



## Benefits of *LinkStar*<sub>S2A</sub> ACM, VCM, and DLA

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### Overview

*LinkStar*<sub>S2A</sub>'s powerful and innovative ACM (Adaptive Coding and Modulation) and DLA (Dynamic Link Adaptation) features improve the overall satellite link robustness in rain fade conditions, while reducing the satellite bandwidth requirements as compared to traditional methods of rain fade mitigation. **The ACM feature reduces satellite bandwidth by up to 63% for the downstream traffic, while the DLA feature reduces satellite bandwidth by up to 18% for the upstream traffic.** This translates directly into a significant reduction in operating expenses for the customer.

### DVB-S2 Technology

Before introducing the *LinkStar*<sub>S2A</sub> ACM bandwidth savings feature, it is important to recognize that the ACM technology is on top of a significant bandwidth savings technology called DVB-S2. DVB-S2 technology uses LDPC (Low Density Parity Check) coding to minimize satellite power and bandwidth requirements, resulting in performance close to the theoretical limit of bandwidth efficiency established by Claude Shannon.

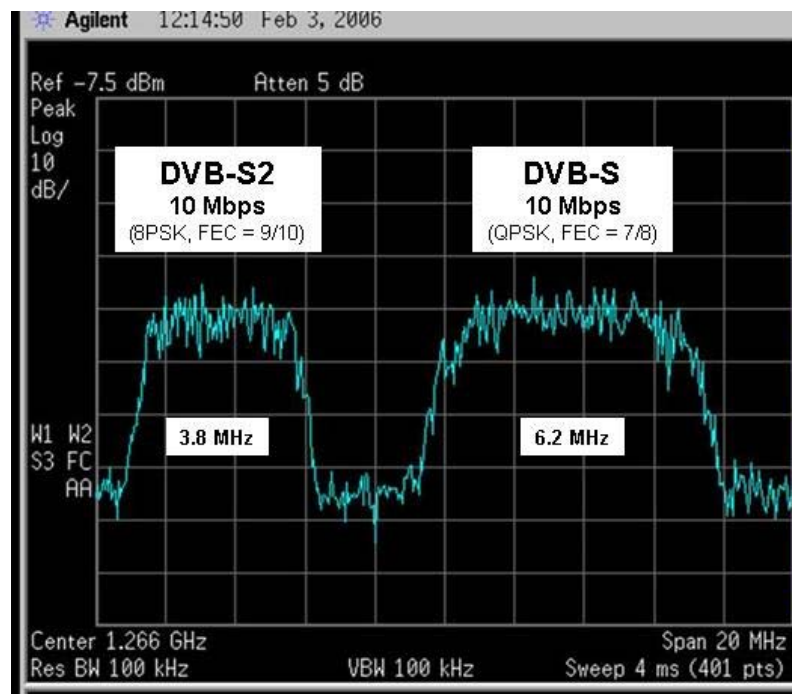
DVB-S2 includes the following modes of operation:

1. **CCM** (Constant Coding and Modulation) – The downstream carrier operates with a single modulation and FEC value. DVB-S2 CCM technology typically reduces the satellite bandwidth for downstream traffic by 30% to 40% as compared to traditional DVB-S technology as shown in the following spectrum analyzer display. The

bandwidth savings described later in this paper for ACM are in addition to the bandwidth savings already achieved by DVB-S2 CCM mode.

2. **VCM** (Variable Coding and Modulation) – The downstream carrier operates with different fixed values of modulation and FEC for different sites in the network.
3. **ACM** (Adaptive Coding and Modulation) – The downstream carrier dynamically changes the values of modulation and FEC in response to changing link conditions.

