Development of a new Camera with Digital Video Time Insertion

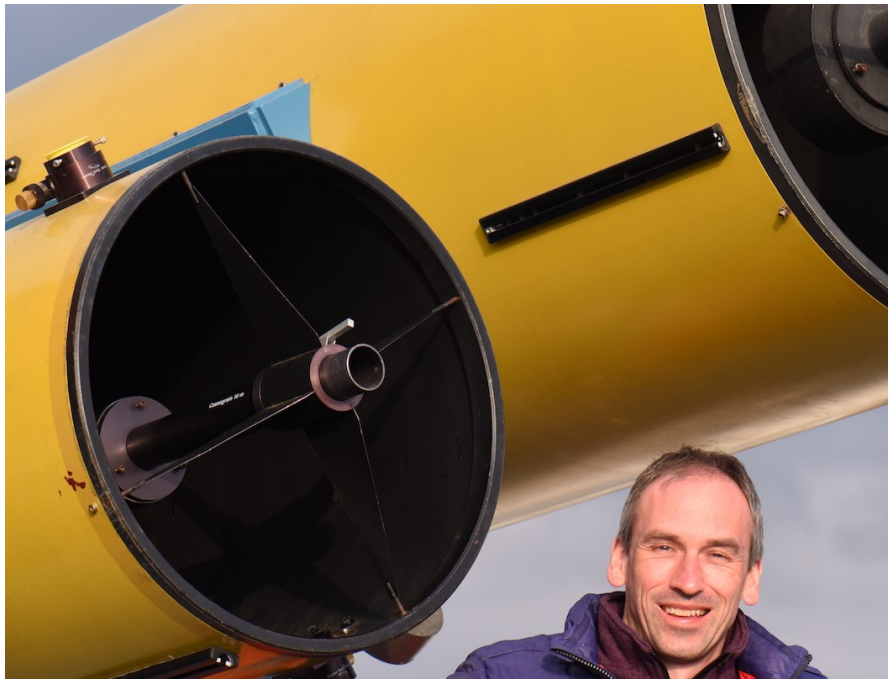
Andreas Schweizer & Stefan Meister

31.08.2019

Who are we?

Andreas Schweizer

- Software Engineer
- Married since 2013, 1 Girl (3½)
- Astronomy as hobby since ~1993
- 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

Motivation

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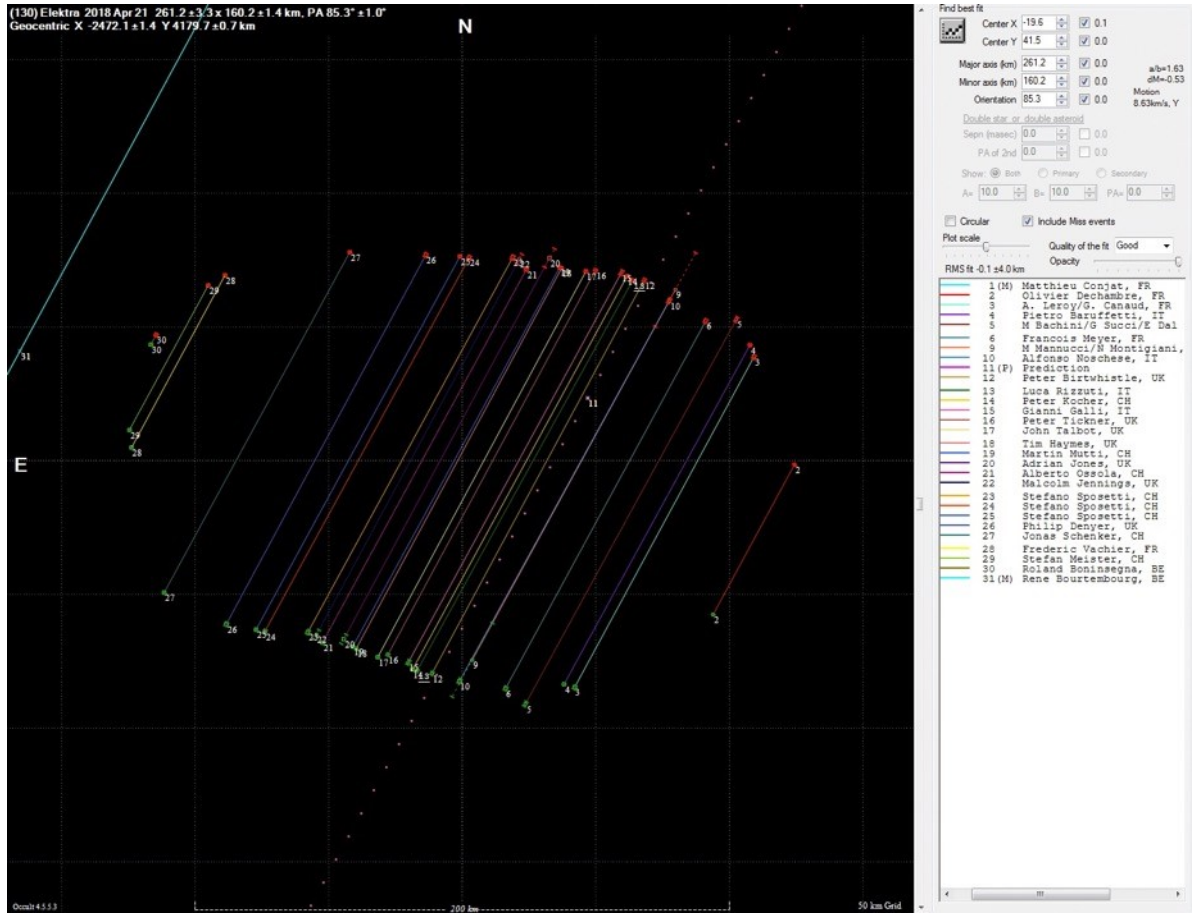
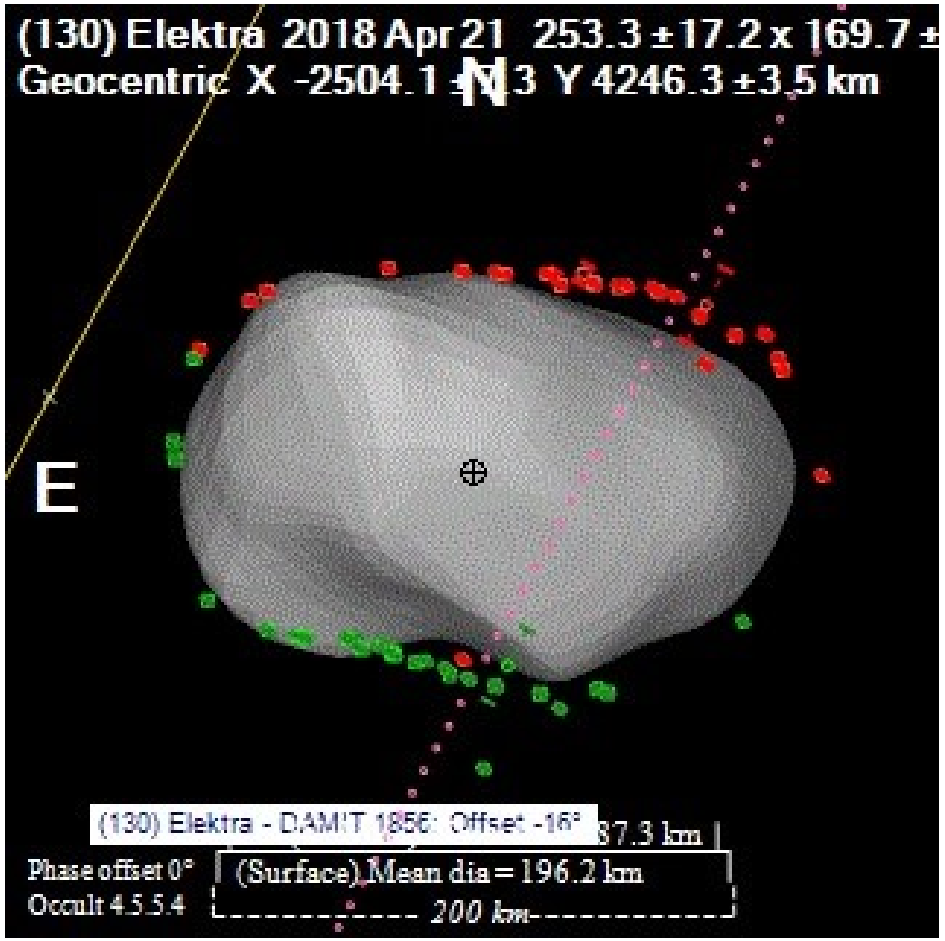


