A Camera Payload and Processing Unit for Autonomous Satellite Deployment Verification Accelerated by Soft GPU

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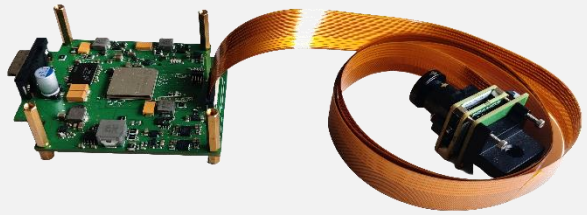
EMM TODAY

Specialised in embedded systems and control units for space payloads.

Smart Power and Processing Module

esa business incubation centre Bavaria

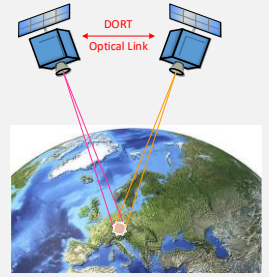
Camera Electronics



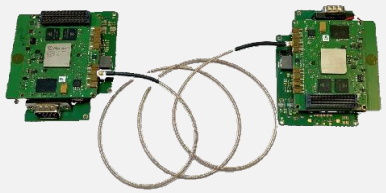
Dynamic Optical Ranging & Timing

MUnique Technology

Bayerisches Staatsministerium für Wirtschaft, Landesentwicklung und Energie

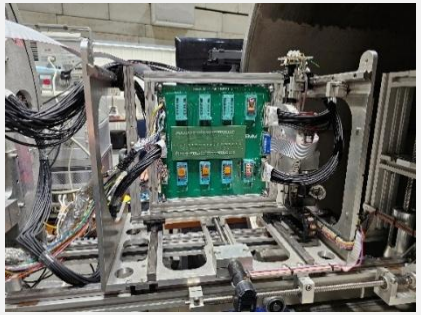


Distributed Multi-OBC



Bayerisches Staatsministerium für Wirtschaft, Landesentwicklung und Energie

Assessment of Non-Volatile Memories

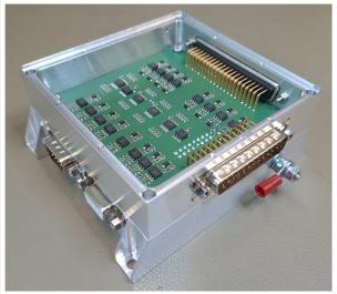


namlab nanoelectronic materials laboratory

Fraunhofer INT

Satellite mixed-signal electronics and data processing

OHB



EMM Embedded System for Satellites

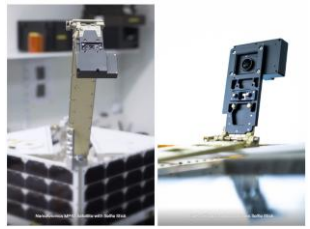
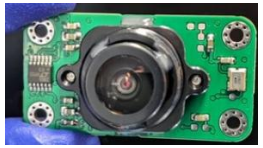
- Small quantities (1..10)
  → System price is dominated by non-recurring engineering resp. development costs

- Specific hardware for custom solutions
  → Development required

- FPGA-based with hardcore processor(s)
  → Configurable logic & software programming serves multiple applications

