DATV on ISS ?

How can this become a reality?

Wolf-Henning Rech DF9IC / N1EOW

Thomas Sailer HB9JNX / AE4WA

D-ATV on ISS?

- Use open worldwide commercial broadcast standards - this ensures easy availability of receiving equipment
- DVB / ETSI standards:
  - DVB-S (EN 300 431) since 1994
  - DVB-S2 (EN 302 307) since 03/2005
- DVB-S FTA receiver costs 50-80 EUR (Germany, 2005)

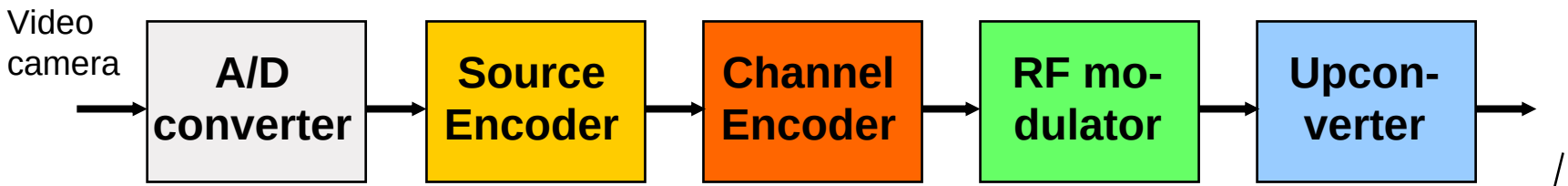
D-ATV on ISS?

- Digital vs. analogue (FM) ATV:
  - scalable performance / bandwidth / RX sensitivity
  - multiple video and audio streams available
  - 10 - 20 dB better link performance

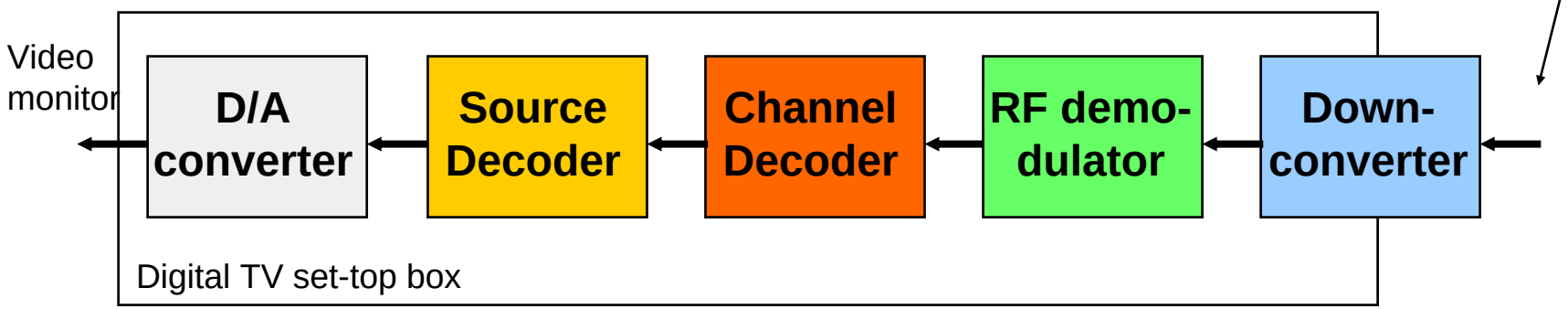
  - PA needs better linearity / has less efficiency
  - source encoder causes latency
  - hard degradation in presence of strong interference

D-ATV on ISS?

- Block diagramm of a DTV transmitter ... :

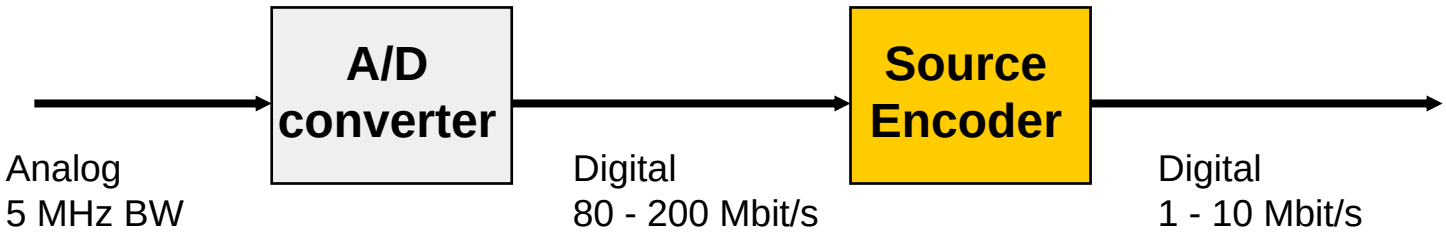


- .... and a receiver:



D-ATV on ISS?

