National Aeronautics and Space Administration

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NEAR EARTH NETWORK

DVB-S2 Demonstration Testing for Enhancing Data Rates for CubeSat/SmallSat Missions August, 2019

Transforming space communications from the ground up.

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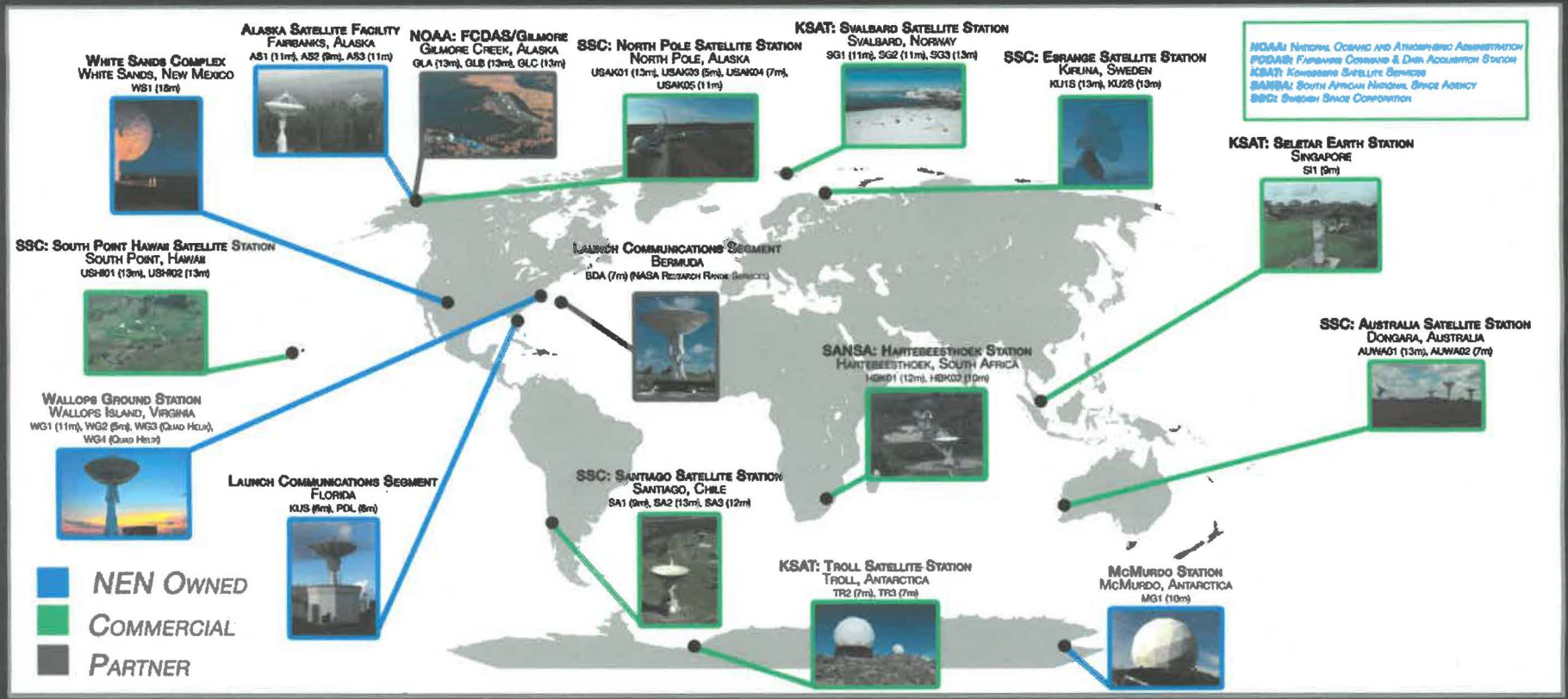
Exploration & SPACE Communications