- Quick design updates and extensions
  → Modularity

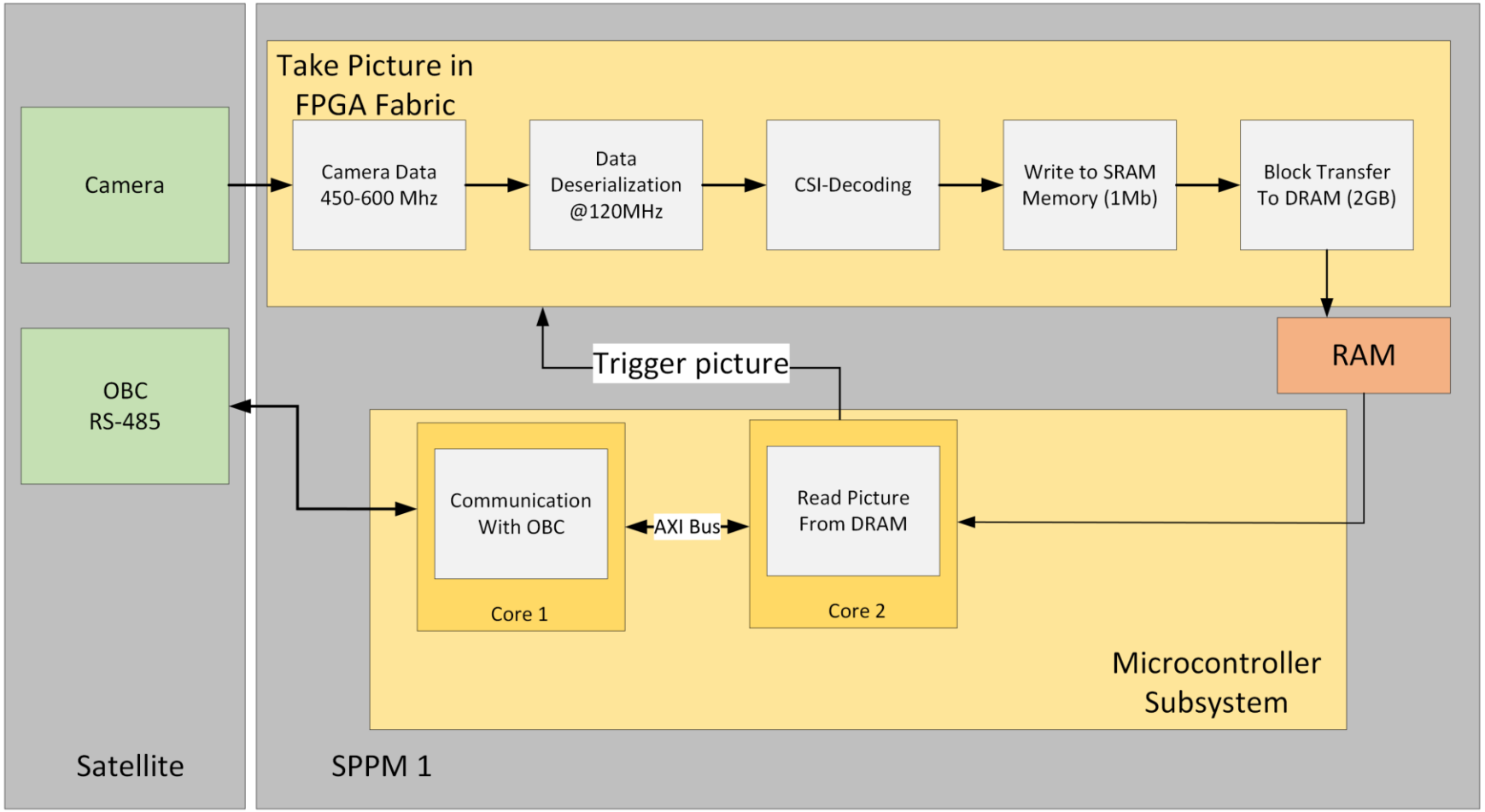
STATE OF THE ART

Infinity Avionics SelfieCam 	UART	1024x 768	4Mbit MRAM = 500 Images	10g	TRL9	750mW	50 x 30 mm	COTS
NanoAvionics Selfiestick 	UART	4000x 3000	32GB	-	TRL9	-		COTS Go-Pro
MVP Aerospace Ltd KissCAM V2 	UART	1280x 960	16Mb MRAM	12g	TRL9	Max 500mW	45x35x17mm	COTS
3D Plus – CASPEX 12M Space Camera 	CL/ Space Wire	4096x 3000	48 GB	120g	TRL9	N/A	40 x 40 x 40 mm	Space Grade (COTS)

CPPU: MAIN INNOVATIONS

- Standard protocol to camera (MIPI)
- Camera up to 1m from processing board via flexible PCB
- RS-485 downlink to OBC at 115.2 Kbaud
- Bare-metal control, deterministic and testable operation
- On-board shape extraction of solarpanels (Processing)

