# *Network Infrastructure for the Television beyond 2000*

*ESA Project conducted by Alenia Spazio, Space Engineering, Kayser Threde and VCS*

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## 1. PROJECT ABSTRACT

The objectives of the TVB2K Project were:

- the identification of all broadcast and interactive services that can be conveniently supported by a dedicated telecom infrastructure to be operated from the beginning of new century;

- the architectural definition of a system infrastructure (i.e. the TVB2K System ) able to offer a world-wide coverage of the main future multimedia events and to elaborate and distribute part of created contents;

- the specification of the main subsystems composing the central element of the previously identified system infrastructure (i.e., the *Core Processing Centre).*

## 2. SERVICE REQUIREMENTS

To exploit all market opportunities opened by emerging TV multimedia services, TVB2K System shall be able:

- to collect professional video/audio/data contributions, each either live or offline from anywhere in the world within the specified geographical coverage;

- to store, without any loss of data, all received contributions;

- to adapt the formats of collected video/audio/data contributions;

- to provide a reliable support for all required processing steps for editing and formatting digital video information;

- to support all others phases of content and program production processes;

- to archive contribution and edited information for long-lasting historical storage;

- to create outgoing live, off-line or on-demand programs for subsequent transmission to broadcasters or to end-users (TV or Internet end-users);

- to provide on demand programs by retrieving multimedia contents from the processing centre archive;

- to allow unlimited access of authorised users to the accumulated information for further processing.

## 3. SYSTEM ARCHITECTURE

The functioning of TVB2K System (see Figure 1) can summarised as follows:

- Leg A, Leg B and Leg C will be used to receive large quantities of information from the external world. Leg C will also act as the interactive front-end of the system. Leg A, Leg B and Leg C will be part of the Interface and Conditioning subsystem that will have the task to harmonise the formats of all received contributions;

- the CPC will perform all required post-processing functions, by returning all contents to the Interface and Conditioning subsystem for the final distribution;

- the Storage and Archive subsystem will be responsible for the dynamic and historical memorisation of raw and elaborated information;

- the Distribution Subsystem (i.e., the Leg D), will distribute the TVB2K System products to all selected end-users according to pre-negotiated service profiles.

With reference to the proposed service configuration, Figure 2 shows a possible arrangement of external and internal interfaces of the CPC, respectively identified with letters (A, B, C and D) and numbers (1, 2, 3, 4, 5 and 6). On the other hand, Figure 3 describes a possible physical implementation of TVB2K CPC.

## 4. TVB2K SYSTEM DESIGN

First of all, there are no doubts about the fact that the Leg B is more critical as far as the RF characteristics of the CPC receiving terminal (e.g., G/T, linearity, dynamic, etc.). In fact, since the quality of Leg A and Leg B contribution channels have to be maintained similar and considering that the Leg B up-link terminals are normally less performing (lower EIRP, worse linearity, etc.), the apportionment of end-to-end performance specification imposes more stringent constraints to Leg B design.

On the other hand, as a consequence of all applicable video service requirements, the base-band part of the Leg B (i.e., the Integrated Receiver Decoder) seems to be simpler than the corresponding element used in the Leg A.

In fact, Leg A video contribution channels are typically more demanding in terms of throughput, quality and additional features with respect to the Leg B case.

As consequence of that, it seems convenient to adopt for Leg A and Leg B a modular approach, where each single module is composed by an RF Front-end and an IRD, respectively designed bearing in mind the performance specifications of Leg A and Leg B.

On the other hand, the role of Leg C will be to gather data, audio and low-resolution video contributions as well as to accept service requests via various terrestrial and mobile links. To this end, TVB2K System will interact by means of Leg C with:

- all end-users using terminals like videophones, telephones, etc.;
- all end-users using ISDN end-users devices;
- all multimedia terminals (i.e., H320 Terminal);
- user Internet navigators;
- all end-users devices compatible with the 2^ generation mobile system improved by GPRS capability;
- all end-users devices compatible with UMTS;
- all satellite end-users using terminals (e.g., Inmarsat, Globalstar, etc).