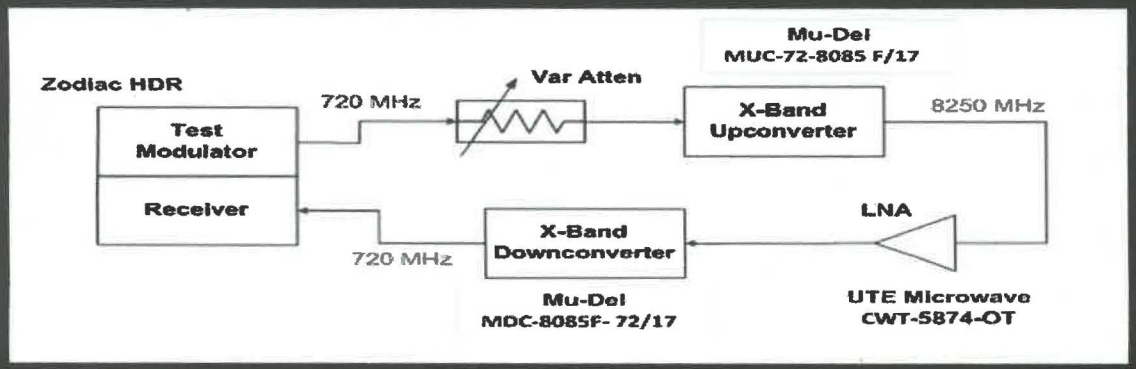
Near Earth Network (NEN) Overview

The NASA NEN, which provides communications support within 2 million km from Earth, is investigating and demonstrating DVB-S2 for the SmallSat community



NEN DVB-S2 Demonstration Test for Enhancing Data Rates

- NASA NEN conducted a DVB-S2 demonstration test at the Wallops Flight Facility in March 2019 for CubeSat/SmallSat missions for enhancing data rate performance
- The primary objective was to determine the BER performance and maximum achievable data rate for DVB-S2 over the NEN S-band 5 MHz channel
- DVB-S2 uses power and bandwidth efficient modulation and coding techniques to deliver performance approaching Radio Frequency (RF) channel theoretical limits
- The demonstration test was conducted using a Cortex high rate receiver (HRD) with Zodiac DVB-S2 demonstration license



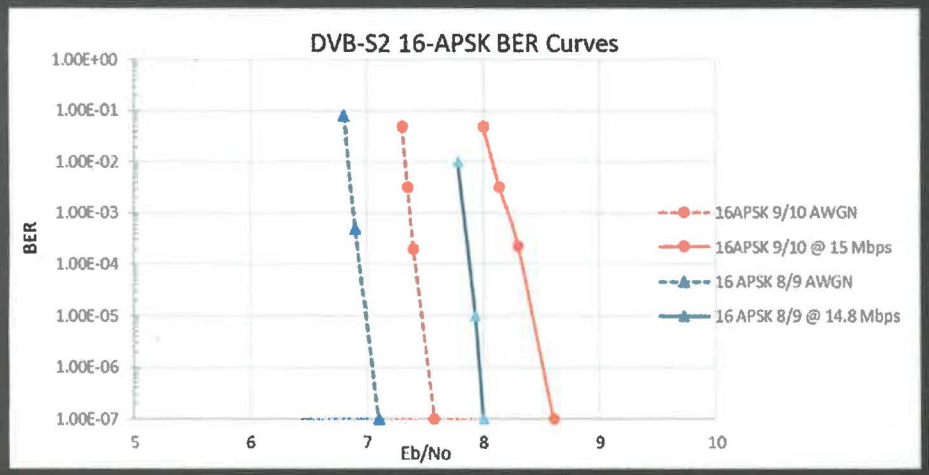
DEMONSTRATION TEST RESULTS
Future Missions & DVB-S2

