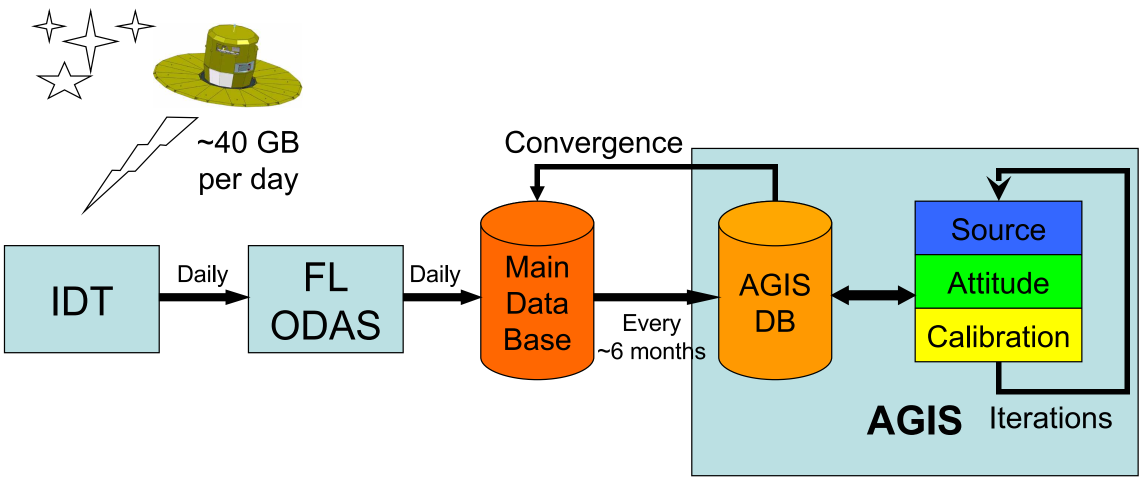

Simplified schematic overview of Gaia's astrometric data reduction system. The main processing modules are IDT, FL-ODAS, and AGIS which will iteratively generate the final astrometric mission products.

The objective of Gaia's astrometric data reduction system is the construction of the core mission products: The five standard astrometric parameters, position (α, δ), parallax (ϖ), and proper motion ($\mu_{\alpha*}$, μ_δ) for all observed stellar objects brighter than $G = 20$ mag with targeted micro-arcsec accuracies (e.g. $<$ 10 μas [$G < 10$ mag], $<$ 25 μas [$G = 15$ mag], $<$ 300 μas [$G = 20$ mag]). To this end, all the available $\sim$70 observations per object gathered during Gaia's 5 year lifetime will have to be combined in a single, global, and self-consistent manner.

The figure depicts a simplified schematic overview of the system. The $\sim$40 GB of daily telemetry data coming from the satellite are first processed by the Initial Data Treatment (IDT) which determines from the raw CCD measurement data astrometric image parameters ("centroids"). A second main task is the so-called "cross-matching" that links observation data to celestial objects. These outputs of IDT form the main input to the One Day Astrometric Solution (ODAS) which is part of Gaia's First-Look system. ODAS produces from one day's worth of data estimates for source positions, satellite attitude and calibration parameters at the level of sub-milli-arcsec accuracy. The results of the daily processings of IDT and ODAS are written to the Main Database.

Gaia's core data processing module is the Astrometric Global Iterative Solution (AGIS) system. AGIS treats the wanted source parameters, the satellite's attitude and calibration parameters as unknowns and tries to find the best global match in a least-square sense between all measurement data and an observational model that is formulated in terms of these unknowns. Numerically this is done through an iterative adjustment of the parameters from a starting point to an approximation to the sought solution of the least-squares problem. The system is considered converged and iterations are stopped if the adjustments become sufficiently small. At this point the results are written back to the Main Database. The fact that attitude and calibration parameters are optimized together with the source parameters in the same scheme is a necessity since they cannot be determined to the required level of micro-arcsec accuracy in any other way. This elegant aspect of the astrometric data reduction is the reason why Gaia is sometimes referred to as a self–calibrating mission.

Only single, non–variable stars which fit the standard 5–parameter astrometric model – in number perhaps up to 500 Million – will take part in such a "primary" AGIS cycle. For the remaining objects (binary, multiple systems, etc.) only provisional values will be computed by AGIS in a subsequent "secondary" cycle which only optimizes source parameters using the attitude and calibration solutions from the preceding primary cycle. Astrometry for secondary objects may be further improved by dedicated software in CU4 ("Object Processing").

Unlike IDT and ODAS which run daily, AGIS is executed only about every 6 months on an ever increasing data volume. IDT, ODAS, and AGIS are developed in the framework of Gaia's Data Processing & Analysis Consortium (DPAC) Coordination Unit 3. During operations all systems will run on dedicated processing hardware installed at ESA's European Space Astronomy Centre (ESAC) in Spain near Madrid. Owing to the large data volume (100 TB) that Gaia will produce and the iterative nature of the processing the computing challenges are formidable: The AGIS processing alone is estimated to require some 10^{21} FLOPs which translates to runtimes of months on a baselined 10 FLOP/s local computing system at ESAC. The usage of external Cloud computing services is being studied as a possible alternative.