### Comparison of DVB-S2 and DVB-S Satellite Carriers

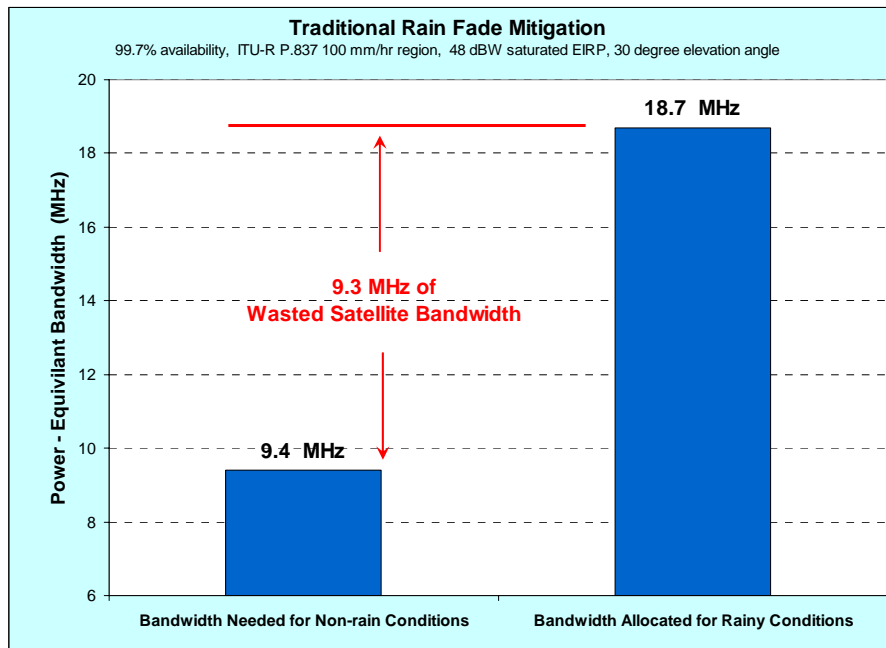


### ***Traditional Rain Fade Mitigation Method***

Operation on Ku band satellites require a means for compensation for signal fading during high rain conditions. The traditional method to compensate for rain fading is to add “link margin” by allocating extra satellite bandwidth and power than what is otherwise required during non- rain conditions. The following diagram shows the bandwidth that would be required for a typical 15 Mbps DVB-S2 carrier during non-fade conditions and what might typically be allocated to maintain service availability during rainy conditions. Under these circumstances, a significant

amount of bandwidth is wasted in order to account for signal fades that occur only intermittently under occasional rainy conditions.

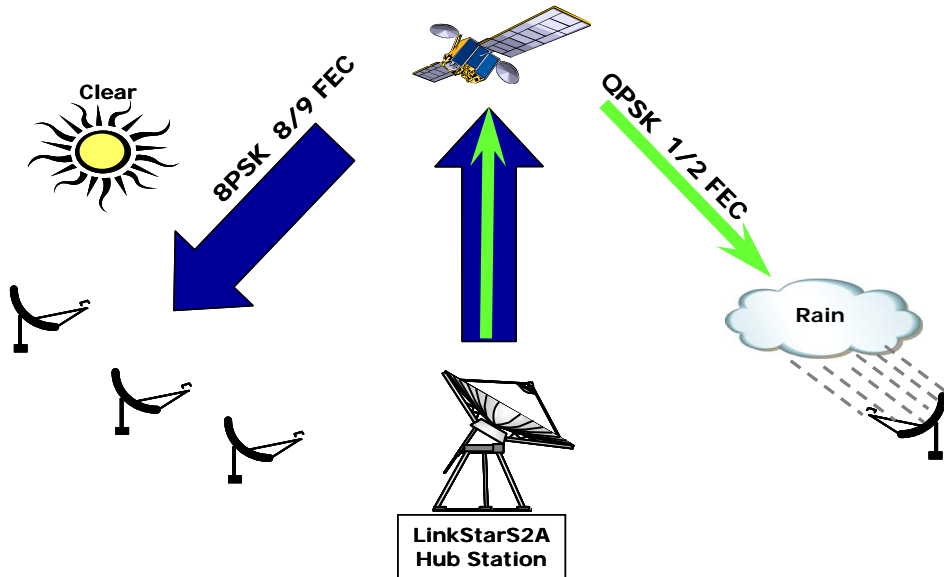
### Satellite Bandwidth for Traditional Rain Fade Mitigation



### ACM - Adaptive Coding & Modulation

*LinkStar<sub>S2A</sub>* includes an advanced ACM (Adaptive Coding and Modulation) algorithm that automatically adjusts the modulation and coding points of the downstream carrier to each RCST in response to both rain fade conditions and/or variations in satellite footprint power. For example, during clear sky conditions at all sites, the downstream carrier operates at a highly bandwidth efficient modulation and coding point (such as 8PSK modulation with 8/9 FEC). When heavy rain fades occur at one or more sites, the modulation and coding automatically changes to a more robust point for the traffic only to the faded sites. The downstream bandwidth for the non-faded sites remains at the highly efficient modulation and coding point. Once the fade is cleared at the faded sites, the modulation and coding is automatically restored to the original highly efficient modulation and coding point. The net effect of this technology is to deliver the highest speed possible in the least amount of bandwidth during the majority of the time, and to slightly reduce the speed to the faded sites during heavy rain conditions.

