APPENDIX B

SATELLITE ANOMALIES

In addition to the failure of the apogee boost motor, a total of 82 anomalies occurred throughout the routine mission, arising mainly from 'single event (radiation) upsets' or hardware failures on-board or on-ground. They are summarised here sequentially, but organised by subject whenever appropriate. The formal Anomaly Report (AR) number and applicable date(s) are given.

Sun acquisition sensor **AR number 1 (89-10-10)**

During the hydrazine sun acquisition manoeuvre the sun acquisition sensor outputs, used to monitor the manoeuvre performance, did not give the expected output. There appeared to be no overlap in the sensor coverage between sun acquisition sensor 1 and sun acquisition sensor 3, and furthermore the maximum output of sun acquisition sensor 1 was much less than expected. The only impact was that eclipse emergency mode would be affected. To cover this possibility, the sun acquisition sensor 3 output was recalibrated during the scanning law acquisition manoeuvre in October 1991.

Solar array panel 3 microswitch status **AR number 2 (89-10-10)**

After the solar array panels deployment, the telemetry indicated a 'no-latch' status on panel 3. Power supply analysis confirmed, however, that the panel had deployed.

Automatic reconfiguration order **AR number 3 (89-10-11)**

After the fill-in antenna deployment commands were executed on-board, an automatic reconfiguration order was issued by the attitude control software, reconfiguring the attitude and orbit control system to the redundant branch. A reconfiguration to the attitude and orbit control system prime branch took place and no operational impact occurred.

Battery 1 & 2 end of charge **AR numbers 4, 7, 40, and 42**

The batteries did not reach the commanded end-of-charge voltage on several occasions, resulting in a thermal runaway of the batteries temperatures. The charge had to be terminated from ground. The end-of-charge voltage settings were revised, taking into account the different thermal environment of this orbit.

Bad telemetry with ranging transponder on **AR number 5 (89-10-11)**

The telemetry quality changed from ‘good’ to ‘bad’ with every telecommand transaction when the ranging transponder was on and high data rate selected. This anomaly was already detected during ground test, but not reflected in relevant documentation. The operational procedures were updated such that ranging and commanding were exclusive.

Tank temperature **AR number 6 (89-10-11)**

Two temperature parameters of the hot gas tanks showed inconsistent values. A thermistor failure of one temperature reading seemed to have been the cause. The fault had no impact on the mission.

Emergency sun reacquisition order **AR number 8 (89-10-11)**

After acquisition of signal, following a perigee and eclipse pass, an emergency sun reacquisition order was triggered and a reconfiguration to the B branch was initiated. From an investigation of the telecommand history file, the workstation event log, and the Hipparcos dedicated control system message file, it was possible to confirm that the emergency sun reacquisition order disable command sent was rejected by the satellite due to sequence counter error.

Real-time attitude initialisation **AR numbers 9, 10 and 11 (89-10-12)**

Several attempts to achieve real-time attitude convergence during sun-pointing operations failed due to early loss of signal or too high background noise on the star mapper.

Image dissector tube piloting **AR number 12 (89-10-19)**

Using the computed coil currents calibration matrix from the latest grid reference marks and internal star pattern assembly results, the image dissector tube data generated from the on-board processing of real stars indicated that the instantaneous field of view was not correctly piloted over the image dissector tube. Based on Matra inputs, the coil currents calibration matrix calculations were revised curing this anomaly.

Excessive star mapper noise **AR number 13 (89-11-09)**

The problem of no real-time attitude determination due to excessive star mapper noise, arising from solar flares and excitation of van Allen belts, occurred repeatedly in the non-nominal orbit, and led to loss of observing time throughout the mission.

Single event upsets **AR numbers 14–15, 18, 20–21, 28–29, 34, 38, 45–49**

The anomalies related to the single event upsets were of a recurring nature and were recovered by, for example, reloading the on-board computer, the programme star file, or by resetting the logic of the unit affected. Two anomalies were detected during subsequent reloading of the on-board computer and were of non-reoccurring nature (AR number 21 and AR number 46).

Star mapper shutter closure — AR number 16 (89-11-09)

On 6 November 1989, the mechanism drive electronics 1 over-exposure flag triggered, indicating that the star mapper shutter had not closed before the occurrence of an occultation. Subsequent analysis showed that the shutter did not close at the expected time since the time-tagged command had an incorrect time entered for execution by the mission plan.

