Newsletter 14

N° 14 - October 26, 2011

Soyuz boosters and main stage ignition seconds before liftoff on 21 October 2011. Boosters burn for about 2 mn before being jettisoned. Similar scenario should happen with Gaia in less than two years (Photo: ESA - S. Corvaja, 2011).

Editorial *by DPAC chair, François Mignard*

Few days ago, all connected with Gaia at ESA, Astrium and in the DPAC, have anxiously awaited the Soyuz launch from the dedicated new launchpad in French Guiana and, eventually, welcomed the flawless liftoff and the subsequent injection of the two Galileo satellites into orbit. Certainly this Russian-built rocket is highly reliable, but this was its maiden flight from the new European Spaceport. This fact combined with the use of the restartable upper stage Fregat, are two important milestones on the way leading to the Gaia launch in summer 2013. A failure implying the new launch site infrastructure or procedures, would have meant an inquiry commission and very likely a delay for the planned launches of the next few years, including Gaia. Definitely, we feel much better after this success. The next similar launch is now scheduled for mid-December this year.

Similarly on the spacecraft side, the current integration and testing are advancing nominally. The launch date appears more and more realistic and has stabilised. Most of flight hardware has now been delivered and the remaining parts are under control. All flight mirrors have been mounted on the SiC torus and the alignment tests are under way. An important and impressive mechanical test took place in early summer with the Payload Module vibration testing, aiming to verify it can sustain the huge launch constraint. This was successfully passed and a new major risk is now behind us.

In this issue you will learn more about the hardship Gaia will go through before it gets qualified for a real flight into space. Qualification of DPAC software is also a major issue, and there are very few possibilities to design tests on real astronomical data: one example for CU8 is presented by C. Worley. As usual, you will learn about two DPAC partners, this time the group of the Astronomical Observatory at Torino and the IMCCE at the Paris Observatory.

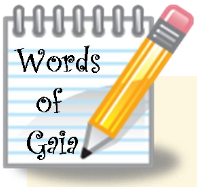
DPAC news *by François Mignard*

Many important events in the DPAC life happened over the last few months, but here I can just focus on the top level activities at the DPAC level rather than the CU's.

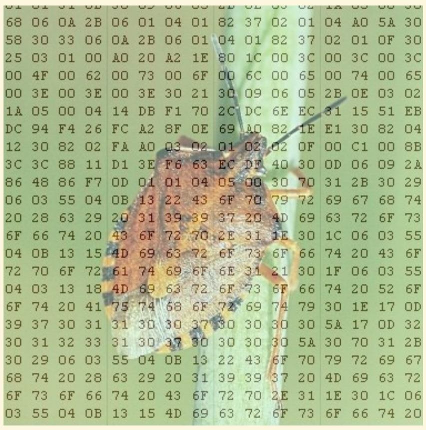
- The Ground Segment Implementation Review (GSIR) has started officially on 27 September with a set of presentations from the DPAC, SOC and MOC to the Review Panel. Two weeks before the DPAC/SOC Data pack was delivered with about 120 documents submitted to the review and nearly as many supporting documents. The review main goal is to verify that the status and planning of the ground segment development, including management aspects and schedule, are commensurate with project requirements and in line with the applicable implementation plans. Reviewers comments are due by 25 October, leaving DPAC a full week to answer. A joint meeting on 10-11 November between ESA and DPAC/SOC is scheduled to discuss the issues more thoroughly. The Board will deliver the final report on November 21st. Related to the review, a special science panel was appointed to look more on the science aspect of the DPAC activities and this has given the opportunity to every CU and major components of the Gaia processing system to be presented in a rather detailed manner to the panel.

- The DPAC Integration Tests are advancing according to plans. The first stage of the End-to-End testing has been passed and important lessons were drawn during the preparation of these tests and from their execution. Interfaces between DPCs worked successfully and the functional tests of the S/W involved in this stage (IDT, FL, MDB) passed the tests. However serious performance issues were discovered during this testing. The second stage is on-going since end of July, with the pieces of software involved in daily processing and all the DPCs. A run of AGIS (a cyclic software, but scientifically critical) is also included. This 2nd stage will last until mid-January 2012.

