DVB-S2 — ready for lift off

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DVB-S2 is the second-generation specification for satellite broadcasting – developed by the DVB (Digital Video Broadcasting) Project in 2003. It benefits from more recent developments in channel coding (LDPC codes) combined with a variety of modulation formats (QPSK, 8PSK, 16APSK and 32APSK). When used for interactive applications, such as Internet navigation, it may implement Adaptive Coding & Modulation (ACM), thus optimizing the transmission parameters for each individual user, dependant on path conditions. Backwards-compatible modes are available, allowing existing DVB-S set-top-boxes to continue working during any transitional period.

This article, based on a presentation given at IBC-2004, gives a variety of examples of DVB-S2 – focusing on television applications including broadcasting, contribution TV links and DSNG, and DTT signal distribution to transmitters – which illustrate the advantages of the new system over DVB-S and, indeed, DVB-DSNG.

The DVB-S2 system has been designed for several satellite broadband applications:

- broadcast services for standard definition TV and HDTV;
- interactive services, including Internet access, for consumer applications;
- professional applications, such as Digital TV contribution and News Gathering, TV distribution to terrestrial VHF/UHF transmitters;
- data content distribution and Internet trunking.

It is based on a “tool-kit” approach which allows us to cover all the application areas while still keeping the single-chip decoder at reasonable complexity levels, thus enabling the use of mass market products also for professional applications.

The DVB-S2 standard has been specified around three key concepts: (i) best transmission performance, (ii) total flexibility and (iii) reasonable receiver complexity. To achieve the best performance-complexity trade-off, quantifiable in about 30% capacity gain over DVB-S, DVB-S2 benefits from more recent developments in channel coding and modulation. For interactive point-to-point applications such as IP unicasting, the adoption of the Adaptive Coding & Modulation (ACM) functionality allows us to optimize the transmission parameters for each individual user on a frame-by-frame basis, dependant on path conditions, under closed-loop control via a return channel (terrestrial or by satellite): the result is an even greater gain of DVB-S2 over DVB-S.

DVB-S2 is so flexible that it can cope with any existing satellite transponder characteristics, with a large variety of spectrum efficiencies and associated C/N requirements. Furthermore, it is not limited to MPEG-2 video and audio coding, but it is designed to handle a variety of advanced audio-video formats which the DVB Project is currently defining. DVB-S2 accommodates any input stream format, including single or multiple MPEG Transport Streams, continuous bit-streams, IP as well as ATM packets.

Forward Error Correction (FEC) and modulation

The DVB-S2 detailed system block diagram is described in [1] and [2]. The FEC is the key subsystem to achieve excellent performance by satellite, in the presence of high levels of noise and interference. The selection process, based on computer simulations, compared seven proposals – parallel or serially concatenated convolutional codes, product codes, low density parity check codes (LDPC) – all using "turbo" (i.e. recursive) decoding techniques. The winning system, based on LDPC, offered the minimum distance from the Shannon limit on the linear AWGN channel, under the constraint of maximum decoder complexity of 14 mm^2 of silicon (0.13 μm technology).

The selected LDPC codes [2] use very large block lengths (64800 bits for applications not too critical for delays, and 16200 bits). Code rates of 1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 8/9 and 9/10 are available, depending on the selected modulation and the system requirements. Coding rates 1/4, 1/3 and 2/5 have been introduced to operate, in combination with QPSK, under exceptionally poor link conditions, where the signal level is below the noise level. Concatenated BCH outer codes are introduced to avoid error floors at low bit error rates (BER).

Four modulation modes can be selected for the transmitted payload *(see Fig. 1)*.

QPSK and 8PSK are typically proposed for broadcast applications, since they are virtually constant envelope modulations and can be used in non-linear satellite transponders driven near saturation. The 16APSK and 32APSK modes, mainly targeted at professional applications, can also be used for broadcasting, but these require a higher level of available C/N and the adoption of advanced pre-distortion methods in the up-link station to minimize the effect of transponder non-linearity.

