



# Publishing Gaia Science Alerts

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## Gaia Science Alerts Project

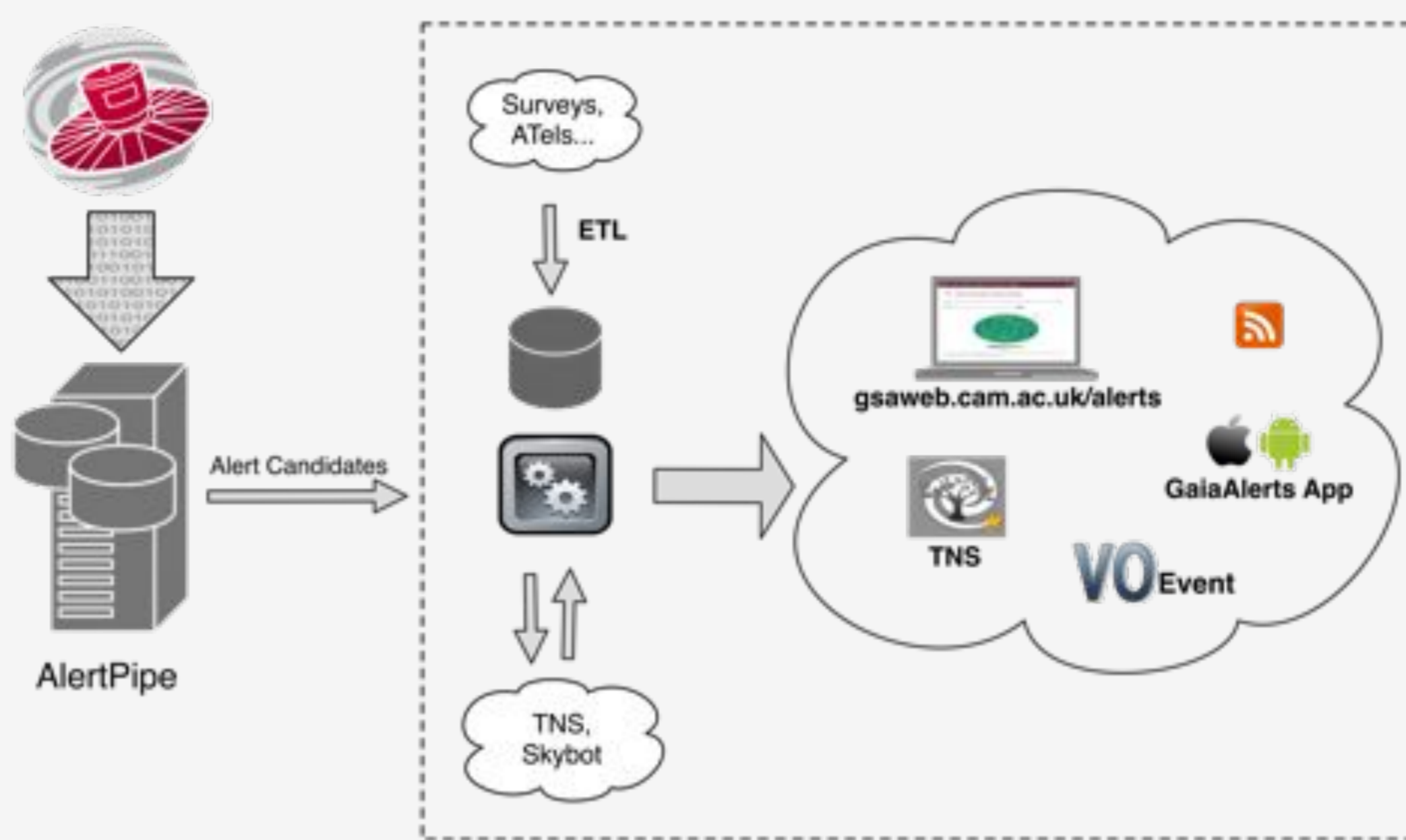
While Gaia is mapping the Milky Way measuring the positions, distances and motions of about a billion stars it is also spotting thousands of transients. These transients could be stars exploding as supernovae, black holes swallowing stars, AGNs, CVs etc. The Gaia Alerts project is working to find such events in the data from Gaia, and to announce them to the world in real time.