(130) Elektra, 21.04.2018



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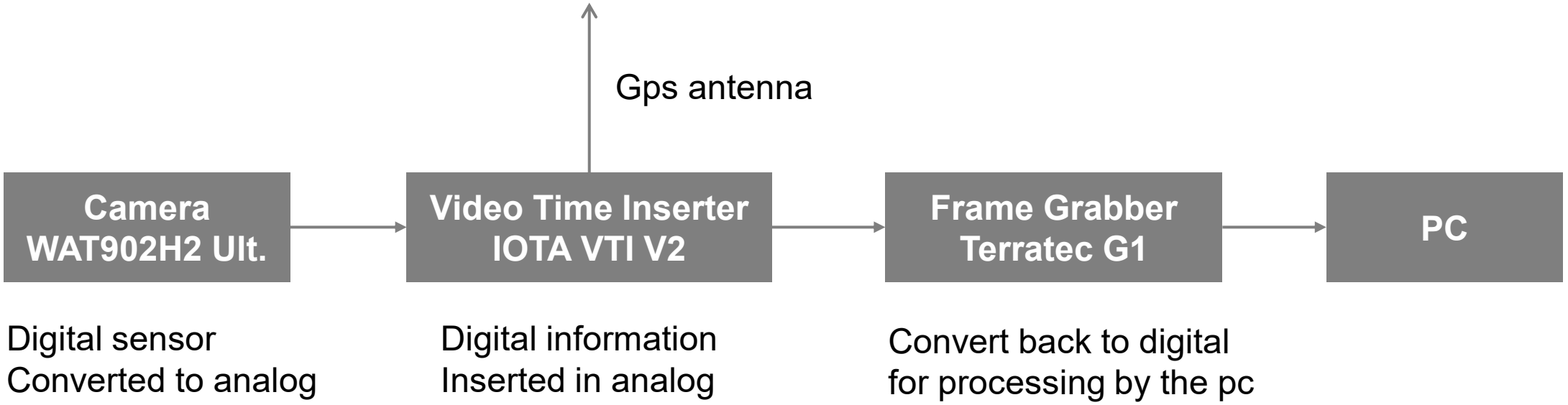
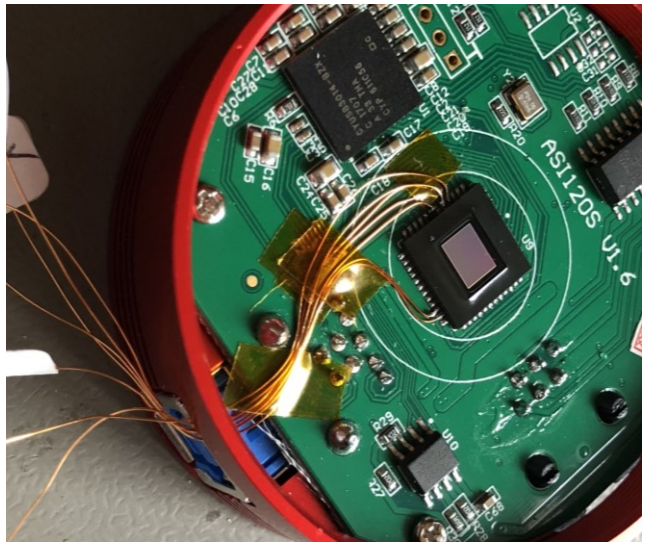
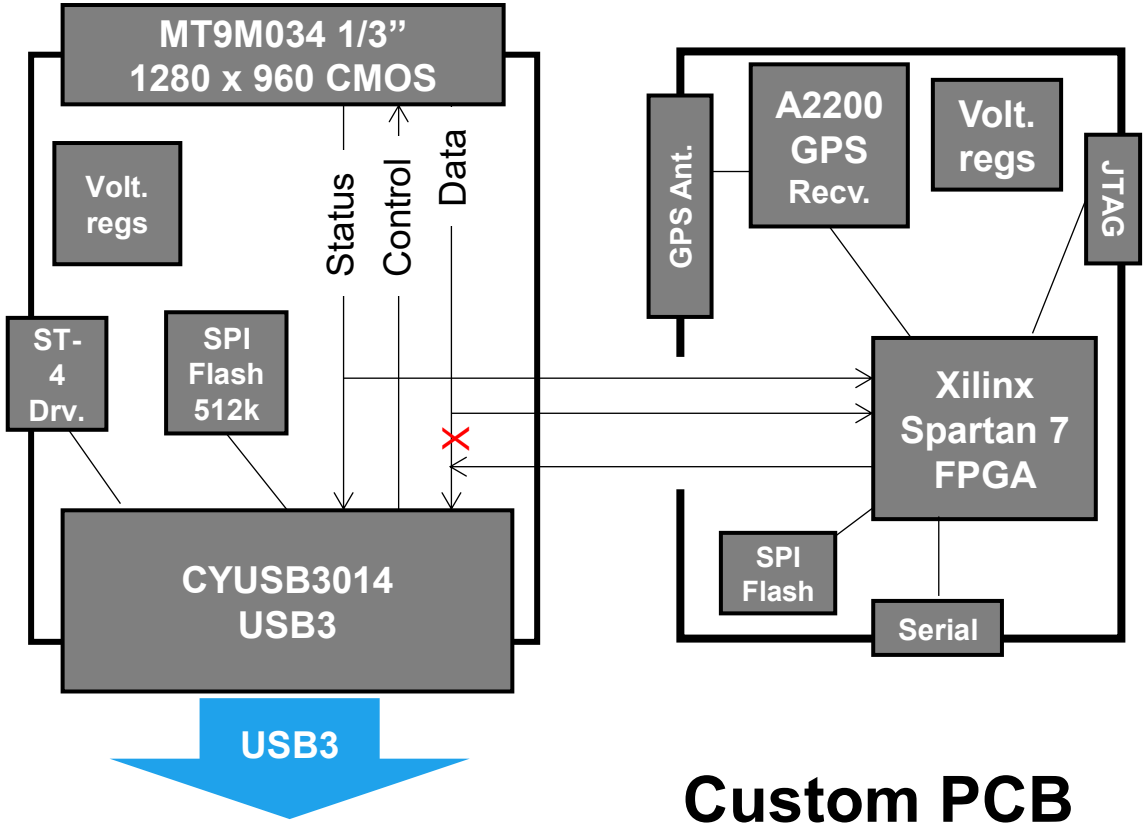


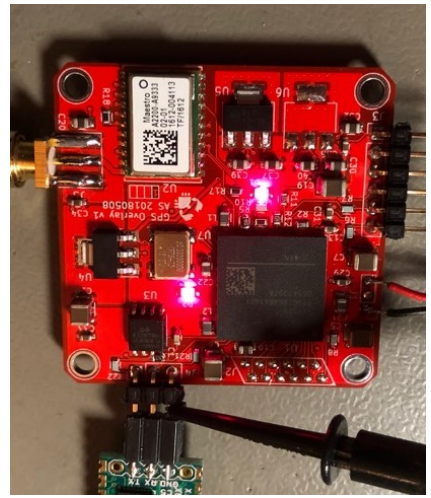
«Why not insert the time information directly into the pixel stream?»

