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The 35-meter antenna in Malargüe, Argentina, has been completed and officially dedicated last December. This is the new ESA antenna built for communication with satellites in deep space. It will be operational in 2013 and will contribute to the Gaia tracking (even if indirectly by relieving Gaia from the ground station booking pressure). Picture credit ESA.

Editorial by DPAC chair, Anthony Brown

The Gaia payload module was subjected to its last major test campaign, the thermal balance/thermal vacuum tests, which were carried out at the Centre Spatial de Liège during 40 days in November and December last year. Although the analysis of the results is still ongoing, no major problems have been found and soon the payload module will be coupled to the service module. This will mark the start of the final assembly, integration, and test campaign for Gaia which will culminate with the launch, now targeted for the end of September this year.

DPAC also has a very busy schedule in 2013. The third operations rehearsal will take place in April and at the same time the

Ground Segment Readiness Review will take place (March to May). The development of the DPAC software systems will continue in order to get these fully ready for launch. The detailed planning of the Gaia commissioning and DPAC initialization phases will happen in parallel. Workshops with Astrium are foreseen to work out the details of the commissioning plans, while a number of workshops are also planned for the data processing centres which will focus on the details of the operations of DPAC.

I would like to wish all DPAC members the best for the busy, stressful, but also exciting time ahead. If all goes well we should be processing the first Gaia data by the end of this year!



The DPAC executive has been strengthened with a new deputy chair, Antonella Vallenari from the University of Padova. Dr. Vallenari has long been an active member of CU8 and the GBOG working group and she is also a member of the Gaia-ESO survey steering committee.

The second operations rehearsal for DPAC took place during two weeks in December 2012. This rehearsal was focused on the Gaia commissioning phase. The telemetry and the contacts with the spacecraft were simulated accordingly. All data processing centres (except Geneva) participated. The DPC at ESAC was in charge of the Initial Data Treatment and First Look processing, the results of which were transmitted to the DPCs in Cambridge, Torino, Barcelona, and Toulouse for further treatment. In addition the SOC calibration team, the First Look scientist team, and the payload experts group participated by rehearsing the assessment of the payload performance and health and providing feedback to ESA and Astrium. Note that also the ground based optical tracking of Gaia was exercised. Observations of the Planck satellite were conducted with the Liverpool telescope on La Palma. The images were processed and the results forwarded to ESOC for use in the reconstruction of the orbit of Planck.

The rehearsal was considered a success but certainly revealed a lot of issues that still need to be resolved to get DPAC ready for launch. Much development of the critical software systems is still needed to make them more robust and easier to operate. In addition the operational interfaces between the data processing centres need to be worked out in detail. During the third operations rehearsal in April we will have a chance to demonstrate the improvements in the software systems and operations.

The December month also saw much activity, coordinated by Xavier Luri and William O'Mullane, to put together the response to ESA's announcement of opportunity for the Gaia archive access element. The resulting proposal is now under evaluation by ESA's Astronomy Working Group. Hopefully within the next few months we can welcome Coordination Unit 9 into the DPAC structure. CU9 will be in charge of delivering the promise of Gaia to the astronomical community and the public at large.

Finally, a very sad news item is that Joël Poels passed away at the end of 2012. Joël worked at the Institute of Astrophysics and Geophysics in Liège and contributed to CU8 (quasar redshifts) and CU6/CU4 (non single stars in RVS) algorithm development.



Words of Gaia: Proper motions

F. Mignard

The Book VII of Ptolemy's *Almagest* is devoted to the Catalogue of the fixed stars and opens with a section entitled " *That the Fixed stars always maintain the same position relative to each other* ", a fact that Ptolemy could not strictly prove by direct measurements. However the issue was considered sufficiently important to deserve serious evidence to support the assumption since his theory of the five planets rested largely upon the determinations of planetary longitudes derived by reference to fixed stars. Ptolemy relied on a set of star alignments already observed by his predecessors and concluded that no change has taken place in the relative arrangement of these stars up to his present time. For centuries ahead the invariability of the Heaven in relative position and brightness remained a central piece of astronomy, except for the rare appearances of "Visiting Stars", known today as supernovae.