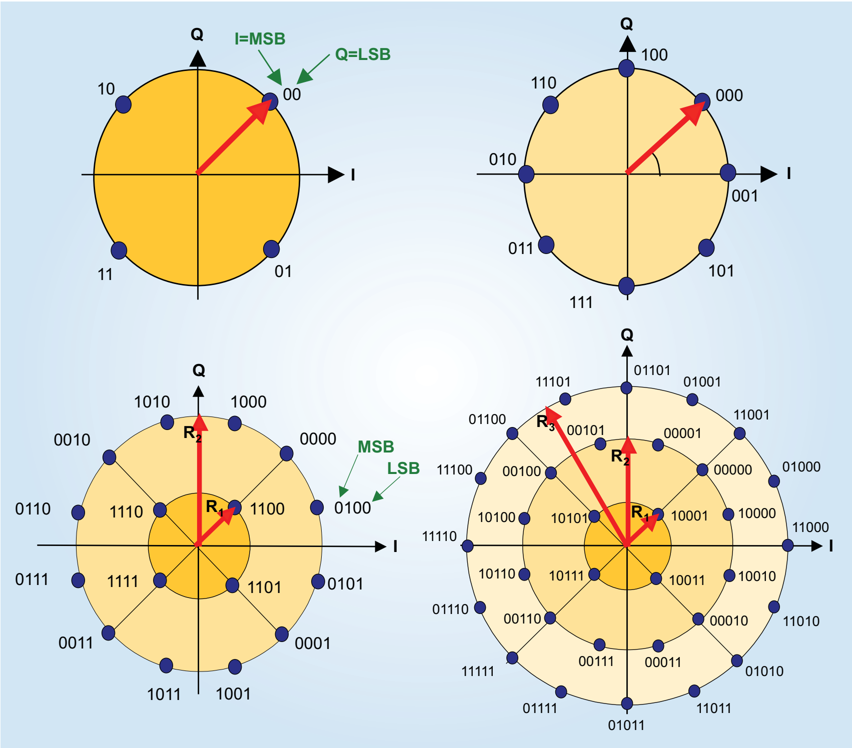

Figure 1
The four possible DVB-S2 constellations before physical layer scrambling

Whilst these modes are not as power-efficient as the other modes, the spectrum efficiency is much greater. The 16APSK and 32APSK constellations have been optimized to operate over a non-linear transponder by placing the points on circles. Nevertheless their performance on a linear channel are comparable with those of 16QAM and 32QAM respectively.

By selecting the modulation constellation and code rates, spectrum efficiencies from 0.5 to 4.5 bit per symbol are available and can be chosen dependant on the capabilities and restrictions of the satellite transponder used.

DVB-S2 has three "roll-off factor" choices to determine spectrum shape: 0.35 as in DVB-S, 0.25 and 0.20 for tighter bandwidth restrictions.

Framing structure

Two levels of framing structures have been designed:

- the first at the physical level (PL), carrying few highly-protected signalling bits;
- the second at base-band level, carrying a variety of signalling bits, to allow maximum flexibility on the input signal adaptation.

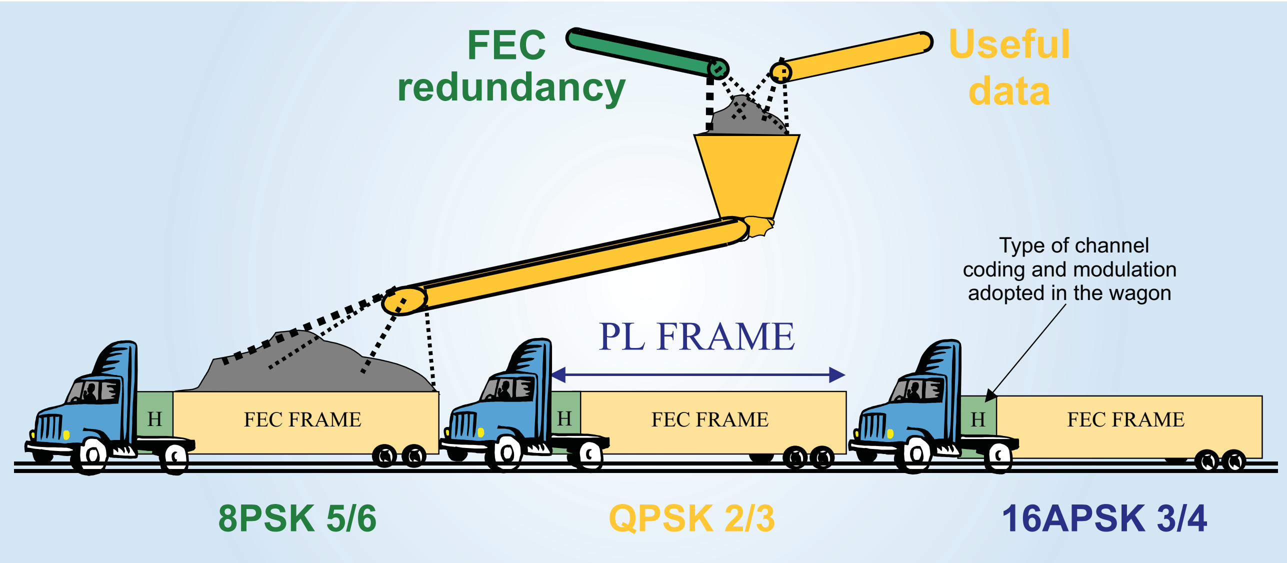

Figure 2
Pictorial representation of the physical-layer framing structure

The first level of framing structure has been designed to provide robust synchronization and signalling at the physical layer [2]. Thus a receiver may synchronize (carrier and phase recovery, frame synchronization) and detect the modulation and coding parameters before demodulation and FEC decoding.

