Project and Study Scientist Reports for AWG # 135

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Report compiled, using inputs from Study and Project Scientists by Jean Clavel, head Astrophysics & Fundamental Physics Missions Division,

1 Satellites in orbit

1.1 HST: Antonella Nota

The last planned Servicing Mission to Hubble (SM4) successfully started on May 11, one day ahead of schedule. Space shuttle Atlantis launched from Launch Pad 39A at 14:02 local time, after a very smooth countdown. Veteran astronaut Scott Altman commands this mission, and retired Navy Capt. Gregory C. Johnson serves as pilot. Mission specialists are: veteran spacewalkers John Grunsfeld and Mike Massimino, and first-time space fliers Andrew Feustel, Michael Good and Megan McArthur. The mission lasted 11 days.

As of writing, Hubble has just been released in space, after a week of exhausting but brilliant astronaut work. All objectives of the ambitious plan have been accomplished, and, with the only exception of the HRC channel of the Advanced Camera for Surveys, all instruments are powered up and ready to start commissioning work, after the out-gassing phase has ended. As a summary, Hubble now has:

- A new imager, the Wide Field Camera 3. This is the first true large field panchromatic camera on Hubble, sensitive in the UV between 200 - 1000nm, and in the near-IR from 900 to 1700 nm.
- A new spectrograph, the Cosmic Origin Spectrograph. COS is a slit-less spectrograph which will operate at very high sensitivity between 115 and 320nm. COS passed both aliveness and functional tests last Saturday. The spectrograph will now need several weeks to outgas before high voltage can be applied to the UV detector.
- A refurbished Advanced Camera for Surveys Wide Field Channel. This repair has been extremely complex. This was the first time a Hubble instrument has been opened to replace electronics boards. The other ACS channel, the High Resolution Channel (HRC) has not been recovered. All involved knew that the HRC recovery might not work. The electrical short that occurred during the June 2006 Side-1 failure turned out to be upstream of the circuitry needed to power the HRC with the new ACS electronics. However, the Wide Field Channel accounts for the large majority of ACS observations, and the team is very thrilled to see it passing aliveness and functional test.
- A refurbished Space Telescope Imaging Spectrograph. STIS passed aliveness and functional tests. The replacement boards appear to be working as expected. The two ultraviolet channels appear to be functional.
- A new Fine Guidance Sensor, that has already passed aliveness and functional tests. The new FGS will extend the life of Hubble's pointing control system.
- In addition, Hubble now has new batteries, new gyros, a new SI & DH computer box, and new insulation.

The following hours will mark the beginning of Servicing Mission Observatory Verification (SMOV), which will extend over approximately the next three months. During this period, the new and repaired instruments will be checked out in detail and initial calibrations will be performed in preparation for normal science observations.

SMOV will culminate with the publication of the Early Release Observations to both the community and the public (expected in early September), to demonstrate the successful commissioning of the instruments.

In the last several months, Hubble has continued obtaining interesting scientific results on a broad variety of astronomical topics. Recently, astronomers have combined Hubble observations of Cepheid stars in the nearby galaxy NGC3021 with 2003 data from the Wilkinson Microwave Anisotropy Probe (WMAP), to refine the value of the Hubble constant to 74.2 ± 3.6 km/s/Mpc. This new result agrees well with an earlier measurement of 72.8, but is more than twice as accurate. Astronomers are using this more accurate value for H_0 to test and constrain the nature of dark energy. Very recently, Hubble has witnessed an outburst in a gas knot of the jet from M87's black hole. This region of the M87 jet has been monitored for seven years, and astronomers believe this recent brightening will provide insight into the variability of black hole jets. Hubble made news recently when it obtained the first image of an extra solar planet, around the star Fomalhaut. At the same time, astronomers using ground based telescopes and high contrast techniques, took images of three massive planets around another star: HR8799. It turns out that astronomers had used Hubble in the past to observe HR8799, and a reanalysis of archival images has revealed that the outermost planet was present in images taken by Hubble back in 1998.

A recent initiative, "Hubble's Next Discovery -- You Decide" has been completed as part of the International Year of Astronomy (IYA), the celebration of the 400th anniversary of Galileo's observations. People around the world have voted to select the next object the Hubble Space Telescope will view, choosing from a list of objects Hubble has never observed before. The winning image has the Galaxy triplet Arp 274. Also in celebration of the International Year of Astronomy, a new section has been added to the Hubble outreach web site, entitled the "Celestial Object of the Month". During the month of April, the Whirlpool Galaxy was showcased, with related resources featured including an Online Exploration, classroom activities, and a Star Witness News Story. As the year continues, the "Celestial Object of the Month" will feature other objects of interest in the universe.

