

## **11th ESA Workshop on Avionics, Data, Control and Software Systems**

Dr. Uwe Schmidt, ADCSS2017, 17 October 2017

**State-of-the-Art Star Tracker Robustness Shown on  
the ASTRO APS Operation on Alphaset under the  
Recent September 10<sup>th</sup> Strong Solar Flare**





## German Optical Valley: Tradition and Future



## ASTRO APS Star Tracker Production and In-Orbit Score

### ASTRO APS Star Tracker

- Contracted units : >160
- Delivered units : >105
- In-Orbit Units : 51



### Key Milestones:

- First launch: July 2013      Alphasat, **Geo-telecom**, 15years
- GPS Constellation      2014      Glonass, **MEO**
- 2xGeo-Spacecrafts: September 2015      **Electrical orbit raising**, Geo-telecom
- Sentinel 2A      June 2015      Earth observation, **LEO**

### Next:

- Orion      Lockheed, NASA      **Human space flight**

## ASTRO APS on Alphasat – Phase E Contract

- A phase E contract covers delivering of 6 years telemetry data.
- Data are delivered through the Inmarsat control center to a Jena-Optronik Server.
- 24hours data with 3sec update rate are delivered.
- Experiments can be scheduled 4weeks in advance such like:
  - Photo Mode
  - “lost in space” acquisitions
  - Submission of engineering data (centroids, magnitudes, etc.)
- A daily performance report is automatically generated in a pdf-file.
- Every 6 Month a summary performance report is delivered to ESA.



TDP6 - ASTRO APS  
Star Tracker



## 24hours real time telemetry from ASTRO APS on Alphasat - Today's Morning

### TM Receiving Status

#### TMs receiving

#### TDP6 TMs receiving

##### TDP6 TM SDB:

OpMode NAT  
 Cycle 6745  
 CycleStart [UTC] 2017/10/17T06:41:09

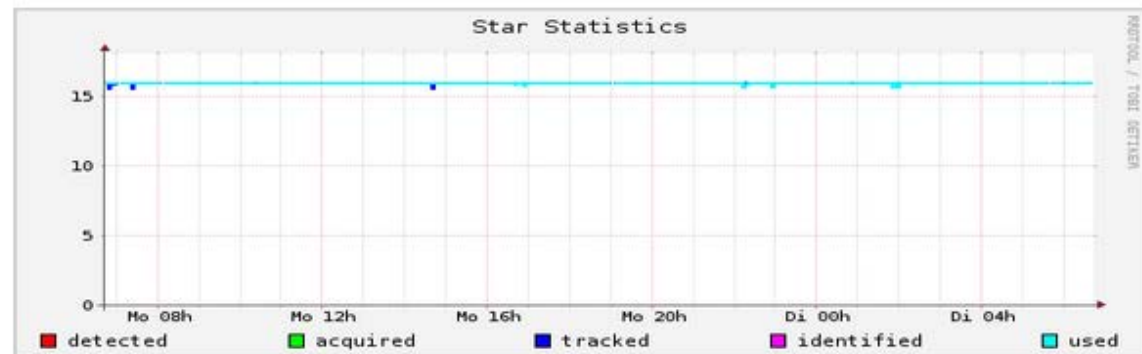
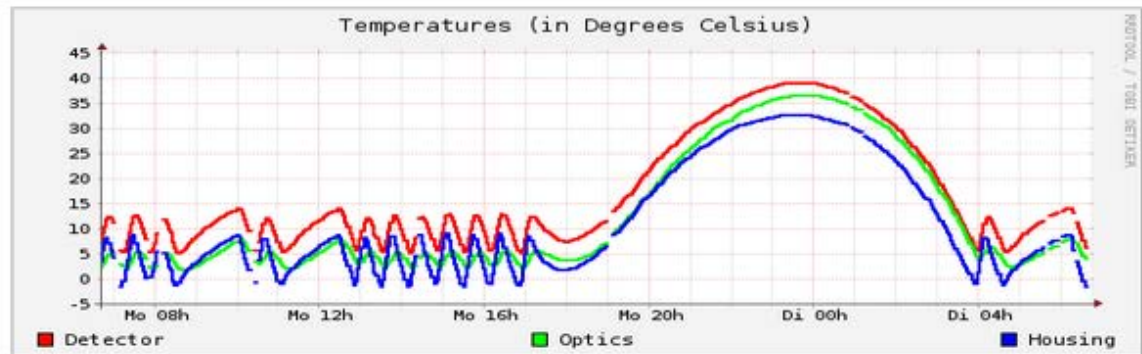
Temperature Detector [°C] 5.6  
 Temperature Optics [°C] 3.4  
 Temperature Housing [°C] -0.1