All interfaces C are critical for what concerns security access. For this reason, the TVB2K System shall identify and authenticate all user access, being C interfaces mainly used for interactive contributions.

TVB2K Leg D will be used by TVB2K System for delivering on large-scale basis a set of commercial-grade enhanced TV services. D-1 interface will support this type of service. The information eventually transmitted by Leg D-1 is formatted as specified by DVB-S MPEG2 standard. End-user will be in the position to receive TVB2K program by using commercial IRD's.

In addition to that, TVB2K will also able to support special TV-based services for selected pools of users. Leg D in this case will feed some remote TV Landing Points responsible for the local distribution of TV Program.

TV Landing Points receive via Internet from registered user the content requests and forward them to the TVB2K CPC after the required harmonisation. The standards to be used for the local distribution will be selected by the TV Landing Points themselves that will be connected with TVB2K CPC by means of D-2a interfaces.

Finally, TVB2K users will also have the chance to receive a large quantity of Internet-based products by accessing through service D-2b interfaces. To this end, TVB2K CPC shall be able to operate as an Internet Service Provider (ISP) specialised in the provision of TV-based services enhanced by traditional Internet multimedia services (point-to-to file transfer, pushing, Web channel, etc.). TVB2K CPC shall directly collect all generated service requests by registered users via Internet.

The communication network supporting this application shall be bi-directional. In fact, an adequate number of DVB-S channels, paired with some terrestrial return channels, shall be used in broadcasting mode over a given distribution area by the CPC.

IP services shall be transported over DVB-S MPEG Stream in a transparent way. Users shall be able to extract their own information from DVB-S stream by using the addressing scheme of MPEG (PID) and Internet (Internet address) multiplexing systems.

Two types of TVB2K users are envisaged:

- single users;
- communities of users.

Single users shall be able to access directly all TVB2K CPC features, while communities of users shall use a gateway node to this end.

To be appealing for potential customers, all D interfaces are designed to maximise the resources allocation efficiency, thus maximising service cost-effectiveness. To this end, the adoption of Skyplex system has been proposed as core element for broadcasting TV-based information and distributing TVB2K products via Internet.

Skyplex is an innovative digital satellite transmission system that performs DVB multiplexing on board the satellite. Unlike conventional satellite systems, Skyplex allows several independent (private or shared) uplink stations to use the same transponder from different locations, while maintaining a single high speed multiplexed downlink signal.

Figure 4 describes a possible physical implementation of Leg D.

Let us consider now the core element of the TVB2K System: the CPC.

To cope with all imposed service requirements, CPC shall be able to support the following main processing functions:

- Post production;
- Editorial an Program Planning;
- Master Control Room;
- Local Production Studio;
- Routing and networking;
- Monitoring & Control.

TVB2K Service requirements defines a set of very critical tasks for the storage and archiving facility. Basically, the process of producing outgoing live, off-line or on-demand programs requires the integration of information elements belonging to the incoming multimedia contributions with the contents stored in the internal archive. TVB2K Storage and Archiving Facility is designed to guarantee the following features:

- the adaptation of all formats of collected video / audio / data contribution delivered by exchangeable media and the formatting of all handled data in the a standardised TVB2K format;
- the distribution of all information within the boundaries of CPC;
- a support to editing and formatting unit concerning all required processing elaboration of digital video information;
- a support to content and program production processes;
- the provision of an easy man-machine interface;
- the archiving of contributions and edited information over a long period;
- the management of historical storage device.

## 5. ECONOMICAL ANALYSIS

Starting from the Hardware and Software-Matrix defined during the course of Project, all major cost items occurring during the procurement-, development- and operational cost elements have been estimated. By taking into account two service availability targets (99% or 99.9%), two alternative analysis rubs have been completed. By observing the achieved results, it should be noted that assuming that:

- all figures are expressed in EURO;
- all subsystem integration tasks included;
- all figures are without VAT.

