ACM Evaluation Using SDR Channel Emulation

2014/2015 SCS Program – Basic Techniques Project

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Introduction

- Project objectives:
  - Demonstrate the use of channel emulation for satellite links using SDRs.
  - Illustrate the advantages of ACM over CCM

DVB-S2 & ACM

DVB-S2

- DVB-S: Digital Video Broadcasting - Satellite (1995)
- High demands for new types of services (HD TV, VoIP, Internet access or interactive services) + improvement of technologies

→ called for an updated standard: **DVB-S2**

	DVB-S	DVB-S2
Usage	Broadcast	Data Streams
Mode	CCM	CCM/ACM
Modulation	QPSK, 8PSK, 16QAM	QPSK, 8PSK, 16APSK, 32APSK
FEC	RS - Convolutional	LDPC-BCH
Roll-off	35%, 25%	35%, 25%, 20%

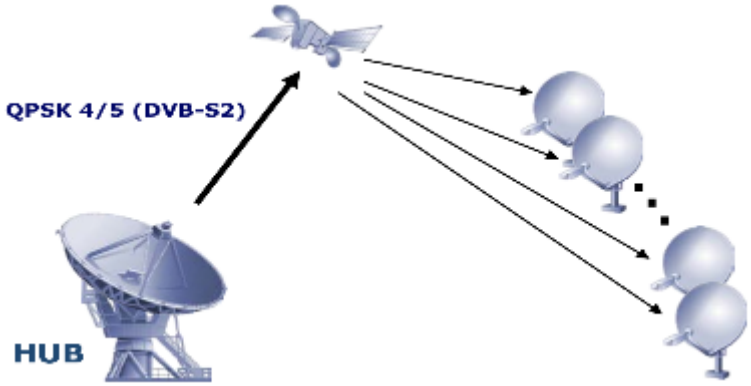
DVB-S2:

- More efficiency
- More flexibility

CCM and ACM - Principles

Constant Coding and Modulation (CCM):

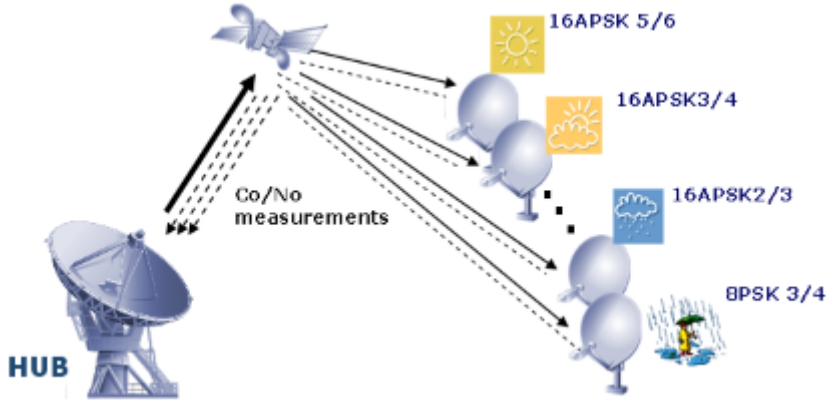
- Fixed MODCOD for each user and all the time
- High margin in link budget (worst case propagation conditions)



Source: Newtec

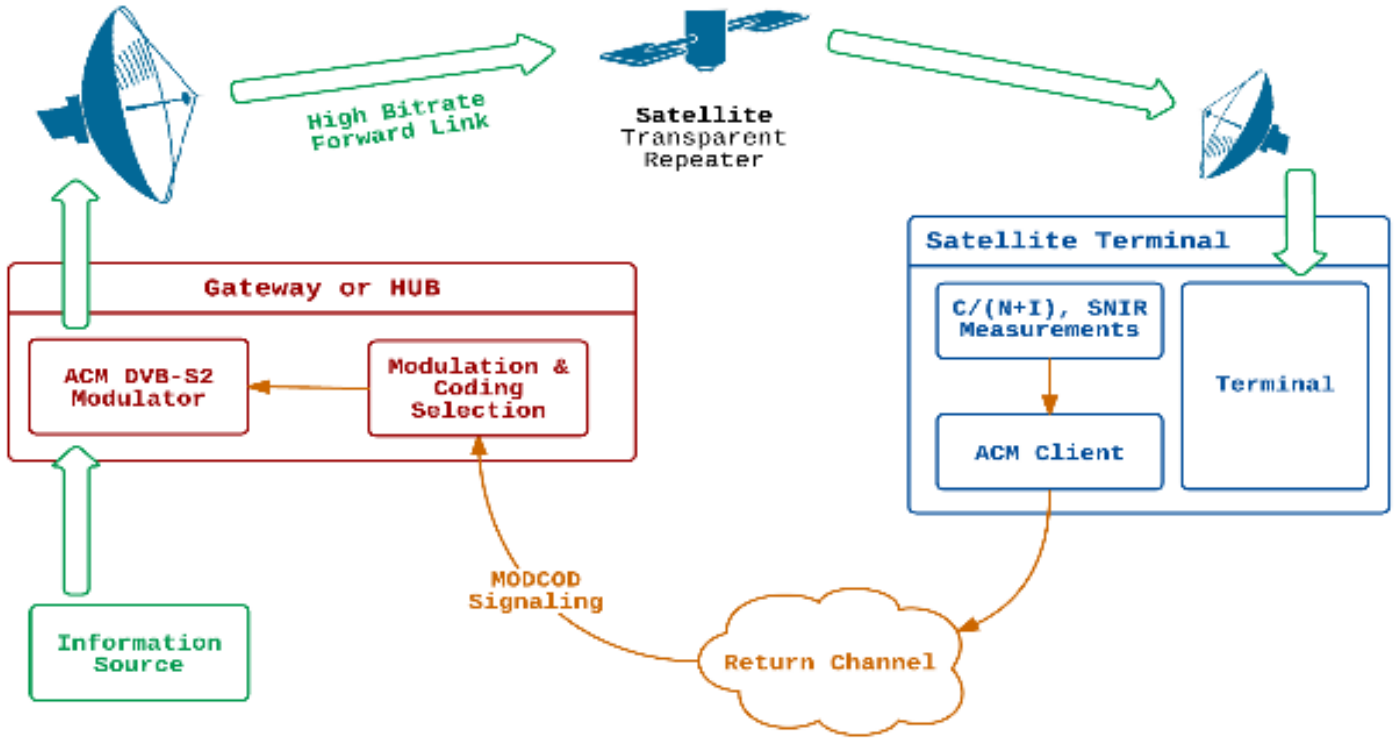
Adaptive Coding and Modulation (ACM):

