# Development of a new Camera with Digital Video Time Insertion

# (Update)

Andreas Schweizer

28.08.2021

# Development of a new Camera with Digital Video Time Insertion

- **Project overview**
  - Team
  - Goals
  - Milestones
- **Hardware**
  - Design
  - Sensors
- **Software**
  - Artefacts
  - Control Tool
- **Examples**
- **Next steps**

# Project Overview – Team Goals Milestones

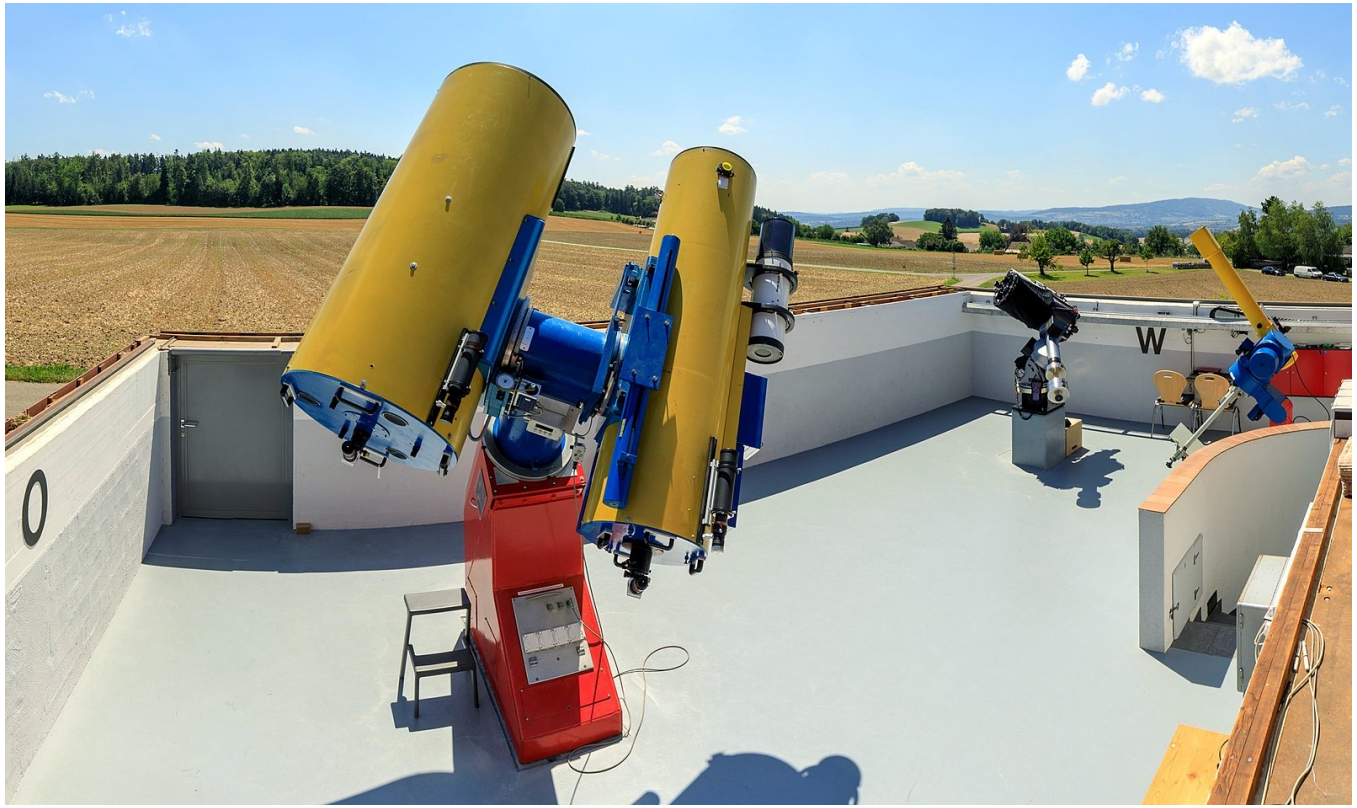
**Andreas Schweizer**

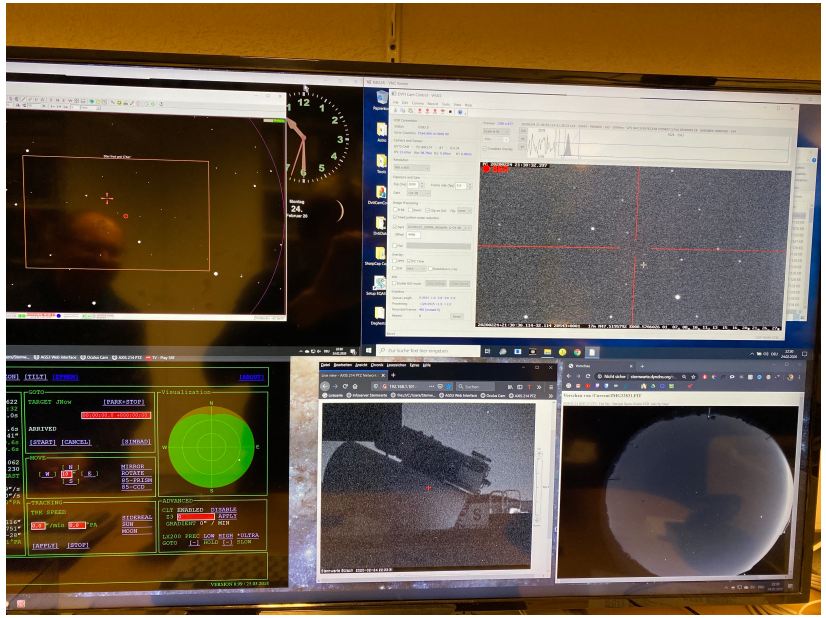
- Embedded Systems and Software Engineer
- AGZU member (association that operates the Sternwarte Bülach)
- Other hobbies: Amateur radio, squash

**Stefan Meister**

- Working for Mettler-Toledo in Finance & Control
- In the board of the Swiss Astronomical Society (SAG/SAS) and active in various working groups (sun, meteors, exoplanets)
- Other hobbies: Cycling, Kayaking

