Department of Signal Processing

Jiří Kadlec

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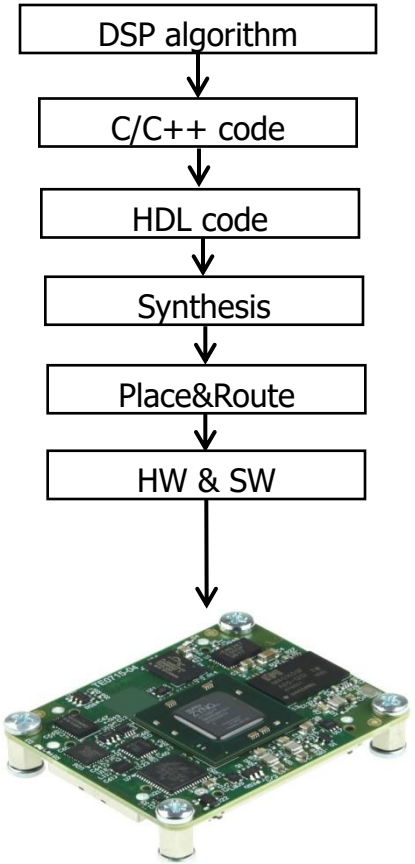
kadlec@utia.cas.cz

Evaluation of the team 2015-19

Overview of the Department

- **Topics**
  - Recursive system identification in digital signal processing (DSP)
  - Systolic arrays, dedicated arithmetic, SW & HW
  - Field programmable gate arrays (FPGA)
  - Dynamically reprogrammable FPGA accelerators
  - Embedded systems,
  - Human-machine-interfaces (HMI)
- **Strengths**
  - Algorithmic engineering for DSP applications
  - HW design of intellectual property (IP) for FPGA
  - Strong track record of research cooperation in EU R&D projects.
  - Contract-based industrial research.
  - Mainly in HMI in cooperation with Skoda Auto.



Overview of the Department

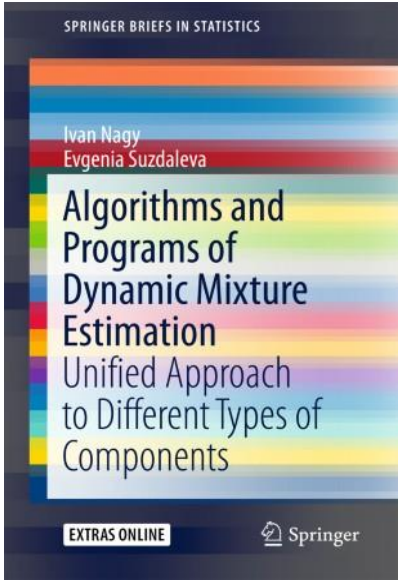
- **Department staff**

Ing. Jiří Kadlec, CSc.	(1.0)	Head of Department, DSP
Ing. Zdeněk Pohl, Ph.D.	(1.0)	Deputy head of Department, DSP
Ing. Lukáš Kohout	(1.0)	FPGA design
Ing. Radim Matulík	(1.0)	HW, PCB design
Doc. Ing. I. Nagy, CSc.	(0.64)	Bayesian mixtures, teaching CTU
Doc. Ing. E. Uglickich, CSc.	(1.0)	Bayesian mixtures, teaching CTU
Ing. Raissa Likhonina	(1.0)	Ph.D. student
Dr. Ing. Jiří Plíhal	(1.0)	Deputy head of Department for Internal projects with Škoda Auto
Ing. David Pavlík Ph.D.	(1.0)	Internal projects with Škoda Auto
Ing. Gabriela Havlíčková	(1.0)	Internal projects with Škoda Auto
Bc. Veronika Kyznarová	(1.0)	Internal projects with Škoda Auto
Mgr. Milada Kadlecová	(1.0)	Secretary
Total	(11.64)	

Overview of the Department

Publications 2015-2019

Books	Chapters in books	Journal articles	Conference Papers	App Notes, Eval. Packages
1	5	10	21	60



Book

- Nagy Ivan, Suzdaleva Evgenia : Algorithms and Programs of Dynamic Mixture Estimation. Unified Approach to Different Types of Components, Springer, (Cham 2017) SpringerBriefs in Statistics [2017] DOI: 10.1007/978-3-319-64671-8
  (Note: Evgenia Suzdalova changed her name to Evženie Uglickich)