- Selection of the optimal MODCOD for each user according to the state of the propagation channel



Source: Newtec

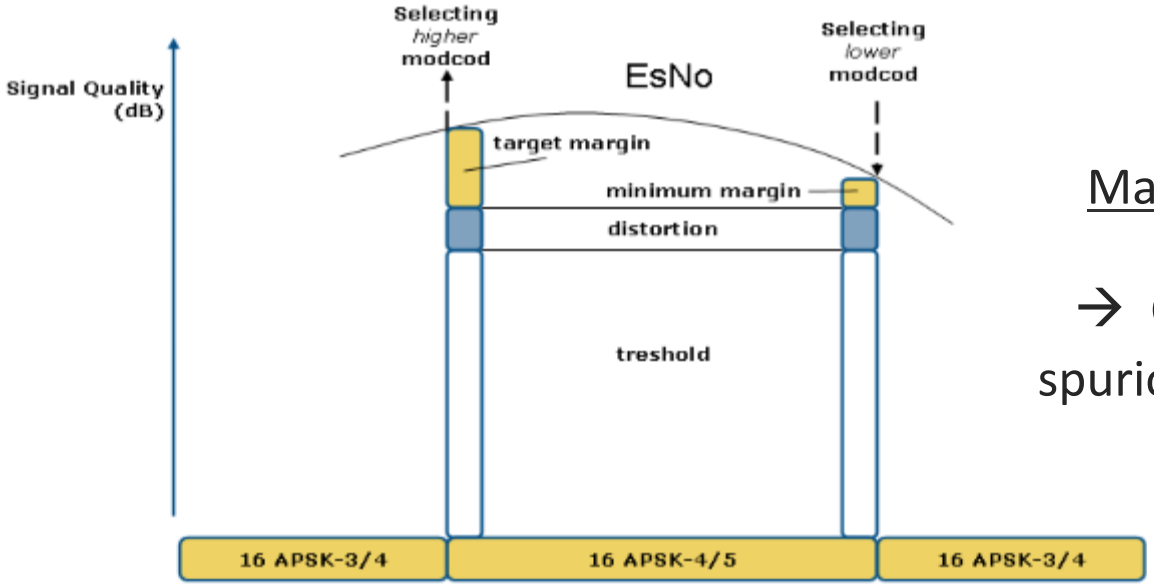
ACM – System Description



→ Complex system as we need to have a **return channel** , a **reliable estimation of CNIR** and an **ACM client/controller**

ACM – Newtec FlexACM

- Selection of the optimal MODCOD is tricky as it has to take into account **distorsion** of the signal. It is estimated by a proprietary algorithm, the ***NoDE*** (Noise and Distorsion Estimator)
- Optimal MODCOD: Compare Es/N0 with (Threshold + **Distorsion** + Margin)



