Formal Definition Meeting for the Packet Radio Experiment RUDAK to be included in AMSAT P3-C

Dr. Karl Meinzer DJ4ZC
Hans Peter Kuhlen DK1YQ

During the weekend February 15 thru 17, AMSAT-DL hosted a formal meeting to define the Packet payload in P3-C. The experiment has been named "RUDAK" for "Regenerativer Umsetzer für Digitale Amateur-Kommunikation".

Attending were:

Hans Peter Kuhlen DK1YQ
Program Manager RUDAK Project

Peter Gülzow DB2OS
Project Manager RUDAK project

Heinz Mölleken DL3AH
Ground Systems Manager RUDAK project

Werner Haas DJ5KQ
Vice President AMSAT-DL e. V.

Karl Meinzer DJ4ZC
President AMSAT-DL e. V.

A. General

After a brief review of the performance and capabilities of existing packet systems, the board set the objectives for the RUDAK payload as follows:

1. Compatability of the system with the present AX.25 standard and the existing Packet Radio boards (e. G. TAPR).

2. Regular Amateur communication equipment should be used without the need of modification or intrusion.

3. Moderate to small antennas should be sufficient for low bit error rates.

Relating to point 3., the board agreed on the nominal amateur station performance parameters as detailed in Annex A. With these in mind, the second point was analysed in great deteil with particular reference to link-performance and modulation techniques available with these results:

a. Link budget considerations require efficient techniques for the downlink which today can only be achieved using (transparent) SSB-equipment with demodulation at baseband (audio). This limits the practical achievable datarate to 1200 bits/s (RSM) or lower (BPSK); a performance better than 12 dB Eb/No can be expected.

b. The uplink could employ standard FM-equipment for straight FSK-modulation. Experiments by DB2OS showed that 2400 bits/s (biphase) can be handled by standard equipment without problems. It remeins to be investigated if 4800 bits/s (NRZ) also can be handled or if special measures are necessary to eliminate the influence of the DC-component (e. G. scrambling for spectrum shaping). Higher data rates cannot be achieved with standard radios. Technical papers reviewed indicate that with a discriminator type of demodulator 17 dB Eb/No are necessary for 2400 bits/s and about 15 dB for 4800 bits/s (FM-threshold), The meeting concluded that also BPSK for the uplink is

viable without intrusion inti equipment by using a high-power passive BPSK-modulator between transmitter and antenna or between exciter and PA. This approach imposes no restrictions on the data rate and yields also a better than 12 dB Eb/No performance. The resulting spectrum needs to be investigated and bandwidth-limiting measures may turn out to be necessary. The board concluded theat in view of the long visibility of the satellite no sgnificant on board storage would be employed. The uplink using essentially ALOHA signalling should have about six times the capacity of the downlink. On board storage should be sufficient to buffer about ten times the packet differential between downlink and uplink (6-7 kByte).

c. presently there is no suitable ISO-layer 3 network definition available, thus the payload initially should emulate the existing digipeater function as defined in the AX.25 version 2.O/Oct. 84. If a more sophisticated level 3 protocol1 becomes available, the S/C will be updated accordingly.

B. Design decisions taken by the board

a. The board agreed on the following main features as design guidelines for the RUDAK experiment:
   - Nominal amateur equipment as defined by Annex A required the selection of the following data-rates and modulation techniques:
     Uplink: (24 cm) 2400 bit/s differential biphase PSK (+-90 deg) spectrum shaping TBD
     Downlink: (70 cm) 400 bit/s differential biphase PSK (+-90 deg) spectrum shaping as used in AO-10
   - continuous operation of the beacon in Mode L (24/70 cm: independant from the transponder passband (and AGC)
   -"Bulletin board" i. e. cyclic repetition of information packets containing
     .updated satellite status (telemetry)
     .orbit information (Keppler data) and present position (MA)
     .uplink parameter set to be used by Packet Radio Stations wishing access to RUDAK (to eliminate unnecessary trial and error experimentation).
     .etc.
   - RUDAK programmes will be resident entirely in RAM facilitating software updates to be executed by AMSAT control stations via the regular P3-C command system.
   - Packet first-in-first-out (FIFO) buffer (6-7 kByte) plus additional storage consistent with available memory to be used.
   - continuous self-test of the s/w with error correction in case of soft errors and auto-recovery in case of problems.