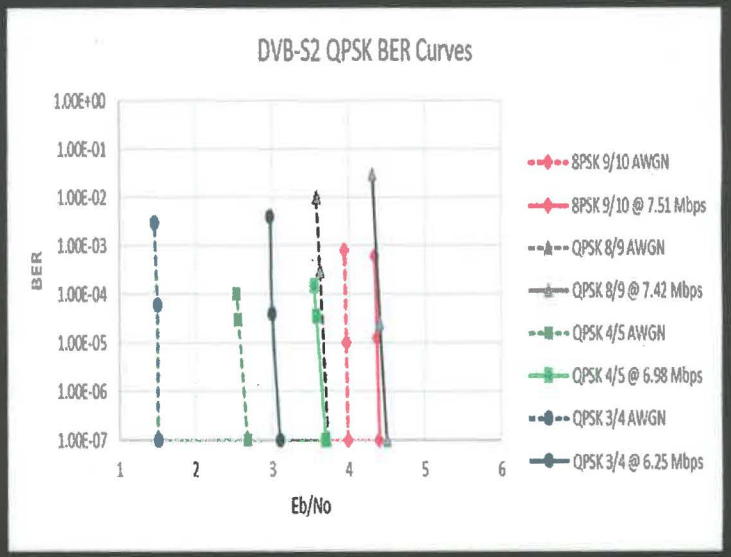
- Results of the DVB-S2 demonstration test were very positive
- The achievable data rates for QPSK, 8PSK and 16 APSK, 32 PSK modulation schemes with various code rates are well above the current data rates for the S-band 5 MHz channel with BPSK/QPSK and CCSDS convolutional and Reed Solomon (RS) coding
- Collaboration between NEN and University of Alaska Fairbanks CubeSat Communications Platform (CCP) is being planned to demonstrate 15 Mbps and Variable coded modulation (VCM) over S-band 5 MHz channel with a NEN ground station in 2022
- DVB-S2 will increase science data return, enable greater numbers of NASA CubeSat missions and is a potential candidate signal scheme for lunar and Lagrange point missions

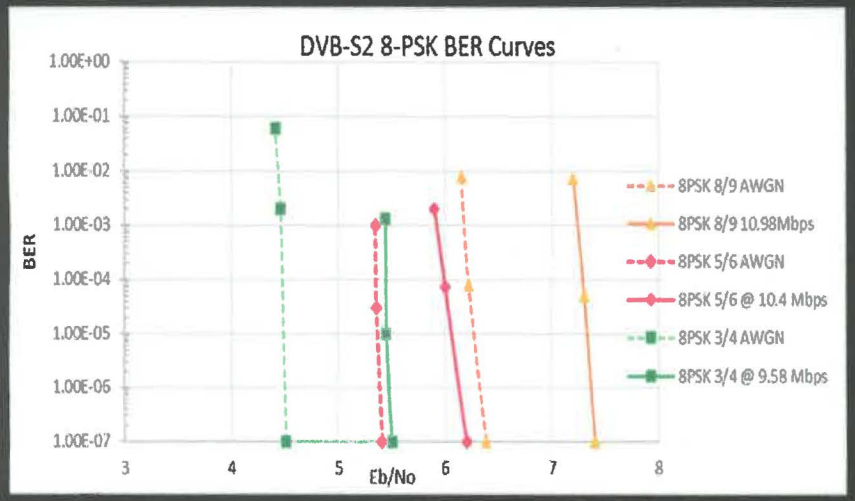
LDPC Coding Rate/ Modulation/Loss	1/2	3/5	2/3	3/4	4/5	5/6	8/9	9/10
QPSK	4.38	5.23	5.95	6.25	6.98	7.12	7.42	7.5
Implementation Loss (dB)	0.8	1.4	0.5	1.0	1.12	0.62	0.7	0.5
8 PSK	-------	7.48	8.12	9.58	10.0	10.4	11.0	11.3
Implementation Loss (dB)	--------	2.5	1.45	0.5	0.6	0.6	0.9	0.8
16 APSK	---------	-------	10.8	12.3	12.5	13.9	14.8	15
Implementation Loss (dB)	---------	--------	2.3	1.8	1.2	0.8	0.8	1.0
Note: An additional BER test for 32 APSK 9/10 was performed. It achieved 16.23 Mbps with approximately 1 dB implementation loss.								