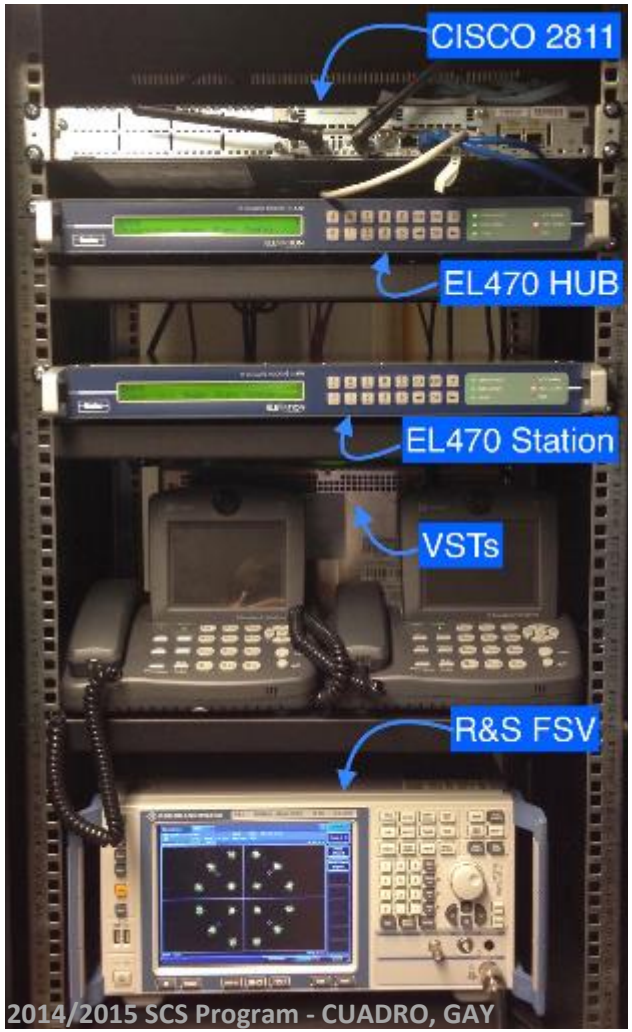
Source: Newtec

Margin UP > Margin DOWN:

