcast (DVB-H) and High-Definition Television (HDTV), it will provide greater bandwidth which, in full consistency with "European Parliament resolution Towards a European policy on the radio spectrum" {2006/2212(INI)}, could increase the widespread availability of affordable mobile/wireless broadband, including in rural areas.

Services ancillary to broadcasting (wireless microphones, talk back links), planned on a national basis, could also be extended.

Because of the complex and interleaving reasons, associated inter alia with the said purpose and mission of the introduction of digital TV terrestrial broadcasting in this country, it will be very difficult in the mid-term future to quantify the spectrum which will be available for use of services other than broadcasting. Therefore it is foreseen that the factual quantitative balance of the spectrum liberated will be done not earlier than the complete analogue switch-off at the end of 2012 and not later than end 2015, in full conformity with the decisions taken at the WRC-07.

4 Canada

4.1 National planning strategies and policy considerations

4.1.1 Introduction

For almost 25 years Canada has carried-out, research, demonstrations, put in place a Task Force, Working Groups, Industry Associations, Regulatory initiatives with minimal government involvement and with a policy firmly based on the market place for the transition to digital terrestrial television. Although the core of all of this work has focussed on terrestrial television transition, there have been some notable diversions along the way including the Advanced Broadcasting Systems of Canada (ABSOC), which dealt with video compression issues for standard digital terrestrial television, cable and satellite.

ABSOC recommended that a digital Task Force look at all the issues surrounding the implementation of Digital Television (DTV) in Canada and the Government set one up in late 1995. It included all industry segments and completed its work in late 1997 with a report presented to the Ministers of Canadian Heritage and Industry Canada.

Following the Task Force report Industry Canada responded by accepting the recommendation to adopt the American Television Systems Committee (ATSC) transmission standard for terrestrial DTV services and made spectrum available to all licensed terrestrial television broadcasters for digital services. The broadcasters, distributors and manufacturers set up an industry association to manage and facilitate the transition realizing another recommendation, Canadian Digital Television (CDTV).

Over the next eight years CDTV working with the industry and the relevant interest groups and government departments, provided a platform for testing the technology, educating both the industry and the consumer, demonstrating HDTV services, and encouraging the production and distribution of HDTV programs and services. Over this period, the Canadian Radio-television and Telecommunications Commission (CRTC) also provided a regulatory framework for terrestrial television broadcasters and pay and specialty services to make the transition to digital High Definition service. The important point to note is that the emphasis of all of these initiatives was not just the introduction of DTV service but that service providing HDTV programs. The benefit for the citizen/consumer was defined both informally and formally as improved video and audio as characterized by HDTV.

In 1999, the industry defined Canada’s DTV transition strategy as a fast follow by two years of the US roll out of DTV services. This strategy was consistent with the market place approach and ensured that the high-end costs associated with early adoption of new technology were avoided for both broadcasters and consumers.

A lot has changed in the broadcast environment since the beginnings of HDTV in the eighties. Broadcasters have lost market share to viewing in both in real terms to pay and specialty services as well as viewers receiving their service directly from the transmitter in favour of distributed cable and satellite. More than 30% of all viewing was from terrestrial transmitters in the eighties where today that figure hovers around 10% or even lower in some markets. Consequently, broadcasters have been reluctant to build digital transmission infrastructure noting that there simply is not a business case to do so. There are currently 12 DTV transmitters on the air concentrated in Toronto, Vancouver and Montreal, even though more than 40 temporary licenses have been granted.

Over this time, progress was made in creating digital HD infrastructure in network operations of the major networks and the production community is just now beginning to embrace HD production. However, for the most part the Canadian terrestrial television broadcast system remains a standard definition one (as do the pay and specialty services) and in many regional centres an analogue throwback.

It is against this background that the CRTC is conducting a television policy review and the Minister of Heritage requested an examination of the impact of new technology on the Canadian Broadcasting System. A lot has changed since the Task Force reported 9 years ago. Internet delivery, Video on Demand, mobile television and consumer empowering personal video recorders and devices have and will have an increasing impact on the traditional broadcast model and in fact on the fundamentals of the Canadian Broadcasting system as Canadians have historically understood it. Decisions made by the CTRC, Government and the interests of the Broadcasting system over the coming 12 months will have a profound impact on the future of broadcasting generally and the roll out of conventional terrestrial broadcast services in particular.

The remainder of the paper will look more closely at the history, present circumstances and future options.

4.2 DTV/HDTV History

4.2.1 The Early Years

Canadian engagement with digital television is rooted in the industry's early interest in High Definition Television (HDTV) as far back as 1982. In that year, the Canadian Broadcasting Corporation (CBC) and the Department of Communications and its research centre organized a Colloquium in Ottawa that drew delegates from all over the world to discuss HDTV and how to develop it as a future service. For almost a decade, there were follow up conferences, demonstrations and debate.

It is probably fair to say that the Department of Communications led a lot of Canada's participation through the eighties and into the nineties. In 1987, a major public demonstration of the Japanese MUSE system of HDTV was done with the cooperation of government, a number of Canadian industry players and the Japanese. It was successful but not practical for terrestrial display in North America because of the amount of bandwidth needed for broadcast, although the Japanese used the MUSE technology from the late eighties through to today via Satellite DTH. At the same time, the CBC produced the first North American High Definition program series, Chasing Rainbows.

As the eighties drew to a close the Canadian Government was involved in that process testing proponents of five different systems in 1991/92 and then the eventual successful effort in the mid nineties. Canada worked closely with US industry and agencies in this process. At the same time Canadian industry recognized the need to become involved in the digital initiatives became apparent and in 1990 ABSOC was set up to perform that role.

From 1990 through to 1997 ABSOC played an important role of both informing the industry on digital developments and recommending standards and practises for MPEG 2 compression technologies as it effected production and distribution of standard digital television. Representing a cross section of the broadcast and distribution community with government liaison and support ABSOC brought a practicality and application to the new digital technologies as they developed.

As the initiative matured and accepted a new digital transmission technology capable of delivering High Definition signals within MHz of spectrum or multicast digital delivery of standard television, ABSOC came to realize that Canada needed to focus on what this new technology meant for Canadian viewers and the broadcast industry. They recommended a Task Force to examine the elements required to implement digital television in Canada and the government responded by naming a Task Force in November of 1995.

It is important to understand the environment that Canadian broadcasters enjoyed in the mid nineties. Although conventional broadcasters faced increasing market fragmentation, they still enjoyed a transmitted market share of their viewers of over 20%. Although pay and specialty services were growing, they had not fragmented the audience share to the degree that would develop and is seen today. The internet as a delivery mechanism, video on demand and other platforms that define today's multi platform broadcast world were barely a dream very much on the horizon but in a business sense not a huge blip on anyone's radar screen. By the end of the nineties, the view of the broadcast world was rapidly disintegrating. What was real was MPEG 2 compression, which made possible digital standard television satellite and cable delivery. Providing for more pay and specialty services with cheaper delivery to Broadcasting Distribution Undertaking (BDU) head ends and production facilities, and the prospect of better quality pictures and sound with HD services very far down the road.

For the newly announced Digital Task Force these problems were all in the future and it focussed on its mandate to recommend the best way to implement digital television for Canada.

Digital Television Task Force

The Task Force was truly representative of all industry interests plus the production and consumer manufacturers’ community. Over ninety people were on the Task Force or committees and many more were consulted throughout the Task Force’s work. It has been noted that Canada does Royal Commissions and Task Forces very well, as they are often vehicles for inaction. However, they also do some remarkable work from time to time and by the time the Task Force reported in late 1997 an industry had been somewhat educated, consulted and had arrived at a consensus; albeit kicking, screaming and probably thinking that many of it’s recommendations were so far down the road that there was nothing really to worry about.

The seventeen recommendations were rooted in the work of four committees who recommended the substance to the Task Force members. The committees included; technology, production, policy and regulation, and economics, consumer services and products. It is interesting to note as Canada moved to an implementation stage those areas of work continue to provide guidance and direction. While it is not useful to review the entire Task Force report and recommendations, it is useful to recognize that much was achieved and many recommendations were acted on:

The ATSC transmission standard, A53, was adopted by Canada and a subsequent allotment plan was adopted providing digital spectrum for all licensed analogue conventional broadcasters. Broadcasters were to make the transition to digital transmission while retaining their analogue spectrum for simulcast until the transition was complete. This was important since it provided a secure business basis for broadcasters to begin the transition.

Many of the policy and regulatory recommendations have found their way into CRTC licensing and carriage frameworks. Again, this was to provide stability during the transition for the industry business models, as they were understood at the time.

A period was suggested for the digital transition with an end date that would be a year to 18 months behind the US. While not acted upon in Canada, virtually every other country in the world has either a notional or a firm target date for analogue shutdown. The Canadian transition has lacked clarity and definition in the absence of such an initiative.

Initiatives concerning the production community for training and HDTV content were never acted upon and regrettably this industry sector has lagged behind many in the global community and Canada has a lack of HD production.

The recommendation to set up an industry organization to help manage, facilitate and advise government on the transition was put into place and will be discussed later in this paper.

Some recommendations like that calling for a universal box which would work for terrestrial television and distributed BDU services were not realized and probably too idealistic.

One recommendation calling for universally available terrestrial services is worth noting:

“Recommendation Fourteen”

Basic terrestrial broadcast television services that are freely and universally available are central to achieving the objectives of the Canadian broadcasting system. This must continue in future digital terrestrial distribution packages.

Freely available broadcast television services are the foundation of the Canadian broadcasting system. This universality of access must be preserved in the emerging digital system.”

This was fundamental to the system in 1997 but in today’s environment terrestrial broadcasters are not committed to this principle given the change in how viewers receive there television services. In fact, the costs associated with this recommendation and the lack of any kind of business case will characterize the discussions of future policy hearings. This issue has also characterized the industry reluctance to move ahead with the digital transition in a timely way.

In looking back, the Task Force got many things right as evidenced by the overwhelming number of recommendations implemented. It set the agenda for the transition for terrestrial services and coincidently the pay and specialty services. However, it did not anticipate the rapid change in the broadcast environment; its multi platform distribution opportunities and the availability of the devices, which would empower consumers with both choice and schedule. Combined with a market place approach these factors inhibited a timely transition to digital High definition services.

Implementation 1998 to 2006

Following the Task Force report the broadcasting and distribution industry, along with manufacturers and producers came together to create CDTV, as recommended by the Task Force. In September of 1998 the organization was formally created as a not profit association, with by-laws, a Board of Directors based on industry sectors and a work plan. Relevant Government Departments and the CRTC were welcome to participate and contribute to committee work and observe in Board meetings.

The Board created Working Groups in the technology, policy and regulation, economics and marketing, communication and education and production. This was not very different from the original Task Force committees. These working groups were a part of the association to a greater or lesser extent through the life of the association responding to the approved work plans from the Board and the changing environment

The work of the association was totally funded by the industry with both direct and indirect funding. Industry Canada provided funds to test the frequency allotments at the CDTV test transmitter in Ottawa in 1998/99.

For eight years, CDTV represented the industry in helping manage and facilitate the transition. The early years focussed on testing, education, and understanding the standards. As time passed demonstrations, seminars, policy, regulation and business models dominated the agenda. Over the last few years CDTV focussed on operational implementation, the creation of HDTV programming, consumer education and awareness, and the impact of new technology including; improved compression technology, IPTV and mobile service. Throughout its mandate, CDTV participated with ATSC committees and on the Board, bringing back to the Canadian broadcasters and relevant government departments and agencies changes and improvements to the ATSC family of digital standards and Canadian input to those discussions.

An industry association that tries for consensus on issues, or at the very least an overwhelming majority is not the easiest of vehicles to manage in an environment of competing interests and agendas. The consensus and goodwill, which characterized the Task Force was not always seen as CDTV grappled with some of the business and regulatory issues where the interests of the principals were seen to be on the line. Yet for all of that the achievements were many over the life of the association and in fact defined the steps of the transition to digital terrestrial television to date.

Test transmitters were set up and operated in Ottawa, Toronto and Montreal. These gave the broadcasters and distribution communities the opportunity to work with the new digital transmission standard, understand its properties, coverage areas and delivery to BDU head ends.

The transmitters were used to test the frequency allotments (funding from Industry Canada), coverage reach, receiver strength and signal strength. This work became increasingly important, as improvements were made to off air receiver reception.

Canada was also called upon by consumer electronic manufacturers and the ATSC to test improvements and additions to the ATSC family of transmission standards.

Demonstrations for both the public and the industry of HDTV programming and delivery on the Canadian broadcasting system.

Seminars and workshops were held to explain to and educate the industry on the full range of the issues surrounding the production and distribution of digital High Definition programs.

A great deal of time and effort was spent on attempting to develop business models that digital terrestrial television in terms of program and non program related data and multi channel delivery. It was hoped that these models could lead to additional resources to help fund the transition. While the process certainly educated the industry there was not a consensus on the right model or an agreement between the conventional broadcasters and the distributors over revenue sharing of distributed terrestrial data and services.

Costs for the transition were also carefully calculated and included transmission, master controls, editing and production all in high definition. Suggestions for upgrading as equipment became obsolete were made available so that the capital costs of conversion would not be an overnight hit and distort budgets. Again, the identification and process were helpful but no overall industry plan was adopted.

Very early in the transition the Board of Directors of CDTV created the policy of a two-year lag behind the US in Canada's transition to digital television. This built on a recommendation in the Task Force report that suggested a year to 18 months. Given the Government's view that Canada's transition to digital high definition broadcasting should be driven by the market this two-year lag policy was sensible and virtually adopted by all parties. It was successful in saving the industry and consumers a great deal of the costs associated with the early adoption of new technology.

Education and consumer awareness was a major focus of the transition work. This work involved not only the broadcast and distribution industry but the consumer electronic manufacturers and the retail sector as well. Several editions of pamphlets aimed first at the retailers and then directly at the consumers were prepared and delivered through retail outlets and reprinted in consumer electronic magazines. They explained digital television and all the choices and variables in services, programs and consumer equipment. This work was recognized as an effective tool in education and adopted by other countries as part of their transition work.

From the work done on consumer education it was decided that a web based information source of information would be a useful tool. CDTV resourced and created a bilingual consumer section open to everyone on its website. Since its creation a couple of years ago hundreds of thousands of Canadians have used it to gather more information about HDTV. In addition a 15-minute infomercial and several 30 s promos were produced and aired to both provide HD information and push people to the website. Similar efforts will be required in the future, as analogue shutdown becomes a reality in Canada.

The education, training and development of the independent production on HD production were the final major projects taken on by CDTV to aid the transition. Again, a bilingual website was created that contained information and practical experience about, equipment, facilities, production and editing of HD material. Originally conceived as a series of training modules that may be adapted to workshop environments, the website has proven a valuable tool for Canada's content creators. It is sad to note that additional funding could not be achieved to run workshops in all regions of the country to work with the production and broadcast community to create a better understanding of the challenges associated with HD production and how to meet these practically and efficiently. The production of HD content is still very modest in Canada but this is beginning to change and it should be encouraged.

While the core mission was on terrestrial broadcasting a great deal of time and effort was spent on assisting pay and specialty services to make the transition and supporting their needs for effective policies and regulation, facilities and capacity, and education.

During this period CDTV became the principle source of HD information in Canada for both trade press and general media. In the late nineties and in the early part of the two thousands the interest tended to be more industry related but today the Canadian consumer is engaged and very hungry for relevant information. Importantly, it is not about digital television that engages the consumer but it is High Definition, which is capturing their interest.

It is probably fair to ask if a transition association like CDTV was working so well, why it ceased its work a few months ago. Probably for two basic reasons:

The environment in 1998 was very different than it is today. There was less concentration in the broadcast industry and generally more reliance on associations to represent the industry sectors in designated areas. Emerging platforms and new technologies like IPTV and mobile applications were not a huge market factor in 1998, yet they are increasingly dominating discussions today.

At the core broadcasters, who were to make the transition from analogue to digital transmission platforms, drove CDTV. As markets fragmented and viewing reception for transmitter received services declined, the consensus achieved by the Task Force to transit to digital transmitted services began to break down and eventually eroded the support for an association whose mandate was to see the transition through.

With the above in mind, the industry members felt the association had gone as far as it could and its mandate was complete from their perspective given the new environmental realities. Many elements of this 8-year phase of Canada's DTV transition were done well and made substantial contributions to the process. Issues of timeliness, a focus on what the Canadian broadcast system should be when the transition is complete, and an end date for analogue needs to be urgently answered before the transition may proceed.

The Present

The Current Players and the Issues

Canadian broadcasters have demonstrated reluctance to build transmission infrastructure and thus there are only transmitters in Toronto, Montreal and Vancouver as noted earlier in this text.

Conventional broadcasters have invested in considerable digital HD equipment in their network centres but very little in regional locations across the country. To date they have depended on cable and satellite delivery of their HD signal to locations across the country. In some cases because of cable and satellite bandwidth constraints and the strict application of the carriage rules, this national coverage is not as good as the broadcasters would like.

There are no French language networks, which are providing digitally transmitted HD or SD services aside from SRC. Most of the transition developments have been within English services. While there have been more than 40 temporary licenses issued there have been relatively few actually act upon. Most of these are English services. With some 12 transmitters on the air and broadcasters reluctant to build out their digital transmission infrastructure the future of conventional terrestrial television, has we have historically understood it, seems to be poised for a change.

Digital HDTV set penetration is projected to be over 3 million by year-end in Canada and most of the sets now coming to market have built in tuners.

Hook ups to HD services from a BDU are still modest in Canada with numbers approaching 600K by year-end in Canada. This figure is expected to dramatically increase over the next few years.

It is difficult to asses IPTV, mobile, and multi platform delivery and their impact on the terrestrial digital transition. All industry sectors are coping with these challenging issues and they are increasingly becoming central issues in developing future business models. However, it is a difficult to suggest that conventional broadcasters have not made the transition to transmitted digital services because of these emerging technologies. At this stage, they are just too peripheral to the core business. The only apparent reason is the declining viewing to terrestrial services directly from the transmitter and the costs of duplicating the existing analogue system with digital transmitters for a decreasing audience return. In simple terms, there is no business case.

Although this paper focuses on terrestrial television it is important to understand the steps taken by the BDU industry to increase capacity that provides both more choice and HDTV capacity. Cable has worked to upgrade its capacity in recent years and has migrated its customer base to digital delivery with demonstrable success. The end of analogue conventional television would ease the bandwidth crunch that is clearly apparent in a transitional environment. Measures to speed up this process would benefit both the consumer and the industry interests. By necessity, these measures must be part of an agreed overall transition plan with a firm analogue shut off date.

Satellite DTH providers are already all digital but face similar capacity issues in this transitional phase which must be addressed. Likewise, Satellite carriers will face increasing demand and capacity issues as more services move to digital HDTV demanding more bandwidth in a finite satellite universe. Delivery to BDU head end, collection and backhaul in a HD environment puts tremendous pressure on the carrier and cost for the service provider whether conventional or pay and specialty. New compression technology and new Satellites may well be part of the solution for DTH providers and Carriers but a definable end to the digital transition would provide some certainty in the market place for all the players.

The above discussion provides some of the background that the recently held Television Review and the Canadian Government Directive concerning the impact of new technology on the future of broadcasting has considered. The reports and decisions, which arrive from it, will be very important to the future digital transition of the industry.

In reviewing the many submissions for consideration in this process, it was clear that most conventional broadcasters do not want duplicate their entire analogue transmitter structure and many see little or no future in transmitted services at all. The difficulty of these submissions is there seems to be no clear alternative or plan for what a new conventional broadcast system would look like in a non-analogue world.

Virtually every country in the world, which has embarked on a Digital Transition plan for terrestrial services, whether it includes HDTV or not, has a definable plan including scope and timeframe. The Canadian situation has suffered from this lack of definition and this now needs to be addressed.

Action Required

In order to expedite the transition of Digital Television, the regulatory process would have to address the following issues:

A policy decision about the future of terrestrial television.

If transmitted terrestrial services are to remain in the digital world do they mirror the current analogue coverage, a part of that coverage or not at all?

If there are Canadians disenfranchised by a decision to reduce transmitter coverage how do they receive their basic service?

Coincidental with this decision an analogue shut off date needs to be established with definable and measurable milestones.

A plan for informing the public and ensuring that all Canadians can receive a television signal with analogue shut off needs to be established.

The digital benefit for consumers needs to be defined (HDTV and/or enhanced choice) and realized by conventional and pay and specialty broadcasters.

Attention needs to focus on the new technologies; how they can both challenge and enhance the core conventional services in a multi platform environment.

Capacity needs to be assessed in the distribution system to ensure that all services that need to transit to digital HDTV can do so in a timely cost efficient manner. There will be a capacity crunch and it cannot be a barrier to transition.

A plan for regional and local participation in the digital transition needs to be addressed, including local HD production and services.

A plan for the creation of Canadian HDTV content in all program genres to service Canadian HD services that now rely largely on foreign produced HD product.

It is worth repeating that a great deal of good work has been accomplished in the last decade and it is important to see these suggestions in light of that work and building upon it. At the same time, the current transition to digital HDTV is in crisis and needs to be firmly put on track, particularly for conventional terrestrial broadcasters. Canada has gained a lot of first hand experience and knowledge of other countries and their challenges and triumphs. It is now time to take that experience and knowledge and resolve the future of the Canadian Broadcasting System in the digital HD world.

The Future

Given the changes to the broadcast environment in the last decade, it is difficult if not foolhardy to try to predict the future. None the less there is some givens that can shape our environment over the next few years.

High Definition programming will become the new norm over the coming years throughout most of the developed world.

All the new emerging technologies and platforms will have a business impact that will benefit and challenge the core conventional broadcast business in a multi platform environment characterized by quality, choice, and consumer empowerment.

Content will need to be created at the highest possible level of quality for shelf life and conversion for multi platform delivery. The 1080 progressive production standard will be the international HDTV program exchange standard. HD delivery will be either 720p or 1080 depending on spectrum availability and the nature of the service distributed

The ATSC family of standards will evolve to an advanced compression codec which will enhance the value of terrestrial television spectrum, this is already happening with the DVB-T standard. Future digital receivers will be capable of receiving both MPEG 2 and MPEG 4 signals (France is currently rolling out these boxes as part of their DTV transition).