1.2 XMM-Newton: Norbert Schartel

The XMM-Newton observatory continues to operate nominally. As of the 3rd of May 2009, the overall completion status of the observing programme is as follows:

- AO-7 programme: 99.6 % (A and B priority)
- AO-7 programme: 33.4 % (C priority)
- AO-8 programme: 2.9 % (A and B priority)

The completion of the AO-8 programme is expected by end of April 2010, in line with the planned start of AO-9 observations.

Several Targets-of-Opportunity were observed during the reporting period, namely 2XMMJ011028.1-460421, 1E 1547.0-5408, Eps Aur, XTE1739-302 and GRB090423.

In coordination with the OTAC chairperson, Prof. C. Cesarsky, the following dates for AO9 were established: Announcement: 25 August 2009; due date for proposals: 9 October 2009; OTAC chairpersons meeting: 26-27 November 2009 and publication of the final OTAC approved programme: late December 2009. The community was informed about the anticipated time line in an XMM-Newton News issued end of January 2009.

The community reacted positively to the XMM-Newton workshop, "Super-soft X-ray Sources - New Developments", to be held at ESAC on 18-20 May 2009. At the time of writing, 44 scientists had registered and 29 abstracts had been received.

Nature published a paper (2009, Nature 458, 603) by C. A. Collins et al. about the assembly of the most massive galaxies. Although the paper primary data were collected in the optical band, the paper uses XMM-Newton data and is built on previous XMM-Newton detections of high-redshift clusters of galaxies. The current consensus is that galaxies begin as small density fluctuations in the early Universe and grow by hierarchical merging. Stars begin to form relatively quickly in sub-galactic-sized building blocks called haloes which are subsequently assembled into galaxies. The authors report that the stellar masses of the brightest cluster galaxies some 9 billion years ago are not significantly different from the stellar masses of their counterparts today. In other words, brightest cluster galaxies appear to be almost fully assembled only 4 to 5 billion years after the Big Bang, having grown to more than 90 per cent of their final stellar mass. This conflicts with current galaxy formation models. These models predict protracted formation of brightest cluster galaxies over a Hubble time, with only 22 per cent of the stellar mass assembled at the epoch probed by the Collins et al sample. The findings suggest a revised picture in which brightest cluster galaxies experience an early period of rapid growth rather than lengthy hierarchical assembly.

XMM-Newton participated in the "100 Hours of Astronomy" cornerstone project of the International Year of Astronomy 2009. Dr. Maria Santos-Lléo from the SOC introduced the observatory as part of the "Around the World in 80 Telescopes" live web cast series, and a 20 ks observation of M82 was carried-out using Project Scientist discretionary time. Illustrating the capacity of XMM-Newton to acquire simultaneous optical and X-ray data, an image of M82 was made public on April 8, 2009.

As of May 3 2009, 2105 articles – either completely or partly based on XMM-Newton observations – have been published in the refereed literature, of which 136 are from 2009. XMM-Newton celebrated the 2000th refereed article landmark on February 17. The event was mentioned in the ESA science web pages.

1.3 Integral: Christoph Winkler

INTEGRAL operations continue smoothly with the spacecraft, instruments and ground segment performing nominally. However, since February 19, the SPI Germanium Detector #5 is no longer usable for science. The anomaly occurred during perigee when the spacecraft is out of contact with the ground. Despite repeated attempts, it was not possible to recover detector #5. No convincing explanation has been found yet for the failure. However, because detector #17 failed in similar circumstances, it was decided to reduce the detectors high-voltage during perigee passages as a precautionary measure. The SPI Ge detector array consists of 19 detectors in total, out of which two (#17, #2) failed several years ago. The sensitivity loss remains limited, i.e. -3% (= √{16/17}) compared to pre-February 19, and -8% with respect to the launch value.

Routine AO-6 observations included - among others - Key Programmes on the Galactic Centre, Bulge and Disk, Cygnus region, North Ecliptic Pole and Virgo Cluster, interrupted by target-of-opportunity (ToO) observations (Blazars, AXP). Several GRB occurred in the telescope field-of-view (FOV).

By the deadline of February 20, 76 observing proposals had been received in response to the AO-7 call, a number comparable to that in AO-6 (74). However, the time oversubscription factor, 3.7, is smaller than in AO-6 (5.8) and AO-5 (6.8). The Time Allocation Committee selected 50 proposals for execution during the period October 2009 - December 2010. All non-ToO proposals (26) will be open for associated data rights proposals for sources which are in their FOV. The Call for associated data-rights will be issued on 25 May, with a deadline of 3 July for the proposals.

D. Götz et al. (ApJ, 695, L208, 2009) used the IBIS imager to measure the polarization of the prompt gamma-ray emission of the long and bright GRB 041219A in the 200-800 keV energy band. They find that the degree of polarization varies from $\leq 4\%$ over the first peak to $43 \pm 25\%$ at the second peak. The average null polarization over the first peak can be explained by the rapid variations of the polarization angle and degree revealed by a time resolved analysis. These results cannot discriminate between competing theories of the prompt GRB emission at these energies; however, they favour models where synchrotron radiation from a relativistic outflow occurs in a magnetic field which is coherent on an angular size comparable to the size of the emitting region. Two ESA web stories were published on this result in April.