→ Create hysteresis to avoid spurious variations of MODCODs

Laboratory Setup & Measurements

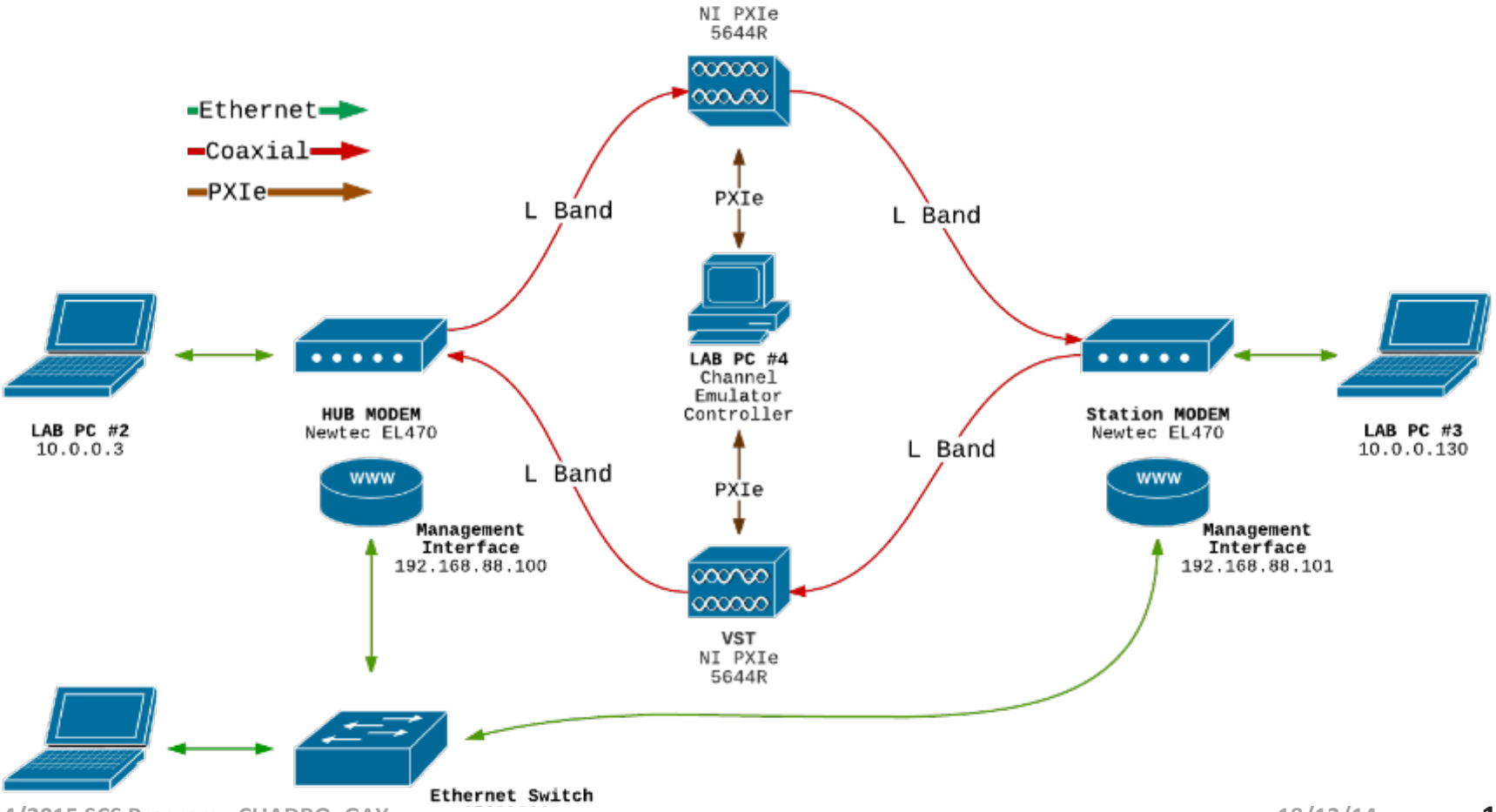
Laboratory Setup



- Ethernet Switch
- Newtec EL470 Modems:
  - HUB
  - Station
- Vector Signal Transceivers
- R&S FSV Signal Analyzer
- Multiple Lab PCs

Laboratory Setup (cont'd)

Connection Diagram



Modems: Newtec EL470

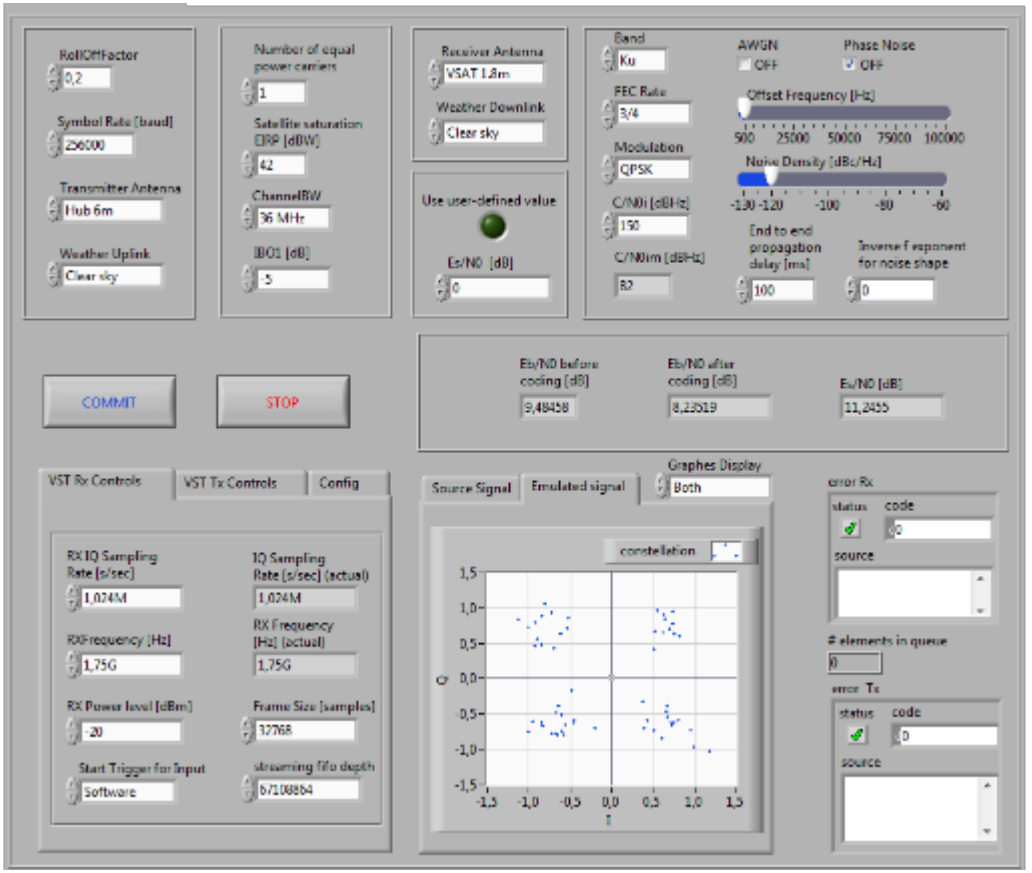
- State-of-the-art modem designed for transmission of IP data over satellite links. Maximum throughput of 133Mbps with strict DVB compliance.
- Available modcods:
  - QPSK: ¼, 1/3, 2/5, ½ , 3/5, 2/3, ¾, 4/5, 5/6, 8/9, 9/10
  - 8PSK: 3/5, 2/3, ¾, 5/6, 8/9, 9/10
  - 16APSK: 2/3, ¾, 4/5, 5/6, 8/9, 9/10
- Embedded point-to-point FlexACM controller (HUB) and client (Station). ACM only available in FW link.
- L-band outputs

Modems (cont'd)