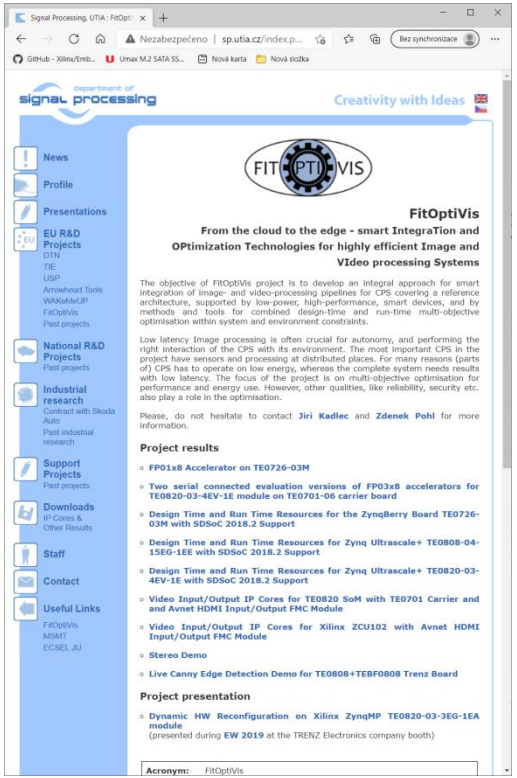
Three selected journal articles

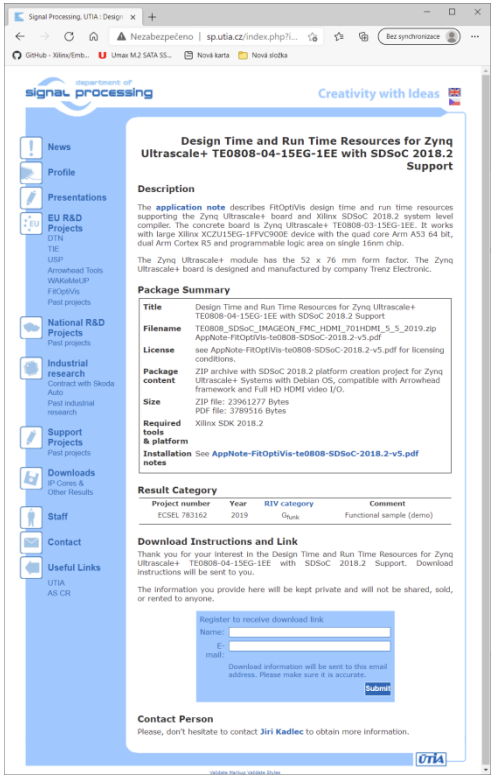
- Suzdaleva Evženie, Nagy Ivan : Two-layer pointer model of driving style depending on the driving environment , *Transportation Research. Part B: Methodological vol.128, 1 (2019), p. 254-270* [2019] DOI: 10.1016/j.trb.2019.08.009
- Suzdaleva Evgenia, Nagy Ivan : An online estimation of driving style using data-dependent pointer model , *Transportation Research. Part C: Emerging Technologies vol.86, 1 (2018), p. 23-36* [2018] DOI: 10.1016/j.trc.2017.11.001
- Hoozemans J., Van Straten J., Viitanen T., Tervo A., Kadlec Jiří, Al-Ars Z. : ALMARVI Execution Platform: Heterogeneous Video Processing SoC Platform on FPGA , *Journal of Signal Processing Systems for Signal Image and Video Technology vol.91, 1 (2019), p. 61-73* [2019] DOI: 10.1007/s11265-018-1424-1

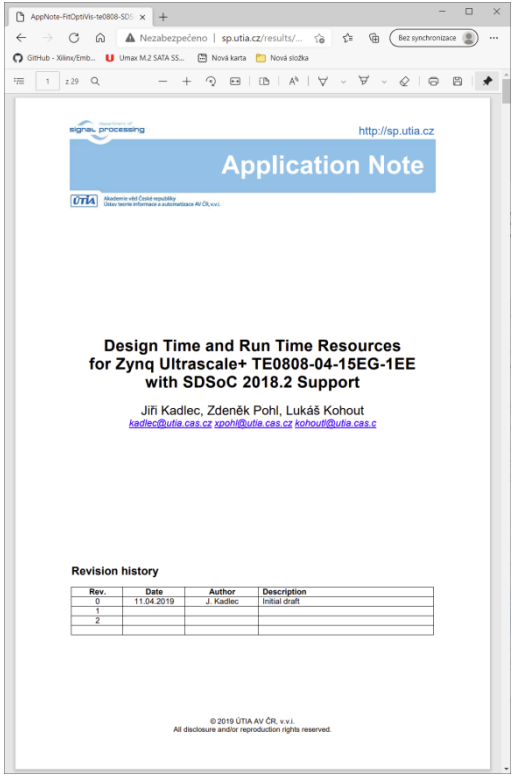
Overview of the Department

Evaluation Packages & Application Notes http://zs.utia.cas.cz/

- Department overview
- Details about projects
- Evaluation package download server
- Application note download
- Licensing conditions