- An intense activity has recently started with the Project Office to prepare the DPAC participation in the Gaia commissioning. DPAC will support the Payload commissioning by running software on real data and providing expertise into the evaluation of the results and real time feedback to ESA and Astrium on the spacecraft performances and related issues. Several important documents are in preparation to ensure the optimal preparation of the DPAC for this very important phase of the project. Several rehearsals are planned before launch and will be closely followed by the Project as elements showing the level of DPAC readiness. This hot topic will be presented in more detail in a forthcoming issue of the NewsLetter.



Bug



It is known that most of the time occupied to produce a reliable computer software is spent in debugging it, rather than implementing the core of its function. The name, or the associated verb, is ubiquitous among the Gaia developers and scientists dealing with Java code and virtually never translated in their own native language. It has been said that there is no program without bug, since there are always instances of input data which will make the program behave in an anomalous way, even if it does not crash.

The great American and pioneer computer scientist Grace Hopper (1906-1992) is often credited for coining the term in this context, based on the fact that she was reported to find a moth in an electric relay blocking the normal functioning of one of the first electromechanical computer in 1947. The computer was then physically 'debugged' by removing the little mite.

Nice story! But she denied repeatedly as being the person who found the little insect there, although she is probably the source that made this word very popular to describe a software error. In fact, the use of 'bug' to refer to defects or malfunctions in hardware predated by decades its use to describe flaws in software, and was known in the jargon of engineers. When the moth was found, the operator who discovered it wrote on a note 'first case of real bug found', clearly referring to the use of the term in engineering environment and enjoying himself with the encounter of the abstract and concrete meaning. Then the word made the successful career we know in software industry and is heard in almost every DPAC technical meeting.

The Gaia team at OATo *by Mario G. Lattanzi and Ronald Drimmel*

The involvement of Osservatorio Astronomico di Torino (OATo, http://www.oato.inaf.it) in Gaia has its roots in the Hipparcos mission.

Currently, there are 23 OATo scientists in DPAC, accounting for more than a third of the Italian FTEs committed to the Consortium. Most of this effort is concentrated in CU3, but there are significant contributions to CU2, CU4, and CU8.

In CU3 OATo contributes mainly in the Astrometric Verification Unit, responsible for the AIM (Astrometric Instrument Model), BAM (Basic Angle Monitoring) and GSR (Global Sphere Reconstruction) SW systems. AIM and BAM are primarily dedicated to instrument monitoring to assure that any variations of the Gaia instrument affecting the final accuracy are detected and characterized and both will issue daily, weekly and monthly reports on the instrument behaviour.

AIM processes raw astrometric images of a selected sample of well behaved objects, while BAM reduces data from the BAM device on-board the satellite. Meanwhile the GSR system is most directly involved in astrometric verification, providing independent processing of the Gaia observations to arrive at global sphere solutions that can be compared directly to a significant subset of the Primary Star solutions provided by AGIS (Astrometric Global Iterative Solution). This verification is motivated by the fact that the AGIS astrometric results will be of precision well beyond present and future all-sky astrometric measures made on-ground or in space, and therefore there will be no opportunity to scientifically validate the AGIS results with external data.

Other key contributions to CU3 include cross-matching algorithms and SW (for IDT and IDU), the IGSL (Initial Gaia Source List), and the BAM-IDT SW. OATo personnel have also primary responsibility in the CU3 REMAT (relativity) group, including preparations for the GAREQ experiment with Jupiter.

Very important are also the contributions to the other CUs, CU4 in particular, where OATo personnel have primary responsibility in developing algorithms/systems dedicated to detect/characterize asteroids, and to detect/characterize extrasolar planetary systems.

Finally, OATo is involved in CU2, contributing to the modelling of interstellar extinction, extrasolar planets, and especially to efforts regarding the modelling of the Gaia instrument, in particular for the optics.