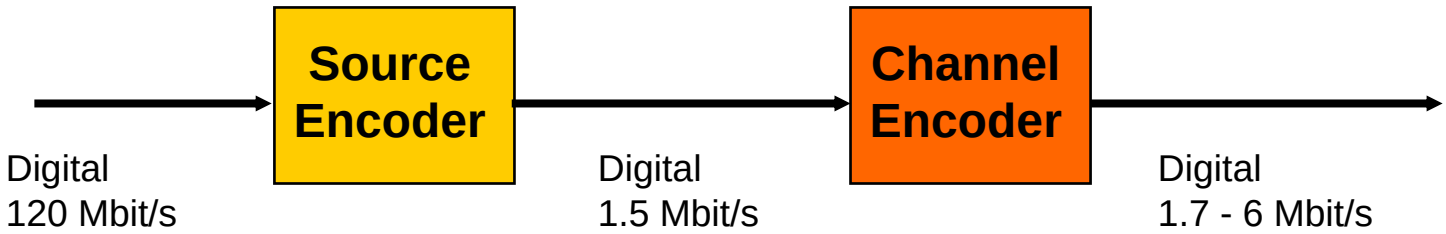
- Source Encoder:



  - removes redundant and irrelevant parts of the signal
  - trade-off between data rate and signal quality/latency
  - 1 ... 2 Mbit/s low quality - 4 ... 6 Mbit/s high quality for SDTV

D-ATV on ISS?

- Channel Encoder:

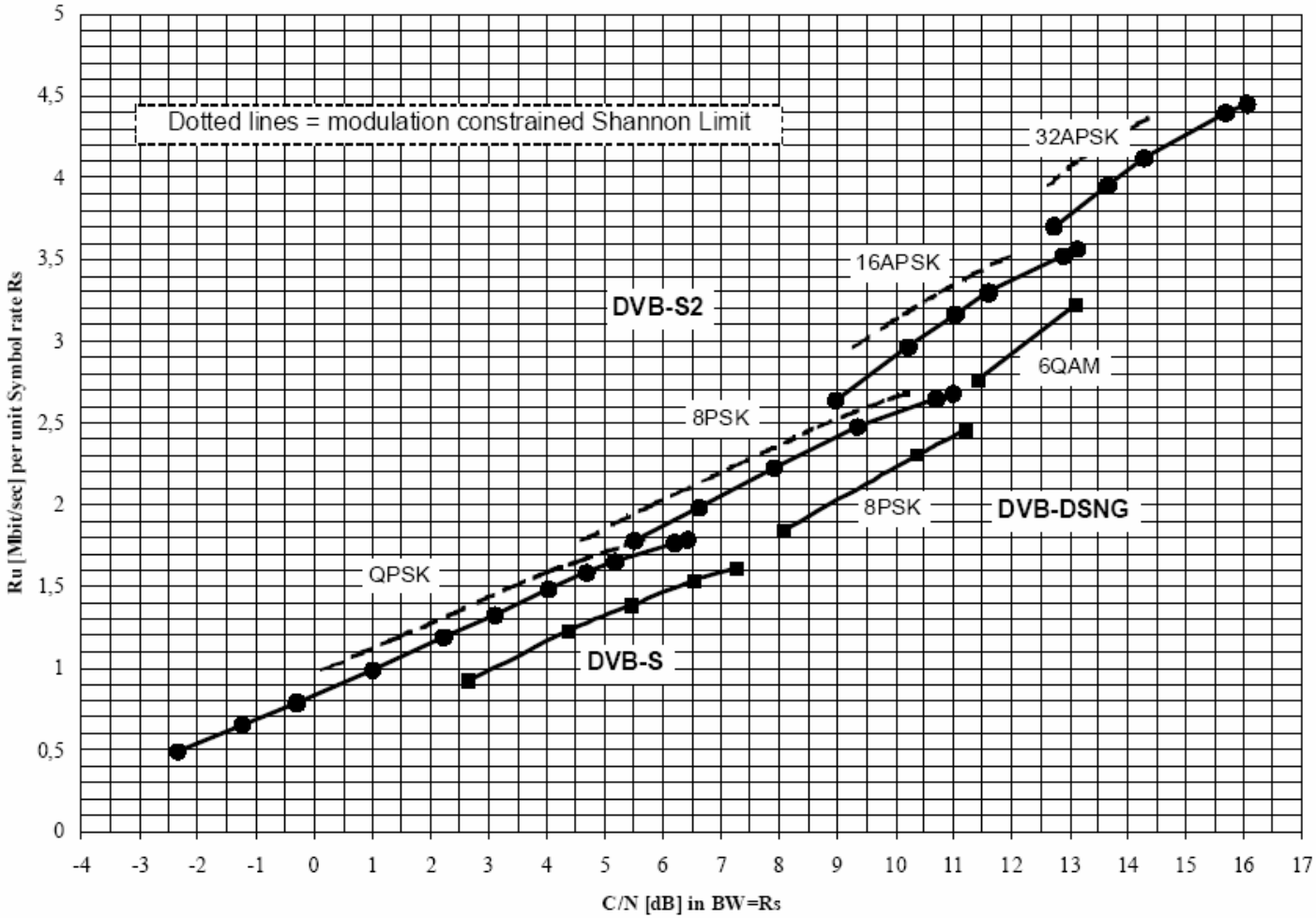


  - adds redundancy to the source coded signal for error correction capability
  - R = input data rate / output data rate = 7/8 ... 1/4
  - trade-off between required E_b/N_0 at receiver and bandwidth

D-ATV on ISS?

- Source encoding:
  - MPEG-2 (DVB-S and DVB-S2)
  - MPEG-4 / H.264 (DVB-S2) for HDTV
- Channel encoding and modulation
  - QPSK with R = 1/2 FEC with convolutional + Reed-Solomon coding (DVB-S)
  - QPSK with R = 1/2 - 1/4 FEC with BCH + LDPC coding (DVB-S2)

D-ATV on ISS?



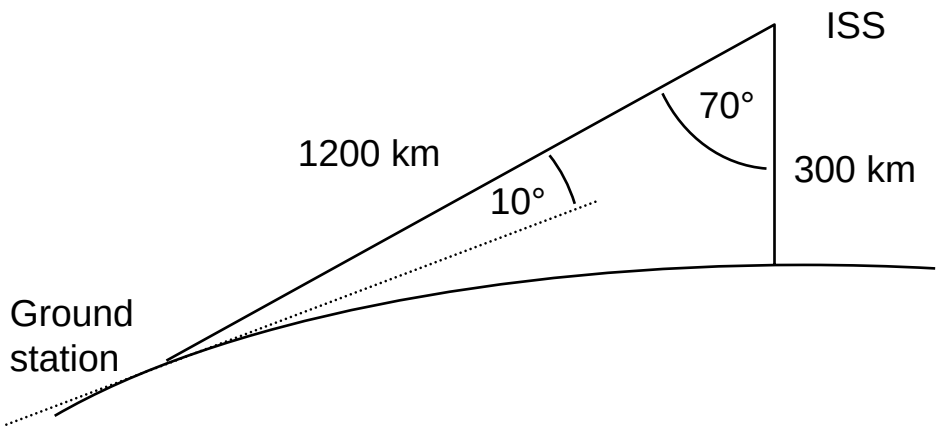
Source: ETSI TR 102 376

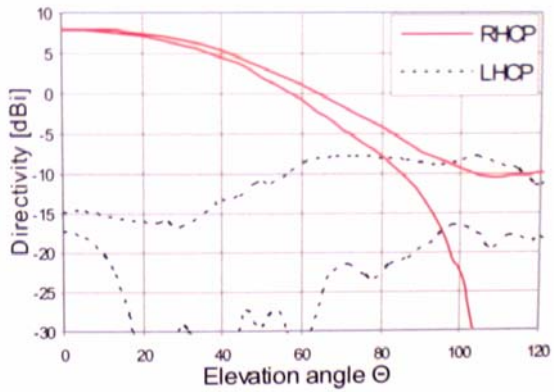
D-ATV on ISS?