# Project Overview – Team Goals Milestones

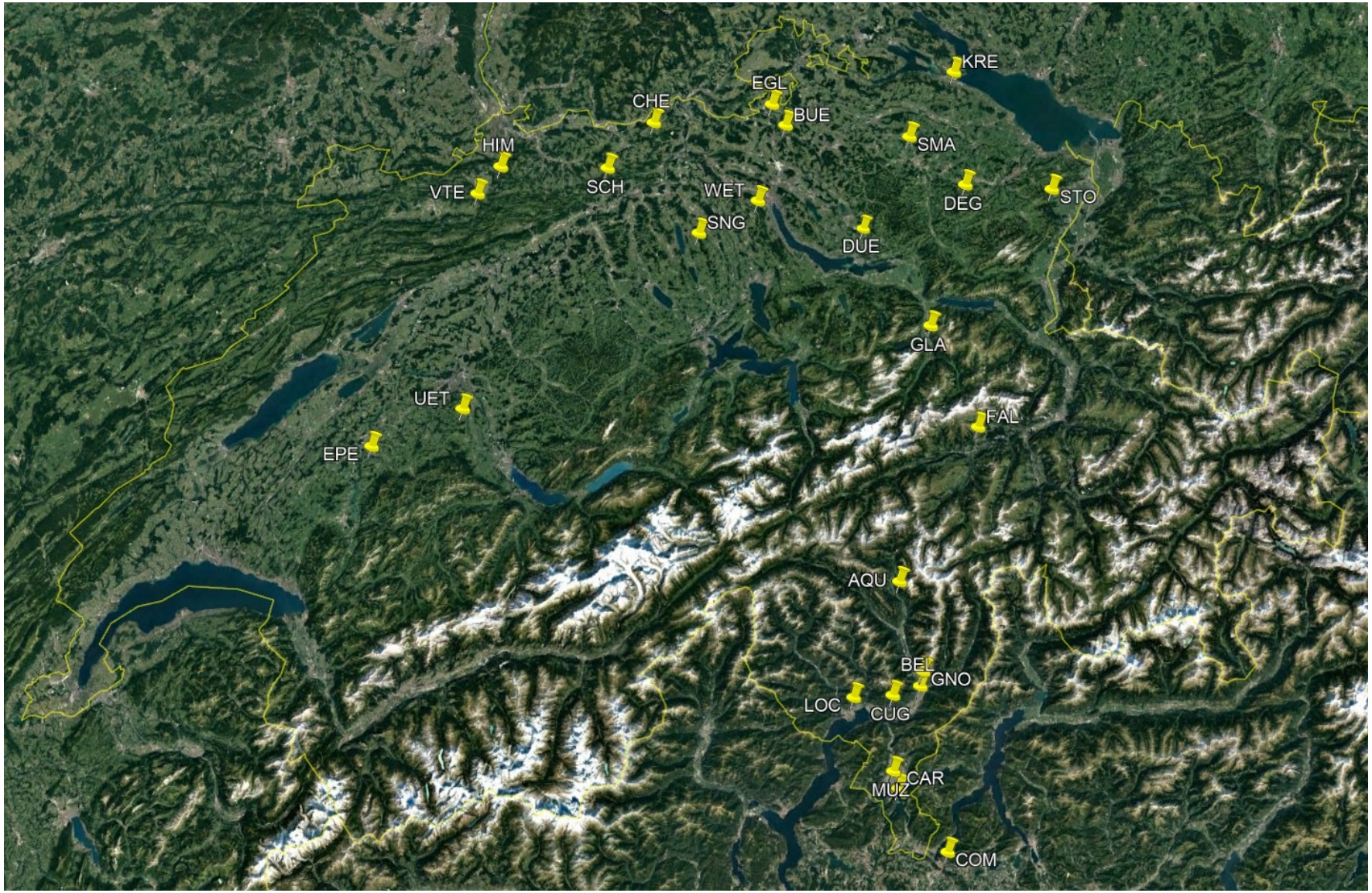




**Home Base: Bülach Observatory (MPC 167)**

- **50cm Newton**/Cassegrain
- 85cm Cassegrain
- Pro RC 360, TEC Refractor, Zeiss/Coudé Refractor

# Project Overview – Team Goals Milestones



# Project Overview – Team Goals Milestones

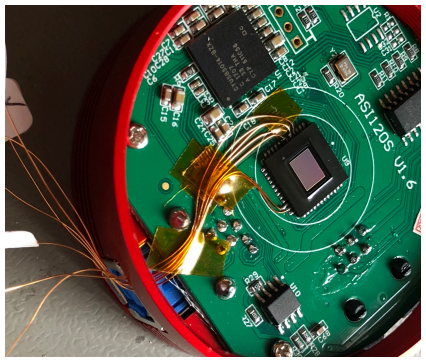
**Design a digital video camera with the following aspects:**

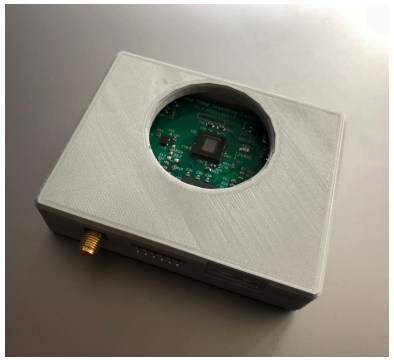
- **Precise timestamp from integrated GPS module**
- **Sensitive monochrome image sensor**
- **Easy to use**
- **Low price**

- **Improve hardware and software with feedback from the community**

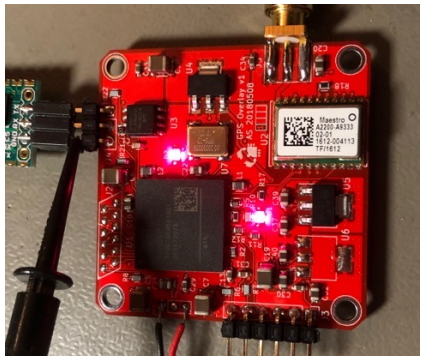
# Project Overview – Team Goals Milestones

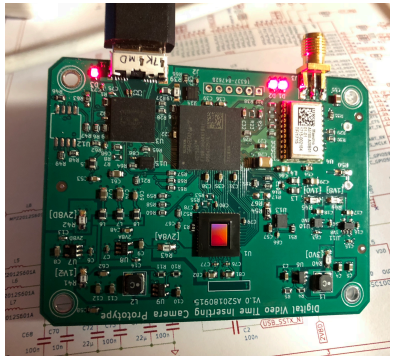
http://www.dangl.at/ausruest/dvti/dvti_v2b.htm

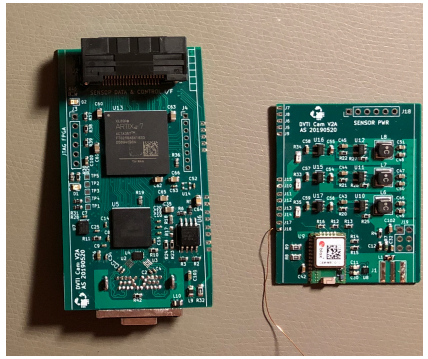



| Software Version | | DvtiCamControl settings | | | | |
|---|---|---|---|---|---|---|
| Camera Firmware | DVTI CamControl | Bit Depth | Resolution | Binning | Exposure set [s] | Real Exposure (EXTA) |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.001 | 0.001 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.002 | 0.002 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.005 | 0.005 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.010 | 0.010 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.020 | 0.020 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.030 | 0.030 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.033 | 0.033 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.040 | 0.040 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.050 | 0.050 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.080 | 0.080 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.100 | 0.100 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.160 | 0.160 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.200 | 0.200 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.250 | 0.250 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.320 | 0.320 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.500 | 0.500 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 0.640 | 0.640 |
| 0.4.35 | 4.8.6 | 16 | 960x600 | 2x2 | 1.000 | 1.000 |





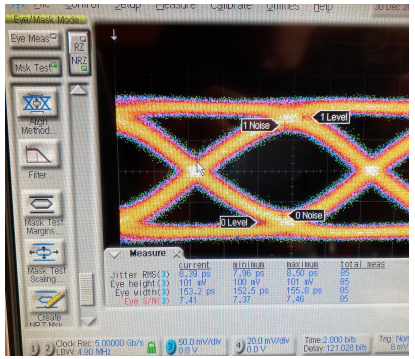

05/2018
**Proof-of-Concept**
with ASI120MM

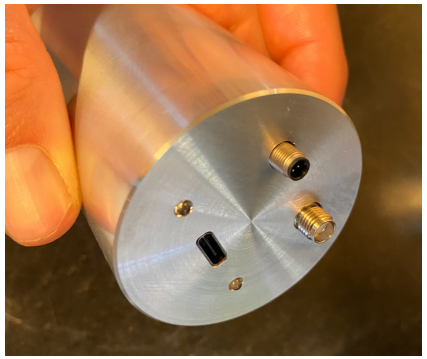
11/2018
**Prototype V1**
AR0130

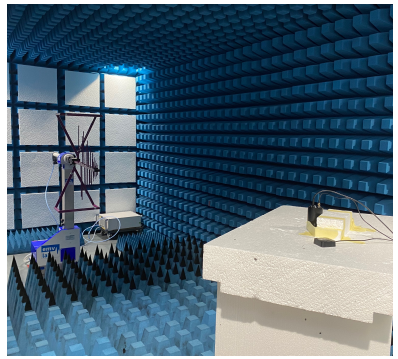
07/2019...
**Prototype V2**
AR0130, IMX174, IMX178