Multiplexer failure — AR number 17 (89-12-04)

Multiplexer channel 8 of input multiplexer 2 failed. All subsequent telemetry acquired through this channel was therefore false.

Focus activation — AR number 19 (90-01-04)

The focus monitoring performed during periods with a step-by-step activation of the refocusing mechanism indicated that the on-board focusing operation was not working properly. Investigation confirmed that the origin of the anomaly was in the refocusing mechanism itself. The design of this mechanism was such that a motor rotation of 60° corresponded to a grid movement of a refocusing step (1.4 μm) and a rotation of 13.5° at the level of the wheel acting as magnetic brake. During ground testing the refocusing mechanism had been activated in a step by step manner. No malfunction was detected, except that the magnetic brake was found to be too small. The permanent magnets had been replaced by stronger magnets. After this change, the refocussing mechanism was not re-tested in a step by step manner, but only by several steps and no malfunction was detected. Due to the stronger magnets, the step by step mode did not function and had to be replaced by at least a two step operation. To allow a better fit between the actual defocus curve and the model (straight line), the last 30 days of observations (instead of 50 days) were used to compute the next grid displacement.

Image dissector tube analogue mode — AR number 22 (90-01-31)

The bright star Alpha Centauri was scheduled to be observed in the analogue mode, but the analogue mode triggered too early, thus corrupting the observation of the preceding star (a faint one) which was supposed to be observed in the photon-counting mode. Thereafter, all stars were observed in photon-counting mode.

Central on-board software error — AR number 23 (90-02-14)

This anomaly was detected whilst preparing special procedures for the ‘long’ eclipse season. A cross-correlation was made between the power the central on-board software commanded to the thermal control electronics and the actual thermal control electronics input current. From the averaging of the thermal control electronics input current over time it was determined that the thermal control electronics consumed about 47 W. The central on-board software however indicated consistently, via the thermal report packet, that it was sending approximately 60 W. The calibration curve to determine the central on-board software telemetered power used a least significant bit of 0.004 W. A new calibration curve was calculated and implemented with a least significant bit of 0.003 W which corrected the anomaly.

Emergency sun reacquisition order **AR number 24 (90-02-14)**

On the morning of 12 February 1990 the automatic commanding task failed to send the commands to disable/enable the emergency sun reacquisition order for the upcoming eclipse. Following an investigation it was discovered that no eclipse commands had been scheduled by the mission planning task for all eclipses after midnight on 11 February 1990. The source of the problem was identified as a typing error in the sequence activity file used by the mission planning task to attach command sequences to activities such as occultation, eclipses and calibrations. Prior to the generation of the mission plan, on 9 February 1990, for the coming week, the sequence activity file was modified to support Goldstone. The fields for occultation, eclipses and calibrations were not modified and hence not checked following the generation of the new mission plan. On generation of the mission plan the software failed to find a match for the eclipse activity sequence and hence failed to generated the appropriate commands.

Unexpected closing of shutters **AR number 25 (90-03-07)**

At 05:28 UTC of 12 February 1991 the image dissector tube 2 shutter closed followed within 10 s by the closing of the star mapper 2 shutter. After investigation of the telemetry, mission plan, command history and time-tag display, it was concluded that: (a) the shutter closure was not triggered by the bright object detector; (b) the mission plan did not identify any commands to be uplinked at this time; (c) the command history did not show any command being uplinked at this time (manually) or as a time-tagged command to be executed at this time; (d) the time-tag displayed confirmed (c) above. The two commands to close the shutters were sent about 6.5 days earlier just as a change of ground stations from Odenwald to Kourou took place. Unfortunately Kourou had portable simulator system data on-line at the time the two commands were uplinked automatically. Therefore, the on-board time from which the Hipparcos dedicated control system calculated the execution time of the time-tagged commands was based on the format counter from the portable simulator system data instead of the satellite data.

Payload remote terminal unit **AR number 26 (90-04-02)**

In the prime payload remote terminal unit, which provided the data interface between the payload and the satellite central processor, the remote control core failed causing the loss of all payload housekeeping telemetry. A reconfiguration to the back-up unit had to be implemented.