HARDWARE AND SOFTWARE ARCHITECTURE

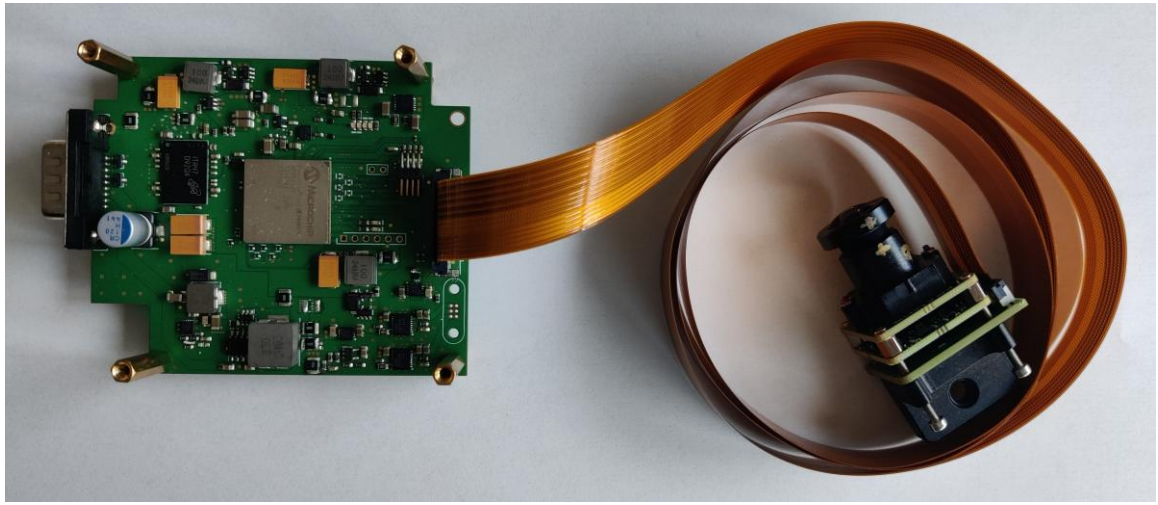


- MIPI decoder and Deserialization
- Core 1 : OBC Communication
  Core 2 : Picture Handling
- Pictures Stored in DDR memory
- Blockwise transfer of Data
- 20 fps
- Camera Configuration

DESIGN PHASES

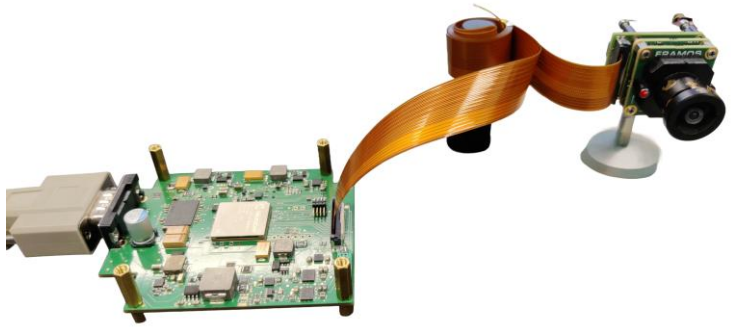
Breadboard

Flight Model



- 10 Layer PCB
- 5W with Camera
- Self-protected power supply
- 2 Gbit RAM buffer
- Based on polarfire SoC

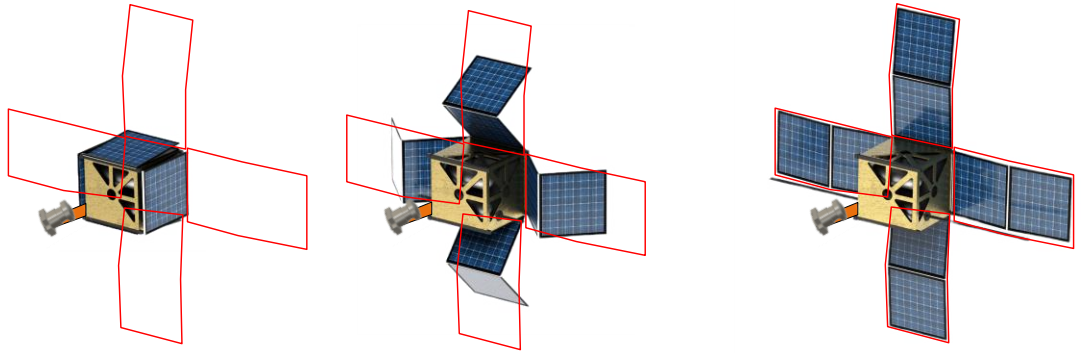
SYSTEM PERFORMANCE AND RESULTS



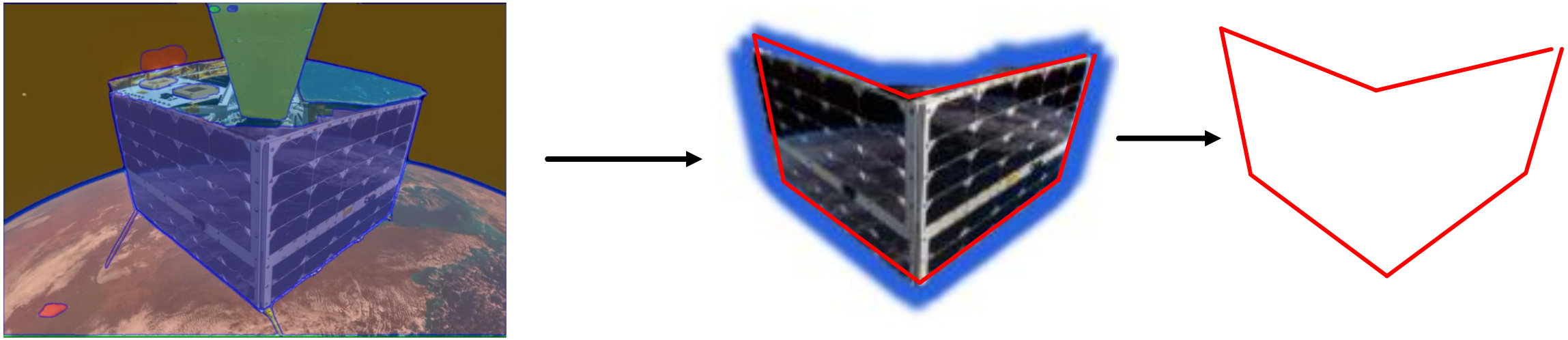
- Operational in rolled state
- Power: 3 W (idle) to 5 W (active), temp-stable (57°C passive lab test)
- Includes house keeping (Temp. / Voltages)