16APSK

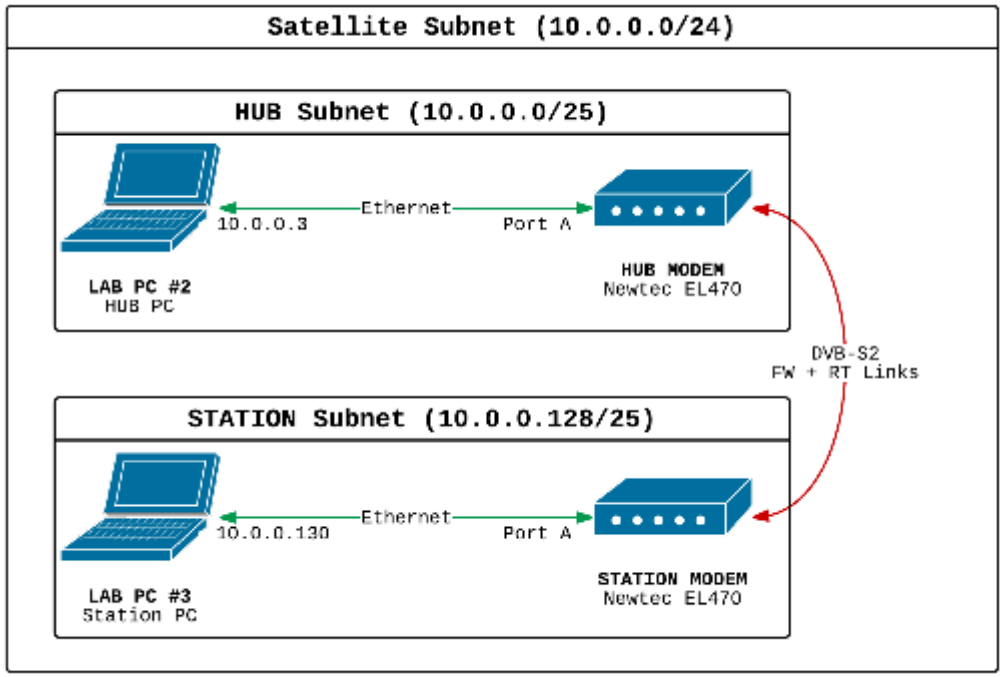
Channel Emulator

- VSTs allow for real-time processing in LabVIEW by streaming IQ samples to and from lab PC
- AWGN injection for Es/N0 setting. Phase noise injection is also available.
- Es/N0 controlled either manually or by inputting a time series.

