Triple Play over Satellite, Ka-Band Making the Difference

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Abstract. Over the last years a number of operators have been deploying satellite-based consumer internet access services to reduce the digital divide and capture the market of households not covered by ADSL, cable or wireless broadband. These operators are proposing a step change improvement in the economics of consumer service, with lower terminal costs, broadband access with monthly fees comparable to ADSL and an integrated technology simplifying the process of terminal installation, provisioning and management.

Until now, these services have been focused on internet access only. Now, full triple play services over satellite are available.

This article presents Eutelsat's European Ka band strategy for the Tooway™ 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, demonstrating the optimal consumer service synergy between existing Ku band and new Ka band services.

Keywords: Broadband internet access, Ka band, triple play, VoIP, IPTV.

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 (see Fig. 1). The HOT BIRD™ constellation at 13°E constitutes the prime position for DTH (Direct to Home) and cable broadcasting, utilising the full Ku-band spectrum from 10.70 GHz to 12.75 GHz. There are 102 transponders delivering about 1100 TV channels. The HOT BIRD™ service area reaches into some 120 million satellite and cable households.

The original constellation comprised five satellites. Beginning in 2009, it will be made up of three satellites including HOT BIRD™ 6 and the high-capacity HOT BIRD™ 8 and HOT BIRD™ 9 satellites to further improve in-orbit reliability. Video services contribute to approximately three quarters of Eutelsat's 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.

K. Sithamparanathan (Ed.): Psats 2009, LNICST 15, pp. 20–28, 2009.

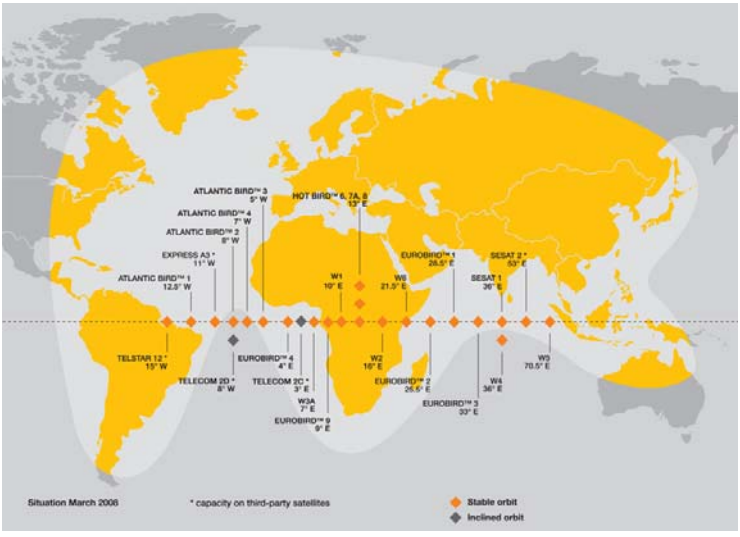

Fig. 1. The Eutelsat satellites on the geostationary arc

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.

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 mid-2010 and positioned at 13 degrees East in geostationary orbit (see Fig. 2).

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 Fig. 3. Efficient frequency reuse enables the system to achieve a total capacity that is in excess of 70 Gb/s. The introduction of KA-SAT will triple the total capacity commercialised by Eutelsat.

ViaSat has ordered a similar satellite for North America, from Space Systems Loral based on their L1300 platform. To be launched in 2011, its total capacity is in excess of 100 Gb/s and constitute with KA-SAT the satellites with largest capacity ever built. Together, KA-SAT and ViaSat-1 represent a new class of satellites with the potential to change the way the world views fixed satellite services.

