



# NEAR EARTH NETWORK

## NASA NEN DVB-S2 Demonstration Testing for Enhancing Higher Data Rates for CubeSat/Small Satellite Missions at X-band and Ka-band August, 2020

*Transforming space communications from the ground up.*



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# Near Earth Network (NEN) Overview



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

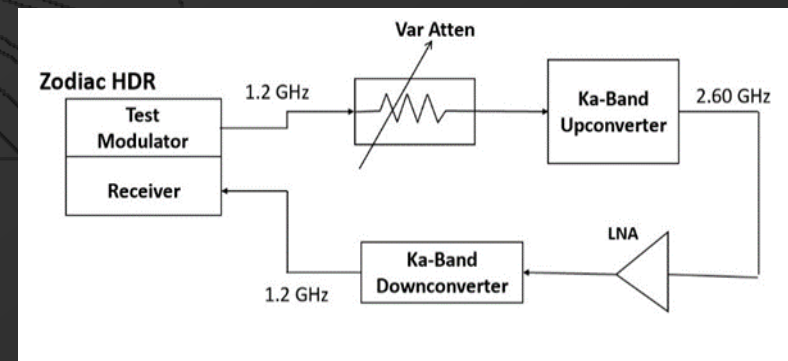
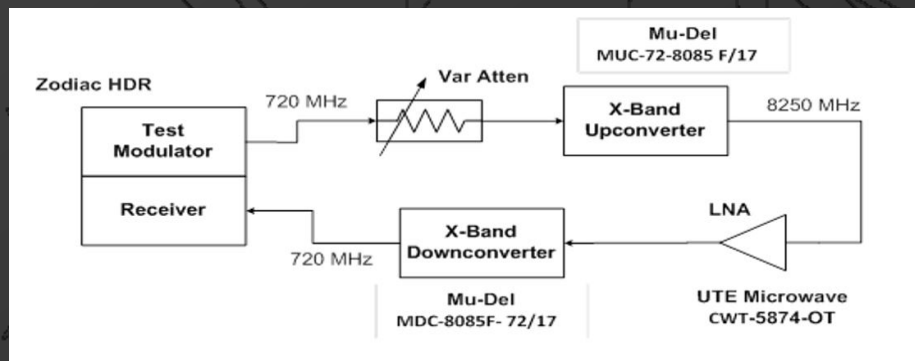




# NEN DVB-S2 Demonstration Test for Enhancing Higher Data Rates at X/Ka-band



- **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 is to determine the bit error rate (BER) performance and maximum achievable data rates 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 data rate (HDR) receiver with a Zodiac DVB-S2 demonstration license
  - The NEN will develop BER curves for selected DVB-S2 modulation and coding (MODCODE) schemes and data rates of interest, as well as summarize implementation loss performance for all test cases





# Predicted DVB-S2 Data Maximum Data Rates (1/2)



- 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
- Prediction factors for maximum data rate in X-band 375 MHz channel
  - 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 predictions are for intermediate frequency (IF) loop back, pilots off, and additive white Gaussian noise (AWGN)
- Predicted X-band maximum achievable data rates are presented in table below

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 Data Maximum Data Rates (2/2)



- **Prediction factors for maximum data rate in Ka-band 1.5 GHz channel**
  - For 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
- **Predicted Ka-band maximum achievable data rates are presented in table below**

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
<b>QPSK</b>	245	328	394.7	494.4	594.5	661	743.7	793.5	827.3	883.3	894.3
<b>8 PSK</b>					890	990	1114	N/A	1239	1323	1340
<b>16 PSK</b>						1318.5	1483	1582.8	1650	1761.5	1783.5
<b>32 PSK</b>							1850	1975.8	2059.5	2219	2226





## ➤ Ka-band Link Analysis Assumptions

- Spacecraft at LEO 625 km altitude,  $f = 26000$  MHz, S/C PA = 5 W, Alaska Station 11m antenna, 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



