Frank Sperber, DL6DBN/AA9KJ, Translated by John J. Bubbers, W1GYD

AMSAT-Phase-3-Express - Eight Months after the Kick-Off

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Less than two years remain until the planned launch date of the P3E-satellite - the work has to proceed in high gear to stay on the tight time schedule. A whole lot of new technology, which is planned for the P5A Mars mission, will be tested on P3E. There are many areas of intensive work proceeding, even though a completed satellite is not yet to been seen.

Mechanical Preparations

It has been rewarding for AMSAT-DL to have kept their own integration room in Marburg from the AO-10 and AO-13 construction era, which took place in the USA. The AMSAT roominess is the central and major area for the mechanical work on the satellite structure. A large room is a prerequisite for the integration of the electronic modules. The core assembly of the flight structures consists of a surplus structure from the construction phase of P3B and P3C, which was used as a display unit at fairs, etc. The short construction time is possible only because this structure is at hand. The structure was cleaned in the meantime and will receive a space-qualified coating. In the meantime a whole row of additional components could be built, among others, the sun and earth sensors.

The satellite's propulsion system will be coming from Astrium; the fuel for it will be contributed by AMSAT-DL. It has been built (Fig. 1), partially tested and is currently at Astrium for final pressure testing. The tank consists of three pieces (Fig. 2), from which the two chambers shown will be for fuel. A further part of the propulsion system, is the helium pressure tank, which must withstand several hundred bars of pressure. Several suitable (pressure) flasks were found for this application. The final decision as to which flask will be used must still be decided based on the available space on the satellite and several technical parameters.

Fig. 1: Welding of the tank of P3E

Fig. 2: Three pieces form two chambers of the tank.

The magnetic attitude control is an important part of the satellite system. It is composed of multiple iron rods, in which several are fitted with electro-magnetic coils. The satellite can be directed in the perigee by a controlled turning on of the coils in conjunction with the earth's magnetic field. As seen in figure 3, the system is close to being finished. Since a few of the materials from the P3B/C era were no longer available, various changes had to be in the details. The mechanical work as executed and was supported by Konrad Müller (DG4FDQ) and Peter Osswald (Fig. 4).

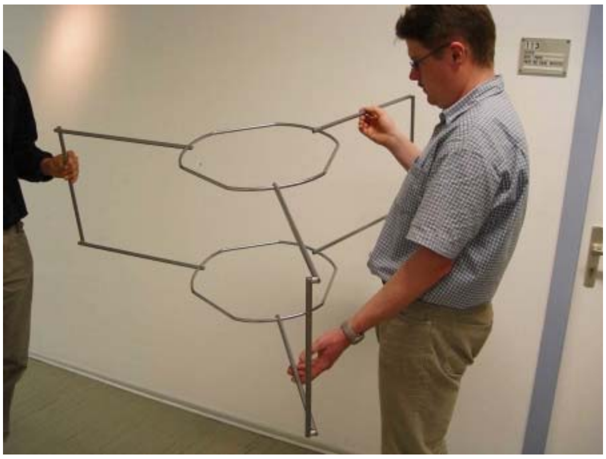

Fig 3: Magnetorquer system

Fig 4: Konrad Müller (left) and Peter Osswald aligning the Magnetorquer rods.

CAN-Bus Ready for Installation

The CAN-Bus, well known in the automobile and industrial area, will replace the expensive cabling used on previous satellites. Besides a saving of weight by using less cabling the connections between modules will be simplified. Such a basic change results from extensive preparation. The requirements of the experimenters and designers, whose module was going to be connected to the CAN-Bus, could be addressed in various steps and prototypes. In the meantime the hardware of the small "CANdo!" interface board is located between the CAN-Bus and the module (Fig. 5).

The CAN-Bus will also be installed in the EAGLE-project as well as in the P3E and P5A, so that nearly 100 modules will be needed in the coming years. The hardware development took place by our America friends Lyle Johnson and Chuck Green. A first delivery of these modules for the experimenters in Europe is expected to happen at the time this Journal appears.

The "CANdo! widgets" fitted with their own micro-controllers are valueless without software. A team around Bdale Garbee is developing the software. It provides for various communication modes between module and CAN-Bus. In direct mode there are 5 analog modes available and eight digital outputs available. Telemetry and binary states can be managed with this, switching operations in the module, for example. Control of the digital outputs will be used to control external multiplexers in the multiplex mode. This increases the number of signals to and from the module many times. The so-called byte-pipe-mode will swap many bytes from time to time from the memory of one of the provided cameras. The on-board computer (IHU) can then read and further process the raw data from the CAN-bus. A further mode will probably be added, a serial pipe mode. The on-board integrated controller, in addition to the CAN-Bus, can also feed a normal asynchronous level. Modules with "self intelligence", with its own computer, can find a simple connection. Cameras could also be considered as scientific payloads on P5A, for example.