With reference to *Fig. 2*, the DVB-S2 physical layer signal is composed of a regular sequence of "lorries" (frames): within a lorry, the modulation and coding scheme is homogeneous, but may change (Adaptive Coding & Modulation) in adjacent lorries. Every frame is composed of a payload of 64800 bits (or 16200 bits), corresponding to a code block of the concatenated LDPC/BCH FEC, and a Header (90 binary modulation symbols), containing synchronization and signalling information. Since the PL Header is the first entity to be decoded by the receiver, it could not be protected by the powerful LDPC/BCH FEC scheme.

On the other hand, it had to be perfectly decodable under the worst-case link conditions. Therefore the system designers selected a very low-rate 7/64 block code to protect it, suitable for soft-decision correlation decoding, and minimized the number of signalling bits to reduce decoding complexity and global efficiency loss.

The second level of framing structure, the "baseband frame", allows a more complete signalling functionality to configure the receiver according to the application scenarios: single or multiple input streams, generic or transport stream, CCM (Constant Coding & Modulation) or ACM (Adaptive Coding & Modulation), and many other configuration details. Thanks to the LDPC/BCH protection and the wide length of the FEC frame, the Baseband (BB) Header may contain many signalling bits (80) without losing transmission efficiency or ruggedness against noise.

Backwards-compatible modes

The large number of DVB-S receivers already installed makes it very difficult for many established broadcasters to think of an abrupt change of technology in favour of DVB-S2 – especially where there is a receiver subsidy and for free-to-air public services. In such scenarios, backwards-compatibility may be required in the migration period, allowing legacy DVB-S receivers to continue operating, while providing additional capacity and services to new, advanced receivers. At the end of the migration process, when the complete receiver population has migrated to DVB-S2, the transmitted signal could be modified to the non-backward compatible mode, thus exploiting the full potential of DVB-S2.

Optional backwards-compatible (BC) modes have therefore been defined in DVB-S2, intended to send two Transport Streams on a single satellite channel. The first (High Priority, HP) stream is compatible with DVB-S receivers (according to EN 300 421 [3]) as well as with DVB-S2 receivers, while the second (Low Priority, LP) stream is compatible with DVB-S2 receivers only [2].

Backwards compatibility can be implemented by hierarchical modulation [4], where the two HP and LP Transport Streams are synchronously combined at modulation symbol level on a non-uniform 8PSK constellation. The LP DVB-S2-compliant signal is BCH and LDPC encoded, with LDPC code rates 1/4, 1/3, 1/2 or 3/5. Then the hierarchical mapper generates the non-uniform 8PSK constellation: the two HP DVB-S bits define a QPSK constellation point, while the single bit from the DVB-S2 LDPC encoder sets an additional rotation $\pm\theta$ before transmission. Since the resulting signal has a quasi-constant envelope, it can be transmitted on a single transponder driven near saturation.

System performance

Dependant on the selected code rate and modulation constellation, the system can operate at carrier-to-noise ratios from –2.4 dB (using QPSK 1/4) to 16 dB (using 32APSK 9/10), assuming an AWGN channel and ideal demodulator *(see Fig. 3)*. These results have been obtained by computer

