National Aeronautics and Space Administration

NEAR EARTH NETWORK

Transforming space communications from the ground up.

NASA NEN DVB-S2 Demonstration Testing for Enhancing Higher Data Rates for CubeSat/Small Satellite Missions at X-band and Ka-band

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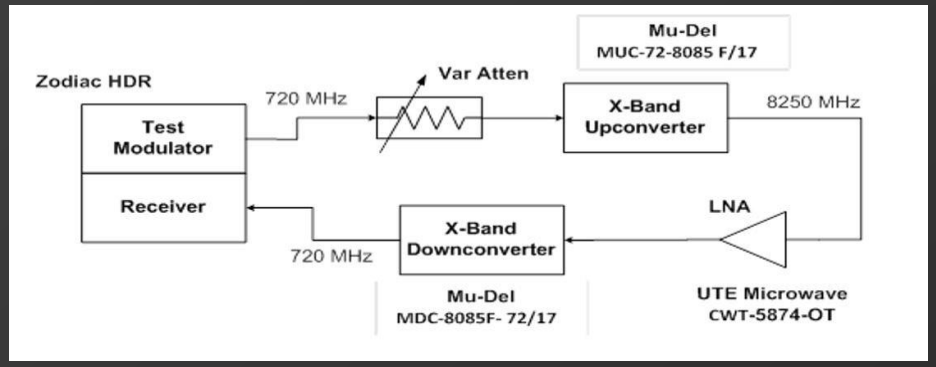
Exploration & SPACE Communications

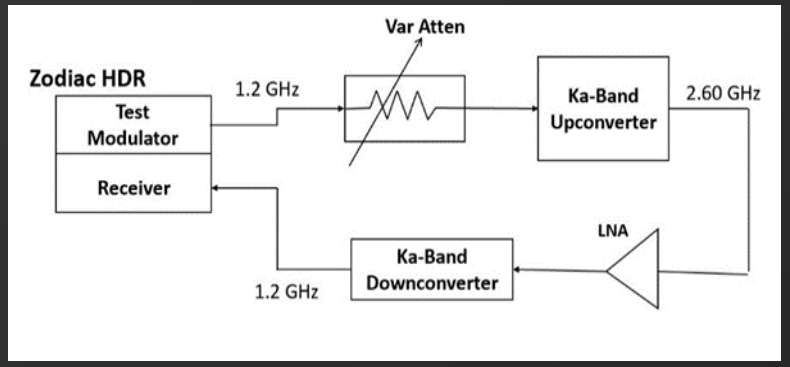
Near Earth Network (NEN) Overview

NASA NEN (Direct to Earth Coverage up to one million miles from Earth)

NEN DVB-S2 Demonstration Test for Enhancing Higher Data Rates at X/Ka-band

- A DVB-S2 high data rate demonstration test is planned to be conducted at the Wallops Flight Facility in 2020 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 X-band 375 MHz and Ka-band 1.5 GHz channels
- DVB-S2 uses power and bandwidth efficient modulation and coding techniques to deliver performance approaching Radio Frequency (RF) channel theoretical limits
- The demonstration test will be conducted using a Cortex high rate receiver (HRD) with a Zodiac DVB-S2 demonstration license
- The NEN will develop BER curves for selected DVB-S2 modulation and coding schemes and data rates of interest, as well as summarize implementation loss performance for all test cases





Predicted DVB-S2 High Data Rate X-band Performance

- Analysis was performed to predict the maximum achievable data rates, based on DVB-S2 spectral efficiency and performance requirements as well as NEN station Cortex HDR capability
- The maximum channel symbol rate is 300 Msps with the roll-off factor of 0.25 for NEN X-band 375 MHz bandwidth
- The predicted maximum data rate = spectral efficiency x 300 Msps
- The prediction is for intermediate frequency (IF) loop back, pilots off, and additive white Gaussian noise (AWGN)

