Ka-Band Satellite Consumer Triple-Play and Professional Video Services

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Abstract. This article presents Eutelsat European Ka-band implementation of the broadband TooWayTM service and its evolution through a dedicated Ka-band exclusive satellite (KA-SAT). It also explains Eutelsat's choice in selecting the Ka-band for interactive services, broadcast video and IPTV services, demonstrating the optimal consumer service synergy between existing Ku-band and new Ka-band services.

KA-SAT satellite is not focusing only on consumer triple-play services. Indeed, Eutelsat strategy consists in offering also professional video and data services in Ka-band (video distribution, video contribution, e-cinema, file transport) sharing the same transparent satellite bandwidth and the same ground segment infrastructure.

For those professional video applications the last content processing (SVC) and satellite transport (DVB-S2 ACM) techniques are under deployment and this paper will present simulation results and link budgets estimations for a large number of future commercial applications.

1 Introduction

Eutelsat operates 25 satellites in the geostationary arc from 15°W to 70.5°E offering a variety of services from corporate networks to broadcasting. The HOT BIRD™ constellation at 13°E constitutes the prime position for DTH (Direct to Home) and cable broadcasting, utilizing the full Ku-band spectrum from 10.70 GHz to 12.75 GHz. There are 102 transponders delivering about 1400 TV channels. The HOT BIRD™ service area reaches some 120 million satellite and cable households.

Video services contribute to approximately three quarters of Eutelsat revenue. With DTH and cable broadcasting, the main objective is to cover as many households as possible through a single service area. However, the requirements of broadband access move away from broadcast to unicast as the data accessed on the Internet by a given user is generally intended for that given user at that given instant.

The KA-SAT system calls for specific system concepts which are different from those of DTH systems. The main objective is to ensure that the cost for the system capacity permits a competitive consumer interactive service.

K. Sithamparanathan et al. (Eds.): PSATS 2010, LNICST 43, pp. 74–85, 2010.

2 The KA-SAT Satellite

KA-SAT will be the first European multi-beam satellite to operate exclusively in Ka-band and dedicated to providing broadband and broadcast services in Extended Europe. It will be launched 3rd quarter 2010 and positioned to be compatible with the 13 degrees East location in geostationary orbit, where the Eutelsat's HOT BIRD broadcast satellites are operated.

The satellite is being manufactured by EADS-Astrium based on their Spacebus 3000 platform. KA-SAT will operate simultaneously 82 spotbeams, which makes it the largest multi-beam Ka-band satellite ever ordered worldwide and also offering the largest service area. The satellite will feature a high level of frequency re-use. The spacecraft is equipped with four multi-feeds deployable antennas with enhanced pointing accuracy and a high efficiency repeater. The cells cover Europe and parts of the Middle East and North Africa as shown in Figure 1. Efficient frequency reuse enables the system to achieve a total capacity that is in excess of 70 Gbps. The introduction of KA-SAT will triple the total capacity commercialized by Eutelsat.