Mean Background 0  
 Latest Command Id 134  
 Latest Command Result Ok

Stars detected 16  
 Stars acquired 16  
 Stars tracked 16  
 Stars identified 16  
 Stars used 16  
 Stars available 28

##### TDP6 TM ADB:

Attitude Quaternion  
 x -0.271038  
 y -0.159675  
 z -0.479301  
 s -0.819337  
 Attitude Quality validAttitude



## ASTRO APS on Alphasat – High Temperature Operation without TEC

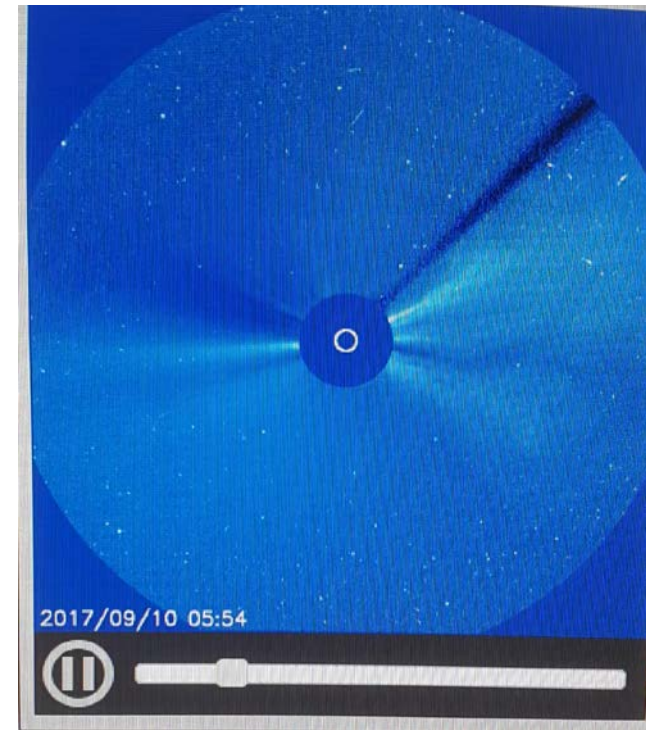
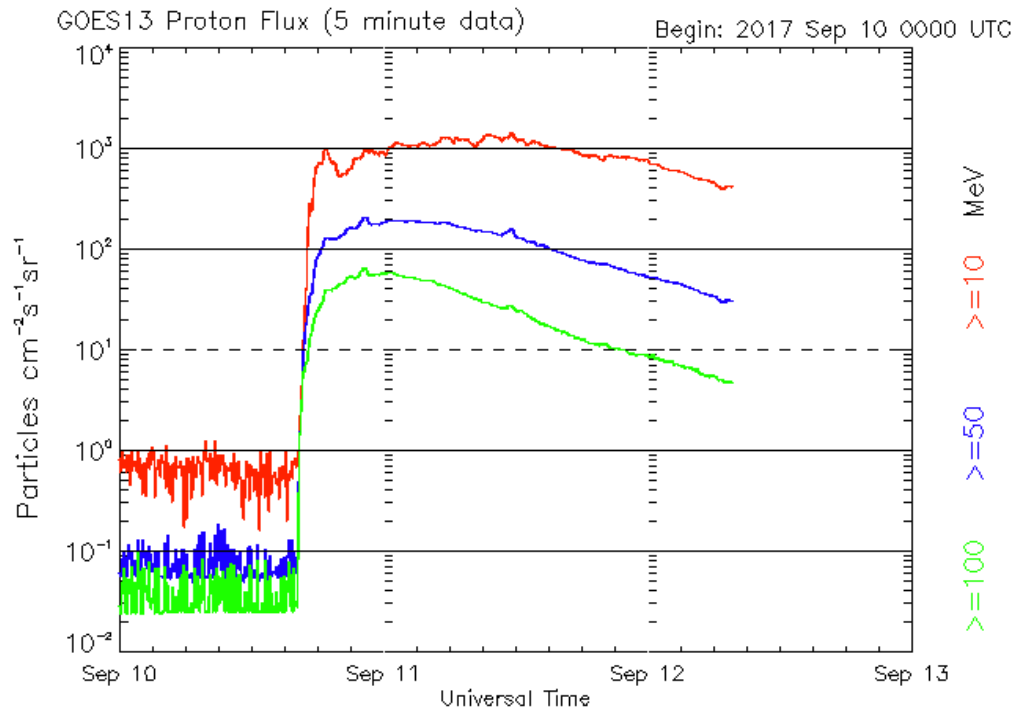
- All ASTRO APS star trackers have “dynamic background noise compensation” implemented.
- This method of noise reduction was invented by Jena-Optronik in 2005 and prototyped on ASTRO15 star tracker units.