Mod/ Coding Rate	1/4	1/3	2/5	1/2	3/5	2/3	3/4	4/5	5/6	8/9	9/10
QPSK	147	170	236.7	296.6	356.5	396.6	446.2	476.16	496.4	530	536.4
8 PSK					534	594	668.4	N/A	743.4	793.8	803.7
16 PSK						791	890	950	990	1057	1070
32 PSK							1111	1185.5	1235.7	1319	1336

Predicted DVB-S2 Ka-band Performance

- In the NEN Ka-band 1.5 GHz channel, the predicted maximum channel data rate equals the spectral efficiency times the channel symbol rate
- With the 1.5 GHz channel bandwidth, the channel symbol rate is the same as the station HDR receiver maximum symbol rate, which is 500 Msps

Mod/ Coding Rate	1/4	1/3	2/5	1/2	3/5	2/3	3/4	4/5	5/6	8/9	9/10
QPSK	245	328	394.7	494.4	594.5	661	743.7	793.5	827.3	883.3	894.3
8 PSK					890	990	1114	N/A	1239	1323	1340
16 PSK						1318.5	1483	1582.8	1650	1761.5	1783.5
32 PSK							1850	1975.8	2059.5	2219	2226

Link Analysis for X-band

- **A link analysis study was performed to determine X-band DVB-S2 Achievable Data Rate vs. MODCODEs and S/C Antenna Size**
- **Assumption:**

S/C at LEO 625 km altitude, f = 8250 MHz, PA=2W, WG1 11.3 m G/T = 34.5 dB/K (clear sky), 3 dB implement loss, 3 dB link margin

Mod/Coding Rate	1/4	1/3	2/5	1/2	3/5	2/3	3/4	4/5	5/6	8/9	9/10
QPSK	147	170	236.7	296.6	356.5	396.6	446.2	476.16	496.4	530	536.4
Antenna Gain, dBi	5.68	6.15	7.73	9.03	10.26	11.13	12.07	12.72	13.03	14.23	14.45
8 PSK					534	594	668.4	N/A	743.4	793.8	803.7
Antenna Gain, dBi					13.35	14.65	15.94	N/A	17.37	18.72	19.01
16 APSK						791	890	950	990	1057	1070
Antenna Gain, dBi						17.73	18.24	19.07	19.64	20.92	21.16
32 APSK							1111	1185.5	1235.7	1319	1336
Antenna Gain, dBi							20.78	21.74	22.31	23.72	24.08

Link Analysis for Ka-band

- **Assumption:**

S/C at 625 km altitude, f = 26000 MHz, S/C PA = 5 W, Alaska Station 11m, G/T= 40.6 dB/K (clear sky), 3 dB implementation loss, 3 dB link margin.