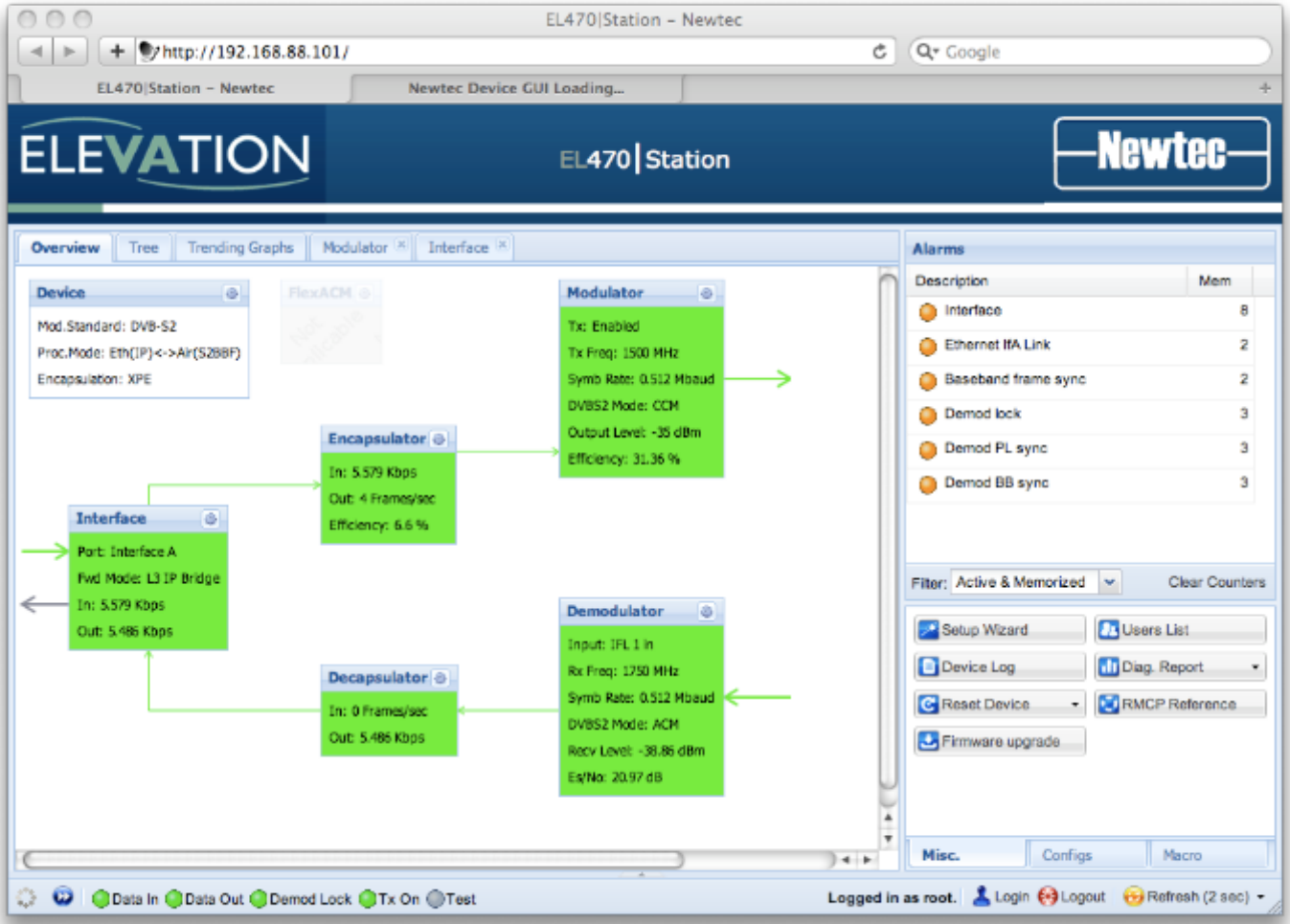


Network Model

- Modems are configured as L3 IP bridges.
- Ethernet link is terminated at each modem.
- Hosts at both ends are neighboring hosts.
- Only IP traffic destined for remote site is transmitted.



Network Model (cont'd)



Measurement Procedure

- Es/N0 time series is fed into channel emulator software and emulation is started.
- At the same time UDP traffic is generated using Iperf by the HUB PC. In addition all Ethernet frames arriving to the Station PC's Ethernet interface are captured using Tcpdump.
- ACM controller log (.csv) is extracted from modem
- All this data is then passed on to a set of matlab and python scripts for parsing and processing.

```
# STATION PC LISTENING ON PORT 5201
$ iperf3 -s -u -i1 -p 5201
------------------------------------------------------------
Server listening on UDP port 5201
Receiving 1470 byte datagrams
UDP buffer size:  192 KByte (default)
------------------------------------------------------------
```

```