U. Schmidt, “*Intelligent error correction method applied on active pixel sensor based star tracker*”, SPIE Optical Systems Design 2005 Symposium, Detectors and Associated Signal Processing II, 12-16 September 2005 in Jena, Germany

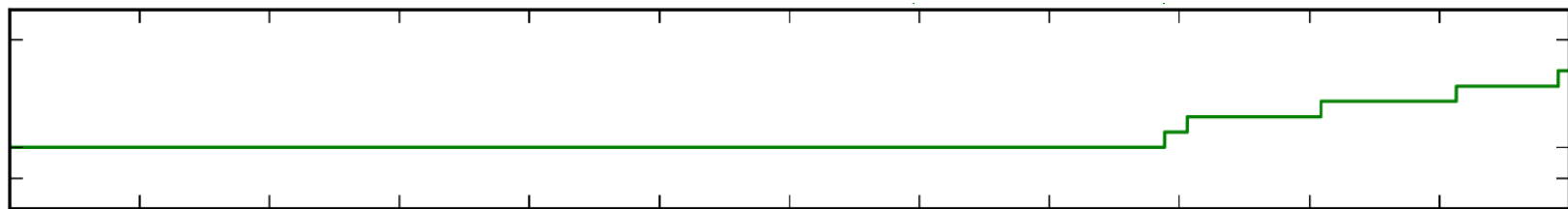


TDP6 - ASTRO APS  
Star Tracker

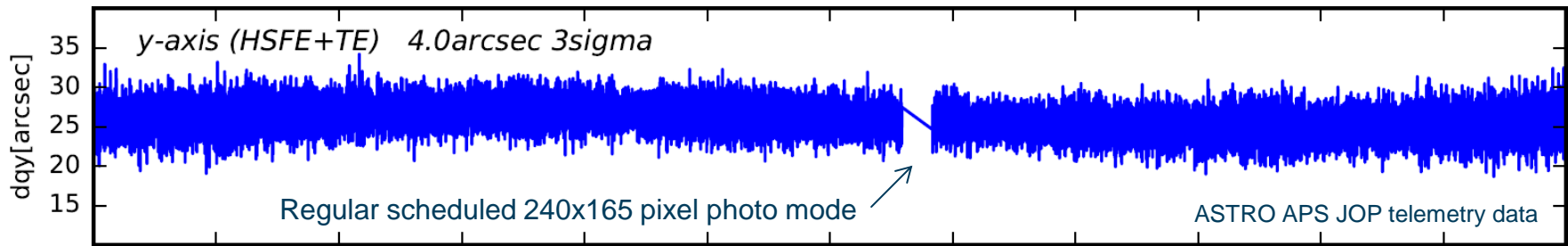