- Required E_b/N_0 incl. implementation loss:
  - 5 dB for DVB-S and 2 dB for DVB-S2
  - compare to >20 dB for 1200 Baud AFSK
    => 30...80 times better efficiency
- Receiver noise level (N_0):
  - T = 290 K => N_0 = -174 dBm/Hz
  - Required signal power for 2 Mbit/s is -106 dBm for DVB-S and -109 dBm for DVB-S2
  - compare to -120 dBm for FM voice signal at threshold and -115 dBm for 9600 Bd packet radio

D-ATV on ISS?

- „Quick and dirty“ link analysis (1):
  - assumed that the patch antenna at ISS is useable up to +-70° with 0 dB_i gain (hopefully!)
  - then the minimum elevation at ground station is 10° and the maximum path length is around 1200 km





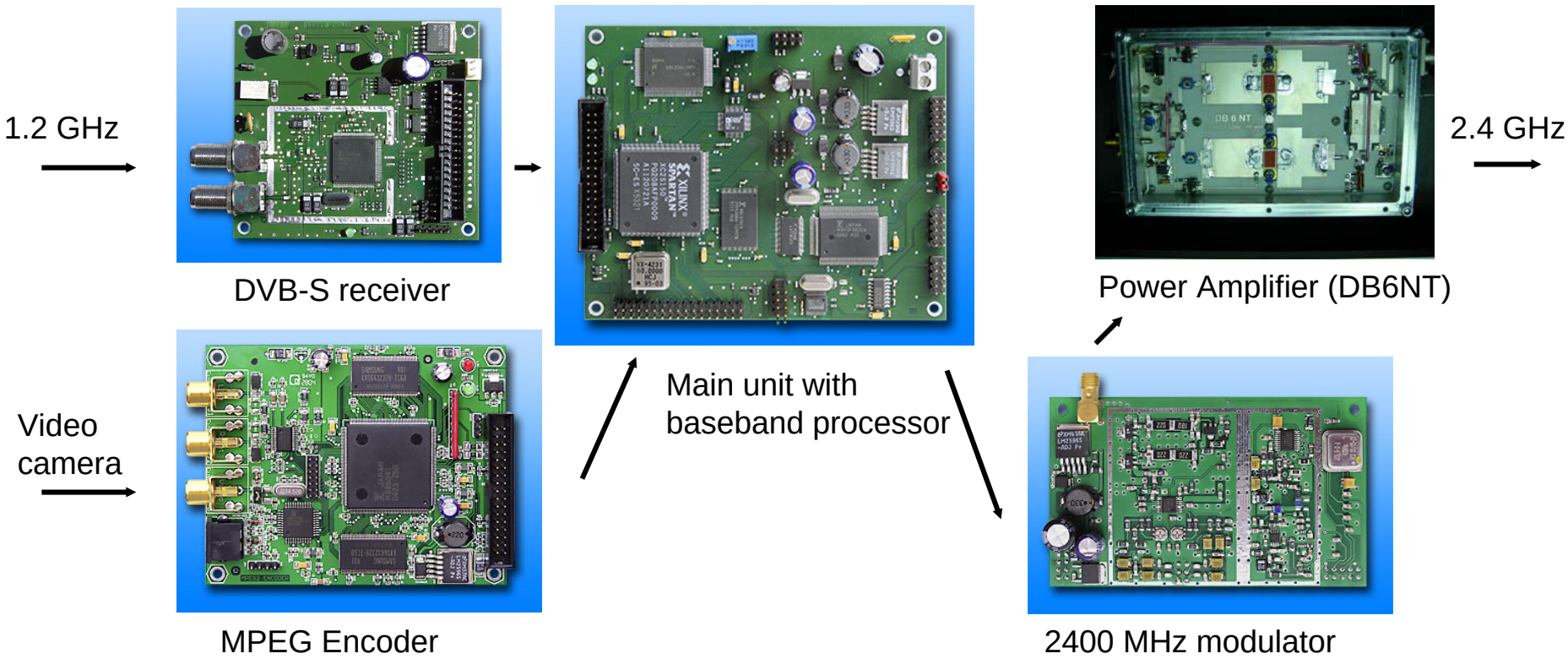
SSETI Express Patch Antenna

D-ATV on ISS?