# HUB PC STARTS UDP DATA STREAM DES_PORT = 5201
$ iperf3 -c 10.0.0.130 -u -t <duration in secs> -b <bandwidth> -l <udp size> -p 5201
------------------------------------------------------------
Client connecting to 10.0.0.130, UDP port 5201
Sending <udp size>  byte datagrams
UDP buffer size: 9.00 KByte (default)
------------------------------------------------------------
```

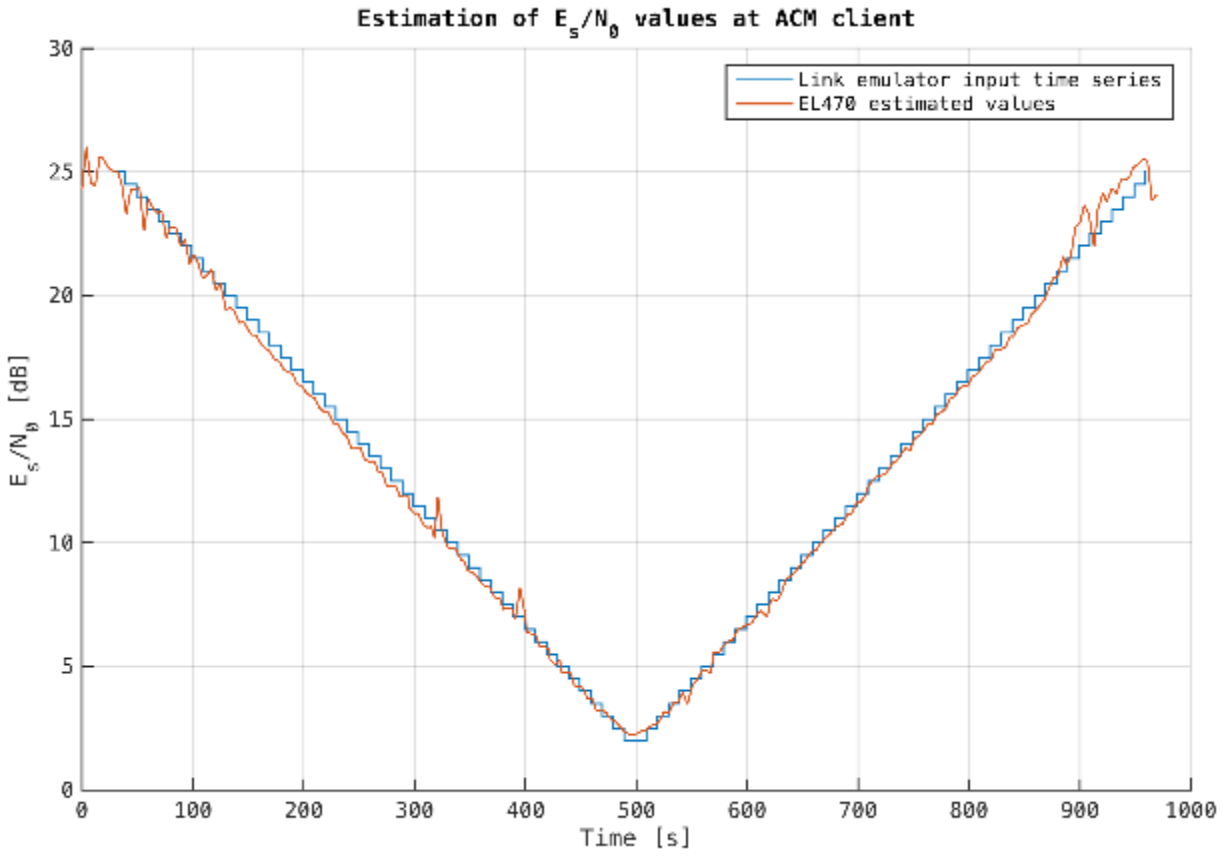
```
# CAPTURE INCOMING TRAFFIC

$ tcpdump -w output_file_name.pcap
```

```
Timestamp,Demod,RqModCod,EsNo,CarrierBitrate
2014-12-12 15:04:58,1,16APSK-2/3,11.30,1445835
2014-12-12 15:05:10,1,16APSK-2/3,11.20,1445835
2014-12-12 15:05:24,1,16APSK-2/3,10.72,1324072
2014-12-12 15:05:28,1,16APSK-2/3,10.61,1324072
2014-12-12 15:05:31,1,16APSK-2/3,10.66,1324072
2014-12-12 15:05:34,1,8PSK-3/4,10.19,1313479
2014-12-12 15:05:37,1,8PSK-3/4,11.87,1313479
2014-12-12 15:05:41,1,8PSK-3/4,10.40,1313479
2014-12-12 15:06:47,1,QPSK-5/6,6.93,884389
2014-12-12 15:06:51,1,QPSK-5/6,8.18,884389
2014-12-12 15:06:54,1,QPSK-5/6,7.02,825503
```