Let us analyse the above-described cost estimations.

The performed analyses indicate that the level of identified investments varies with the required availability figures. In fact for an system availability equal to 99%, the overall investments are in the range of 15338 K EURO, while 22626 K EURO have to be spent for achieving a system availability equal to 99.9%. This results shows a certain correspondence to the 30 M EURO limit of a typical TV real system and, being below this value, confirms the economic feasibility of TVB2K concept.

The Signal Interfacing & Conditioning equipment seems to be non-critical in respect of technology and price level that is expressed by the low portion of investments.

More than 50% of the total investment is related the CPC infrastructure. The Local Production Studio can be identified as the essential item that solely covers about half of the investments.

As far as the maintenance costs are concerned, the results still depend on the required availability figures. For an system availability equal to 99%, the maintenance costs are in the range of 2559 K EURO, while 3415 K EURO have to be spent for maintaining operational a system having an availability equal to 99.9%.

The storage equipment is known to require a certain level of continuous maintenance. Those numbers fit into the general experience of industry.

With regards to the staff requirements for technical and production whose headcount is reported in the previous section, it is obvious that the CPC concentrates the workforce in the CPC. In the assumed total of 170 team members in the CPC during production, only a minimum percentage (about 10 persons) is allocated to assure continuous functionality of the system before and after prime time operations for a 24-hours cycle.

The adoption of one of two analysed availability targets, (i.e., 99% and 99.9%), impacts the CPC System in two different ways.

The study team confirms that the achievement of 99% availability is already an ambitious target for the TVB2K System. Consequently, the system

architecture is configured that due to basic monitoring and control means, redundancy elements and a predefined maintenance concept, this level of quality can continuously maintained. This statement is also represented in the headcount, indicated as minimum amount.

The increase of the TVB2K availability from 99% to 99.9% is therefore manifested mostly and obvious in the increased investment figures.

The total investment cost move to 22626 K EURO, which represent +47% of the initial amount. In respect to the O&M cost per year, the high availability requirement increases the total O&M expenses for the system about + 1 M EURO, which is roughly +4% more per year than in the initial case. These conclusions are summarised in the following Table 1.

Due to the importance to know the "cost per year" of TVB2K System, the following, the following Table 2 reports this result for the first ten years of system lifetime.

Table 2 clearly indicates that the investment costs do not play an important role in the expenditures per year, even in the years from 1 to 5 in which most of the equipment will be tax deducted. Also the maintenance costs play a minor role in the expenditures compared to the operational and personnel cost and the annual fees for satellite usage.

Again, Table 2 dictates that the mission and the profiling a future TVB2K operator may have an larger impact on the expenditures per year and the relevant cost figures with respect to the cost for equipment and investment.

## 6. CONCLUSIONS

The Multimedia TV System defined and specified by TVB2K Project Team can rightly claim to be considered a comprehensive platform including most of the potential means presently conceivable for supporting in a very future emerging TV multimedia services.

One of the main merit of the proposed architecture is the capability to adapt its service offer to the specific needs of final users. In fact, TVB2K System will have a service capability ranging from the simple broadcasting of traditional TV programs up to the support of special interactive services. In both cases, information base used to generate TVB2K Products will be all the video/audio/data contributions received from sources sparse anywhere around the world. Furthermore, it will be possible to integrate this information integrated with historical video and audio materials stored inside the TVB2K System itself

Once in place, this infrastructure will be able to provide operational services to remote users, video magazines and will introduce live interaction, during specific events. To reach this challenging target, TVB2K System has to be equipped essentially with four types of subsystems, respectively necessary to receive, elaborate, store and finally distribute TV-based information.