- 4K Pictures
- Take picture with 20 fps
- Picture RAW format ~ 8 MB
- Trasmit time ~ 20 min.
- Chunked Transfer

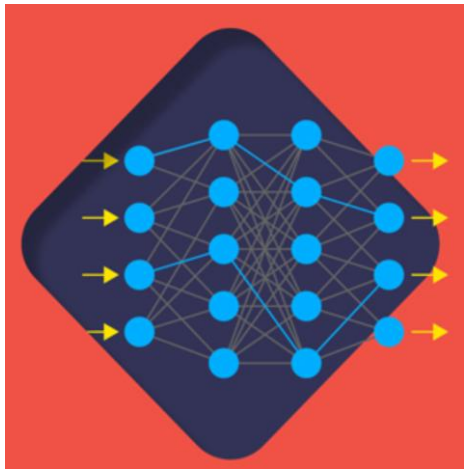
DEPLOYMENT VERIFICATION



- Deployable shape extraction/vectorization (SVG format)
- Data reduction: 8 Mbit (4K RAW) to 1.6 kbit (vectorized info)



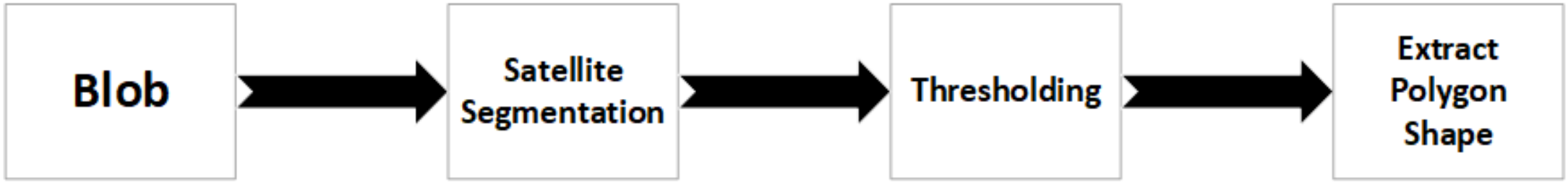
GPU WORKFLOW



- Configuration.xml
- Scheduler.xml

- Compiled and .txt files generated

IMAGE SEGMENTATION ON GPU @ SAT



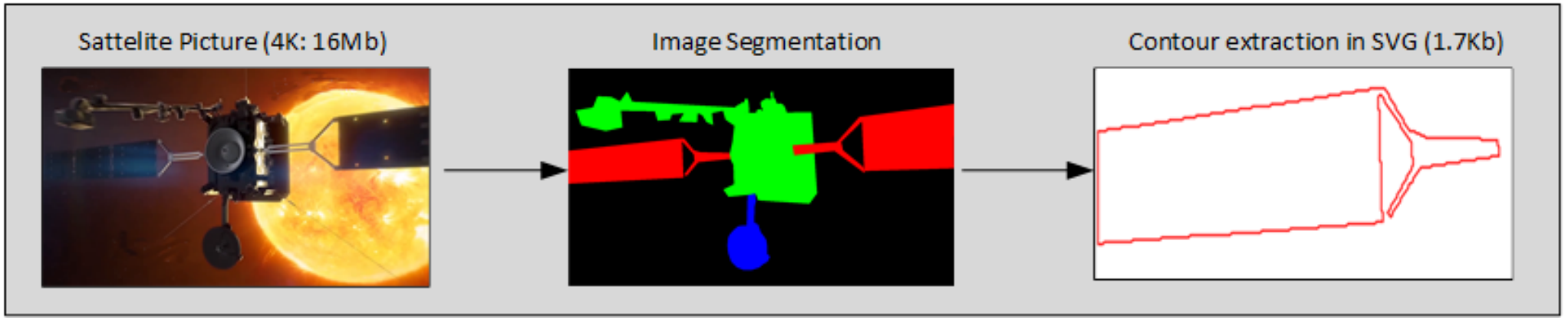
- Convert from image to Vector format

DNN

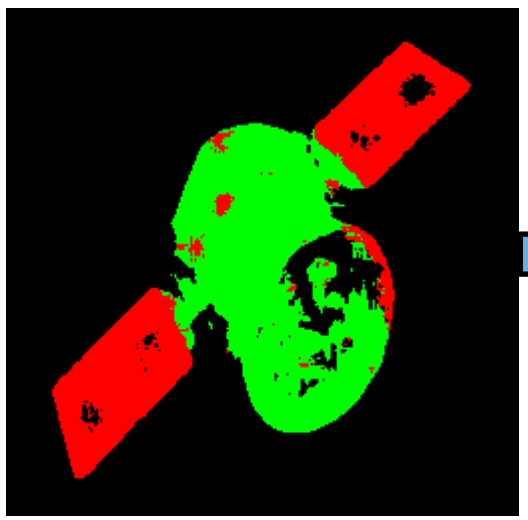
- Binary labels,
- Quantize picture

Contour detection
Create Polygon shape