Results & Conclusions

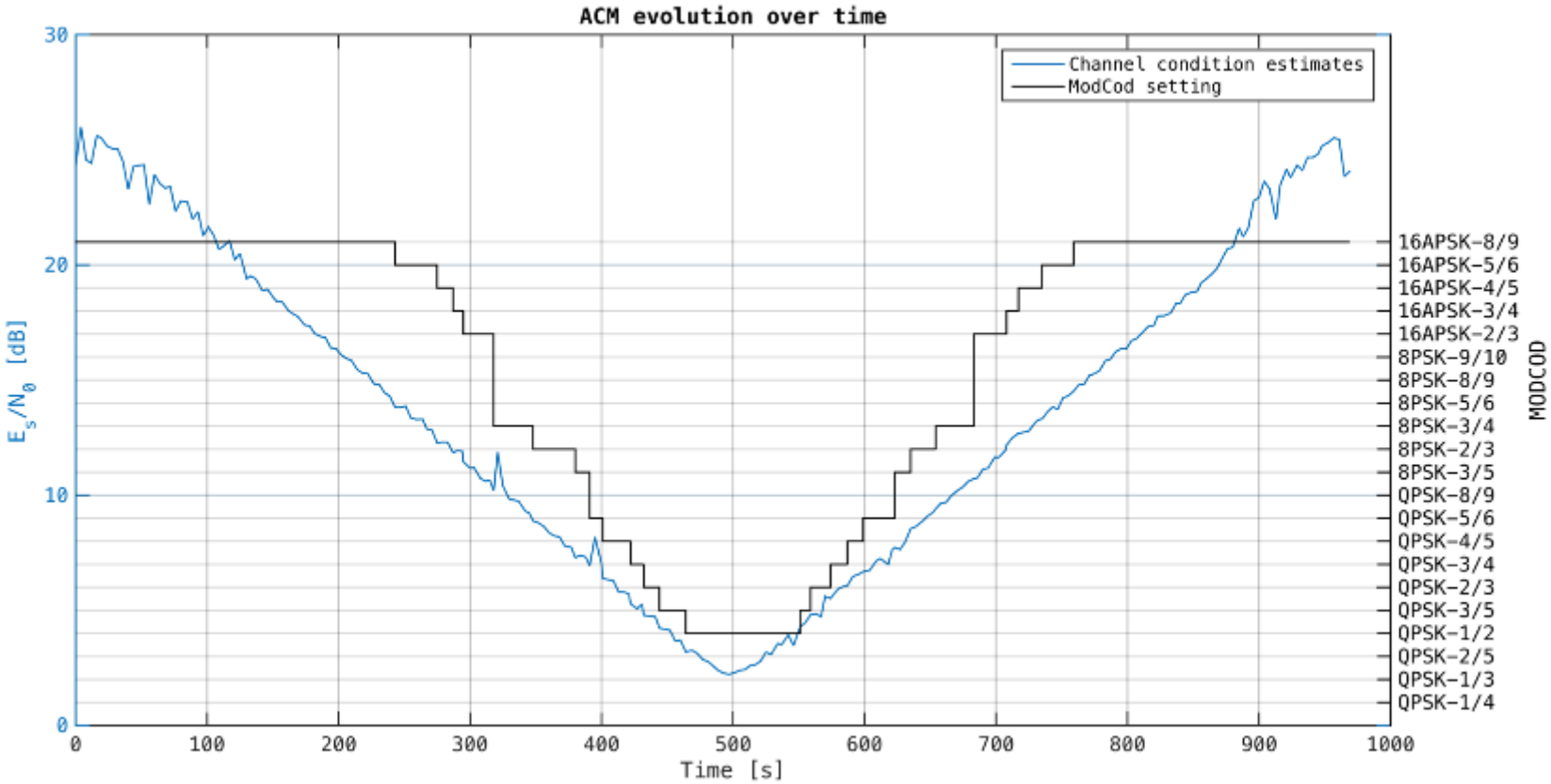
Results – Es/No Emulation



- 16 minute emulation
- Es/N0 ranging from 25dB to 2dB.
- 0.5dB steps lasting each 10s.

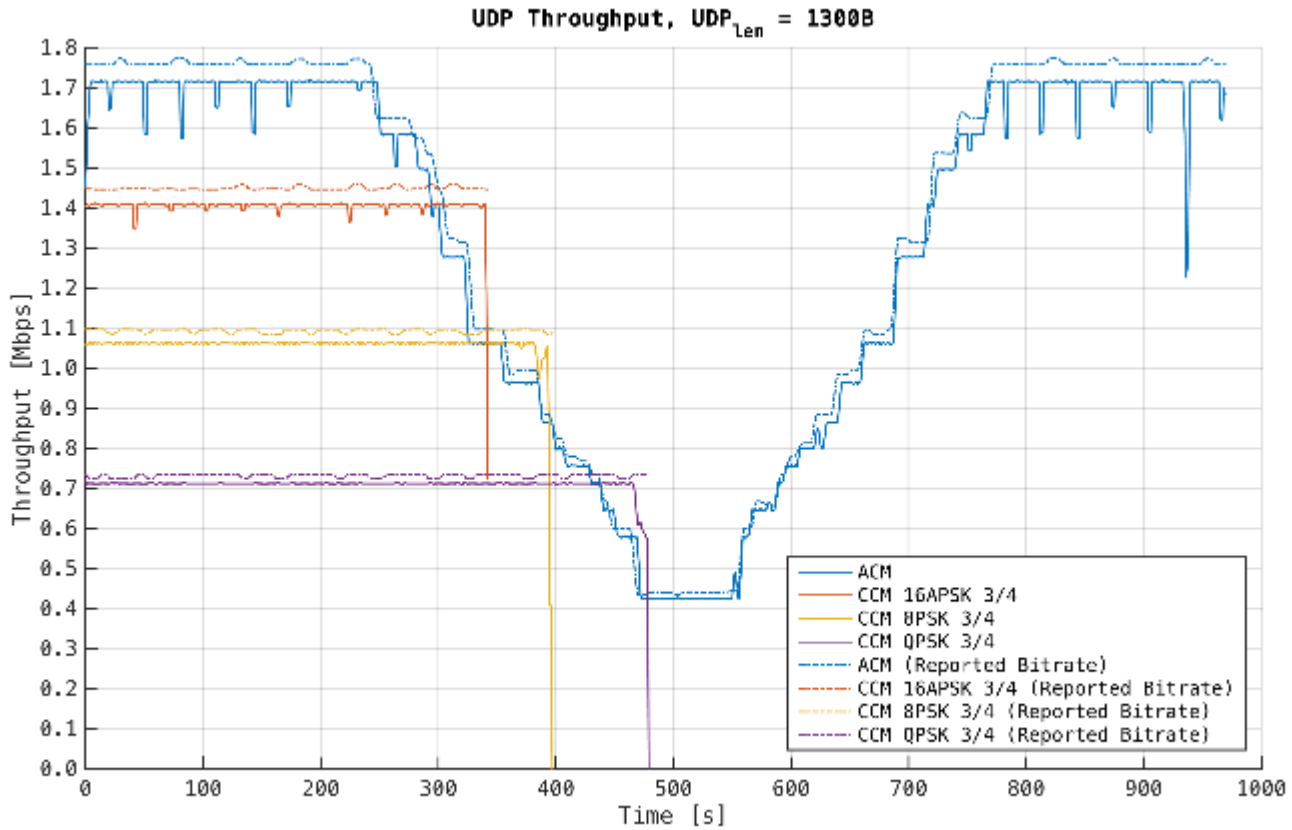
Both curves overlap. There seems to be some underestimation as well as spurious values.

Results – ACM Behavior



ACM adapts modulation and coding depending on link conditions to achieve QEF target (PER = 10^-7).

Results – Throughput ACM vs CCM



Naturally, UDP throughput varies as modcod parameters vary. UDP throughput disappears quickly because of LDPC BER curve steepness.

Conclusions

- Results highlight the importance of ACM-type schemes in current DVB-S2 systems as well as their potential for future satellite systems.
- We achieve better spectral efficiency when favorable conditions occur.
- Better availability with respect to CCM.
- Work shows that SDR based channel emulation is a viable and reliable option which is cost-efficient in comparison with dedicated hardware.

Thank you.