To find new transients, brightness measurements for objects in the same patch of sky observed by Gaia at different times must be compared to see what has changed. The Gaia Science Alerts team has developed the software, *AlertPipe*, which performs this check automatically and detects any new sources, and the *Gaia Science Alerts (GSA) Publisher system* makes the discoveries available to the astronomical community.

These new findings are advertised in different formats and ways:

- > Though a dedicated website in CSV, HTML and RSS formats
- > Reported to IAU-Transient Name Server<sup>1</sup>
- > Broadcast as VOEvents
- > Notifications to GaiaAlerts App (iOS and Android)
- > On Gaia in the UK website (<https://gaia.ac.uk>)

## Gaia Science Alerts Publisher



The Gaia Science Alerts (GSA) Publisher is located at:

<http://gsaweb.ast.cam.ac.uk/alerts>

This web application has a front end with a public area where all the information about the alerts is made accessible to the astronomical community, and a restricted area where the administration of the site and the publication of the alert candidates takes place.

The back end of the GSA Publisher system manages the update of the information of the published alerts with the latest data from Gaia as it comes in, and also handles the collection of all open access data from other transient surveys available on the Web.

The administration area allows granting granular access to groups and users to the different pages and functionalities of the GSA Publisher.

There is a versioning system in place to track the modifications.

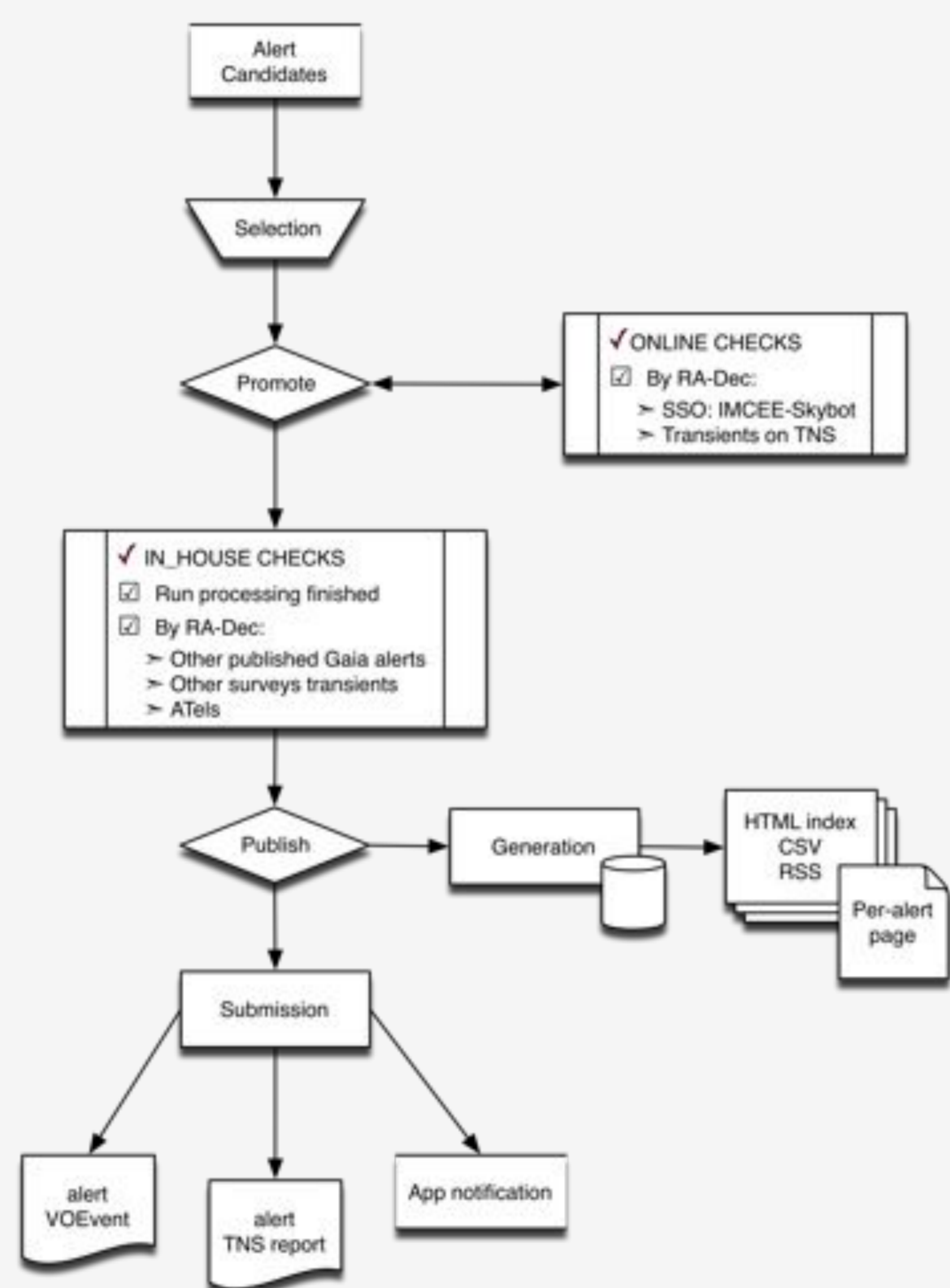
## Alerts Publishing Workflow in a Nutshell