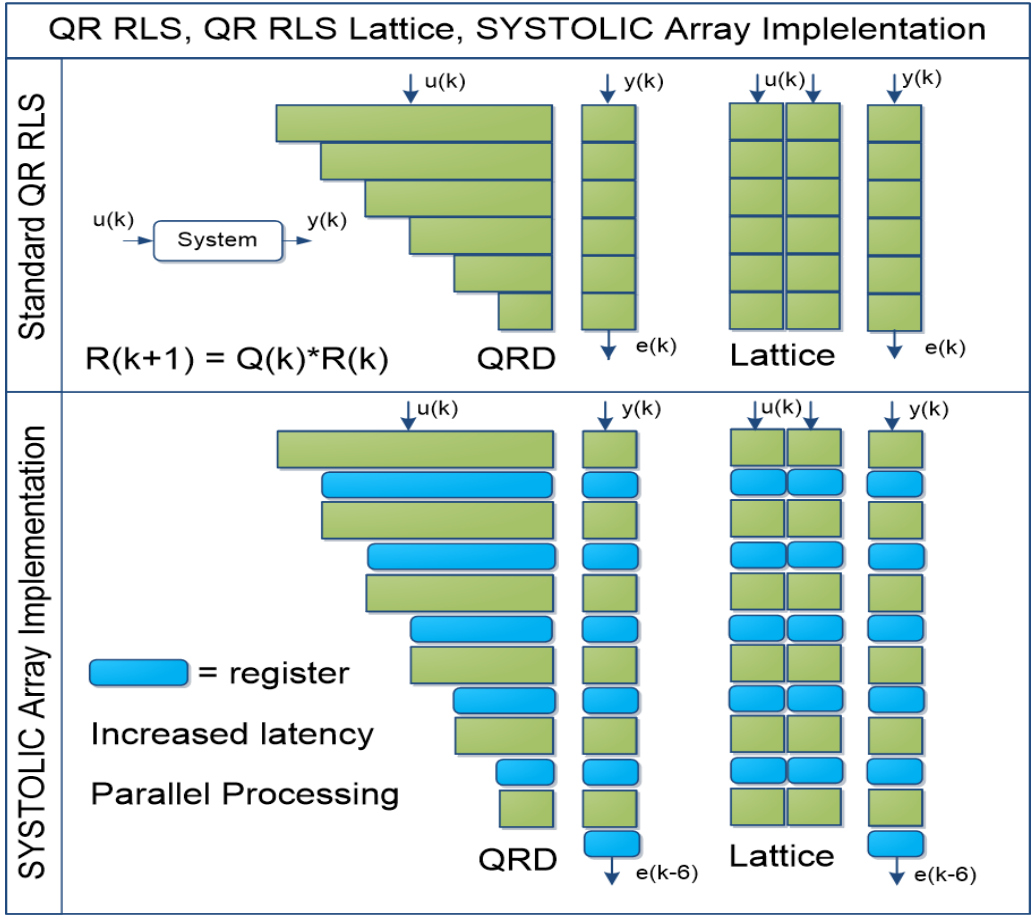


QR RLS Algorithms → Systolic Arrays

- **Results**
  - Matlab C MEX tbx.
  - SciLab C MEX tbx.
  - ARM A9 SciLab C
  - ARM A53 SciLab C
  - STM32H7 QR RLS STM32Cube tbx.
  - Parallel, C Pthread SW implementations of QR RLS Lattice algorithms on ARM A9 and ARM A53