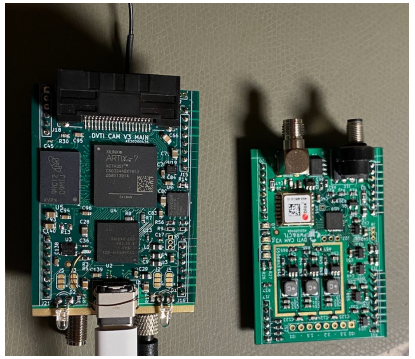
late 2019 / early 2020
**Prototype V2**
Beta testers, EXTA test, improvements

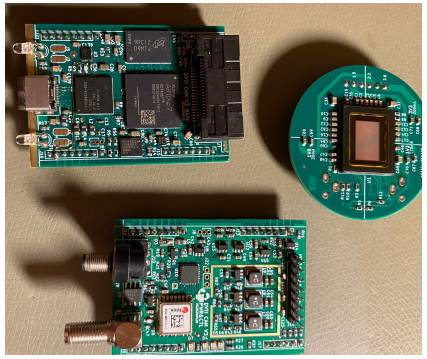
# Project Overview – Team Goals Milestones

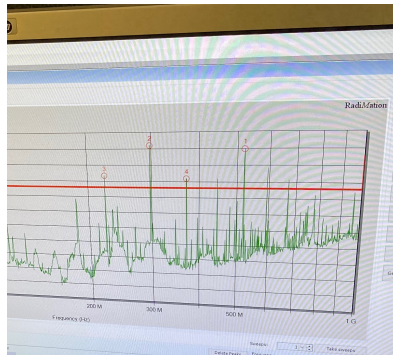








06/2020
**Prototype V3A**
IMX174, IMX178, IMX432

...08/2020
**Prototype V3A**
Milled case

02/2021
**Prototype V3B RC1**
EMC testing

05/2021
**Prototype V3B RC2**
EMC testing

# Project Overview – Team Goals Milestones

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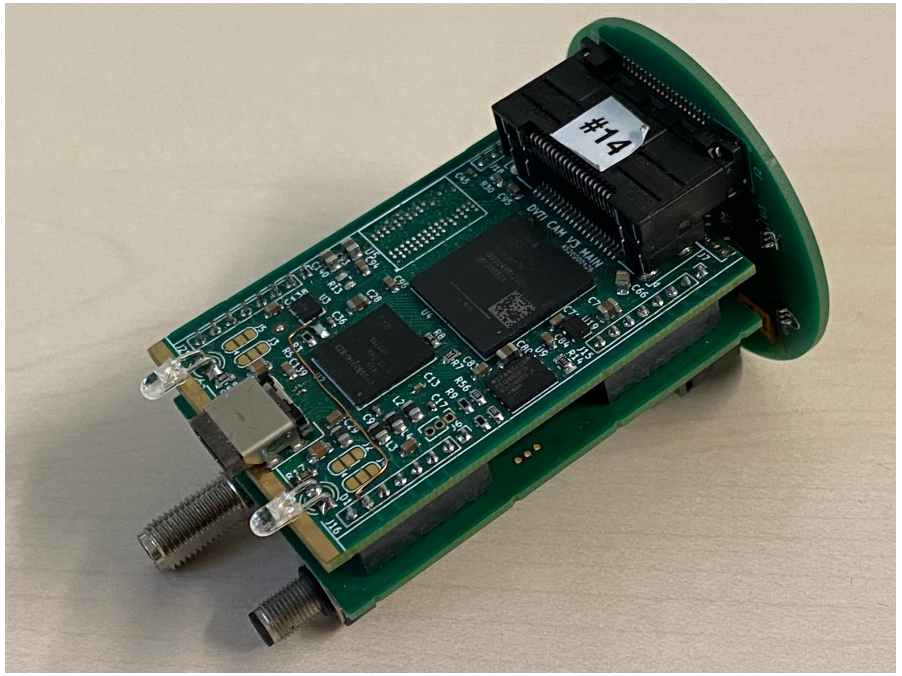
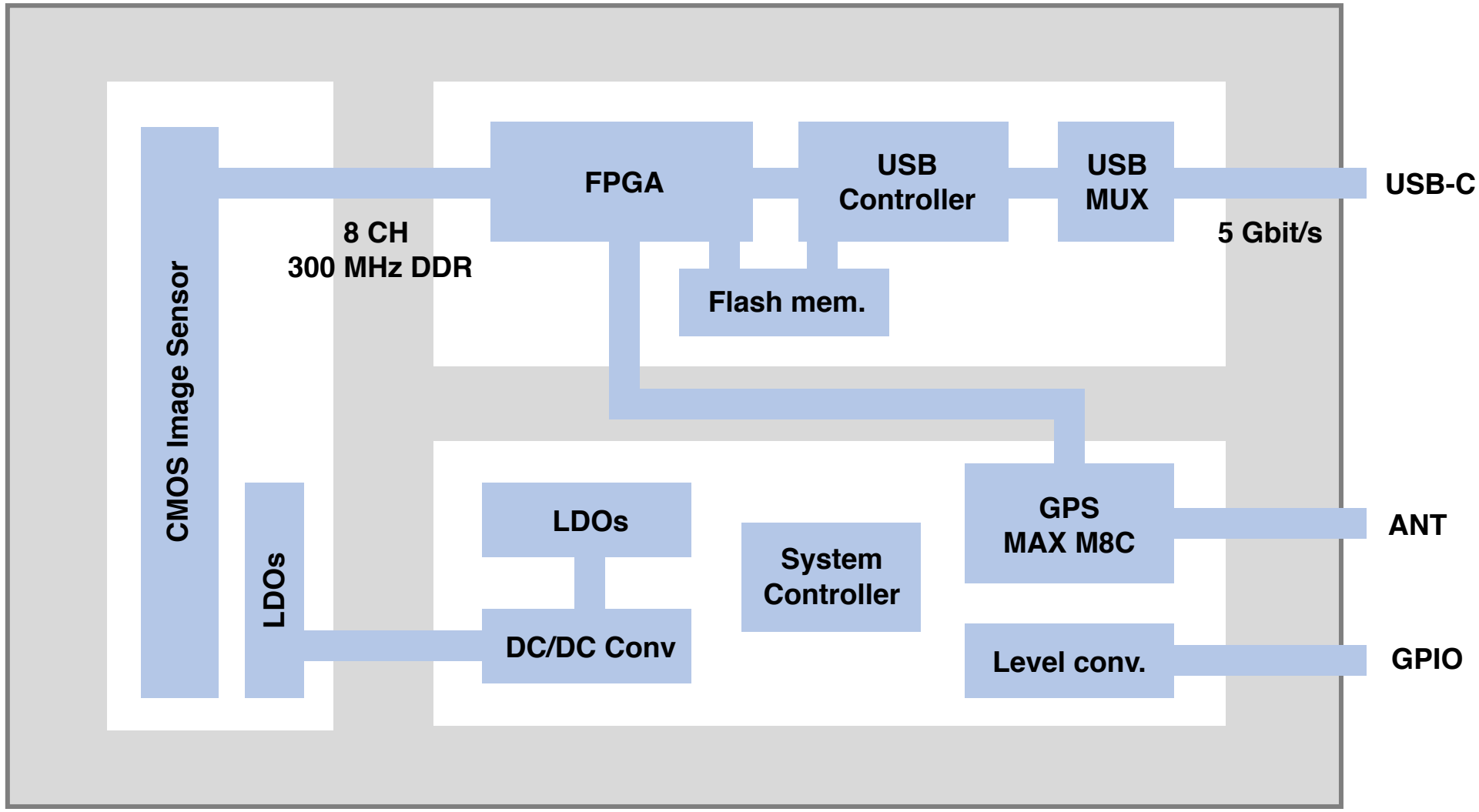
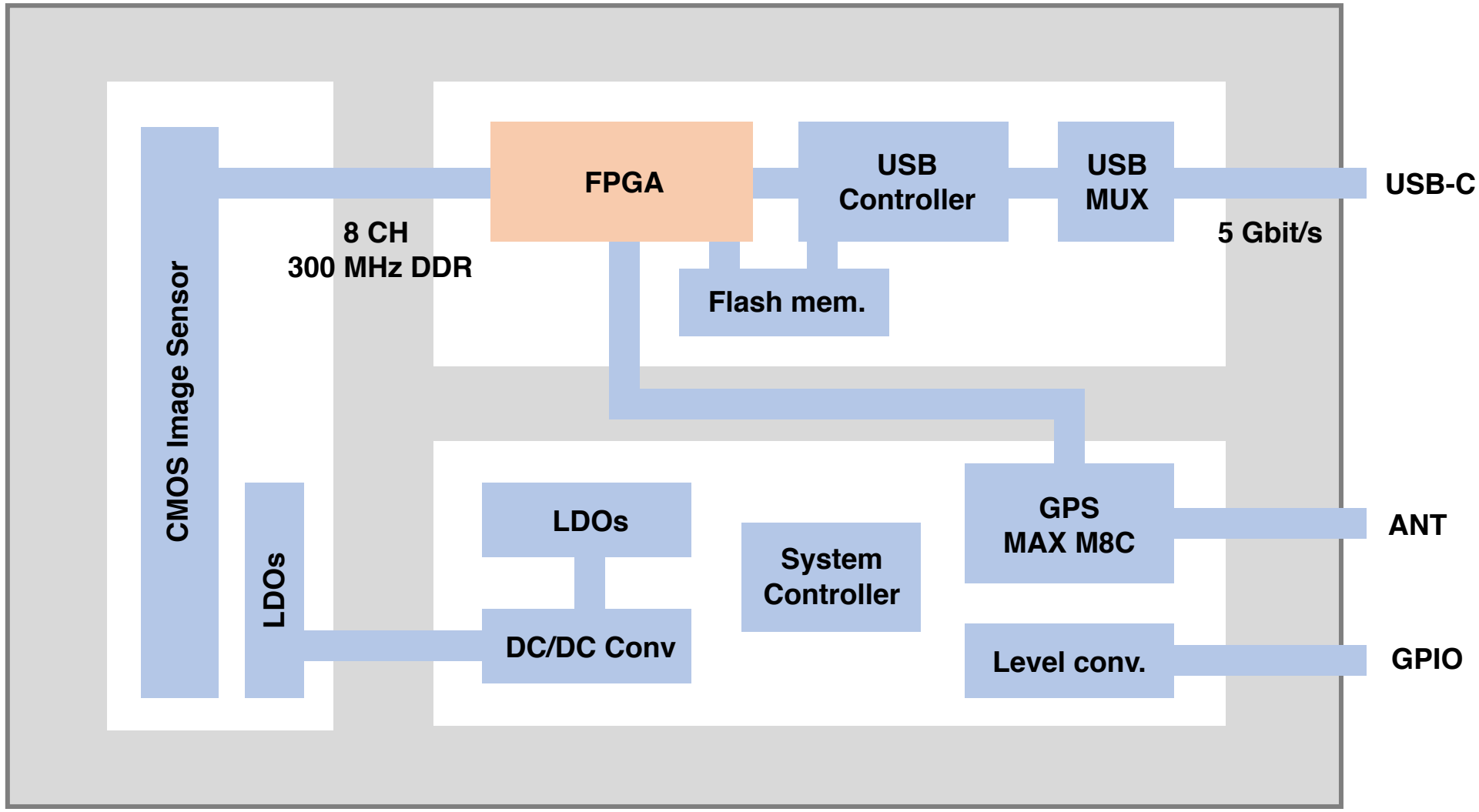