The total number of refereed articles using INTEGRAL data since launch reached 438 at the end of February, with 30 published in the first two months of 2009.

1.4 Suzaku (ASTRO-E2): Arvind Parmar

Scientists from institutes located in ESA Member States appear as first, or co-authors, of 51-refereed articles that make direct use of data from the Japanese-US X-ray astronomy mission Suzaku. ESA does not provide the only way for Europeans to access Suzaku data and the above number presumably includes papers resulting from archival studies and involvements as co-investigators on Japanese or US proposals, or through membership of the Suzaku Science Working Group.

The European AO-4 proposals were ranked by the ESA appointed TAC and the results forwarded to JAXA for merging with the Japanese and US proposal selections. The approved target list for the European AO-4 observations to be performed between April 2009 and March 2010 is to be found under http://www.rssd.esa.int/suzaku. As in previous AOs, the European targets will account for 8% of the total observing time.

1.5 Akari (ASTRO-F): Alberto Salama

AKARI continues routine operations in its post-helium phase. By April 2009, 392 European observations have been successfully executed. Processed data, reduction software and documentation were recently released. Scientific results from the mission were discussed at the conference “AKARI, a light to illuminate the misty Universe”, held in the University of Tokyo last February. The conference was attended by 140 participants, 20% of whom were from Europe. AKARI has so far produced 51 refereed articles, 14 of which with European participation. The legacy version of the Pointing Reconstruction results was delivered to Japan for inclusion in the public release of the survey catalogue; the positional accuracy are at the arcsecond level, better than the specifications.

1.6 CoRoT: Malcolm Fridlund

CoRoT is approaching its 900^{th} day in space. On March 8, it experienced its first serious failure, when contact with detector chain #1 was lost without prior indication of a problem. All attempts to re-start chain #1 have failed. CoRoT has two detector chains, consisting of

2 CCD detectors each -one for astroseismology and spacecraft attitude determination and the other one for exoplanetology. Each chain has its own Data Processing Unit (DPU; provided by the Research and Scientific Support Department of ESA) which processes the detector read outs. The data are then transferred over a single data bus to a mass memory. The loss of one chain therefore implies the loss of half of the imaging area on the sky.

So far, the investigatory board convened by CNES, with support from ESA and industry, has been unable to determine exactly the nature and the location of the problem. It must lie either with the DPU or with the data bus. There are indications that DPU #1 is still functional at least at some level, which suggests that the problem may be in the data bus. There is a "cold" spare data bus onboard the spacecraft. However, the entire spacecraft must first be switched-off before the spare bus can be activated, an obviously risky endeavour. The decision by CNES - supported by the CoRoT Science Committee - is that no such attempt will be made unless chain # 2 also fails.

On the positive side, the loss of chain #1 frees up telemetry bandwidth. This allows doubling the number of "imagette" observations. An imagette is a special observing mode whereby a 100 x 100 pixel frame around a target star is transmitted to the ground, instead of only one single light curve. Because they allow direct measurements of the background, Imagette provide better quality light-curves. It will also be possible to double the number of stars with full colour information, i.e. where the red, green and blue light curves are transmitted individually to the ground instead of being merged by the on-board processor.

To offset the loss of half of the imaging area, the science programme was adjusted as follows:

- The next long run (LRc03 = galactic centre) was shortened to 80 days instead of 150
- A new field in an adjacent area of the sky will be observed for the remaining 70 days

The shortening of LRc03 is motivated by the fact that very few valid planetary candidates have been found with periods longer than 70 days. Out of ~30,000 light-curves, only one candidate had been detected with a 72-d period; follow-up observations however indicated that it is most likely a binary star. Another recently identified candidate has a 95-d period. In addition, the confirmation process is quite lengthy and difficult for these rare long period objects. The Science Team therefore decided instead to focus on two other classes of targets which have proven to be more immediately rewarding, i.e.

1. Very small planets with a short period, like CoRoT 7b.
2. Neptune-class planets with periods of up to 20-30 days, maximum.

Data from 560 days of observations have been released to the Co-Investigators. In this data-set, 8 planets, with periods ranging fro 20 h to 9.2 days have been firmly confirmed. A further 6 promising candidates are being intensively followed-up with photometric, spectroscopic, and radial velocity measurements from the ground. Forty-six candidates have been discarded (background eclipsing binaries, spectroscopic binary stars...) A further 142 candidates are in various stages of the confirmation process.