1 Eval. Package

http://sp.utia.cz/index.php?ids=results&id=dsp_1_6

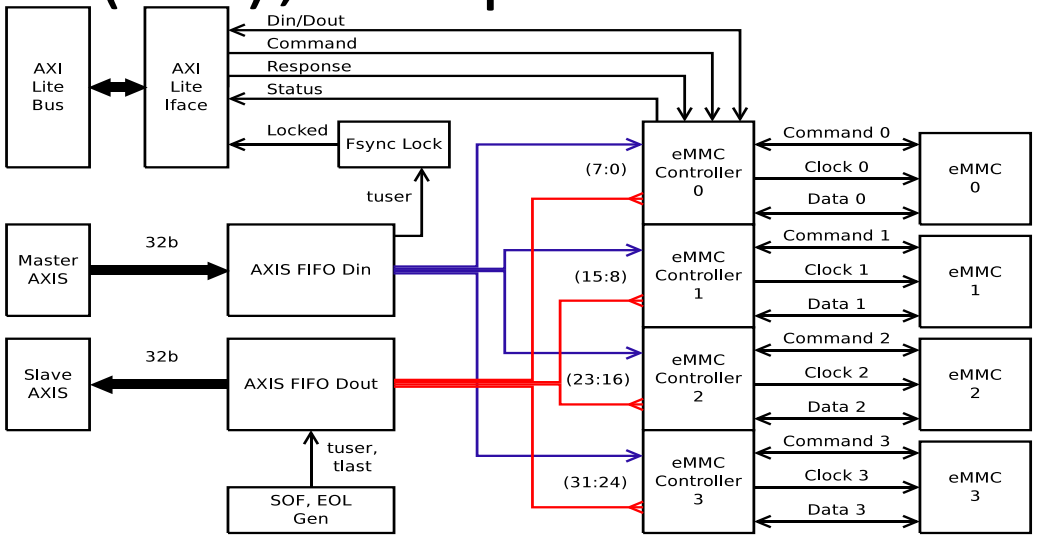


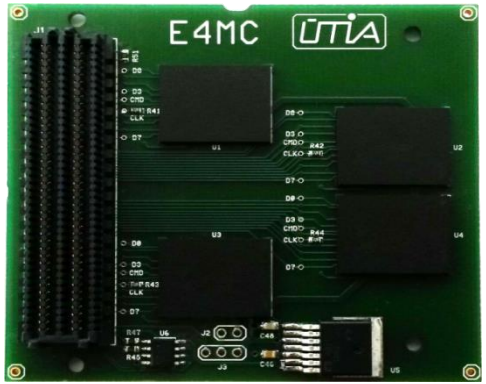
External Funding 2015-2019

	2015	2016	2017	2018	2019
IDEAS (FP7 ENIAC JU)					
ALMARVI (FP7 ARTEMIS JU)					
EMC2 (FP7 ARTEMIS JU)					
PANACHE (FP7 ENIAC JU)					
THINGSTODO (FP7 ENIAC JU)					
SILENSE (H2020 ECSEL JU)					
PRODUCTIVE4.0 (H2020 ECSEL JU)					
WAKEMEUP (H2020 ECSEL JU)					
FITOPTIVIS (H2020 ECSEL JU)					
ARROWHEAD TOOLS (ECSEL JU)					
iTEAM (H2020-MSCA-ITN-2015)					
External funding ECSEL (Mil Kč)	11,683	11,088	6,435	8,714	11,157
External funding ECSEL 2015-19	49,077 Mil Kč = 1,817 Mil €				

IDEAS – IMA s.r.o. (CZ), 15 partners

- **Research**
  - **Micron eMMC Flash devices**
- **UTIA Results**
  - **FPGA controller for Micron eMMC Flash devices**
  - **FMC PCB card**
  - **SW supporting storage of video from an image sensor in bank of 4 eMMCs.**



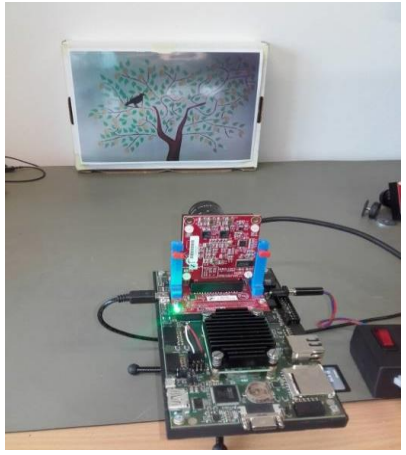


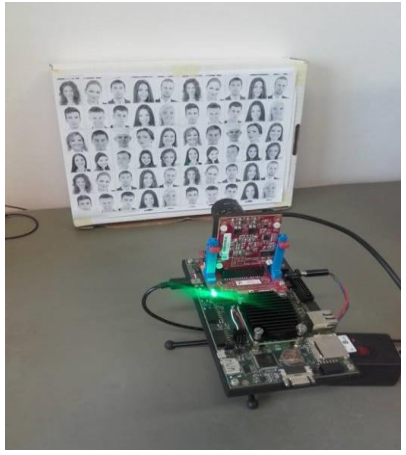
2 Eval. Packages

http://sp.utia.cz/index.php?ids=projects/ideas

ALMARVI – Philips (NL), 16 partners

- **Research**
  - **HW accele-rated video processing**
- **UTIA Results**
  - **Support for Xilinx SDSoC C to HW flow for 28nm Xilinx Zynq industrial modules**
  - **HW acceleration of the Viola Jones algorithm delivered 5-10 FPS on 28nm Zynq HW**
- **13 Eval. Packages**
  http://sp.utia.cz/index.php?ids=projects/almarvi