# Project Overview – Team Goals Milestones

# Hardware – Design Sensors

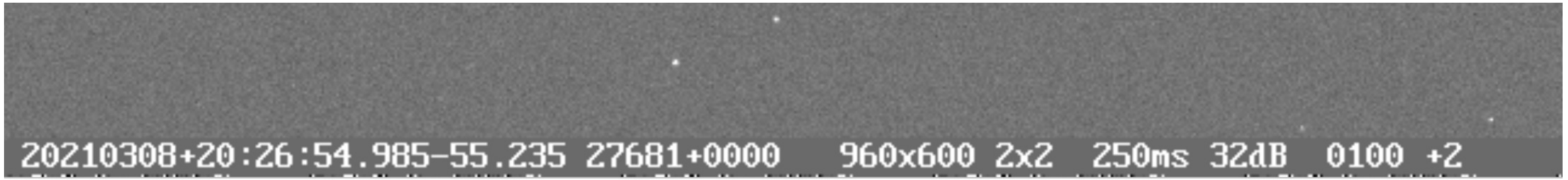


# Hardware – Design Sensors



# Hardware – Design Sensors

The FPGA maintains a precise time based on the GPS 1PPS signal.
For each frame, the start and end time (together with other meta information such as frame nr, gain, satellite DOP) are injected into the image stream in the last line:

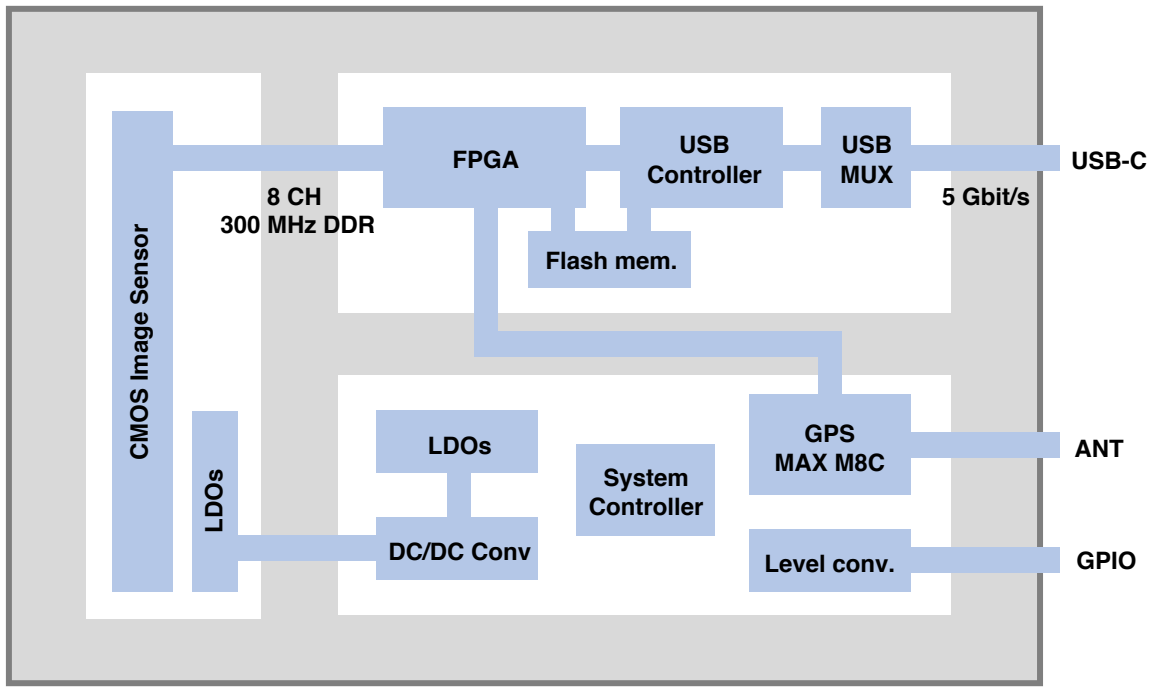


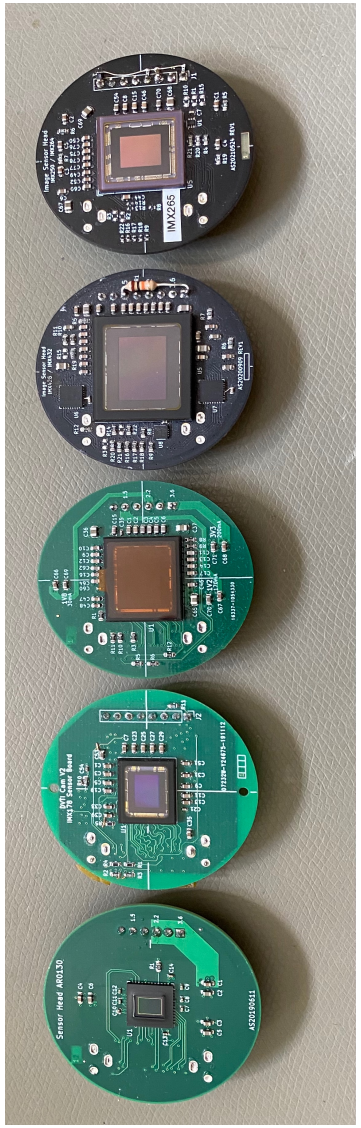

Optionally, the FPGA can overlay a textual timestamp above the binary timestamp.

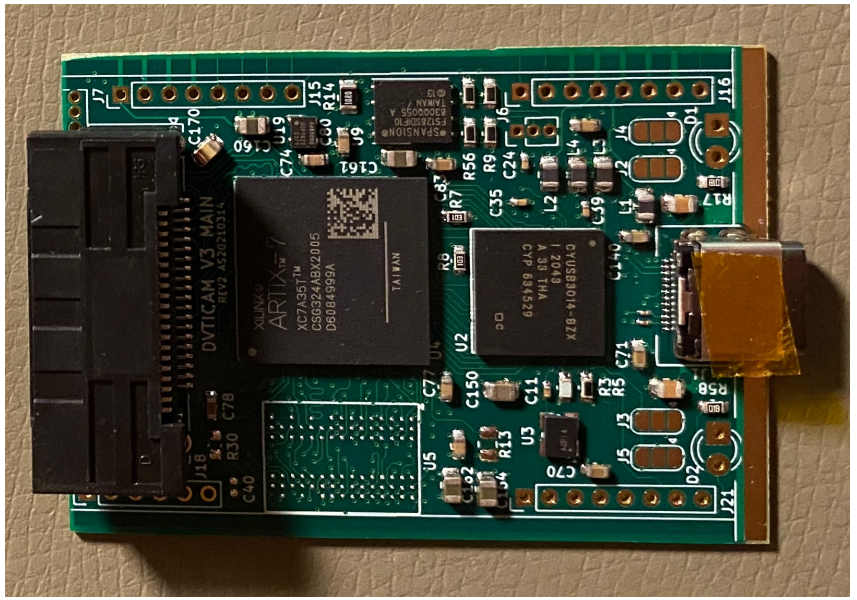
The DVTI control tool extracts the metadata and writes it into the recorded file (ADV, FITS, SER).

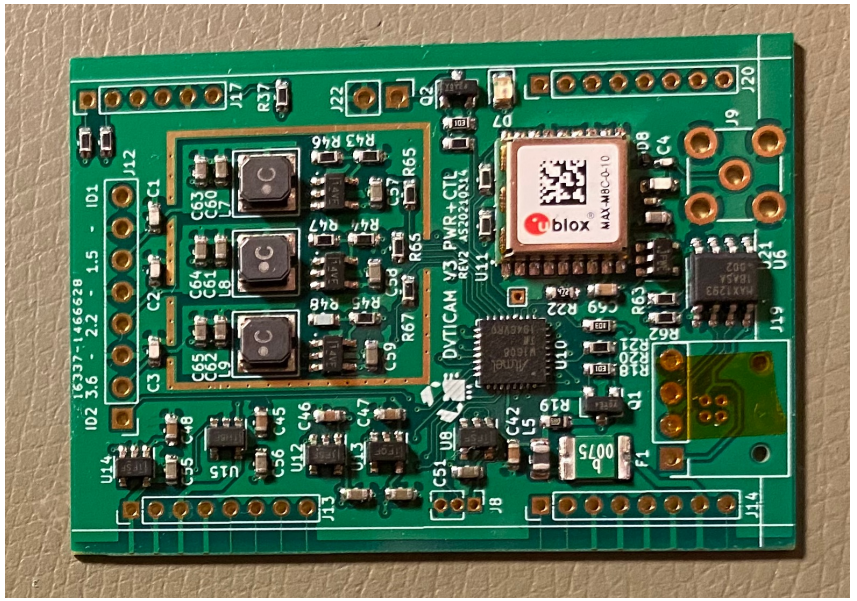
More information: https://groups.io/g/d-vti-cam/wiki/11974