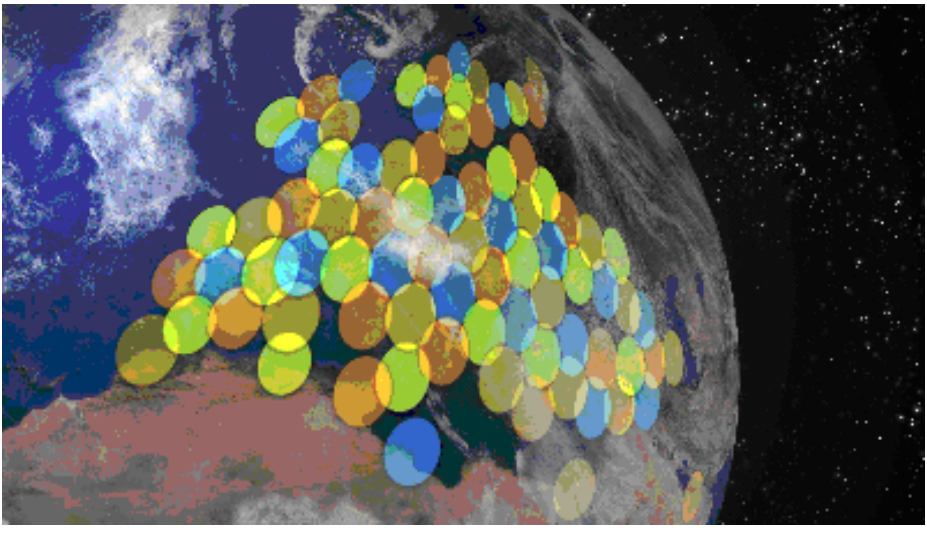

Fig. 1. KA-SAT illustrative coverage

The KA-SAT satellite will form the cornerstone of a major new infrastructure in Europe and the Mediterranean Basin that will also comprise eight gateways, interconnected by fibre and connected to the Internet backbone. Each gateway will manage broadband connections between the Internet and the users via a group of spotbeams on the satellite. The overall network will be managed by Eutelsat's Skylogic subsidiary from its Turin teleport in Italy.

KA-SAT supports a variety of broadband services ranging from consumer services (including triple- play solutions), professional services (e.g. SNG, occasional use, and

platform contributions) and TV broadcast services. In addition KA-SAT will be an opportunity to open up a new resource optimised for the development of local and regional television channels targeting specific geographical audiences.

KA-SAT's innovative design will enable the provision of up to 900 Mbit/s of capacity for each spotbeam, which will be shared on the forward and return paths. This exceptionally high throughput heralds the arrival of future video applications requiring very high bit rates, notably HD digital cinema and 3D television.

3 KA-SAT Performance Assessment

The design of the KA-SAT system has been also based on a detailed link budget assessment in order to optimise all the system parameters. The present section provides an assessment of KA-SAT performance on the Forward Link.

An approach based on the Adaptive Coding Modulation (ACM) has been of valuable importance for the optimisation of the system performance to the different propagation condition inside the KA-SAT service area. The Modulation/Code (MOD/COD) thresholds are based on DVB-S2 standard [1].

The example of performance assessment over the Italian Peninsula affords a good example for the wide diversity that prevails in terms of geographical, atmospheric and climatic conditions. All performances shown are given for illustrative purposes only and are not contractual binding.

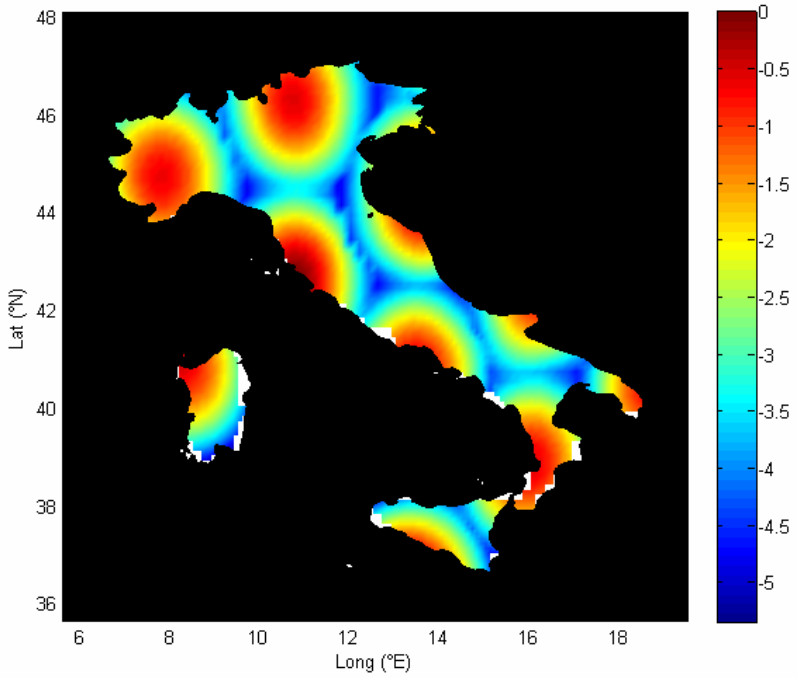

Fig. 2. KA-SAT Forward Overall Performance (clear sky condition) over Italian Peninsula

In this context, the overall performance is expressed as the normalised carrier-to-noise+interference ratio calculated at each point of the coverage, and expressed as C/(N+I). Figure 2 shows the KA-SAT overall performance over the Italian Peninsula in clear sky conditions on the Forward Link.

Figure 3 below shows a possible MOD/COD assignment based on this performance in clear sky conditions. The MOD/COD thresholds are based on the DVB-S2 standard [1]. By assigning a specific MOD/COD value to each individual terminal, it is possible to take advantage of the KA-SAT's multi-spot coverage and adapt efficiently to the diverse geographical and atmospheric conditions that prevail.

