Gaia Downlink Data Processing

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The Gaia Mission

The Gaia spacecraft was launched in December 2013 and placed around the Earth-Sun Lagrangian L2 point (due to its thermal stability) and will observe approximately 1.2 billion stars or 1% of the stellar population of the galaxy, on average 70 times during a 5-year mission. With these star observations combined with on-ground software processing, it is able to map the positions, distances (parallax) and proper motions of the stars to an unprecedented accuracy [1].

The first of a number of Gaia Data Releases was made to the astronomical community on September 2016 [2]. Further updates with refined positions, parallaxes, and other stellar properties based on further stellar observations will be made over the next three years.

Daily Downlink Data Processing

Spacecraft telemetry are downlinked to the Mission Operations Centre (MOC) at ESOC, Germany and forwarded to the Data Processing Centre at ESAC (DPCE), Madrid. Typically 40 GB of telemetry are processed at DPCE per day. The main processing subsystems are the MOC Interface Task (MIT), the Initial Data Treatment (IDT) and First Look (FL). The MIT extracts raw data for each source observation from the telemetry provided by MOC along with housekeeping data, and IDT determines the initial position of each source using centroiding techniques, and associates that position with a star by cross-matching against a working star catalogue. FL provides information related to the payload health (attitude problems, CCD damage, etc).

DPCE Resources

Typically 40 million source observations are processed per day. To achieve this, the daily pipeline is run on approximately 15 RHEL machines, each with 64 GB of memory and 20 cores. The subsystems exchange data through a database running the Cache Database Management system [3].

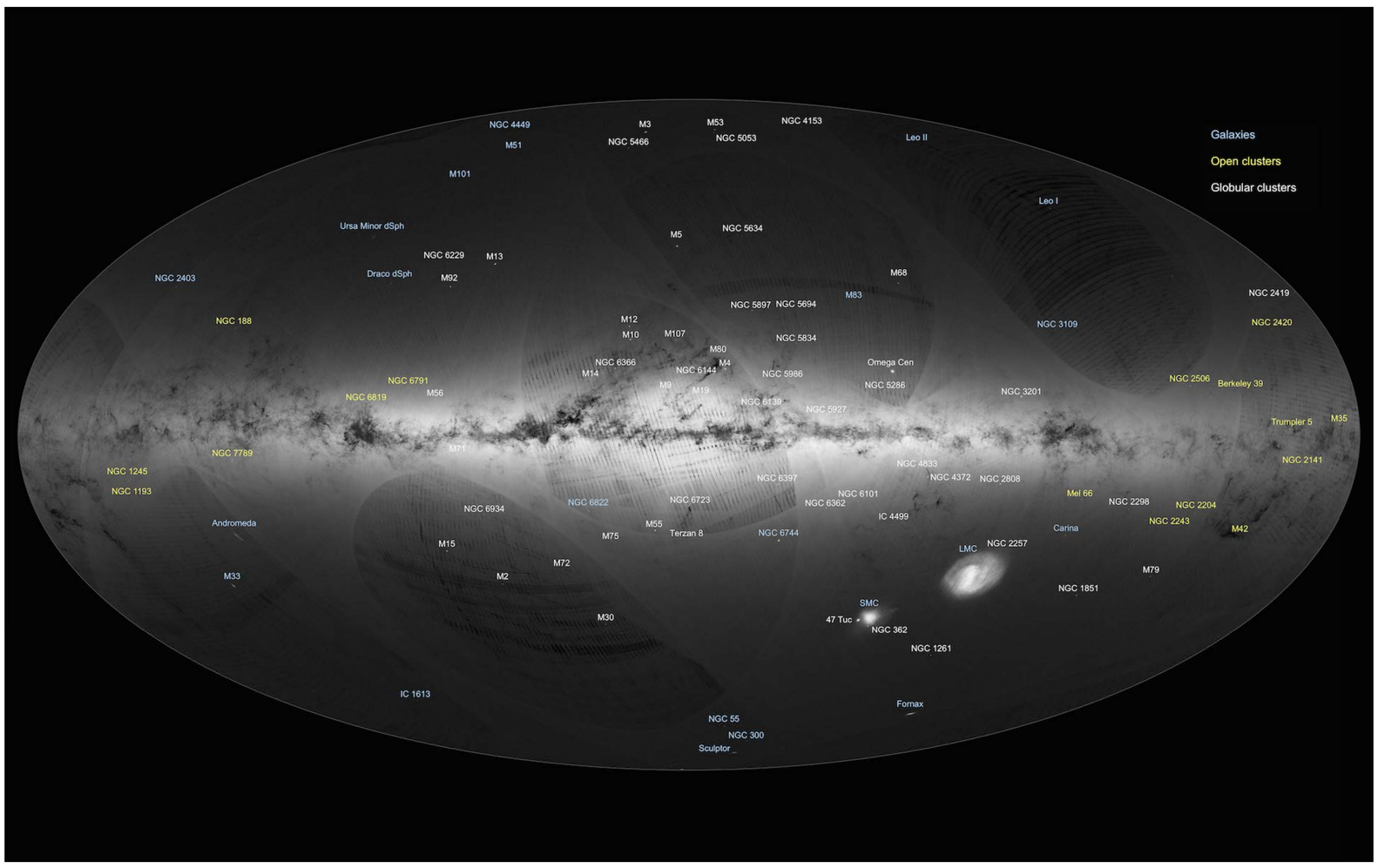
Cyclic Data Processing

Data from the daily processing are sent to the external Data Processing Centres (DPCs) across Europe for subsequent detailed processing, that determines further stellar properties such as temperature, variability, spectroscopy and binary star classifications. The data are also forwarded, after some further treatment by DPCB, to the AGIS system running at DPCE that determines accurate star positions and distances.