The publishing process takes place in a restricted access area of the GSA Publisher website. The alerts pinpointed by the AlertPipe are displayed to the publisher user who selects the most reliable candidates.

After confirming that there was not any preceding Gaia alert in that position and the completion of processing the run, the application connects to IMCEE-Skybot<sup>2</sup> to check if there is any Solar system object (SSO) in the surroundings and then to the Transient Name Server (TNS) website to establish whether this transient has already been discovered by someone else. To finalise the alert candidates promotion process, the coordinates are cross-matched against the in-house data collected from other transient surveys and Astronomer's Telegrams<sup>3</sup>.

The publication action triggers the submission of the report containing the alert data to TNS, generates a VOEvent and submits the notification to GaiaAlerts mobile app. In the website, the published alert has now a per-alert web page that comprises all the scientific parameters of the object, a finding chart, the lightcurve as an image and in CSV formats, the dispersed spectra<sup>4</sup> from the red and blue photometer prisms on board Gaia and the results of cross-matching the position of the newly alerting source and other transients discovered at the moment of publishing.

The lightcurve and spectra are updated daily with the new data coming from Gaia. The cross-matches are updated hourly with the new findings of other transient surveys. Along with these data, the alerts follow-up observations collected by the Cambridge Photometry Calibration Server<sup>5</sup> are provided to give more contextual information to the Gaia discoveries.