Further work on the development of improvements in the ATSC system and receiver sensitivity with emphasis on work which may lead to solutions for wireless services and broadcast services in remote communities. This could be a part of the answer for bringing transmitted digital services to rural Canada.

A plan for analogue shutdown with a responsible agency or group who may be held accountable by the viewer and citizen will be critical to analogue shut off.

The Canadian Broadcasting System will continue to enjoy a balance of cable and satellite delivery along with the internet, and telecommunications services all providing real time, video on demand, and streaming services to the viewer. Consumer devices will enhance the viewer as programmer but for the foreseeable future conventional television will continue to drive the industry in terms of content and national, regional, and local reflection. Wireless delivery of these services has a role to play within this system.

Conclusion

Canadian distribution and collection of programming via satellite led the world in using this new technology to the benefit of broadcasting. Canada built the longest stereo FM network in the world. And Canada's television production industry has thrived in the most competitive market in the world producing indigenous product for Canadians, while producing and selling for the rest of the world. Not bad! Canada has done so with the right balance of policy, regulation, incentives, creativity and entrepreneurial skill.

Canada is again at another critical point in its broadcast history. The environment has rapidly changed and yet the issue of valued Canadian services for all Canadians in all parts of the country remains as the constant core issue. Decisions made over the coming year will provide the framework that will define Canadian success in completing the digital transition to HD service for conventional broadcasting and in turn the rest of the system. These are important decisions that require a timely response. Not to respond will leave the current system in disarray and less relevant for both the Canadian viewer and the global community in which it has been a player.

ATSC-DTV distributed transmission network

Introduction

Distributed transmission (DTx) network is a network of transmitters that covers a large service area with a number of synchronized transmitters operating on the same TV channel. DTx offers interesting possibilities for digital TV transmission systems.

As explained in the ATSC Recommended Practice for Design of Synchronized Multiple Transmitter Networks[20], DTx networks have a number of benefits over the single central transmitter approach, which has so far been the usual way of covering a large service area with analogue TV transmission. These benefits include:

- More uniform and higher average signal levels throughout the coverage area
- More reliable indoor reception
- Stronger signals at the edges of the service area without increasing interference to neighboring stations
- Less overall effective radiated power (ERP) and/or antenna height resulting in less interference.

DTx networks can also reduce the number of channels used to cover a large service area and can free spectrum for other applications such as interactive TV, multimedia broadcasting, or any other application that may come up in the future.

As a trade-off for these benefits, implementation of a DTx network requires a very careful design when a DTV adjacent channel is operating in the same market area[21]. A more serious limitation on the DTx operation is that in the possible presence of NTSC adjacent channels operating within the same market area. In such cases, implementation would be very challenging if not impossible. This is due to the higher protection ratios required by NTSC, as opposed to DTV, from an adjacent channel DTV. However, such limitation will not exist after the transition period from NTSC to DTV.

Another important issue affecting the design of a DTx network is the ATSC-DTV receivers' performance with respect to their multipath handling capabilities. Better receivers, capable of handling stronger pre- and post-multipath distortions (pre- and post-echoes) on a wider range of delays, make DTx network design more

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[20] Advanced Television System Committee (ATSC), Recommended Practice – A/111, "Design of Synchronized Multiple Transmitter Networks."

[21] Advanced Television System Committee (ATSC), Recommended Practice – A/111, "Design of Synchronized Multiple Transmitter Networks."

flexible and simpler. On the other hand, receivers with weaker multipath handling capabilities put more restrictions on the design and implementation of DTx networks.

In addition to providing many guidelines for designing a DTx network and managing its internal and external interference under different conditions, the above mentioned Recommended Practice proposes three methods (or their combinations) for implementing a DTx network.

DTx Methods

The first method is distributed transmitter network, commonly known as single frequency network (SFN), consisting of a central studio that sends baseband signal or video-audio data stream to the SFN transmitters via studio-transmitter-links (STL). STLs can be fiber optics, microwave links, satellite links, etc. The SFNs may be costly to implement and operate. The SFN transmitters in this configuration require subtle (and rather complex) processes for their frequency and time synchronization with each other.

The second method is called distributed translator network in which the transmitters contributing to the SFN, which are some coherent translators all operating on the same channel, translate the frequency of an over-the-air signal received from a main DTV transmitter to a second RF channel. This eliminates the need for a costly Studio to Transmitter Links (STL). On the other hand, frequency and time synchronization for this configuration is quite simpler than the first method. During the translation process to the designated output channel, necessary corrections may also be applied to the signal. In this configuration, however, the main transmitter feeding the coherent translators is operating on another channel and is not part of the SFN. But one may consider this as a sort of frequency diversity in the overlapping coverage area of the main transmitter and the SFN.

The third method consists of digital on-channel repeaters (DOCR) that can differ from each other in the way that they process the signal through the path from their input to their output antennas. The DOCRs contributing to the SFN again pick up their inputs from a main transmitter, eliminating the need for any STL, and transmit on the same channel as they receive. Each DOCR can work on the basis of direct RF operation, conversion to IF or to baseband and up-convert again to the same channel as it receives. In order to form an SFN, however, all the repeaters' outputs should be synchronized with each other and also with the main transmitter feeding them.

With this approach, two limiting factors exist on the operation of the network. First, the main transmitter signal can create advanced multipath (pre-echo) in the overlapping coverage areas between the main transmitter and the repeaters. For creating pre-echo, the repeater's signal must be dominant in such overlapping areas. This may be problematic to the ATSC legacy receivers that are vulnerable to pre-echoes. Second, depending on the amount of feedback from DOCR transmitting to receiving antenna, there is a power limitation on the repeaters' output.

The Communications Research Centre (CRC) of Canada has already studied, by performing various field tests, different applications of direct RF operation OCRs and their performance under different conditions, and has published the results[22, 23]. The below study focuses on the second configuration of distributed transmission network, which is "distributed translators".

Setup and Methodology

The distributed transmission network under consideration by the CRC consisted of three coherent translators. The translators received their input signal on channel 67 (788-794 MHz) from a medium power DTV transmitter having a tower height and EHAAT of 209 and 215.4 meters, and located at about 30 km south of Ottawa, Canada. This DTV transmitter covers Ottawa and its surroundings with an average ERP of 30 kW through a horizontally polarized omni-directional antenna system.

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22 SALEHIAN, K., GUILLET, M., CARON, B. and KENNEDY, A: On-channel repeater for digital television broadcasting service. *IEEE Trans. Broadcast.*, Vol. 48, **2**, p. 97-102.

23 SALEHIAN, K., CARON, B. and GUILLET, M. Using on-channel repeater to improve reception in DTV broadcasting service area. *IEEE Trans. Broadcast.*, Vol. 49, **3,** p. 309-313.

The translators converted the received channel 67 to channel 54 (710-716 MHz) through direct RF to RF operation. They were all frequency synchronized and their timing was adjusted to make them transmit with no delay with respect to each other.

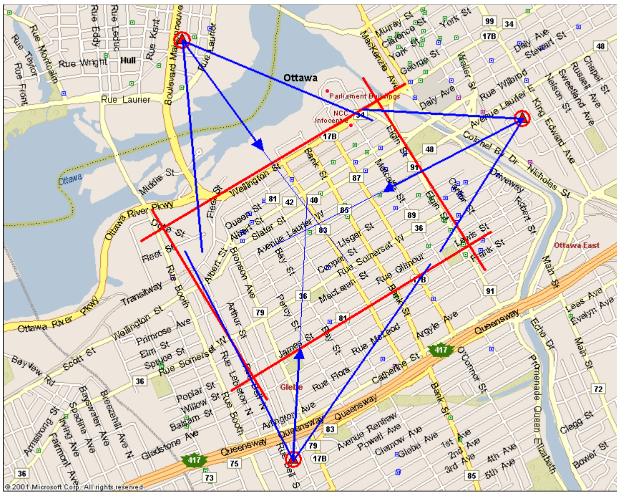
The translators were installed on the top of three high-rise buildings in downtown Ottawa. They covered a common rectangular target area of approximately 1.66 by 1.14 km, and their output powers, which were between 15 to 25 W ERP (enough to cover the small rectangular target area), were adjusted to produce equal signal strengths at the centre of the target area. Figure 39 shows the relative locations of the three synchronized translators along with their overlapping target area. Also shown is the direction of transmission of the three translators' output antennas and their 60º beam width. The main DTV station, which covers the whole Ottawa area including its downtown in which the DTx target area is located, is outside the map in the bottom right direction at a distance of 25 km from the centre of the target area.

Receiving conditions

The receiving conditions for these tests were intentionally selected to make a worst case scenario for the study. A single target area was selected for all three translators (see Fig. 39). In this way, the translators could create a lot of artificial multipaths (active echoes) in the target area. On the other hand, the downtown canyon, in which such target area was located, made the situation worse by creating additional static and dynamic multipath through reflections of each of the translator's signal from high-rise buildings and moving vehicles (passive echoes).

FIGURE 39

Ottawa distributed translator network. The rectangular target area is 1.6 × 1.14 km



The measurement points were at the corners of the grids of a lattice covering the target area. A total of 59 points, at distances between 100 to 200 m from each other were measured. For the measurements, which were made on the street sidewalks at about 1.5 m above ground level (AGL), two types of antennas were used, an omni-directional antenna and a low gain directional antenna (usually used for indoor reception) with about 5 dB gain and 60º beam width.

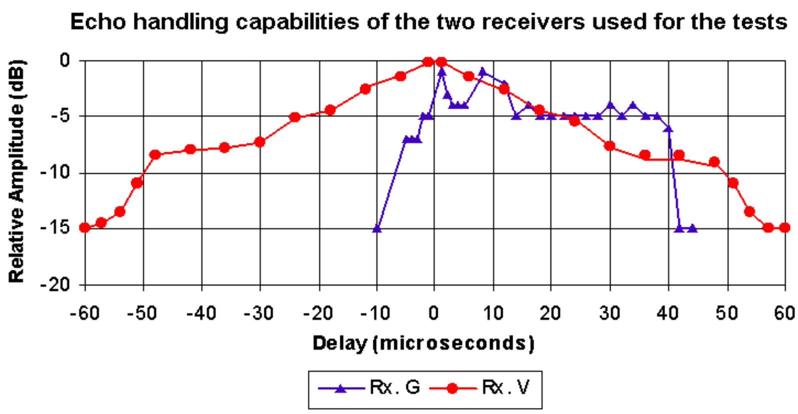
Both antennas were made active by connecting them to a low noise amplifier (LNA) of about 1.2 dB noise figure and 20 dB gain, and also a band pass (BP) filter installed on the same stand as the antennas.

Characteristics of the receivers used for the tests

For these tests, two types of receivers were used, a new prototype, and an older generation receiver. The new prototype receiver, as compared with the older generation, was capable of handling pre-and post-echoes with a much wider delay range.

Figure 40 shows the relative attenuation of a single static echo at different delays, at which the receivers are at the threshold of visibility (TOV). As it is seen, the older generation receiver (Receiver G in the figure) could operate with about –5 dB echo in the range of –3 to +40 µs. The new generation receiver (Receiver V in the figure), on the other hand, could handle pre and post echoes over a wider range. It was capable of handling –10 dB pre- or post-echo with a delay spread of –50 to +50 µs, or –5 dB echo in the range of –25 to +25 µs.

FIGURE 40



Performance of the two receivers used for the tests

Test results

In the first phase of the tests, the feasibility of implementation of such a network was verified. In the next phase of the study, measurements were performed in 59 points inside the target area. Table 8 shows the percentage of locations in which successful reception was achieved.

TABLE 8

Percentage of reception points with successful reception

	DTx (CH-54)	
	New Prototype Rx.	Older Generation Rx.
Directional Rx. Ant	97%	54%
Omni-directional Rx. Ant.	71%	19%
	Main Tx (CH-67)	
	New Prototype Rx.	Older Generation Rx.
Directional Rx. Ant	93%	36%
Omni-directional Rx. Ant.	44%	10%

Table 8 shows the results for DTx (CH-54) and also for the single distant transmitter (CH-67), using the new prototype and the older generation receivers, and also using directional and omni-directional antennas. As it is seen, the results are somehow better, under all circumstances, with the DTx network as compared to the single transmitter configuration.

Comparison of the results, however, can be made based on the type of the receiver, type of the receiving antenna, or type of coverage. What is quite evident is that under any condition, the reception situation is remarkably improved when the new generation receiver is used instead of the older generation receiver. Another major improvement can also be seen with using directional antenna instead of omni-directional antenna for both DTx and single transmitter. This has probably been due to the attenuation effect of the antenna on signals coming from the directions other than the main signal and acting as multipath.

Another important result that can be highlighted from this table is the fact that the DTx network, as compared to single transmitter configuration, has improved the situation also for the older generation receiver under all conditions (although not significant in all cases). The most significant improvement is when directional receiving-antenna is used. Under this condition, distributed transmission could improve the percentage of points with successful reception from 36% for single transmitter configuration to 54% for DTx network.

Conclusion

For the study in this section, a distributed transmission (DTx) network, consisting of three coherent translators, was used to cover parts of the coverage area of a single transmitter. Two types of receivers and two types of receiving antennas were used and measurements were made in both channels corresponding to the DTx network and the single distant transmitter. The reception conditions were made very tough by choosing overlapping coverage area located in the hostile downtown environment for the DTx network, and also by making the measurements at 1.5 m AGL on the street sidewalks.

The results showed that the DTx network had better reception availability than the single transmitter, especially when omni-directional receiving antenna was used.

The results also showed remarkable improvement in the performance of a new prototype receiver in the SFN environment, as compared to an older generation receiver that was used in the tests. This was because of the major improvement in the multipath handling capabilities of the new prototype receiver, which makes the implementation and operation of ATSC distributed transmission networks possible and reliable.

Another important result was the impact of even small directivity of the receiving antenna on reception. Directional receiving antenna, as compared to the omni-directional one, could provide successful reception for a greater percentage of the measurement points.

The test results also demonstrated reception improvement for the older generation receiver under SFN operation. However, because that receiver was only one generation older than the new prototype one, more tests are required to investigate the performance of the legacy receivers in a distributed transmission environment.

5 Germany

DTTB was officially launched on 1 November 2002 and, by the end of 2008, all transmissions were completely digital, using the DVB-T standard. The business model is free-to-air broadcasting. The country’s channel planning is based on the framework of the national frequency rights resulting from the ITU-R Geneva Agreement 2006 (GE-06), using predominantly the service concept "portable outdoor" (RPC-2 according to the Geneva Plan plus one or several assignments per city for high-power transmitter). This service concept generally enables indoor reception in the German agglomerations, which makes up one half of the total area, where typically more than twenty digital programmes are available in standard definition (SD) quality. Outside of these agglomerations, DVB-T can either be received as "portable outdoor" or by using directive antennae. With respect to HDTV, first test transmissions have taken place. Trials are also carried out concerning the transmission of sound radio programmes within a DVB-T multiplex.

There are various types of receivers on the market, ranging from USB dongles for PC and laptops over small portable TV sets for handheld and in-car reception (screen size typically between 5 and 7 inch of diameter) to set-top boxes and stand-alone TV sets for stationary reception (typically with flat-screen displays). In May

2008, the first mobile phones with integrated DVB-T receivers appeared on the market. In addition, car navigation systems are nowadays equipped with DVB-T receivers.

The switch-off started in Berlin-Brandenburg in August 2003. Already by the end of 2003, some six million people were able to receive 26 digital channels in SD quality in the city of Berlin and the federal member state of Brandenburg. This was the first switch-off of terrestrial analogue television worldwide. This success can be ascribed in part to the Government, which decreed that the service was to be totally free of charge, and which provided, only in 2003, free decoders to the poorest households. Under no other circumstances, the purchase of DVB-T receivers was subsidised. By the end of 2007, more than 85% of the German population (68 million people) could already receive digital terrestrial television. More than nine million receivers had been sold by that data. The success of DVB-T in Germany was due to the fact that the reception of a multitude of German-speaking programmes was available to the general public free-of-charge. In 2008, DVB-T is used by 16,8% of the households in Berlin –Brandenburg.

In other metropolitan areas, DVB-T transmissions started in 2004. One key element of the German approach was the implementation of the digital broadcasting service region by region, initially after an announced transition period of as little as six months and later on without any simulcast period. By the end of 2008, the switch-over will definitely have been completed (two years earlier than originally planned).

By the end of 2008, some 15 million DVB-T receivers are expected to have been sold since the launch of the service. Nevertheless, for their primary TV service in the households (large flat screen in the living room) approximately 90% of the Germans still rely on cable TV or satellite distribution.

Detailed information could be found at following links:

http://www.alm.de/fileadmin/forschungsprojekte/GSDZ/digitalisierungsbericht2008D.pdf

and

http://www.ueberallfernsehen.de/

6 Guinea

Legal and regulatory aspects

It has to be acknowledged that analogue radio and television broadcasting are not very developed in certain African countries, for example the Republic of Guinea, where radio broadcasting was introduced only in 1952, and television in 1977.

The transmission medium initially used was the radio-relay network, constructed in 1977.

Today, this network, operated by the Department of Posts and Telecommunications and digitized to the tune of 85%, does not carry television and radio signals owing to the advance of satellite broadcasting, which is favoured by the Government. However, we are convinced that the rapid development of radio and television broadcasting will of necessity involve digitization through liberalization of the audiovisual sphere.

Legal and regulatory framework for DTT

In the Republic of Guinea, the tools and infrastructures conducive to the rapid opening up of digital radio and television broadcasting are to be found in different sectors, with much of the equipment (radio and television transmitters, studios) being administered by the Ministry of Information, while other equipment (shortwave and medium wave radio transmitters and terrestrial radio-relay transmission facilities) is administered by the Ministry of Posts and Telecommunications. The Government would be better advised, with support from the development partners, to group the various communication media under the same authority, pending the opening up of the audiovisual sphere.

Technical aspects

Two alternatives may be envisaged for the migration from analogue broadcasting to DTT:

− close down the analogue system and construct an entirely digital network, or

− deploy a hybrid system (analogue and digital).

The second option would seem to be the most appropriate for developing countries. It involves using the existing analogue network with a certain amount of refitting and the construction of a number of sites. However, the paramount requirement for making the DTT network more operational is a redistribution (replanning) of the frequencies used, this being the task of the regional radiocommunication conference (RRC) over the coming months.

Furthermore, the fact that our States currently use the radio-relay network for their radio and television signals leads us to recommend, for those countries that share a common border, that they jointly replan their frequencies and select the same digital television system, namely DVB-T, which is technically more adaptable than the ATSC(A) and ISDB-T(C) standards. The B(DVB-T) standard is less costly and more advantageous to developing countries during the transition period. This will allow for more fruitful regional consultation aimed at harmonizing the technical facilities to be used when introducing digital broadcasting equipment.

7 Italy

7.1 Legal Framework

The bodies involved in Italy in the spectrum management and planning are:

− Ministry of communication (MIN COM): entitled for spectrum allocation and for private and public services frequency assignment for civil utilisation as well as the elaboration of the assignment plans apart of broadcasting services. The Ministry is also in charge of representing Italy in relevant international bodies, such as, ITU, CEPT, EC.

− Authority of telecommunications (AGCOM): entitled of frequency planning for broadcasting services. The Authority was appointed in 1997.

The main AGCOM tools are Plans and Resolutions for broadcasting services. During last years different Plans were defined:

− 1998: Analogue TV Plan

− 2002: DAB Plan for VHF-Band and L-Band

− 2003: DTT Plan.

Up to now none of these Plans has been implemented. Probably the difficulties are related to the actual use of the very overcrowded Italian radio electric spectrum:

− 10 National Analogue broadcasters (Rai1, Rai2, Rai3, Canale 5, Italia 1, Rete 4, La 7, MTV, ReteA-Allmusic, Rete Capri)

− 7 National Digital broadcasters (Rai-MuxA; Rai-MuxB; Mediaset1, Mediaset2; PrimaTV-Dfree; TIMB-MBOne; ReteA-AllMusic)

− 584 local broadcasters (divided in two politically strong associations).

A total of 24 000 transmitters/frequencies are today used in Italy.

7.2 Laws and Provisions for DTT

In 2001 Italian Parliament approved a law (n. 66/01 updated in 2007), which envisages the complete transition from analogue to digital terrestrial television by the end of 2012 (the previuos term for A.S.O. was 2008).

In 2004 a further law (n. 112/04), under the co-ordination of the Ministry of Communications, fixed a number of pre-operating activities which have been undertaken by the public and private Italian broadcasters. In this context RAI obligations were to implement 2 DTT Multiplexes which had to reach:

− 50% of national population coverage by the end of 2003.

− 70% of national population coverage by the end of 2004.

7.3 DTT at Present

The coverage of the digital national broadcasters is reported in Table 9 (source: MinCom –2007).

TABLE 9

DTT national broadcaster coverage

Broadcaster	Mux	Transmitters	Coverage (% Pop.)
RAI	Rai DVB A	66	71%
RAI	Rai DVB B	75	71%
RTI	Mediaset 1	373	79%
RTI	Mediaset 2	278	78%
Prima TV	Dfree	261	78%
TIMB (La7)	MBOne	155	65%
Rete A	Rete A All Music	32	50%

7.4 The "Italia Digitale" Committee

A solution to the complexity in the process of Italian digitisation, seems to be emerging from the work which has been carrying out by the "Italia Digitale" committee. In August 2006 the Minister for Communications set this national committee bringing together: broadcasters (national and local), network operators, Ministry, Authority, universities.

The goal is to define the way to achieve the national switch off for the transition to DTT service according to the results of GE06 Plan trying, where possible, to release frequencies in order to create a digital dividend.

The Committee is divided in two different groups:

– The "Steering Group" (with address purpose), chaired by the Italian Minister for Communications.

– The "Technical Group" (a group for the technical support), divided in different working groups: communication to users, data and research, assistance to users, network development and monitoring, regulatory aspects, contents and programs (for digital television).