Proof-of-Concept and Prototypes

Proof-of-Concept



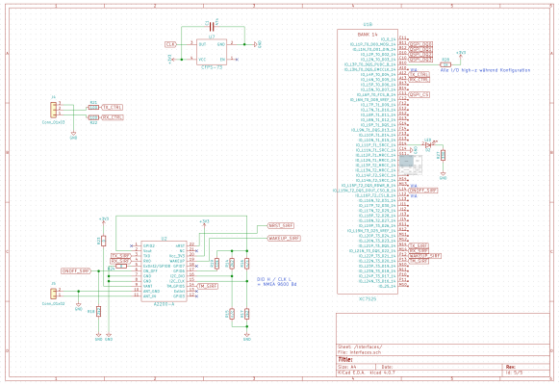




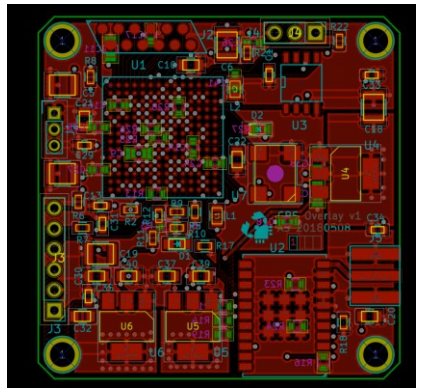
ASI 120 MM
- Cut 2 most significant data lines
- Inject timestamp overlay