# Hardware – Design Sensors

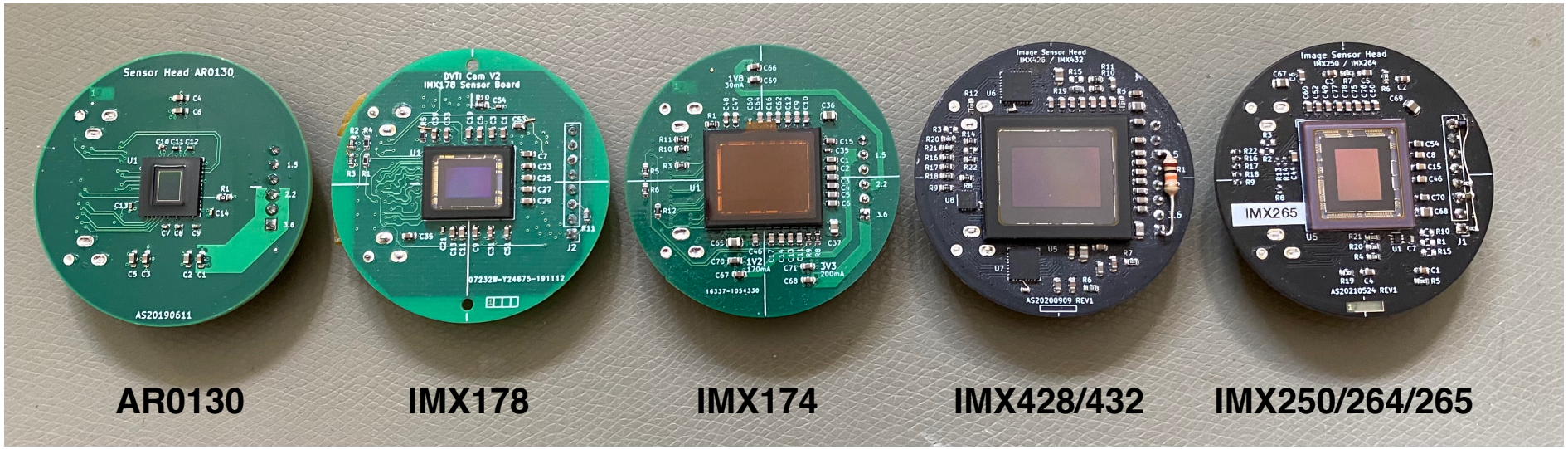


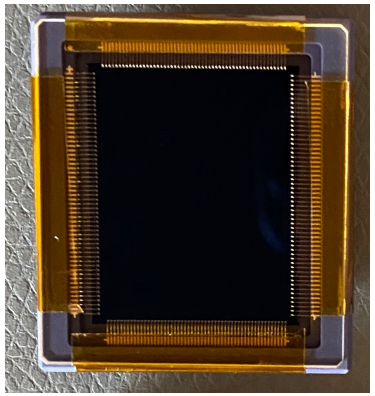





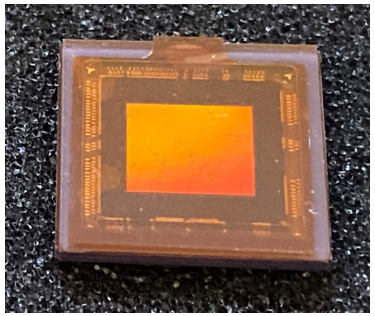


# Hardware – Design Sensors



GSENSE4040



IMX250MZR

# Software – Artefacts Control Tool

**Camera Firmware**

- USB Firmware
- FPGA Bitstream

**DVTI Control Tool (MS Windows)**

**Occult Watcher Plugin**

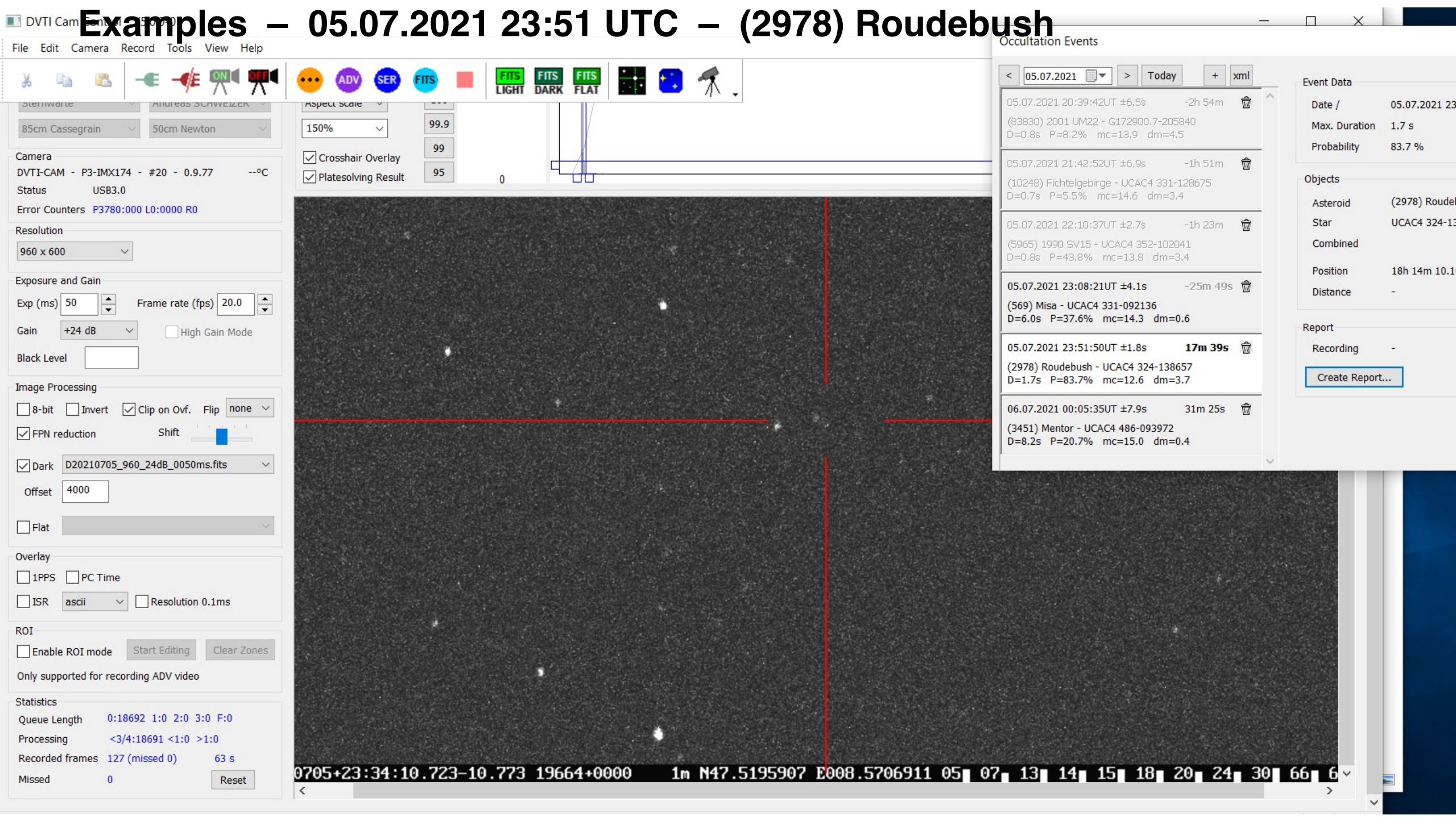
- **Download from wiki page**
- **Camera Firmware update option in the control tool**