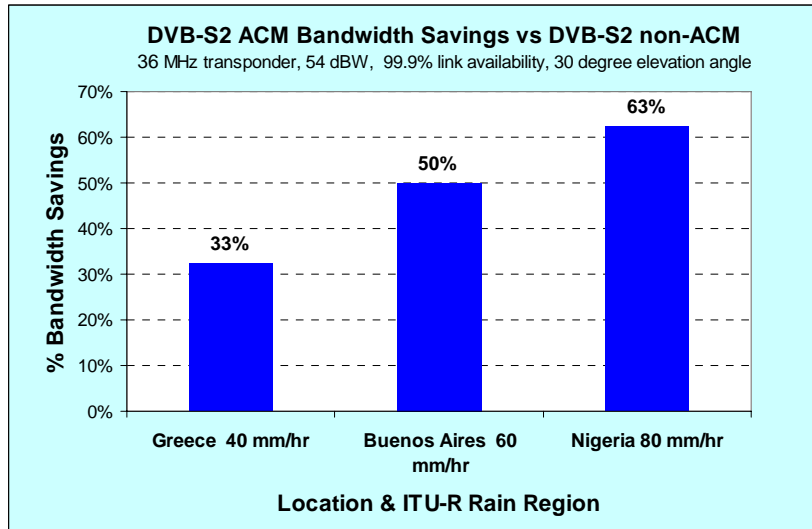
## LinkStarS2A ACM



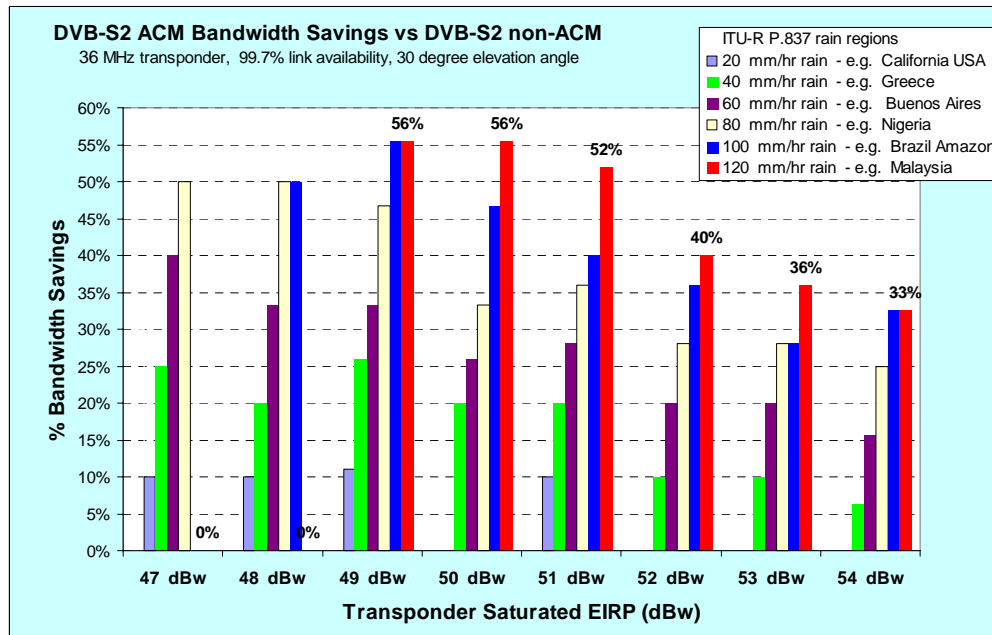
### **ACM Bandwidth Savings**

The ACM feature provides up to 63% reduction in satellite bandwidth vs. a non-ACM (“CCM” – Constant Coding and Modulation”) implementation of DVB-S2. The degree of benefit varies with the link availability objective, intensity of rain, and satellite performance characteristics in the region of interest. The charts which follow present typical benefits of ACM for a variety of conditions. To present a fair comparison, the transponder power and transponder bandwidth are balanced in each case.