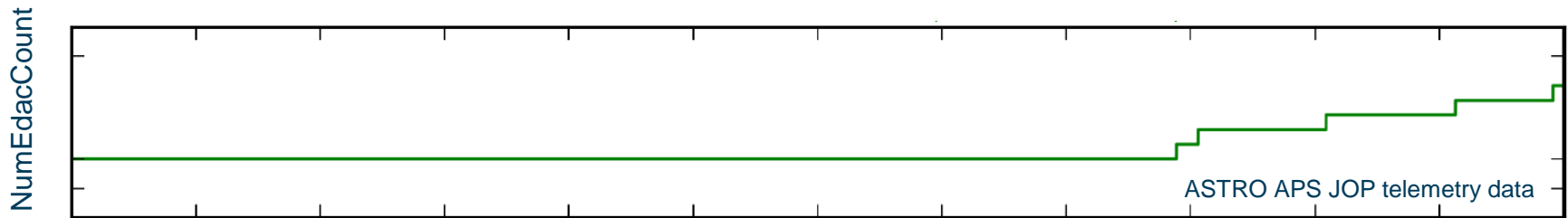
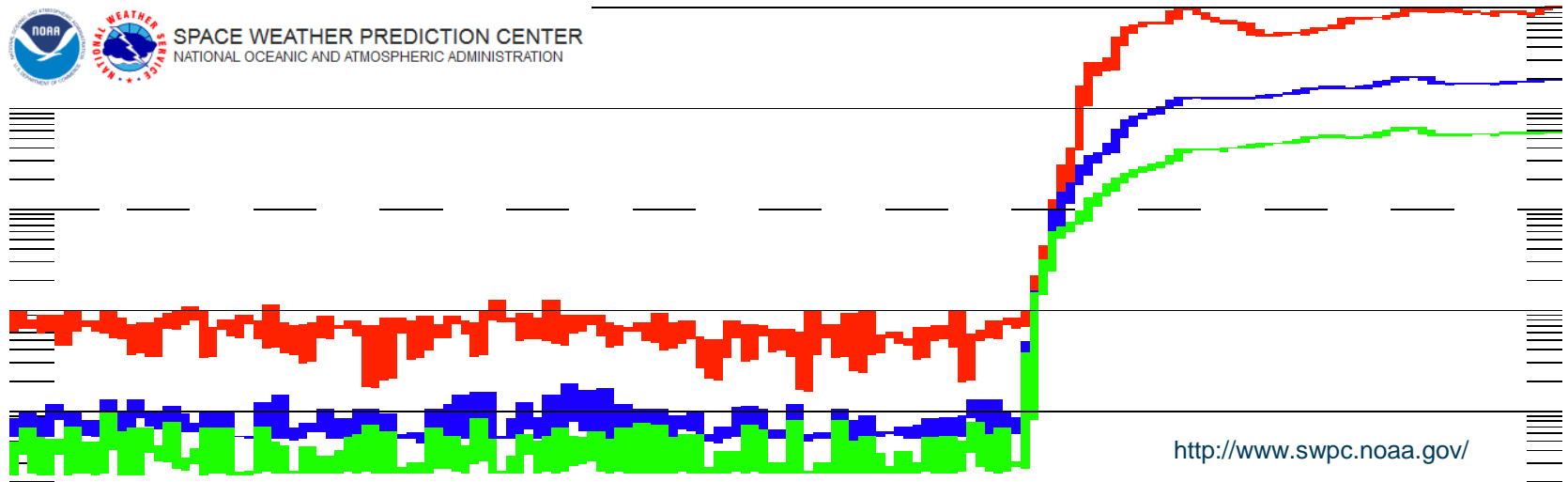
- TEC operation on Alphasat was tested but in the following never enabled.
- At 45°C STAR1000 CMOS detector chip temperature no performance degradation can be seen.
- Ground tests showed nominal performance at +55°C without TEC enabled.