As briefly alluded in the last report, CoRoT finally achieved its design goal, namely detect an earth-size planet. Indeed, the G9/K0 star CoRoT-7 harbours several planets, among which 7b has a radius that is only 1.7 times that of the Earth. With a mass of about 6 Earth-masses and a density of 5.5 $g.cm^{-3}$, CoRoT-7b is definitely a rocky planet. Its very short orbital period of 0.85 day (distance from the star ~4.5 stellar radii) makes it

unsuitable for life however. The second confirmed planet, CoRoT-7c, is a Neptune size object with a mass of about 12 Earth-masses and a period of 3.7 days. The CoRoT-7 system possibly harbours a third planet with a period of 9.2 days and a mass ~20 times that of the Earth, which has not been confirmed yet. Only planet 7b transits in front of its star. The other two planets were discovered during the campaign of radial velocity measurements aimed at determining the mass of CoRoT-7b. The CoRoT-7 dataset will be released in 4 months.

The CoRoT symposium held in Paris last February generated a large (> 80) number of refereed articles which will appear in a special issue of Astronomy & Astrophysics.

Using the 1-m telescope at the Optical Ground Station (OGS) in Tenerife, Spain, equipped with a 42.5' FOV camera designed to track space-debris, ESA personnel will initiate a campaign of observations in support of CoRoT.

1.7 Herschel: Göran Pilbratt

The Herschel spacecraft was shipped by air to CSG Kourou, where it arrived on 12 February 2009. It was installed in the clean-room in the S1B "payload preparation" facility, where, after incoming inspection, the telescope was subjected to cleaning. A period of functional testing, software updates, etc, followed. The instrument short functional testing (SFT) took place in the period 26 February to 9 March 2009 in 'normal' (as opposed to superfluid) helium conditions. The SFTs verified the proper functioning of SPIRE, PACS, and HIFI. All three Herschel instruments were declared ready for flight.

On March 27, Herschel was moved from the clean-room to the S5 facility where hydrazine filling took place on 9-10 April. Helium filling and superfluid helium production followed, with top-up achieved on April 25. Herschel was then transported to the final assembly building (BAF) where it was mated to the launcher on April 30, one week after Planck. A final helium top-up of the cryostat took place which achieved 96.6% filling at a temperature of 1.64 K - excellent for the mission. The cryostat was then closed and the fairing integrated on May10. Further information on the launch campaign can be found at http://herschel.esac.esa.int/latest_news.shtml

Fairing integration in the BAF at CSG Kourou on 10 May 2009.

The Ariane-V roll-out took place in the morning of May 13. On May 14 May 2009 at 13:12 (UT), exactly at the opening of the launch window, Herschel and Planck lifted-off from Kourou. Herschel separated from the rocket at L+26 minutes, 2½ minutes before Planck; Herschel signal acquisition occurred at L+38 minutes, followed by Planck a minute later. The orbit injection was close to perfect. At the time of writing, all LEOP activities are being carried-out as planned and only minor problems were encountered.

Several Science Ground Segment (SGS) simulation campaigns have been conducted on 2-17 February, 9-23 March and 20-26 April 2009. As a result, several improvements have been made which have considerably enhanced the performances and reliability of the SGS.

Two "hands-on" data processing workshops – one dedicated to spectroscopy and the other to photometry and mapping - took place at ESAC on 24-25 and 26-27 March 2009. They were attended by about 50 external people each. The material from these workshops is available online at http://herschel.esac.esa.int/DP_wkshop2.shtml. A similar workshop took take place at the NASA Herschel Science Centre in Pasadena on 8-10 April 2009.

1.8 Planck: Jan Tauber

Since February, the Planck satellite has completed all planned activities and tests. Like Herschel, it was transported to Kourou, verified after transport, fuelled, filled with Helium, and mated to the Ariane 5 rocket. After this, the SYLDA adaptor has been placed around Planck, and Herschel mated to the adapter. The launch occurred exactly at the beginning of the window and resulted in a near perfect injection (see above).

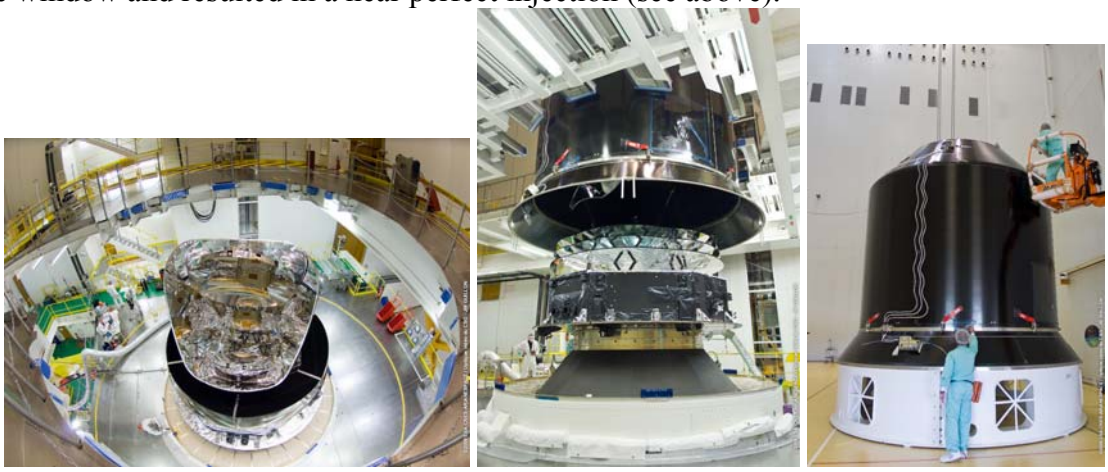

Figure caption: (left) The Planck satellite integrated onto the Ariane 5 rocket (hidden below a platform). (middle) The SYLDA adapter being lowered onto Planck. (right) the SYLDA installed on the rocket around Planck.