Solar array 3 temperature **AR number 32 (90-05-15)**

The average temperature readings over one spacecraft revolution (128 mins) from the three solar arrays should have been within one least significant bit (4°) of the calibration curve. Moreover, the measured minimum and maximum temperatures for each solar array should have been identical for this time period. However, after 6 February 1990, the average temperature of solar array 3 started to differ from the temperatures of array 1 and 2. By 14 February 1993 the difference was almost 4.6° in the average temperature. The temperature difference was caused by power not being dumped on this panel. Thus the temperature was lower than on the other panels.

Star mapper rejection of very bright stars **AR number 33 (90-05-28)**

This anomaly refers to the rejection of very bright stars on the basis of 'main lobe truncation at the border'. The observed anomaly was a direct effect of the central on-board software patch which was implemented to correct for false stars detection during high background noise periods. The objective of this patch was the deletion of all star transits which were characterized by only one valid maximum after correlation. All the star transits which were rejected for the above mentioned reason were assigned an error code which, for simplicity reasons, was the same as the one allocated for the 'main lobe truncation error'. The majority of these rejections were due to the star side lobes being below the minimum allowed threshold. However, this problem applied only to a limited number of bright stars. This anomaly had no impact on the mission.

Gyros 3 and 4 **AR numbers 35 (90-07-03) and 52 (91-08-06)**

The satellite was equipped with five rate-integrating gyros. Two of these measured rates around the spin axis (gyros 4 and 5), one being for back-up. The other three gyros were in the plane perpendicular to the spin axis (gyros 1 to 3), one being the back-up for the other two. Gyro 3, which acts as a back-up to gyro 1 or 2, suffered a failure in its electronics such that the operating temperature of 70 °C could not be reached, and this implied that no gyro back-up in the plane perpendicular to the spin axis existed any more. Gyro 4 (along the spin axis) showed erratic behaviour on several occasions which caused irregular attitude control firings leading to loss of real-time attitude convergence. Reconfiguration to gyro 5, the back-up spin-axis gyro, was performed in order to continue the nominal mission. This of course implied that no back-up existed any more for this axis. With the possibility of a further gyro failure, investigations and modifications were carried out to operate the spacecraft with only two gyros. Software modifications to the on-board control logic and the ground supporting software modules were developed to cope with a possible gyro 5 failure. Further modifications were developed should gyro 1 or 2 fail.

Loss of spacecraft attitude **AR number 36 (90-08-22)**

After the perigee pass in the evening of 16 August 1990 and the subsequent crossing of the inner and outer van Allen belt, the spacecraft had diverged from its optimal pointing, necessitating an uplink of the Tait-Bryan error angles. The error angles were uplinked at 23:15 UTC causing several attitude and orbit control system parameters to raise out of limit alarms because of large thruster firings around all three axes. Moreover, no convergence of real-time attitude had been achieved. During the subsequent validation of the ground data used to uplink the error angles, the limited history file did not contain the magnitude of the uplinked angles, but it was believed that the magnitude had been approximately 0.9°.

Payload thermal control **AR numbers 37 (90-09-04) and 44 (91-01-28)**

Several heater and/or thermistor failures occurred in the payload active thermal control. As a consequence, a reconfiguration to the back-up thermal control electronics had to be performed. On the second unit, some thermistors also failed. These were excluded from the control loop by setting the relevant heaters to a fixed power level.

Radio frequency 1 **AR number 39 (90-09-04)**

The on-board automatic control gain of receiver 1 and 2 showed high variations whenever telecommands were being uplinked. The variations were in the order of −21 dbm. The analysis of this anomaly concluded that the automatic control gain bandwidth was too wide and out of specification. However, no evidence of a generic problem with the telemetry, tracking and command transponder design and corresponding specifications was found, as the automatic control gain malfunction and corresponding discrepancies were not critical with respect to the overall uplink function.

Payload mechanism drive electronics 1 **AR number 41 (90-09-26)**

On 24 September 1990 at 17:26 UTC, mechanic drive electronics 1 secondary voltage (parameter J001) dropped from 2.44 V to 1.88 V, falling below the nominal operating range (‘out of limits’ status). A short test showed that both shutters (image dissector tube and star mapper) were still able to work (opening and closing properly) under this anomalous voltage. However, the decision was taken to switch to redundant unit mechanic drive electronics 2 and the spacecraft was subsequently reconfigured at 19:23 UTC. On 14 March 1991 tests were performed and proved that mechanic drive electronics 1 was in fact functioning thus implying a fault in the multiplexer of the payload remote terminal unit.