# Software – Artefacts Control Tool

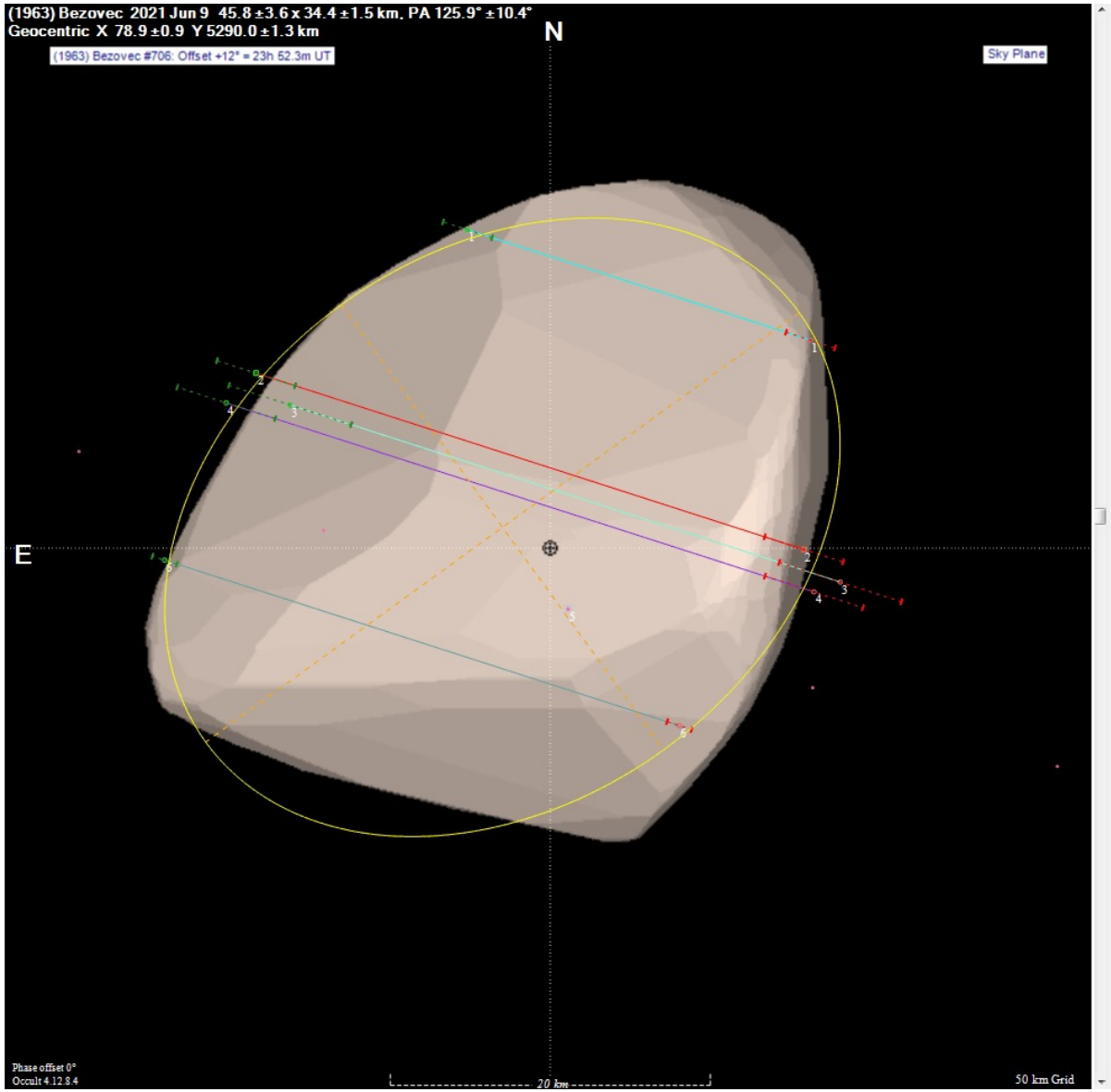
- Control camera settings (resolution, frame rate, gain etc.)
- Preview image
- Histogram
- Record ADV, FITS, SER
- On-the-fly dark subtraction, flat field correction, fixed pattern noise reduction

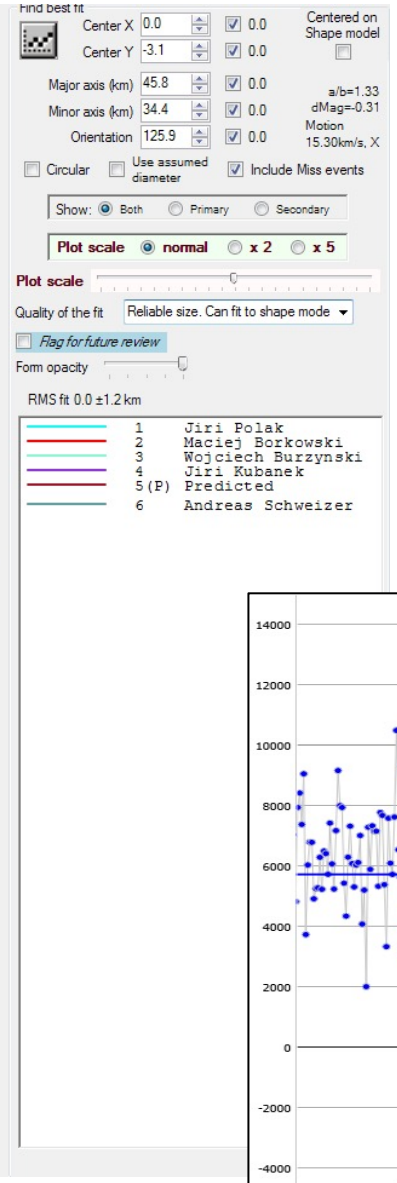
- Observation planner (Occult + OW integration, open-in-O2A)
- Plate solving
- Telescope control
- Report generation (European format)
- Define Locations / Equipment / Mounts

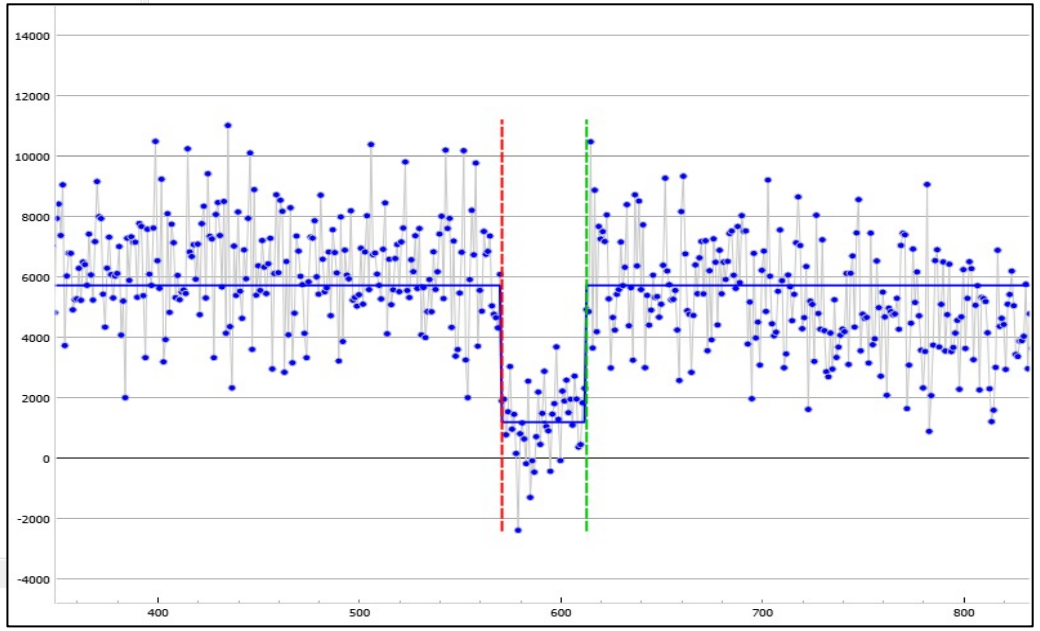
# Examples – 05.07.2021 23:51 UTC – (2978) Roudebush