The sensor electronic unit (SEU) is one of the modules to activate the multiplex-mode. It processes the signals from the classic sun and earth sensors for the on-board computer and controls the magnetorquer. Ulrich Müller is currently developing a version that is adapted to the innovations in the CAN-Bus, based on the AO-10 and AO-13 circuitry (P3B and P3C).

P3E's "Eyes"

After the positive experiences, especially those from the navigation related YACE camera onboard AO-40, it soon became clear that P3-E should have a similar system. The available optical navigation of star constellations us very important to determining the flight attitude and flight path during the Mars mission. A similar navigation system with the STAR-module is to be installed on P3E. The development work is taking place under the coordination of Chuck Green in Arizona. Two camera sensors are being considered, which can view from the upper and lower satellite sides and has its own computer for picture evaluation. The Belgian company FillFactory made suitable newly developed CMOS sensors of type STAR1000 available. They have a resolution of 1024 x 1024 pixels (four times that of YACE) and are radiation hardened for space use.

A second camera is being developed under the guidance of Peter Gülzow, which uses a completely new chip of the IBIS line, which is also from the FillFactory. These building blocks have extensive electronics along with an image sensor, that naturally stores pictures and can further deliver pictures via different circuits. An IBIS camera could result in several memory building blocks and be available to the CANdo! Interface (fig. 5); this also means a further simplification, fewer building blocks and thereby fewer possibilities for failure. Both cameras operate in black and white. This is meaningless for the star sensor STAR, but for the IBIS camera color images would provide a more interesting look at the earth. This chip will possibly be available as a color sensor by the time of integration.

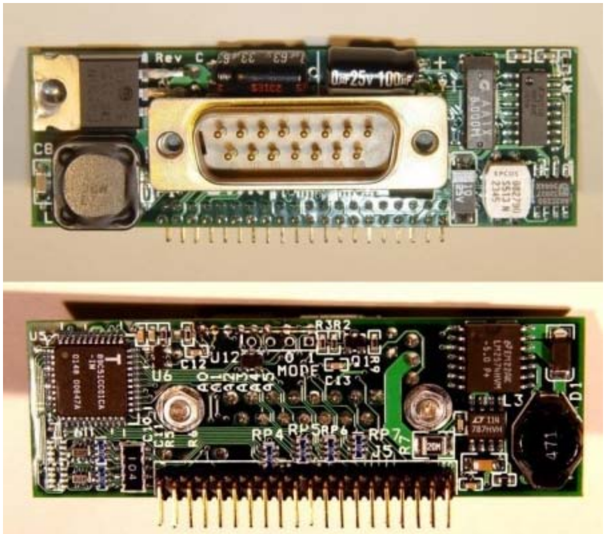

Fig. 5: The modules will be connected to the CAN-Buss through the CANdo!-Interfaces.

IHU-3

A new concept was developed for the on-board computer, and the Integrated Housekeeping Unit (IHU), after the successful results of the FEC techniques for AO-40 and with the requirements of the Mars mission.

The low bit-rates (5 Bit/s) that have to be invoked in an emergency cannot be effectively processed by the classic hardware demodulators, which scan the command receiver's passband. With integration times of about 1 s and 1 Hz resolution, a 3000 Hz wide passband it would take 50 minutes to be read. This is far too long for an effective command operation. The computer capabilities of the new IHU processor with its ARM7-Basis make the digital signal processing possible. Using a Fast Fourier Transform the passband can be read more quickly as it appears to in parallel.

On earlier satellites the hardware demodulators could reset a program crash by the on-board computer. This will no longer be possible with the new method. The DSP software function will also be required to perform an extreme Reset function. In the possible event of a computer crash the computer must be reliably rescue itself. Karl Meinzer has developed a Watchdog mechanism, which is controlled by several levels of the system software. If the control remains off, or the bit stream is completed without error, an appropriate reset will be invoked.

If the error repeats itself within a given time span, because the program memory has a permanent error, the operation software will be automatically switched over to another image, for example.

Lyle Johnson and Chuck Green are reviewing the functional design of the new on-board computer, and thereby developing the third generation of the P3 satellites. There is also the opportunity to develop an IPS32 operation system, since this IHU is based on a 32-bit processor.