b. The original RUDAK design constraints (power 5 W, Volume 5 litres, mass 5 kg) were reviewed. It was concluded that one large P3-module (300x200x40 mm) would be sufficient to house the digital part of the experiment. The board was made aware that for a continuous operation of the RUDAK computer a considerably lower power consumption than 5 W would be desirable. If this turns out to be impractical, the availability of a stand-by mode with memory retention should be investigated. The transmitter and receiver of RUDAK will be built and integrated into the L-transponder by the group building the transponder.

C. A work assignment and schedule has been agreed upon consistent with the AMSAT-P3-C launch (Annex B).

d. The board elected H. Kuhlen, DK1YQ, to compile the full RUDAK specification for definition of hardware and software requirements including the interfaces to the"Integrated Housekeeping Unit" (IHU) and the Mode-L-transponder.

e. Offers of participation to interested AMSAT groups will be released after availability of the full specification set.

f. Development of a compatible ground MODEM ans its early publication will be initiated in parallel with the space segment development.

ANNEX A. (Link assumptions and calculations)

Both Mode-B and Mode-L link-scenarios have been investigated. Mode-B finally was rejected because the expected downlink-performance in the 2m-Band was considered unsatisfactory in Japan and European metropolitan areas. Also the lack of suitable spectrum space in the 2m-Band, the bulk and cost of the required 2m-antenna and the fact, that the U-transponder exists already, entered into the decision. For the sake of completeness, the links are also presented for Mode-B.

Ground station assumptions:

Mode B:	Receiving (2m)	Gant:	+9 dBi
		Tn:	1000 k
	Transmitting (70cm)	Gant:	+10 dBi
		P-Tx:	5+ w
			--27 dBWi
Mode L:	Receiving (70 cm)	Gant:	+10 dBi
		Tn:	1000 k
	Transmitting (24cm)	Gant:	+15 dBi
	P-Tx: 12 w	-- 26 dBWi	

All links are to be designed with 7 dB margin to cover the less than perfect equipment to be expected in the amateur-environment.

Mode-B links: (for reference only)

Downlink	P-Tx	5 dBW (3W)
	Gant S/C	3 dBi (min during spin)
	link at apogee	-168 dB
	misc losses in link and S/C	-3 dB
	margin	-7 dB
	Gant-ground	+9 dBi
	Received power ground Rx	-161 dBW
	Pn (400bit/s)	-173 dBW
	--- Eb/No	12 dB

Mode-B uplink (Assuming 2400 Bit/s FSK)

Gant ground	10 dBi
P-Tx (50 W)	17 dBW
link	-177 dB
misc. losses	-3 dB
margin	-7 dB
G-ant S/C	+9 dBi
Received power at S/C	-151 dBW
Pn (500 k,2400 b/s)	-168 dBW
--- Eb/No	+17 dB

Mode-L links (selected for RUDAK)

Downlink	P-Tx-S/C (5W)	7 dBW
	Gant-S/C	9 dBi
	Link-loss (apogee)	-177dB
	misc. losses in S/C and link	-3 dB
	margin	-7 dB
	Gant-ground	+10 dBi
	Power arriving at ground Rx	-161 dBW
	Pn (400 b/s,1000K)	-173 dBW
	--- Eb/No	+12 dB

Uplink	**P-Tx** ground (12 **W)**	**+11 dBW**
	Gant-ground	**+15 dBi**
	link-loss	-187 **dB**
	misc. losses	- 3 **dB**
	margin	- 7 **dB**
	Gant-S/C	**+13 dBi**
	Power at S/C Rx	-158 **dBW**
	Pn	
	(2400 b/s, 500 **k)**	-168 **dBW**
	--- **Eb/No**	**+10 dB**
		(OK with PSK)