The main task assigned to the Working Group "Network development and monitoring" (of the Technical Group), is the definition and scheduling of the so named "All digital" Areas (in which the analogue switch off has been accomplished).

7.5 The "Technical Area" Concept

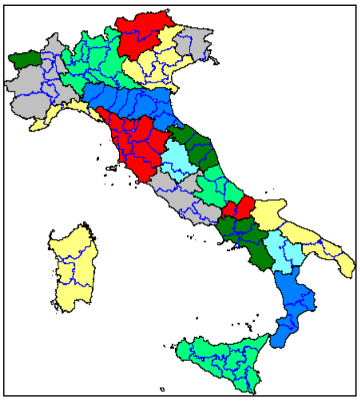
The best approach to identify the "All digital" areas appeared to be taking into account the present broadcasting network architecture. This has been done introducing the "Technical Area" concept: part of the country not necessarily limited by administrative boundaries.

In Fig. 41 is illustrated a comparison between the Italian Administrative Regions (Fig. 41a)) and Technical Areas geographies (Fig. 41b)).

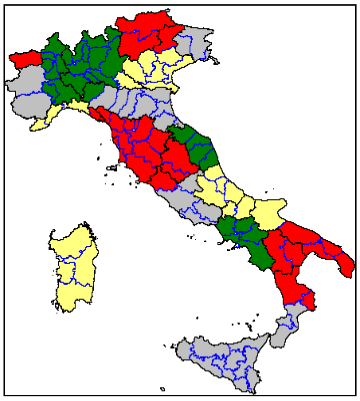
FIGURE 41

The Technical Areas

a) **The Administrative Italian Regions**



b) **The Technical Areas**



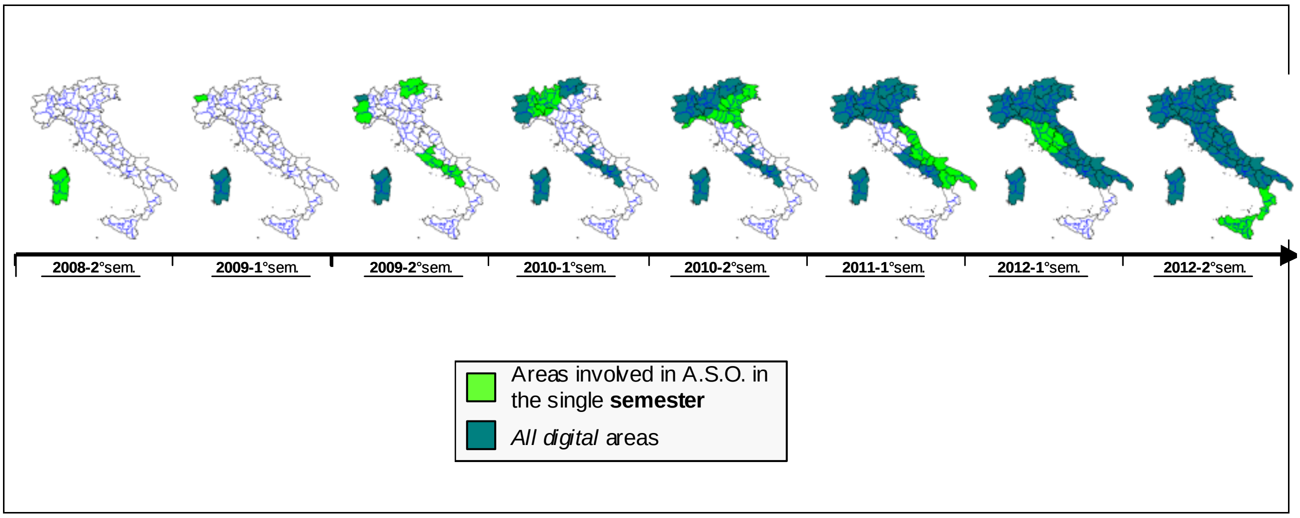
7.6 The A.S.O. Plan

The full plan for national switchover was presented on 10 September 2008 by Ministry of Communication; it is subdivided in 8 semesters as detailed in Fig. 42.

Analogue switch-off has been completed in Sardinia on 31 October 2008. In the Val d'Aosta region it will begin in the spring of 2009. The next steps will concern the provinces of Turin and Cuneo and the regions of Trentino and Alto Adige.

FIGURE 42

The 8 semesters of the A.S.O. Plan



The advantages of this approach are:

– ease in industrial decoder distribution;

– ease in direct communication to users due to the fact that the cities involved in switch off are exactly defined;

– minimization of the area with analogue-digital simulcast encouraging the technological renewal trend similarity to the allotment attribution of the GE06 Plan.

7.6.1 Development of the Plan

On 15 October 2008 at 0830 hours. Sardinia, and with it Italy, has finally entered the new era of digital television. That was the beginning of a process that ended in 31October when the whole island of Sardinia moved into digital broadcasting. Sardinia, with its 1 600 000 habitants and more than 640 000 households is now one of the largest areas in Europe that has converted to digital television.

On 10 September 2008, the Italian government, with a decree signed by the Minister of Economic Development, Claudio Scajola, and presented by the Secretary with special responsibility for Communications, Paolo Romani, presented the timetable for the final passage of the whole country to digital terrestrial television. The decree provides for a division of the gradual transition of the various Italian regions into 16 areas, which will make the transition to digital television from the second half of 2009 to the second half of 2012.

The positive experience of Sardinia confirms that switching to digital terrestrial operation benefits broadcasters, but especially users. Citizens of Sardinia, that had received 26 analogue television channels (10 national and 16 local), can now choose from a new offer of 59 free digital television channels (29 national and 30 local), well structured and accessible to all citizens.

The Val d'Aosta region in its entirety will make the transition to digital terrestrial television on May 2009. It is a historical step, which the telecommunications industry is following with great interest, and it will also be a test case because Val d'Aosta will be the first Italian region where the switch off will be done in full compliance with international spectrum coordination provisions.

The transition to digital television will free a large number of valuable frequencies in the UHF band, and these will become available to new entrants. The Italian government expects to release more frequencies in Val d'Aosta than they did in Sardinia. This will be possible because of the characteristics of the region, where the migration to digital terrestrial television is easier, as the Alps protect against interference

In the Val d'Aosta region it should be possible to use all the 55 digital terrestrial television frequencies and, and addition, a frequency dedicated to digital terrestrial radio services. In fact, the transition in the Val d'Aosta region runs ahead of schedule, since the RAI 2 and the Rete 4 networks have already made the transition to digital television in the spring of 2007. This step has encouraged the audience to purchase the decoders required to watch those networks. The same technical approach may be adopted in other regions so that the audience is prepared for the analogue television switch off.

The Italian government, at the request of the European Union, is committed to deliver a dividend in the digital TV transition from analog to digital, which will provide operators of new entrants five multiplexes, each one with the availability of 5-6 channels.

RAI and Mediaset have created a new company (48% each) and a minority stake in the hands of Telecom Italia Media. The task of the new company is to promote the development of digital terrestrial television through cooperation among the various broadcasters, but also to give birth, in June 2009, to a satellite platform called "TV Sat", that will be open to all broadcasters. This platform will re-broadcast the programmes already broadcasted by the digital terrestrial television service, in order to cover those areas that cannot be reached by the terrestrial service.

7.7 The DTT Receivers Penetration

According to the latest estimates at the end of May 2008 the number of DTT households (with at least one DTT receiver in the main family home) has risen to 5.912.000, with a net growth of 130 thousand (+2.2%) units in April ("Digital TV Monitor" survey by Makno).

Between April and May the overall number of DTT receivers increased from 6.288.000 to 6.427.196 implying a monthly growth of 140 thousand units.

7.8 40% DTT Capacity

The 2001 law n. 66 obliges Rai, Mediaset and Telecom Italia Media to handover 40% of transmission capacity to third parties. Thanks to this law in august 2008 AGCOM has received 25 programme applications from 17 different companies wishing to gain access to DTT. A special commission has to draw-up the list of channels to which AGCOM will allocate transmission capacity.

The applicants include international companies such as Disney; NBC Universal, with two requests; Swedish.

Airplus with six requests; ESPN; Turner Entertainment Networks; the English Top Up TV, and Qvc, specialized in teleshopping. There are also regional TV networks such as Telelombardia and Antenna 3 Nord Est as well as other national broadcasters: Sitcom, Class Editori, AnicaFlash (Coming Soon) and Rete Blu. Other national applicants include Infront Italy (with two requests), Archimede and finally Consorzio Alphabet, which will only be officially set-up if their application is successful.

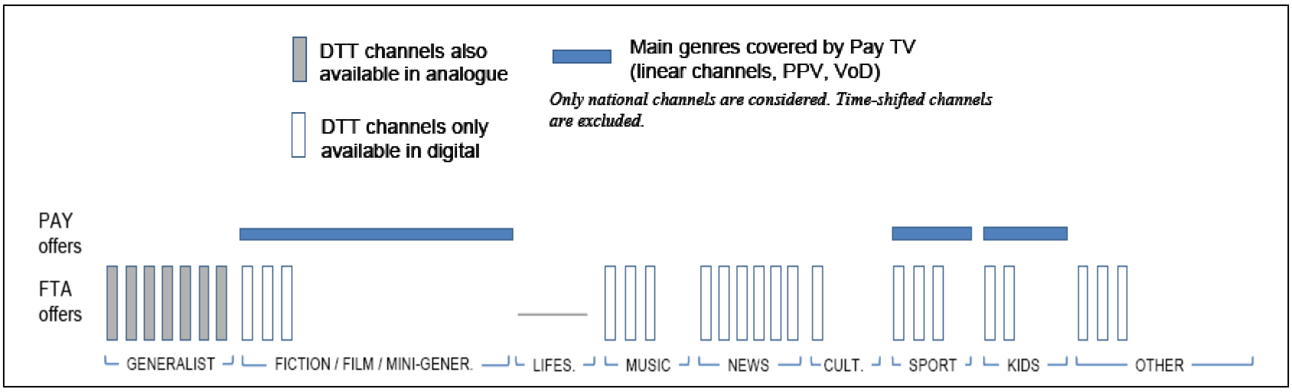
7.9 The Italian DTT Offer

Italian DTT offer includes 28 FTA national channels (including 9 terrestrial analogues) as well as Pay services. There are 6 all-news channels; 3 channels each for the entertainment, music and sports areas; kids' programmes have two thematic channels: Boing and Rai Gulp. Pay offers, including PPV, generally cover the areas of film, fiction, sports and kids (with Disney Channel's recent entry).

Moreover since June 2008 Rai has been broadcasting HD programs in the areas of Rome, Turin, Milan, Sardinia and Valle d'Aosta. The European Football Cup and the Peking Olympics were broadcasted through DTT in high quality 16:9 format on RAI 2 and on RAI Sport Più.

FIGURE 43

The Italian DTT offer (source: e-Media Institute)



7.10 Historical Considerations

Introduction

Digital Terrestrial Television in Italy existed only in project plans and in technical laboratories until late 2003. Scheduled DTT services were started in December 2003. Six multiplexes at national level are in operation, conveying in excess more than 42 TV channels. At the moment this report is being written, tens of interactive services are already available on top of audio-video services. Tens of local digital channels have become progressively available. The current coverage of population, in terms of reach of digital signals, is more than 70% in complex. Pay-per-view services, via prepaid (possibly rechargeable) smart-cards have been introduced one year after the start-up of the system, with virtually no breaking of the free-to-air, interoperability characteristics of the set top box. Four millions set top boxes are installed in the Italian households as of end of year 2006. This means that 20% of Italian households are provided of digital TV boxes. By all benchmarks this appears as a major success story, so far.

This contribution aims at describing some key factors of the Italian way to Digital Terrestrial Television:

The new value chain and the new stakeholders

Deployment of digital networks

The spread of set top boxes

The availability of audio-video contents

The challenge of interactivity, as a means to achieve t-government

The challenge of interactivity, as a means to attract revenue into the new DTT market

Cooperation and coordination of actors at national level.

The challenges at stake

The go-ahead to digital terrestrial television has given a decisive jolt to the reorganisation of television broadcasting by designing new scenarios that are modelling attractive business opportunities, new content and technological innovation on the part of all the players involved in the transition from analogue to digital.

A variety of problems have yet to be confronted and solved, as may well be imagined for an experimentation of a profoundly structural nature both in terms of the investment needed and the numbers involved. But there is great enthusiasm for the new challenge and a desire to find ample space for sharing experiences and comparing notes, as long as the switch-off date, year 2012 is reached with everything in order.

The stakes in digital are high, ranging from content to the technological capacity to create infrastructures able to sustain the change.

The passage to digital and the abandonment of analogue broadcasts will transform the traditional television set into a new, practical, interactive consumer appliance in which traditional TV functions will converge with computing and the latest applications of remote communication technologies. Remote medical consultation and distance teaching, T-government are just some examples of what digital television will be able to offer ordinary citizens. And all this will allow Italians direct access to new services directly from their own homes, instead of having to suffer long queues in public and private offices.

While television consumption used to be passive, with digital TV public interaction will become more dynamic. With analogue TV the user has to use the remote control and change programmes, while digital TV will shift the user towards a higher, more complete composition of genres.

Digital terrestrial television is therefore set for integration with new forms of social globalisation, creating new codes for the time consumed in front of the TV set. It will take on the appearance of a new medium able to guarantee connection to information and interactivity.

Feedback from viewers will become an integral part of content planning, development and organisation. And the commercial spin-off, expected to be substantial, should not be forgotten if the packaging of more complex products, with its effect on the production system, changes distribution as well.

With the introduction of digital TV also the traditional professional figures will be caused to change, such as the installers, who will tend rather to become sellers of entertainment and bits. But the broadcasters will also change, and will have the opportunity to choose whether to become just a seller of band and megabytes or to keep also the role of producers of content, which will have a knock-on effect on the entire industrial fabric and on its potential for development.

Brief history before start of scheduled DTT services

The history of DTT in Italy starts in the early Nineties, with active participation of technical experts from Italian broadcasting operators and industry in the works of the international DVB group, since the time of its formation. Digital techniques are first applied on satellite systems, where there is a more dramatic needs of optimising spectrum use, given the cost of satellite payload and the need to definitely improve quality of reception. Along the Nineties the transition from analogue to digital satellite TV takes place. Similar needs, for a more rational use of spectrum and for better quality of reception, arise for terrestrial television, leading to studying the feasibility of introduction of DTT in Italy.

In 1997, the Parliament act 249/97 establishes the Authority on communications (AGCOM), which is given the task – among others – of drafting a national frequency assignment plan. For the first time in Italian legislation, DTT is mentioned, by foreseeing an ad hoc frequency reservation for trials of this new technique. Such plan is actually issued in 1998.

In 1999 the AGCOM sets up a DTT National Committee, i.e. a Forum bringing together broadcasters, network operators, industry, universities and R&D institutes. The results of the work, carried out by four Study Groups on service requirements, network and frequency planning, architectural and costs evaluation, planning of the launching phase, are reported in the White Book published in September 2000 and submitted by the AGCOM to the Parliament. The White Book also suggests the opportunity of financial incentives for local broadcasters to free up frequencies.

In 2001 the Italian Parliament approved act n. 66/01, which, in conjunction with subsequent Acts and amendments, envisages the complete transition from analogue to digital terrestrial television (switch-off) after a predefined period of coexistence of both systems. According to this law the AGCOM elaborates and publishes at beginning of February 2003 the plan for digital television broadcasting named planning of first level.

During the following years, under the co-ordination of the Ministry of Communications, a number of pre-operating activities are undertaken by the public and some private Italian broadcasters in all Italian territory. Concertation activities and joint demonstrative trials are carried out to ascertain the feasibility of transition from several viewpoints: technical, economical, regulatory and marketing.

It is during this time that the Italian Administration, in agreement with major players in the broadcasting arena, gives a strong push to go for fully interactive digital terrestrial television (see specific paragraphs in the sequel). Interactivity has since then become a major watermark of the Italian way to digital terrestrial television.

The value chain of DTT

The analogue terrestrial television market is vertically structured, i.e. one single stakeholder, owner of the licence to transmit, covers the entire chain of production, transport, distribution and broadcasting.

In the Italian DTT market, a single stakeholder role is replaced by three roles:

– *content provider*, which is responsible for the production of audio/video services;
– *network operator*, which uses a set of frequencies to operate a network of transmission sites, through which a set of audio/video services and multimedia/data services is broadcast on a national or local level;
– *service provider*, which provides conditional access services or information services (data services).

Content providers and service providers need an authorization from the State in order to operate. Network operators need a licence.

In Italy, special emphasis has been given to interactive services, which foresee communication, through connection of the set top box to a telecom network, with servers belonging to service providers (possibly third-parties with respect to the network operator and the content provider), to exchange data of specific, personal or private interest upon request by the user. Therefore, the value chain of DTT completes with the role of *telecom operator*, as the provider of the so-called return channel. Interactive service provision requires the set up of a (possibly distributed) system called service center, relaying information among the broadcaster playout center, the application and data repositories in the domain of the service provider and the user set top box.

The above described value chain revolutionises the traditional television business model and opens up the market place to a number of newcomers, not only broadcasters, but also third-party service providers like public administrations, public utilities, healthcare establishments, schools, and so on.

The transition from analogue to digital terrestrial

Since year 2000, it was understood in Italy that an orderly and effective transition process from the analogue to the digital system could only be possible by coordinated effort of a number of stakeholder roles. In fact the process involves the following phases, to be achieved concurrently and in parallel: deployment of digital networks with progressive coverage of the population; adaptation of existing receiving antennas whenever necessary; provisioning of digital receivers in all households, availability of audio-video, multimedia and interactive contents.

Deployment of digital networks

The overcrowded Italian analogue system (the result of several stratified provisions, across more than twenty years, often introduced as patches to intricate problems) did not allow to have a given number of VHF and/or UHF channels consistently reserved in all transmission sites for implementation of as much Single Frequency Networks (SFN) as needed to broadcast DTT services. Therefore, a pragmatic approach was taken: digital broadcasting was allowed from transmission sites where frequencies would be available or could be made available by reclaiming them from the analogue domain. To this purpose, i.e. for the sake of converting usage of frequencies from analogue to digital, legal provisions have been made for *frequency trading*. Otherwise said, to build a digital network (multiplex) the broadcasters have two options: (a) buy licensed frequencies from other broadcasters; (b) convert to digital operations the so-called redundant frequencies, i.e. channels used in several areas just for little improvement of the analogue coverage.

The Parliament Act n. 66/2001 and the related regulatory package 435/01/CONS of AGCOM, plus the Parliament Act n. 112/2004 do provide the legal framework for fair trade of frequencies in the evolution towards an “all digital” scene. In this perspective, and according to the orientation of the other Member Countries of the European Union (at the moment this report is being written the furthest term for the transition from analogue to digital transmissions in Europe is established in year 2012), that legal framework is still evolving.

The situation of digital networks as of end of year 2006

By following the approach described above, national broadcasters have been able to set up digital networks, covering more than 70% of the population. By visiting the website www.dgtvi.it TV viewers can check whether their town is covered by digital signals and find out which multiplexes and from which transmission sites are available in their area. In major areas even 5 or 6 multiplexes are available.

From the side of RAI, only six months after the starting date of the digital transmissions, 80 DVB-T transmitters were already operating in the greatest Italian cities. At the moment this report is being written, more than 150 DVB-T transmitters have been achieved by RAI and are operating, for a coverage of more than 70% of the population. Two multiplexes are radiated.

Mediaset is strongly committed in experiments on DVB-T systems to accelerate the introduction of digital terrestrial television. Mediaset has 93 DVB-T transmitters operating and covers a significant percentage of the Italian population with one multiplex. All these transmitters are obtained from conversion from existing analogue ones. A similar number of digital transmitters is also planned in the near future, to further enlarge the coverage. The existing multiplex includes MHP interactive applications.

As regards other broadcasters, Home Shopping Europe is using 17 DVB-T transmitters, Rete A is using 163 DVB-T transmitters, LA7 is using 121 DVB-T transmitters and Prima TV is using 58 DVB-T transmitters.

A significant number of local broadcasters have been able to trade frequencies to be devoted to the digital exercise. Those that could not purchase such frequencies, have only one option: keep analogue broadcasting, until availability of set top boxes in their area of coverage guarantees a digital audience greater than the analogue one. Since transition regulations impose that actual digital emissions do take place, for an analogue broadcaster be enabled to apply for a long-term licence in the DTT market, the most common solution for minor local broadcasters is to reserve some lowest-audience hours of the 24hour-day for digital trials. It must be said, that the most recent transmission systems are dual, i.e. are able to toggle from analogue to digital mode.

It is obvious that for any analogue broadcasting station that closes down, the system will be able to activate at least five DTT channels. Therefore, at some stage, there should be a landslide effect in the availability of frequencies.

Adaptation of receiving antenna installations

On-field experience has shown that receiving antenna installations are, in most cases (70-80% according to different sources), directly reusable to receive the digital signals. Most interventions are related to re-adaptation of centralised installations (one single antenna serving a number of apartments), where some VHF-UHF channels may have been filtered out (to avoid interference) or ad-hoc selections of channels have been designed (like for instance in hotel installations).

Provisioning of set top boxes for the households

By encouragement from the Ministry of communications and voluntary concertation and commitment by all major stakeholders, the Italian DTT STB:

is broadcaster-independent: no hard pre-setting or customisation in the STB by any particular broadcaster;

is interoperable, i.e. works with any channel or service from any broadcaster;

has no subscription associated with it;

accommodates CA for pay-services, while remaining interoperable. CA is embedded in smart cards and in ad-hoc software add-on’s that can be downloaded as OTA upgrades.

The STB model selected in Italy, by concerted voluntary agreement among all market players, is conformant to the “interactive broadcasting profile” of DVB-MHP specification version 1.0.3 (endorsed as ETSI TS 101 812). This standard defines a hardware-independent middleware for digital broadcast services, allowing the consumer to choose their own MHP device (set-top box, digital TV set, multimedia PC, etc) and plug it in to work with their preferred digital video service operators. The conformance to the MHP platform allows users to purchase any MHP-compliant device (STB or iDTV, from any manufacturer) and receive TV programmes and interactive services from any MHP-compliant broadcaster.