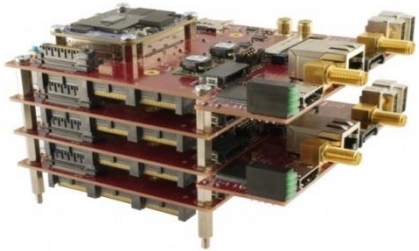


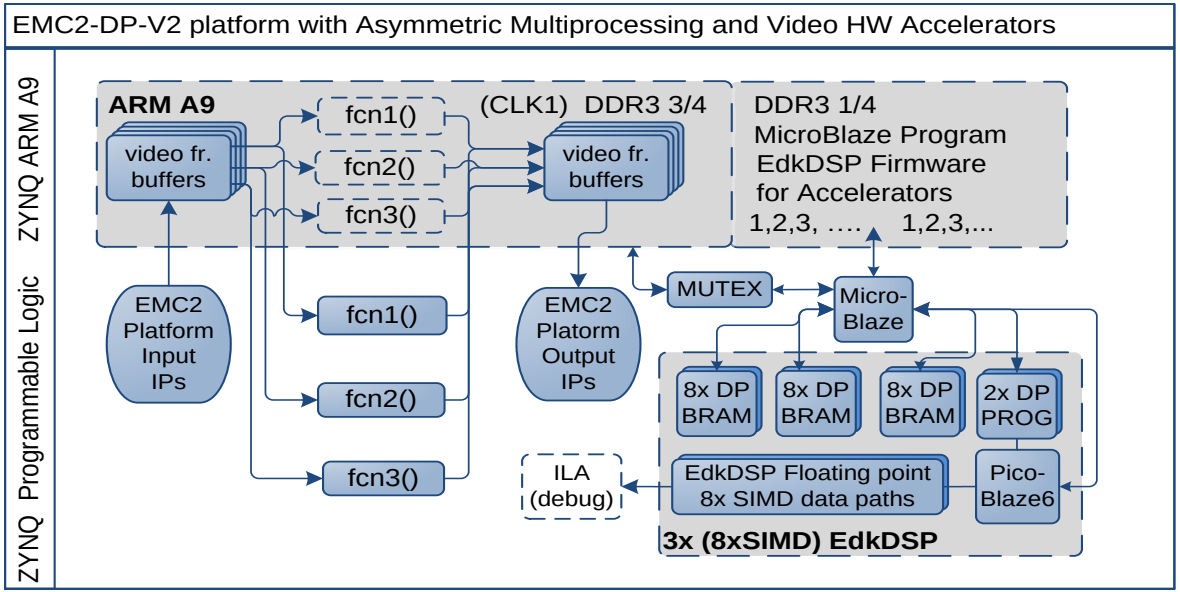
EMC² - Infineon (DE), 100 partners

- **Research**
  - **MixedCriticality MultiCore**
- **UTIA Results**
  - **Support for Xilinx SDSoC C to HW flow EMC2-DP-V2 (Sundance UK)**
  - **Support for 3x 8xSIMD EdkDSP FP32 Accelerators**

9 Eval. Packages

http://sp.utia.cz/index.php?ids=projects/emc2

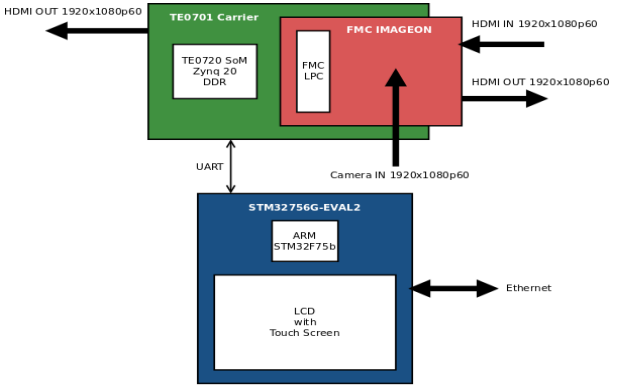




PANACHE – STM (FR), 20 partners

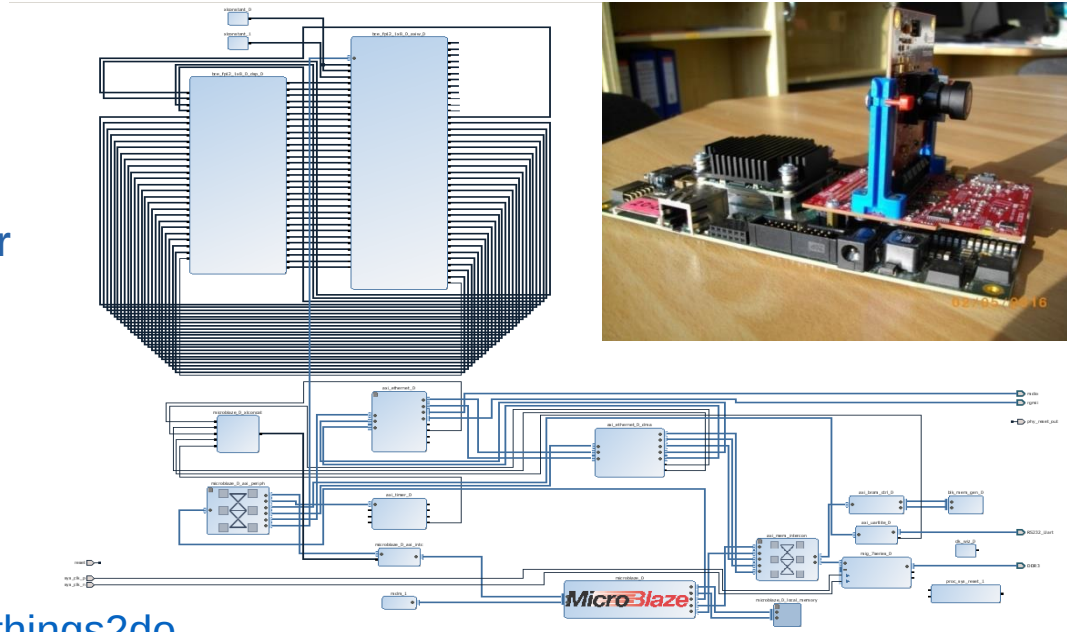
- **Research**
  - **CMOS 40nm STM32H7 micro-controllers with 2 MBytes on-chip FLASH**
- **UTIA Results**
  - **Terminal with STM32H7 MCU chip and Touch screen GUI**
  - **Terminal served for user control of HW-accelerated video processing algorithms running on Xilinx 28 nm Zynq devices.**

