Value of a Turn-key, Integrated Satellite Broadband Solution

9 April 2010

Broadband satellite networks, which are single-purpose designed to provide high speed broadband connectivity to households and small enterprises in dispersed rural and remote areas, are unlike standard fixed-satellite service (FSS) C-band and Ku-band satellites that are general-purpose designed to support a diversity of applications including broadcast video, two-way data, and trunked point-to-point backhaul. General purpose FSS satellites are flexibly and generically designed to typical industry standards to interoperate with a variety of ground equipment serving different needs. Consequently, these FSS satellites can be efficiently procured apart from the ground equipment yet still achieve reasonable performance and cost across the breadth of ground equipment and applications employed.

However, broadband satellite networks have a dedicated purpose that to be successful, must achieve high system capacity in terms of total throughput, high data rates to individual user terminals and a low cost-per-bit so as to be competitive with terrestrial alternatives. The next-generation of so-called "high throughput satellites" operating at Ka-band, achieve an order of magnitude (10 times) improvement in all three of these metrics by treating the end-to-end network consisting of the gateway earth stations with modem termination systems, the satellite, and the user VSAT terminals, along with the available spectrum allocated within the region of operation, as a multi-dimensional trade space that must be jointly optimised for design, manufacturing, and operation. End-to-end system performance must be deeply understood and optimised to a degree that is virtually impossible to replicate by a more fragmented approach of specifying and procuring the network components separately. This is why the operators of the "high throughput satellite" Ka-band systems ViaSat-1, Hughes Jupiter, and KA-SAT have all taken this integrated approach.

The most critical optimisation involves achieving the highest system capacity and lowest cost per bit by trading such elements as available spectrum, which is typically not in contiguous blocks; population distribution; satellite spot beam size and location; inter-beam interference; power and bandwidth of spot beams; gateway design; modem modulation, coding, and bandwidth schemes; number of translation frequencies in the satellite, gateways, and user terminals; and network parameters that drive cost. This critical optimization must be performed across all network elements and cannot be performed exclusively in either the satellite, in the gateway or in the user terminal. Other important optimizations include selecting gateway locations considering constraints of terrestrial fiber access and satellite spot beam design; integrating two-way data paths and one-way IPTV broadcast paths considering available spectrum, satellite spot beam design, and set-top box cost drivers; and planning a satellite and gateway design that will be efficient for operation with multiple user-terminal manufacturers.[1] If a broadband satellite network is designed, procured, manufactured and operated without these trades being optimised and managed in an integrated, across-the-network fashion, the system performance, CapEx and OpEx costs will suffer.

Significantly, if an organisation requires a satellite broadband system and decides to procure the system network components separately, it would be its responsibility for achieving the performance and cost targets of the end-to-end system. Should the system achieve only 90% of the target capacity, or the system cost-per-bit be 120% of the target, or the annual system OpEx be similarly high, the organisation would necessarily be responsible and would have no recourse to an alternate

[1] Further description and explanation of these optimizations and end-to-end system trades are provided later in this paper within the **Technical System Trades** section.

integrated system supplier or operator. On the other hand, if the organisation engages an integrated systems supplier to deliver a complete, turn-key satellite broadband network and to operate that network for its lifetime, that supplier will be responsible for the end-to-end system performance and cost. The procuring organisation would have recourse for deficiencies in network performance, cost or operation.

By procuring a turn-key, integrated satellite broadband network, the organisation can follow the path that is appropriate for this type of single purpose network that will ensure optimised performance and minimised cost while simplifying its procurement, operation, and management by having one supplying entity being held responsible.

Technical System Trades

KaComm believes that by approaching the system design as an integrated whole rather than separate ground and space segments, organisations can achieve significant improvements in system effectiveness while producing an overall lower cost per bit. In particular, KaComm believes that it can provide the following specific advantages through a system level design when compared to a separate component approach:

- Improved return link availability in high rain fade areas.
- Improved return link capacity in high population density spot beams.
- Improved forward link capacity in high population density areas.
- Supporting broadband and broadcast services in a single CPE.
- Implementing efficient broadcast across multiple time zones and daylight saving zones.