The Gaia OATo Team (photo: M. Crosta and R. Morbidelli)

The Gaia team at IMCCE *by Daniel Hestroffer*

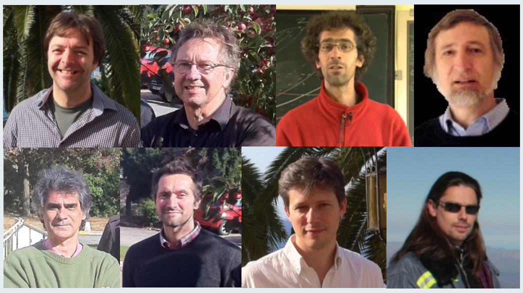
The Institut de Mécanique Céleste et de Calculs des Ephémérides (IMCCE, http://www.imcce.fr/langues/en/) is a laboratory from the Paris observatory, associated to the university Pierre & Marie Curie (UPMC, Paris) and university Lille1, and also to the French CNRS. As research institute, the IMCCE has three missions:

- produce and publish the French ephemerides of solar system bodies under the responsibility of the Bureau des longitudes (BDL), and provide support in this area to observatories and space agencies;
- perform theoretical and observational research activities in the dynamics of solar and extrasolar system bodies;
- teaching, education and public outreach.

The Paris observatory views its participation in Gaia as an integrating project running across several of its laboratories for which the GEPI, the SYRTE and IMCCE are strong components.

Among the 50 permanent and non permanent staff at IMCCE, there are 8 in the Gaia team with few others being called on an ad hoc basis for particular expertise. Most of the members have been involved as early as 2003 in the preparatory scientific tasks, before joining the DPAC CU4. We are in charge of several DUs (451, 452, 457, 459) related to solar system objects and participate also actively in DU437 for extrasolar planets. This concerns primarily the software development, and associated research activities on the orbits and ephemerides of small bodies of the solar system (asteroids, satellites, comets) and exoplanets. Several members of the Gaia team are also, or have been, involved with other CUs (basically CU2 and CU6), REMAT, and GBOG as well, in relation with their expertise in solar system science.

IMCCE is also the single source of planetary ephemerides for the Gaia data reduction pipeline (INPOP, see Newsletter #13) and the spacecraft tracking at ESOC. Within the framework of GREAT ESF, we are active through exchanges and workshops in the field of small bodies of the Solar System. Members of our group have expressed interest in GAP for the data validation and future data access preparation. Our Gaia activities are supported by the Paris observatory, the CNES and the CNRS-funded "Action Spécifique" Gaia.



The Gaia IMCCE team, from top left to bottom right: D. Hestroffer, W. Thuillot, M. Fouchard, J.-E. Arlot, P. David, N. Rambaux, V. Lainey, J. Berthier

Spacecraft Test Campaigns *by Vincent Poinsignon (EADS ASTRIUM)*

Gaia spacecraft development is completed by an extensive Verification programme to demonstrate that it meets, both in terms of design and performance, the challenging mission requirements and ensure that the spacecraft is suitable for use, free from manufacturing defects.

This Verification programme is comprised of a combination of tests, analyses, reviews of design and inspections. Test campaigns are of paramount importance in the Verification programme, and culminate with tests on the fully assembled spacecraft flight model, combining the Payload and Service Modules (PLM & SVM).

Gaia spacecraft equipped with a PLM mechanical dummy is being prepared for the mechanical test campaign (October 2011)

Development models of Gaia have gone through several functional and environmental qualification test campaigns. We are now entering test phases involving the flight models. This starts with a combination of mechanical, optical, electrical and functional tests aiming to verify that Gaia behaves as expected. They also provide a reference basis before the environmental campaigns.

A set of electrical and functional tests have been carried out on the spacecraft and on the PLM focal plane. Optical alignments within the Payload Module are currently being performed and the large sunshield installed on the spacecraft will be deployed very soon.

The environmental verification to come includes:

- **mechanical campaigns,** to verify robustness to the tremendous loads experienced during launch,
- **thermal campaigns** in large vacuum chambers to correlate the thermal models and verify functions and performances in vacuum conditions over the range of temperatures expected in space,
- **electromagnetic compatibility,** “EMC” campaigns, to verify the compatibility of Gaia with its launcher as well as the Gaia auto-compatibility during operational mission phases.

Environmental campaigns are all carried out at Intespace test facilities in Toulouse, with the exception of the PLM thermal campaign performed in the cryogenic vacuum facilities of Liège in Belgium.