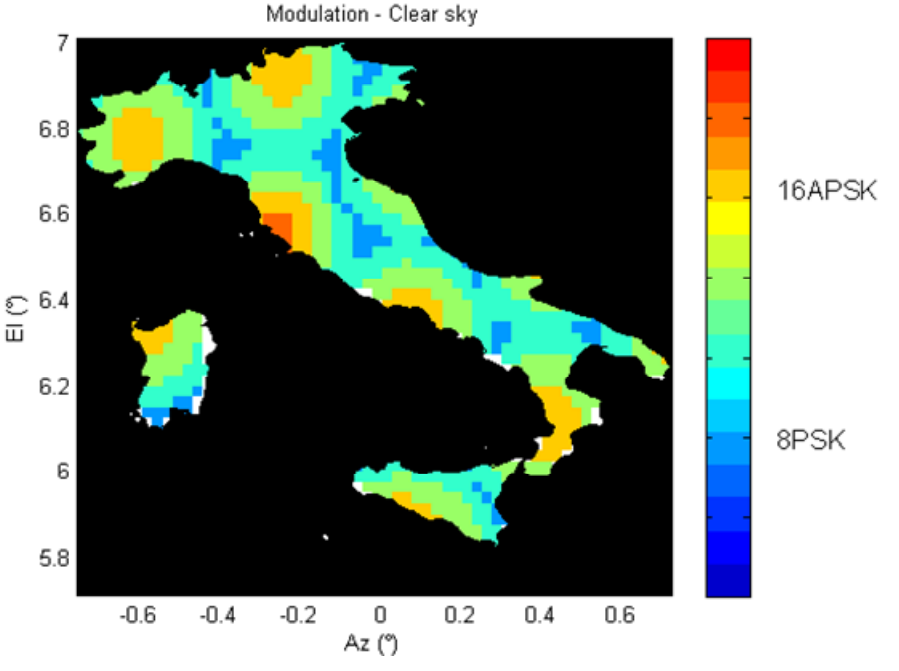

Fig. 3. Possible MODCOD Assignment (clear sky condition) over Italian Peninsula on the Forward Link

Figure 4 below shows the KA-SAT's overall performance (normalised C/(N+I)) over the Italian Peninsula with rain-fade conditions on the user downlink of the Forward Link assuming a downlink availability of 99.9%.

Figure 5 below shows a MOD/COD assignment based on this performance in rain conditions, using the ACM capabilities of the DVB-S2 standard [1]. By assigning an adaptive MOD/COD value to each individual terminal, it is possible to adapt efficiently to the diverse weather conditions of the Italian Peninsula. From this Figure, one can obtain the minimum rate that can be guaranteed 99.9% of the time to each location.

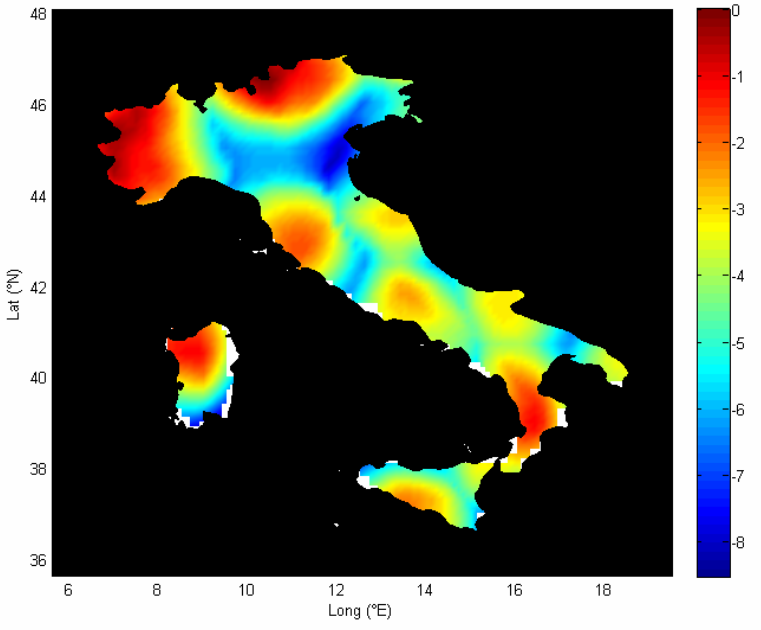

Fig. 4. KA-SAT Forward Overall Performance (rain fade condition) over Italian Peninsula