Interactive services are implemented via software applications that are delivered to the client MHP-compliant device via the broadcast DVB-T channel, and they run on the middleware. Interactivity is supported through an interactive TCP/IP-based channel; the presence and the support of this auxiliary channel, at present implemented mostly as a PSTN modem, is mandatory for interactive decoders in the Italian market.

Significant is the "new" usage introduced for the remote control, since in this new context it allows the user to make with a single touch operations that actually requires the involvement of a plurality of tools and means: phones, PCs, mail, etc. The convergence over a single device opens new and interesting scenarios, since it makes more simple and intuitive for the TV user to interact at various levels and in real-time with the TV programme: it allows the TV user to navigate across an enriched and interactive TV content.

Navigation is also expedited by the association between contexts which the user can move across and related standardized colours of buttons of the remote control. Common actions are associated to standardized colours too.

Finally, the MHP platform enables the user to navigate without loosing contact with the current TV programme: this feature is provided by overlapping A/V content and graphics.

Availability of digital contents

Current availability of digital contents (audio-video services and interactive services) is reported at the www.dgtvi.it site. At the time of writing, almost 42 TV channels are available on a national basis (11 of them are simulcast of analogue ones, but most often enhanced with multimedia and interactive services; 20 are brand-new channels not available in any other platform; others are re-broadcast of satellite channels). Among these 42 TV channels, 31 are Free-To-Air channels, while 11 are for payment (usually a pre-paid event-based purchase model is applied).

Some tens of superteletext services are already available. The development of EPG, super-teletext and interactive advertising applications is ongoing, based on the DVB-MHP open API platform. Each major broadcaster has his own EPG, although there are plans for a system-wide EPG service.

Some interactive services with exchange of personal data are in place. Transactive services are in the focus of several t-government projects (see below): worth of note are some trials of t-banking services.
T-government applications (information regarding Public Administrations, payment of taxes, retirement funds) are being developed in the framework of the DTT Commission, under the auspices of the Communication Ministry.

The challenge of interactivity

Since the year 2000 the European Council has introduced the concept of *e-government*, as inclusion of public administrations and citizens in the information society. The digital terrestrial platform, powered with interactivity, has been seen as a new candidate access path to services for citizens, in addition and in complement to Internet browsing via pc and via cellular phones. The Italian government has promoted interactive digital terrestrial television as a means to overcome the divide between citizens endowed with digital multimedia devices and computers for Internet access and citizens that can only rely on traditional appliances (among which, the TV set virtually available in every household).

At the moment of writing, the Italian government is strongly committed to support the spread of connectivity and interactivity nationwide, through different media: broad band access and digital terrestrial television infrastructures are in the focus of public investments.

Service classification

Services of the information society were classified in three categories:

– **informative services**, conveying information along with audio-video programs (just like in teletext). Obviously, the only information that can be conveyed in this way, is that of general interest for the viewers. The user can "browse" through pages, by interacting by means of the remote control.

– **interactive services**, enabling users to access and manipulate data of their own specific interest, although neither private nor sensitive. Access to such data requires connecting, through a return path, to **a service center**, which in turn accesses data repositories of service providers to fetch (deliver) data requested (supplied) by users.

– **transactive services**, enabling users to access and manipulate data of their own specific interest that should be protected from unauthorised viewing and usage, either for the sake of privacy or for financial security.

Examples of informative services are Superteletext, the natural multimedia evolution of plain old teletext, and the Electronic Program Guide (EPG). Another category of informative services is broadcast by some network operators under agreement with some Public Administrations, regions or municipalities, wishing to offer portals with news of relevance for the local communities, announcement on available facilities, useful contacts and addresses, charities, etc.

An example of an interactive service is retrieving data related to a motor vehicle, from the public registrar of ACI (Automobil Club Italia): users input a plate number via the remote control and the system replies with public data such as the owner, his/her address, power of the engine, annual payable traffic fee, etc.

Speaking of transactive services, we can refer to the reservation of a medical visit, or the reading of a medical diagnose. In this case, the user should not only input his/her health insurance number but also be authenticated and authorised by the system. We can also refer to financial transactions, like in the case of on-line purchases or operations on one's own bank account. Not only for immediate and safe input of personal data, but also for the sake of data protection and security a smart-card could be used. The ability to use transactive services will enable the decoder to be a simple but powerful terminal for on-line reservations, purchase of theatre tickets, air-tickets, delivery of administrative documents, tax payment and e-commerce.

Business models for interactivity

Interactivity can boost considerable turn-over, if proper charging model and revenue sharing models (among the different stakeholders roles contributing the provision of interactive services) are devised.

As regards charging models, the prevailing attitude of service consumers in Italy is clear: services should be convenient to use and should be payable on a mere per-use base (no scheduled bills, possibly). The huge success of prepaid rechargeable SIM cards in cellular telephony is a clear proof of this statement. The success of the SMS is another example: users' willingness to pay is related to the perceived usefulness of a service in front of a nominal (micro)payment requested (although price is very high compared with the real cost of providing the service). Considering, by instance, that in 2003, the total revenue from SMS collected by Italian mobile operators was in the order of a few billion euro, it is reasonable to foresee that a comparable pattern (in frequency of usage and in the charging model) for interactive services over the DTT platform might generate a revenue figure that can compare with the current annual amount of investment on advertising through TV. Interactivity becomes then a means to inject definitely more significant resources on the new DTT system, compared with the analogue system. Even for t-government services the payment of nominal fees (in the order of a few tens of cents) for each usage might generate a cash-flow that would probably make service provision self-sustainable.

As regards revenue sharing models, one could think of the sharing model used in relation with premium-rate numbers in telephony or other similar schemes. In this case the sharing of revenue should involve the service provider, the content provider (hosting pointers to the service from within its audio-video programs), the network operator and the telecom operator.

Digital terrestrial television comes along in a special historical moment. Just after the success of GSM and SMS, just when Internet services are taking up, just when pre-paid models for charging are more and more acceptable to people. Interactive DTT inherits several assets from its analogue predecessor: user friendliness, easy of use, amount of time the average viewer spends in watching TV. It can also inherit some assets from the usage of internet, micropayment and prepaid cards.

Opportunities for local broadcasters

Local broadcasters will keep their role of providers of TV contents of local or topical interest. They can evolve into network operators at local level. The can also "go aboard" a multiplex operated by other parties and become mere content providers.

However, the area where most opportunities are offered to local broadcasters is the area of interactive services, for several reasons.

Most services are intrinsically of local scope. Imagine, e.g., reservations of museum, shows and restaurants and administrative operations with the municipalities or with the utility companies.

Local broadcasters, when operating a multiplex, are not likely to fill it with audio-video contents. They will have a huge percentage of available bandwidth in the multiplex that can be used for data services.

Interactive services already on air

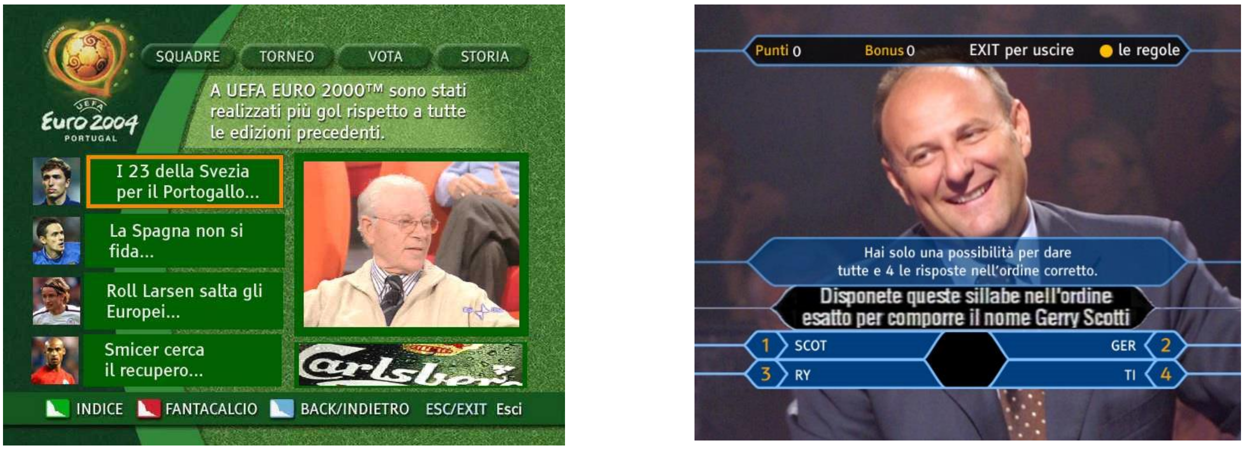
According to the above framework, new services have been designed and realized to exploit the potentials of DTT based on the MHP platform. A first range of services is:

– enrichments of news services;
– more versatile animation and graphics;
– polling applications;
– games and quiz;
– interactive advertising.

These services, that keep a strong relationship with the TV content, are called *content-related services*. In Fig. 44 some shots from real TV screens are provided as examples.

FIGURE 44

Examples of content-related (left picture, courtesy from RAI; courtesy from Mediaset)



In Fig. 45, an example of a non content-related service is reported. It is an Electronic Programme Guide (EPG) service, that provides the user with information over the whole TV offer.

FIGURE 45

Example of EPG (Courtesy from RAI)

The EPG designed for DTT allows the operator to unify the presentation layout of its offer at the bouquet level, and to customize it in respect to the other operators. It enables also the enrichment with enhanced graphics and images, and the adoption of specific creative solutions for each class of users.

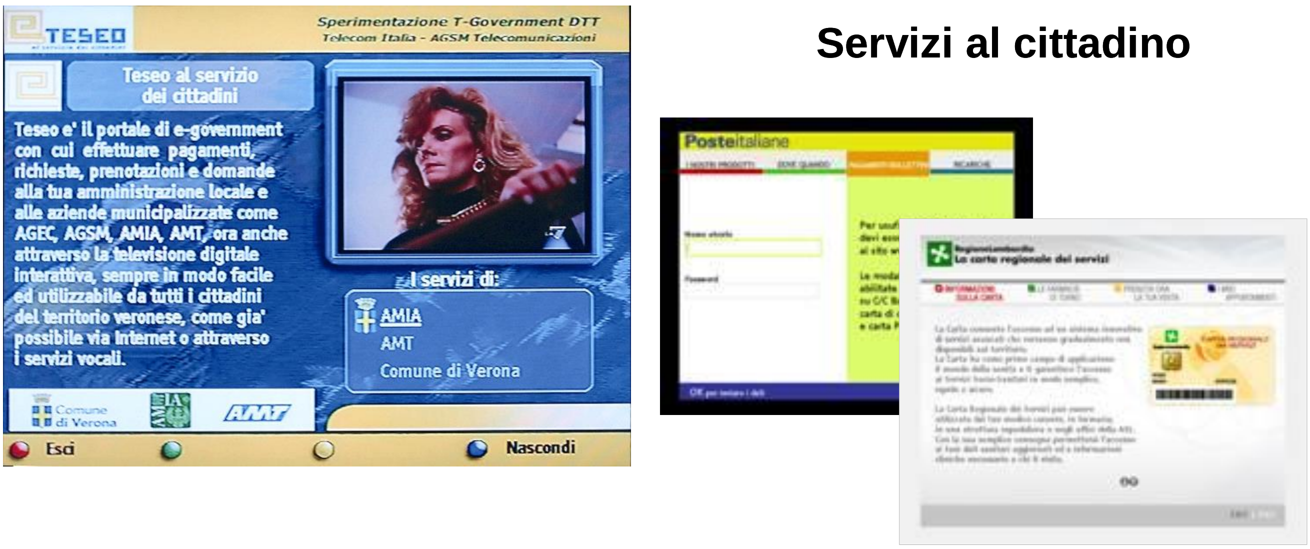
Of course, in the non content-related range of services T-Government services are included (examples of screen shots are provided in Figs. 46 and 47). This new level of interactive enables the user to gain access to services provided by a plenty of public institutions (hospitals, schools, local and central administration, …) while staying at home. Private entities, like banks, travel agencies, … are also reachable.

FIGURE 46

Examples of T-Government services offered through DTT (courtesy from RAI)

FIGURE 47

Examples of T-Government services offered through DTT (left picture: courtesy from La7. Right picture: courtesy from Mediaset)



Interactive services of the near future

The Research Centre of RAI has developed a prototype portal for T-government services to be offered through the DTT infrastructure, based on MHP platform. In particular, the present effort is focused on the user interface and on a user assistance service, including audio and video, that shall help the user in using the "new" digital TV and shall provide her information and interactivity.

Figure 48 shows a picture spilled from a demo of this new services, realized with the courtesy of a well known Italian anchorwoman.

In the effective MHP implementation of this application, A/V clips shall be delivered to the receiver through the broadcast channel, together with application code. Timing and bandwidth considerations strictly suggest to investigate the possibility of caching data on the STB, reducing consequently bandwidth allocation for this service. Present memory availability of commercial STB is not appropriate for this kind of demand, neither it's envisaged future implementation will meet the requirements whether not equipped with large capacity devices like Hard Disks.

FIGURE 48

User assistance services with a set of predefined A/V clips (courtesy from RAI)

Another interesting perspective for the evolution of DTT is offered by its integration in the context of digital home networks. A new scenario the Research Centre of RAI is exploring in the scope of some international research project is the integration of the MHP STB with the home automation network. Thus, the TV set offers a very intuitive, easy-to-use interface for handling and interacting with domestic devices while staying on the sofa. This kind of service is particularly targeted to senior citizens or people with special needs.

Still open, in particular from the point of view of mass feasibility, is the problem of interfacing MHP STBs and commercial available home automation systems. There is a lack of standardization that must be fulfilled before a mass deployment of this solution be possible, but lot of efforts are currently spent in this directions.

An important part of the Italian project for DTT is the use of DTT receivers to provide T-Government services to the citizens. For that purpose, the receivers will need to be able to interact with different smart cards issued or to be issued by the Authorities, such as:

− national electronic ID card;

− national local government service cards;

− health service cards.

The level of access to the contents of those cards is determined by:

− the security of the reader terminal (in this case the receiver);

− the security of the circumstances in which the terminal is used;

− the security of the interaction channel when a distant interaction is expected;

− the exact level of service that will be provided to the citizen.

Furthermore it is envisioned that the receiver shall also be used as a banking terminal for program acquisitions, e-commerce transactions and financial/banking transactions. The security requirements for those services are evolving, and the European Union – to foster trust in e-services - is supporting different projects to produce unified recommendations and solutions.

National level recommendations for smart cards

The protocols for those cards, and the exact security requirements for the services, are not yet fully defined. Different solutions exist at European and International levels, some standardized and other proprietary.

As a minimum, the receiver shall be compatible with:

− citizen’s service cards;

− conditional access smart cards.

This compatibility can be reached by different means:

a single smart card reader (ISO 7816) with the different protocol stacks implemented;

a smart card reader and a Common Interface slot;

a Common Interface slot populated with a smart card reader module.

In case A, switching between service card and conditional access card shall not require rebooting of the receiver or a multi-menu navigation Selection of the active conditional access may be done through the set-up menu. In case C, the smart card reader shall be provided as a default. In all cases mentioned above (A, B and C), it is recommended that the smart card reader be compatible with the EMV specification for banking terminals.

For non-CA services, the receiver shall implement the SATSA proposal by Sun Microsystems Inc., which is supported by the current MHP specification.

Public promotion of T-government projects

To encourage the uptake of T-government, the Ministry of communications and the Ministry for Innovation Technologies have launched a funding scheme for projects presented by public administration, as well as service and utility providers. Financing, overall management and supervision of projects have been assigned to Fondazione Ugo Bordoni and CNIPA. Two categories of projects are funded: (a) those privileging simplicity and effectiveness of use, by as many citizens as possible; (b) those targeting innovative solutions like authentication, authorisation of users, on-line payments (based on use of smart-cards) and always-on return path (xDSL, GPRS, UMTS). Projects are entitled to funding after passing an evaluation procedure. Real-time broadcast of developed services with real user panels is required as a working commitment for successful projects.

At the moment of writing, more than 34 millions of Euros of public funds have been assigned as co-financing to projects enforced by local administrations in cooperation with broadcasters and third parties.

RAI is actively participating, in cooperation with local administrations (Regione Emilia Romagna, Comune di Roma, Regione Lombardia and Comune di Reggio Calabria), to four projects that received a very high ranking in the evaluation procedure from the Public Authority, and for which the planned total investments (from partners and from the Government) amounts to about 6 millions of Euros.

Cooperating while competing

A key factor for the success of DTT in Italy so far has been close cooperation among all stakeholders, from the same and from different categories (service providers, content providers, network operators, telecom operators).

Cooperation has been strongly encouraged by the Government, by mandating Fondazione Ugo Bordoni (an independent research and consultancy institute closely cooperating with the Ministry of Communications for several decades), to set up the following collaborative initiatives:

− DGTVi, the association of digital terrestrial broadcasters;

− Ambiente Digitale, the association of interactive content providers and interactive application developers;

− Sistema Digitale, the association of equipment manufacturers, of middleware providers and system integrators.

It is worth noting that the above initiatives put together in excess of 100 stakeholders, thus showing that Interactive Digital Terrestrial Television has got the focus of the entire ICT sector and is considered a good business potential by a high number of enterprises in Italy.

Dgtvi (www.dgtvi.it)

This association includes four national digital broadcasters (RAI, Mediaset, Telecom Italia, D-Free), a long-established association of national and local analogue broadcasters (FRT) and Fondazione Ugo Bordoni. The main mission of the association is to promote the uptake of DTT in Italy by harmonising potentially diverging approaches, by ensuring interoperability of decoders, conformance to standards and security of OTA applications/services, and by communicating with all stakeholders of the value chain and with final users. The activity of the association results in the publication of technical specs (like for instance, the D-Book, a localised consolidation of DVB and MHP specifications for set top boxes) and in the organisation of communication events of major impact for policy makers and opinion leaders.

Ambiente Digitale (www.ambientedigitale.it)

This association includes network and telecom operators, CE manufacturers, software corporations and public bodies; and its network relies on more than 160 companies active in the digital weaving factory.

The goals of the association include the development of an application service market, new ways of interacting and browsing, the definition of best practices in DTT service design, development and offering. The association is also willing to harmonise services, applications and software platforms and user interfaces to services for better usability. Stressing the specificity of interactive DTT with respect to the WEB (too complex for most citizens) is also within the goals of the association.

Sistema Digitale (www.sistemadigitale.it)

The association aims at promoting the development of DTT devices and equipment, in the interest of the users and in respect of competition and fair interest of stakeholders. Monitoring evolution of technology, planning roll-out of new technologies, interacting with public institutions and monitoring the ICT multimedia and interactive market are also activities within the scope of the association.

Boosting the switch-over process

To boost the switch-over process, anticipated switch-off is being planned in selected areas of the country (Sardinia, March 2008, and Aosta Valley, October 2008), identified in regions that are “islands” from a geographical or an e.m. viewpoint. In these areas, named also “all digital zones” all broadcasters (national and local) will use their best endeavour to show that digital TV is within everybody’s reach and users are not going to regret analogue TV. In January 2007, the active operators in the main towns of these regions are going to definitely and simultaneously turn into digital one of their analogue TV channel each. Complete switch-off will be synchronously applied by all stakeholders. At the moment of writing, the purchase of STBs by residents of these areas is being encouraged with special provisions.

Technological evolution and perspectives beyond switch-off

High definition TV. This is no longer a dream, thank to digital encoding and transmission technology and to flat display technology. In digital technology and with MPEG-2 an HDTV channel will use 10-15 Mbit/s, thus saturating between 50 and 75% of the capacity of a multiplex. Obviously, in Italy, where there is already trouble in claiming frequencies to be converted to the digital mode, there is little chance for adoption of HDTV before switch-off. Thereafter, there should be enough bandwidth available for HDTV services.At the moment of writing, at least an HDTV trial has started on a local basis (at RAI labs in Torino, for Winter Olympics in 2006). Meanwhile, the introduction of MPEG-4/H.264 will make it possible to fit an HDTV signal in the same bandwidth that is nowadays necessary for an MPEG-2 encode SDTV signal. High definition may then become “the television” of tomorrow.

Mobile TV in handheld devices. Mobile TV via IP streaming not in GPRS/EDGE/UMTS mode, but in DVB-H mode, appears an attractive solution.With the adoption of DVB-H a major step towards full convergence of TV, mobile telephony and Internet will be achieved. The terminal has two radio interfaces, in the GPRS/EDGE/UMTS spectrum range and in the DVB-H range. Reception of broadcast audio-video programs occur through DVB-H, while reception of video on demand and specific and private data exchange occur through UMTS. DVB-H experiments have been launched in late 2004 in Italy (primarily, at RAI research labs in Torino). At the moment of writing, DVB-H technology-based consumer services have been made commercially available from major mobile phones operators.

From the viewpoint of business we will experience a further widening of the value chain. Video content providers will not intervene only in the broadcast chain, but also in the return channel. Mobile operators may become content providers on the DVB-H interface too. Digital right management will become a major issue, in order to preserve motivation in the production of contents of good quality.

8 Japan

8.1 History in Brief

The digital broadcasting system was discussed in Japan by the Telecommunications Technology Council (TTC) of the Ministry of Post and Telecommunications – MPT (current MIC: Ministry of Internal Affairs and Communications), and detailed technical matters have been discussed at the Association of Radio Industries and Businesses (ARIB).