Electrical and functional campaign

This campaign is split into two main steps. First one validates the electrical and functional concept on the Avionic Model bench, built with flight representative units and running with all flight software. Then the second campaign is carried out on the fully assembled S/C with flight units, repeating similar tests to check the correct functional behaviour of the S/C.

Mechanical campaign

The PLM has passed its mechanical qualification against launch vibration environment during summer 2011 and the spacecraft will start its mechanical campaign this fall. The spacecraft equipped with a PLM dummy will be first mounted on a shaker to demonstrate its ability to stand up to the launch vibrations and then, moved to an acoustic chamber to be submitted to the launcher acoustic loads, simulated by a siren. Those tests will be played again, at a lower level, after final assembly of the PLM flight model inside the spacecraft, in early 2013.

Thermal campaign

In 2012, the spacecraft and the PLM will undergo thermal environment campaigns. A thermal balance phase enables to correlate thermal models and confirm the thermal architecture adequacy. It is followed by a thermal vacuum phase to demonstrate that Gaia elements perform and operate properly at the upper and lower acceptance temperature.

The PLM thermal campaign will last more than two months, fifty days of which being needed to cool down to the low stabilised operating temperature, allowing to verify the optical and detection performance of the instruments. The spacecraft model equipped with a PLM thermal simulator will be submitted to a more classical campaign lasting about two weeks.

EMC campaign

During the EMC campaign, Gaia susceptibility to external conducted and radiated disturbance is checked, as well as its level of conducted and radiated emissions. The radiated tests are carried out in large anechoic chambers in which the spacecraft is fitted on radio-transparent supports. This later facility is also used to check the spacecraft radiofrequency auto-compatibility during which the whole Gaia is operated as in flight.

At the end of the environmental campaigns, a second set of functional tests is run, as well as alignment checks to demonstrate that Gaia has not suffered from the environmental tests. The spacecraft is then ready to be prepared for the launch campaign.

The AMBRE Project *by Clare Worley (Observatoire de la Côte d'Azur, France)*

Galactic Archaeology is a new and exciting field of astronomical research that seeks to understand the formation and evolution of the galaxy by analysing as many stars as possible in the Milky Way.

There are many large spectroscopic surveys already collecting data but the project that has the greatest potential to fundamentally change our understanding of the galaxy is the Gaia Mission. Gaia will observe millions upon millions of stars in the galaxy and with this data we will begin to unravel the secrets of the Milky Way.

There are many projects underway that are working to ensure that the optimum results are obtained from the Gaia observations. The AMBRE (French acronym for archaeology with MATISSE: abundances in ESO's archives) Project (P.I.: P. de Laverny) is one such project that has been conceived to test the Generalized Stellar Parametrizer-spectroscopy (GSP-spec) algorithm within the CU8 pipeline (APSIS). GSP-spec will determine the stellar parameters from the Gaia Radial Velocity Spectrometer (RVS) spectra of single stars.

Under a contract between the European Southern Observatory (ESO) and the Observatoire de la Côte d'Azur (OCA), the AMBRE Project is tasked with determining the stellar parameters (effective temperature, surface gravity, metallicity and the alpha element abundances with respect to the iron content) for the archived spectra of four of ESO's spectrographs: FEROS, UVES, HARPS and Flames/GIRAFFE. The resolving power, wavelength range, and number of archived spectra for each spectrograph are listed in Table 1.

The ESO archive represents a unique opportunity to test GSP-spec on a large dataset of real spectra. In particular, key observational set-ups for the Flames/GIRAFFE spectrograph are very similar to the Gaia RVS observations and so GSP-spec will be tested on as close to Gaia RVS-like spectra as possible.

For the AMBRE Project, the stellar parameters of the archived spectra are being derived using the automated stellar parameterisation algorithms MATISSE (Recio-Blanco et al. 2006) and DEGAS (Kordopatis et al. 2011). These algorithms have been integrated into GSP-spec and have been developed at OCA primarily to be used for the chemical analysis of the Gaia RVS spectra.

