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# P3E Transponder Meeting

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*On January 22 and 23 the builders of the transponders for the Phase 3 satellite met in Marburg to clarify open questions and to further clarify the on-going events leading to the integration of the flight modules. The good news: for all of the planned frequencies work being done on the transponders, and we are confident that we will be able to integrate all modules within this year.*

The participants to the meeting in alphabetical order: Michael; Fletcher (OH2AUE), Jens Geisler (DL8SDL), Peter Gülzow (DB2OS), Konrad Hupfer (DJ1EE), Mirek Kasal (OK2AQK), Petri Kotilainen (OH3MCK), Michael Kuhne (DB6NT), WilliamLeijenaar (PE1RAH), Karl Meinzer (DJ4ZC), Gerald Moernaut (ON4EDA), Ulrich Müller (DK4VW), Helmut Neidel (DL1IN), Danny Orban (ON4AOD), Hartmut Päsler (DL1YDD), Janne Peltonen (OH1LRY), Frank Sperber (DL6DBN), and Heike Straube. The list of participants from Belgium, Finland, Czech Republic, the Netherlands and Germany clearly underscores the international character of the P3E project.

The easiest way to describe the results of the meeting is to list the individual modules in order. The modules have been given an identifying number for AMSAT-DL internal processing, which consists of a letter – in this case E for P3E – and a two-digit number. Eventually a further letter will be added, if a second identical system is integrated. This is the case with the on-board computer and the STAR camera.

*Figure 1: During the transponder meeting in January 2005*

## Module overview

The actual list of modules accordingly appears as follows:

E01 Main Battery
E02 S-Exciter
E03 V/S Power Amplifier
E04 K-Transmitter
E05 P5 Coherent Transponder S/X
E06 U/V Transponder (optional 29-RX)
E07 L-Receiver
E08 Sensor Electronic Unit (SEU)
E09 Battery Charge Regulator (BCR)
E10 Auxiliary Battery
E11A Integrated Housekeeping Unit A (IHU3-A)
E11B Integrated Housekeeping Unit B (IHU3-B/RUDAK)
E12 Ultra Stable Oscillator (USO)
E13 Liquid Ignition Unit (LIU)
E14A Arizona Star Sensor A (STAR Camera)
E14B Arizona Star Sensor B (STAR Camera)
E15 C-Receiver/R-Transmitter

During the transponder meeting the modules E02, E03, E04, E05, E06, E07, E015 were in the focus. They will now be reviewed in order.

## E02 S-Band Transmitter

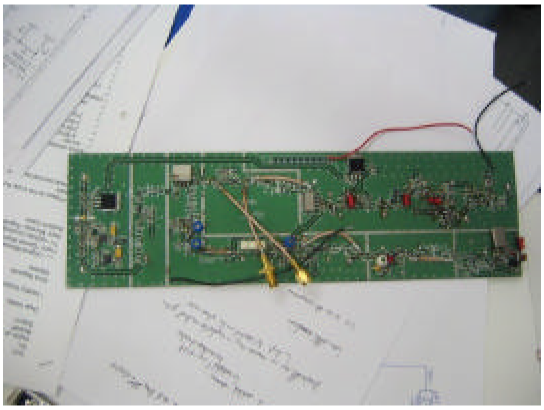

*Figure 2: The layout for the S-band exciter; a first board for the prototypes was shown during the meeting.*

Danny Orban and Gerald Moernaut are completing this exciter for 2400 MHz in Belgium. For a long time there was no final decision as to where the exciter would be built, so this module is not yet up to the prototype stage. A further delay resulted in the frequency preparation, which is tied to the ultra stable oscillator (USO). A constant downlink frequency is thereby achieved that has hardly any variation – and is independent of temperature-based variations. If the USO should not be functioning, because of energy reasons, for example, then the S-band transmitter depends on an internal reference signal.

## E03 Power-Amplifier Module

The output stage module consists of three units: the 145 MHz amplifier, the 2400 MHz amplifier, and the HELAPS-modulator to increase the efficiency. Although Konrad Hupfert is contributing to both amplifier areas, the HELAPS unit is from Gerald Moernaut. The V-band PA is flight ready to be integrated into the module. The remainder is still being worked on.