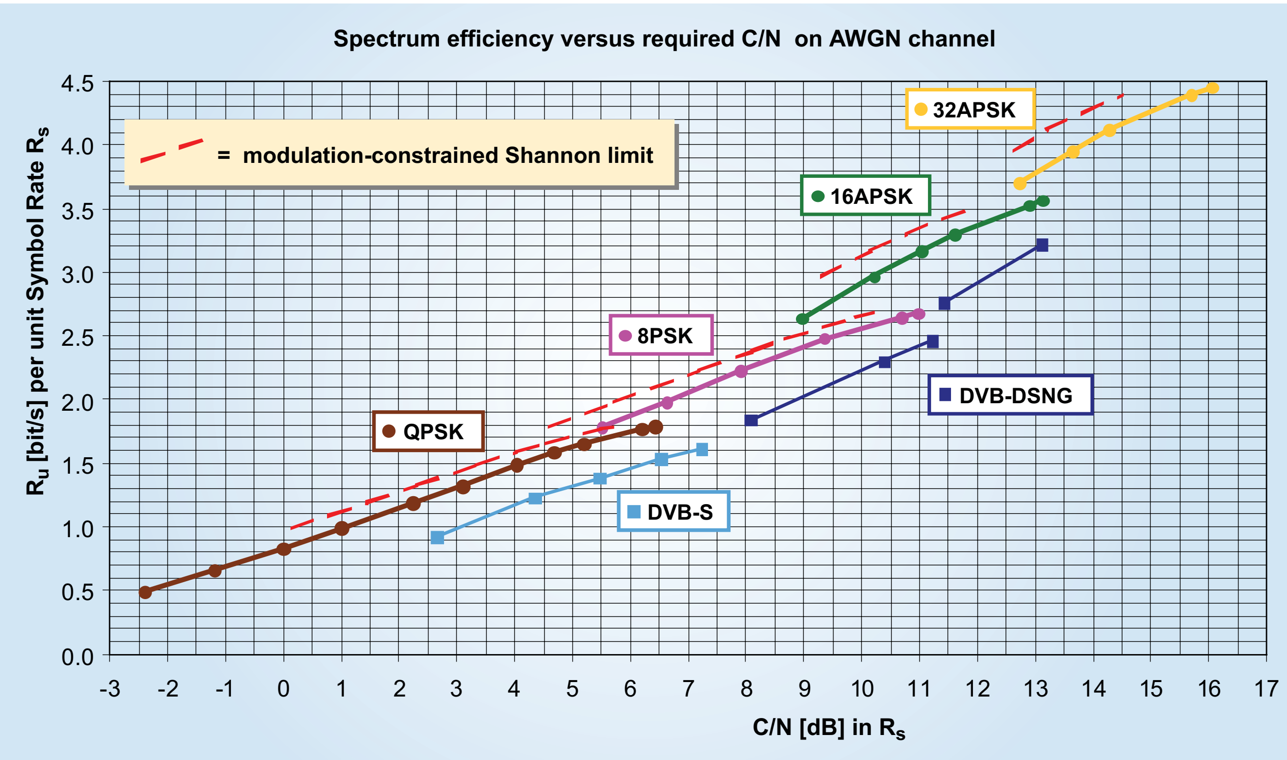

Figure 3
Required C/N versus spectrum efficiency on the AWGN channel (ideal demodulation), where C/N refers to the average power

simulations for a Packet Error Rate of 10^{-7} (one erroneous Transport Stream Packet per transmission hour in a 5 Mbit/s video service). The distance from the Shannon limit ranges from 0.7 to 1.2 dB. On AWGN, the result is typically a 20 – 35 percent capacity increase over DVB-S and DVB-DSNG under the same transmission conditions and 2 – 2.5 dB more robust reception for the same spectrum efficiency.

The DVB-S2 system may be used in “single-carrier-per-transponder” or in “multi-carriers-per-transponder” (FDM) configurations. *Fig. 3* also indicates examples of the useful bitrate capacity R_u achievable by the system in the different modulation/coding configurations, assuming unit symbol rate R_S. The symbol rate R_S corresponds to the –3dB bandwidth of the modulated signal, while $R_S(1+\alpha)$ corresponds to the theoretical total signal bandwidth after the modulator, with α representing the roll-off factor of the modulation. The use of the narrower roll-off $\alpha = 0.25$ and $\alpha = 0.20$ may allow a transmission capacity increase, but may also produce larger non-linear degradations by satellite for single-carrier operation.

When DVB-S2 is transmitted by satellite, quasi-constant envelope modulations such as QPSK and 8PSK are power efficient in the single-carrier-per-transponder configuration, since they can operate on transponders driven near saturation. 16APSK and 32APSK, which are inherently more sensitive to non-linear distortions and would require quasi-linear transponders (i.e., with larger Output Back-Off, OBO) may be improved in terms of power efficiency by using non-linear compensation techniques in the up-link station [2]. In FDM configurations, where multiple carriers occupy the same transponder, this latter must be kept in the quasi-linear operating region (i.e., with large OBO) to avoid excessive inter-modulation interference between signals. In this case, the AWGN performance figures may be adopted for link budget computations.