It is in the 5th dialogue of his *Cena de le Ceneri*, 1584 (The Ash Wednesday Supper) that the Italian (and highly controversial) polymath Giordano Bruno rejected the concept of fixed stars and surmised that, like all the celestial bodies, they must have a space motion which remains imperceptible to us due to their great distance. He also said that to perceive this displacement " *lengthy observations should be undertaken, which has not been attempted just because nobody believed in such a motion*". Bruno's views had no influence at all on practi-

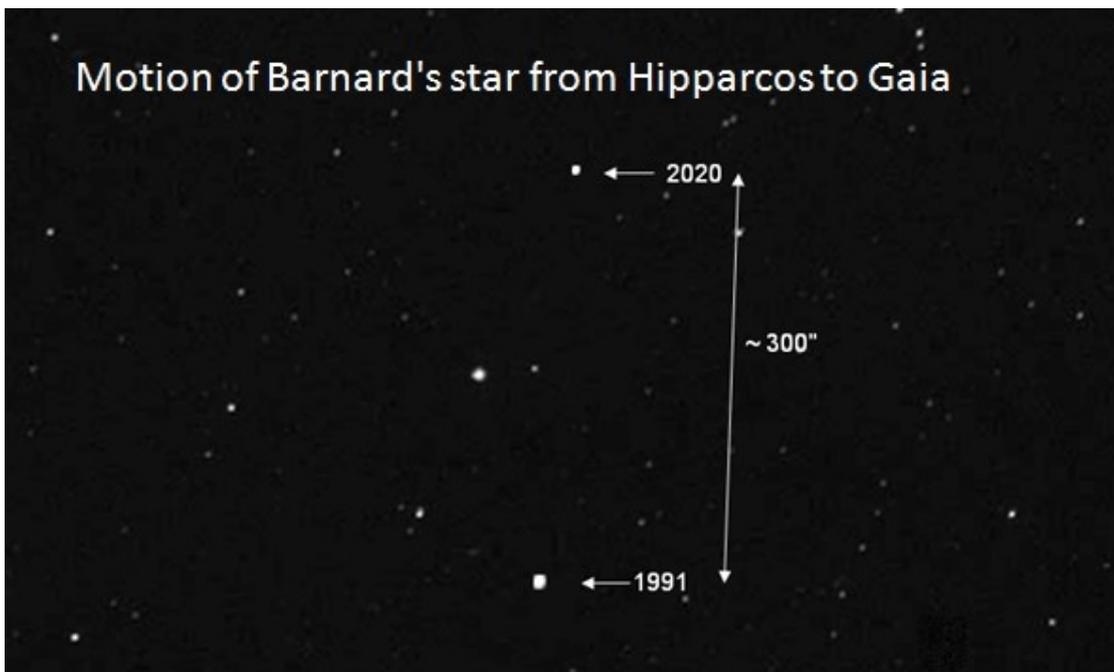
cal astronomy and remained largely unknown until late 19th century, when measurements of stellar proper motions had become almost routine, albeit very delicate.

The first person who suspected from observations that the stars have proper motions was the famous Edmund Halley in a paper inserted in the *Philosophical Transactions of the Royal Society* for 1718. This is (rightly) quoted in every book in history of astronomy, despite the weak evidence brought by Halley, while the much more convincing memoir of J. Cassini in *Mémoires Acad. Scien.* 1738 p. 331-42 is largely ignored. Here, the son of J.D. Cassini provides true measures of annual variations of the ecliptic latitude of few bright stars and shows that this cannot be accounted for by the motion of the ecliptic.

The path to the modern and more systematic determination of proper motions must be credited to the great German astronomer T. Mayer in a communication to the Acad. of Sci. of Göttingen in 1760. In this work one finds the first list of proper motions of any real value for a handful of stars (~ 80) observed 50 years earlier by O. Rømer in Copenhagen. A few years later W. Herschel will use this set to derive the motion of the sun.

Like the Gaia project, this episode displays the wonderful combinations of skills of European people leading to an epoch-making achievement. Gaia will stand on their shoulders.