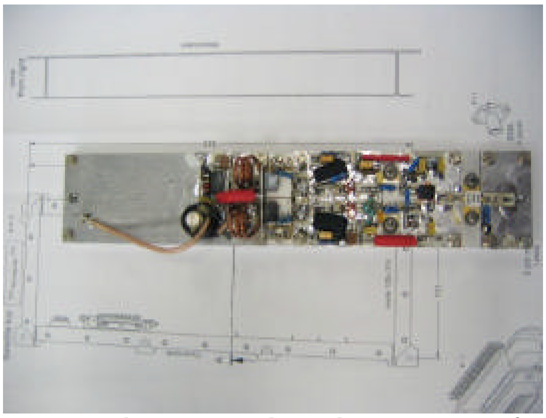

*Figure 3: The operational sample construction of the 2-meter final stage power amplifier.*

## E04 K-Transmitter

The 24.000 MHz transmitter is the one that is the most advanced. The housing of the flight module has already been delivered to Michael Kuhne. Helmut Neidel is guiding the beacon creation of the K-Transmitter as well as the transmitters for 145 MHz, 2400 MHz and the 47 GHz. Additionally he has taken over the LF and PLL for the 24 and 47 GHz transmitters. The K-TX gets a reference signal from the USO for increased frequency stability.

## E05 Transponder

It is not quite as easy to proceed with the experimental P5 transponder. In addition to the Karl Meinzer's basic concepts there have been several parts problems. The sticking point, so it can proceed expeditiously, has not been fully eliminated.

AMSAT-DL has entered completely new ground in amateur radio with this transponder, which explains the start up difficulties. The core operation of the transponder is the coherent mode. The transmitter synchronizes a highly simplified uplink signal from the earth station. This will simplify the acquisition of the downlink signals for the ranging which is used to determine the distance for interplanetary missions like P5A. The USO also delivers a reference signal to the transponder.

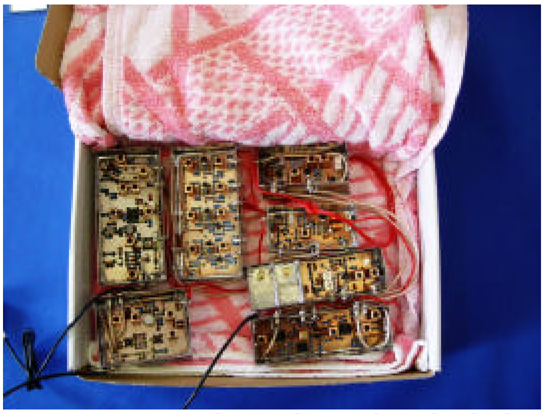

*Figure 4: Transponder in a box – The individual modules (local oscillators, mixers, amplifier stages, and IF) of the U/V transponder.*

During the transponder meeting the Finish group, Michael Fletcher, Janne Peltonnen and Petri Kotilainen became interested in the transponder. The group had already performed a great deal on the preliminary approaches to the output stage of the transponder. The transponder should make alternate linear operation possible between S and X-band in addition to its experimental function for the P5 mission that can be further controlled by other uplink signals.

## E06 U/V Transponder

Out of four offerings to build a Mode-B transponder, that of William Leijenaar was chosen and that one will fly. William is working feverishly under the pressure of leaving Europe for an extended period of time to make the transponder flight ready, which consists of a 435 MHz receiver and the 145 MHz exciter. The module housing for the flight hardware is under way as this article is being written.

The modular built transponder will be completed with the inclusion of the beacon units by Helmut Neidel and the command receiver by Mirek Kasal. The Finish group is working on an additional 29 MHz receiver front-end that can be integrated into the transponder.

## E07 L-Receiver

The L-band receiver from Mirek Kasal is as good as flight ready, which also contains the main command receiver. The receiver with its PLL can likewise be connected to the USO. The flight-ready module housing has already been delivered to the constructor.

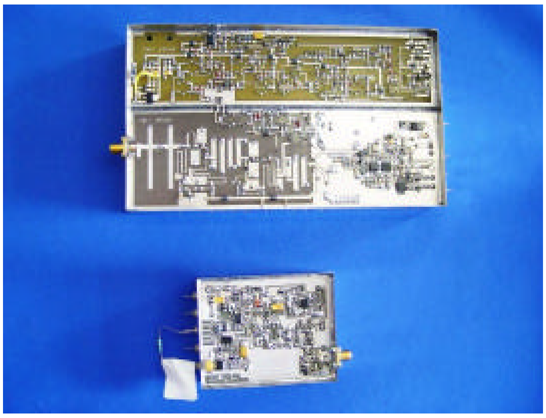

*Figure 5: The L-band receiver (upper) and the command receiver (lower) for P3E.*

## E15 C-Receiver/R-Transmitter

This module has also made good progress, and contains the 5.7 GHz receiver as well as the transmitter for 47 GHz. The flight case has already been delivered to Michael Kuhne from AMSAT-DL. Helmut Neidel has placed the beacon, the LF section and the PLL that can be synchronized with the USO. Jens Geisler from the technical college Pforzheim has joined as a new addition to the project. He relieves

Henning Rech with his work on the C-band receiver, who, until now had taken over the design for this part. Parallel to the installation of the R-band transmitter sections results in the C-RX.