At the time of writing, Planck, like Herschel, is in the midst of its 2-days Launch & Early Orbit Operations Phase (LEOP). So far, all planned LEOP operations have been conducted according to plan, with no serious problem encountered along the way. The payload module (passively) cooled significantly faster than predicted, which is bodes well for the mission. This allowed advancing some activities and in particular the commissioning of the HFI instrumenting. The JFETs were activated and HFI was put in science production mode. The Commissioning Phase will last until L+2 months. It will be followed by a one-month long Calibration & Performance Verification Phase. The routine surveying of the sky will thus start around mid-August. The management of the mission will be transferred from the Herschel-Planck Project Manager to the Planck Mission Manager at the start of CPV phase. A light review is planned shortly after launch to ensure readiness for CPV.

The launch date of 14 May was rather favourable in terms of foreseen fuel consumption en route to the final orbit. Depending on the actual performance, it may be possible to reduce the size of the orbit (currently 15 degrees as seen from Earth) to something closer to 10 degrees. This would have operational and scientific advantages.

End-to-end system-level testing of the *scientific* elements (essentially the data-processing

pipeline) of the Ground Segment is progressing, but as usual, slower than foreseen. A mini-review is planned to take place when these tests are finished; this is now likely to happen sometime during CPV phase.

Planck figured prominently at the opening ceremony of the International Year of Astronomy in Paris on 15 January 2009, with an exhibit (the "Planck Dome") developed by scientists at the Institut d'Astrophysique de Paris together with ESA. It was also featured at the ESA session organised during JENAM 2009 in Hertfordshire (UK). Many Public Relations activities have taken place in the lead-up to launch. Planck (and Herschel) will be presented at a plenary session of the IAU General Assembly in August 2009.

The Planck Science Team is supervising the preparation of a set of papers describing the performances and capabilities of Planck based on the results of the ground test and calibration campaigns. These papers will represent the best estimate of in-flight performances at the time of launch and will be published as a special electronic issue in Astronomy & Astrophysics.

2 Projects under development

2.1 JWST: Peter Jakobsen

In conjunction with the release of NASA's Fiscal Year 2010 budget on 7 May, it was announced that the JWST Launch Readiness Date has officially slipped by 12 months. The new launch date of June 2014 stated in the newly signed formal NASA Program Commitment Agreement for JWST follows the recommendations of the Senior Review Board resulting from last year's JWST Confirmation Review. The revised JWST schedule contains 7 months of contingency, and reflects in part changes in the Congress-mandated rules for the budget and schedule contingency levels to be included at mission confirmation, and in part real delays in the JWST instrument deliveries. In particular, NIRCam has been encountering difficulties meeting its wavefront error in the short wavelength channel of its refractive optics. A workmanship problem with the NASA-supplied ASICs controlling the HgCdTe arrays of all three near-IR instruments also threatens to delay the deliveries of NIRCam, NIRSpec and the FGS/TF. On a more positive note, the first of the 18 JWST mirror segments has recently completed cryo-testing at NASA's MSFC in preparation for the final cryo-polishing stage.

On the ESA side, NIRSpec and MIRI hardware procurement remains steady. All NIRSpec flight optics have now been manufactured. The flight Pick-off Mirrors, Fore-optics, harness and kinematic mounts have been integrated onto the flight Optical Bench. The flight Collimator TMA (Three Mirror Anastigmat) has completed alignment and the flight Camera Optics is undergoing fine polish.

The MIRI flight optical bench has been manufactured and the MIRI imager has completed its cryo-testing. The previously observed issue with vignetting of the field has been solved, and the image quality is well within specifications. The Spectrometer pre-optics are presently undergoing cryo-testing. A decision to encase the flight MIRI instrument in a special thermal tent has been made with the objective of increasing the margin on the required heat-lift of the NASA-supplied MIRI cryo-cooler, which remains an area of concern.

A central activity for the NIRSpec Science Operations Team at ESTEC team has been to support the ESA Project and Astrium in preparing for the cryogenic testing of the NIRSpec

Demonstration Model (DM) currently taking place at IABG in Ottobrunn. In addition to repeating the earlier ambient DM optical testing under cryogenic conditions, an equally important objective of the campaign is to verify and commission the test facilities and complex optical ground support equipment that will be used to scientifically calibrate the flight instrument prior to its delivery to NASA.