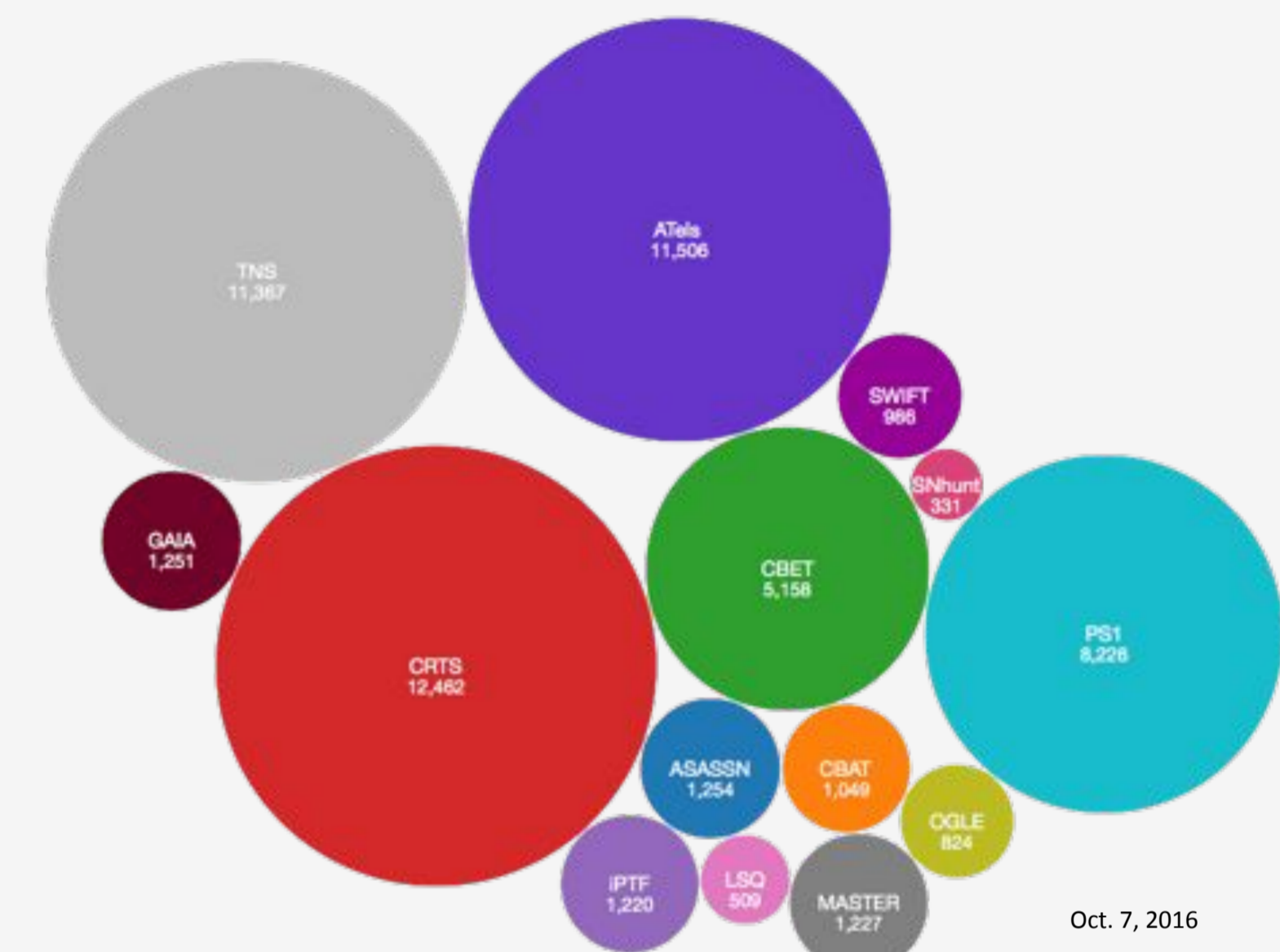
Gaia alerts publishing workflow.

## Collecting Data from Other Transient Surveys

It is important to know before publishing a new alert if it has been observed by any other survey, for this reason the GSA Publisher system collects as much data as possible about past and present transient events.

There are many transient surveys and as many if not more ways in which their discoveries are announced and hence made available to the astronomical community. The transient events are generally made public on the survey websites, which all have different schemas and data formats, and in addition the information content is very inhomogeneous.