- **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 MHz and 2.2 Gbps at Ka-band 1.5 GHz channels with today's station receiver capability**
- **A future station receiver upgrade will enable achievable data rates above 5 Gbps at Ka-band (10 Gbps with dual polarization)**
- **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**



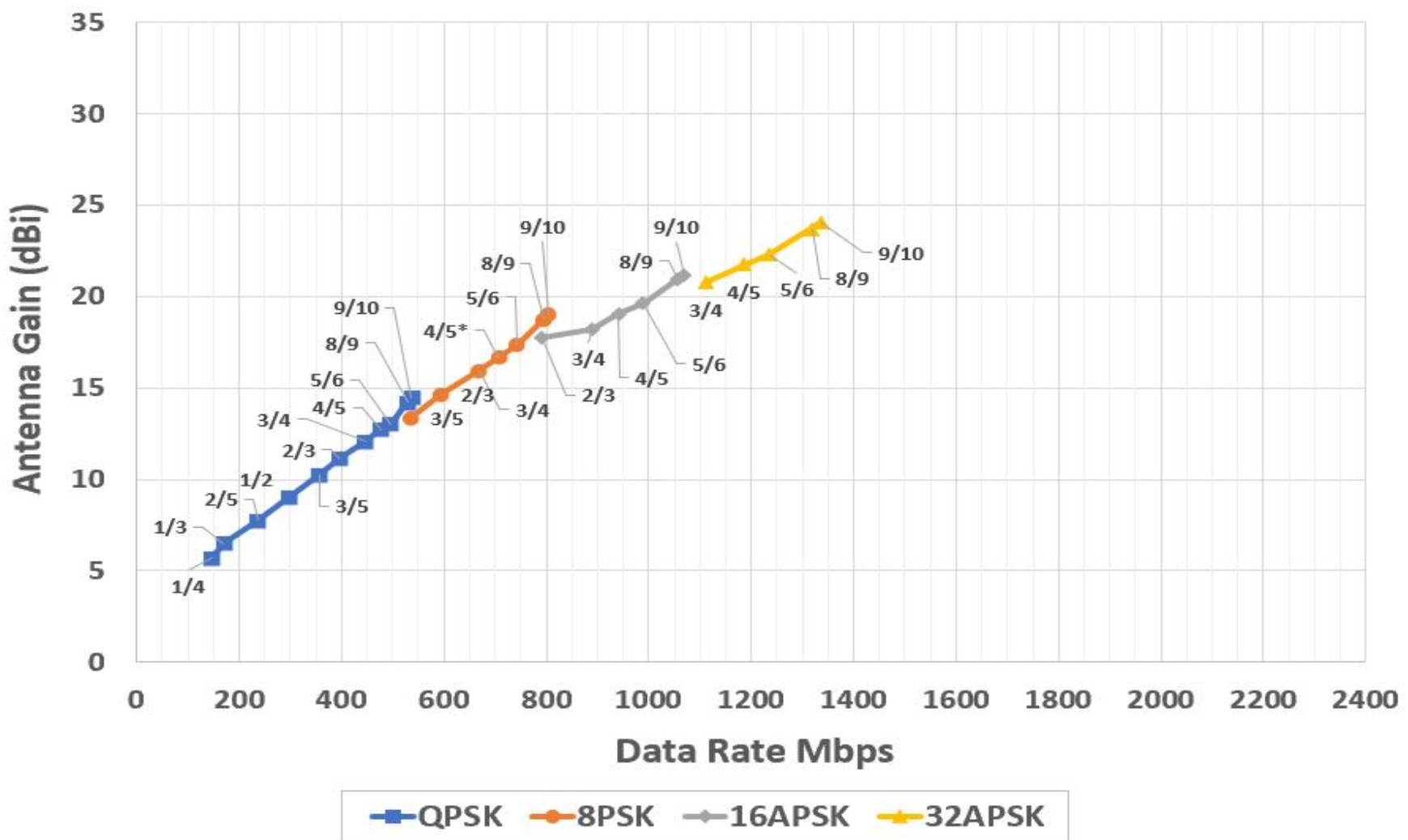


# Backup





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





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