Uplink

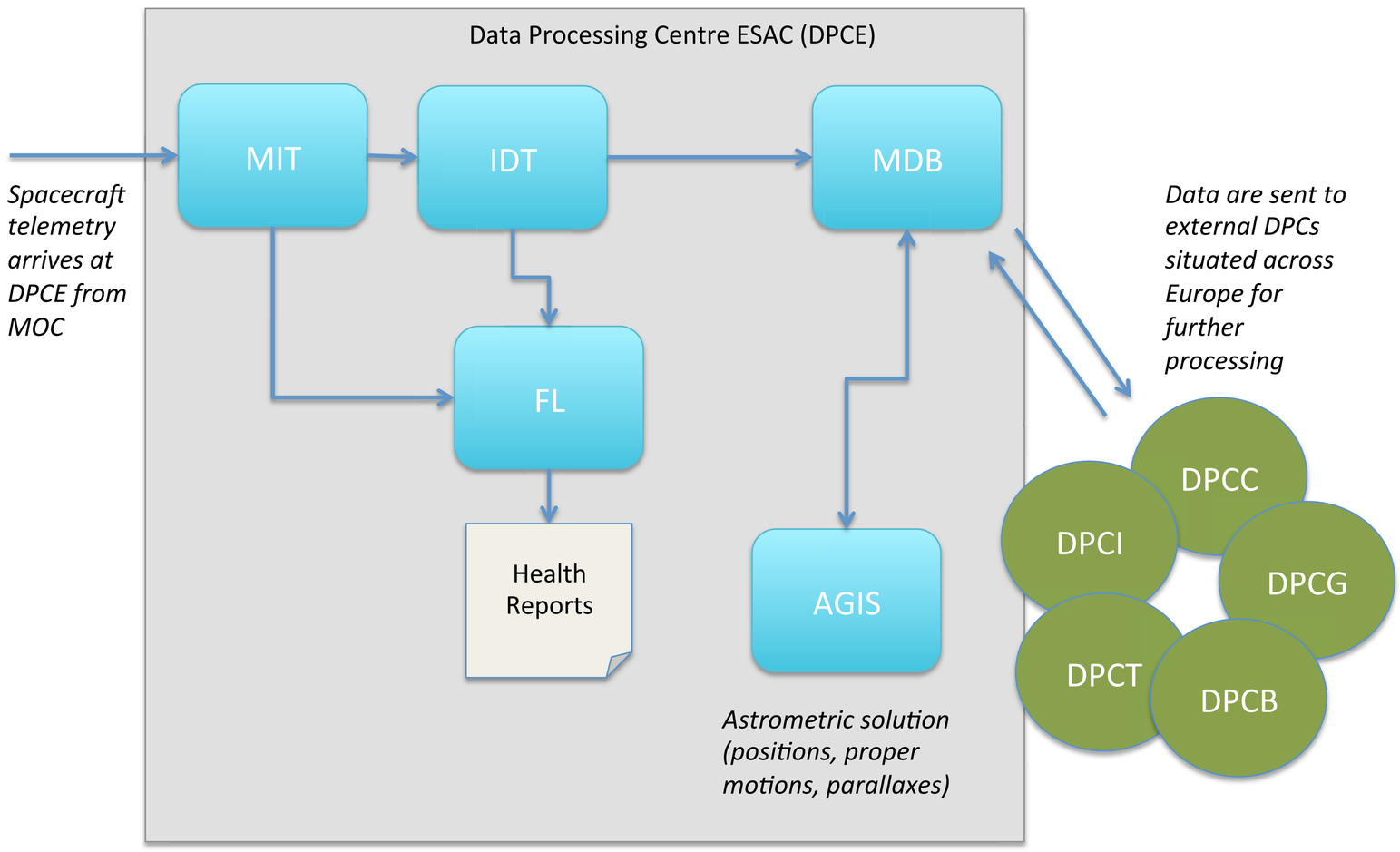
Payload characteristics (eg CCD performance) occasionally requires changing. Inputs from the Calibration Team at ESAC are translated into XML files that are then forwarded to MOC for review and uplinked to the spacecraft.

Gaia Star Map



Map of stellar positions determined from Gaia Data Release 1 (Credit: ESA/Gaia/DPAC)

Downlink Processing



Problems and Lessons Learnt

1. **Implement continuous integration** at the outset
2. **Identify critical items** that need careful attention in detail, and address them early
3. **Ensure that the interfaces with other groups are clear**
4. **Test campaigns** involving the exchange of meaningful simulated data across interfaces should be conducted as soon as possible
5. **Make systems robust to data gaps** or out-of-order data
6. **Account for data losses at each subsystem output**
7. **Trace source of processed data at each stage**

References

[1] Gaia Collaboration, Prusti, T., de Bruijne, J.H.J., et al., 2016a https://arxiv.org/abs/1609.04153
[2] Gaia Collaboration, Brown, A.G.A., Vallenari, A., et al., 2016b https://arxiv.org/abs/1609.04172
[3] http://www.intersystems.com

Acknowledgements

Sky map credit: ESA/Gaia/DPAC, courtesy of A. Moitinho & M. Barros (CENTRA University of Lisbon), F. Mignard (Observatoire de la Côte d'Azur), on behalf of DPAC. See http://sci.esa.int/gaia/58209-gaia-s-first-sky-map.