Table 1 shows, for the single-carrier-per-transponder configuration, the simulated C/N degradation using the satellite channel models and phase noise mask given in [1] (non-linearised TWTA, phase noise relevant to consumer LNBs), at the optimum operating TWTA point (computer simulations by ESA). C_{SAT} is the un-modulated carrier power at HPA saturation, OBO is the measured power ratio (dB) between the un-modulated carrier at saturation and the modulated carrier (after OMUX). The figures show the large advantage offered by the use of dynamic pre-distortion for 16APSK and 32APSK. The large phase noise degradations quoted for APSK, and in particular for 32APSK, can be considered as pessimistic, since they refer to consumer-type LNBs while, for professional applications, better front-ends may be adopted at negligible additional cost.

Table 1
C_{SAT}/N loss [dB] on the satellite channel

Transmission Mode	No pre-distortion No Phase Noise	Dynamic pre-distortion No Phase Noise	Dynamic pre-distortion Phase Noise
QPSK 1/2	0.6 (OBO=0.4)	0.5 (IBO=0; OBO=0.4)	0.6
8PSK 2/3	1.0 (OBO=0.3)	0.6 (IBO=0; OBO=0.4)	0.9
16APSK 3/4	3.2 (OBO=1.7)	1.5 (IBO=1.0; OBO=1.1)	1.8
32APSK 4/5	6.2 (OBO=3.8)	2.8 (IBO=3.6; OBO=2.0)	3.5

Examples of possible uses of the system

Some examples may better clarify the functionalities and flexibility of DVB-S2. Starting from TV broadcasting using constant coding and modulation, and variable coding and modulation, some examples are given in the following to cover professional TV applications such as DSNG and DTT distribution to transmitters. Examples on IP unicast services to consumers are instead available in [2]. For broadcasting services, only down-link parameters have been evaluated, for satellite EIRPs of 51 and 53.7 dBW at the service area contour. Conversely, for professional applications, link budget evaluations have been carried out for a typical Ku-band 36 MHz satellite with European-wide up-link and down-link coverage, following the simplified analysis method described in [5]. Ideal target carrier-to-noise ratios are derived from *Fig. 3*; implementation margins are included, as derived from [3] for DVB-S and [6] for DVB-DSNG. The following link characteristics have been adopted:

- **Up-link**: ITU climatic zone L; frequency: 14.29 GHz; Atmospheric loss and rain attenuation for 99.9% of average year (a.y.): 0.2 + 5.6 dB.
- **Satellite**: G/T(dB/°K): 4.3; transmitted EIRP at saturation: 46.5 dBW.
- **Down-link**: ITU climatic zone K; frequency: 10.99 GHz; antenna efficiency: 60%; coupling loss: 0.5 dB, pointing loss: 0.5 dB; LNB noise figure: 1.1 dB; Atmospheric loss and rain attenuation for 99.9% a.y.: 0.1 + 2.4 dB.

SDTV and HDTV broadcasting (CCM and VCM)

Table 2 compares DVB-S2 and DVB-S broadcasting services via 36 MHz (at –3 dB) satellite transponders in Europe, using 60 cm receiving antenna diameters. The example video coding bitrates are: 4.4 Mbit/s (SDTV) and 18 Mbit/s (HDTV) using traditional MPEG-2 coding, or 2.2 Mbit/s (SDTV) and 9 Mbit/s (HDTV) using advanced video coding (AVC) systems which the DVB Project is currently defining for future applications.

The required C/N of the two systems, DVB-S and DVB-S2, have been balanced by exploiting different transmission modes and by fine tuning the DVB-S2 roll-off factor and symbol rate. The results confirm the capacity gain of DVB-S2 versus DVB-S, exceeding 30%. Furthermore, by combining DVB-S2 and AVC coding, an impressive number of 21 to 26 SDTV channels per transponder are obtained, thus dramatically reducing the cost per channel of the satellite capacity. The combination of DVB-S2 and new AVC coding schemes can favour the introduction of new HDTV services, with an adequate number of programmes per transponder (e.g. 5 to 6), reducing the satellite capacity cost increase with respect to current SDTV services.