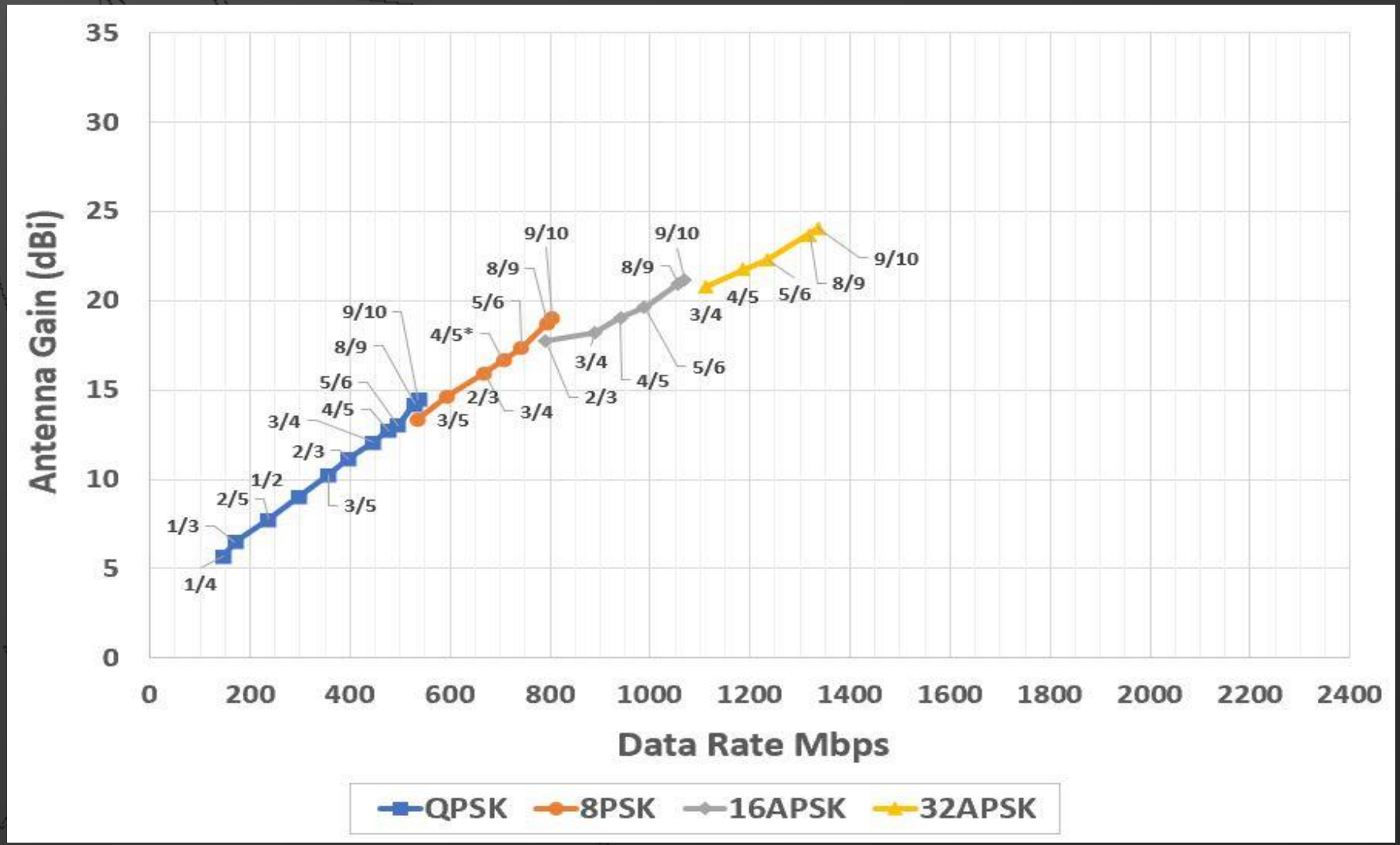
Mod/Coding Rate	1/4	1/3	2/5	1/2	3/5	2/3	3/4	4/5	5/6	8/9	9/10
QPSK	245	328	394.7	494.4	594.5	661	743.7	793.5	827.3	883.2	894.3
Antenna Gain, dBi	11.92	13.03	13.97	15.27	16.50	17.37	18.30	18.96	19.45	20.47	20.69
8 PSK					890	990	1114	N/A	1239	1323	1340
Antenna Gain, dBi					19.79	20.93	22.18	N/A	23.62	24.96	25.25
16 APSK						1318.5	1483	1582.8	1650	1761.5	1783.5
Antenna Gain, dBi						23.24	24.48	25.31	25.87	27.16	27.40
32 APSK							1850	1975.8	2059.5	2199	2226
Antenna Gain, dBi							27.01	27.98	29.55	29.96	30.31

Conclusion

- A DVB-S2 high data rate demonstration test is planned to be conducted at the Wallops Flight Facility in 2020 for CubeSat/SmallSat missions for enhancing data rate performance
- The maximum data rate is predicted to achieve 1.3 Gbps at X-band 375 MH and 2.2 Gbps at Ka-band 1.5 GHz channels with today's station receiver capability
- A future station receiver upgrade will enable the achievable data rate to above 5 Gbps (10 Gbps with dual polarization) at Ka-band
- DVB-S2 will increase science data return for all missions and enable support for a greater number of CubeSats/SmallSats at high data rates
- The NEN is actively seeking additional flight and ground solutions for evaluation and welcomes contact for technical discussions

Backup

X-band Achievable Data Rates vs. Spacecraft Antenna Gain and MODCODES



Ka-band Achievable Data Rates vs. Spacecraft Antenna Gain and MODCODES