# AIRBUS ROBOTIC TELESCOPE

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## ABSTRACT

Airbus Robotic Telescope (ART) is Airbus' own end-to-end capability for Space Surveillance & Tracking, performing automated optical observations of space objects from LEO to GEO.

ART

- is a ground-based test-bed as a key enabler in the development of a future space-based system, allowing to test observation strategies and the end-to-end processing pipeline
- provides the data for SSA development activities (image processing, data analytics, tracklet correlation, orbit determination, uncertainty realism, SSA products & services)
- fosters cooperation within the SSA/SST community
- is participating sensor in measurement campaigns and activities (national, ESA, NATO, …)

A preliminary version with a 20 cm aperture ASA H8 telescope has been deployed in April 2018, while the final 40 cm aperture ASA H400 telescope has been installed in June 2018.

The paper will describe system elements and performances.

## 1 BASIC INFORMATION

In the following, basic system properties are summarised for the Airbus Robotic Telescope.


*Figure 1. Airbus Robotic Telescope (ART)*

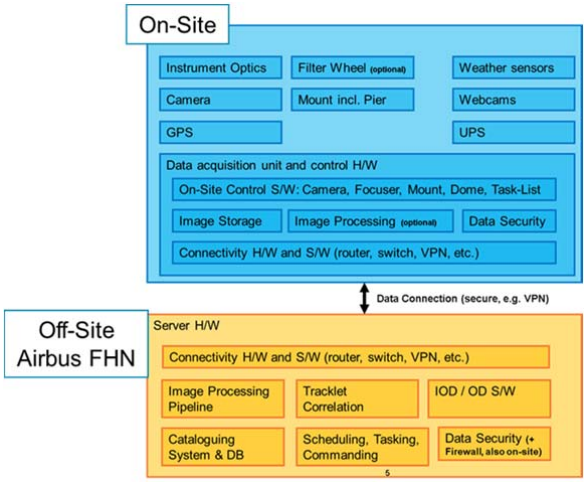


*Figure 2. System elements of ART*

| | |
|---|---|
| **Location** | **Extremadura, Spain** |
| Lat., Long., Alt. [deg, deg, m] | 38.21607 deg, -6.62778 deg, 570 m |
| **Aperture diameter** | **400 mm** |
| Focal length | 960 mm |
| Detector type | CCD, Interline |
| **Detector size [pixel]** | **4008 x 2672** |
| **Pixel scale [arcsec/pixel]** | **1.93** |
| Pixel size [µm] | 9 |
| **Field of view** | **2.15 deg x 1.43 deg** |
| Typical readout time | 2MHz (slow)/12MHz (fast) corresponding to<br>~8s readout / ~1.5 s readout |
| Wavelengths | 300 nm – 1000 nm panchromatic |
| Typical exposure time (GEO/MEO/GTO) | 0.5s – 5s |
| Tracking types | Surveillance, Tracking |
| Tasking methods | Scheduler (TLE-based, CPF-based, RADEC time series-based, |

| | |
|---|---|
| | etc.) |
| **Data products, format** | **Raw images: FITS**<br>**Astrometric and photometric reduction to CCSDS TDM format** |
| **Accuracy of products** | **< 1 arcsec (1-sigma)** |

*Table 3.Basic system properties*

## 2 ART SITE & INFRASTRUCTURE

ART is located in Extremadura, southern Spain for

- easy access
- favorable environmental and meteorological conditions

Observation conditions (which are yet to be confirmed over longer time period) are good:

- average of 21.7 mag/arcsec2
- seeing below 2 arcsec
- between 250 and 270 clear nights per year

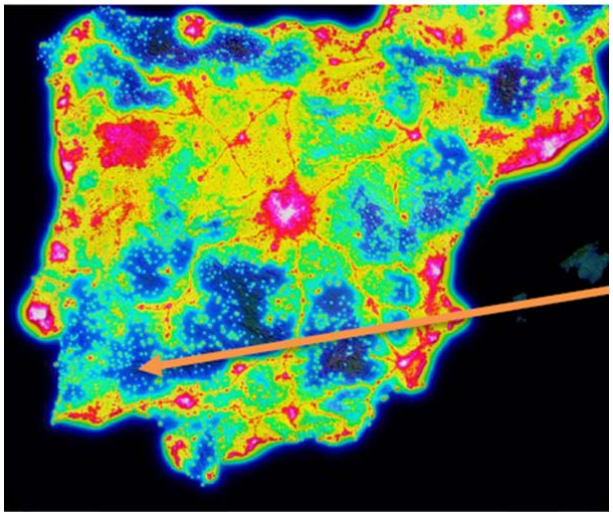

*Figure 4. Location of ART.*

Following infrastructure is provided as a service:

- Pier and roll-off roof
- Fibre-optic internet connection
- Power
- Maintenance

The facility is fully equipped for remote control of the robotic telescope

*Figure 5. Accommodation of ART*

## 3 OBSERVATION MODE: SURVEY

The instrument possesses a relatively wide FOV for its aperture:

- 2.15 deg x 1.43 deg (2.58 diagonal, limited by sensor size)
- Up to 4.2 deg diagonal possible (for 70 mm sensor)

Different kinds of survey patterns are possible.