U/V Prototype Transponder Tested

On July 5th William Leijenaar (PE1RAH) tested the first prototype transponder for 435 MHz after the 145 MHz as the payload on a balloon launch in Meiningen (Fig. 6). Signal reports indicated a strong and clear beacon signal from the 100-mW transmitter. Unfortunately a lot of transmitter power had to be used to hear the its own signal through the 100 kHz wide linear transponder. In retrospect it turned out that apparently there was a problem in the cabling between the temporary band switch and the receiver. The transponder, which is mainly made up of SMD parts, needed only a housing area of only 100 x 160 mm (Fig. 7).

Fig 6: Prototype of U/V transponder prior to balloon launch

Fig. 7: The U/V transponder: at left the TX board, upper right 70 cm input filter, lower right the 100 kHz wide IF filter. Below the TX the RX board is located.

The 145 MHz output stage from Konrad Hupfer is likewise operational. It delivers about 70 W PEP with 10 mW of drive. Using HELAPS technology the operational level of the output stage will be raised to 50 W PEP without negatively affecting the energy budget. Signals similar to those from AO-10 and AO-13 can be expected, as a result.

HELAPS technology will be used at 145 MHz and 2400 MHz. Danny Orban and his team will take over this part. A meeting has taken place in the meantime in Marburg for know-how transfer.

New Territory with the P5-Simulator

Karl Meinzer and Matjaz Vidmar have made several steps forward with the basic designs for a coherent P5A transponder that will simulate the link paths to Mars. AMSAT enters its own new territory with this transponder. In addition to communications "ranging" must be possible between earth and satellite, in order to accurately determine the distance to the satellite from a given transit time measurement in order to accurately determine the distance to the Mars radio sounder within a few kilometers. A further increase in the magnitude of the position determination would then be available.

The P3D transponder should be operated as a linear transponder on modes L/X and S/X. In order to receive sufficient signals in normal radio operation the transponder will be fitted with an output stage and a parabolic reflector. A group under Michael Fletcher in Finland is currently constructing the output stage.

Wolfgang Müller has supported the major problem of precise frequency control. Professionally he is occupied with high stability oscillators. At the low bit rates of 5 Bit/s, which could at times be necessary, the oscillators must generate very little phase shift. Only then can longer integration times of the weak signals be possible. This will be achieved with the ultra stable oscillator (USO) provided. As a secondary effect the other oscillators can lock onto the USO as needs arise. This is already in accord with the preliminary design of the L-Band receiver by Mirek Kasal.

A Closer Look at 24/27GHz

The originally proposed transmitters for 24 and 27 GHz have turned out to have a problem. Global illumination would not be possible with the desired link budget and the proposed antennas. A spot beam with about a 6,000 km footprint would only be possible on the earth's surface and for 47 GHz only about 3,500 km. These spot beams would traverse at the apogee for only 30, sometimes 15 minutes. It would have been more reasonable with a spin-stabilized satellite, as it will be with P3E.

We hope that it will be possible for the developers of these transmitters, Freddy Guchteneire and Michael Kuhne, to achieve a larger viewing angle to achieve global coverage, without noticeably worsening the radio link. Such a signal reduction would increase the cost of the ground stations in relationship to the antenna gain and positioning accuracy.

P3E on ARIANE 5

The launch configuration has not been finally decided. The AMSAT-DL proposal to use the proven and known SBS for P3E as well as P5A has been found to be very interesting at Arianespace. However, because of the increased payloads on the newer Ariane 5 increased modifications are needed for the Satellite Bearing Structure (SBS). Arianespace is currently asking if the AMSAT developed SBS technology might be further developed as a permanent possible launch option for other future loads.

In any event for P3E it is independent of whether AMSAT-DL or Arianespace will make an SBS ring available, or an auxiliary table becomes necessary that functions as an adapter between the three mounting points in the SBS and the smaller, round separation interface of the P3E. Robert Knoblauch has made a design (Fig. 9) and has found sources for making the table. The SBS could also be made there if needed.

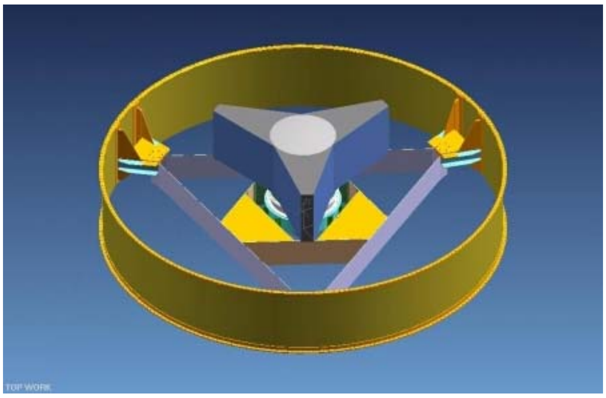

Fig 9: P3E auf dem Adaptertisch, der im SBS aufgehängt ist

P3E Time Schedule

Although several items have not yet been finalized, such as the propulsion system, the solar cells and the transponder area, the tight time schedule of 2005 has until now been maintained. The goal is now, as before, to be able to fully test the satellite in the second half of 2004.