Custom PCB
- GPS module, FPGA

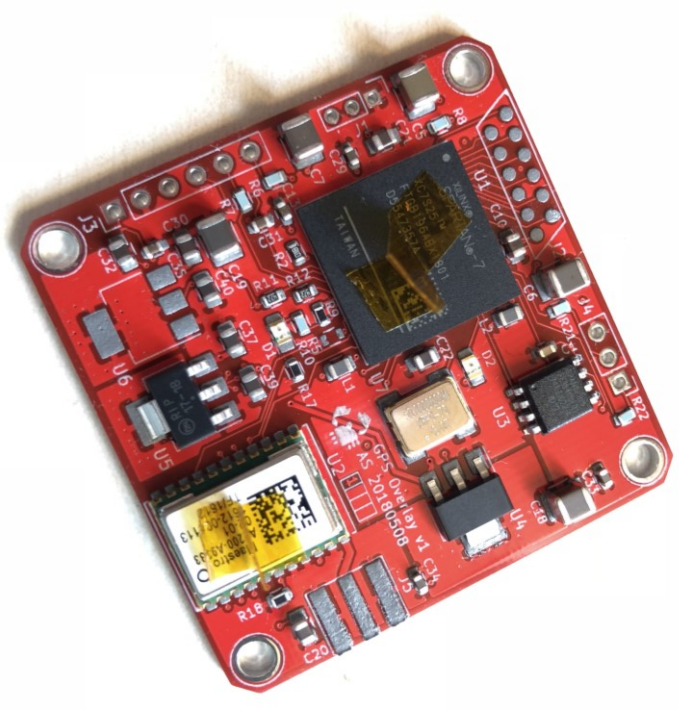
PoC Development

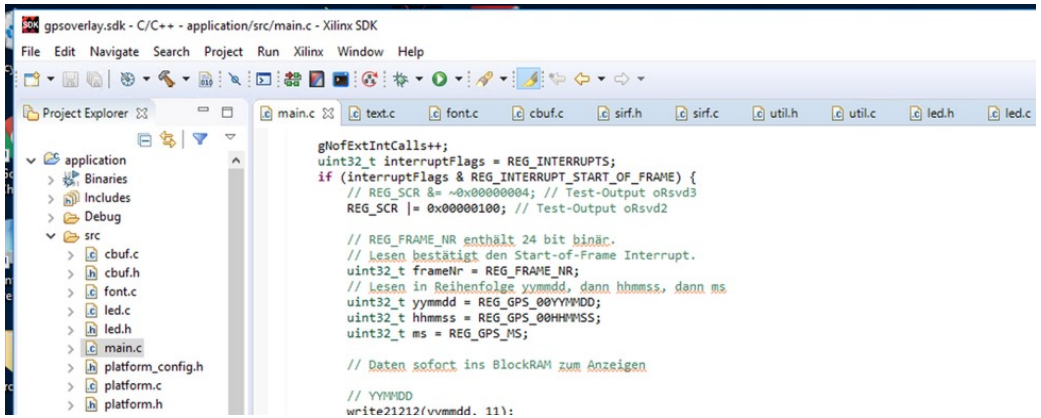


Schematics

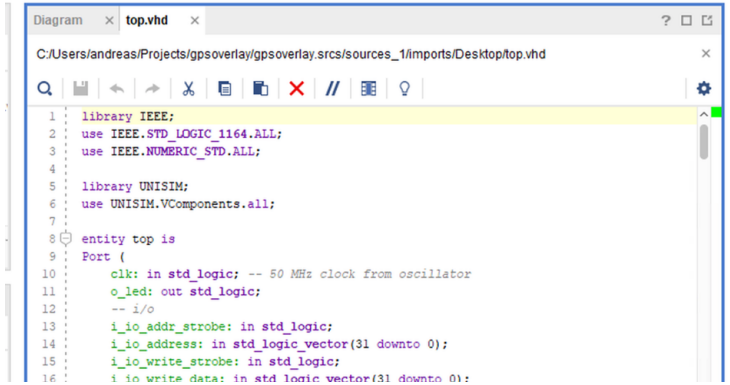


→ Layout



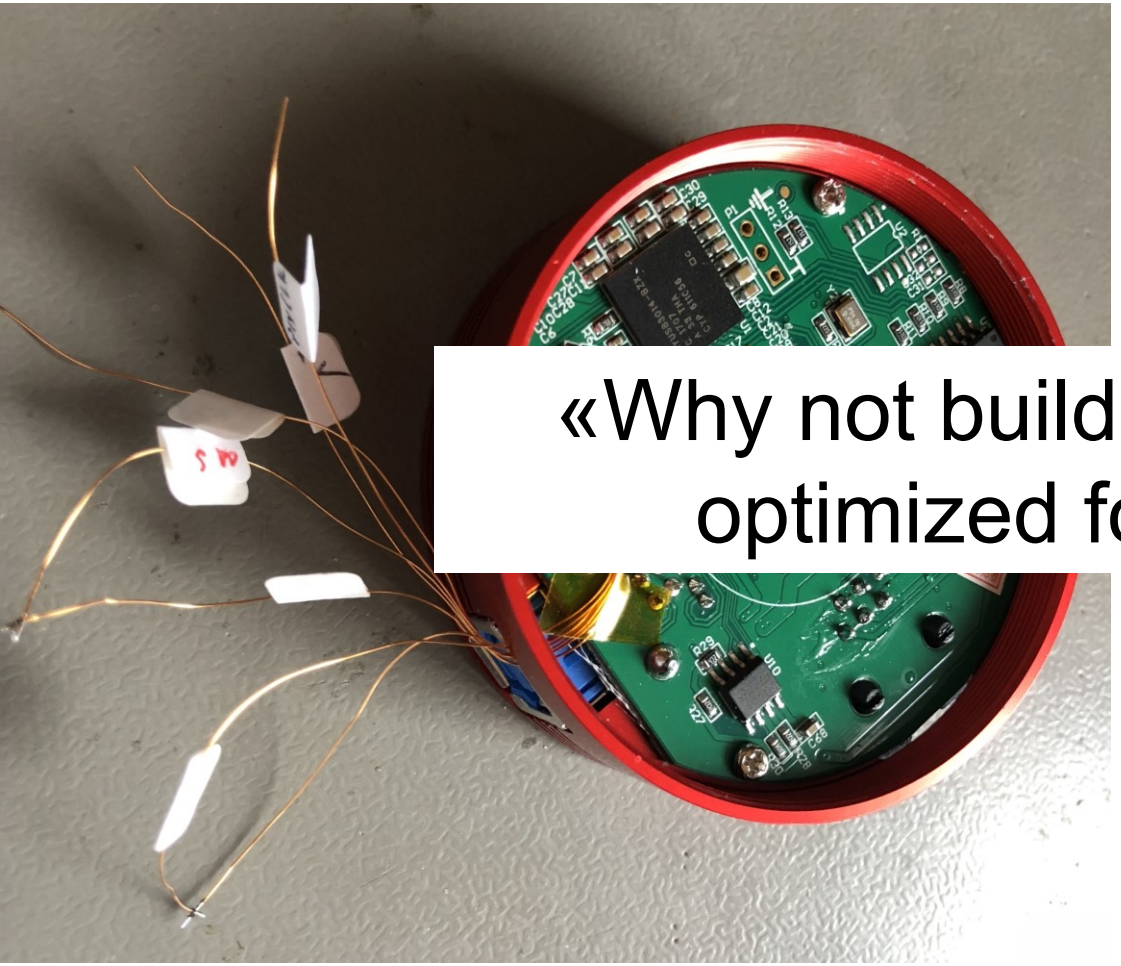


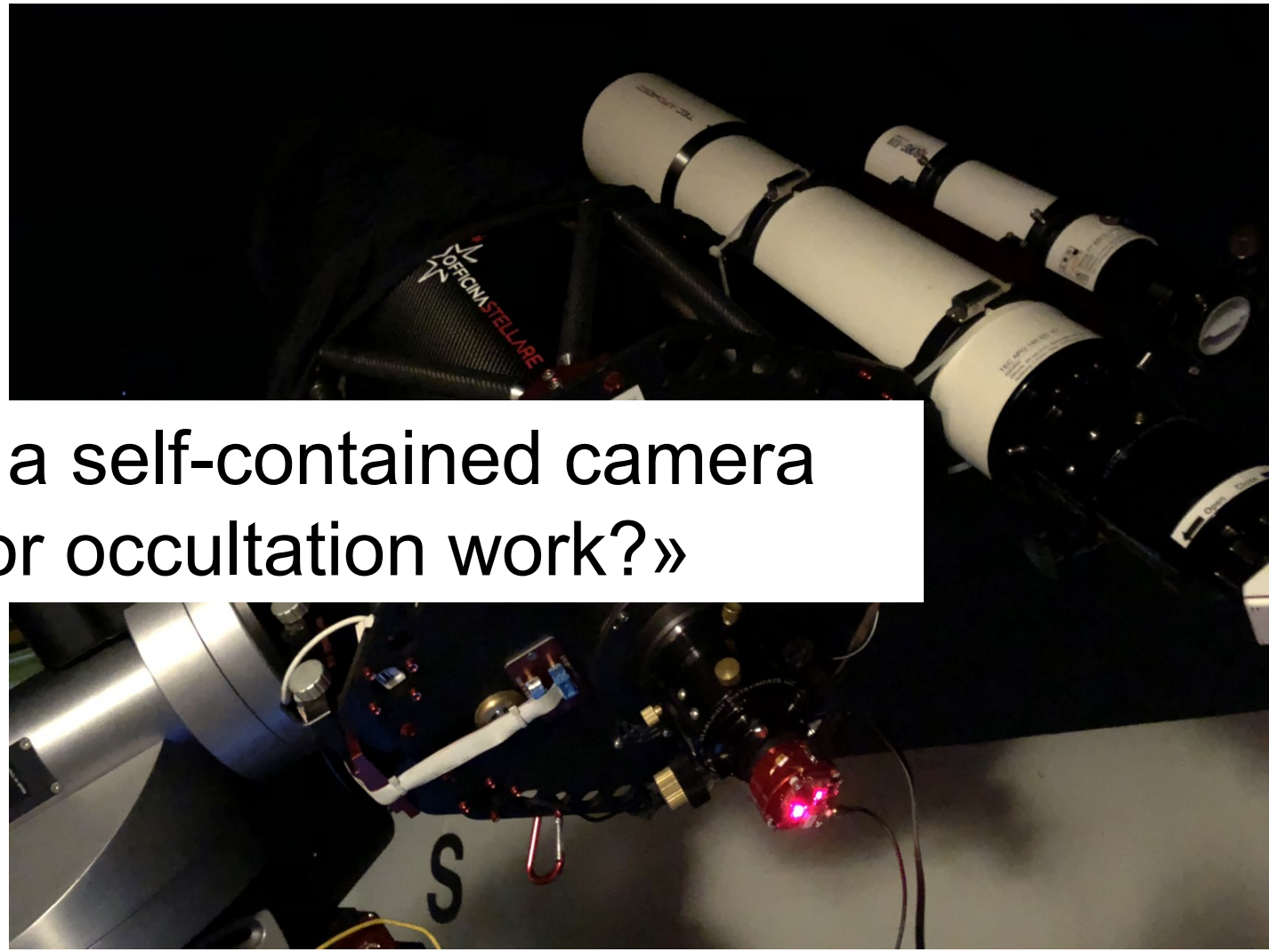