Loss of attitude **AR number 50 (91-06-17)**

Ultimately triggered by high solar activity, severe problems were experienced with real-time attitude determination from 5 – 11 June 1991. On 6 June at 18:16 UTC the spacecraft attitude was lost after a series of large innovations caused real-time attitude determination to diverge.

Erroneous orbital oscillator command **AR number 53 (91-10-08)**

On 29 September 1991 at 17:01 UTC an orbital oscillator command was executed on-board with a value for the z component of the torque six orders of magnitude larger than the nominal calculated value, (this command was ground-calculated and uplinked every 15 mins for time-tagged execution on board) triggering a z thruster firing request of 213.33 s.). The spacecraft started to move away from its nominal spin-rate of -168.75 arcsec s^{-1} through zero and to the other direction. Corrective action was taken to bring the spacecraft back to safe sun-pointing configuration.

Suspect pre-processed gyro readings **AR number 54 (91-10-15)**

During the recovery from the ‘erroneous orbital oscillator anomaly’, the pre-processed on-board estimates of the body rates were shown to be inconsistent with the actual gyro outputs. In particular, the x and y body rates were about eight times larger than expected. The attitude control software was in standby mode 2 at the time. Confirmation was needed that the software mode standby mode 2 assumed the gyros to be in coarse range.

Gyro heating **AR number 55 (91-10-15)**

On 30 September 1991 at 02:10 UTC gyros 1, 2 and 5 were switched on as part of the recovery following the anomaly AR number 53. The temperature behaviour of all gyros was not as expected, since normally a continuous and smooth increase of temperature up to 70 °C was observed followed by a steady state lasting approximately 10–15 min. The anomaly had no impact on the mission.

Status reading of switching mirror **AR number 56 (91-10-15)**

On 30 September 1991 at 07:14 UTC when the payload was switched on following the recovery from the 'erroneous orbital oscillator command' (see AR number 53), the telemetry readings of the switching mirror both indicated a 'CLOSED' status, which did not reflect a valid position. However, from science data analysis it could be verified that the switching mirror was pointing towards detector 2 as it was commanded before payload switch-off. The anomaly had no impact on the mission.

Image dissector tube 1 voltages **AR number 57 (91-10-15)**

On 10 October 1991 at 11:42 UTC a procedure to switch image dissector tube 1 on and to perform a calibration was implemented to verify correct functioning of the detector chain before the switching mirror was moved. After switching the image dissector tube 1 electronics on, the secondary supply voltages telemetered in parameters G007 (image dissector tube 1 +15/ – 12 V) and G008 (image dissector tube 1 +6/ – 5.2/ + 30 V) indicated a low out of limit. The procedure was terminated and image dissector tube 1 was switched off again. The anomaly had no impact on the mission since only image dissector tube 2 was normally used for the operations. A telemetry problem (faulty payload remote terminal unit multiplexer) was suspected and confirmed on 29 July 1993 implying that image dissector tube 1 could have been used operationally.

Battery charge during perigee **AR number 58 (92-01-13)**

Since the end of the eclipse season, 21 October 1991, it was noted that both batteries were commanded to 'charge' by the on-board logic. This change of status was only happening during perigee (non-visibility periods) and was observed at almost every pass. Because no eclipses occurred during that time, the only change of spacecraft status was caused by occultations where the payload shutters were closed and opened via time-tagged commands. This abnormal behaviour was explained by orbit geometry. The spacecraft was crossing the Earth albedo and during these periods, the already degraded solar panels generated less power. Thus, high power demanding commands were enough to trigger the battery logic. The anomaly had no impact on the mission.

Gyro 1 real-time attitude drift **AR number 59 (92-06-11)**

At acquisition of signal from the Goldstone ground station at 23:23 UTC on 9 June 1992, following 6 hours of non-coverage, the gyro 1 drift had changed from its previous recorded value of 0.16 to 0.12 arcsec s^{-1} and was further decreasing. Correction to the 'old' drift value was uplinked at 23:25 UTC. However, the drift rate started to decrease again, until real-time attitude diverged (at about 01:00 UTC on the next day) and the drift started to increase. The anomaly had no impact on the mission.