Motion of Barnard's star from Hipparcos to Gaia



Gaia at the Astronomical Observatory of Strasbourg

J.-L. Halbwachs, P. Fernique

The Astronomical Observatory of Strasbourg is a department of the University of Strasbourg, which is the result of the evolution of a university founded shortly after 1870 when Alsace was under German administration. The observatory was inaugurated in 1881.

<http://astro.u-strasbg.fr/eng/index.php>

The connection between the Strasbourg Observatory and Gaia is much older than Gaia itself, since the idea of an astrometric satellite superposing two fields separated by a large and fixed angle was proposed by Pierre Lacroute as early as 1967, when he was director of the observatory. This project resulted in the Hipparcos satellite, and Gaia is another application of the same basic design.



The Strasbourg Gaia team. From left to right, CU4 people: Patrick Guilout and Jean-Louis Halbwachs; CU9 people: Pierre Fernique, François Ochsenbein, François-Xavier Pineau and Thomas Boch.

Today, the main contributions of Strasbourg to DPAC concern CU4 and CU9. In CU4, we are involved in the astrometric treatment of unresolved double stars, and especially of systems containing a component with variable brightness (the so-called VIM, from the pairs with fixed components to the true orbital binaries). In CU9, the Strasbourg astronomical Data Centre is preparing the integration of the future Gaia catalogue releases in Vizier (catalogue on-line access) and Aladin (visualization) services; as a demonstration, a simulated Gaia catalogue is already distributed on-line for DPAC internal use.

Aside from these DPAC activities, several scientists are preparing the scientific interpretation of the Gaia data in various fields, from the derivation of masses and luminosities of double star components to the dynamical evolution of the Galaxy.

Coordination Unit I – the launch year!

W. O’Mullane, B. Frezouls

CU1 System Architecture, currently with 51 members (Figure 1), has been very active since the start of DPAC in 2006. We have attempted to bring together members of all CUs to agree on important interfaces and working policies. One



Fig1: CU1 members at the 15th CU1 meeting held in ESAC in Oct. 2012

of the first decisions of CU1 (backed by DPAC) was to endorse Java as the single language of DPAC processing software. We have also attempted not to be too rigid with a distributed architecture allowing each Data Processing Centre a lot of leeway in choice of infrastructure including use of languages other than Java in some specific cases. DPAC has stood out for this decision, mainly for its ability to have practically all processing software in a single language.

CU1 instigated guidelines for documentation, reporting, tracking of effort and milestones. The Information Management Tool (Comoretto et al., 2012) has been a major piece of work in CU1. We maintain the LaTeX environment and provide the templates which most of DPAC use; we hope this saves time and effort. It helped get us through the agency reviews!

Over the past six years, several technical workshops have been organised for DPAC developers. Some of these workshops took place at ESAC and CNES (the two main contributors of manpower to CU1) but others were

held in Torino, Cambridge, Geneva and most memorably Tenerife! These started out as tutorials on working together with Subversion, MANTIS, Eclipse etc., and progressed to more advanced topics such as performance and numerical programming. Feedback from attendees has been generally positive and the next workshop will be operations-oriented.

Many common tools for the DPAC

CU1 is not just about documentation; there is also a lot of software written. GaiaTools, for example, provides a number of common utilities for DPAC developers, written by DPAC developers, such as numerical algorithms, database access tools, job scheduling facilities and much more. There is also the MBDDictionary Tool, which has been used to define a single data model for DPAC. The MDB itself is less visible outside of ESAC and yet is the core repository of all Gaia data during the mission! It is so important that we will keep a copy at CNES. Most visible to the DPCs is the Gaia Transfer System (GTS), we have now settled on a commercial product, Aspera, for this. Its proprietary UDP transfer protocol allows us to transfer data extremely quickly and reliably between the DPCs easily meeting all the GTS requirements (Figure 2). Also essential to Gaia, is the MOC Interface Task (MIT), it handles all data coming from the Mission Operations Centre (MOC) in Darmstadt. The latest version works faster than real time on a single computer node.

CU1 continues to serve DPAC as a whole through software and techniques and we look forward to serving up the Gaia data stream in the near future!