4 Eval. Packages
http://sp.utia.cz/index.php?ids=projects/panache



THINGS2DO – STM (FR), 45 partners

- **Research**
  - **Pilot line for the European, low-power 28 nm FD SOI integrated circuits**
- **UTIA Results**
  - **Model of UTIA 8xSIMD EdkDSP FP HW Accelerator on 28nm Xilinx Artix FPGA**
  - **It served for the initial power estimation of the EdkDSP IP**
  - **HW accelerated video processing for the FULL HD video sensor with 60 FPS.**



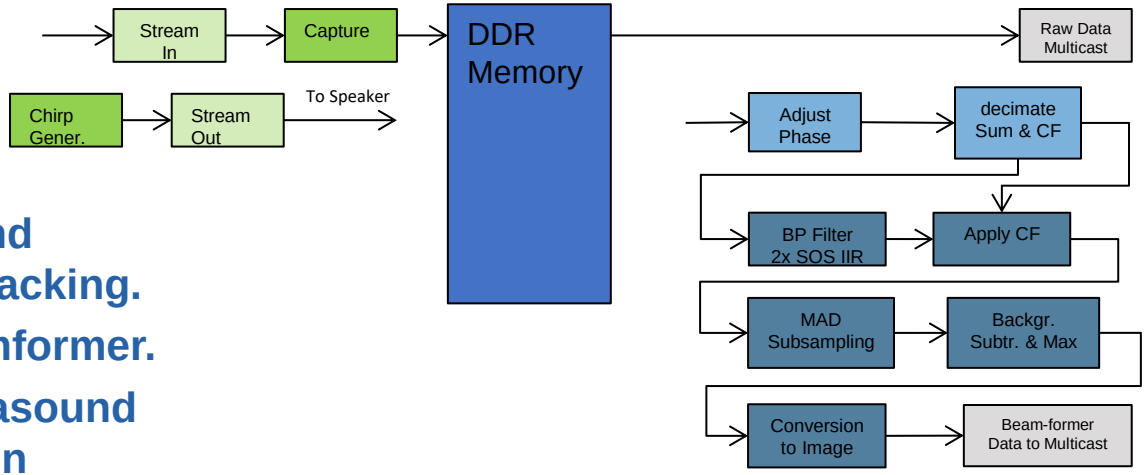
4 Eval. Packages

http://sp.utia.cz/index.php?ids=projects/things2do