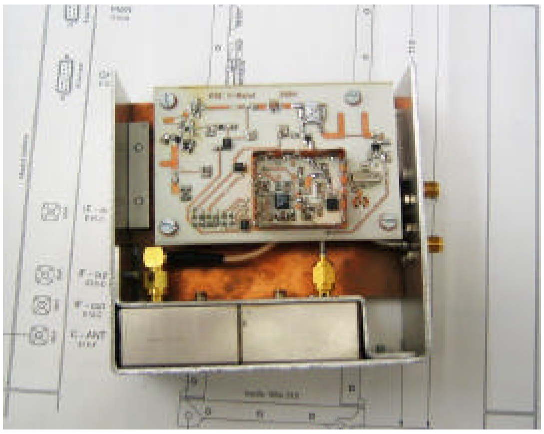

*Figure 6: A first construction sample of the C-band receiver shows the compact construction (left under the filters).*

## Mode Combinations

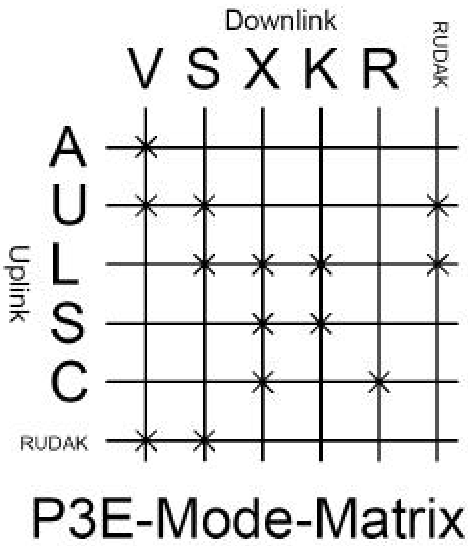


*Figure 7: The Mode Combinations, as they are planned for P3E. At publication time the noted option for 29 MHz (A-band) and RUDAK was not included.*

In contrast to AO-40 there is no IF matrix on P3E that is able to individually connect receivers and transmitters with each other. This space was not available in consideration of the module complexity.

However, multiple connections of transmitters and receivers were taken into account. Under the current plan the following modes are possible:

**A/V**
29 MHz Uplink/ 145 MHz Downlink
**U/V**
435 MHz Uplink/ 145 MHz Downlink
**U/S**
435 MHz Uplink/ 2400 MHz Downlink
**L/S**
1268 MHz Uplink/ 2400 MHz Downlink
**L/X**
1268 MHz Uplink/ 10.5 GHz Downlink
**L/K**
1268MHz Uplink/ 24 GHz Downlink
**S/X**
2448 MHz Uplink/ 10.5 GHz Downlink
**S/K**
2448 MHz Uplink/ 24 GHz Downlink
**C/X**
5669 MHz Uplink/ 10.5 GHz Downlink
**C/R**
5669 MHz Uplink/ 47 GHz Downlink
(Also see Figure 7)

The combinations of S-uplink and X-downlink take on a special meaning. Uplink and downlink are part of the P5 experimental transponder. This transponder, as further explained above, is intended primarily for the simulation and test of interplanetary communication. Alternatively it can also be operated in linear mode with a bandwidth of between 25 kHz and 50 kHz. The S-uplink passband can then be put onto another transmitter (K or R) or the X-band downlink transmitter can also transmit signals from the L- and C-receiver.

Based on the power budget and the thermal design of the satellite only one transmitter can currently be operated at a time. In comparison, several receivers can be turned on at a time, so that mixed mode connections are conceivable. Consequently, if a station transmits on 435 MHz, a second one on 1268 MHz, both signals will be radiated on the 2400 MHz transmitter.

## Key Word LEILA

For those who have been following the P3E news updates for a long time, it will be noticed that the well-known power limiting warning, LEILA, doesn't show up anywhere. In reality, no LEILA system will fly to indicate overly strong uplink signals.

There are many reasons for this. Most closely related is the lack of space on board P3E and in the individual modules. In addition, on AO-40 LEILA was closely connected to the IF matrix which is not available on P3E. Presumably this could have been solved accordingly with great effort.

The main reason, however, is the sensible use of the LEILA system under the given conditions. On AO-40 it could often be observed that the LEILA system marked so-called phantom signals. There were no useable signals at these points in the pass-band being received. The effect also showed up in the U- as well as in the L-band uplink. In this case LEILA most likely recognized a radar pulse while scanning the pass-band and immediately placed the jamming signal on the just scanned point. There is radar use over the entire Northern Hemisphere on 70 cm as well as 23 cm. It doesn't make much sense currently with this limitation for implementation on P3Express.