The equivalent MIRI ground calibration efforts coordinated through the MIRI Test Team are also progressing well. The team is developing all the data reduction techniques, and is refining the on-ground calibration procedures for the Flight Model.

Instrument operations development in collaboration with STScI remains steady for both NIRSpec and MIRI. A "Calibration Summit" organized by STScI and involving all four JWST instrument teams was supported by both the ESA NIRSpec team and the MIRI European Consortium. Topics discussed included commonality of detector data handling, pipeline reduction algorithms and instrument ground calibration plans.

2.2 GAIA: Timo Prusti

As of July 1, Gaia development will continue under a new, still to be nominated, Project Manager, since Rudi Schmidt, the current PM moves on to new tasks in the Agency.

The payload and mirrors in Gaia are supported by a 3.5-m diameter SiC torus. The torus is manufactured from 17 individual SiC pieces which are brazed together in a special oven into one piece in a single process. This process is very critical as it has to succeed in one go. The torus brazing is currently scheduled to June immediately after the remaining 3 torus pieces have been stress-tested. A successful brazing will retire a major development risk from the project.

Polishing of the large mirror is progressing slower than anticipated as the improvement of the surface shape is not converging as rapidly as expected. As a consequence, it could be that real mirrors have to be replaced with dummies in the structural model tests.

Production of the CCD is nearing completion, except for the red-sensitive devices which will not be completed before February 2010 because of a lower than expected yield at e2V.

Tests demonstrated good performances and low noise levels for the CCD Proximity Electronics Modules (PEM). However, they also revealed new problems. An effect called non-uniformity response induces a bias to the measurements. The problem is that this bias depends on the configuration of the observing windows on the whole CCD, i.e. it depends on how the target stars project onto the CCD at the time of observation. The effect is most severe in the Radial Velocity Spectrometer (RVS) where, in the worst case, the bias level could change for every 12 pixels section of a spectrum. A review team has been put in place to investigate the problem and devise ways to remove or mitigate its impact. The review team is scheduled to complete its investigations in June. Preliminary results indicate that the bias is not only internal to the PEM, but could be related to the way the PEM and the CCD are coupled as well. In any case, it seems that an additional data processing step will be required on the ground to attenuate the effect.

The third CCD irradiation test campaign currently under way will be completed in August. The RVS tests have already been completed and a test report is expected shortly. The astrometric tests, with a sky-like mask, have also been completed and the analysis is in

progress. At the moment, testing concentrates on the effect of radiation on the serial register before the campaign resumes with photometry tests.

The Design Review of Mission Operation Centre (MOC) has been completed successfully. The design review of the Science Operations Centre (SOC) and Data Processing & Analysis Consortium (DPAC) is underway. The DPAC Project Office is now operational and actively contributing to the review process.

The Gaia Science Team together with the DPAC Executive is currently setting-up the requirements for the Gaia catalogue access. A top level approach for intermediate catalogue releases has been agreed; the work can now continue with the definition of lower-level and more detailed of requirements.

2.3 Lisa Pathfinder: McNamara

Several issues had been raised at the System Critical Design Review (CDR) last December. Specifically, the issue of CPU load (116% of capacity) and EEPROM (~100% of memory capacity) had been flagged as unacceptable. The problem was solved by a change in the data handling and application software architecture, including the removal of obsolete code, bringing the CPU load at 65% and EEPROM at 80% of capacity, respectively. Upon recommendations from the CDR Board, an Independent Review Team (IRT) has also been set-up to look critically at the mission performances. The IRT, which comprises scientists and engineers external to the Project and/or ESA, will present their findings at the Mission-level CDR (M-CDR) at the end of 2009. In summary, all critical issues identified at the system CDR have either been closed or are on track for a resolution by the M-CDR.

In addition to technical issues, the CDR Board had also criticised the organisation and management of the project at Astrium UK, the LISA Pathfinder prime contractor. Since December, Astrium has taken steps to address these concerns, including the replacement of the Project Manager.

Structural testing of the flight-structures has also proceeded according to plan. The propulsion module structure successfully underwent static tests at IABG, Berlin. The spacecraft flight-structure also successfully passed the sine dwell test campaign at ESTEC, and has now been shipped back to Astrium UK for the start of the hardware integration campaign. The hardware integration will begin with the installation of the electrical harness before the end of May.

As concerns the instrument payload - the LISA Technology Package (LTP) - all flight units are now in manufacturing. Real-time test bed operations using the engineering models (EM) are proceeding according to plan. In addition, closed-loop tests of the full optical metrology system (laser, modulator, optical bench, phase-meter and digital controller) have been completed, and demonstrate a performance which exceeds requirements over the full measurement bandwidth.