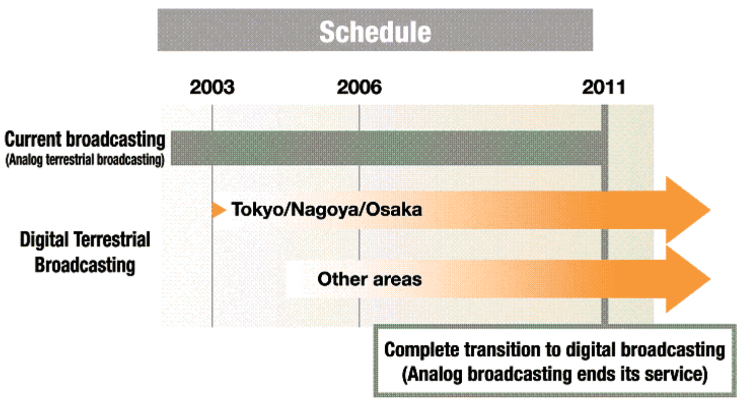
ISDB (Integrated Services Digital Broadcasting) is an emerging digital broadcasting concept. With ISDB, everything is handled digitally. The three kinds of systems, ISDB-S (Satellite), ISDB-T (Terrestrial) and ISDB-C (Cable) were developed in Japan to provide flexibility, expandability and commonality for the multimedia broadcasting services using each network.

Based on the results of field trials, ISDB-T system was found to offer superior reception characteristics; and consequently, the ISDB-T system was adopted in Japan as the digital terrestrial television broadcasting (DTTB) system and digital terrestrial sound broadcasting (ISDB-T_{SB}) system in 1999.

8.2 Time schedule for digital terrestrial television

Figure 49 shown below presents the time schedule for Digital Broadcasting in Japan.

FIGURE 49



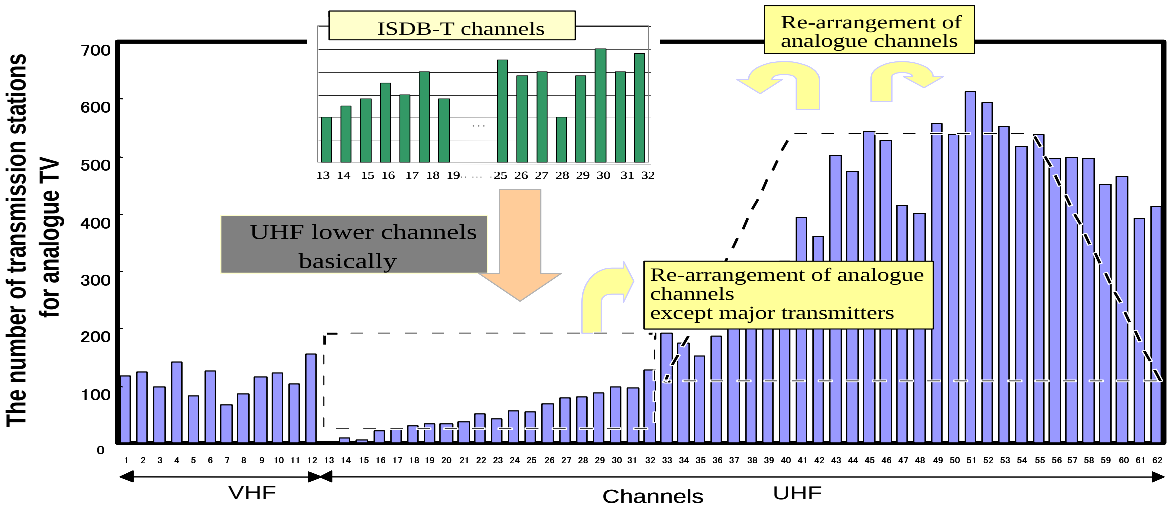
Digital terrestrial broadcasting was launched in December 2003 in Tokyo, Osaka and Nagoya metropolitan areas. In addition, digital terrestrial broadcasting has started at the main cities in all other prefectures as of the end of 2006. The service areas become wider step by step. Analog terrestrial television broadcasting will be terminated in 2011.

8.3 Frequency Situation

Analog terrestrial broadcasting utilizes MFN (Multi-Frequency Network), a transmission scheme that uses a different transmitting frequency in each service area. MFN with many transmitting stations is a solution for delivering programs to the national audience without causing harmful radio interference among service areas. Approximately 15,000 transmitting stations for analog terrestrial television broadcasting were constructed throughout Japan. So there are not enough frequencies for digital television broadcasting.

The Japanese Government is undertaking a huge program which will cost around 180 billion Yen (approx. 1.8 billion US $) to move a quantity of analog television stations to the upper part of the spectrum in order to free up the frequencies for digital television.

FIGURE 50



8.4 TV channels in Tokyo

Nine digital TV channels are transmitted from Tokyo tower.

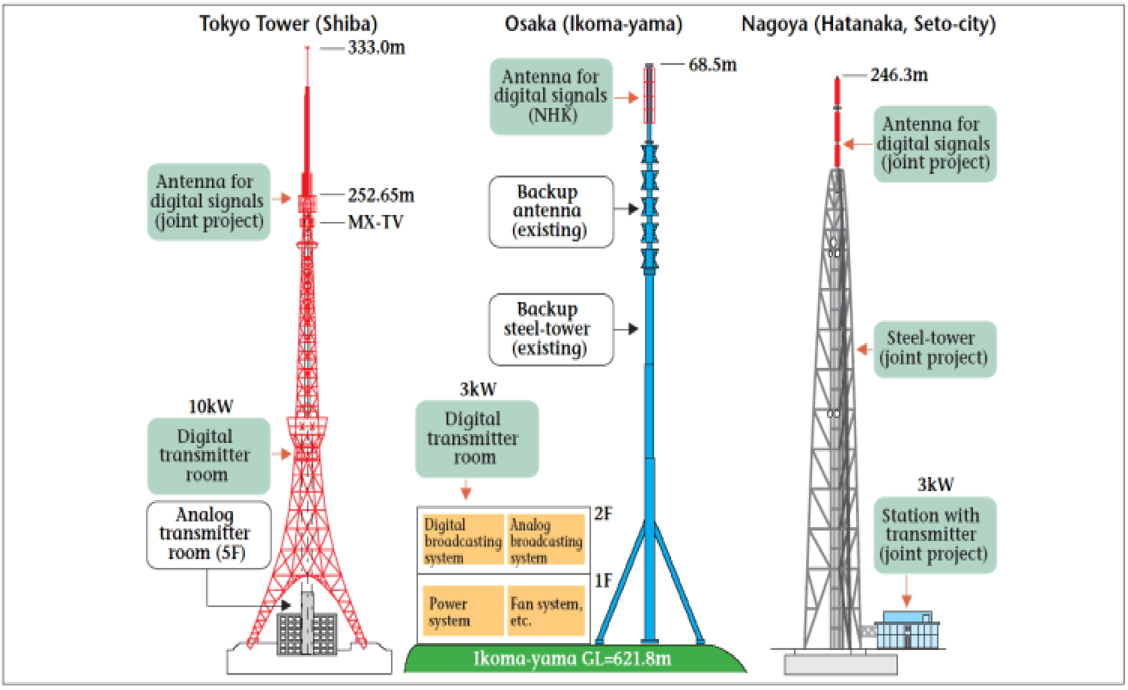
8.5 Transmission Antennas

In the Tokyo area, broadcasters have placed new antennas at a height of 250 m on Tokyo Tower. A transmitter room was built under the tower's large observatory. In the Nagoya area, a new facility with a 246-m steel tower and a broadcasting station has opened in Seto city. In the Osaka area, broadcasters installed antennas on their own towers. An overview of these facilities is shown in Fig. 52.

FIGURE 51

Nine ISDB-T channels in Tokyo area

FIGURE 52

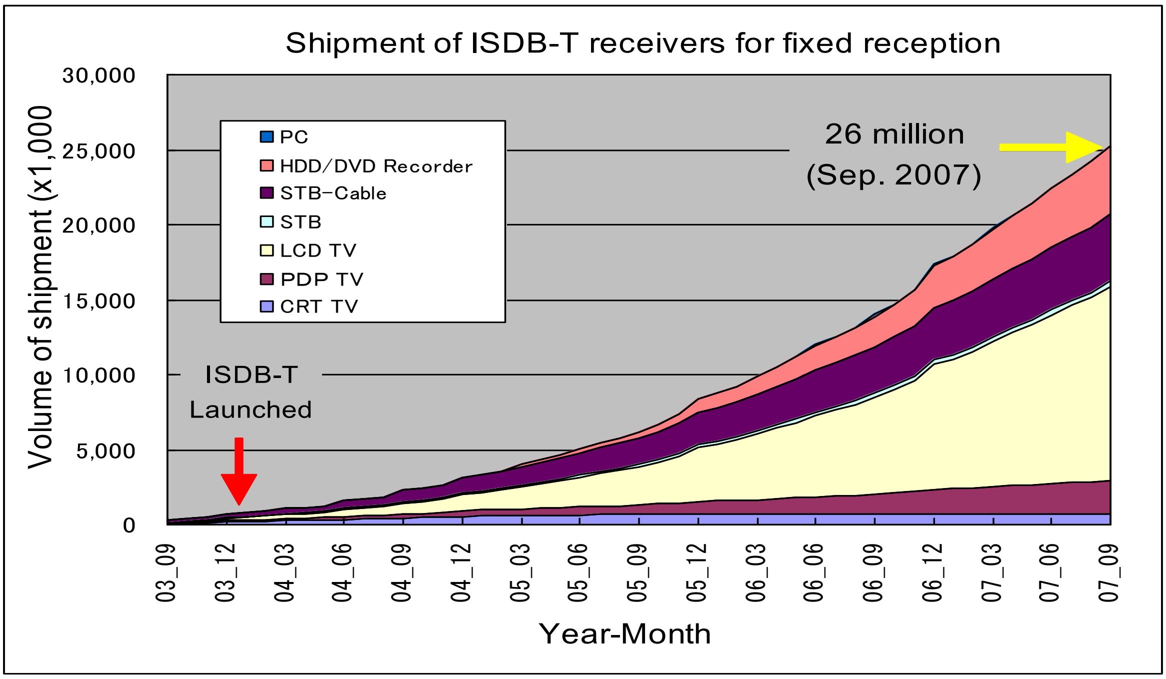


Tokyo/Nagoya/Osaka digital transmitting facility overview

8.6 Shipments of ISDB-T receivers in Japan

Although digital terrestrial broadcasting started only approximately 4 years ago (December 2003), over 25 million ISDB-T receivers have been shipped to date (50 million households in Japan).

FIGURE 53



8.7 Technical Characteristics of ISDB-T

The system compatibility between digital television and digital sound broadcasting is taken into consideration in ISDB-T. ISDB-T with full segments serves digital terrestrial television broadcasting and ISDB-T$_{SB}$ using one segment or three segments serves digital terrestrial sound broadcasting.

ISDB-T is also capable of providing data broadcasting consisting of text, diagrams, still pictures, and video image for handheld devices, in addition to high quality pictures and stereo sound. In contrast with digital satellite broadcasting, it is able to feature detailed local interest information. Furthermore, it has great potential to diffuse information to mobile multimedia terminals, such as car radios and pocket-sized receivers.

The following requirements were considered in the development of ISDB-T.

It should:

– be capable of providing a variety of video, sound, and data services;
– be sufficiently robust to any multipath and fading interference encountered during portable or mobile reception,
– have separate receivers dedicated to television, sound, and data, as well as fully integrated receivers,
– be flexible enough to accommodate different service configurations and ensure flexible use of transmission capacity,
– be extendible enough to ensure that future needs can be met,
– accommodate single frequency networks (SFN),
– use vacant frequencies effectively, and
– be compatible with existing analog services and other digital services.

To comply with all the specified requirements ISDB-T made use of a series of unique tools such as the OFDM modulation system associated with band segmentation, which gives the system great flexibility and the possibility of hierarchical transmission, time interleaving which contributes to achieving the necessary robustness for mobile and portable reception besides giving the system powerful robustness against impulsive noise and TMCC (Transmission and Multiplex Configuration Control) which allows dynamic change of transmission parameters in order to set the system for optimized performance depending on the type of broadcasting (HDTV, mobile reception, etc).

These unique characteristics make ISDB-T able to provide a wide range of applications such as those presented in the next chapter.

8.8 Applications on ISDB-T

In this section some examples of applications on ISDB-T are shown.

HDTV program in 6 MHz

A HDTV program requires 6 MHz bandwidth.

FIGURE 54

Multi SDTV programs in 6 MHz

Three SDTV programs require 6 MHz bandwidth.

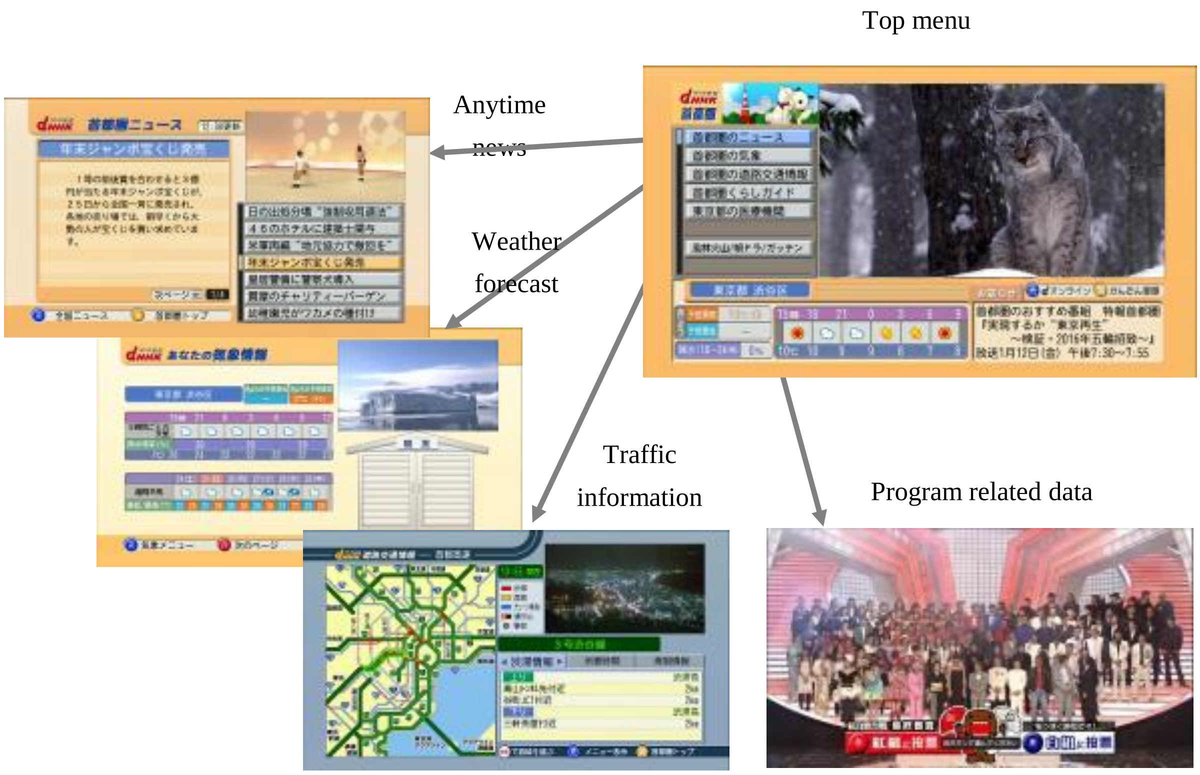
FIGURE 55

EPG (Electronic Program Guide)

An Electronic Program Guide which presents program guide information in table form enables a user to quickly and seamlessly go from a TV channel selection mode to a TV program selection mode.

FIGURE 56

FIGURE 57



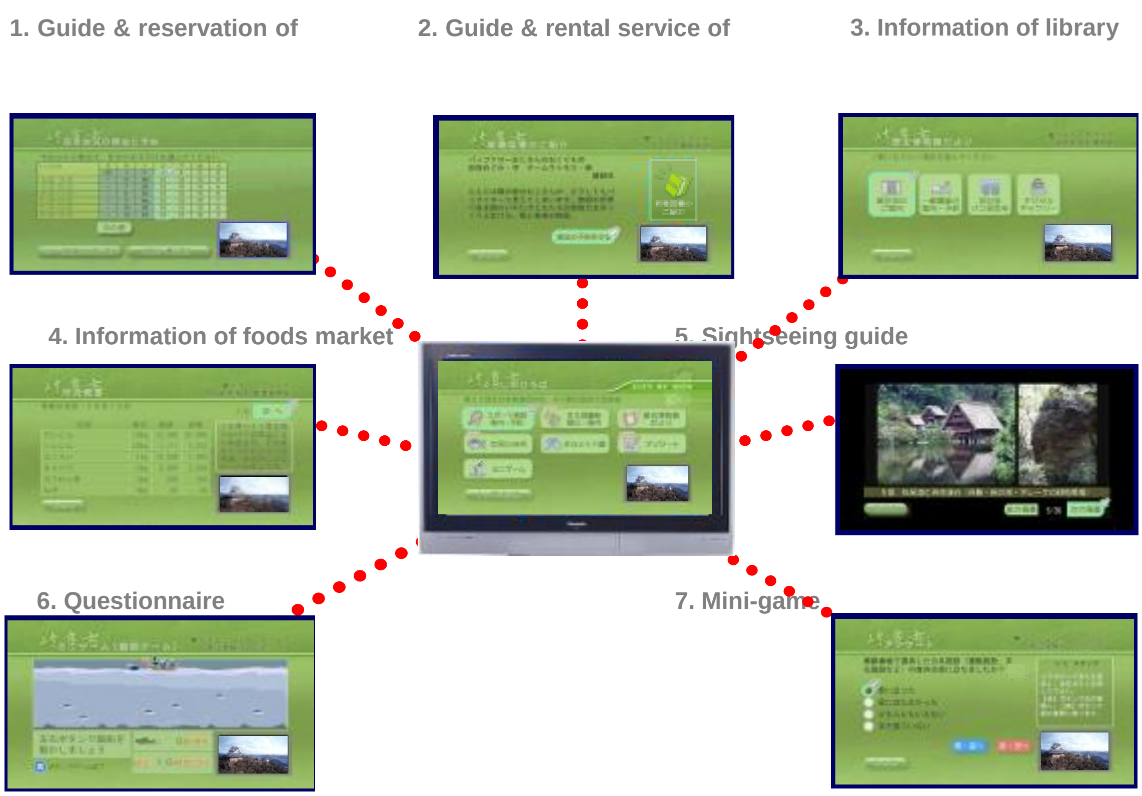
Data broadcasting

Data broadcasting provides a variety of information such as anytime news, weather forecast, traffic information and program related data.

Internet access

All ISDB-T receivers can access to the Internet.

FIGURE 58



HDTV Mobile reception

HDTV program broadcasted through the ISDB-T system can be received even in mobile reception. Several car receivers are on the market.

FIGURE 59

One-Seg service : TV service for handheld/portable receivers

One-Seg TV service for cellular phones or portable TV receivers was launched in April 2006 in Japan. Such a terminal with a communications link is able to receive network-linked data broadcasting.

FIGURE 60

Human-friendly broadcasting services

Digital broadcasting has a variety of forms, from textual data and diagrams to regular video and audio data. It is intended to exploit this diversity to provide human-friendly broadcasting services that would be accessible to everyone, including the elderly and people with physical impairments.

FIGURE 61

8.9 Outline of ISDB-T transmission scheme, and related ARIB standards, ITU-R Recommendations

TABLE 10

Item	Contents	ARIB standards	ITU-R Recommen-dations
Video coding	MPEG-2 Video (ISO/IEC 13818-2)	STD-B32	BT.1208
Audio coding	MPEG-2 AAC (ISO/IEC 13818-7)	STD-B32	BS.1115
Data broadcasting	BML (XHTML), ECMA Script	STD-B24	BT.1699
Multiplex	MPEG-2 Systems (ISO/IEC 13818-1)	STD-B10, STD-B32	BT.1300, BT.1209
Conditional access	Multi 2	STD-B25	—
Transmission	ISDB-T transmission	STD-B31	BT.1306 System C
Channel Bandwidth	6MHz, 7MHz, 8MHz		
Modulation	Segmented OFDM (13 segment / ch)		
Mode, guard	Mode : 1, 2, 3 Guard Interval ratio : 1/4, 1/8, 1/16, 1/32		
Carrier Modulation	QPSK,16QAM,64QAM, DQPSK		
Error correction – Inner	Convolutional code (Coding rate : 1/2, 2/3, 3/4, 5/6, 7/8)		
Error correction – Outer	(204,188) Reed-Solomon code		
Interleave	Frequency and time interleave Time interleave : 0 - 0.5 sec		
Information bit rate (depends on parameters)	6MHz : 3.7 – 23.2 Mbit/s 7MHz : 4.3 – 27.1 Mbit/s 8MHz : 4.9 – 31.0 Mbit/s		
Receiver	ISDB-T receiver	STD-B21	—
Operational guideline	ISDB-T broadcasting operation	TR-B14	—

8.10 Emergency warning by broadcasting

Early warning against massive natural disasters such as earthquakes, tsunami, hurricanes and volcanic activity, is a very effective measure for those who may suffer from the effects. Emergency warning by broadcasting is very effective to inform many people of the event and its related information for defending their lives and properties from disaster. In this chapter some emergency warning systems using broadcasting are shown.

8.10.1 Automatic activation of handheld receivers by EWS (Emergency Warning System) signals (See Recommendation ITU-R BT/BO.1774)

The Emergency Warning System (EWS) described in Recommendation ITU-R BT/BO.1774 enables a public warning to be made in the case of emergency due to disasters etc. through analog radio and/or analog TV sound channels. As analog broadcasting is one of the most widespread broadcasting services, it is quite effective to make the public warning using this method.

Digital terrestrial broadcasting has an emergency warning mechanism similar to that of analog broadcasting. Broadcasting differs from communications in that it can send information to a large number of handheld receivers at the same time. The ability to activate handheld receivers to receive emergency information would lead to a reduction in the damages caused by a disaster. For this to be effective, a handheld receiver would have to be in constant stand-by mode for the EWS signals, but if the power consumption were too high, it would be difficult to maintain stand-by for a long time.

To solve this problem, a low-power-consumption EWS signals stand-by circuit that can maintain stand-by for the digital terrestrial broadcasting EWS signals has been studied.

Figure 61 shows handheld receiver activation using EWS signals of digital terrestrial broadcasting.