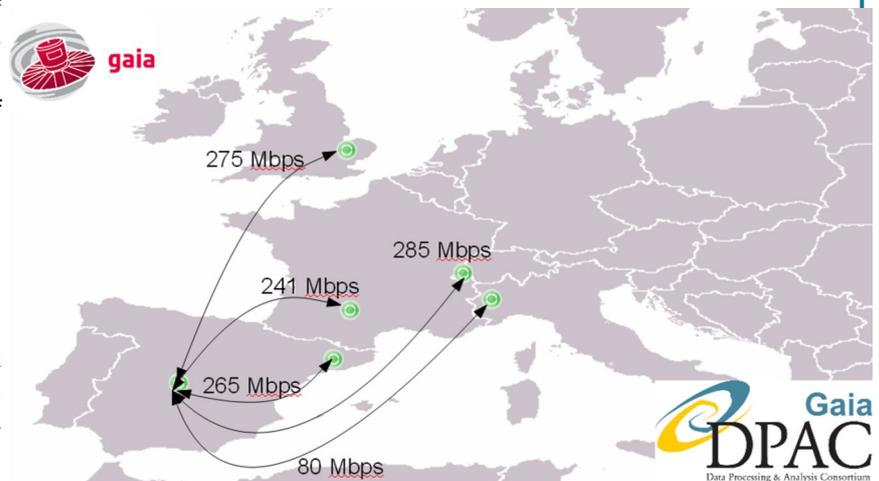


Fig 2: Data Rates achieved to each DPC from ESAC using 300Mb Aspera license.

Gaia and unresolved galaxies

M. Kontizas, I. Bellas-Velidis, for the Athens University Gaia Extragalactic Team

Gaia is expected to provide valuable information not only on objects of the Milky Way but on extragalactic objects as well, such as:

- i. Those galaxies, near enough to be resolved in stars and with their brightest stellar component (depending on the distance of course) within the detection limit and spatial resolution of Gaia.
- ii. Galaxies far enough to show up as unresolved sources (point-like).
- iii. Quasars are also expected to be very significant objects for Gaia (about 5×10^5 objects), investigated by another team.

We concentrate here on our work concerning the exploitation of the very low resolution BP/RP spectra of about 10^7 unresolved galaxies (seen as point sources) that are expected to be detected by Gaia. Our work is divided in two parts, a) production of a synthetic galaxy spectra library as realistic as possible and b) development of an algorithm for the classification and parameterization of the unresolved galaxies (UGC) and its implementation in the DPAC science pipeline.

Filtering the spectra

The library of galaxy spectra has been produced with the code PEGASE.2 (Fioc & B. Rocca-Volmerange, 1997, 1999; Le Borgne & Rocca-Volmerange 2002). The major requirement of our team is to obtain, not just a small typical set of synthetic spectra (Figure on the left, the yellow points), but to derive an extended realistic library, in order to cover as much possible the variety of the galaxy spectra in the Universe as seen by Gaia.

A very large grid of physical parameters is explored with PEGASE.2. It is common that not all mathematical values in a theoretical model (particularly in a very complicated

code as this) are meaningful to describe real situations. So the final spectra have to be compared with real ones in order to eliminate the sets of parameters that lead to production of unrealistic spectra. The tools we have been using to investigate this are:

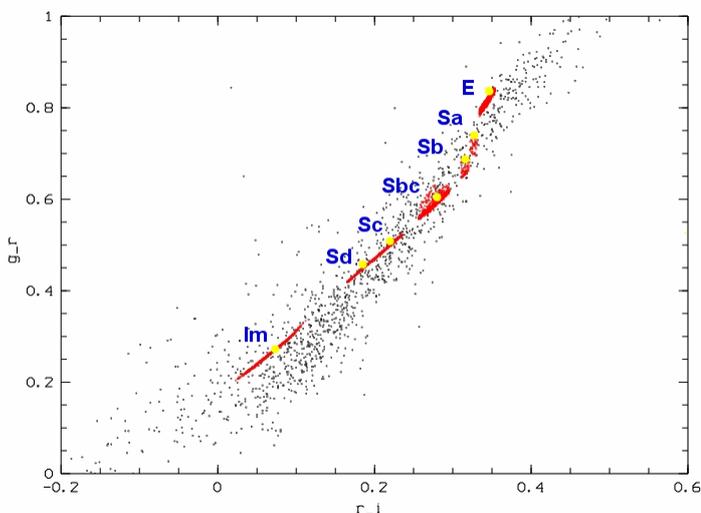
- Principal Component Analysis (PCA) applied to the synthetic spectra.
- Specific examination of the appearance of the spectra with emphasis on Star Formation Rate (SFR) behaviour.
- Analysis of colours derived from the synthetic spectra with the 2-color diagrams of observed galaxies.