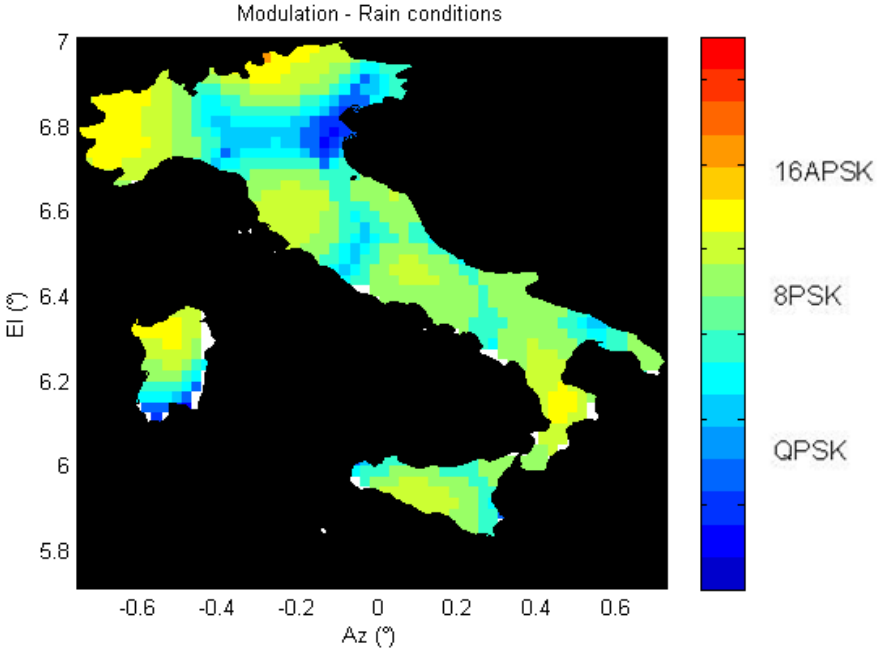

Fig. 5. Possible MODCOD Assignment (rain fade condition) over Italian Peninsula on the Forward Link

A similar performance analysis can be conducted for the Return Link. The performance assessment over the full KA-SAT coverage has demonstrated a traffic capacity in excess of 70 Gbps and the ability of providing services comparable to ADSL2+.

4 The Tooway™ Service

Consumer broadband expectations (triple play) are in continuous evolution for high bandwidth consuming applications such as Web TV, VoIP, music, P2P, online gaming, database and video. These applications must be accessible at higher speeds and lower prices. KA-SAT will form the cornerstone of a major new satellite infrastructure that will significantly expand capacity for consumer broadband services across Europe and the Mediterranean Basin (triple play), while providing new opportunities for professional services like:

- Broadband internet access for SOHO market,
- Close user group of terminals,
- Regional video services,
- Service restoration.

4.1 Consumer TriplePlay Services

Broadband Internet Access
Households located within KA-SAT's coverage who do not have access to ADSL will be able to benefit from Tooway™ for full satellite-based broadband connectivity. The potential ADSL un-served market for pure satellite broadband services in 2010 is estimated to be 6 million homes in Western Europe and 8 million homes in Eastern Europe.

Capitalizing on the Ka-band capacity that is already available via Eutelsat's existing resource, on HOT BIRD™ 6 and the Ku-band capacity on EUROBIRD™ 3, Eutelsat has already introduced Tooway™ for consumer broadband access using the SurfbeamTM system developed by ViaSat:

- HOT BIRD™ 6 was the first European commercial satellite with a Ka-band payload and was a real opportunity for Eutelsat to deploy a full Ka-band system in Europe as done already by WildBlue in USA, awaiting KA-SAT.
- EUROBIRD™ 3 was the first Eutelsat satellite specifically designed for broadband applications in Ku-band and offers strong coverage over Eastern parts of Europe where HOT BIRD™ 6 is not able to provide Ka band Tooway™ services.

The current TowayTM service definition over HOT BIRD™ 6 and EUROBIRD™ 3 is allowing download up to 3.6Mbps and upload up to 384Kbps. The service differentiation is done on volume consumption per month through a Fair Access Policy (FAP). To promote a fair access use of service and avoid abuse, when consumption is above volume thresholds, the service remains available but at a lower speed.

KA-SAT with the new SurfbeamTM generation system from ViaSat will allow much higher throughput and volume for each subscriber at a price comparable to ADSL and cable modem connections.