Development of the Science and Technology Operations Centre (STOC) is also proceeding well. In the reporting period, the STOC has acceptance-tested several important subsystems, including the mission planning software, the data ingestion software, the engineering release of the STOC simulator and version 2 of the data analysis software. With these software systems in place, the STOC could initiate the process of writing Payload Operations Requests and simulating these science operations on the STOC

Simulator. This process will be used to validate all science operations prior to their upload to the spacecraft. The STOC is currently in the midst of its own CDR, which started on May 20 and will be completed on July 2.

As an outcome of the System CDR, the mission schedule has been critically reviewed by all parties. The consolidated schedule shows a launch date of July 2011 which, however, depends critically on the timely delivery of the LTP, and the availability of the VEGA launcher.

3 Ongoing studies

3.1 IXO (formerly XEUS): Arvind Parmar

A series of IXO meetings were held in Boston, 27-30 January 2009. These included the first full meetings of the Telescope Working Group (TWG) and Instrument Working Group and the Science Definition Team (SDT). The 3rd meeting of the Study Coordination Group (SCG) concluded this series of meetings. At the SCG meeting it was agreed to have a *goal* area of 3000 cm^2 for the IXO grating spectrometer (the requirement remains 1000 cm^2). This is mainly driven by the sensitivity needed to perform WHIM studies of sufficient numbers of lines of sight to "see" the structure of the cosmic web.

A second set of IXO sessions at the Concurrent Design Facility (CDF) was completed in March. This concentrated on the optical bench extension mechanism, telescope accommodation, cryogenic system and the overall system design and budgets. The TWG and SCG were briefed on the outcome of the sessions. The report will be released in June.

Much work in the last months has been in support of the IXO submission to the NASA Decadal Survey, which has been naturally led by the US members of the team. A total of 15 Science "White Papers" were submitted, addressing the wide range of science issues covered by IXO. Three papers - "The Evolution of Galaxy Clusters across Cosmic Time", "The Growth of Supermassive Black Holes over Cosmic Time" and "Cosmic Feedback from Massive Black Holes" - were led by European authors. Europeans were co-authors on 11 of the remaining 12 papers illustrating the good level of cooperation between the partners. Subsequently, a 20-page mission summary has been submitted to the Decadal process. This details the mission's scientific goals and requirements, technology drivers, mission concept and organisation including roles of the international partners and (NASA derived only) costs. The team is on standby in case further information is requested at the June AAS meeting.

The Invitation-to-Tender (ITT) to industry for the parallel 1-year duration IXO system studies was released on May 8, with responses due by the end of June. Important documents applicable to the ITT, such as the Mission Requirements Document, have been reviewed by the SCG. The industrial studies will focus on a European implementation of IXO, but will ensure compatibility with possible major NASA provided elements, such as the slumped glass optics and Atlas 551 launcher.

The request for Declaration of Interest for payload consortia to support the industrial system studies has been issued, with responses due by 9 June. Since the teams behind the two potential designs of the X-ray gratings do not have any European members, the GSFC IXO Project team has agreed to act as the interface to the US instrument teams and provide

any necessary information. The other four potential IXO instruments have a European element (or lead) and it is expected that these consortia will support the studies.

3.2 LISA: Oliver Jennrich

The first quarter of 2009 has seen significant activities by the Project in answering the Request for Information (RfI) issued by the Astronomy and Astrophysics Decadal Survey (Astro2010) of the US National Academy of Sciences. The RfI asked for input on the key science goals, a technical overview of the mission, a discussion of the technology drivers, a description of Activity Organization, Partnerships, and Current Status, a schedule for the activities and a cost estimate. Answers to the RfI were delivered by the 1 April deadline. As the answers were strictly limited in length, proposers were allowed to display further background material on a dedicated website. This background information for LISA is available at http://lisa.gsfc.nasa.gov/documentation.html

Round 3 of the Mock LISA Data Challenge (MLDC) that was issued in March 2008 and initially scheduled to end in November 2008 was completed on April 30, after a deadline extension to allow a more thorough investigation of the stochastic background signals. Round 3 was a year-long challenge building on Round 2 with improved source models and some new types of GW sources. A total of 15 collaborations, submitting 17 entries to the challenge, took part, including some new groups that did not contribute to earlier challenges. A full evaluation of the results is still in progress but some highlights can already be identified. Very good results were obtained in the detection of signals from massive black hole binaries (the total number of events was unknown) as well as in the parameter extraction of the sources. The groups that engaged in detecting the signals from extreme mass ratio in-spirals (EMRI) - compact objects with 10 solar masses falling into massive black holes with about 10^6 solar masses - were able to recover the parameters of the systems with high accuracy. It is worth noting that EMRI with a signal-to-noise ratio (SNR) as low as 19 were successfully recovered, though such an SNR is significantly lower than the formal science requirements on the mission. Two of the newly introduced signal types - cosmic string cusps and a stochastic background - were also correctly recovered, often by more than one team. The overall quality of the entries and the sophistication and diversity of the techniques being used in round 3 were much higher than in previous rounds of the MLDC. While the full LISA Data Analysis is still some time in the future, the progress made in the community is nevertheless more than encouraging. A full report will be presented at the Amaldi meeting this June, where MLDC round 4 will most likely be announced as well.