In fact tests with PCA have indicated that the SFR in each scenario is the most significant process dominating a galaxy's evolution history and consequently the stellar content during its lifetime. So we have to check a) which sets of SFR parameters produce unique spectra and b) search for non desirable spectra considering the definition of specific spectral types (for example too many emission lines in an Early type galaxy spectrum, very slow SFR for the specific types etc.).

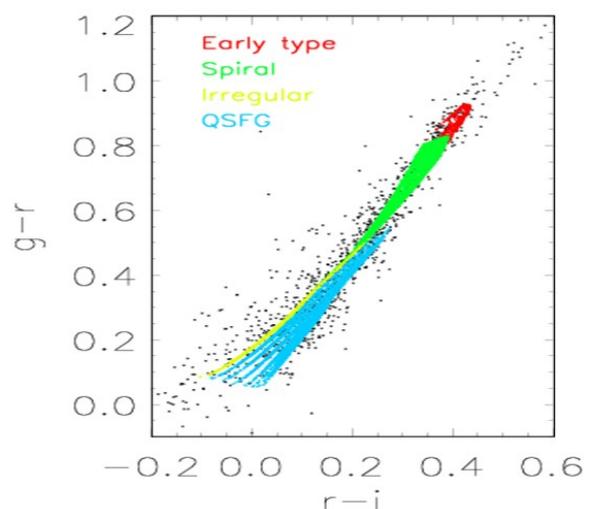
Conclusion

We have reached the conclusion that an optimal classification of our synthetic spectra leads to only four spectral types: Early, Spiral, Irregular, and Quenched star Forming Galaxies (QSFG) produced with a certain, optimized set of parameters and specific law of SFR. In the Figure on the right we show the synthetic colors of the spectral library for the four galaxy types, superimposed on the real colours of observed galaxies from SDSS (black points).

Our very warm acknowledgements are due to SDSS consortium for the observed galaxies data and to ESA/PRODEX for the current financial support (2012-2014) that enable us to continue working for DPAC.



Tsalmantza 2009 A&A



Karamelas et al, A&A, 2012

Initial data flow: from Gaia to DPAC

S. Els, N. Cheek, H. Siddiqui

By the time the DPAC processing machinery is busily crunching the data collected by Gaia, those bits and bytes will have travelled a long way and undergone a number of storage and transmission steps. This article outlines the route from Gaia to DPAC, and shows that the data will arrive in a rather “unorthodox” order, posing quite some challenges to the DPAC daily processing pipelines.

Gaia is continuously scanning the sky and the data which have been generated on-board are stored in memory ready for transmission to Earth. The storage system on-board Gaia has been highly optimised. Not only to make it safe against data loss, but also to guarantee a priority transmission of the most important data to Earth.

Basically all observations brighter than 16mag receive a high priority. Also a number of narrow bins in magnitude for fainter objects are of high priority. This scheme will enable us to perform the daily calibrations as well for the fainter magnitudes.

This prioritizing also means that some data cannot be sent to the ground during a contact, but will remain on-board until all data with higher priority, or older data of the same low priority have been telemerged. In particular during periods when Gaia is conducting galactic plane scans it is expected that some data will remain for up to two or three weeks on board.