## Typical Bandwidth Savings for DVB-S2 ACM vs. CCM for 99.9% Availability



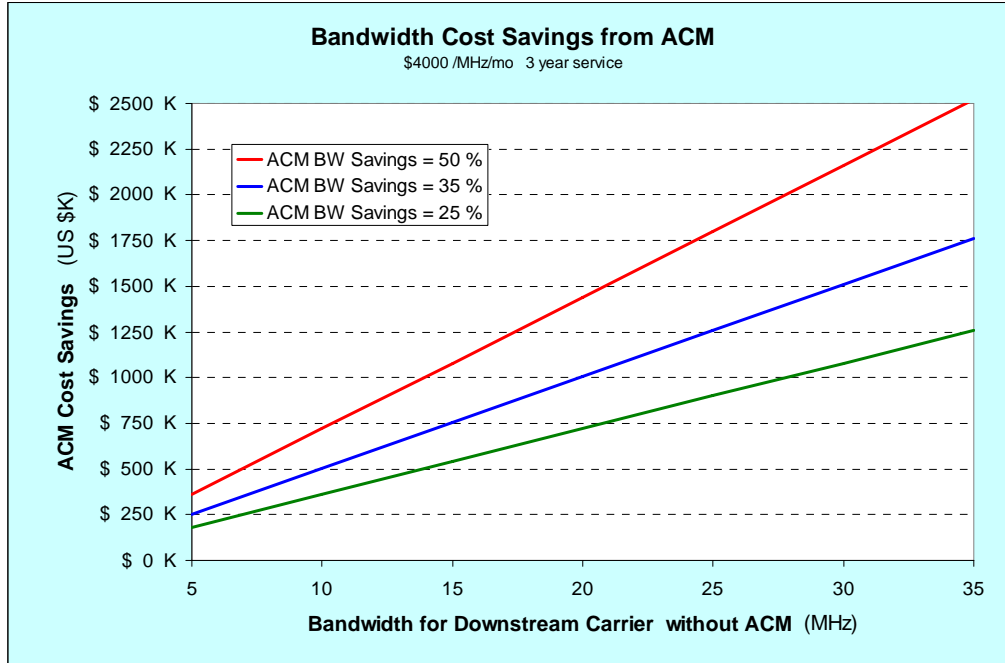
## Typical Bandwidth Savings for DVB-S2 ACM vs. CCM for 99.7% Availability



As a reminder, these bandwidth savings due to ACM are in addition to the bandwidth savings already provided by the baseline DVB-S2 CCM technology as compared to DVB-S. These satellite bandwidth savings result in a tremendous reduction in operating costs for the customer as shown in the diagram which follows. This diagram is based

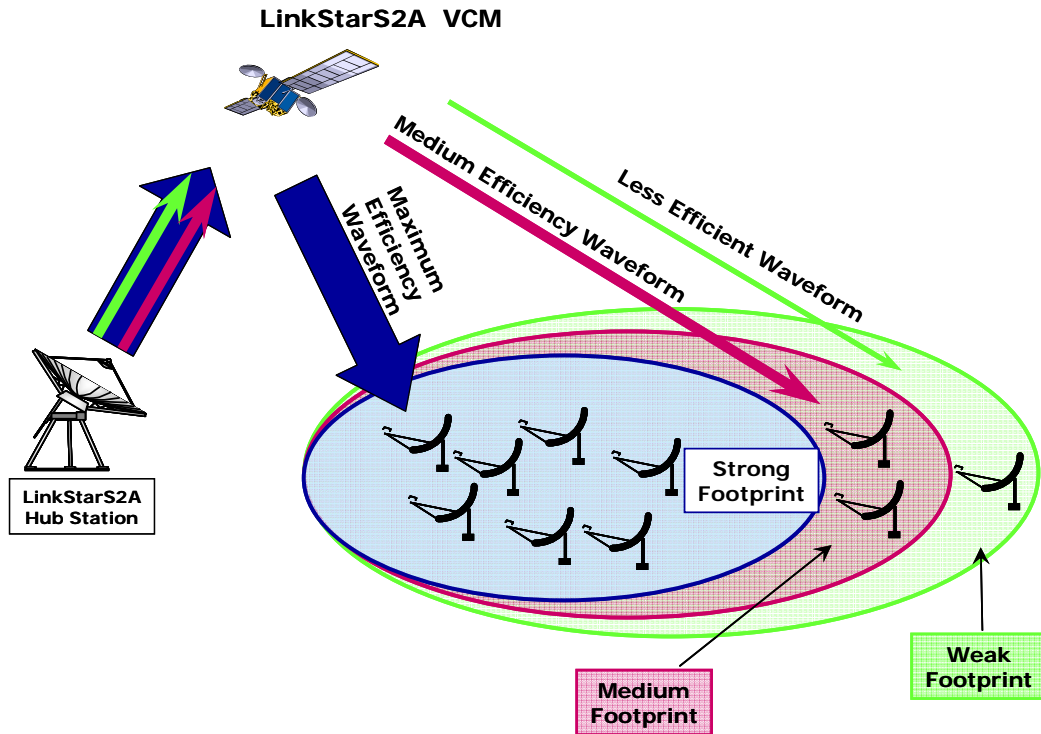
upon a typical bandwidth cost of US\$4000 per MHz per month over a 36-month service period.