A particular attention of TVB2K Project Team has been paid to provide a complete functional specification of CPC facilities. The results of this high-level activity have been used to identify all main internal and external interfaces and to provide a detailed specification of main subsystems. In this context, a large collection of detailed block diagrams showing the breakdown of most critical elementary functions have been defined. This work can be used by ESA in a later stage when there will be the need to actually procure such components from different vendors.

Finally, an economic analysis has been performed with the aim to assess the cost-effectiveness of the proposed system architecture and, as consequence of that, of its chance to enter future markets. The results of this work were quite good, thus confirming the feasibility of the adopted design approach and the acceptability of required investments. As far as the operational costs are concerned, it is interesting to note that the cost per year are dominated by assumed service requirements, rather than by the adopted technological solution.

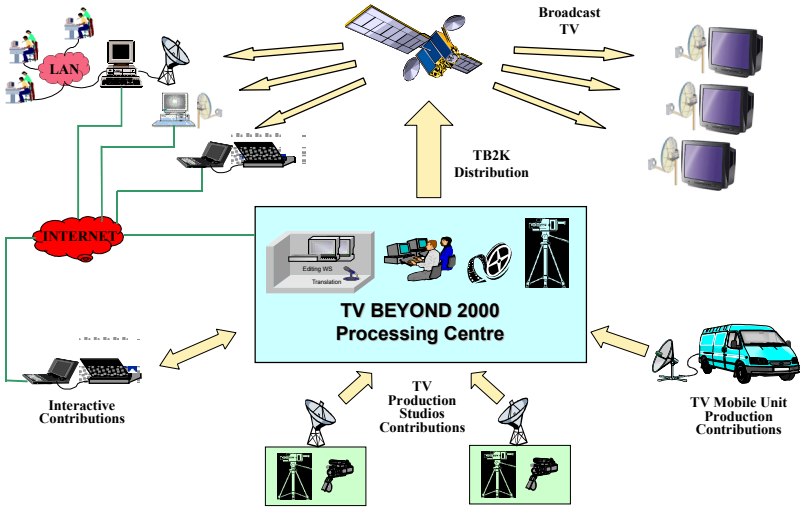


*Figure 1 TVB2K System service architecture*

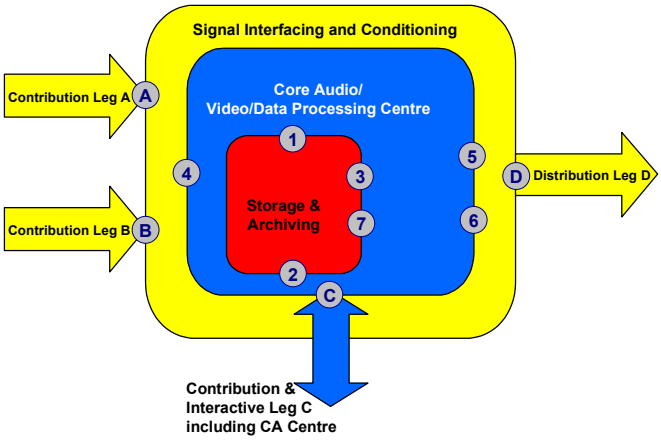