Firmware Code in C



FPGA Design in VHDL

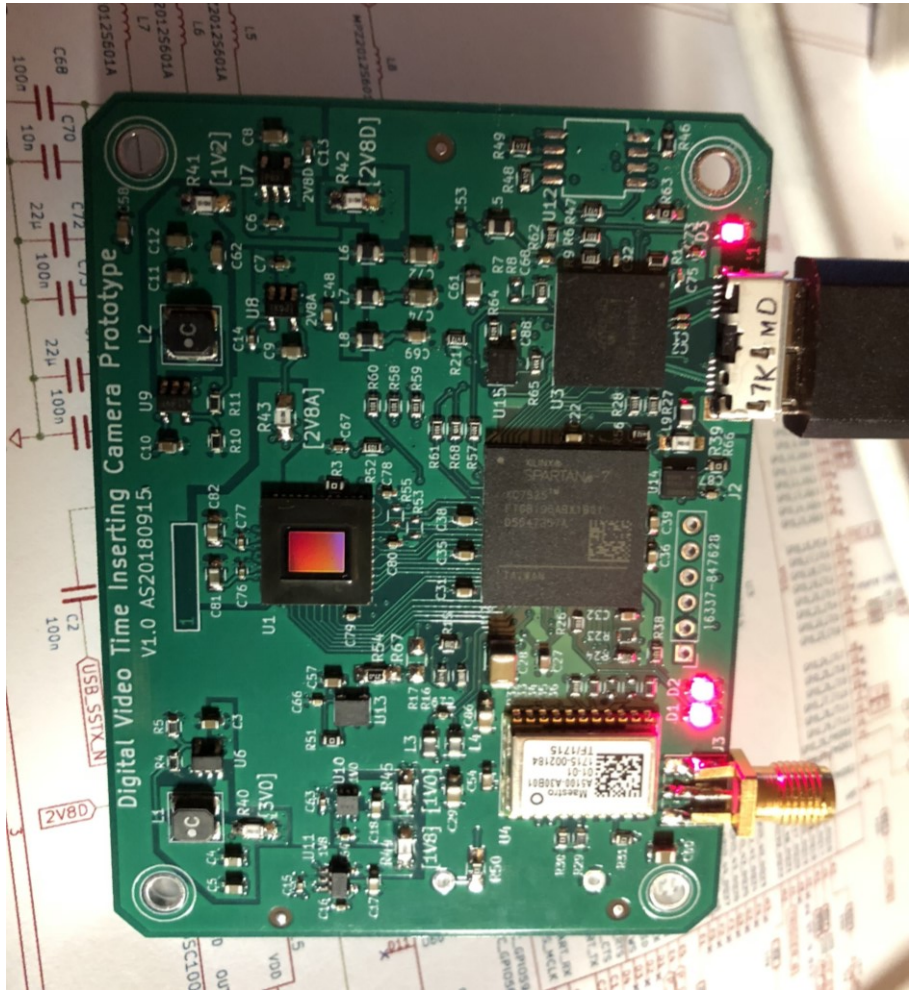
Proof-of-Concept

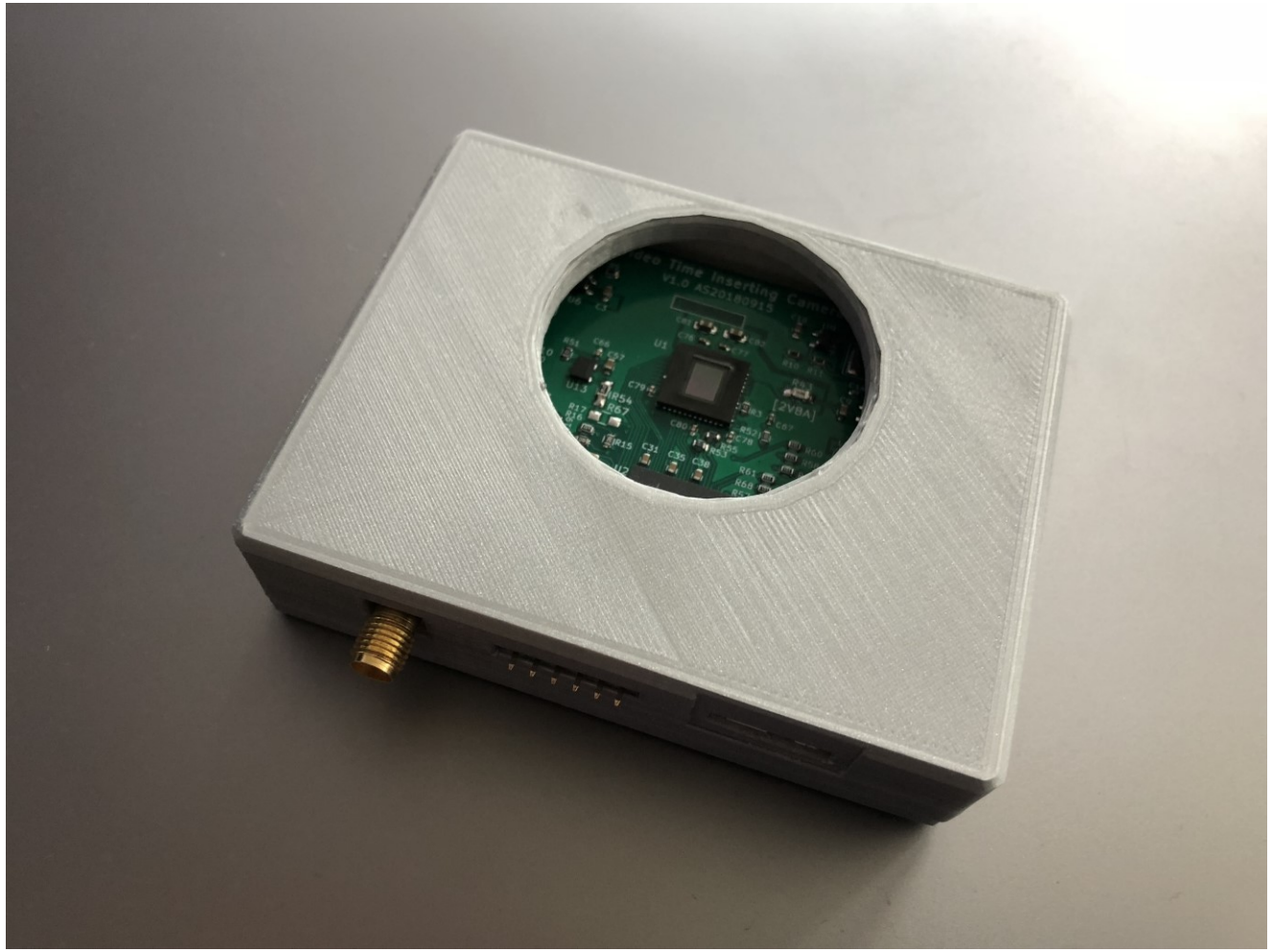




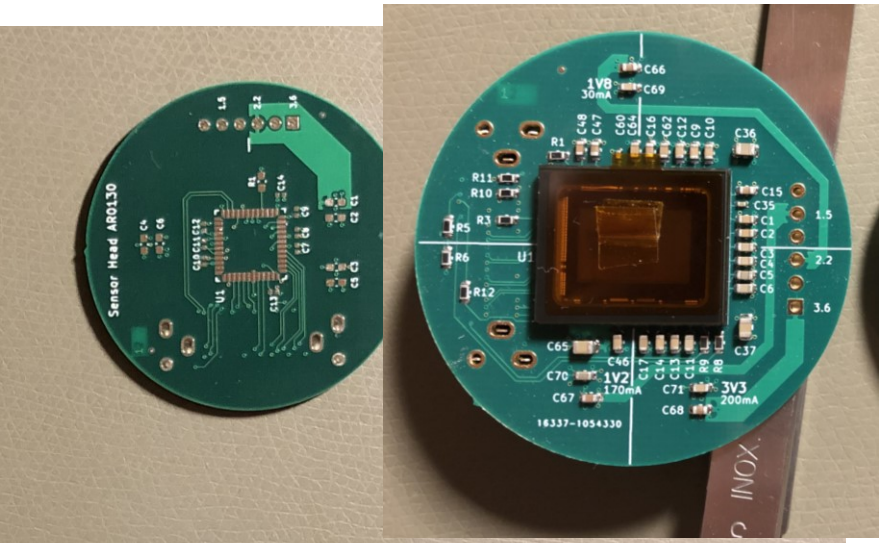
«Why not build a self-contained camera optimized for occultation work?»