For automated observations, the system needs to be provided with

- Right Ascension / Declination time series for the pointing of the telescope
- respective observation parameters (camera settings, etc.)

*Figure 6. Survey in sidereal mode.*

## 4 OBSERVATION MODE: TRACKING

Object tracking is possible down to LEO angular rates.

The system's interline CCD possesses an electronic shutter and an event timer card for very precise epoch registration.

Sensor tasking is possible via

- high-level inputs (i.e. TLE, CPF, etc.) or
- low-level inputs (RA/DEC time series)

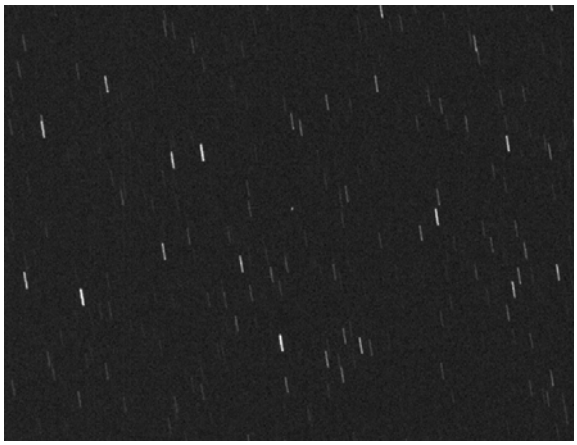

*Figure 7. Tracking mode*

## 5 AIRBUS SST DATA PROCESSING

The Airbus SST data processing system handles

- Ground-based and space-based sensors (simulated or real)
- Radar and optical measurements
- Orbit determination
- Object catalogue
- Standardised CCSDS data formats
    - Tracking Data Message (TDM)
    - Orbit Data Message (ODM)

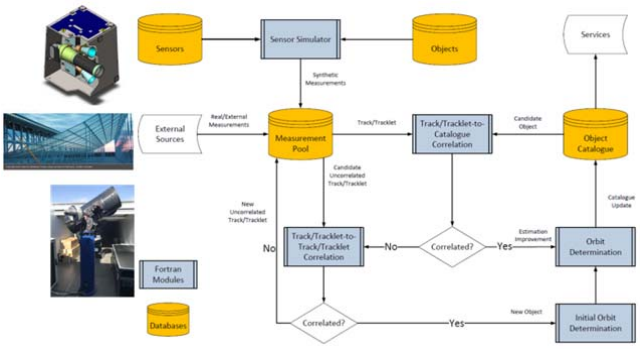


*Figure 8. Elements of the Airbus SST Data Processing System*

The system is an on-going Airbus-internal development

- PHD Thesis on Tracklet Correlation
- PHD Thesis on Uncertainty Realism
- Master Theses

## 6 ASTROMETRIC ACCURACY

Astrometric calibration is currently an on-going effort. In the following, preliminary findings are presented.

Shown results are derived from the comparison of GNSS tracklets against truth ephemerides from SP3 files:

- 10 tracklets (~ 20 measurements per tracklet)
- Averaged over 6 objects
- All from the same night (8.11.2018)

Following corrections have been taken into account:

- Light Time Delay of the target
- Annual and orbital aberration
- Refraction (already removed by optical fitting of image processing software)

| | Bias | 1-Sigma |
|---|---|---|
| **RA [arcsec]** | 0.06 | **0.38** |
| **DEC [arcsec]** | -0.011 | **0.44** |