Telemetry after radio frequency switching **AR number 60 (92-06-23)**

On 6 June 1992 at 18:04:50 UTC, the command to change transponder 1 to the fill-in antenna and transponder 2 to the cardioid antenna was executed from the on-board time-tag buffer previously loaded by the uplinked mission plan (one command for the two functions). The subsequent telemetry readout showed that transponder 1 was connected to the fill-in antenna. However, the telemetry readout for transponder 2 did not indicate the expected change to the cardioid antenna, but remained on the fill-in antenna. Since the on-board automatic control gain had changed as expected after the antenna switch command was executed it was concluded that the radio frequency switch had functioned as expected, the anomaly seemed to be a 'false' telemetry readout.

Thermal control electronics **AR number 61 (92-07-07)**

Temperatures of the telescope focal plane and the beam combiner decreased below specified minimum even after the maximum power to some of the control area heaters were applied. No action could be taken besides a close monitoring of the relevant thermal areas since thermal control electronics 2 was replacing thermal control electronics 1 after the failure of the heaters used for the same areas.

Gyro 5 **AR number 62 (92-07-07)**

From 3 July 1992, occurrences of 'false' gyro readouts were experienced. These readouts resulted in spurious z-thruster firings and in most cases caused real-time attitude to diverge. The attitude had to be subsequently corrected by ground intervention.

Gyro 5 and two gyro implementation **AR number 63 (92-07-10)**

On 10 July 1992 after acquisition of signal by Goldstone at 00:30 UTC 'glitches' in the raw output of gyro 5 occurred for approximately one hour during the outer van Allen belt crossing. The same was experienced during the following Odenwald pass. In both cases the z thruster firings were inhibited by the action of the on-board z thruster accumulator patch which stopped the firings when the accumulated thruster on-time reached the limit (60 s). However, because the normal mode z error angle was outside limits, and could not be corrected by the disabled z thruster, continuous demands to fire the z thruster were present, which resulted also in x and y thruster firings. The thruster firings were short but continuous until the 'glitches' disappeared, then the on-board software patch was reset from ground thus re-enabling the z thruster firings. At 16:01 UTC gyro 5 was taken out of the control loop and its function replaced by the two-gyro patch. Real-time attitude convergence was maintained confirming that the new on-board software was working correctly.

Attitude and orbit control system **AR number 66 (92-08-05)**

On 4 August 1992, just before loss of signal at the Odenwald ground station at 13:21 UTC, attitude and orbit control system telemetry packets were not present in the downlink. Furthermore, an attitude control software error was observed as well as several central on-board software errors. Special support was immediately requested from the Perth station, and the data received between 13:59 UTC and 14:16 UTC (loss of signal at Perth) confirmed that no communication was available between the central on-board software and the attitude control software. At about 14:06 UTC, power was generated by the solar arrays and the batteries were discharging. This was a clear indication of a serious attitude anomaly. Goldstone was requested to provide emergency support some four hours ahead of schedule starting at 14:48 UTC. This allowed an immediate reconfiguration of the attitude and orbit control system to the redundant branch to be carried out, and by 17:17 UTC good attitude and orbit control system telemetry was again received. It was then confirmed from sun sensor and gyro data, that the spacecraft was badly nutating (half-cone of about 19°). At 17:57 UTC a ground commanded emergency sun reacquisition brought the spacecraft to a safe sun-pointing mode. Thereafter the spacecraft was configured for sun-pointing operation. The spacecraft was moved back to the nominal scanning law at 43° and convergence was achieved on 11 August 1992. Another emergency sun reacquisition was caused by the failure of gyro 5 a few hours later. After a 3-month hibernation period routine operations at 43° were resumed on 29 October 1992.