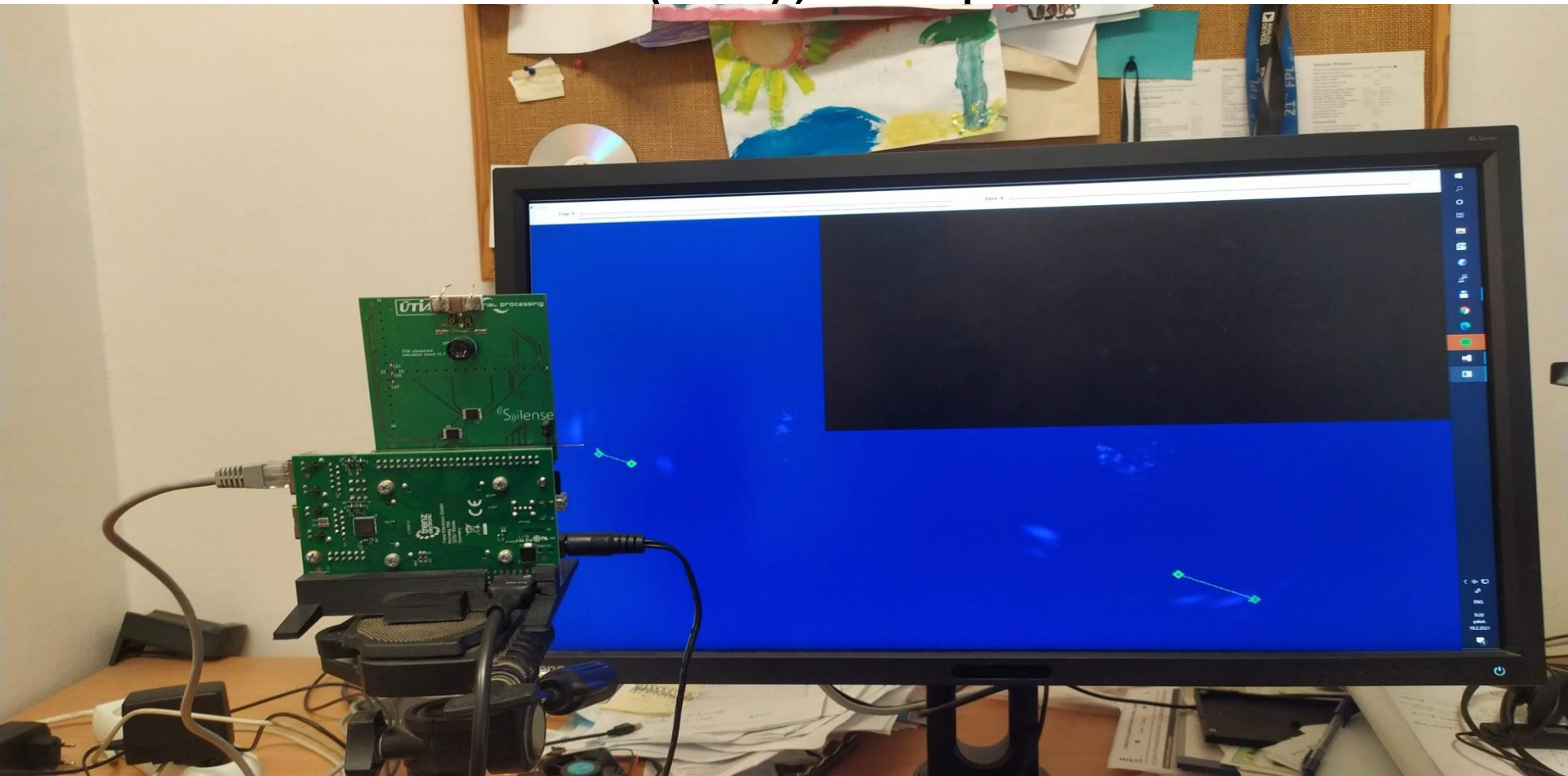
SILENSE –NXP (BE), 31 partners

- **Research**
  - **Ultrasound applications**
- **UTIA Results**
  - **HW/SW for an Ultrasound based, Hand-Gesture Tracking.**
  - **HW 2D ultrasound Beamformer.**
  - **HW/SW support for ultrasound hand-gesture recognition with the 2D microphone array**
  - **HW accelerated active noise cancellation.**
  - **Recursive Hypothesis Testing (in SW).**
  - **3 systems have been sold to project partners.**

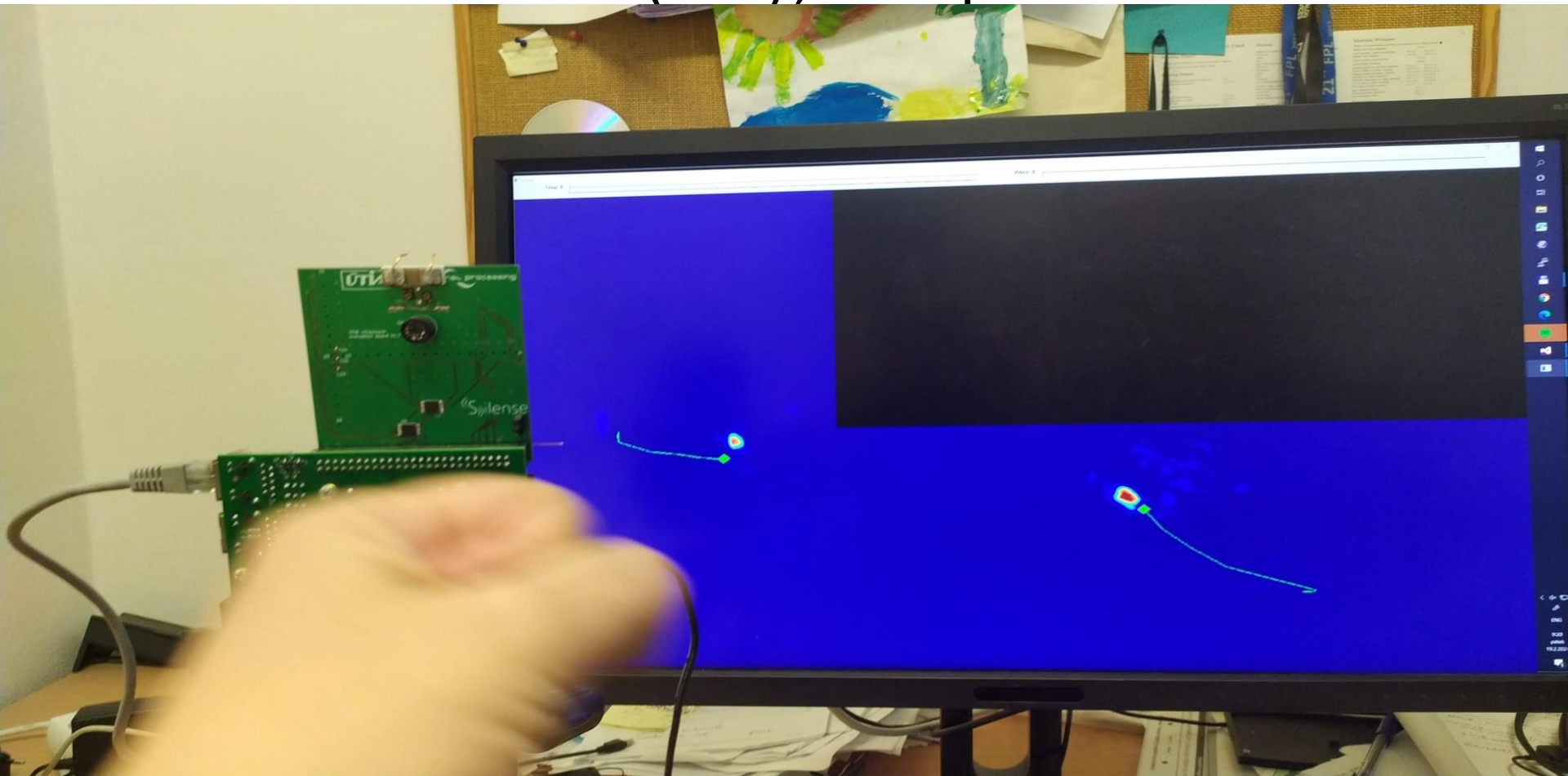
7 Eval. Packages:
http://sp.utia.cz/index.php?ids=projects/silense