An EWS signal is indicated by bit 26 of the TMCC (transmission and multiplexing configuration control) signals comprising 204 bits in System C of Recommendation ITU-R BT.1306-3. In the case of Mode 3 (number of carriers: 5,617), the number of TMCC carriers is 52 in total for 13 segments, or four carriers per segment. The TMCC signals modulated by differential binary phase shift keying (DBPSK) are transmitted at an interval of approximately 0.2 s.

To achieve remote activation, the EWS signals in one or more TMCC carriers are to be continuously monitored by each receiver. Furthermore, continuous monitoring shall be achieved without substantially shortening the stand-by time of handheld receivers. To reduce the power consumption, a dedicated stand-by algorithm is introduced that:

a) extracts only TMCC carriers, and

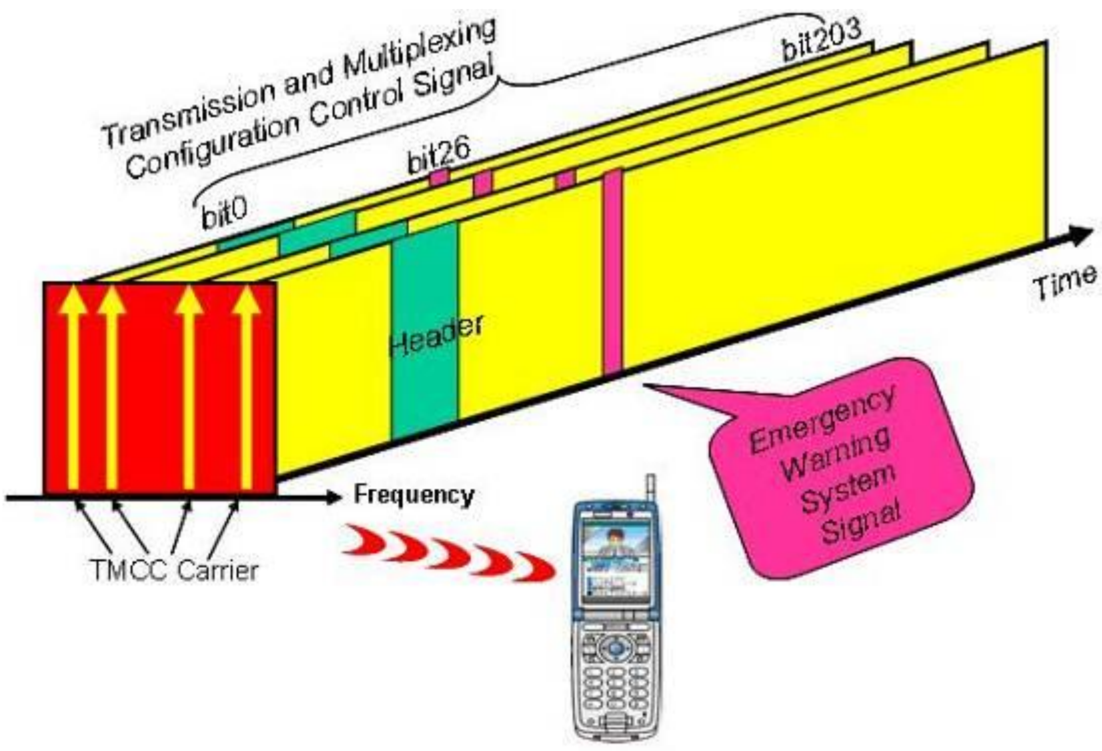
b) monitors only the EWS signals by limiting time slots.

The function for EWS stand-by with very low power consumption has been verified.

The remote activation technique which uses the EWS signals in TMCC can also be applied to the fixed receivers in System C of Recommendation ITU-R BT.1306-3. Many existing TV receivers are able to receive the EWS signal. In the case of analog TV receivers, they turn on automatically when the TV receiver detects the EWS signal even if the switch is off, and the viewer can obtain the urgent information. However, digital TV receivers can receive this signal only when the switch of the TV receivers is turned on under the current situation. Fundamentally, the operation when the EWS signal is received is established by the product specification of each manufacturer.

FIGURE 62

Handheld receiver activation using EWS signals of digital terrestrial broadcasting



8.10.2 Earthquake and Tsunami information services via data broadcasting

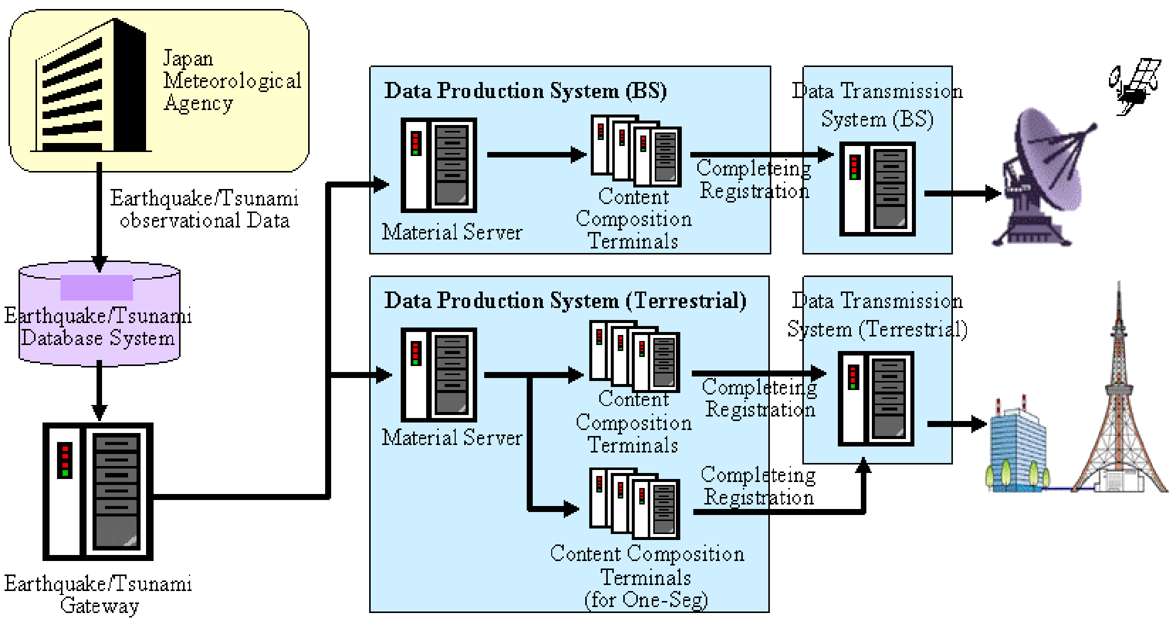
In January 2007 Japan began offering earthquake and tsunami information via data broadcasts, using three delivery media—BS (broadcast satellite) digital broadcasts, terrestrial digital broadcasts, and terrestrial digital broadcasts for mobile receivers (One-Seg). The features of this new "earthquake and tsunami information" service are that it enables people to get information about earthquakes that have just occurred or past earthquakes, and to rapidly learn of any impending danger due to a tsunami following an earthquake.

The content of "earthquake and tsunami information" via data broadcast is based on the information obtained from the Japan Meteorological Agency (JMA). The data broadcast content production system (hereinafter "production system") processes data received from outside the station and automatically produces content in BML format*. The content that is automatically generated by the production system is registered to the data broadcast transmission system and then broadcasted. Earthquake and tsunami information is also produced automatically.

In the case of "earthquake and tsunami information" content, data delivered to the broadcaster from the JMA is first received by the "earthquake tsunami database system" which is commonly used by broadcasters for managing earthquake and tsunami information. Then, data is transferred to the "earthquake tsunami gateway (GW)" which is a dedicated system developed for "earthquake and tsunami information" content. The GW converts the data to data broadcast-ready format and sends it to the production system. Thus, content is produced automatically. The system configuration for "earthquake and tsunami information" service is shown below.

FIGURE 63

System configuration for earthquake and tsunami information



The "earthquake and tsunami information" service consists essentially of six kinds of screens. These are "Earthquake occurrence notification," "Latest earthquake information," "Most recent earthquakes," "Tsunami Warnings/Advisories," "Tsunami- Related earthquake information," and "Tsunami monitoring information." At the bottom of each screen are buttons for moving to other screens, and viewers can use a remote controller to switch between any of these screens.

* BML is an XML-based data content format as described in Recommendation ITU-R BT.1699, originally developed by the ARIB.

Within a month of the commencement of earthquake and tsunami information services in January 2007, there were five occurrences of earthquakes of intensity 3 or higher, and information on these earthquakes was delivered via data broadcasts. On each occasion, the automatic production function to enable data broadcasts immediately after they occur worked effectively to enable the earthquake information to be broadcast rapidly. Due to the large volume of information involved in reporting earthquake magnitudes for areas throughout Japan, on regular TV services viewers sometimes fail to see the information relevant to their areas of residence. The data broadcasts, in contrast, were found to be extremely useful, because they enabled people to display relevant information after the broadcast was made, using their remote controllers. So the service is very helpful for this reason, too.

8.10.3 Broadcasting earthquake early warning

The Japan Meteorological Agency has introduced an Earthquake Early Warning system, which can alert people to an approaching earthquake upon detecting its initial small-scale vibrations (Primary waves) and by getting an estimated fix on its epicentre and magnitude (scale). The system can predict such factors as the amount of time remaining until the arrival of the earthquake's main and potentially destructive vibrations (Secondary waves), and the intensity (degree of jolting). The Agency will issue an Earthquake Early Warning in the event the earthquake is likely to have a minimum intensity of 5 on the Japanese scale of intensity which runs from 0 to 7, alerting people that they can expect severe jolting within the next several or fifty or so seconds' time.

Japan Broadcasting Corporation (NHK) has developed a system for relaying the alerts issued by the Meteorological Agency. The system, which commenced operation on 1 October 2007, can relay alerts nationwide via all of NHK's radio and television channels.

Any Earthquake Early Warning issued by the Meteorological Agency must be conveyed to the public promptly and in a readily intelligible format. The system adopted by NHK for relaying such alerts is characterised by the following features:

1 *Alerts are broadcasted on all NHK radio and television channels*

Any alert is simultaneously broadcasted on all twelve NHK radio and television channels.

2 *The alerts are fully automated*

Speed is essential, which means a fully automated system is in place for relaying an alert the moment it is received from the Meteorological Agency, without any decision or intervention from a member of NHK staff.

3 *A special chime sounds in the event an alert is being issued*

A distinctive chime sounds and a CG (computer Graphics) appears on the television screen when an alert is being issued. The CG provides a map and lists the names of the prefectures that can expect jolting.

The alert is superimposed on all nationwide and local NHK TV broadcasts.

On NHK radio stations, an alert issued from Tokyo will interrupt all nationwide and local broadcasts. The warning chime is followed by a synthesised voice announcing the prefectures that can expect seismic jolting.

9 Russian Federation

Strategy basics for transition from analogue to digital broadcasting within an individual region (based on the experience of introduction of DVB-T broadcasting in the Primorsky region of Russia)

Modernization of a regional broadcasting network aims at updating the transmission firmware of the TV and radio broadcasting network in a region, expanding the range and list of services provided by the broadcasting operator to the users, increasing revenue for the operator and effecting a phased transformation of such an operator into an information package provider for the region allowing both commercial and social problems to be solved.

Overall strategy of updating the regional TV and radio transmission network and transition to digital broadcasting in the region

As a rule the degree of wear of analogue transmitters operated in the region is pretty high. The useful life of many transmitters is already over. Replacement of worn-out analogue transmitters by new analogue equipment appears senseless both from the technological and economic point of view, as in the transition to digital broadcasting it will be necessary to replace such new transmitters again with digital ones, this time long before the end of their useful life. Besides, one cannot see any ways of compensating for such replacement costs as analogue broadcasting in principle cannot support the new information services and products that the population would be prepared to buy and that could generate additional revenue for broadcasting operators. In this connection it seems worthwhile making the transition to digital broadcasting in the region without delay.

It is evident that transition to digital broadcasting should be effected within the framework of current frequency arrangements, that is digital TV programmes should be broadcast in the same frequency bands as analogue broadcasting formerly. This means that overnight transition to digital broadcasting should be accompanied by stopping analogue broadcasting of the same programmes within the coverage area where such transition takes place.

It goes without saying that overnight transition to digital broadcasting is not possible without equipping the population with digital receivers, i.e. subscriber set-top boxes (STBs). Transition to digital broadcasting can only be effected provided that every subscriber has such an STB, so that in the transition process no small group's interests suffer. A broadcasting operator is not responsible for the provision of STBs to the population. Without going in detail on the organization of such provision one should mention that this problem must be solved through local funding under a comprehensive target programme implemented by the regional administration with the help of private investments. Thus the financial burden should be distributed between the commercial structures of the region the overwhelming majority of which is interested in new advanced interactive multimedia infocommunication services and products (including e-commerce and e-banking systems) supported by digital broadcasting. Introduction of such systems within a united regional information system (to be described below) may give a powerful impetus to business development in the region with the corresponding growth of commercial structures' turnover and revenues.

As for providing STBs for digital broadcasting to the population, this should be done according to a uniform schedule approved by the administration and coordinated with the broadcasters in one transmitter broadcasting coverage zone after another. Under the schedule, STBs should be provided to all rather than part of the people residing within one coverage zone, then another and so on. This will ensure the possibility of making a final transition to digital broadcasting in the region successfully. The STBs themselves are multipurpose interactive terminals capable of supporting a wide range of modern interactive information services and products besides broadcasting.

It is clear that transmitters replacing the old worn-out analogue ones should be hybrid, i.e. equally capable of operating both in analogue and digital broadcasting mode. At the first stage such a newly installed transmitter will operate in analogue mode. Later on when the population in the coverage zone is 100% equipped with STBs the transmitter will go over to digital mode with the DVB-T modulator switched on and the driver replaced (it is desirable to have both devices supplied in a complete set with the transmitter). It goes without saying that at the first stage the transmitter will broadcast only those programmes that used to be broadcast for the given coverage zone in analogue mode. Thus the next problem that arises is of most importance for urban areas where several TV programmes can be received within one coverage zone. In each broadcasting zone several analogue programmes broadcast by different transmitters may be received. Digital broadcasting is multiprogram, i.e. one digital transmitter will broadcast all those programmes that used to be broadcast by several analogue transmitters. Thus only one “head” analogue transmitter should be chosen out of the group for the coverage zone to be replaced by hybrid equipment. The transmitter should be connected with MPEG-2 signal feeder lines for all the TV programmes broadcast for the given coverage zone. All the signals should be joined together in a multiplexer into an MPEG-2 transport flow and fed into the DVB-T modulator. After this the transmitter may be switched over to the digital broadcasting mode and the analogue broadcasting of other transmitters may be stopped and dismantled.

It is clear that transition to digital broadcasting should entail an increase in the number of programmes provided to the population. As a result the situation should emerge when the regional programme package (i.e. all the programmes that are currently broadcast to at least part of the population of the region) will be accessible to every TV viewer. Of course with time the package should be expanded gradually with new commercial programmes (including pay programmes) and with free regional programmes of social and informational importance. To achieve this it is necessary to solve the problem of constructing a full regional network of TV programmes supply and distribution, i.e. when each programme received in the region via satellite channels or produced in the region itself would be supplied to every transmitter (or a group of transmitters) operated in the region. The problem can be best solved on the basis of a fibre-optic line laid in the region and running through its major populated areas. Fibre-optic line branches, i.e. TV programmes supply lines to other populated areas of the region, should be based on the exiting radio relay lines or MMDS systems. Moreover the radio relay lines must be updated to transmit digital data streams. This can be done through using modems and MUXes ensuring the transmission of digital data streams along the existing radio relay lines at the rate of 51 Mbit/s. The equipment will digitize the radio relay lines and at the same time the UHF equipment installed will remain intact. In many cases MMDS systems can also be used to bring digital broadcasting programmes to home cable networks. Naturally to expand the digital broadcasting programmes package broadcast to the population it is necessary to install some additional digital transmitters. However it is important that reception of digital broadcasting programme packages from several DVB-T transmitters by outdoor antennas in many cases may be ensured without amending the existing home cable networks.

The regional programme package may be expanded both through increasing the number of programmes made up in the region itself and through receiving more programmes via satellite communication channels.

Stages of comprehensive modernization of the regional TV and radio broadcasting network

Thus with the above approaches the following stages of comprehensive modernization of the regional TV and radio broadcasting network for transition to digital broadcasting can be defined:

– distribution of DVB-T STB to the population. STB manufacture funding may be effected within a target programme of the regional administration funded by regional investors. The STBs should be multifunctional interactive terminals supporting a wide range of modern multimedia services and products along with broadcasting;
– choosing a "head" transmitter out of the operating ones in each broadcasting zone to be replaced by a hybrid unit (with analogue broadcasting at the initial stage) with digital signals of all the programmes broadcast in the area fed to the latter;
– starting digital DVB-T broadcasting of those programmes that used to be analogue from the head transmitter, stopping analogue broadcasting and dismantling all the other transmitters in the broadcasting zone with the process going on in one broadcasting zone after another as these are ready for the change;
– constructing a regional TV programmes supply and distribution network on the basis of fibre-optic lines and digital radio relay lines, MMDS and cable lines used in the "last mile" section;
– as the regional distribution network is expanded bringing the regional TV programme package (i.e. all the programmes coming to the region via satellite channels and all the regional programmes) to each populated area in the region, with further expansion of the range of such programmes, including new regional ones (regional TV, commercial programmes); installing new DVB-T transmitters;
– on the basis of digital TV broadcasting, organizing data transmission (including web and web-type multimedia services) from the very beginning of digital TV broadcasting to provide to the population modern infocommunication services and products, both socially-oriented and commercial;
– introducing interactive products from the very beginning of digital TV broadcasting, primarily web and web-type services on TV broadcasting basis;
– constructing in the region a united interactive information multimedia regional network on the basis of subscriber's STB with an interactive platform specially designed to take care of the region's needs and interests and a uniform system of conditional access chosen upon agreement reached between digital broadcasting operators.

Further development of the TV and radio broadcasting transmission network in the region, expansion of the range of services and network functions through interactive servicing and provision of multimedia services

Transition to digital broadcasting is not the end of TV and radio broadcasting transmission network modernization. It goes without saying that more TV broadcasting programmes will bring more revenue for broadcasting operators. However, the largest source of higher revenues is in the sphere of provision of a wide range of modern infocommunication services and products on the broadcasting basis to corporate and individual users. Technologically this can be achieved through encapsulation of multimedia data streams (including web and web-type services data) into TV broadcasting digital flows. Reception of the above services and their data display on the TV screen will be done with the help of digital TV broadcasting STBs. The same STBs with their software and firmware support return channels organized on telephone lines (on the basis of built-in dial-up modems) or with xDSL facilities or, provided there are home cable lines, HFC (hybrid fibre cable) on the basis of the DOCSIS standard (built-in or external DOCSIS modems connected with the STBs by Ethernet interface).

Overall description of information and interactive services and products based on digital TV broadcasting. The initial stage of introduction of the services in the region

Enhanced TV and interactive TV are principally new TV broadcasting services that can only be provided on the basis of digital broadcasting. The concept of enhanced TV envisages pay services with a coded signal that requires using smart cards and conditional access systems. Private companies leasing equipment from the operator may provide such services to the population under subscription for pay packages. Moreover the possibility of free reception of the social programmes package (both national and regional) by the population remains.

Enhanced TV envisages the technology of pseudo-interactive DVB-T services without a return channel. These include various information services and reference materials, such as TV – the press, weather forecasts, ratings, advertisement channels, etc. In transition to digital broadcasting such services may be provided at once in those populated areas of the region where there is a shortage of telephones and where it is yet impossible to organize a return channel for full-scale interactive service.

In the towns of the region with sufficient telephone penetration, interactive systems may be deployed on the basis of a return channel on a telephone line. A return channel can support various e-commerce services, on-line shops as well as rating votes and population polls that are important socially and may be needed by the regional administration. At the same time high-rate access to the Internet on dedicated digital DVB-T channels may be provided. For this a TV viewer will not need a PC as in this case its function will be performed by the STB for digital broadcasting: it will display web pages on the screen after appropriate reformatting and rescaling of text and graphic objects in web pages in a way allowing their display on the screen of a standard definition TV set. The web browser is operated with the help of a cordless keyboard. Connection does not require any additional time, as the Internet channel is permanently available. In fact the service is a factor of new quality of life, as television becomes a powerful information gateway concentrating most advanced information technologies that enable any person regardless of his or her age, education and social status to be a full-scale member of the global information infrastructure without buying a PC, just with the help of a familiar TV set. The digital TV broadcasting STB supports the Internet access and e-mail functions.

At the next stage of deploying a digital TV broadcasting system in the region it becomes possible to extend the interactive services to remote rural areas with insufficient telephone penetration. This becomes possible through using return channel cordless DVB-RCT technology.

Construction of a united interactive multipurpose information system on the basis of digital TV broadcasting in a region

If there are return channels, the following interactive infocommunication services may be provided on the basis of digital TV broadcasting to corporate and individual users:

- access to the Internet without using a PC;
- e-trade;
- e-commerce;
- management of a bank account, including execution of commercial transactions at a distance using a digital signature;
- e-system for ordering municipal services;
- communal utilities payment e-system;
- services base on “video-on-demand” technology;
- cottage industry e-systems;
- e-health;
- e-learning systems;
- virtual CD-ROM;
- web games.

All together the above-listed information services may form a united interactive multipurpose information system implemented on the basis of a single user's interface (browser) and a uniform interactive platform. Thus a broadcasting operator may become a provider of the service system to corporate and individual users. It makes sense to shape such systems on a regional basis. For this there should be in the region data formation centres for corresponding information services, including specialized servers and devices for encapsulation of the said services in TV broadcasting signals. Server software represents a multifunctional software package including, in particular, billing modules, modules of interoperation with banking payment systems, advertising management, mediametrics collection and processing of return (interactive) channels data, etc. The user part of the software for such a system (browser) is installed in the digital broadcasting STBs.