The utility of satellite broadband systems is defined by the bits-per-second that can be received and transmitted by the subscribers and the services that can be provided to the subscribers. A satellite broadband system with the highest utility will provide the highest bps at the lowest $/bit with the richest set of services. The optimisation issue has become more important in recent years because of two trends. Firstly, satellite capacity has increased significantly and secondly, CPE pricing has dropped significantly. Traditionally expensive CPEs were required to receive a low capacity service from a satellite. Consider a scenario from the early 1990s where a $1,500 CPE might enable a 512 Kbps service compared to a contemporary scenario where a $500 CPE enables a 12 Mbps service. In the first example, reducing CPE price by $50 and improving performance by 10% leads to a 13% improvement in system efficiency. In the contemporary example, the same improvements lead to a 22% efficiently gain for the system. Reduction in price of $50 and improvements in throughput of 10% are well within the realm of the gains that can be expected when designing the system as an integrated system rather than a collection of parts.

In traditional general-purpose FSS systems, it was not possible to exploit all the benefits of system optimisation because the systems were ‘general purpose’. Special purpose systems provide the opportunity to optimize and as a result, can produce far cheaper bits-per-second than traditional general-purpose systems. These outcomes can only be achieved by designing the system as an integrated whole because of two considerations:

- Link Budget.
- Practical limitations on the performance of affordable electronics.

‘Link Budget’ refers to the aggregate power of the signal at the receiver. For forward links (i.e. from the gateway to the subscriber), the link budget defines the bps that the subscriber can receive. For return links (i.e. from the subscriber back to the gateway), the link budget defines bps that can be transmitted by the subscriber. In the NBN Co Request for Capability Statement requirement of 12Mbps forward and 2 Mbps return, the forward link budget drives the 12 Mbps figure and the return link budget drives the 2 Mbps figure. The link budget figure itself reflects the total power transmitted plus all of the gains and losses in the system. Across a system as complex as a satellite broadband system, there are literally dozens of gains and losses that impact the final link budget. The optimisation challenge is to achieve the link budget requirement at the cheapest price.

Optimising link budgets has traditionally focused on the characteristics of the hardware in various components of the system. Higher quality (and therefore more expensive) electronics typically introduce less ‘noise’ into the system, which in turns means fewer losses. The optimisation challenge is to determine the appropriate quality (and therefore cost) electronics for each component of the system (including satellite, gateway and CPE) to achieve the link budget and minimise cost. Similarly, antenna size also influences the link budget. Larger antennas reflect more of the transmitted energy and therefore improve link budgets, but it is more expensive to install large antennas on satellites than to install them on the ground at either the gateway or CPE. However satellite antennas are closer to the transmission source for forward link capacity and therefore have a disproportionate large positive influence on the link budget compared to increasing CPE antenna size. The optimisation challenge becomes one of determining whether a few larger antennas in space are more cost efficient than many larger antennas on subscribers homes. Of course larger antennas may also be installed at the gateway locations, however large antennas require more expensive electronics and mechanics to keep them pointed at the satellite and may require radomes to prevent pointing errors caused by high velocity winds.

The introduction of Adaptive Coding Modulation (ACM) technology has added an additional opportunity for optimisation in special purpose systems, especially satellite broadband. By modifying the signal coding on the fly, significant gains can be achieved in the link budget beyond those associated with traditional electronics, antennas and physical infrastructure. Even better performance can be achieved if the frequency plan is harmonised with ACM. For instance, coupling ACM with wide radio spectrum allocation allows for high effective gains than from ACM alone. However the frequency allocation needs to be planned in terms of the overall system wide frequency re-use plan and coupled with the satellite and CPE radio frequency performance. Also while wideband frequency allocations coupled with ACM significantly improves the link budget, it also requires more costly CPE electronics to be employed. In particular, producing wideband radio receivers is difficult and expensive for the CPE. Conversely, wideband payloads are easier and cheaper to develop on the satellite and less stringent filters are required to support the service. In fact, narrow band receive equipment onboard the satellite is more expensive. Therefore optimising coding and frequency performance gains against CPE and satellite receiver costs can lead to significant system improvements and cost savings. This is a level of optimisation not typically considered in traditional FSS systems but can produce significant efficiencies and costs savings if considered in a system context.