The technology development activity for the optical bench has finally started with AEI Hannover, University of Glasgow TNO Delft, and Astrium GmbH forming the industrial collaboration.

3.3 Euclid: René Laureijs

In the first 4 months of 2009, ESA and NASA held intensive discussions on a possible joint dark energy mission. The ESA Euclid Study Team and the NASA Goddard JDEM project office were involved in merging the JDEM and Euclid concepts. The implied change of direction had a large impact on the ongoing industrial and instrument studies, which were facing dramatic changes in requirements. However, for purely internal reasons, NASA was not able to proceed with the planned joint ESA/NASA AO on a timescale compatible with the Cosmic Visions schedule. It was therefore agreed to defer a Euclid-JDEM merge to a later stage, after the mission has been down-selected for a definition phase.

The assessment studies returned to the initial Euclid mission concept, namely an ESA only mission with a 1.2 meter primary mirror telescope and with three instruments: a visual imager for weak lensing, a near infrared (NIR) photo-imaging instrument for photo-z measurements, and a medium resolution NIR spectrometer (R=400-600) to measure baryonic acoustic oscillations. Slit-less spectroscopy has become the baseline design instead a slit spectroscopy. Another change concerns the NIR detectors which will have a cut-off at 2.5 micron instead of 1.7 micron. An optical design which accommodates the instruments to the telescope optics will be provided by ESA to the two industrial contractors as well as to the instrument consortia. The impact of these changes on the BAO experiment is investigated by the spectroscopic channel consortium.

All parties understand that not much time is left to complete the mission design. The instrument consortia have agreed to produce a draft payload section for the Euclid assessment study report by the end of July. The working groups which are coordinated by the Euclid Science Study Team have a tight schedule for the completion of the science related sections of the study report by the submission date of 30 September.

3.4 Plato: Malcolm Fridlund

The PLATO study is continuing after re-consolidation of the science case. A key element is a better understanding of the stellar density as a function of magnitude. The two contractors are on track to complete the industrial studies by the end of July. Drafting of the Assessment Study Report started in early May.

The PLATO consolidated scientific case is defined in the table below. The samples are to be considered in order of priority. The required photon noise levels are given in part per million (ppm) per hour for each sample. Both contractors confirm now that they have a design that is compliant with each one of the samples. Magnitude ranges for samples #1 and #2b set the requirement for the field-of-view which drives the design.

Number of dwarfs	Sample#1	Sample#2	Sample#2b	Sample#3	Sample#4	Sample#5
Number of dwarfs	20,000	80,000	80-100	1,000	3,000	250,000
Magnitudes	8-11	8-11	<8	<8	<8	11-14
Phot. Accuracy	27ppm	80ppm	27 ppm	27ppm	27ppm	80ppm
Number of fields	2	2	NA	2	TBC	2

After an independent verifications of the stellar count model, by I. Ribas (and co-workers), all parties agree that the scientific objectives can be met. Sample #1 is the key element to the mission: two fields with 20,000 cool dwarf stars in total will be monitored for 2 years each (goal 3 years). Planetary candidates with orbital periods of ~1 year will be followed up and confirmed in a subsequent step and stare phase. Each of the 20,000 dwarfs will be fully characterized by astroseismology. Earth-size planets will also be found around the 250,000 targets in sample #5

3.5 SPICA: Ana Heras

Industrial studies of the SPICA Telescope Assembly are progressing well. The mechanical design and thermal analysis are being finalised. The stray-light analysis, which is particularly relevant for SPICA, is on-going in close cooperation with the Science Study Team. Final presentations of the Industrial studies are planned toward the end of July. The schedule for telescope delivery is under discussion with JAXA.

JAXA/ISAS are preparing the System Requirements Review that will take place in autumn 2009. Cycle 1 of the satellite concept design has been completed and includes a preliminary thermal design of the Service and Payload modules, and the clarification of the available resources for the focal plane instruments.

The first SAFARI Technology Readiness Review, held at the beginning of February, focused on the four candidate detector technologies, the FTS mechanism and the sub-K instrument cooler design. The Review panel consists of ESA experts, SAFARI consortium members and the SPICA Study Team. A second and final Technology Readiness Review will take place in early July.

A SAFARI consortium meeting took place on 31 March – 1 April to review and consolidate the instrument science case. Preparation of the science part of the Assessment Study Report is coordinated with the production by JAXA of the Mission Requirements Document. Progress has been made on the definition of the science operations concept, which includes contributions from ESA. The observing time allocation scheme is currently being negotiated with JAXA. A SPICA Science workshop will be held at Oxford, next July 6 to 9. It is organised by the SAFARI Consortium, jointly with ESA and JAXA.