*Figure 2 Functional architecture of TVB2K CPC*

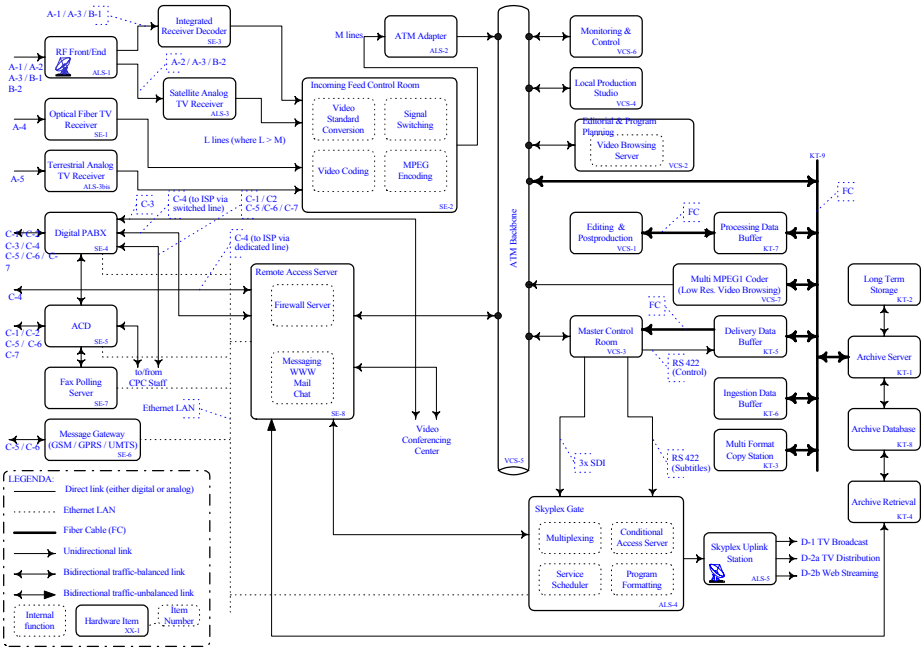


*Figure 3 Physical architecture of TVB2K CPC*

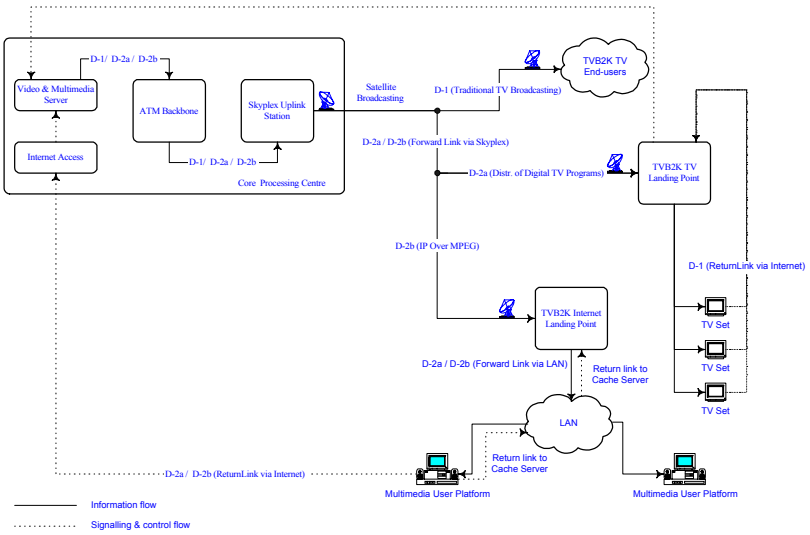


***Figure 4 Leg D functional description***

| Cost Element | Cost Data (K EURO) | Δ % |
|---|---|---|
| Investment 99% | 15338 | + 47 % |
| Investment 99.9% | 22626 | |
| Total O&M 99 % | 19559 | +4 % p.a. |
| Total O&M 99.9% | 20415 | |

***Table 1 Cost comparison***

| CPC Cost per Year (K EURO) 99% Availability | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Cost Elements per Year** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Investments | 1846 | 1846 | | | | 160 | 160 | 90 | 90 | 90 |
| Maintenance | 2559 | → | | | | → | → | → | → | → |
| Personnel (Ops.) | 15000 | → | | | | → | → | → | → | → |
| Subtotal CPC | 19405 | | | | | 17.719 | 17.719 | 17.650 | → | → |
| Transmission Europe (25% Contribution & Distribution) | 13250 | → | | | | → | → | → | → | → |
| Transmission Global (25% Contribution & Distribution) | 22250 | → | | | | → | → | → | → | → |
| **TOTAL Europe** | **32655** | | | | | **30969** | | **30900** | | |
| **TOTAL Global** | **41655** | | | | | **39969** | | **39900** | | |

***Table 2 - TVB2K System cost-per-year***