### Typical Cost Savings for DVB-S2 ACM vs. CCM



### VCM – Variable Coding and Modulation

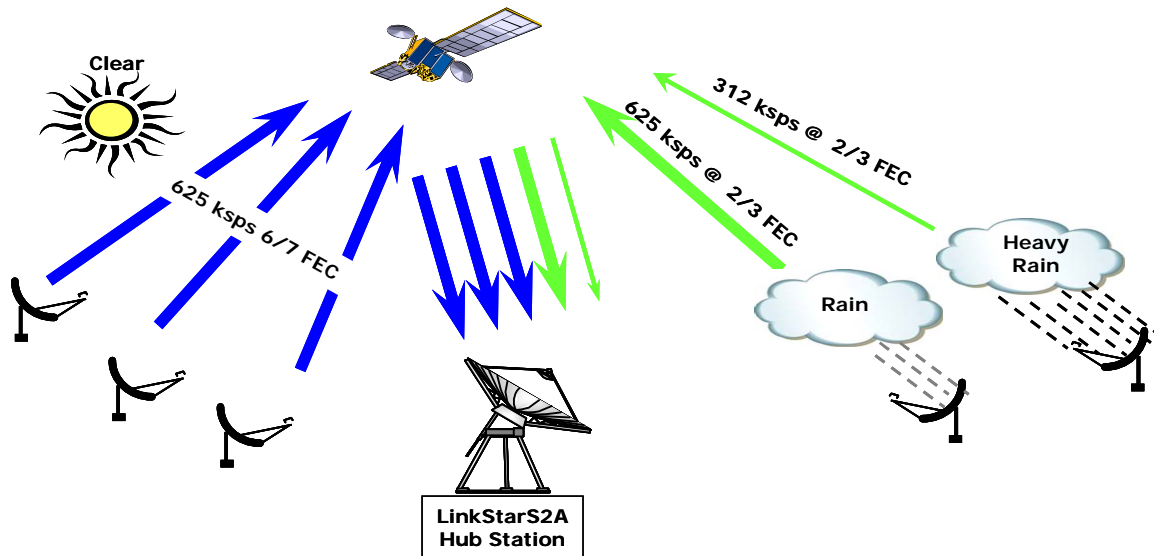
Traditionally, either bandwidth efficiency is sacrificed in strong footprint areas due to the performance of the VSATs in the weakest footprint areas or VSAT antenna sizes are forced to vary across differing satellite footprint areas. For logistical reasons, it is often convenient to have common VSAT antenna sizes throughout a network. The *LinkStar<sub>S2A</sub>* VCM capability provides maximum bandwidth efficiency in strong footprint areas while effectively extending the satellite coverage area available for a common VSAT antenna size. As shown in the following diagram, service can be provided to a large quantity of VSATs in the strong footprint area using the most bandwidth efficient modulation and coding point, while providing service to VSATs in weaker fringe areas of the footprint using a more robust, but less bandwidth efficient, modulation and coding point. The *LinkStar<sub>S2A</sub>* VCM capability is a benefit included as part of the *LinkStar<sub>S2A</sub>* ACM feature.



### ***DLA – Dynamic Link Adaptation***

The LinkStar DLA (Dynamic Link Adaptation) feature provides additional robustness against fading conditions for the upstream traffic. During clear sky conditions, the upstream carrier may operate at a high code point such as 6/7 FEC. As the link fades due to rain, the code point for upstream traffic from the faded traffic will change to a more robust FEC point of 2/3. If the rain fade gets severe enough, the remote site is automatically assigned to a lower symbol rate carrier for maximum robustness against fading conditions. Hence, the LinkStar DLA feature provides the maximum traffic speed possible in the least amount of satellite bandwidth for the majority of the time.