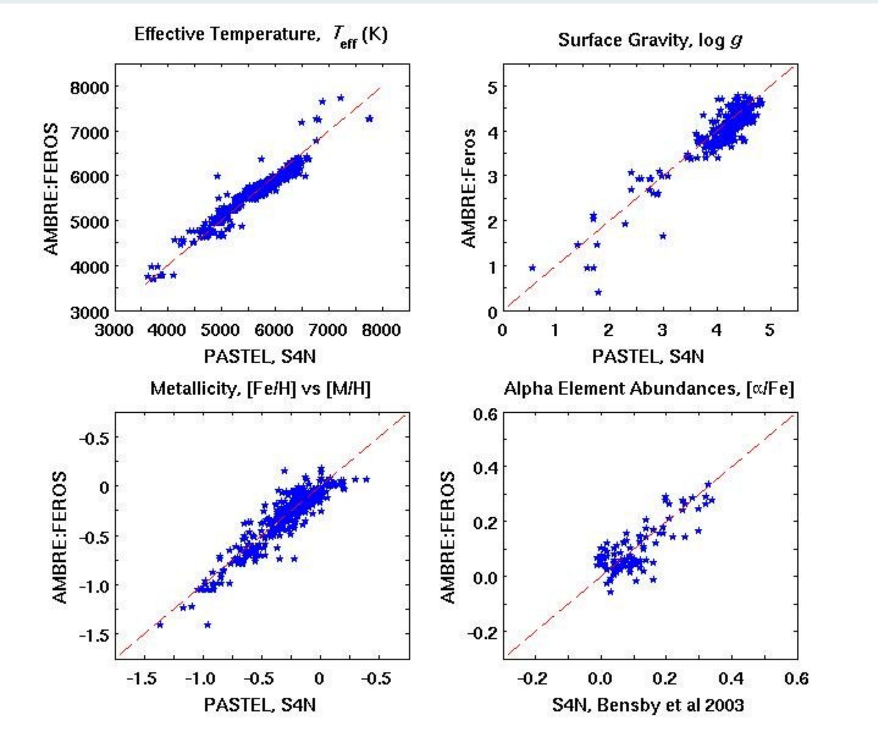
Table 1. Characteristics of ESO spectrographs

ESO Spectrograph	Resolving Power	Spectral Domain	No. archived spectra
FEROS	48000	350nm - 920nm	20000
HARPS	115000	378nm - 691nm	40000
UVES	40,000 to 110,000	300nm - 1100nm	90000
Flames/GIRAFFE	5,600 to 46,000	370nm - 900nm	100000
		Total Sample	**250000**

The stellar parameters of the archived spectra derived in AMBRE will be made available to the astronomical community by ESO as advanced data products in the ESO archive. This will allow researchers to recycle the archived spectra, generating new samples of stars for analysis outside the goals of the original observing programs. As a whole the parameters can be considered as a homogeneously determined chemical chart of the Milky Way for use in studies of Galactic Archaeology.

Finally, the stars analysed within the AMBRE project are considered as secondary standards by the GBOG as they will constitute a large catalogue of homogeneously determined stellar parameters.

The analysis of the FEROS archived spectra is now complete (Worley et al. 2011, in prep.). A complex reduction pipeline has been built that further treats the archived spectra, which have been processed in the ESO reduction pipeline, in order to optimise them for analysis by MATISSE.



A comparison of the AMBRE:FEROS results to high quality spectroscopic studies and spectral libraries (Bensby et al 2003, Allende-Prieto et al. 2004 (S4N), Soubiran et al. 2010 (PASTEL)), showed excellent agreement in the stellar parameter determinations as shown in Figure1.