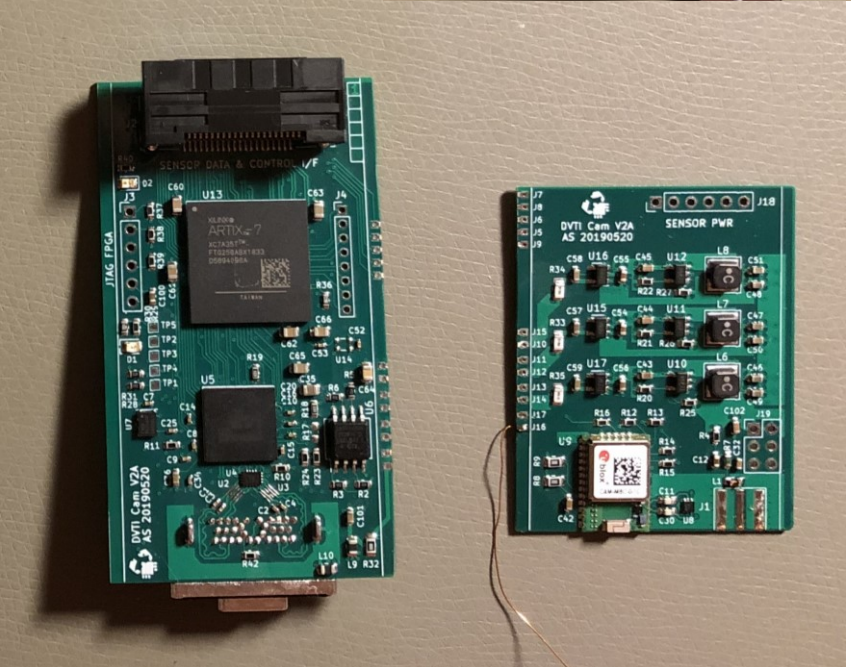
Prototype V1 (Oct 2018)





Prototype V2 (Jun 2019)



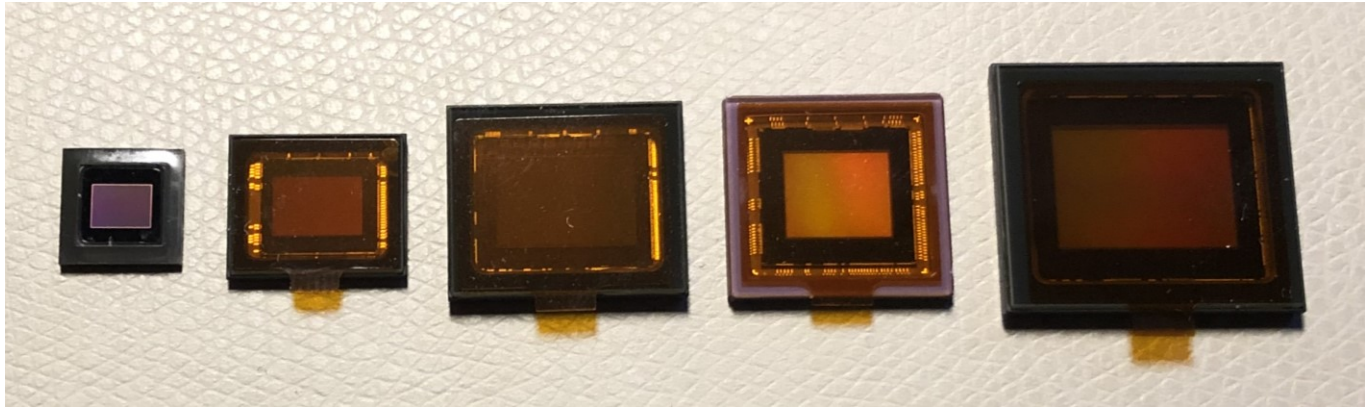


- Sensor plugin module (AR0130, IMX174, ...)
- uBlox GPS module
- Xilinx Artix FPGA
- USB-C connection

Prototype V3 (planned)

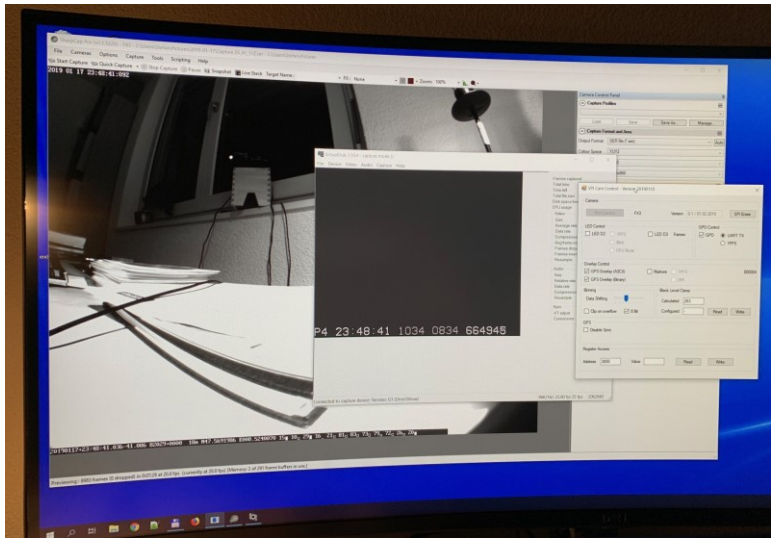
- Sensor plugin modules (AR0130, IMX174, **IMX428**)
- Internal GPS antenna, if possible (?)
- Frame buffer on board (?)
- SD Card slot (?)
- USB-C connector
- 2" cylinder, M42 thread

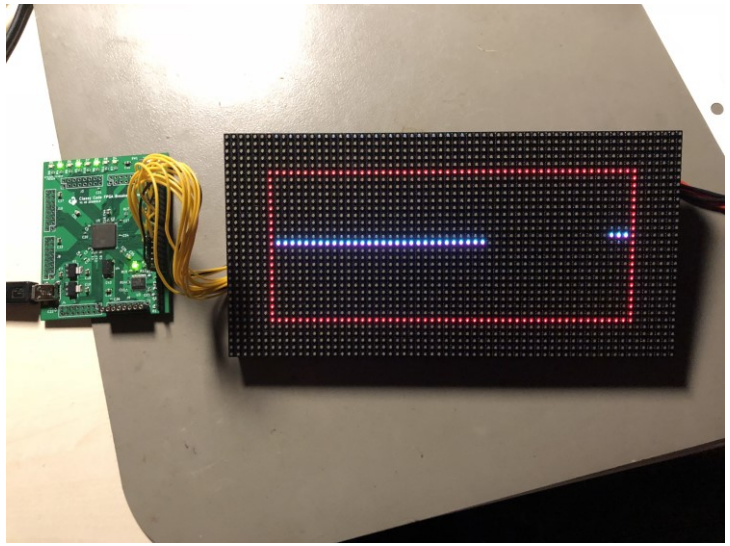
→ Kickstarter Project



Testing, Results

Testing (accurancy of time stamp)





1 Simple 1PPS LED Test
Watec and DVTI Cam
Integrity tests over 40 min.

2 Flash Test (Nikon SB-700)
Watec and DVTI Cam

3 Construction of an own EXTA.
Testing of integration time and time stamp

4 Additional independent timing tests by Gerhard Dangl (July and Aug. 2019)

Results (by Gerhard Dangl)

Recorded file			SharpCapVersion 3.2.5986.0 + VtiCamControl_20190529 settings					EXTA measurement results (V			
Number	Date	AVI file	Colour Space	Frame Rate Limit	Capture Area	Binning	Exposure set	Real Exposure	Time stamp error	Gap in sequence	Measurement tolerance = EXTA resolution
27	2019/08/18	23_15_01	YUY2	Maximum	1280 x 960	1x1	0.040	0.040	0.001	0.000	+/-0.001
28	2019/08/18	23_16_35	YUY2	Maximum	1280 x 960	1x1	0.020	0.020	0.001	0.002	+/-0.001
29	2019/08/18	23_17_05	YUY2	Maximum	1280 x 960	1x1	0.010	0.010	0.001	0.012	+/-0.001
30	2019/08/18	23_17_37	YUY2	Maximum	1280 x 960	1x1	0.005	0.005	0.001	0.017	+/-0.001
31	2019/08/18	23_18_10	YUY2	Maximum	1280 x 960	1x1	0.002	0.002	0.001	0.020	+/-0.001
32	2019/08/18	23_18_26	YUY2	Maximum	1280 x 960	1x1	0.001	0.001	0.001	0.021	+/-0.001
33	2019/08/18	23_19_21	YUY2	Maximum	1280 x 960	1x1	0.020	0.020	0.001	0.002	+/-0.001
34	2019/08/18	23_20_08	YUY2	Maximum	1280 x 960	1x1	0.040	0.040	0.001	0.000	+/-0.001
35	2019/08/18	23_20_56	YUY2	Maximum	1280 x 960	1x1	0.080	0.080	0.001	0.000	+/-0.001
36	2019/08/18	23_23_00	YUY2	Maximum	1280 x 960	1x1	0.160	0.160	0.001	0.000	+/-0.001
37	2019/08/18	23_24_30	YUY2	Maximum	1280 x 960	1x1	0.320	0.320	0.001	0.000	+/-0.001
38	2019/08/18	23_25_11	YUY2	Maximum	1280 x 960	1x1	0.640	0.637 - 0.640 *	0.001	0.000	+/-0.001
39	2019/08/18	23_26_44	YUY2	Maximum	1280 x 960	1x1	1.280	1.300 - 1.320 *	0.025 *	0.000	+/-0.002
40	2019/08/18	23_29_06	YUY2	Maximum	1280 x 960	1x1	2.560	2.615 - 2.635 *	-0.01 *	0.000	+/-0.005