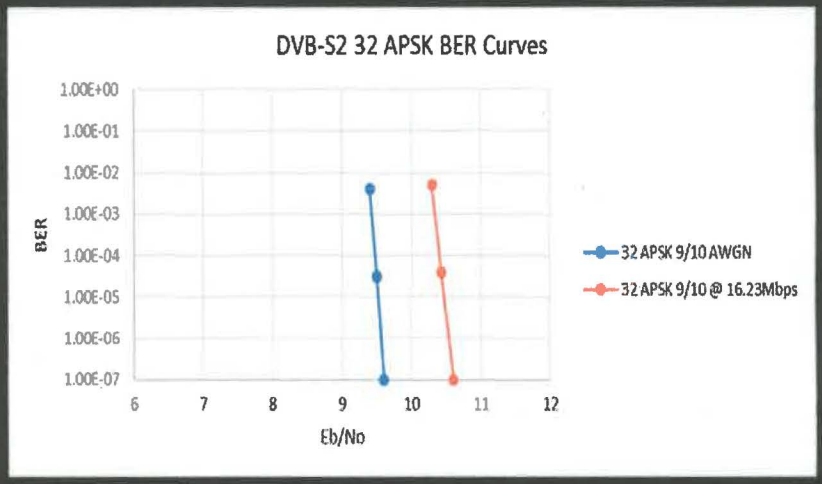
Backup

BER Performance









Link Margin Performance Analysis

- A NEN down link data rate analysis was performed for a SmallSat/CubeSat using DVB-S2 signal schemes with a typical communication system of a 2W PA and a patch antenna of 0 dBi gain. Overall, there is plenty of link margin
- With a 5W PA and 6 dBi antenna gain, the link margin for 16 APSK 8/9 rate is 14.09 dB and for 16 APSK 9/10 rate is 13.55 dB (TechEdSat)

Mod/Rate and Link Margin	1/2	3/5	2/3	3/4	4/5	5/6	8/9	9/10
QPSK (Mbps)	4.38	5.23	5.95	6.25	6.98	7.12	7.42	7.51
Link Margin (dB)	14.45	13.25	11.77	12.44	10.79	10.40	9.48	9.16
8PSK (Mbps)	------	7.48	8.12	9.58	10.0	10.4	10.98	11.25
Link Margin (dB)	------	10.17	9.16	7.66	6.41	6.0	5.09	4.7
16APSK (Mbps)	------	------	10.81	12.3	12.46	13.86	14.8	15.0
Link Margin (dB)	------	------	6.81	5.52	4.92	4.23	3.11	2.57

COMPARISON OF DVB-S2 RADIO BASED ON DEMONSTRATION TEST RESULTS WITH EVOLVED SMALLSAT RADIOS TESTED WITH THE NEN FOR DATA RATES AND PERFORMANCE

- **DVB-S2 is capable of increasing data rates for S-band 5 Mhz channel, relative to conventional modulation and coding schemes with the same spacecraft EIRP and same bandwidth**

Radio	Band	Power (W)	Data Rate from Low Earth Orbit (Mbps)	Bandwidth (MHz)	Test History
S-band Radio #1	S-band	2.0	1.0	2.0	Successfully compatibility tested in 2015
S-band Radio #2	S-band	2.0	2.0	4.5	Risk mitigation testing done in February and July, 2016
S-band Radio # 3	S-band	1.0	1.0	2.0	Radio tested in 2016
X-band Radio # 1	X-band	3.0	100.0	200.0	The SOCON spacecraft with the flight X-band communication system was successfully downlinked 100 Mbps to the Wallops 11m in 2019.
S-band Radio # 4	S-Band	1.0	1.0	1.0	Radio successfully tested with Morehead State University Ground station in 2017
S-band Radio # 5 without DVB-S2	S-band	2.0	5.0	5.0	Compatibility test was conducted successfully in 2018 at 120 Kbps and at 5 Mbps after a Software upgrade
S-band Radio # 5 with DVB-S2	S-band	2.0	15.0	5.0	To be tested in 2020