In closing, once more we address our appeal to participate in contributing to the P3E project. Donations can be made online on our Internet site. Many thanks, because only with your help will P3E find its way into orbit!

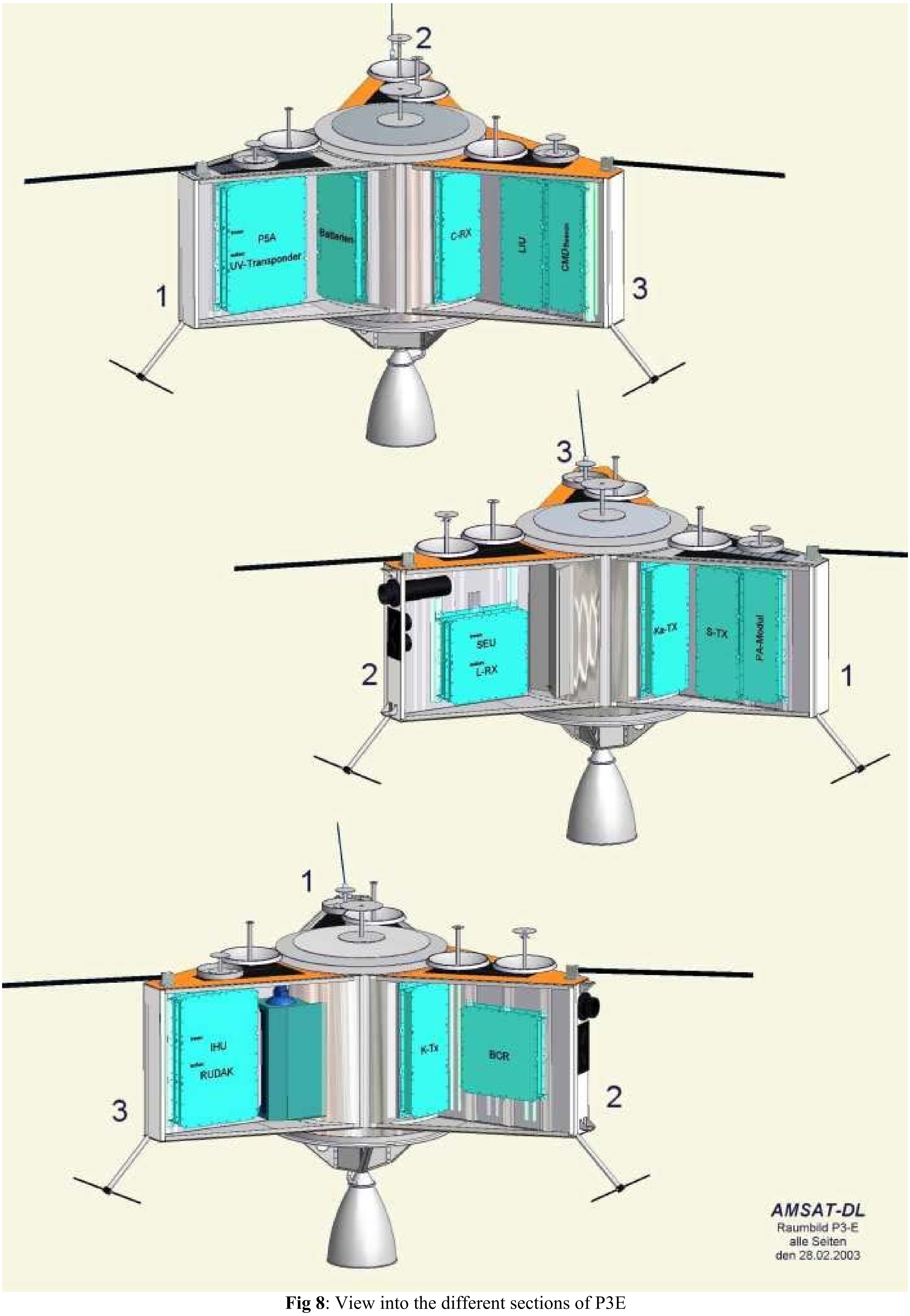

Fig 8: View into the different sections of P3E