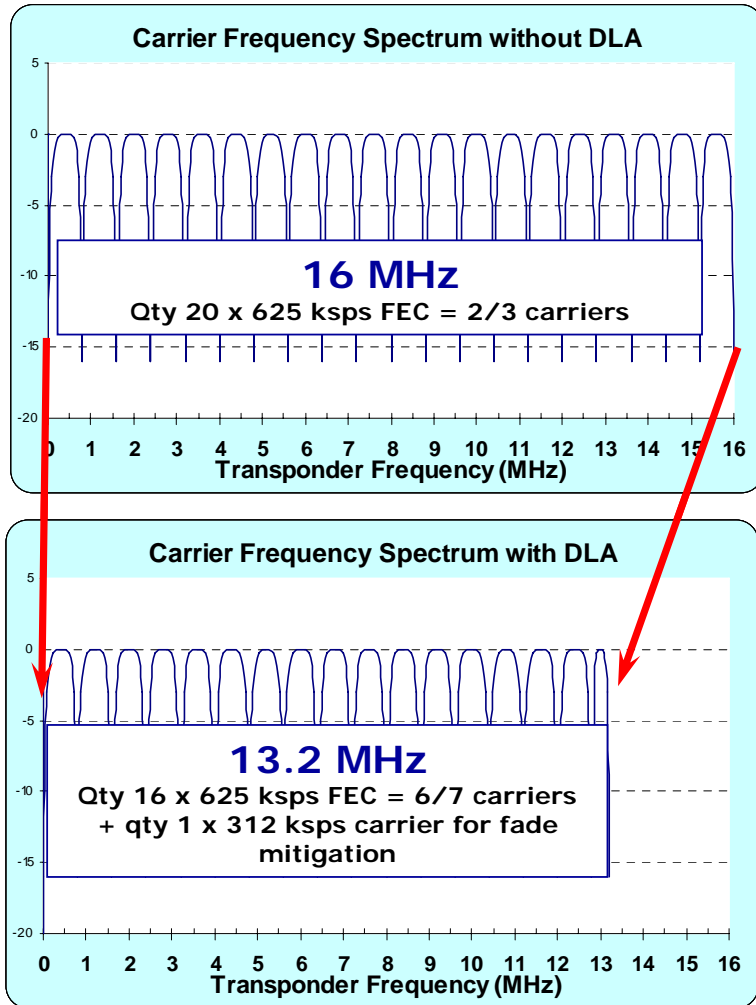
## LinkStarS2A DLA Concept



### **DLA Bandwidth Savings**

As with ACM, the degree of benefit of the LinkStar DLA feature varies with characteristics of the site, satellite, and user traffic. As an example, let us assume that the traffic and satellite characteristics of a network without DLA require quantity (20) carriers at a symbol rate of 625 ksym/sec with 2/3 FEC, which corresponds to an aggregate over-the-air link rate of 16.7 Mbps requiring 16.0 MHz of satellite bandwidth. Using DLA with 6/7 FEC, this same aggregate rate of 16.7 Mbps can be contained within quantity (16) carriers. A single 312 ksym/sec carrier is added to allow rate downspeed which results in bandwidth of only 13.2 MHz and a bandwidth savings of 18%.

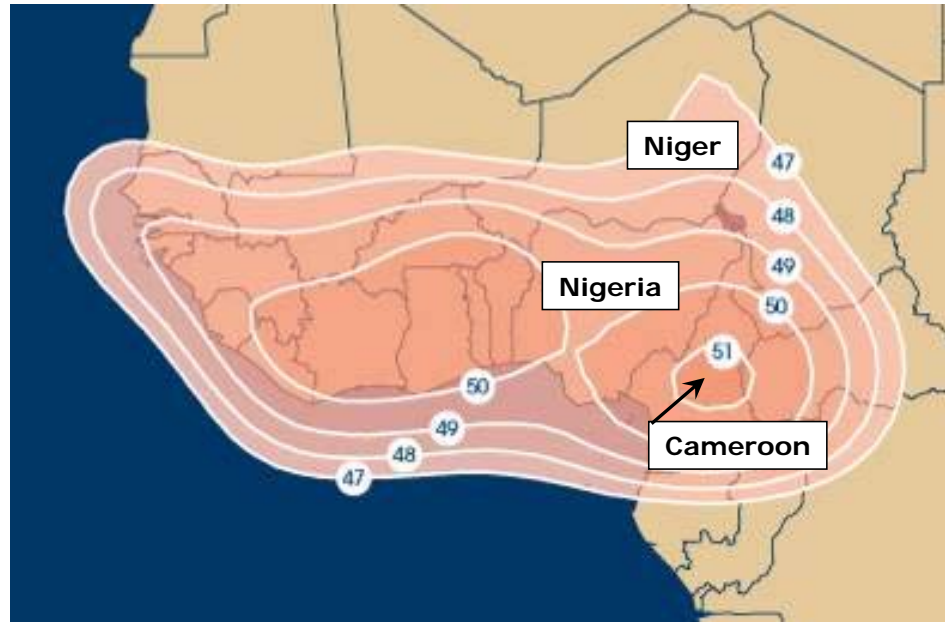
## Bandwidth Savings for DLA



## ACM Case Study - Nigeria

A case study for a network in Nigeria via the NSS-7 satellite is presented as a typical example of the benefits of the ACM and DLA technologies.