*Table 9.Astrometric accuracy (preliminary results)*

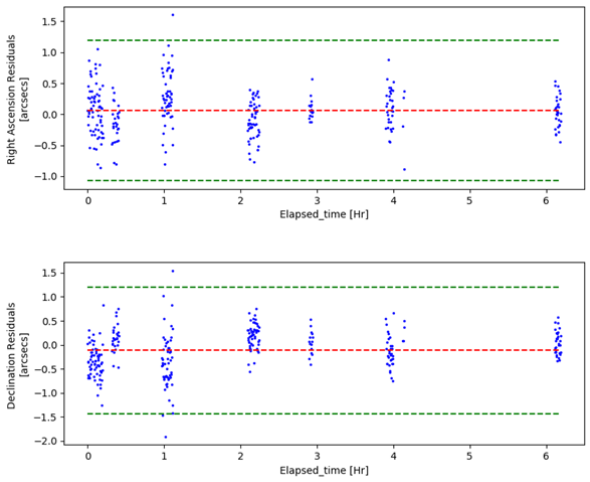


*Figure 10. Residuals in Right Ascension and Declination after corrections.*

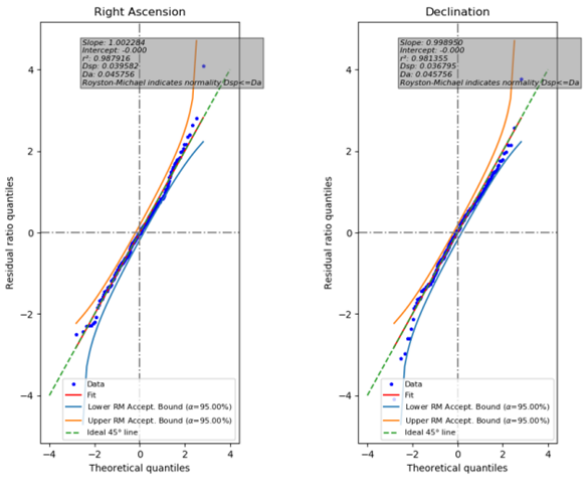


*Figure 11. QQ-Plot of residual ratios (Gaussianity)*

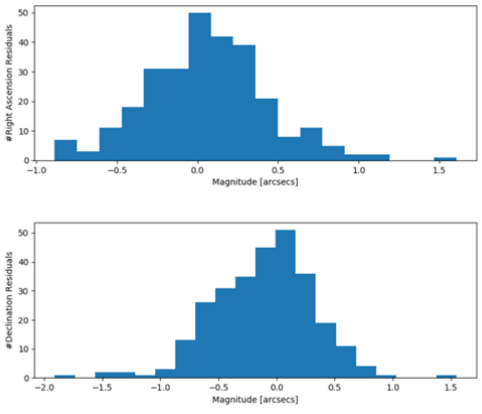


*Figure 12. Histogram of residuals.*

## 7 TEST-BED FOR FUTURE SPACE-BASED OPTICAL SENSOR

Airbus Robotic Telescope is used as ground-based test-bed for the development of a future space-based optical system and enables the real-world test of observation strategies and of the end-to-end processing pipeline

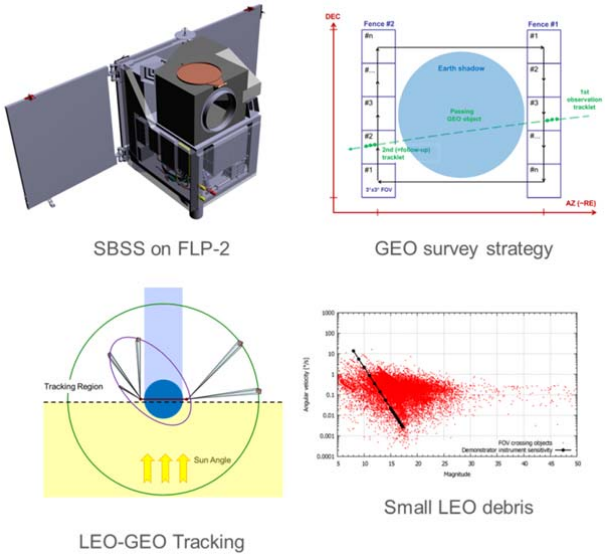


*Figure 13. ESA „SBSS Demonstrator Phase A“, 2014*

## 8 ESA SSA P3-SST-XII SST Sensor Data Acquisition

ART will be used as optical sensor within the ESA activity “SSA P3-SST-XII SST Sensor Data Acquisition” (Kick-Off 16th January 2019).

Objective of the activity is the delivery of SST data to ESA for validation/test of their data center software.

The SST sensor network comprises phased-array radars, a network of passive optical surveillance & tracking telescopes as well as SLR stations capable of tracking uncooperative targets.


*Figure 14. Sensor Network for ESA SST Data*

*Acquisition*

## 9 CONCLUSION

ART is Airbus' own end-to-end capability for SST and is used as

- Ground-based test-bed of a future space-based optical system
- R&D Tool
- Asset for cooperation within the SSA/SST community
- Sensor for measurement campaigns

Current work comprises

- Streamlining of the system
- Detailed characterization and calibration
- Testing limits
- Performing observation campaigns

ART, 26.6.2018 (J. Utzmann, O. Rodriguez, M. Dimitrova)