## NumEdacCount



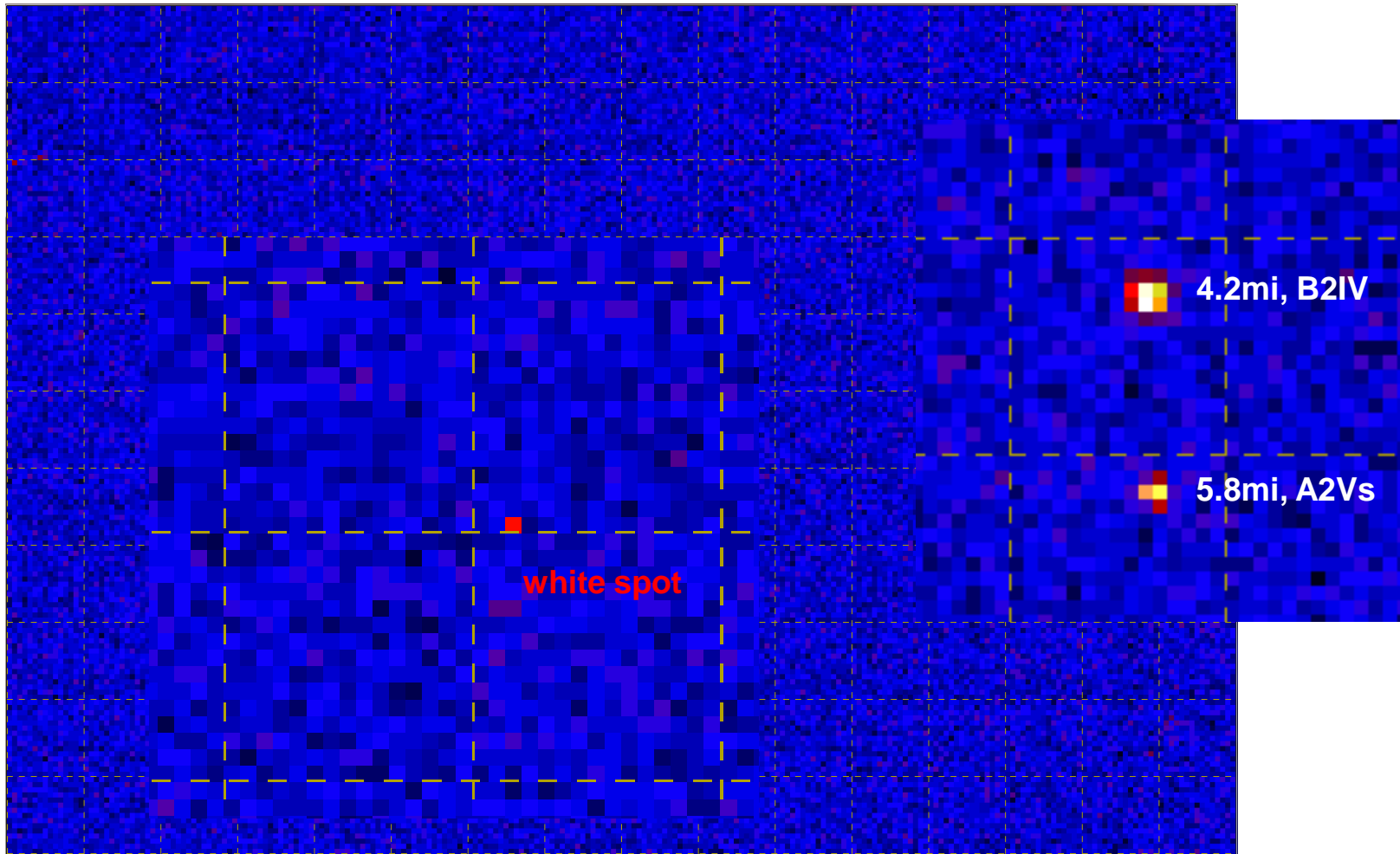
September 10<sup>th</sup>, 24hours



September 10<sup>th</sup> 24hours

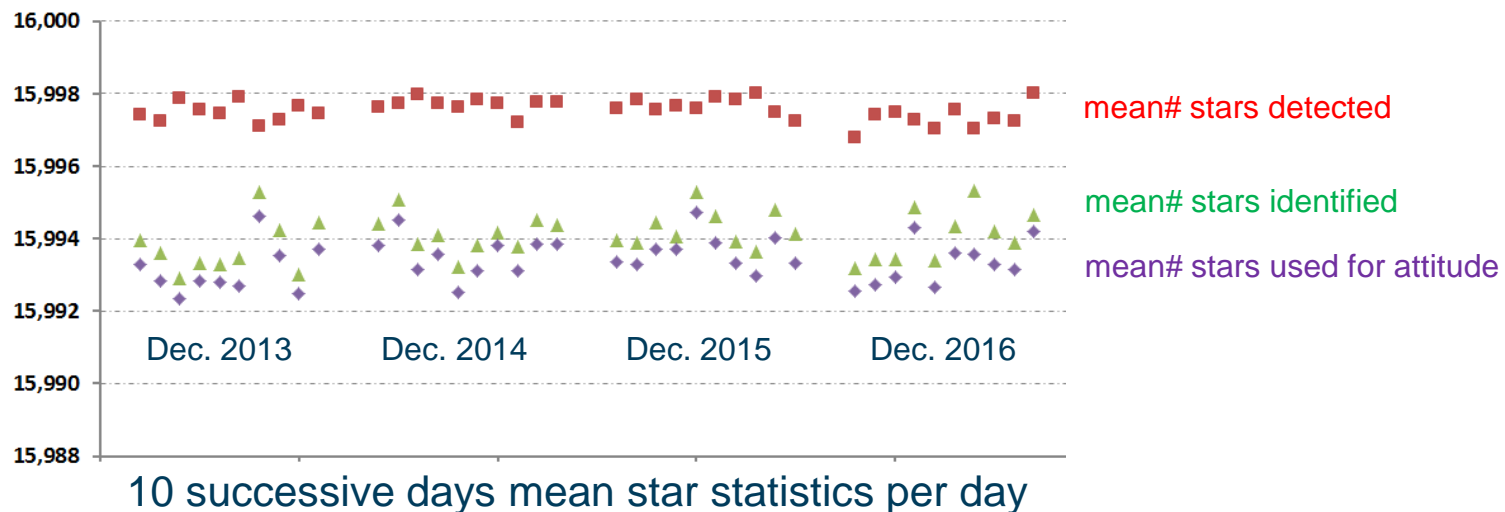


## Regular scheduled 240x165 pixel photo mode



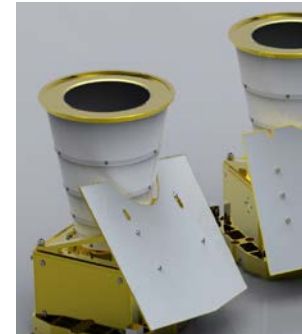
## Summary – ASTRO APS star tracker on Alphasat

- Due to the continuous data monitoring the star tracker operation under a strong solar flare was recorded and evaluated.
- The star tracker remained with full performance in nominal attitude tracking mode
- The presence of a strong solar flare was only seen on a higher EDAC event frequency than nominal.
- Attitude quaternion noise showed no “spikes” or outliers due to the efficient single star quality selection.
- Long term performance:



## ASTRO APS on Sentinel 2A/B – Phase E Contract

- A Phase E contract provides us real time data of the 2 star trackers under operation per s/c.
- Real time 10Hz data are delivered from 2 fully synchronized units.
- Quarterly summary performance reports to Airbus DS and ESA.
- September 10<sup>th</sup> flare:
  - 2 star trackers per spacecraft in operation, so we have 4 units under data monitoring.
  - None of them showed mode switch or performance degradation.
  - 2 of 4 trackers showed 1 EDAC event each only.



ASTRO APS Flight Set  
Sentinel2 Star Trackers

## All other ASTRO APS units under in-orbit operation

- 51 ASTRO APS units were under operation during the recent September 10<sup>th</sup> flare.
- SmallGeo/OHB reported a similar EDAC event count signature as experienced from Alphasat.
- All 51 trackers in orbit remained with full performance in nominal attitude tracking. No operational disturbance was reported by the operators.

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Uwe Schmidt, ADCSS2017, 17 October 2017

Thank you for your attention!

Questions?

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