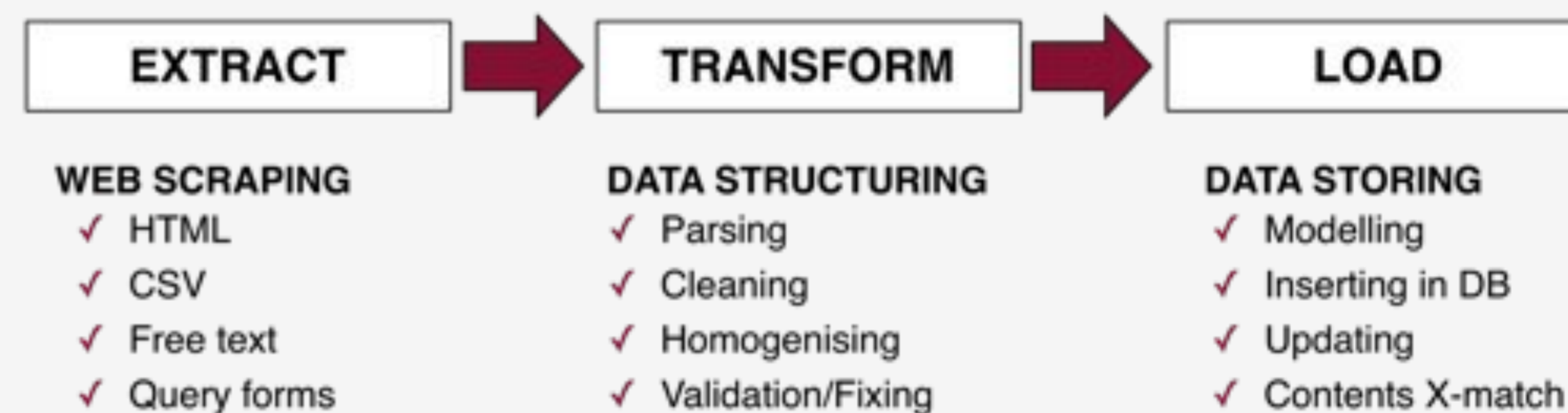
Another common way of announcing a transient event or its classification is through Astronomer's Telegrams (ATels), which are written mostly in free format text. For extracting any useful information in an automatic way, the HTML parsers must be developed to cope with any structure in the text and very diverse data formats.