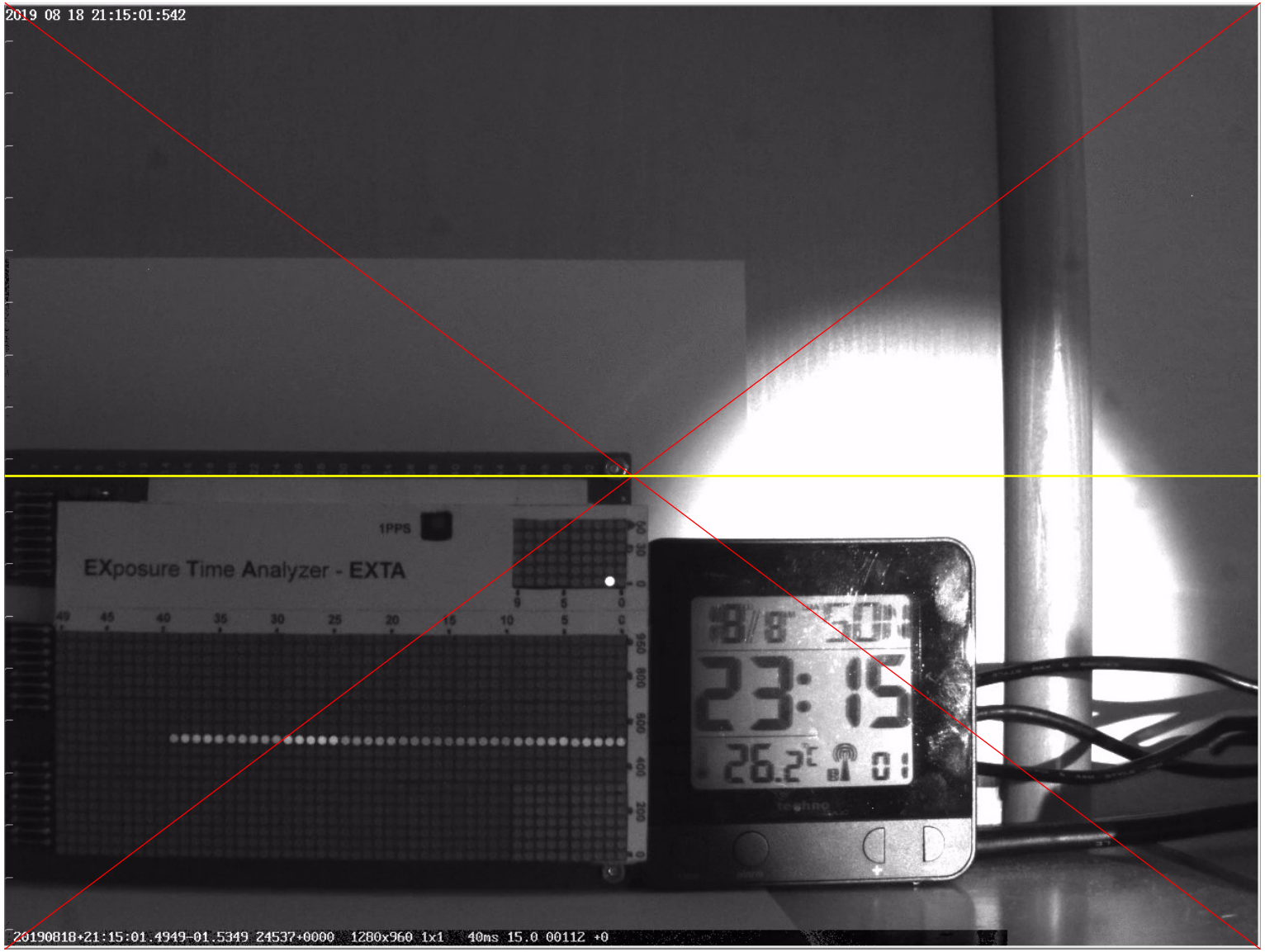
* different values possible

Hardware:	HP ProBook 6570b with Intel core i5 2.6GHz CPU, 8GB RAM, Samsung SSD, EVO 840, 500GB, 512MB Cache, SATA III
	Camera DVTI_v1_Prototype connected via USB3.0; no additional external Power supply
Software:	W7P/64 (all updates) + SharpCapVersion 3.2.5986.0 + VtiCamControl_20190529
	Disk write speed test made by SharpCap showed 348 MB/s and 297 fps with format 1280x960

- High absolute accurancy in all exposure modes <1s: 1 ms or better
- Some issues with insonsistent exp. times >1s
- Exp. times below 22.2ms (>45 fps) in full frame videos produce gaps between frames (time stamp is still accurate)