Only a further development of the LEILA concept, which eventually can handle such radar pulses using an "intelligent" DSP, could present a satisfactory solution. However, enough time for defining the P3E tasks was not readily available. Since LEILA only serves to compensate for the inadequacy of some few satellite users, the hope remains that with increased sensitivity the user will come to using appropriate transmitter power.

## The Antenna Situation

Unfortunately, the antenna configuration could not be completely cleared up. It is certain that the AO-10 and AO-13 familiar high-gain antennas for 145 MHz and 435 MHz will be installed again. It is presumed there will be no change in the three parabolic antennas with a diameter of about 15 cm. These reflectors are currently for the high-power output of the X-band transmitter, (10.5 GHz), the K-band transmitter (24 GHz) and in combination for the C-band receiver (5.7 GHz) and the R-transmitter (47 GHz). According to all predictions the earlier helix antenna will be installed for L-band reception.

The question of an S-band high gain antenna and the omni-antennas for V/U/L/S and X is still to be clarified. All of these antennas should have as much as possible a symmetrical pattern and should not cause Doppler shift because of spinmodulation. This phenomenon has been recognized since AO-13, in which a varying high Doppler shift was presented from the S-helix situated at the edge of the satellite depending on the squint angle. It means that the still-missing antennas should be located symmetrically for rotation around the Z-axis on P3E.

Doppler must be considered because of the antenna location for the C/X High Power/K/R bands. Since the radiation angles of the antennas are very small, operation close to a 0-degree squint angle makes sense, which in comparison minimizes the Doppler shift.
The antenna question for the 29 MHz receiver (A-band) is completely unsolved. On the one hand, very large antenna structures cannot be used because of rotation dynamics. On the other hand it is unclear what will result from the self-generated noise spectrum on 29 MHz (switching controllers, oscillators, data circuits, etc.). The final GO/NOGO for this receiver can, therefor, only be made during the integration.

## RUDAK

Nothing has basically changed in the matter of RUDAK. From questions and practical observations of the satellites it is clear that a RUDAK system is no longer timely in the sense of a mailbox. The Internet has very clearly moved away from the level of amateur radio. The advantage of a satellite like P3E in a high orbital plane lies in its ability to distribute news and information in real time.

Data services similar to the APRS position locating system or broadcasting news of DX clusters were considered in the early development phase of P3E. Particularly attractive, especially for the younger users, could be a short news program, which is similar to that found on cell phones. Apart from other amateur radio infrastructure written contact could be made. In aid or catastrophic situations such a service could be useful.

In any event with RUDAK there is the possibility of making the so-called Turbo-codes useable for general amateur radio not just for beacon and command purposes. The patent owner of the Turbo-codes, France Telecom, has licensed their use to AMSAT-DL for AO-40, P3E and P5A. Thanks to this coding method very weak radio signals can be communicated reliably.
Until now there has, unfortunately, been no group to take on the RUDAK project. The software part especially needs to be reworked. On the P3E hardware level there is already an operational computer on hand in the redundant IHU3. It could be used for RUDAK, as long as the primary IHU3 can be put into service for satellite control. L-band and U-band receivers are already equipped with an IF output for RUDAK demodulators. And the transmitters for the V-band and the S-band can be steered on the IF level with RUDAK signals.

However, the connecting link (demodulators and modulators) between the computer and the IF level doesn't have a solution. So now it is important to conduct a system evaluation of the link budgets, in order to be able to select in the short term a suitable design from the AMSAT-DL circuit supply. On the transmitting side, for example, the multiple use of the beacon could be employed, which can be modulated in BPSK and FSK/FM modes.

## Summary and Prospect

In spite of its smaller antenna area and energy reserves compared to AO-40, P3E results in a satellite which can offer much to amateur radio. The transponder combinations achieve almost about the same diversity as AO-40. The anticipated signal strengths for the V, U, and L bands will be similar to those of AO-10 and AO-13. P3E approaches the capabilities of the

S2 transmitter on AO-40. In the next news release, once the power output of the flight modules has been measured, we will present a view of the individual link budgets for the known 12 hour orbit of AO10/13 and the 14 hour orbit presented by Viktor Kudielka in [1].

All of the module builders have much to do until then, while in the P3E laboratory everything thing is being prepared for integration. Thus, things are progressing!

Reference:

[1] Decisions for the P3E Orbital Path, Viktor Kudielka, OE1VKW, AMSAT-DL Journal 1/2005, P.27