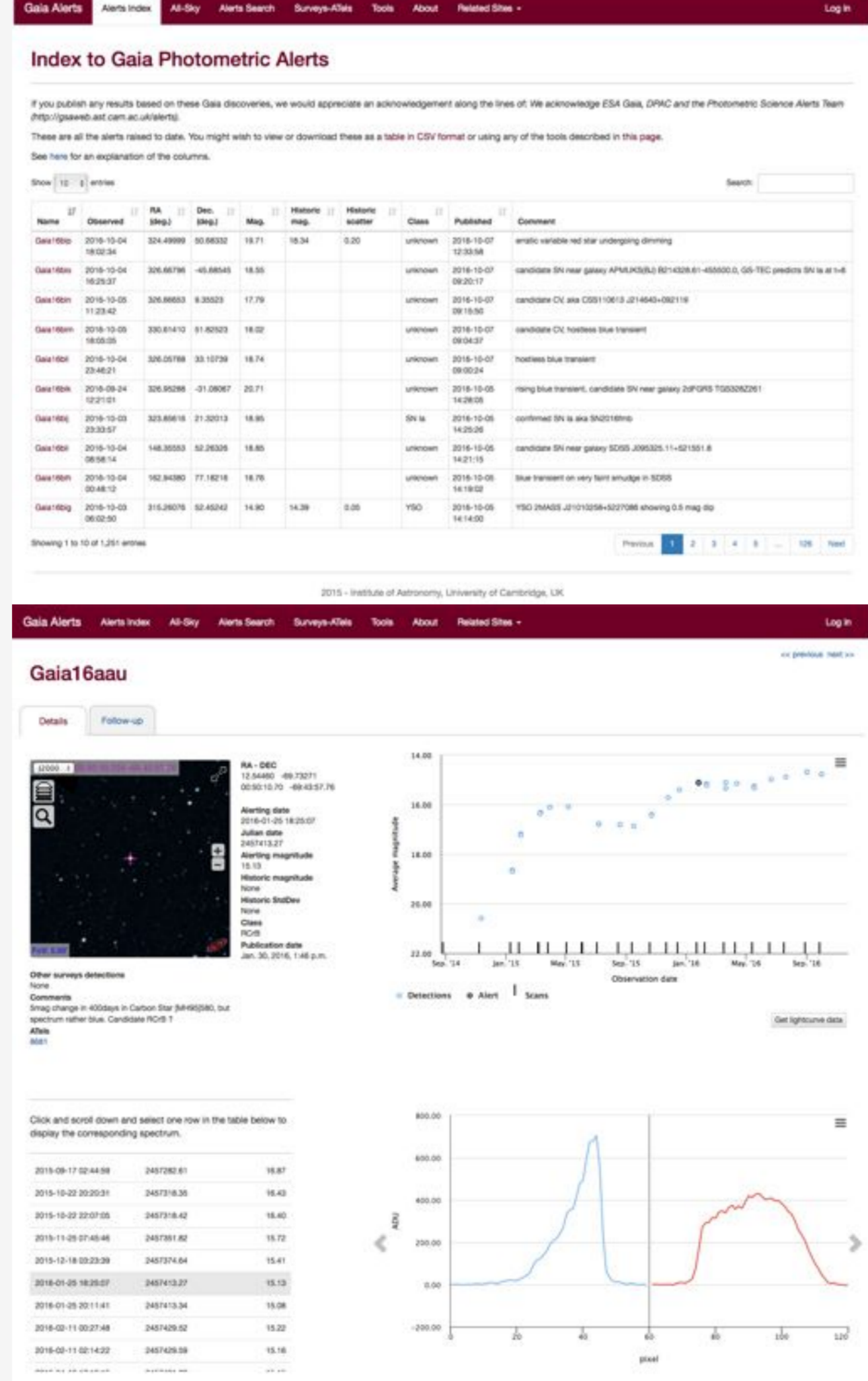
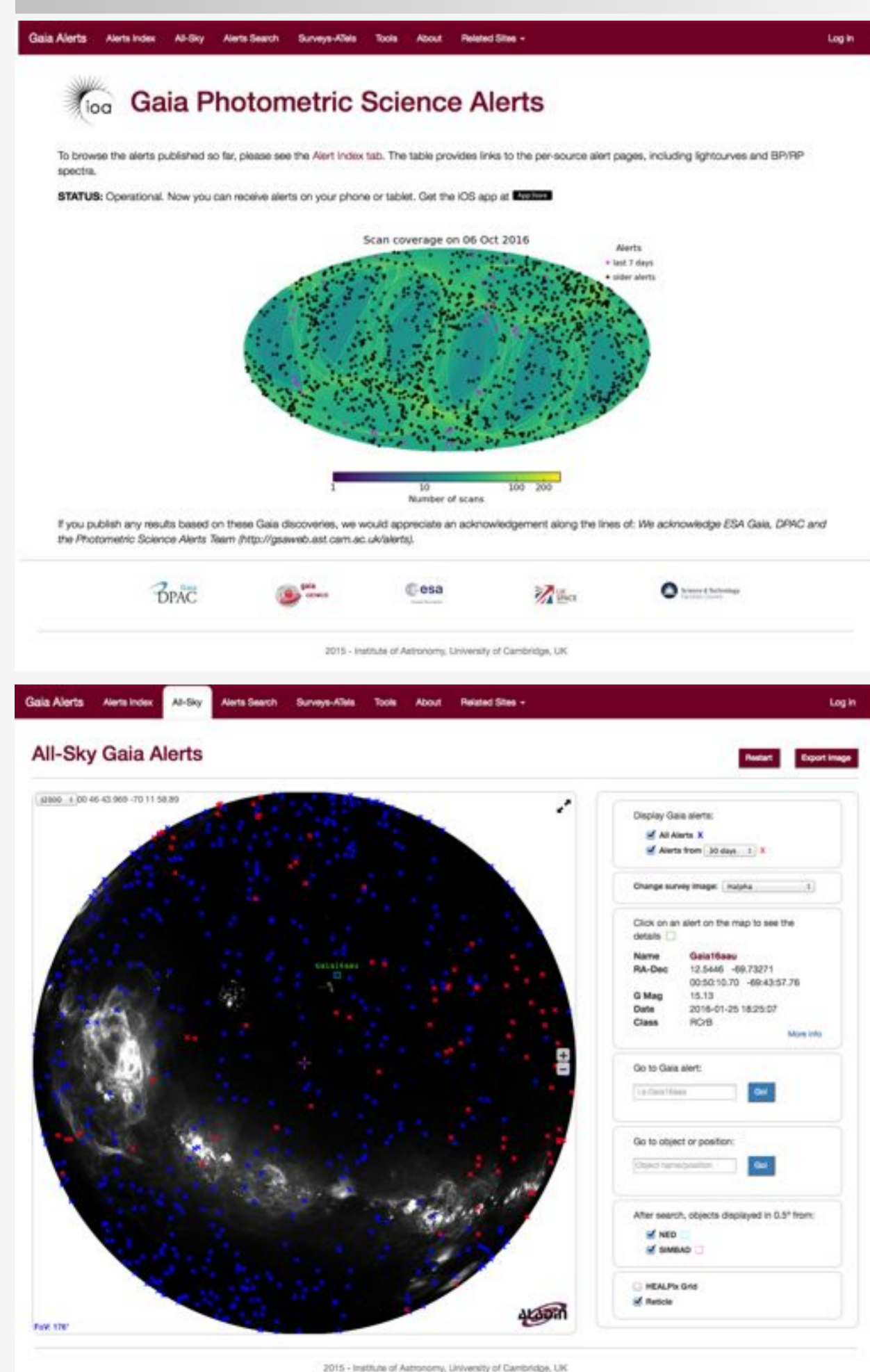
The chart shows the transient surveys collected on GSA Publisher database and the number of objects of each survey.