The transmission of “unordered” data is thus inherent to the Gaia system. It is to such a level that we

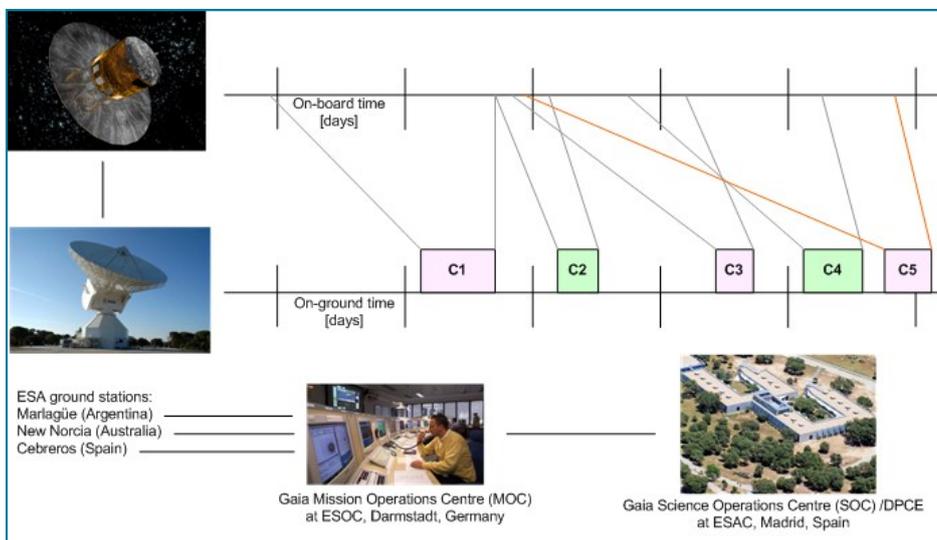
may not always be able to predict when the observation of a certain object will become available for scientific processing.

Data transfers on ground

The Gaia ground segment will make use of the three antennas of ESA's deep space network; Cebros (Spain), New Norcia (Australia), and Marlagüe (Argentina), pictured in the opening page of this issue. The times when any of these ground stations are used to communicate with Gaia are called “contacts”, and are in principle scheduled months in advance.

From here the data are sent to the Mission Operations Centre (MOC) at ESOC, and finally being forwarded to the Science Operations Centre (SOC) at ESAC. While these transfers are straightforward one must expect that, like with any other complex data transfer system, contingencies can occur. With a mission duration of more than five years some interesting situations are certainly to be expected. And those will result in an additional reordering of data.

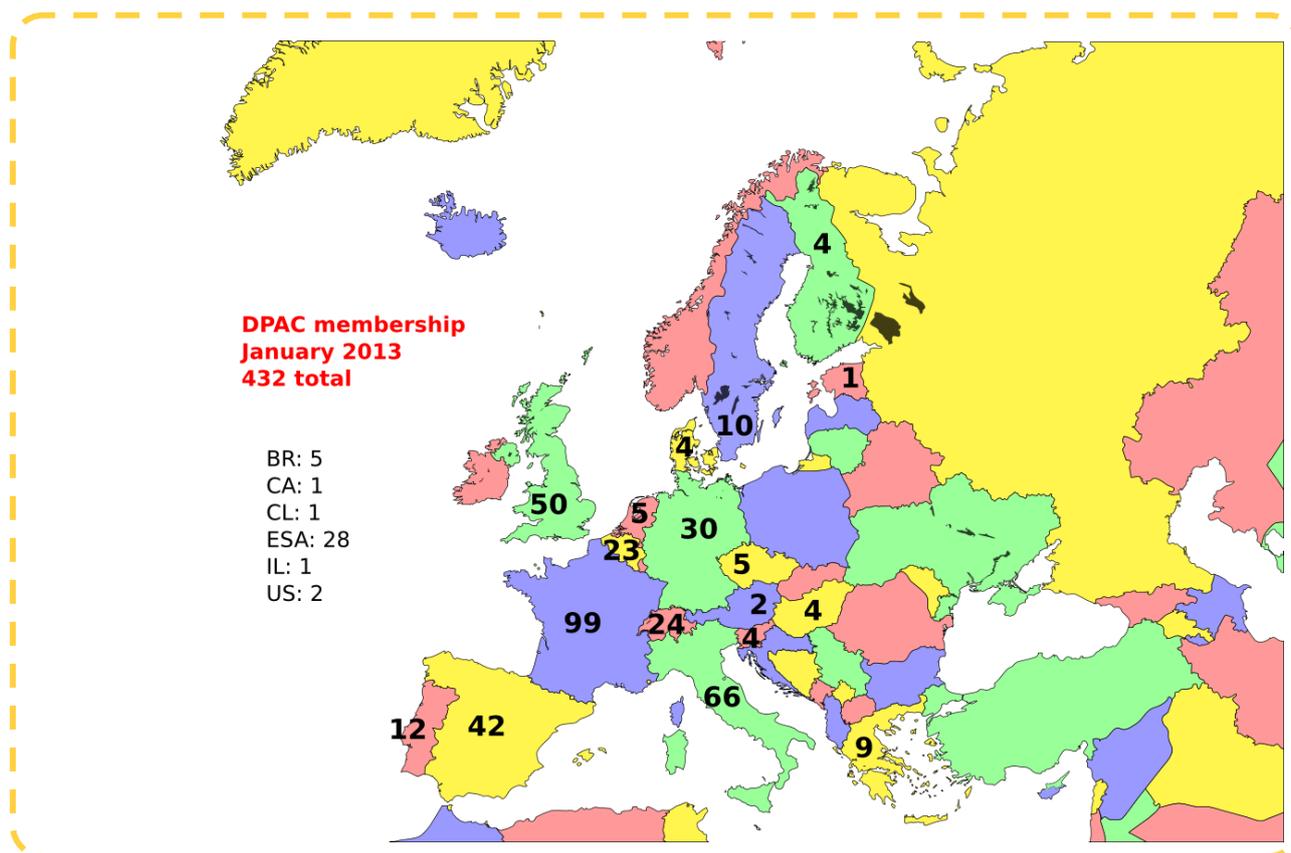
The data flow from Gaia to DPAC is long and optimized for some very good reasons. We are accustomed to reading information in chronological order, but despite all the care exercised to optimise the data flow one must be aware this may not be the case for Gaia. The daily DPAC processing chains will have to cope with such data, and be prepared to handle contingency situations. All this poses challenges to the daily processing pipelines. With the currently on-going rehearsals, DPAC is preparing itself for this data challenge.