PhD and Post Doc Corner

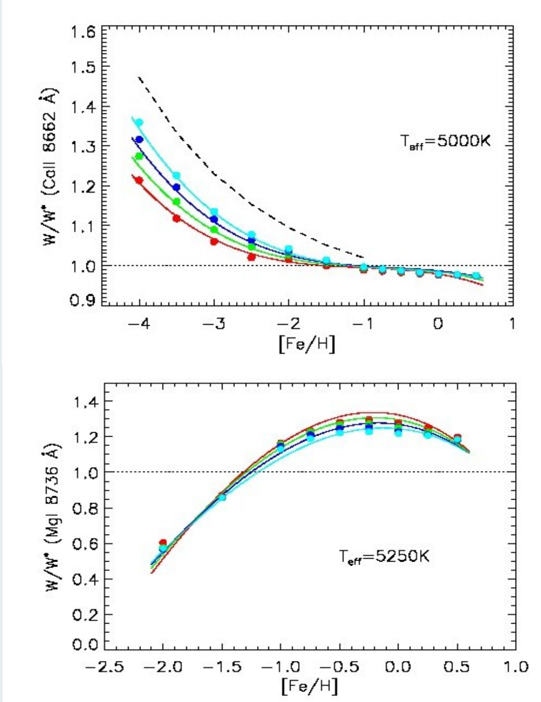
Thibault Merle, *Observatoire de la Côte d'Azur, France*

Thibault Merle is a Ph.D. student in the Gaia team at the Observatoire de la Côte d'Azur (UNS-OCA-CNRS). His work supervised by F. Thévenin, L. Bigot and B. Pichon, is dedicated to the Non Local Thermodynamic Equilibrium (NLTE) effects in atmospheres of late-type stars for the α elements. He focuses on the determination of the NLTE Equivalent Width (W) of Mg and Ca lines from UV to IR wavelengths, covering in particular the RVS range. This work is part of WP-811 of CU8.

Part of his thesis deals with the CaII triplet and the Mg I 873.6 nm lines in the RVS range. The stellar parameters (3500 ≤ T_{eff} ≤ 5250 K, 0.5 ≤ log g ≤ 2.0, -4 ≤ [Fe/H] ≤ +0.5) cover late-type giant and supergiant stars. Computations are done using the code MULTI 2.2 (Carlsson, 1986) with stellar atmosphere models from MARCS database, in order to compare the LTE and NLTE hypothesis.

For that purpose accurate model atoms of Ca and Mg have been constructed. Resultant ratios of W(NLTE)/W*(LTE) are published in Merle et al. (2011).

How significant the deviations from the LTE are, depends on the line and on the atmospheric parameters. At [Fe/H] = -4, for the CaII triplet IR, a correction of -0.13 dex on the LTE abundance of calcium has to be applied. One can see on figure 1 that the NLTE effects can reach more than 30% of correction compared to classical LTE computations. Similar results are shown on figure 2 for the strongest MgI line of the RVS. This is a very important issue for the algorithms of extraction of APs from the RVS spectra. Extension of the investigation to dwarfs stars is in progress.



NLTE/LTE ratio for the CaII 866.2 nm as a function of the metallicity for T_{eff} = 5000 K and for four values of the surface gravity (log g = 0.5, 1, 1.5 and 2 in red, green, blue and cyan respectively). Same for MgI 873.6 nm.

Calendar of next DPAC related meetings

08-10/11	Brussels	CU4: Object Processing #12	D. Pourbaix
08-10/11	Tel Aviv	CU7: Variability Processing #13	L. Eyer / S. Zucker
15-16/11	Bordeaux	CU8: Calibration of parametrization algorithms	C. Bailer-Jones / C. Soubiran
23-24/11	Brussels	GBOG meeting #10	C. Soubiran / Y. Fremat
23-25/11	Dresden	GBOT meeting #3	M. Altmann / S. Klioner
29/11-01/12	Geneva	CU6: Spectroscopic Processing #12	D. Katz / L. Guy
01-02/12	Dresden	AGIS #16	U. Lammers / S. Klioner
14-16/12	Barcelona	IDT/FL meeting	G. Gracia/M. Biermann/J. Torra
18-19/01	ESTEC	DPACE #14	F. Mignard / T. Prusti
19-20/01	ESTEC	GST # 37	T. Prusti

Gaia and related science meetings

06 - 10/11	Paris Observatory, France	**Astronomical Data Analysis Software and Systems (ADASS) XXI Conference**	http://www.eso.org/sci/meetings/2011/adass2011.html

More information on calendar of Gaia : http://www.rssd.esa.int/index.php?project=Gaia&page=Calendar_of_meetings

This newsletter is published by DPAC Chair. To publish news or articles please contact: nl_editorial_board@oca.eu