Table 2
Example comparison between DVB-S and DVB-S2 for TV broadcasting

Satellite EIRP (dBW)	51		53.7	
System	DVB-S	DVB-S2	DVB-S	DVB-S2
Modulation & coding	QPSK 2/3	QPSK 3/4	QPSK 7/8	8PSK 2/3
Symbol rate (Mbaud)	27.5 (α = 0.35)	30.9 (α = 0.0)	27.5 (α = 0.35)	29.7 (α = 0.25)
C/N (in 27. 5 MHz) (dB)	5.1	5.1	7.8	7.8
Useful bitrate (Mbit/s)	33.8	46 (gain = 36%)	44.4	58.8 (gain = 32%)
Number of SDTV programmes	7 MPEG-2 15 AVC	10 MPEG-2 21 AVC	10 MPEG-2 20 AVC	13 MPEG-2 26 AVC
Number of HDTV programmes	1-2 MPEG-2 3 - 4 AVC	2 MPEG-2 5 AVC	2 MPEG-2 5 AVC	3 MPEG-2 6 AVC

The DVB-S2 system may also deliver broadcasting services over multiple Transport Streams, providing differentiated error protection per multiplex (VCM). A typical application is broadcasting of a highly protected multiplex for SDTV, and of a less protected multiplex for HDTV. Assuming we transmit a symbol rate of 27.5 Mbaud and use 8PSK 3/4 and QPSK 2/3 modulation, 40 Mbit/s could be available for two HDTV programmes and 12 Mbit/s for two to three SDTV programmes, with a difference in C/N requirements of around 5 dB.

Distribution of multiple MPEG multiplexes to DTT transmitters

Digital Terrestrial Television (DTT) is being introduced in many countries around the world. One of the possible solutions for distributing the MPEG streams to the digital terrestrial transmitters is via satellite. Current systems are based on DVB-S, allowing the transmission of a single MPEG multiplex per signal. The result is that, for the distribution of ***n*** MPEG multiplexes, ***n*** carriers per transponder should be transmitted, requiring a large satellite HPA OBO (alternatively, ***n*** transponders are to be used). The adoption of DVB-S2 allows the distribution of multiple MPEG multiplexes using a single-carrier-per-transponder configuration, thus optimizing the power efficiency by saturating the satellite HPA. Adaptive coding and modulation is not considered, since multiple stations have to receive the same signals.

For example, a DVB-S2 signal at the symbol rate of 30 Mbaud may be transmitted on a 36 MHz transponder using $\alpha = 0.20$. Thus to transmit two DTT MUXes over DVB-S2 at 24 Mbit/s each, a spectrum efficiency of 1.6 [bit/s/Hz] is required, corresponding to QPSK 5/6. The required C/N would be around 6 dB in 30 MHz bandwidth. The target link availability (99.9% a.y.) could be achieved with a 3 m up-link antenna (EIRP of 64 dBW), near-saturated transponder in clear sky, and 1.2 m receiving antennas at the terrestrial transmitter sites. Using DVB-DSNG with 8PSK 2/3 and allocating two FDM carriers in 36 MHz at a symbol rate of 13.3 Mbaud, the required C/N would be 9 dB in the receiver bandwidth. To guarantee 99.9% a.y. link availability, the transmitted up-link EIRP was set to 75 dBW, the transponder gain setting adjusted to achieve OBO = 5.5 dB per carrier in clear sky and the receiving antenna size could not be less than 2 m. Therefore DVB-S2 would allow significantly smaller receiving antennas (nearly halved diameters) and cheaper up-link stations.

Adaptive Coding and Modulation for one-to-one services

When DVB-S2 is used for interactive point-to-point applications like IP unicasting, its gain over DVB-S is even greater, if Adaptive Coding and Modulation (ACM) schemes are used. In fact ACM allows us to recover the so called “clear sky margin” (4 to 8 dB of power), typically wasted in conventional “constant coding and modulation” satellite links, thus doubling or even tripling the average satellite throughput and reducing dramatically the service cost [2]. The ACM gain versus CCM increases for critical propagation conditions: therefore ACM is fundamental for the higher frequency bands (e.g. Ka band) and for tropical climatic zones.