(CGAL with OpenCV)

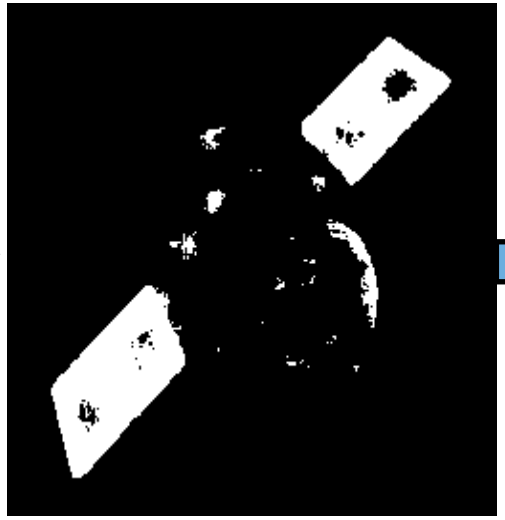
OpenCL kernels



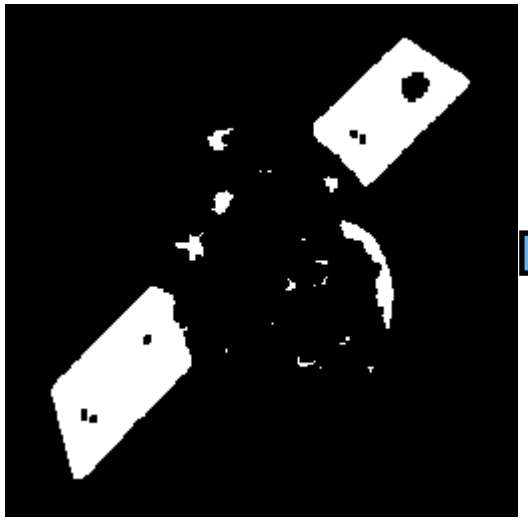
OPENCL PIPELINE FOR SOLAR PANEL DETECTION



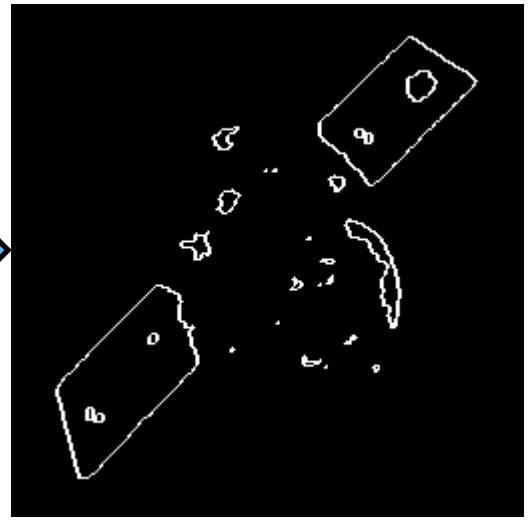
CNN output (HxWx4)



- selects the class ID with max.probability per pixel
- Selects only solar panel pixels => panel mask



•Dilate: expands panel regions, fills small holes
•Erode: contracts panel regions, removes noise



- Contour extraction : converts pixel mask into line segments =>SVG

FUTURE WORK

- Expand autonomous onboard processing and anomaly detection.
- Integrate GPU@SAT in the CPPU Platform

THANK YOU

engineering
minds
munich