Example of one Test Case

5 ticks below center line:
Recording happened 5ms after creation of time stamp



Rolling Shutter

1/10'000s accurancy used to avoid rounding differences

Start Time

Time stamp: 01.4949s
\- EXTA: 01.500 s
\+ RS corr.: 00.005 s
Deviation: -

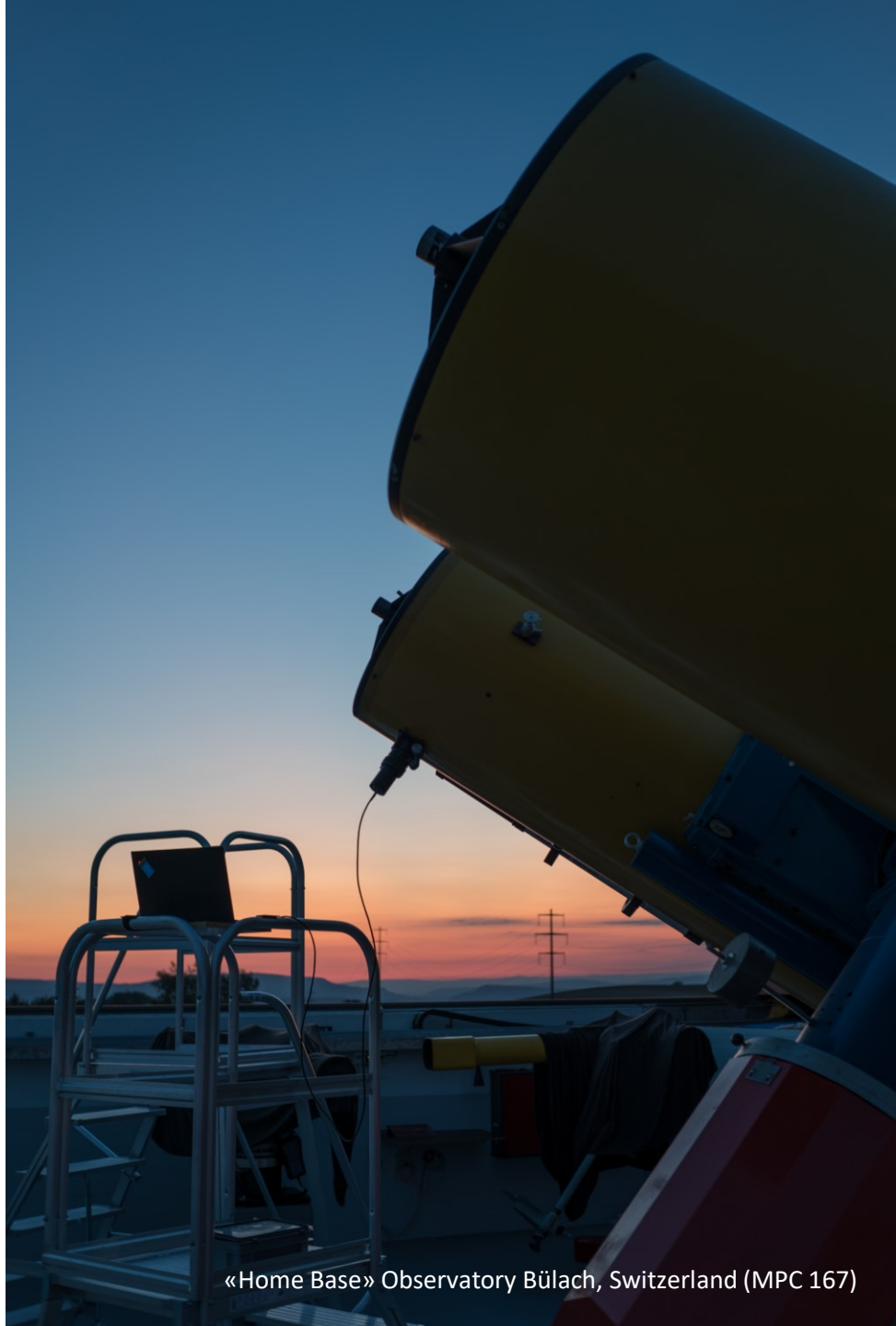
End Time

Time stamp: 01.5349s
\- EXTA: 01.540 s
\+ RS corr.: 00.005 s
Deviation: -

Results of actual Occultations

Camera Model	Time period	Pos	Neg	Total
mod. ASI120MM	Oct-Nov 2018	1	2	3
Prototype 1	Jan-Jul 2019	4	35	39
Prototype 2	Jul-Aug 2019	1	12	13
		6	49	55


(34339) 2000 QH218 occults the 3.4 mag star Rasalas in Leo on 5th Feb. 2019.
Mobile station Hulftegg, 950 m altitude, Switzerland.

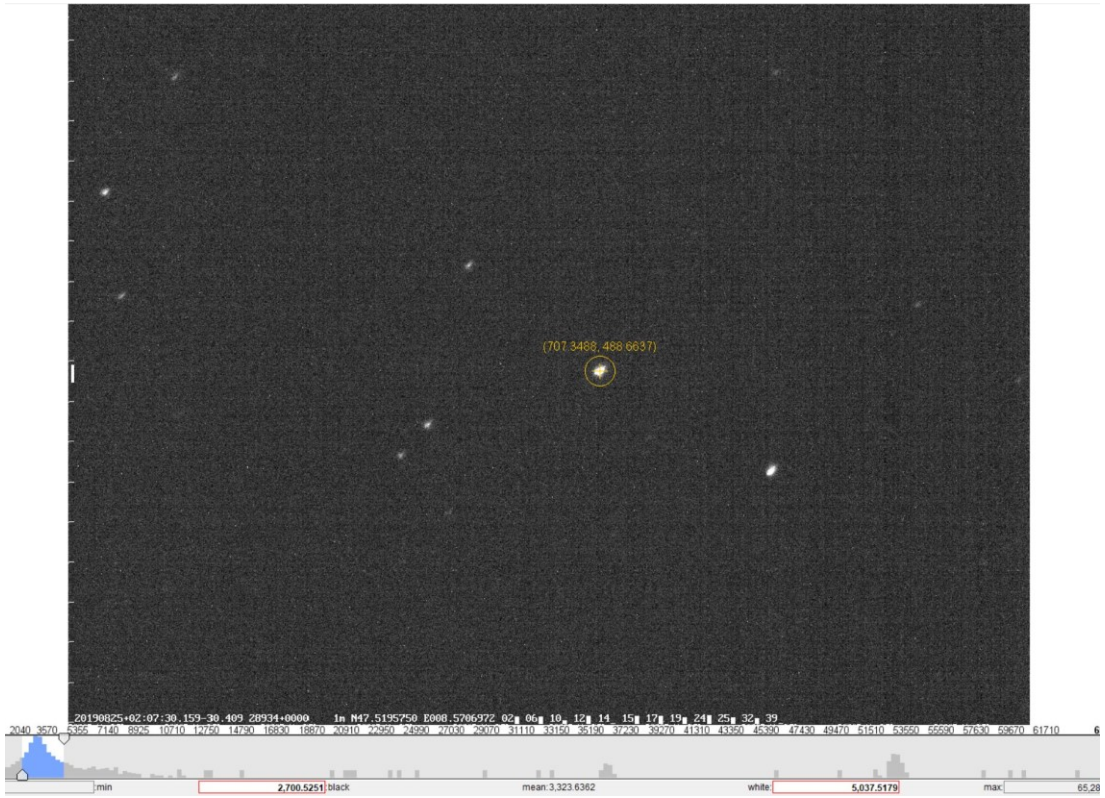

«Home Base» Observatory Bülach, Switzerland (MPC 167)

Example of this week…

Video recorded in SER format including all metadata.
Visual timestamp only used as a «backup» to the binary.

DATE: 2019 Aug 25, 02:05 (UTC)

STAR: UCAC4 561-26842 mv: 10.9 mag
ASTEROID: (1010) Marlene mv: 16.3 mag (diam. 47 km)
delta-magnitude: mv: 5.4 mag



→

Demo

Thank you!

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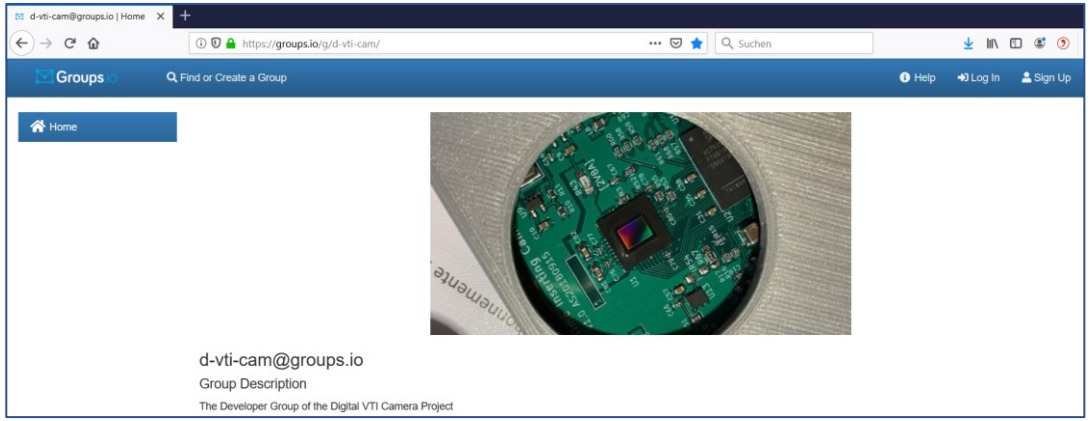
stefan.meister@sag-sas.ch

Stellar Occultation Timing
Association Switzerland (SOTAS)
www.occultations.ch



The DVTI Cam Project Website:
groups.io/g/d-vti-cam