# Examples – 09.06.2021 23:16 UTC – (1963) Bezovec

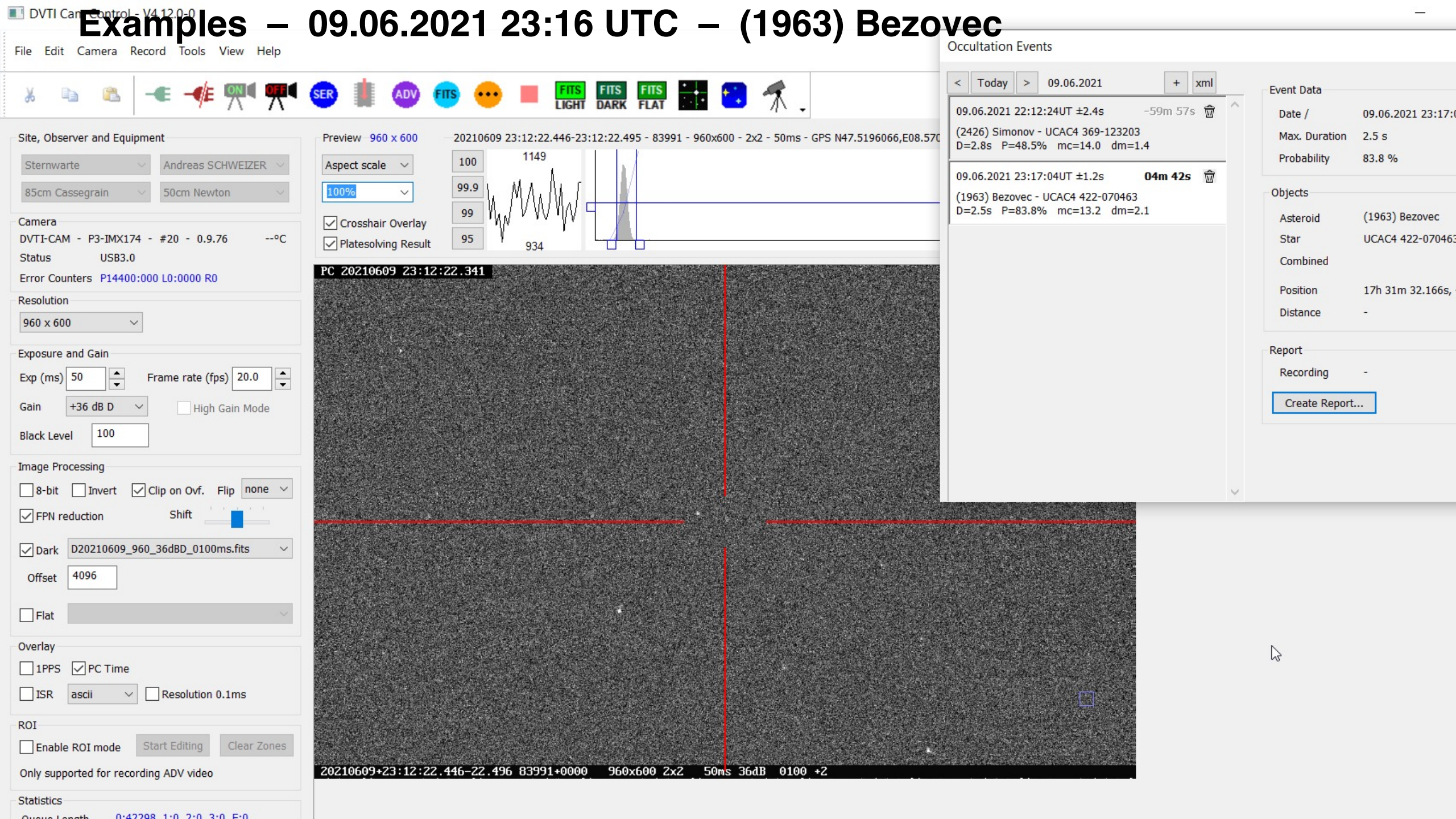



http://www.euraster.net/results/2021/20210609-Bezovec_crd+DAMIT706.gif

# Examples – 09.06.2021 23:16 UTC – (1963) Bezovec



# Examples – 09.06.2021 23:16 UTC – (1963) Bezovec

```
                ASTEROIDAL OCCULTATION - REPORT FORM

   +------------------------------+  +------------------------------+
   |            EAON              |  |            IOTA/ES           |
   |                              |  |   INTERNATIONAL OCCULTATION  |
   |     EUROPEAN  ASTEROIDAL     |  |      TIMING  ASSOCIATION     |
   |     OCCULTATION NETWORK      |  |       EUROPEAN SECTION       |
   +------------------------------+  +------------------------------+

1 DATE:                  2021 Jun 09, 23:17 (UTC)

  STAR:                  UCAC4 422-070463      mv: 13.4 mag
  ASTEROID:              (1963) Bezovec        mv: 15.3 mag  (diam. 39.0 km)
                         combined magnitude:   mv: 13.2 mag
                         delta-magnitude:      mv:  2.1 mag

2 OBSERVER:
  Name:                  Andreas SCHWEIZER
  E-mail:                aschweiz@mac.com
  Address:               Strumbergächerstr. 3A, 8907 Wettswil, Switzerland

3 OBSERVING STATION:
  Nearest city:          Bülach
  Station:               Sternwarte Bülach
  Latitude:              N47 31' 10.402" (WGS84)
  Longitude:             E08 34' 14.300" (WGS84)
  Altitude:              550 m (MSL)  (WGS84)

  Predicted observation: yes (Distance 5.2 km from C.L.)
                         Probability: 83.8 percent

  Single station:        yes

                         +----------------------------------+
4 TIMING OF EVENT:       |                                  |
                         |  OCCULTATION RECORDED: POSITIVE  |
                         |                                  |
                         +----------------------------------+
  Type of event:
   S = Start observation I = Interrupt-start   D = Disappearance
   B = Blink             F = Flash             E = End observation
   I = Interrupt-end     R = Reappearance
   M = Mid-event         P = Predicted time

  Event  Time (UTC)      Acc.         Comments
  Code   HH MM SS.sss    S.sss

   S     23 16 34.765    +/-  0.001 s  : Start observation (UTC)
   D     23 17 03.435    +/-  *1)   s  : Disappearance     (UTC)
   R     23 17 05.540    +/-  *2)   s  : Reappearance      (UTC)
   E     23 17 34.912    +/-  0.001 s  : End observation   (UTC)

   Duration:    2.105    +/-  *3)   s  : (predicted: max. 2.5 s)

   P     23 17 04.380    +/-  1.212 s  : Predicted time    (UTC)
```

```
*1)
D time: [23:17:03.4350]
D: 0.6800 confidence intervals:  {+/- 0.0199} seconds
D: 0.9500 confidence intervals:  {+/- 0.0548} seconds
D: 0.9973 confidence intervals:  {+/- 0.1306} seconds

*2)
R time: [23:17:05.5400]
R: 0.6800 confidence intervals:  {+/- 0.0199} seconds
R: 0.9500 confidence intervals:  {+/- 0.0548} seconds
R: 0.9973 confidence intervals:  {+/- 0.1306} seconds

*3)
Duration (R - D): 2.1050 seconds
Duration: 0.6800 confidence intervals:  {+/- 0.0291} seconds
Duration: 0.9500 confidence intervals:  {+/- 0.0705} seconds
Duration: 0.9973 confidence intervals:  {+/- 0.1516} seconds

5 TELESCOPE:
  Type:                  Newton Reflector f/5
  Aperture:              500 mm
  Focal length:          2500 mm
  Magnification:         focal (resulting field of view: 15.5' in x-axis)
  Mount:                 equatorial
  Motor drive:           yes

6 TIMING & RECORDING:
  Time source:           GPS
  Quality of signal:     Accuracy 2m
  Camera/Sensor:         Digital Camera with integrated GPS-VTI (DVTI CAM Prototype V3 RC2, serial #20)
                         Image Sensor Sony IMX174LLJ-C (1/1.2" 1920x1200 5.86um CIS)
                         Website of the project: https://groups.io/g/d-vti-cam/
  Settings:              960x600, Exposure time 50 ms, Gain +36 dB D, Binning 2x2, Format ADV 16-bit
  Time insertion:        Digital GNSS timestamp into image sensor data stream

7 OBSERVING CONDITIONS:
  Atmospheric transp.:   good
  Moon:                  below horizon
  Wind:                  no
  Star image stability:  good
  Altitude of star:      36 deg
  Azimut of star:        170 deg in Ophiuchus

8 ADDITIONAL COMMENTS:
  Feed:                        Planned Observations
  Video recording software:    DVTI Cam Control v4.12.0
  Light measurement tool:      PyMovie 2.9.7, PyOTE 3.7.4
  Remarks:

  Published by e-mail to planoccult@ls.vvs.be (Planoccult mailing list)
```

# Next Steps

- First batch of 25 cameras fabricated and tested
- Re-test of the timing precision by Gerhard Dangl
- Bureaucratic + Legal aspects
- Software and firmware improvements
- Other sensors
- More cameras

**More information:** https://groups.io/g/d-vti-cam/

# Thank you!