VoIP Services
Voice over IP is also an expectation of any broadband subscriber interested in good call quality at low cost, taking advantage of competition between all the VoIP operators. VoIP through Tooway™ is already available and marketed by several service distributors. The new generation of Surfbeam™ manufactured by ViaSat will provide the same VoIP capabilities with QoS.

TV Services
As KA-SAT will be collocated at Eutelsat's HOT BIRD™ TV premium neighborhood, the IPTV services delivered via Tooway™ will complement and enrich the DTH TV offer using new combined Ku/Ka-band receive terminals. Indeed as Tooway™ is delivering ADSL-like services via satellite, Tooway™ subscribers will expect to be able to access IPTV services with VoD and PVR features. IPTV offers will benefit from the new techniques including DVB-S2 VCM/ACM mode and H.264 SVC coding in order to guarantee higher bit rates and quality standards.

- **DVB-S2 VCM/ACM**

In the DVB-S2 standard, the VCM (Variable Code and Modulation) mode is defined to avoid feedback from each terminal for waveform efficiency configuration. In such a case, a specific link budget is performed for each terminal and a static efficiency is defined for each of them according to the availability needed. In this case, the adaptive linked to the evolution of the weather is lost, but there are no longer constraints for the worst link budget applied for the entire spot. The ACM (Adaptive Code and Modulation) needs a terminal feedback on the return channel and allows each terminal to receive the best efficiency related to its fading conditions.

- **H.264 SVC**

The SVC (Scalable Video Coding) is a feature developed for H.264 (MPEG-4 Part 10) source coding, which allows transmitting the same video sequence coded with:

- spatial scalability
- temporal scalability
- SNR/Fidelity/Quality scalability

SVC is being developed to be basically applied to mobile ecosystems (DVB-SH) and ADSL video services but it will have important legacy applications for IP video services over Ka band satellite systems.

As an example, the same video sequence can be coded in SD and HD format:

- SD 720x576i @50 Hz
- HD 1920x1080p @ 60 Hz

Combined with SVC the HD format could be received by a terminal in clear sky conditions as the SD format could be received by another terminal affected by fading

conditions (e.g. rain). In case of stringent fading conditions an SD program with lower bit rate will be available in order to maintain TV service.

Applied to satellite, the SVC feature with DVB-S2 VCM/ACM capability will allow to not multicast the full 3 programs detailed in the figure below but only one program with 3 layers protected with different efficiencies. The bit rates and the efficiencies of interest are under study.

Definition	**MPEG4 encoding bit rate** ***under study***	**DVB-S2 Efficiency** ***under study***	**Example of quality**
SD	1Mbps	QPSK 2/3 1.33	
SD	2.5Mbps	QPSK 5/6 1.66	
HD	8Mbps	8PSK 2/3 1.99	

Fig. 6. Image source from Institut Nachrichtentechnik Heinrich-Hertz-Institut

Eutelsat is participating in an ESA project (SVConS) with other companies (NOMOR, Fraunhofer HHI and IIS) which are assessing the performances of SVC over satellite links.

A complete range of simulations is running and preliminary results will be available beginning of 2010.

4.2 Video Services

Three main video services will be covered with KA-SAT.

DTT Primary Distribution

All the countries which are implementing a DTT network on their territory are facing the same problem: it would not be possible to cover 100% of the population with the transmission from DTT terrestrial headends.

On the top of that, it will be impossible to feed all the terrestrial headends by fiber and/or microwave links.

KA-SAT will be the natural solution to:

- feed the terrestrial headends not connected by fiber.
- complement the DTT offer with DTH reception for households not receiving DTT.

Thanks to the spot beam coverage of KA-SAT, this solution will be complete the existing national distribution with regional distribution. Regional DTT channels can be inserted in the national MUXes only in the spots covering the region of interest.

This will avoid the distribution of all the regional channels in the DTT MUXes optimizing the bandwidth utilization and saving CAPEX (headends equipment optimization).

The DTT primary distribution in Ka-band will achieve with a dish size of 120 cm an acceptable operational availability.

Figure 7 is depicting a hybrid solution which will consist in the transport of the DTT multiplexes via satellite for the feeding of headends and complementary DTH reception.