Gyro 5 and gyro 2 failure **AR number 67 (92-08-12)**

At 10:45 UTC on 11 August 1992, gyro 5 failed (output data corruption), inducing high torques around all three axes. At this time, the two gyro real-time attitude convergence had not been achieved. Immediate ground interventions failed to reduce the rapidly increasing body rates. The on-board anomaly detector triggered the emergency sun reacquisition and the spacecraft returned to a safe sun-pointing mode. In order to safeguard the attitude at sun-pointing for the upcoming perigee passage including an eclipse, the spacecraft was spun up to about 0.4 rpm which would guarantee stable dynamic behaviour. However, during the spin-up nutation had arisen and could not be damped before the loss of signal. Goldstone was requested to provide emergency support some three hours ahead of schedule starting at 17:04 UTC. At acquisition of signal another anomaly, this time on gyro 2, was detected. The gyro 2 output was corrupted in an identical manner to gyro 5. The additional failure of gyro 2 complicated the nutation control from ground, which was finally achieved around 18:00 UTC.

On-board computer 1 **AR number 68 (92-09-07)**

On 5 September 1992 at acquisition of signal by Perth (02:24 UTC) a continuous stream of memory error alarms was received. The error was identified as related to the programme star file buffer area, which was not being used in the present mode. An attempt to reset the on-board computer was unsuccessful; a reset of the programme star file buffer did not clear the problem. In addition on-board computer 1 could not be commanded to monitoring mode. A central on-board software reload was commanded, but the watchdog 1 could not be enabled. Power was removed and enabled into on-board computer 1 to reset the watchdog 1 signal. After a period of loss of signal (05:45 to 06:50 UTC), several attempts were made to bring on-board computer 1 to a proper initial state (therefore disabling the watchdog) by removing/restoring power to on-board computer 1, but all subsequent attempts to reconfigure the watchdog failed. Commands were verified through the demodulator and frame synchronizer channels, other possible sources of error were checked (receiver, decoder chain, etc.) and discarded. At this point a reconfiguration to the redundant unit (on-board computer 2) was carried out. A reload of the central on-board software software was performed without problems. Watchdog 2 was enabled successfully on the first attempt. Reconfiguration was finished at 09:08 UTC.

On-board computer 2 **AR number 69 (92-09-22)**

On 16 September 1992, a test was performed on on-board computer 2 in order to check all of its functions, whilst the watchdog was disabled. All functioned nominally and it was therefore concluded that on-board computer 1 was usable having the watchdog disabled. To finally validate the proper function of on-board computer 1, a switch-over was attempted. However, the command necessary to reset on-board computer 2 did not work. On-board computer 2 remained then the operational unit.

Gyro 1 spin-down **AR number 70 (92-09-28)**

Since 25 September 1992 three spin-downs of gyro 1 had taken place. The first occurrence lasted about 3 mins with a maximum variation of 36 arcsec s^{-1}. This was followed 15 mins later by a second spin-down of a smaller magnitude. The third occurrence was noticed two days later.

Gyro 1 breakdown **AR number 71 (92-10-14)**

On 10 October 1992 at 23:26 UTC gyro 1 stopped functioning completely. The gyro stopped spinning, and could not be started again. All attempts, including change of attitude and orbit control system from branch A to branch B and switching off/on the power supply channel, failed. Gyro 4, fed by the same channel, was switched on and spun up nominally. This excluded a failure of the power supply.

Emergency sun reacquisition order **AR number 72 (92-10-14)**

On 14 October 1992, an emergency sun reacquisition order was triggered at eclipse exit which reconfigured the spacecraft to the attitude and orbit control system branch B. Emergency sun reacquisition order had to be disabled by time-tagged command for each eclipse period while sun-pointing because at this attitude the on-board attitude anomaly detector sensor was illuminated by the Sun and triggered. The required uplink times had been miscalculated, thus emergency sun reacquisition order was not disabled during the eclipse period and consequently triggered.

Emergency sun reacquisition order **AR number 73 (92-11-13)**

On 10 November 1992, emergency sun reacquisition order triggered at 15:33 UTC as a consequence of a command resetting the z gyro drift rates to zero. The spacecraft returned to sun-pointing mode and reconfiguration from attitude and orbit control system branch A to branch B was immediately performed. Real-time attitude determination at sun-pointing was initialised at 20:31 UTC. At 20:48 UTC the manoeuvre to return the spacecraft to the nominal scanning law (43° solar aspect angle) was started and successfully terminated at 21:36 UTC. Real-time attitude determination was initialised at 22:06 UTC and science data collection re-commenced.