- „Quick and dirty“ link analysis (2):
  - 1200 km @ 2.4 GHz mean 162 dB path loss
  - TX EIRP assumed +40 dBm (+10 dBW, 10 W at the antenna feeding point with 0 dB_i gain)
  - RX antenna assumed 1 m diameter dish with 40 % efficiency, 10° angle at -3 dB and 24 dB_i gain
  - results in a received signal power of (+40 - 162 + 24) dBm = -98 dBm
  - 8 dB margin at -106 dBm RX sensitivity

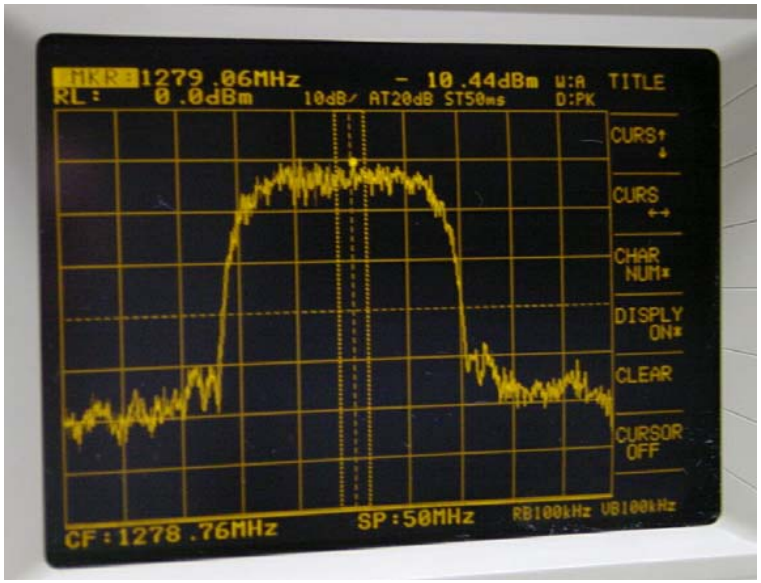
D-ATV on ISS?

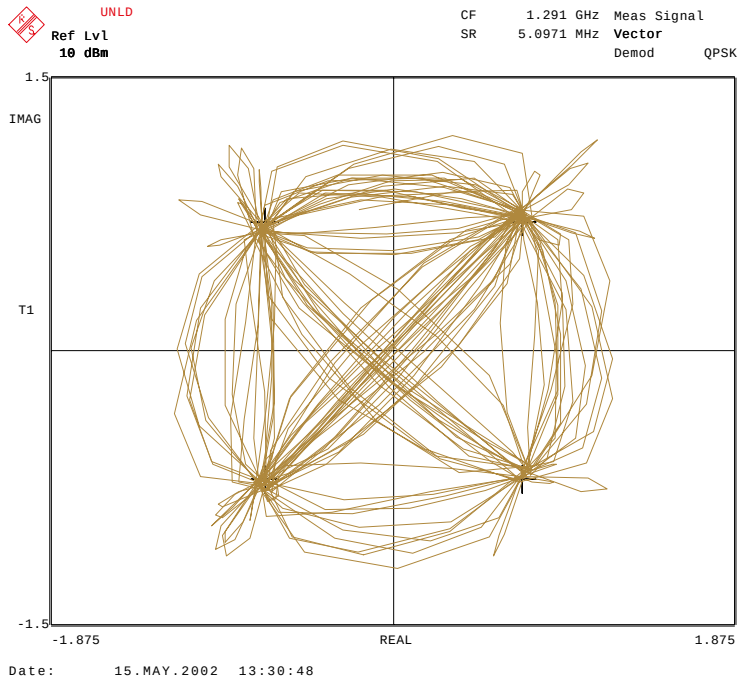
- Amateur radio hardware for DVB-S:



D-ATV on ISS?

⌘... and what comes out of it





D-ATV on ISS?

- Summary:
  - Digital video over 1200 km LOS path is possible with a 10 W EIRP transmitter and 24 dB_i receiver antenna gain
  - Low cost transmitter technology is available to amateur radio and can be modified / adapted to the special needs at ISS
  - Ground station is more complex that for FM voice operation but within the capabilities of technically skilled hams

D-ATV on ISS?

- When and how does it happen?