Data transmission to the ground

To do so, every piece of data generated on-board is stored in a sector of a file of certain type. Each file type is associated with a certain priority for being down-linked. This means that data in files with a high priority will be transmitted to Earth before data in files with a lower priority. But sectors from (most) files are read and transmitted in chronological order, i.e., oldest first. The housekeeping data - the data which hold the important parameters of the spacecraft operations, like voltages, micro-thruster values, basic angle monitor data and the attitude determined by the Gaia spacecraft - receive the highest priority; even higher than science observations. This assures that during a contact with the ground all data necessary to verify Gaia's proper function are being transmitted. The science data, i.e., the observations collected by the CCDs of the various instruments, are prioritized according to the object's magnitude.

DPAC info



DPAC meetings

IIOC meeting #5			
5 - 6 March 13	MSSL	A. Brown	http://www.rssd.esa.int/wikiSI/index.php?instance=Gaia&title=Calibration_Task_Force:_Meetings:_IIOCSSL2013
CU1: System Architecture #16			
13 - 15 March 13	ALTEC, Torino	A. Brown / W. O'Mullane	http://www.rssd.esa.int/wikiSI/index.php?instance=Gaia&title=CU1:_System_Architecture:_Meetings:_CU1M16
CU5: Photometric Processing #12			
19 - 21 March 13	Cambridge	F. Leeuwen / F. de Angeli	http://www.rssd.esa.int/wikiSI/index.php?instance=Gaia&title=CU5:_Photometric_Processing:_Meetings:_CU5M12
GSRR kick off meeting			
20 March 13	ESTEC	W. O'Mullane	http://www.rssd.esa.int/wikiSI/index.php?instance=Gaia&title=DPAC_Reviews:GSRR
CU8: Astrophysical Parameters #11			
15 - 16 April 13	Royal Observatory of Belgium, Brussels	Y. Fremat / C. Bailer-Jones	http://www.rssd.esa.int/wikiSI/index.php?instance=Gaia&title=CU8:_Astrophysical_Parameters#Meetings
GST #41			
18 - 19 April 13	ESTEC	T. Prusti	http://www.rssd.esa.int/wikiSI/index.php?instance=Gaia-GST&title=Meetings:_GST41
DPAC/SOC Operations Rehearsal #3			
22 - 30 April 13	several locations	A. Brown / others	