## ETL Techniques

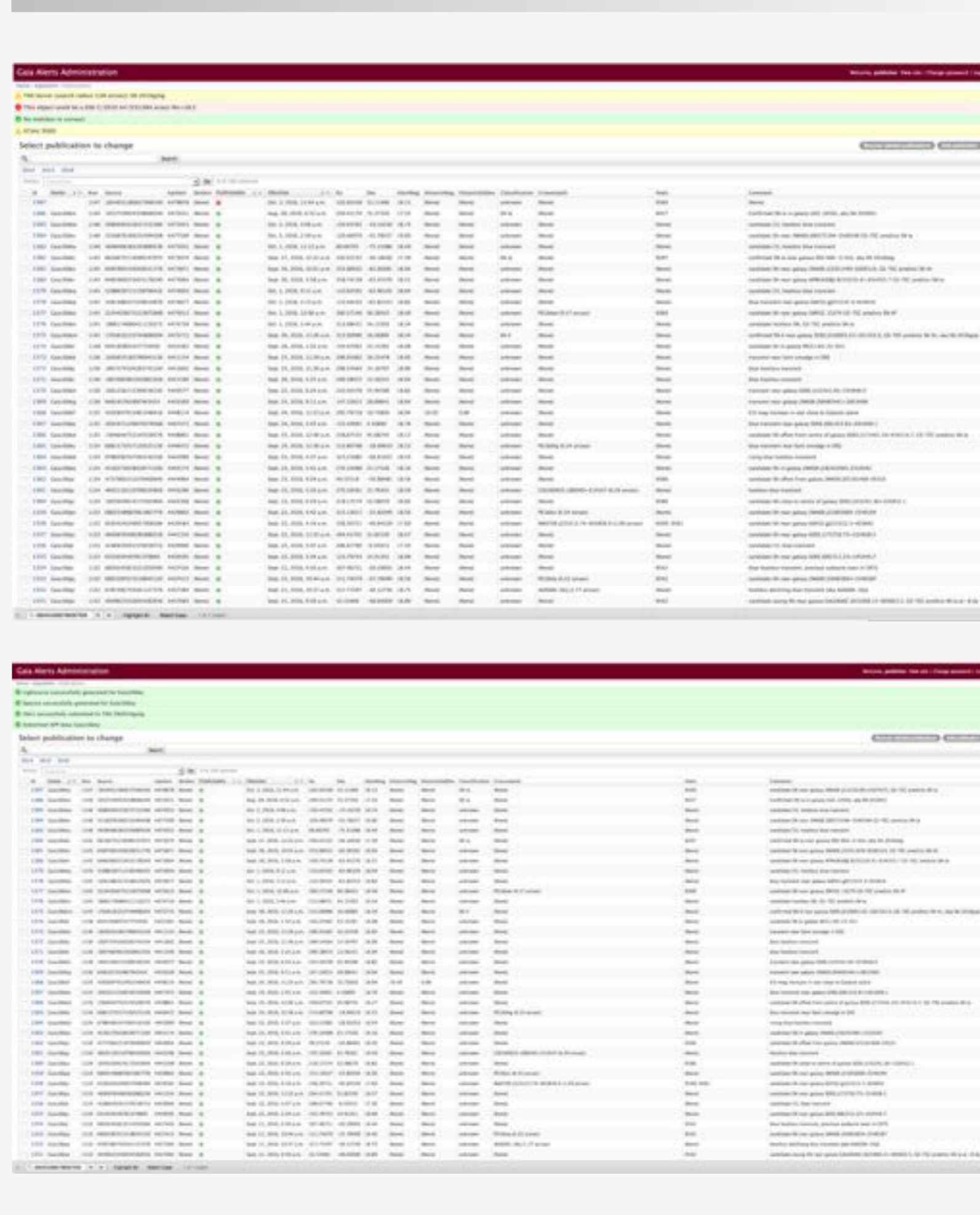
The techniques used in GSA Publisher system for gathering this valuable information are based on the ETL (Extract, Transform, Load) technologies that are widely known in Data Science.



## Open access website



## Publishing area (restricted access)



## Technologies

- ✓ Python
  - Django framework
  - Virtualenv, Astropy, Astroquery, lxml, matplotlib
- ✓ Responsive Web Design approach: Bootstrap 3
- ✓ PostgreSQL with Q3C<sup>6</sup> spatial indexing
- ✓ Javascript
  - Aladin Lite
  - Highcharts
  - jQuery, jQuery IU, dataTables
  - Tailored scripts for the website

## Future Work

The functionalities of the GSA Publisher system will be extended in the near future with a new access controlled area where the astronomers will be able to exchange followup data and comments to facilitate and contribute to the classification of the Gaia alerts.

The development is already ongoing and will be released before the end of 2016.

## References

- [1] "Transient Name Server" <https://wis-tns.weizmann.ac.il>
- [2] Berthier et al., *SkyBot, a new VO service to identify solar system objects*. ADASS XV. (2006ASPC..351..367B)
- [3] "Astronomer's Telegrams" <http://www.astronomersteam.org>
- [4] Blagorodnova et al. 2014. <http://ukads.nottingham.ac.uk/abs/2014MNRAS.442..327B>
- [5] "Cambridge Photometry Calibration Server" <http://gsaweb.ast.cam.ac.uk/followup/>
- [6] Kozlov et al., *Q3C, Quad Tree Cube*. ADASS XV. (2006ASPC..351..735)



## Acknowledgements

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