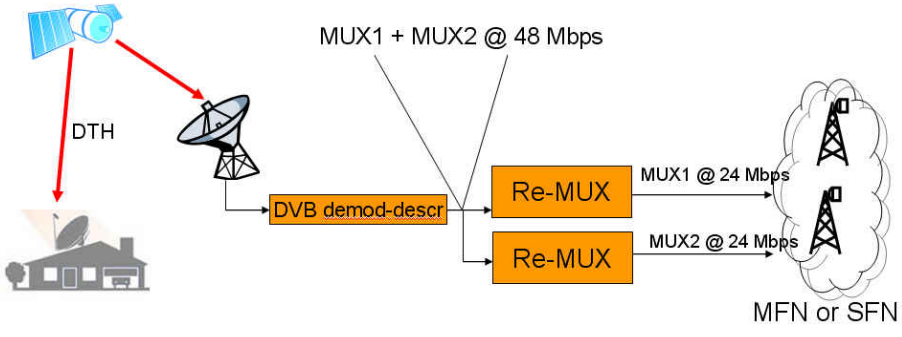

Fig. 7. Primary DTT distribution

Professional Video Contribution

In order to complement the offer of SNG services a professional contribution system is under development in order to allow the implementation of video contributions on KA-SAT.

This system will allow the uplink of a video contribution (SD or HD, 4:2:2 profile) under a spot of KA-SAT and the potential distribution of this signal on some or all the 82 spots via the fibre ring.

This terminal will feature a professional indoor unit with enhanced throughput performances, a most powerful ODU and bigger size Ka-band dish (with an option for auto-deploy systems).

Diameter	SSPA	Bitrate	Application
60cm	4W	5 Mbps	1 SDTV channel
120cm	4W	10 Mbps	1 HDTV channel
120 cm	10W	15 Mbps	2 HDTV channels

DTH Broadcast Services

The pan-european coverage of KA-SAT can be used for DTH broadcasting. It will complement and enrich the offer from the HotBird™ fleet at 13ºEast.

This offer currently provides more than 1400 TV channels over all Europe, Middle East and North Africa; with KA-SAT this offer can be extended with regional channels and new actors in the Digital TV scenarios.

KA-SAT broadcast services will benefit of a full redundant fiber ring relaying the 10 Ka-band gateways and allowing multiple insertion points for local video contributions.

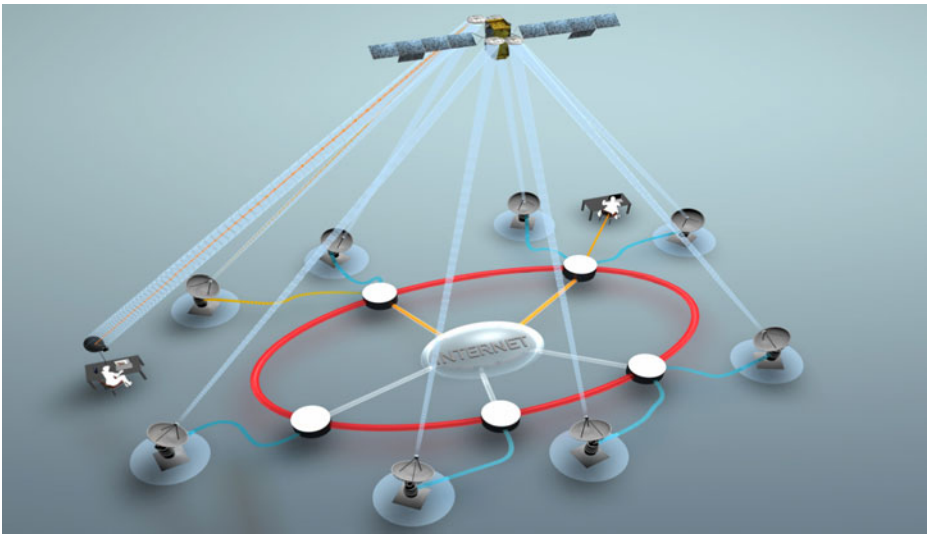

Fig. 8. KA-SAT Gateway system

This architecture will allow distributed video platforms (optimized CAPEX and OPEX) as well as local video insertion for regional content (via fiber and/or KA-SAT contribution).

The use of DVB-S2 will optimize the bandwidth utilization with typical DTH reception diameters (70 cm).

Figure 9 is depicting a typical architecture of a DTH video platform on KA-SAT. The platform will be located in the central KA-SAT hub and will distribute the DTH contents along the fibre inter-POP ring for the uplink from the different gateways.