Gyro 5 **AR number 74 (92-11-13)**

The noise of gyro 5 raw output increased suddenly on 18 November 1992 at about 03:45 UTC and remained high until loss of signal (06:02 UTC). At acquisition of signal (06:51 UTC), the gyro output noise characteristic had not changed, but also high spin variations between 100 and 200 arcsec s^{-1} were observed. Furthermore, gyro 2 (sharing the same power supply as gyro 5) had similar spin variations. Gyro 4 was switched on, confirming a constant spacecraft spin rate. Gyro 5 was switched off at 10:31 UTC and gyro 2 output immediately recovered.

Gyro 2 spikes **AR number 75 (92-12-28)**

At acquisition of signal (17:44 UTC) on 22 December 1992, gyro 2 raw output data showed an increasing noise envelope. At around 18:40 UTC, spikes on the gyro data similar to the previously observed spikes on gyro 5 triggered the emergency sun reacquisition order which returned the satellite to sun-pointing mode. The satellite was reconfigured and gyros 2 and 3 switched on. The noise (spikes) on gyro 2 was still present, but disappeared after the temperature of the gyro electronics had passed 22 °C.

On-board computer 2 **AR number 76 (93-02-18)**

On 16 February 1993 at 08:17 UTC a few packet commands were rejected on-board due to checksum error. The number of rejections varied depending upon the command uplink rate, but with increasing tendency. The anomaly was present with all four ground stations. No evidence of a ground problem was detected. On 17 February 1993 starting at 13:15 UTC, a reload of on-board computer 2 was attempted but failed because some of the load commands were rejected on-board. The ground system was again thoroughly checked, including a further attempt to reload on-board computer 2 with the back-up system resulting again in on-board command rejections. A reconfiguration from on-board computer 2 to on-board computer 1 was done followed by a successful reload of on-board computer 1. Science collection re-commenced at 18:15 UTC.

Gyro 2 failure **AR number 77 (93-03-18)**

On 18 March 1993 at 20:26 UTC gyro 2 failed causing an emergency sun reacquisition. Prior to this, increased noise had been observed on the raw gyro output data. Attempts to restart gyro 2 (and any of the previously failed gyros) were unsuccessful. Only gyro 3 started. The satellite was spun up to 0.25 rpm followed by nutation damping.

Antenna switch command failure **AR number 78 (93-03-30)**

On 28 March 1993 the command to connect transponder 1 to the fill-in antenna and transponder 2 to the cardioid antenna failed execution. The command was sent as a time-tagged command from the on-board computer. The command was transmitted from ground for immediate execution, but failed again. The back-up command was then used and correct antenna switching was achieved. From then on, only the back-up command was used to switch antennae. A possible explanation could be a fault in the relevant on/off module. An on/off module was a module of the payload remote terminal unit responsible for the distribution of the commands (de-multiplexer).

Star mapper 1 and 2 partial failures **AR number 79 (93-05-25)**

On 5 May 1993 star mapper 2 was switched on and it was found that the V_T channel was no longer working. The following day star mapper 1 was tested and it was found that on this unit the B_T channel did not work. Ground real-time attitude determination required both channels to identify star magnitude and colour to perform correct star pattern matching. The ground software was then modified to operate with both star mapper streams available in telemetry (B_T channel of star mapper 1 and V_T channel of star mapper 2).

Suspect control law electronics **AR number 80 (93-05-27)**

The processor of the control law electronics of the attitude and orbit control system branch A stopped twice during the week 28 June to 4 July 1993. Once without any error messages and once with the error indicating a 'CPU overload'. The attitude and orbit control system was configured into a cross-strapped mode using the branch B control law electronics and the branch A control actuation electronics, which retained all safety aspects in case of attitude anomaly detection.

Gyro 3 noise **AR number 81 (93-05-31)**

On 26 May 1993 gyro 3 was switched on at 07:02 UTC and showed nominal behaviour. During the early morning hours of 27 May increasing noise (spikes) appeared, reaching peak values of more than 50 arcsec s^{-1}. The gyro was switched off at 08:12 UTC.

On-board software 1 and 2 failure **AR number 82 (93-06-28)**

On 24 June 1993 at 14:41 UTC central on-board software 1 halted with an error message indicating an 'illegal instruction' in memory. Prior to this, three error messages were received indicating checksum errors at the same location. Several further attempts to start either central on-board software 1 or central on-board software 2 during the following days were unsuccessful.