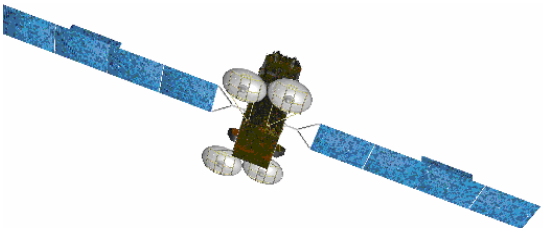

Fig. 2. KA-SAT satellite

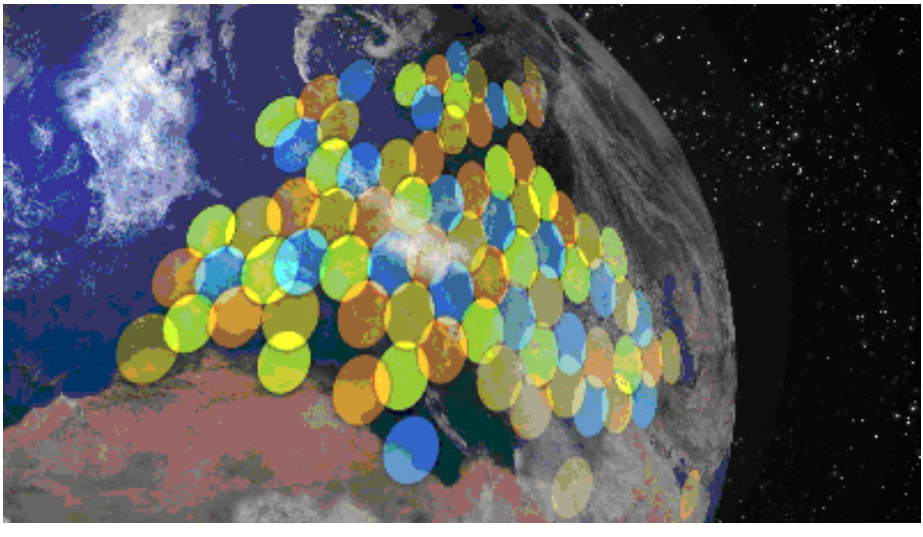

Fig. 3. KA-SAT coverage

KA-SAT will supply Eutelsat with a substantial platform for expansion of its Tooway™ consumer broadband service which was launched in 2007 via Ka-band capacity already available on its HOT BIRD™ 6 satellite and in Ku-band via EUROBIRD™ 3.

3 Why Ka-Band for KA-SAT

Several reasons explain Eutelsat's choice to manufacture a dedicated Ka band satellite for interactive services :

1. There is more exclusive spectrum available at Ka-band. The Exclusive Band in Ku-band is limited to 250 MHz on the uplink and spans from 14.25 GHz to 14.50 GHz while the available spectrum at Ka-band is double that spectrum, i.e. 500 MHz on both uplink (29.5 – 30GHz) and downlink (19.7 – 20.2GHz). The Exclusive Band in Ka-band has a better interference environment and its use is limited to small terminals. The equivalent in

Ku-band is more widely used and interference could be the limiting factor in terms of terminal size for the Return Link.

2. The antenna gain and free space loss are functions of the square of the frequency. Thus assuming that the satellite antenna aperture is limited by the satellite configuration and the launch vehicle fairing and that the terminal aperture is defined by the service, the improvement in the link budget under clear sky conditions is also a function of the square of the frequency inducing a 4 dB improvement on the downlink and a 6 dB improvement on the uplink going from Ku-band to Ka-band. Rain fade represents a more complex aspect. Nevertheless, it can be shown that in Europe, for an availability of up to 99.7%, it is still more suitable to work in Ka-band with respect to a Ku-band system.
3. Ka-band is approximately two times higher in frequency than Ku-band. The Ka and Ku bands are given as follows.

	Ka band	Ku band
Uplink	27.5 GHz to 30.0 GHz	12.75 GHz to 14.5 GHz
Downlink	17.7 GHz to 20.2 GHz	10.7 GHz to 12.75 GHz

Higher frequency also means that for a given satellite antenna aperture the beam is smaller, allowing smaller cells. Smaller cells imply a better individual coverage :

- On the Forward Link (gateway-to-terminals) this permits to ensure that the satellite power is used efficiently on a more limited area with the required EIRP (effective isotropic radiated power) to get closer to the given user.
- On the Return Link (terminals-to-gateway), this improves the G/T (gain-over-temperature) of the satellite ensuring that for a given bit rate smaller resources are required at the terminals in terms of RF (radio frequency) power required from the HPA (high power amplifier) and antenna aperture. All this contributes towards smaller terminals.