### NSS – 7 Satellite Downlink Footprint



Given the following conditions:

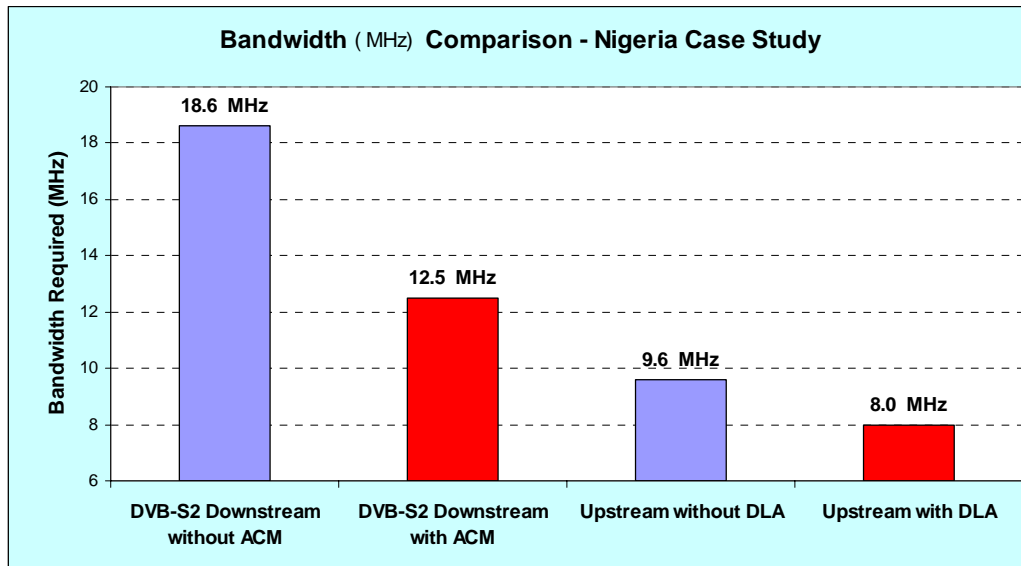
- NSS-7 satellite with performance values over Nigeria of EIRP = 49 dBw, G/T = +3 dB/K, SFD = -86 dBw/m<sup>2</sup>, and IBO/OBO = 6/3 dB in a 54 MHz Ku band transponder
- Downstream over-the-air link rate of 20 Mbps and upstream over-the-air link rate of 10 Mbps
- ITU-R P.837-3 rain rate of 80 m/hr for Nigeria
- Downstream link availability objective of 99.7% with balanced transponder power and bandwidth
- 1.2 meter antennas with 2.5 watt SSPA

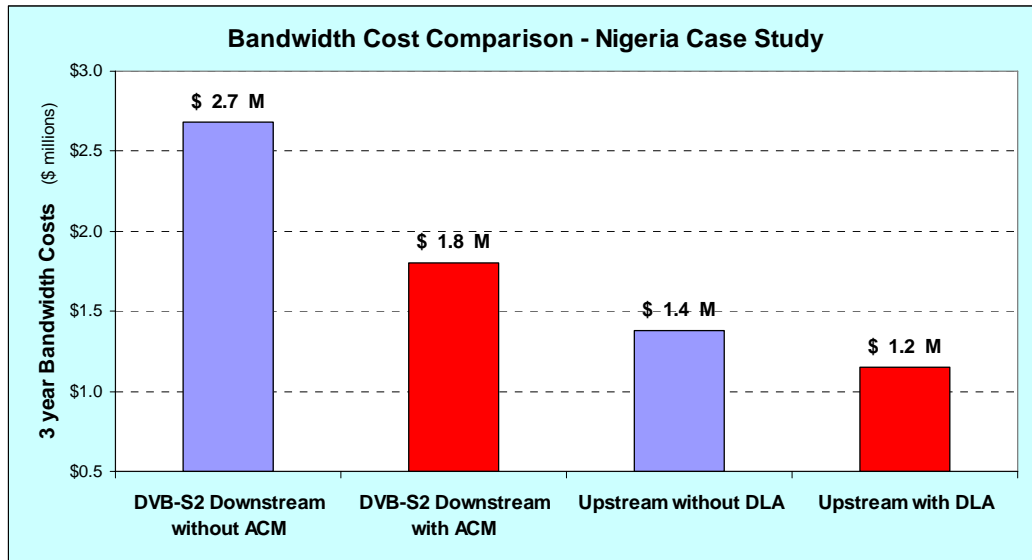
Detailed satellite link calculations yield that a 20 Mbps DVB-S2 downstream carrier without ACM requires QPSK modulation with FEC = 4/5 for a bandwidth requirement of 18.6 MHz to support the required link objective. Conversely, a 20 Mbps DVB-S2 downstream carrier with ACM can operate in the more bandwidth efficient 8PSK modulation with FEC = 2/3 for a bandwidth requirement of only 12.5 MHz to support the

required link objective. This yields a tremendous bandwidth savings of 6.1 MHz, or 33%!