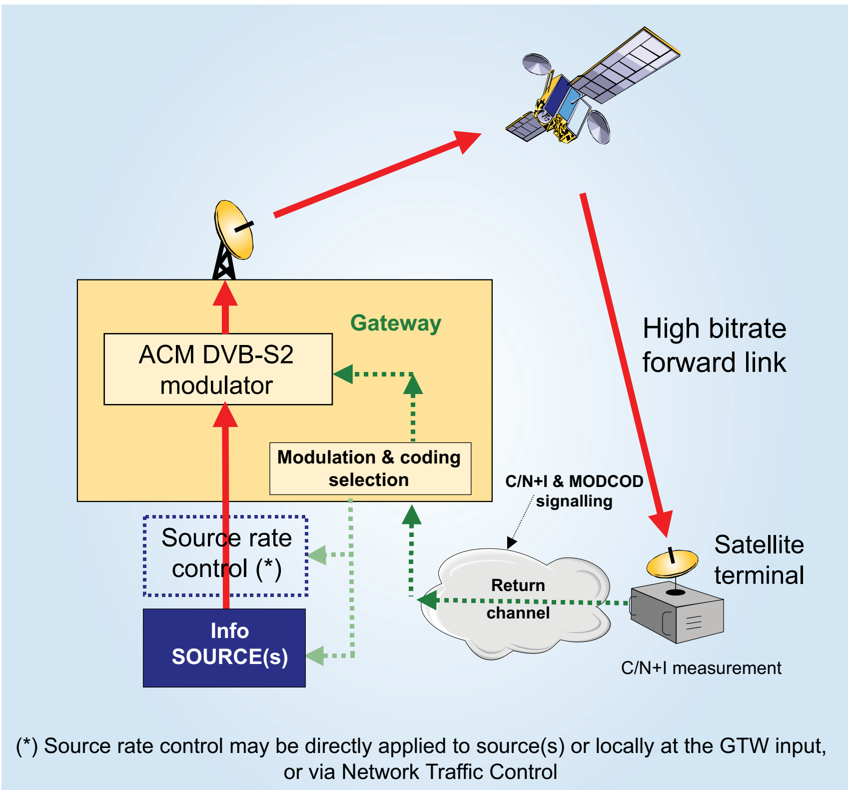

Figure 4
Block diagram of a DVB-S2 ACM link

Fig. 4 shows the scheme of an ACM satellite link, composed of an ACM Gateway (GW), the DVB-S2 ACM modulator, the up-link station, the Satellite and the Satellite receiving Terminal (ST) connected to the ACM GW via a return channel. The DVB-S2 ACM modulator operates at constant symbol rate, since the available transponder bandwidth is assumed to be constant. ACM is implemented by the DVB-S2 modulator by transmitting a TDM sequence of frames, where coding and modulation format may change frame-by-frame. Therefore service continuity is achieved, during rain fades, by reducing user bits while increasing at the same time the FEC redundancy and/or modulation ruggedness.

Physical layer adaptation is achieved as follows:

1) Each ST measures the channel status (available C/N+I) and reports it via the return channel to the Gateway (GW);
2) The ST reports are taken into account by the GW while selecting the assigned protection level for data packets addressed to the ST;
3) In order to avoid information overflow during fades, a user bitrate control mechanism should in principle be implemented, adapting the offered traffic to the available channel capacity. This can be implemented in various ways, according to the specific service requirements and network architecture. The GW imposes error protection, applied to a given portion of user data via suitable interfacing mechanisms. With respect to one-to-one services (e.g., DSNG), IP unicast links using DVB-S2 ACM must adapt the error protection on a user-per-user basis: the number of users may be very large (e.g. up to hundreds of thousands). Furthermore, direct source rate control may be impossible, since information sources (IP information providers) are far from the satellite GW. Further details on this application scenario is given in [2].

A crucial issue in ACM systems is the physical layer adaptation loop delay, as it is strictly linked to the system capability of tracking channel variations. If loop adaptation is fast, service continuity may be guaranteed even during fast rain fades while, at the same time, keeping low C/N transmission margins to maximize the overall system throughput. Since maximum C/N+I variation rates at Ka band have been estimated to be of about 0.5 dB per second during heavy rain fades [2], and since the C/N distance between two adjacent DVB-S2 protection levels is around 1 dB, control loop delays smaller than 1 second should allow minimization of transmission packet losses.

TV contribution and DSNG services using ACM

ACM techniques look very promising to improve the performance of point-to-point and point-to-multipoint TV contribution links (e.g. DSNG), where a single TS is sent to a unique or multiple (few)

Abbreviations

ACM	Adaptive Coding and Modulation
AHG	Ad hoc Group
APSK	Amplitude Phase-Shift Keying
ATM	Asynchronous Transfer Mode
AVC	(MPEG-4) Advanced Video Coding
AWGN	Additive White Gaussian Noise
BCH	Bose-Chaudhuri-Hocquenghem (code)
BER	Bit-Error Ratio
C/N	Carrier-to-Noise ratio
CCM	Constant Coding and Modulation
DSNG	Digital Satellite News Gathering
DTT	Digital Terrestrial Television
DVB	Digital Video Broadcasting
DVB-S	DVB - Satellite
DVB-S2	DVB - Satellite, version 2
EIRP	Effective Isotropic Radiated Power
ESA	European Space Agency
ETSI	European Telecommunication Standards Institute
FDM	Frequency Division Multiplex
FEC	Forward Error Correction
HP	High-Priority
HPA	High Power Amplifier
IBO	Input Back-Off
IP	Internet Protocol
LDPC	Low Density Parity Check
LNB	Low-Noise Block
LP	Low-Priority
MUX	Multiplex / multiplexer / multiplexing
OBO	Output Back-Off
OMUX	Output Multiplexer
PER	Packet Error Rate
PSK	Phase-Shift Keying
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature (Quaternary) Phase-Shift Keying
TWTA	Travelling-Wave-Tube Amplifier
VCM	Variable Coding and Modulation