Without going into detail concerning the construction and functioning of such a system it is possible to point out its major sources of additional revenues for the operator. These include among others subscription fee charged on the basis of a conditional access system (implemented through STB smart cards). However, it is advertisers' payments that constitute the most important source of revenue for the operator of an interactive information system. Advertising in interactive information systems radically differs from traditional linear advertising in analogue broadcasting. Its main distinction lies in its target nature (different groups of users get different advertisements) and in the built-in function of measuring the audience (mediametrics). Actually STBs can support the following functions:

1 Assignment of a consumer index to the subscriber. When a subscriber is switched in the system a questionnaire is displayed on the screen with a number of items referring to the subscriber's social status, age, sex, revenue, interests in various spheres, goods and services of interest, etc. (such a poll may be repeated in certain periods of time, e.g. annually, to identify the changes, if any). The questionnaire aims at establishing what type of advertising should be supplied to the subscriber. The questionnaire is based on multiple choices. A given consumer index is assigned depending on the choice of answers. The index is forwarded to the operator's server and further on is used to identify the advertising materials to be supplied to this subscriber.

2 Mediametrics of TV programmes. An STB registers each switch over from one TV channel to another and certainly the viewing time on each channel. Periodically (say, once a day) the obtained viewing data is forwarded to the operator's server. The function allows calculation of the exact rather than approximate rating of TV programmes.

3 Advertising mediametrics. Each payment for goods and services effected by a subscriber with an STB (supporting the e-payments function) is registered and the information about the type of goods or services bought is transmitted to the operator's server where the connection between the purchase of the goods and services and their advertising supplied to the subscriber earlier is analysed. This function is necessary to appraise the effectiveness of advertising materials.

It is clear that with these functions the operator of an interactive information system obtains data of vital importance both for TV companies (programme ratings) and advertisers (much higher effectiveness of advertising thanks to its target character, information about the effectiveness of advertising materials). This enhances the attractiveness of the system for the TV companies and advertisers and affects the operator's revenues accordingly.

Another important source of revenue for the operator is payments by commercial structures selling goods and services within the framework of the e-trade system, as part of the system as a whole. The e-trade system is in great demand for commercial structures as it enables these to increase significantly their sales. A new market is open to the sellers - electronic retail sales with immediate payment for goods and services in non-cash form via e-banking.

TV viewers may choose the goods via the on-line shops system in which they may view video clips of the goods, order these to be delivered to their homes or not and pay for them with the help of their smart card. Foreign practice confirms great success of such projects as in addition to convenience and time saving the customer pays less for the goods than in traditional shops (thanks to lower seller's overheads and non-cash payments) and due to that fact that e-payment systems in closed digital TV networks are more reliable than those on the Internet.

If the above regional interactive information system based on digital broadcasting is established in a region as a next logical step after overall transition to digital broadcasting in the region, it would also be logical to base the system of subscription fees on a uniform conditional access system. It goes without saying that such a system should have an open (socially oriented) component and a commercial component and subscription fees will be charged only for services provided by the commercial component.

10 Tanzania

Introduction

Tanzania has been addressing the migration from analogue to digital terrestrial broadcasting immediately after the RRC-04. The Tanzania Communications Regulatory Authority (TCRA), the regulator of Communications, Broadcasting and Postal sectors participated in the RRC-06 processes. After RRC-06, two consultation documents were issued followed by workshops, annual conferences and forums aimed at addressing how digital terrestrial broadcasting will be implemented, managed and regulated in Tanzania.

Important issues addressed, include the way digital television operates and its efficient use of frequency spectrum resource and its associated value added services.

Furthermore, the Authority has worked out major issues that will guide smooth migration.

Among the measures undertaken by TCRA is the introduction of the Converged Licensing Framework (CLF) with four (4) major licences, 1. Network Facility Licence, 2. Network Service Licence, 3. Content Licence 4. Application Service Licence addresses the complex licensing issues associated with digitization.

To realize smooth migration, TCRA produced two consultation documents on digital broadcasting which were discussed by all stakeholders. National Technical Committee has been formed to handle migration issues and workout the roadmap to full digital broadcasting in Tanzania.

The consultations, yielded initial framework on the new broadcasting landscape in Tanzania. The new broadcasting chain landscape is such that, there will be two distinctive features namely, the Content Service Provider and Signal Distributor who will be charged with multiplexing. There will be ***two commercial Multiplex Operators, and one Public Service Multiplex Operator under the initial licensing framework*** that will be charged with the responsibility of signal distribution.

Tanzania, a country at the eastern coast of the African continent, spans 1122Sq. Kilometres with a population of 36 million inhabitants. Tanzania falls under ITU Region1.There are 26 licensed analogue television stations, out of which 4 are national coverage, 5 regional coverage (covering ten administrative district areas) and the rest district administrative coverage.

There are also three (3) licensed digital satellite pay television stations and one digital terrestrial television operator in the City of Dar Es salaam under a pilot DVB-T project. There are 95 analogue television transmitters countrywide.

After the two consultation processes between 2005 and 2007, a final document on "The Transition from Analogue to Digital Terrestrial Broadcasting in Tanzania" addressing the Regulatory and Legal Framework under which Digital Television will be implemented, managed and regulated. The Authority has so far run an awareness campaign among the media stakeholders during the consultation process that has come up with the roadmap for licensing of Multiplex Operators. The Authority has so far achieved the following goals and is set to licence the pilot project in the financial year, 2008/2009 on a phased approach basis.

In the interim period, the Authority has formed the Work Group on Digital Broadcasting (WGDB) with experts from broadcasting, spectrum management, ICT development and legal sector tasked to address the following issues:

- Consider licensing issues of MUX.
- Consider National Plan of Digital Broadcasting and simulcast period.
- Consider Licensing issues of other services like, Mobile TV, IPTV etc.
- Consider and adopt a positional paper on availability of STB.
- Editing of the final document on Digital Broadcasting in Tanzania.

In April, 2008, TCRA announced an Expression Of Interest (EOI) for prequalification for interested parties to submit their interest for provision of digital multiplex services in Tanzania. The response was positive.

The Authority has postponed licensing of new television applicants from 2007 in order to audit the UHF and VHF channels countrywide and plan for digital terrestrial services countrywide during simulcast period. The digital plan status will be ready before the end of this year.

The digital plan will give detail to the WRC–07 decisions, on smooth implementation of digital broadcasting.

The Authority is carrying out an exercise of reviewing the Broadcasting Services Act, 1993, Tanzania Communications Act, 1993 and the Tanzania Communications Regulatory Authority Act, 2003 with a view of incorporating Digital Terrestrial Broadcasting and Multiplex Operator a legal force.

The Authority will embark on public awareness campaign on digital migration and coordinate with neighbouring countries on best ways of efficient utilization of spectrum, interference mitigation and protection of existing analogue services during dual illumination.

Digital Migration Policy in Tanzania

The Tanzanian ICT Policy, 2003 governs the digital migration process in Tanzania.

And the realization of digital dividend prior to WRC 07 by allocating the broadcasting sub band 825.285-862 MHz (about 37 MHz) for CDMA mobile operators realizing digital dividend earlier.

Tanzania’s position during WRC-07 was very clear. It supported new broadcasting band at 470-790 MHz to promote mobile phone industry as a catalyst to universal access. The mobile industry penetration in the past few years has dominated the communication market than fixed lines whose roll out has been slowing down.

The Authority is constructively engaging the Government on possibilities of giving out subsidies to importation of set-top-boxes so as to make them available to common people.

TCRA in collaboration with the Government is setting up policies and recommendations on availability of set-top boxes. The idea of fees from the dividend is still raw and under discussion.

Migration from Analogue to Digital broadcasting in Tanzania in Tanzania is policy driven. It has taken TCRA three years to prepare broadcasters for the uptake of digital broadcasting. Worries have been on the fate of the analogue infrastructure investment and ‘fear’ of revocation of frequency channels by incumbents. Worries have even been on consumers on the availability of affordable set-top boxes.

Tanzania has adopted phased migration approach. This will help correct mistakes experienced in initial stages of implementation.

Tanzania will switch off analogue systems by 2015 and the chances of doing it before that time is clear.

Challenges on licensing; There are digital TV products which the Authority is working on the proper framework to cater for the country’s ICT trend.

There have been concerns during the migration process on existing analogue infrastructure.

During consultations, it was agreed that, the licensed multiplex operator enters into agreement with analogue broadcasters to use part of their usable infrastructure.

Tanzania is actively participating in all activities pertaining to digital broadcasting in Region 1 of the ITU and the CTO-Digital Broadcasting Forum in Johannesburg every year. This has been instrumental in having common migration strategies and has acted as sensitizing machinery among participating African nations. Even those that have not initiated efforts to migrate from Analogue to Digital broadcasting have been supported to initiate steps towards migration.

Organizations like Communications Regulatory Authorities of Southern Africa (CRASA) and East African Communication Regulatory authorities are engaged in efforts aimed at successful implementation of digital broadcasting.

11 United States of America

Background

The United States has moved forward aggressively with the implementation of DTV using the ATSC Digital Television (DTV) Standard, a powerful technology that is transforming the nature of broadcast television service. This new broadcast transmission standard provides broadcasters with many new capabilities to serve the public, such as HDTV and standard resolution pictures, multicasting, data delivery, interactive communication, robust reception modes, and other features. These capabilities provide broadcasters the technical flexibility and options to compete with other digital media such as cable and direct broadcast satellite services. The ATSC DTV standard was developed through a lengthy initial specification process that began in 1987 and its evolution is continuing today, due to the flexibility for extending the digital system to include new capabilities as technology continues to develop. Coincident with the development of the transmission technology, the U.S. Government, through actions by its Federal Communications Commission (FCC) and legislation by the U.S. Congress, has developed public policies under which digital television is being implemented.

The U.S. Government is implementing broadcast DTV service as a replacement technology for the existing analog National Television System Committee (NTSC) technology that has been used for transmission of broadcast television service in the United States since the late 1940s. Under this policy approach, all eligible existing television stations were provided a second channel to be used for DTV service during a transition period from the analog to digital operation. This transition period, which began in 1998, is intended to facilitate an orderly change to the digital television technology while taking account of consumer investments in analog television sets. At the end of this transition period, TV stations will cease analog transmissions so that all broadcast television service will then be in the digital format. The FCC will also recover one of each TV station's two channels at this time. Because operation with the ATSC standard is very spectrum efficient, it is possible for all of the existing TV stations to operate in a much smaller amount of spectrum bandwidth, thereby allowing a portion of the existing TV channels 2-69 to be recovered for new uses. The U.S. Government plan is for all DTV stations to operate on channels 2-51 (the DTV core spectrum) after the transition ends and to recover channels 52-69 (698 MHz to 806 MHz) for new uses.

After very careful consideration and review in the FCC's public rule making processes, the Commission afforded broadcasters great flexibility in the use of their DTT channels. Broadcasters were required at least to match the hours of operation of their existing analog station. For example, if the analog station operated 24 hours/day, then the digital station would also be required to operate 24 h/day.

Broadcasters were given almost unlimited flexibility in the services that could be offered over their 6 MHz digital channel. They were required to offer one free-to-air video program service with resolution equivalent to their existing analog service. Beyond this, they could offer whatever other services they chose on the digital channel.

The FCC did not impose any requirement that broadcasters offer HDTV, and there is no legal requirement for U.S. broadcasters to offer HDTV. However, HDTV was the initial focal point of the U.S. transition to DTT broadcasting, and it has remained the centerpiece application throughout the U.S. deployment.

Pay services were explicitly permitted by the FCC, once a single, free, standard-definition program had been provided. If broadcasters do use their DTT channel to offer services for which a subscription fee or charge is required in order to receive service, they are required to pay the U.S. government a spectrum use fee in the amount of 5% of gross revenues from any such service.

The basic transition plan followed in the U.S. was to require stations affiliated with the four largest TV networks in the 30 largest cities to implement DTT first, while allowing more time for stations in smaller cities to make the transition. In addition, public TV stations were given an extra year beyond the deadline that applied to commercial stations. The FCC's initial plan applied to approximately 1,600 commercial and non-commercial (public) stations. Transition planning for low-power TV stations and for translators was deferred for several years, but has now been completed. Low power TV stations generally will be allowed to transition to DTV operation on their existing channels. In addition, if they so desire and a channel is available, low power stations may request a "companion channel" for DTV operation during the transition. The FCC further stated that it would establish a deadline at the end of the transition for low power stations that would be after the end of the transition for full service stations.

Each station was given a new assignment for its DTT broadcast channel, along with an antenna height, antenna pattern and maximum radiated power level, in an effort to replicate the station's analog coverage area. Assignments for all 1,600 stations were made shortly after the FCC formally adopted the ATSC Standard and approximately 18 months before the launch of commercial DTT service.

At the request of the FCC, 28 stations in the ten largest cities volunteered to launch DTT service in November 1998, six months ahead of the deadline established by the FCC. Six months later (May 1999) all stations in the top 10 markets that were affiliated with the four largest broadcast networks were required to provide service, and in another six months (November 1999) this requirement was extended to the affiliates of the four largest networks in all of the 30 largest cities. All commercial broadcasters were required to be on the air by May 2002 and all non-commercial broadcasters by May 2003. Broadcasters who could not meet these deadlines were allowed to apply for a six-month extension and in some cases a second six-month extension under certain circumstances.

The U.S. Congress and the FCC are determined to conclude the transition to DTT broadcasting as rapidly as possible for a variety of reasons, most notably to recapture 108 MHz of invaluable nationwide spectrum that will be made available once analog TV transmissions cease. Broadcasters also want to make the conversion as rapidly as possible in order to eliminate the expense of operating two TV stations in parallel.

In early 2006, legislation was enacted by the U.S. Congress requiring broadcasters to terminate their analog transmissions by February 17, 2009. This legislation included provision of up to $1.5 billion to subsidize the purchase by television viewers of digital-to-analog set-top converters that could be used to view DTT signals on existing analog television receivers.

Each television household would be permitted to apply for up to two $40 coupons that could be used to purchase such converters, with only one coupon allowed per converter. The price of these converters is typically about $50 (without a coupon).

The FCC adopted regulations that phased in a requirement for inclusion of ATSC receiving capability starting with the largest TV sets first, in 2004, and for all sets over 13 inches by July 2007. In November 2005 the FCC amended its rules to advance the date for the completion of the phase-in period to March 1, 2007, and to apply the requirement to all receivers regardless of screen size. Thus, every television set sold in the U.S. must now contain ATSC DTT reception and decoding capabilities. The U.S. Consumer Electronics Association predicts that over 100 million integrtaed ATSC DTT receivers per year will be sold in the U.S. alone by 2009. This is ina addition to ATSC HDTV Set-top boxes and digital to analog converters.

Although it is not required by the government, all DTV receivers available in the United States are capable of decoding all ATSC specified video formats. All-format decoding is essential to permit the introduction of HDTV – later, if not initially.

While there are no government requirements for DTT receiver performance, on a voluntary basis (and upon the recommendation of the FCC) the ATSC has adopted a recommended practice giving performance parameter guidelines for DTT receivers.

Implementation Progress

The United States is now in the final stages of its DTV transition and there have been many challenges that have been faced and overcome in the period since 1997. In recent years the desire of the U.S. Government to recover TV channels 52-69 for new uses has given rise to greater emphasis on completing the transition as rapidly as possible. The FCC has taken a variety of steps to achieve a rapid conclusion to the transition and to ensure that the benefits and services of DTV broadcasting are available to all Americans. The U.S. Congress has also enacted legislation that mandates the end of analog television transmissions on February 17, 2009.

DTT broadcasting is moving ahead at a feverish pace. More than 1,700 DTV stations are on the air in 211 metropolitan areas, reaching 99.99% of U.S. television households with at least one digital signal. More than 90% of households have access to at least five digital signals, and more than 80% have access to at least eight. In the largest U.S. cities, as many as 23 digital stations are on the air.

HDTV programming is widely available, not only via DTT broadcasts, but over cable and satellite systems as well. Most network primetime and sports programming is now produced in HDTV. Local TV stations are beginning to offer their local news in HDTV.

Manufacturers throughout the world have responded to this demand by developing and marketing more than 750 different models of HDTV and other ATSC DTT consumer products, using a wide variety of new display technologies. Competition is frenzied, with prices continuing to fall rapidly and sales skyrocketing. Since late 1998 when the service was launched and March 31, 2006, more than 30 million units of DTT consumer products worth more than $50 billion have been sold in the U.S. alone. Moreover, sales are continuing to grow exponentially, with projected sales for all of 2006 of approximately 20 million units worth $30 billion.

Standard-definition (SDTV) integrated 27” ATSC receivers are now available for as little as US$299, and integrated 27” HDTV receivers for as little as US$430. Indeed, prices for HDTVs are converging rapidly with those for analog color TVs. It is no longer possible to purchase a large-screen analog color TV in the U.S. They have all been replaced by digital HDTVs. This trend will accelerate and spread to smaller screen sizes over the next few years as prices continue to fall and as the phase-in of the FCC’s tuner mandate is completed. Under this regulation, all television receivers sold in the U.S. must have ATSC tuning and decoding capability by March 2007. As a result, by 2007 an estimated *34 million* ATSC receivers per year will be sold in the U.S. alone, with cumulative sales reaching *152 million* by 2009. Such massive sales volumes will further drive down the price of ATSC receivers, such that many experts believe that within three or four years, virtually all TV sets sold in the U.S. will be HDTVs, because they will cost no more than analog color TVs by that time, even at the smaller screen sizes.

In addition to HDTV, broadcasters in the U.S. are using DTT to provide innovative packages of new services. Some broadcasters are providing multiple simultaneous programs of SDTV. This is especially important for public broadcasters in achieving their goals to support public education, providing multiple education programs instead of just one program at one time. Many commercial broadcasters are now offering a main program in HDTV, plus another SDTV program such as 24-hour news or weather. Some broadcasters are also pooling their excess capacity to offer basic pay-TV platforms in competition with cable and satellite systems.

Broadcasters are also beginning to offer various data services using the ATSC family of standards, including interactive information services.

The U.S. government is planning to complete the transition to DTT broadcasting by February 2009, in order to free up extremely valuable nationwide spectrum that can be used to promote public safety and national security, and to support new wireless services that will be engines of economic growth for decades to come. To support its decision to end analog television transmissions, the U.S. Congress urged the development of an inexpensive digital-to-analog set-top converter box to permit consumers to view DTT signals on their existing analog TV sets. Several manufacturers responded, demonstrating prototype converters that are expected to cost US$50 by 2008, if sold in large quantities.

With respect to reception by portable hand-held receivers or in fast-moving vehicles, the ATSC Standard was not originally designed to provide this type of reception. Rather, the goal was to deliver the largest possible payload data rate to the largest service area, to ensure that broadcasters could reach the largest possible audience with high-quality HDTV images and associated surround sound.

Now that HDTV is firmly in hand, however, U.S. broadcasters are showing increasing interest in receiving DTV signals in moving vehicles and by pedestrians with hand-held devices. A number of companies have been working on adding such applications to the ATSC Standard.

Conclusion

The implementation of digital television service based on the ATSC family of standards is moving ahead dramatically in the U.S. (.HDTV is firmly entrenched, and is replacing analog color television at a rapid pace. SDTV multicasting and information services are also important and are being expanded, as broadcasters learn to take full advantage of the rich possibilities of DTT broadcasting using the ATSC family of standards. A cornucopia of dazzling new consumer products is available, at rapidly falling prices that make DTT receivers affordable for all socio-economic classes. Continuing improvements in ATSC receivers and further extensions and new additions to the ATSC family of standards are laying the groundwork for additional new services and applications in the future.

The U.S. is now in the final stages of its transition to digital television broadcasting, with a hard date set for the end of analog transmissions. Ending analog transmissions will mark the end of the transition to DTT broadcasting, which will permit the recovery of extremely valuable spectrum that will support new wireless services that will be engines of economic growth for decades to come.

12 Republic of Korea

The Republic of Korea decided digital transition from analogue broadcasting services to provide spectrum efficient and high quality services. With careful studies and field test, standards to achieve effectively the digital transition of each analogue media were chosen. For fixed reception at home, high quality services on large screen display will be major service models but low or intermediate quality acceptable on small and handheld receivers for mobile reception.

In the Republic of Korea, digital terrestrial television broadcasting was started in 2001, digital satellite broadcasting in 2002, and terrestrial multimedia broadcasting in 2005. Cable TV is also in service of digital programs since 2002.

12.1 Digital TV for fixed reception

Terrestrial television sets may be appropriate receivers to enjoy high definition video and multi-channel audio with a large screen at home. The Republic of Korea adopted ATSC system in 1997 for digital transition of analogue television broadcasting in the UHF band according to the policy to obtain high definition quality within 6 MHz raster and conducted field tests in 1999 and 2000.

There are 160 ATSC transmitters currently installed around the country covering about 92% of territory as of 2006. Several principles were given to digital terrestrial television broadcasters to follow government policies on digital transition as follows:

Simulcast of analogue and digital broadcasting until analogue switchover

Requirement of minimum time for HDTV programs (annually increasing)

Return of frequencies allocated to analogue television stations

It was not an easy job to find frequencies for digital television stations, because the UHF band from 470-752 MHz is already occupied with analogue television broadcasting. Hence, the band of 752-806, currently allocated to fixed and mobile services in Korea, was decided to use for broadcasting services during the transition time only, but these bands will be returned after analogue switchover. In order to facilitate frequency assignments, Equalization Digital On-Channel Repeater and Distributed Translator are devised for ATSC system to use same frequencies.

More than 4 million Set-Top-Boxes, about 23% of households, were sold as of 2006. It is expected to increase penetration rates of Set-Top-Boxes, since data broadcasting was started in 2005. Data services provide information on dramas or records of sports games as well as EPG.

12.2 T-DMB for mobile reception

For mobile multimedia broadcasting service, the Republic of Korea developed the video standard, which is fully backward compatible with the T-DAB, and named as Terrestrial Digital Multimedia Broadcasting (T-DMB). The specification of T-DMB was standardized as ETSI TS102 427 and ETSI TS 102 428 and submitted to WP 6M for a new recommendation of mobile multimedia broadcasting by handheld receivers.