For a given service area, more cells can be included if the cells are smaller. On the upside, this supports a higher order of frequency reuse. Typically four colour schemes are used to ensure a good C/I (carrier to interference ratio). Four represents an acceptable compromise between the performance and the complexity of the number of antenna apertures on the satellite. Thus the spectral resources are utilised more efficiently and more system capacity can be attained for a given available spectrum.

Ka-band offers opportunities to design a payload with higher system capacity with respect to Ku-band. At the technical level, high system capacity can permit:

- increase of the data rates to and from the terminals,
- increase in quality of service,
- increase in the population of terminals within the system or
- a combination of the above

Using a traditional Ku band satellite at a premium orbital slot dedicated to DTH services would increase the subscriber fee by a factor of 5 to 10 and reduce capacity for DTH channels.

At the commercial level, these factors combine to help the Ka-band system reduce the cost of the service provision making broadband access an affordable service for the consumer market.

4 The Tooway™ Service

Consumer broadband expectations 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 local and regional television markets.

4.1 Broadband 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.

Capitalising 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 Surfbeam™ 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 Tooway™ service definition over HOT BIRD™ 6 and EUROBIRD™ 3 is allowing download up to 2Mbps 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. More Tooway™ service information is available on www.tooway.com website.

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

4.2 The VoIP Service

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.

4.3 TV Services

As KA-SAT will be collocated at Eutelsat's HOT BIRD™ TV premium neighborhood, the IP services delivered via Tooway™ will complement and enrich the DVB 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 new feature developed for H.264 (MPEG-4 Part 10) source coding, which allows transmitting the same video sequence coded with different resolutions and/or bit rate and/or SD-HD format. 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 Fig. 4 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	

Image source from Institut Nachrichtentechnik Heinrich-Hertz-Institut, URL : http://www.ist-ipmedianet.org/FlyerSVC.PDF.

Fig. 4. SVC feature applied on KA-SAT for new TV services

5 The Tooway™ Consumer Terminal

The consumer equipment will include an ODU (outdoor unit) with antenna diameter of less than 75 cm and a compact IDU (indoor unit) providing a simple customer interface: plug and play Ethernet and/or Wifi. The installation will employ automated tools for simplified antenna alignment and commissioning. The use of circular

Fig. 5. The new Tooway™ Ka band customer equipment which will be used on KA-SAT satellite

polarization further simplifies the installation. The installation procedure is the same anywhere within the satellite service area and it requires no software in the PC.

As KA-SAT will be located at 13°E, joining three large HOT BIRD™ Ku-band broadcasting satellites, Eutelsat will be able to enrich the range of consumer entertainment services offered from the Group's prime neighborhood by enabling satellite homes to receive television in the Ku-band and new rich media services in the Ka-band through a single dual-band antenna which was first demonstrated at the Satexpo exhibition in Italy in 2008 (see Fig. 6).

The antenna employs a frequency selective sub reflector which is transparent to Ku band and reflecting Ka band, allowing the use of a traditional Universal LNB. Ku band reception on this modified Ka band interactive antenna is equivalent to a typical 60-70cm receive only DTH antenna.

Fig. 6. Prototype of Ka & Ku bands Tooway™ ODU

6 Conclusion

Through the high power and broad coverage of its HOT BIRD™ broadcast satellites, Eutelsat has built the world's leading video neighborhood, assembling over 1,100 channels.

In 2010 with the launch of KA-SAT, Eutelsat will triple the total capacity commercialised 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.

Thanks to KA-SAT and the new generation Surfbeam™ system from ViaSat, the Tooway™ service will increase the throughput in services already offered to subscribers at a price comparable to ADSL and cable modem connections. Tooway™ is increasing its capabilities to satisfy customer needs.

The Ka band is really making the difference for triple play services over satellite.