receiving stations. In this case, the TS packets protection must follow the C/N+I variations on the satellite channel in the receiving location. Constant Transport Stream bitrate and end-to-end delay, as required by MPEG, may be guaranteed by using DVB-S2 stream adaptation tools which are described in detail in [2]. In order to avoid stream overflow when the channel throughput is reduced, a variable bitrate (VBR) video encoder has to be adopted.

Let us consider first the examples of TV contribution services using large transmitting and receiving stations to access a typical 36 MHz transponder with four FDMA signals. Using the DVB-DSNG standard and 16QAM 3/4 mode, four TV contribution signals at 18.5 Mbit/s may be allocated in the transponder (76 dBW up-link EIRP, 14.3 global IBO and 7 m transmitting/receiving antenna diameters, 99.9% a.y. link availability). Using DVB-S2, 16APSK 5/6 and roll-off = 0.2, the information rate of each link can be increased to 24.75 Mbit/s, thus confirming a bitrate gain of DVB-S2 over DVB-DSNG of more than 30%. On the other side, keeping the same bitrate as DVB-DSNG, the better performance of DVB-S2 may be used to significantly decrease the dimension of the transmitting/receiving antennas down to 4.5 m (8PSK 5/6, 74 dBW up-link EIRP, 13 dB global IBO). With the same 4.5 m antennas, but adding the ACM functionality of DVB-S2, the useful bitrate would be increased again to 24.75 Mbit/s, at least under clear sky conditions.

The advantages of DVB-S2 and ACM are also evident for DSNG services. For example, in a 9 MHz satellite bandwidth slot, a DSNG van with 1.2m antenna (61 dBW up-link EIRP) may transmit 19.8 Mbit/s in clear sky conditions (16APSK 2/3, roll-off = 0.2) and switch to 14.85 Mbit/s under heavy fading (8PSK 2/3). For sake of comparison, DVB-DSNG with QPSK 7/8 would allow the transmission of 10.7 Mbit/s only.

As a last example, let us consider a fly-away emergency DSNG station, with a 90 cm antenna and only 12 W HPA power (99.9% a.y., 49 dBW up-link EIRP, 12 dB global IBO, 4 m receiving antenna, four signals per transponder). Using DVB-S2 and ACM, 9.9 Mbit/s (QPSK 2/3, roll-off = 0.2) would be available in clear sky, 8.9 Mbit/s (QPSK 3/5) under typical propagation conditions and 3.68 Mbit/s (QPSK 1/4) under critical link conditions. This would offer a good picture quality using MPEG-2 video coding, and an excellent quality using new AVC encoders. DVB-S (QPSK 1/2) would require a 5 dB more powerful station to offer a constant bitrate of 6.1 Mbit/s.

Conclusions

The DVB Project does not see DVB-S2 replacing DVB-S in the short term for conventional TV broadcasting applications. Millions of DVB-S decoders are already operating reliably and contributing to successful digital satellite businesses around the world. New applications are being envisaged for satellite environments such as the delivery of consumer HDTV and the delivery of IP-based services. Two examples can highlight the revolution we have in front of us. Combining DVB-S2 and new video and audio coding schemes (e.g. H.264), some 20 – 25 SDTV or 5 – 6 HDTV programmes may be broadcast in a conventional 36 MHz transponder. In the area of professional TV applications, the ACM tool may offer very large benefits for one-to-one connections, such as fly-away small DSNG stations. In these new application areas, DVB-S2 will do what DVB-S could never have done.

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References

[1] ETSI: Draft EN 302 307: **Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2)**.

[2] **The DVB-S2 standard for broadband satellite systems**
Special Issue of the International Journal of Satellite Communications Networks, 2004.

[3] ETSI: EN 300 421: **Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for 11/12 GHz satellite services**

[4] Chris Weck : **Hierarchical modulation — the transmission of two independent DVB-T multiplexes on a single TV frequency**
EBU Technical Review No. 294, April 2003

[5] A. Morello and V. Mignone: **New DVB standard for DSNG — and contribution satellite links**
EBU Technical Review No. 277, Autumn 1998

[6] ETSI: EN 301 210: **DVB: Framing structure, channel coding and modulation for DSNG and other contribution applications by satellite**.