For 10 Mbps of aggregate over-the-air link rate in the upstream direction, quantity (12) traffic carriers at 625 ksym/sec at  $FEC = 2/3$  are required for a traditional returnlink scheme without DLA technology, resulting in a requirement of 9.6 MHz of satellite bandwidth. Using DLA technology,  $FEC = 6/7$  can be used for clear sky operation, whereby the 10 Mbps aggregate over-the-air link rate requires only quantity (9) upstream traffic carriers at 625 ksym/sec, plus quantity (1) upstream traffic carrier at 312 ksym/sec. A single 312 kpsps carrier is added to allow rate downspeed, which results in bandwidth of only 8.0 MHz. This yields a bandwidth savings of 1.6 MHz or 17%.

The results of this case study are presented in the following diagrams:



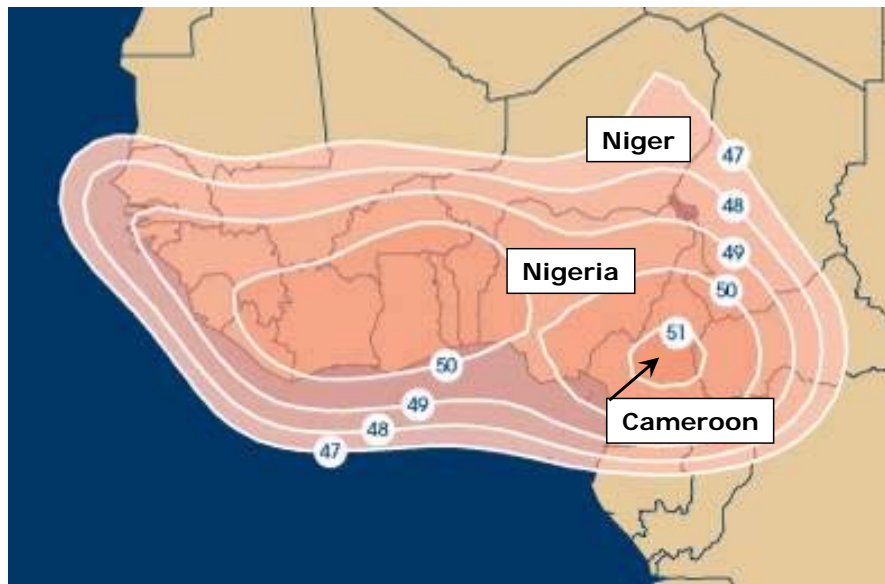


The combined bandwidth savings from ACM and DLA technologies in this case study is 7.7 MHz. Assuming a transponder cost of US\$ 4000 per MHz per month, this translates into a tremendous cost savings of US\$ 1.1 Million over a 3-year service period!

### VCM Case Study – Nigeria, Cameroon, & Niger

The footprint diagram for NSS- 7 shows that Niger is in a weaker portion (47 dBw) of the footprint than Nigeria (49 dBw), while Cameroon is in a stronger portion (51 dBw) of the footprint.

NSS – 7 Satellite Downlink Footprint



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The *LinkStar*<sub>S2A</sub> VCM capability simplifies logistics by allowing the use of the same 1.2-meter antenna in all three locations, while optimizing satellite bandwidth by matching the optimum modulation-coding point to the specific satellite footprint characteristics of each location. Results from detailed satellite link calculations are:

1. Sites in Nigeria use FEC = 2/3 with 8PSK modulation.
2. Sites in Cameroon use the 14% more bandwidth efficient FEC = 3/4 with 8PSK modulation.
3. Sites in Niger use the 9 % less efficient FEC = 3/5 with 8PSK modulation.

## **Conclusions**

1. *LinkStar*<sub>S2</sub> with DVB-S2 CCM technology typically provides a satellite bandwidth savings of 30 % to 40% as compared to traditional DVB-S technology.
2. *LinkStar*<sub>S2A</sub> ACM technology can provide an additional satellite bandwidth savings of up to 46% as compared to non-ACM in high rain environments on Ku-band satellites.
3. *LinkStar*<sub>S2A</sub> VCM technology simplifies logistics by allowing the use of the same VSAT antenna size across different satellite footprint areas, while optimizing satellite bandwidth usage by matching the optimum modulation-coding point to the satellite footprint characteristics of each location.
4. *LinkStar* DLA technology can provide a typical satellite bandwidth savings of up to 18% as compared to non-DLA.

*Note: Values presented in this paper reflect typical performance for the features described but do not represent a performance guarantee on the part of ViaSat.*

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