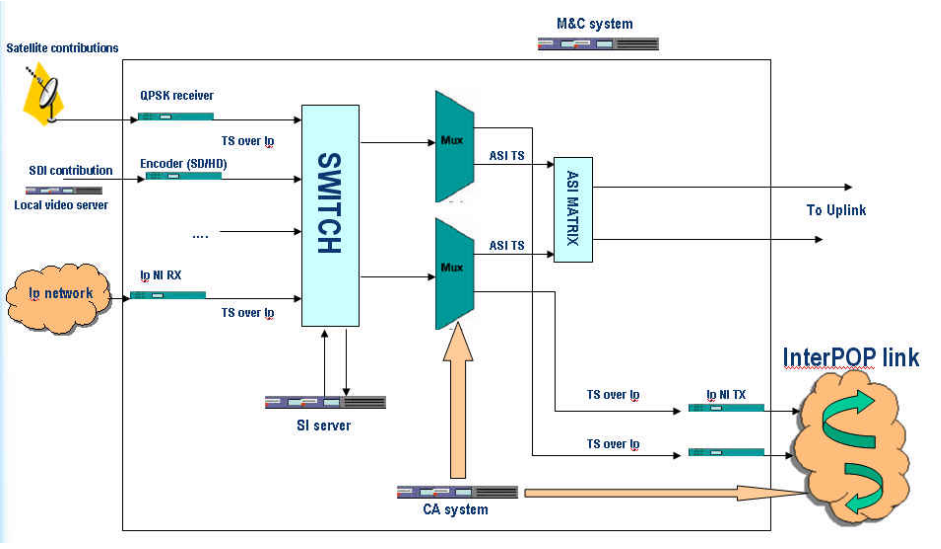

Fig. 9. KA-SAT DTH service platform

Figure 10 is depicting a typical Tooway ™ residential installation under KA-SAT. The service will include triple-play services (including IPTV and push-VoD services) and DTH broadcast services.

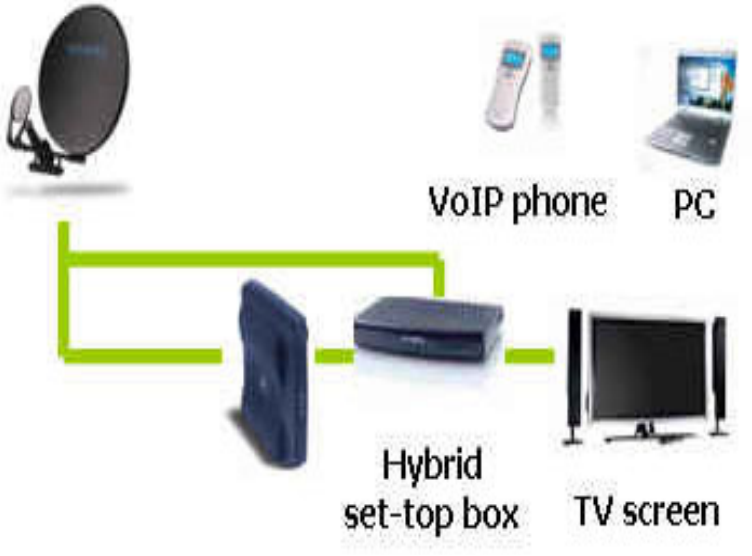

Fig. 10. Residential Tooway™ installation

5 Conclusions

Through the high power and broad coverage of its HOT BIRD™ broadcast satellites, Eutelsat has built the world's leading video neighborhood, assembling over 1400 channels.

In 2010 with the launch of KA-SAT, Eutelsat will triple the total capacity commercialized by its in-orbit resource and drive broadband to new frontiers.

By uniting these leading-edge Ku and Ka-band technologies at one satellite neighborhood, Eutelsat is developing a unique infrastructure in Europe able to:

- deliver a full range of digital services to consumers (DTH and interactive services such as triple play),
- take advantage of a new band (Ka) enabling Ku band capacity to be preserved for TV broadcasting,
- satisfy a real and common solution to the digital divide over the full Europe area,
- extend the market of professional applications via satellite with lower OPEX and CAPEX saving, enabling new opportunities by taking advantage of the spot beam coverage of KA-SAT.

Thanks to KA-SAT and the new generation Surfbeam™ system from ViaSat, the Tooway™ service will increase the throughput in services and applications without sacrificing service availability.

Reference

[1] ETSI EN 302 307 V1.1.1, Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (June 2006)