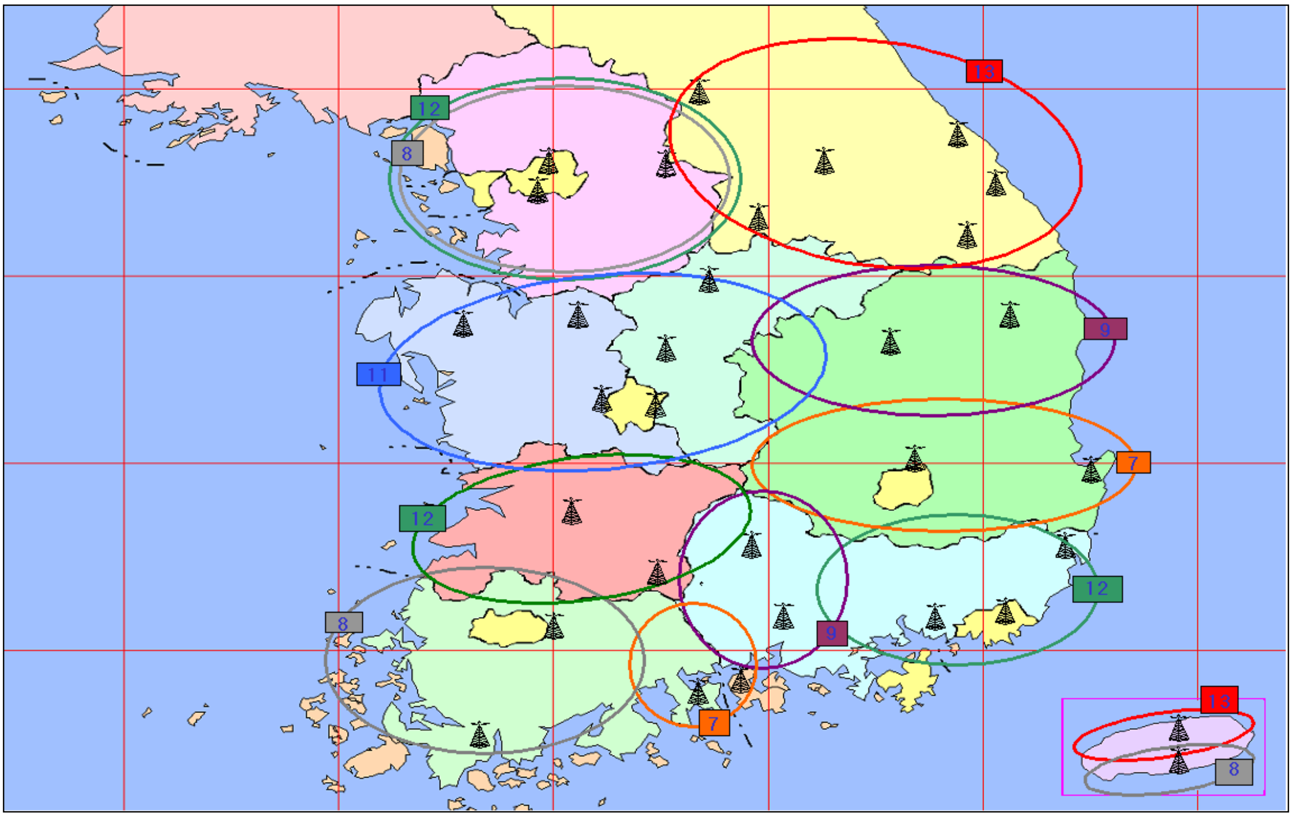
T-DMB pilot services were conducted in Band III in Seoul metropolitan area and its vicinity and field test results showed good mobile reception quality. Field test results were submitted to 6M meeting held in April 2004 and included in the Report ITU-R BT.2049 (see also Doc. 6E/186).

In December 2005, the Republic of Korea launched commercial service of T-DMB in Seoul Metropolitan area and expanded to the nationwide services in March 2007. Each broadcaster provides two video services or one video with three audio services within an ensemble and optionally with data services.

The whole territory was divided into seven regions including Jeju Island for business. One national broadcaster and seventeen regional broadcasters were licensed to serve T-DMB nationIIde. It was intInded to serve each region with the same frequency and most transmitters are linked with Single Frequency Networks to cover the wanted regional area. Fortunately, Seoul Metropolitan area is assigned two TV channels, 8 and 12, and served by six broadcasters. In order to allocate frequencies to T-DMB stations, frequencies of 44 analogue TVR in the band III were changed after simulation of mutual interference and analysis. The channel assignment plan in the Band III for the services is shown in Fig. 64.

FIGURE 64

Channel Assignments for T-DMB in Korea



However some transmitters in southern part do not have same frequencies due to pre-occupied frequencies for analogue TV stations and some regions consist of Multi Frequency Networks; Channel 7 and Channel 8 of the south-western region, Channel 7 and Channel 9 of the middle of eastern region, Channel 9 and Channel 12 of south-eastern region and Channel 8 and Channel 12 of Jeju Island. Hand-over technology was implemented on receivers for continued reception of a wanted service, even in other ensembles or different RF channels, while moving into other network.

In order to enjoy T-DMB services even underground, low powered T-DMB gap-fillers, which receive outdoor T-DMB signals and retransmit, were installed at 294 points to cover the whole lines of Metros in Seoul.

A variety of commercial receivers for portable or handheld reception are introduced in the market. Since the launch of T-DMB service in December 2005, 3.14 million receivers are sold in Korea as of 31 January 2007.

Data services such as EPG, TPEG and BWS are in services and interactive services using return channel will be appeared soon with the cooperation of telecommunication operators. These data services are expected to produce pay services for business by providing information on traffic jam, stock and even Internet access.

13 Venezuela

Adoption of standards for digital sound and digital television in Venezuela

Introduction

In order to assist in the selection of Digital Radio and Television systems in Venezuela, the National Commission of Telecommunications (CONATEL) has created a Digital Radio and Television project, supported by constant research. Its ultimate goal is advancing the tasks for the introduction of this service, and thus, making Digital Radio and Television systems in Venezuela a medium-term reality.

Digital Radio and Television project – Development stages

The development of the Digital Radio and Television project involves four (4) stages, as described below:

Stage 1: Feasibility study (technical, economic and legal aspects)

The tasks that comprised the feasibility study –still under development- are the following:

Review of national television and radio stations regarding location, frequency, service quality, technology and regulatory aspects.

Review of digital radio and television technology development, equipment suppliers, costs, comparison and selection of the most suitable technology.

Detailed study of the band frequencies that are to be assigned to analog and digital radio and television stations, with the purpose of optimizing the use of spectrum.

Study of the required investments, economic impact and investment recuperation involved in the switching from analogical to digital radio and television systems.

Evaluation of foreign experiences regarding this matter, and possible variables for the acceptance of this technology in Venezuela.

Documental analysis of digital radio and television regulations.

Stage 2: Forum and operating tables

During this stage, contacts are made with companies in charged of the development of digital radio and television standards, as well as with equipment suppliers and regulation departments, with the cooperation of domestic radio and television operators.

Stage 3: Trials

Trials help to adopt suitable policies to benefit Venezuela's technological smooth switch to digital radio and television. This stage will produce both experimental and regulating experiences:

Trials

Switch to the digital system.

Setting of regulation framework.

In general, domestic and foreign investments for the development of new technologies require a regulation framework, which will settle the rules for their evolution and put into practice.

The efficient performance of the above-mentioned functions will be a key aspect to plan legally sustained trials for digital radio and television systems, which can prove trustful and safe for both domestic and foreign investors. Besides, this option will facilitate the study of spectrum shares, not assigned to digital radio and television.

Other important legal aspects relate to the obligation to mention the specific spectrum share to be used by the incumbent. This share can only be used and exploited within the specific cover indicated on a special permission.

Besides, getting a special permission will not grant expectations of rights to incumbents or preferential rights whatsoever in getting of a grant for the use and exploitation of the spectrum share necessary for developing all the activities foreseen by the regulations. Once a special permission has expired, its incumbent will not be able to continue using the spectrum shares assigned, unless they update their permission.

Incumbents with special permission will not obtain any counter-payment from users because of service rendering during trials. Once the trial is over, they should present a detailed report about the activities carried out and the results obtained. At any given moment, CONATEL can inspect or supervise the trials.

For the special permission, the interested incumbents will have to indicate the accurate date for the beginning of trials and the length the trials (up to three months).

If there are justifiable reasons, the beginning of trials can be adjourned unless decided otherwise by CONATEL. The trials can only be adjourned once.

During the deliberation period, CONATEL can require any concerning information from the incumbents, in order to evaluate the application. In this case, CONATEL will notify the titular that they have 10 days to submit their requirements. From the date of the application, CONATEL can interrupt the deliberation period for ten days. Due to the complexity of the matter, this period can be extended up to fifteen continuous days.

Stage 4: Standards adoption

This stage is the milestone for the digital radio and television adoption process. The fitting of the legislation in force to the characteristics of the chosen system will provide strength and trust to the process of putting digital radio and television services into practice in Venezuela.

Appendix 2
to Part 2

1 Definitions

From Radio Regulations.

Section II – Specific terms related to frequency management

1.16 *allocation* (of a frequency band)*:* Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more terrestrial or space *radiocommunication services* or the *radio astronomy service* under specified conditions. This term shall also be applied to the frequency band concerned.

1.17 *allotment* (of a radio frequency or radio frequency channel)*:* Entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by one or more administrations for a terrestrial or space *radiocommunication service* in one or more identified countries or geographical areas and under specified conditions.

1.18 *assignment* (of a radio frequency or radio frequency channel)*:* Authorization given by an administration for a radio *station* to use a radio frequency or radio frequency channel under specified conditions.

Section III – Radio services

1.19 *radiocommunication service:* A service as defined in this Section involving the transmission, *emission* and/or reception of *radio waves* for specific *telecommunication* purposes.

In these Regulations, unless otherwise stated, any radiocommunication service relates to *terrestrial radiocommunication*.

1.20 *fixed service:* A *radiocommunication service* between specified fixed points.

1.24 *mobile service:* A *radiocommunication service* between *mobile* and *land stations*, or between *mobile stations* (CV).

1.26 *land mobile service:* A *mobile service* between *base stations* and *land mobile stations*, or between *land mobile stations*.

1.38 *broadcasting service:* A *radiocommunication service* in which the transmissions are intended for direct reception by the general public. This service may include sound transmissions, *television* transmissions or other types of transmission (CS).

1.39 *broadcasting-satellite service:* A *radiocommunication service* in which signals transmitted or retransmitted by *space stations* are intended for direct reception by the general public.

In the broadcasting-satellite service, the term "direct reception" shall encompass both *individual reception* and *community reception*.

1.56 *amateur service:* A *radiocommunication service* for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.

1.57 *amateur-satellite service:* A *radiocommunication service* using *space stations* on earth *satellites* for the same purposes as those of the *amateur service*.

Section IV – Radio stations and systems

1.61 *station:* One or more transmitters or receivers or a combination of transmitters and receivers, including the accessory equipment, necessary at one location for carrying on a *radiocommunication service*, or the *radio astronomy service*.

Each station shall be classified by the service in which it operates permanently or temporarily.

1.62 *terrestrial station:* A *station* effecting *terrestrial radiocommunication*.

In these Regulations, unless otherwise stated, any *station* is a terrestrial station.

1.63 *earth station:* A *station* located either on the Earth's surface or within the major portion of the Earth's atmosphere and intended for communication:

– with one or more *space stations*; or

– with one or more *stations* of the same kind by means of one or more reflecting *satellites* or other objects in space.

1.66 *fixed station:* A *station* in the *fixed service*.

1.66A *high altitude platform station:* A station located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth.

1.67 *mobile station:* A *station* in the *mobile service* intended to be used while in motion or during halts at unspecified points.

1.68 *mobile earth station:* An *earth station* in the *mobile-satellite service* intended to be used while in motion or during halts at unspecified points.

1.69 *land station:* A *station* in the *mobile service* not intended to be used while in motion.

1.70 *land earth station:* An *earth station* in the *fixed-satellite service* or, in some cases, in the *mobile-satellite service*, located at a specified fixed point or within a specified area on land to provide a *feeder link* for the *mobile-satellite service*.

1.71 *base station:* A *land station* in the *land mobile service*.

1.72 *base earth station:* An *earth station* in the *fixed-satellite service* or, in some cases, in the *land mobile-satellite service*, located at a specified fixed point or within a specified area on land to provide a *feeder link* for the *land mobile-satellite service*.

1.73 *land mobile station:* A *mobile station* in the *land mobile service* capable of surface movement within the geographical limits of a country or continent.

1.74 *land mobile earth station:* A *mobile earth station* in the *land mobile-satellite service* capable of surface movement within the geographical limits of a country or continent.

1.75 *coast station:* A *land station* in the *maritime mobile service*.

1.76 *coast earth station:* An *earth station* in the *fixed-satellite service* or, in some cases, in the *maritime mobile-satellite service*, located at a specified fixed point on land to provide a *feeder link* for the *maritime mobile-satellite service*.

1.77 *ship station:* A *mobile station* in the *maritime mobile service* located on board a vessel which is not permanently moored, other than a *survival craft station*.

1.78 *ship earth station:* A *mobile earth station* in the *maritime mobile-satellite service* located on board ship.

1.79 *on-board communication station:* A low-powered *mobile station* in the *maritime mobile service* intended for use for internal communications on board a ship, or between a ship and its lifeboats and life-rafts during lifeboat drills or operations, or for communication within a group of vessels being towed or pushed, as well as for line handling and mooring instructions.

1.80 *port station:* A *coast station* in the *port operations service*.

1.81 *aeronautical station:* A *land station* in the *aeronautical mobile service*.

In certain instances, an aeronautical station may be located, for example, on board ship or on a platform at sea.

1.82 *aeronautical earth station:* An *earth station* in the *fixed-satellite service*, or, in some cases, in the *aeronautical mobile-satellite service*, located at a specified fixed point on land to provide a *feeder link* for the *aeronautical mobile-satellite service*.

1.84 *aircraft earth station:* A *mobile earth station* in the *aeronautical mobile-satellite service* located on board an aircraft.

1.85 *broadcasting station:* A *station* in the *broadcasting service*.

1.96 *amateur station:* A *station* in the *amateur service.*

1.97 *radio astronomy station:* A *station* in the *radio astronomy service*.

1.98 *experimental station:* A *station* utilizing *radio waves* in experiments with a view to the development of science or technique.

This definition does not include *amateur stations.*

1.128 *television:* A form of *telecommunication* for the transmission of transient images of fixed or moving objects.

1.129 *individual reception* (in the broadcasting-satellite service)*:* The reception of *emissions* from a *space station* in the *broadcasting-satellite service* by simple domestic installations and in particular those possessing small antennae.

1.130 *community reception* (in the broadcasting-satellite service)*:* The reception of *emissions* from a *space station* in the *broadcasting-satellite service* by receiving equipment, which in some cases may be complex and have antennae larger than those used for *individual reception*, and intended for use:

– by a group of the general public at one location; or

– through a distribution system covering a limited area.

1.134 *telecommand:* The use of *telecommunication* for the transmission of signals to initiate, modify or terminate functions of equipment at a distance.

Section VI – Characteristics of emissions and radio equipment

1.137 *radiation:* The outward flow of energy from any source in the form of *radio waves*.

1.138 *emission: Radiation* produced, or the production of *radiation*, by a radio transmitting *station*.

For example, the energy radiated by the local oscillator of a radio receiver would not be an emission but a *radiation*.

1.139 *class of emission:* The set of characteristics of an *emission*, designated by standard symbols, e.g. type of modulation of the main carrier, modulating signal, type of information to be transmitted, and also, if appropriate, any additional signal characteristics.

1.140 *single-sideband emission:* An amplitude modulated *emission* with one sideband only.

1.141 *full carrier single-sideband emission:* A *single-sideband emission* without reduction of the carrier.

1.142 *reduced carrier single-sideband emission:* A *single-sideband emission* in which the degree of carrier suppression enables the carrier to be reconstituted and to be used for demodulation.

1.143 *suppressed carrier single-sideband emission:* A *single-sideband emission* in which the carrier is virtually suppressed and not intended to be used for demodulation.

1.144 *out-of-band emission**: *Emission* on a frequency or frequencies immediately outside the *necessary bandwidth* which results from the modulation process, but excluding *spurious emissions*.

1.145 *spurious emission**: *Emission* on a frequency or frequencies which are outside the *necessary bandwidth* and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic *emissions*, parasitic *emissions*, intermodulation products and frequency conversion products, but exclude *out-of-band emissions*.

1.146 *unwanted emissions**: Consist of *spurious emissions* and *out-of-band emissions*.

1.146A *out-of-band domain* (of an emission): The frequency range, immediately outside the necessary bandwidth but excluding the *spurious domain*, in which *out-of-band emissions* generally predominate. *Out-of-band emissions*, defined based on their source, occur in the out-of-band domain and, to a lesser extent, in the *spurious domain*. *Spurious emissions* likewise may occur in the out-of-band domain as well as in the *spurious domain*. (WRC-03)

1.146B *spurious domain* (of an emission): The frequency range beyond the *out-of-band domain* in which *spurious emissions* generally predominate. (WRC-03)

1.147 *assigned frequency band:* The frequency band within which the *emission* of a *station* is authorized; the width of the band equals the *necessary bandwidth* plus twice the absolute value of the *frequency tolerance*. Where *space stations* are concerned, the assigned frequency band includes twice the maximum Doppler shift that may occur in relation to any point of the Earth's surface.

1.148 *assigned frequency:* The centre of the frequency band assigned to a *station*.

1.149 *characteristic frequency:* A frequency which can be easily identified and measured in a given *emission*.

A carrier frequency may, for example, be designated as the characteristic frequency.

1.150 *reference frequency:* A frequency having a fixed and specified position with respect to the *assigned frequency*. The displacement of this frequency with respect to the *assigned frequency* has the same absolute value and sign that the displacement of the *characteristic frequency* has with respect to the centre of the frequency band occupied by the *emission*.

1.151 *frequency tolerance:* The maximum permissible departure by the centre frequency of the frequency band occupied by an *emission* from the *assigned frequency* or, by the *characteristic frequency* of an *emission* from the *reference frequency*.

* The terms associated with the definitions given by Nos. **1.144**, **1.145** and **1.146** shall be expressed in the working languages as follows:

Numbers	In French	In English	In Spanish
1.144	Emission hors bande	Out-of-band emission	Emisión fuera de banda
1.145	Rayonnement non essentiel	Spurious emission	Emisión no esencial
1.146	Rayonnements non désirés	Unwanted emissions	Emisiones no deseadas

The frequency tolerance is expressed in parts in 10^6 or in hertz.

1.152 *necessary bandwidth:* For a given *class of emission*, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

1.153 *occupied bandwidth:* The width of a frequency band such that, below the lower and above the upper frequency limits, the *mean powers* emitted are each equal to a specified percentage β/2 of the total *mean power* of a given *emission*.

Unless otherwise specified in an ITU-R Recommendation for the appropriate *class of emission*, the value of β/2 should be taken as 0.5%.

1.154 *right-hand* (clockwise) *polarized wave:* An elliptically- or circularly-polarized wave, in which the electric field vector, observed in any fixed plane, normal to the direction of propagation, whilst looking in the direction of propagation, rotates with time in a right-hand or clockwise direction.

1.155 *left-hand* (anticlockwise) *polarized wave:* An elliptically- or circularly-polarized wave, in which the electric field vector, observed in any fixed plane, normal to the direction of propagation, whilst looking in the direction of propagation, rotates with time in a left-hand or anticlockwise direction.

1.156 *power:* Whenever the power of a radio transmitter, etc. is referred to it shall be expressed in one of the following forms, according to the class of *emission*, using the arbitrary symbols indicated:

– *peak envelope power* (*P*X or *p*X);
– *mean power* (*P*Y or *p*Y);
– *carrier power* (*P*Z or *p*Z).

For different *classes of emission*, the relationships between *peak envelope power*, *mean power* and *carrier power*, under the conditions of normal operation and of no modulation, are contained in ITU-R Recommendations which may be used as a guide.

For use in formulae, the symbol *p* denotes power expressed in watts and the symbol *P* denotes power expressed in decibels relative to a reference level.

1.157 *peak envelope power* (of a radio transmitter)*:* The average power supplied to the antenna transmission line by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken under normal operating conditions.

1.158 *mean power* (of a radio transmitter)*:* The average power supplied to the antenna transmission line by a transmitter during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation taken under normal operating conditions.

1.159 *carrier power* (of a radio transmitter)*:* The average power supplied to the antenna transmission line by a transmitter during one radio frequency cycle taken under the condition of no modulation.

1.160 *gain of an antenna:* The ratio, usually expressed in decibels, of the power required at the input of a loss-free reference antenna to the power supplied to the input of the given antenna to produce, in a given direction, the same field strength or the same power flux-density at the same distance. When not specified otherwise, the gain refers to the direction of maximum *radiation*. The gain may be considered for a specified polarization.

Depending on the choice of the reference antenna a distinction is made between:

a) absolute or isotropic gain (G_i), when the reference antenna is an isotropic antenna isolated in space;

b) gain relative to a half-wave dipole (G_d), when the reference antenna is a half-wave dipole isolated in space whose equatorial plane contains the given direction;

c) gain relative to a short vertical antenna (G_v), when the reference antenna is a linear conductor, much shorter than one quarter of the wavelength, normal to the surface of a perfectly conducting plane which contains the given direction.

1.161 *equivalent isotropically radiated power (e.i.r.p.):* The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna *(absolute or isotropic gain)*.

1.162 *effective radiated power (e.r.p.)* (in a given direction)*:* The product of the power supplied to the antenna and its *gain relative to a half-wave dipole* in a given direction.

1.163 *effective monopole radiated power (e.m.r.p.)* (in a given direction)*:* The product of the power supplied to the antenna and its *gain relative to a short vertical antenna* in a given direction.

1.164 *tropospheric scatter:* The propagation of *radio waves* by scattering as a result of irregularities or discontinuities in the physical properties of the troposphere.

1.165 *ionospheric scatter:* The propagation of *radio waves* by scattering as a result of irregularities or discontinuities in the ionization of the ionosphere.

For all definitions and terminology see the ITU database:

http://www.itu.int/ITU-R/go/terminology-database .