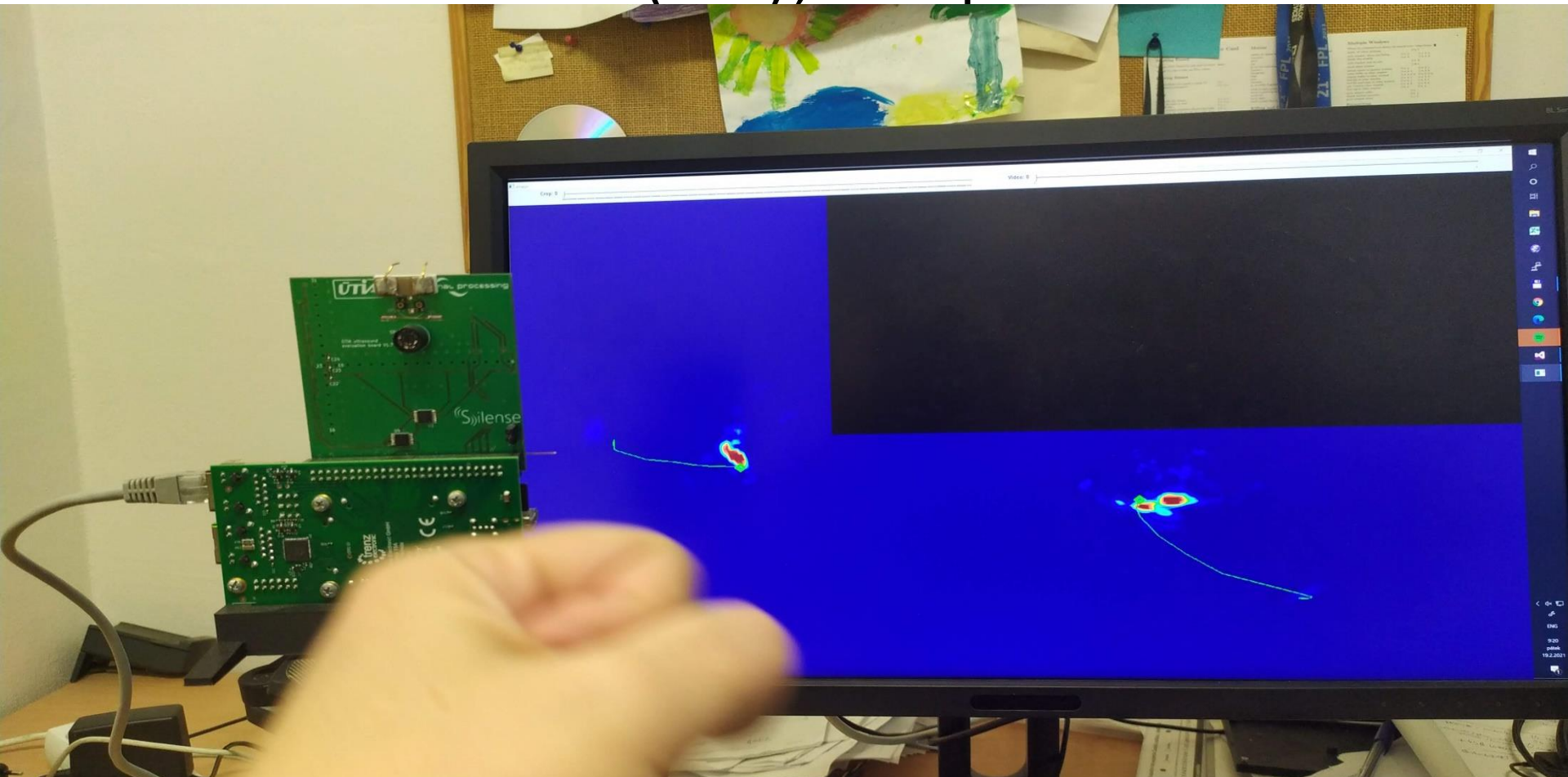
SILENSE –NXP (BE), 31 partners



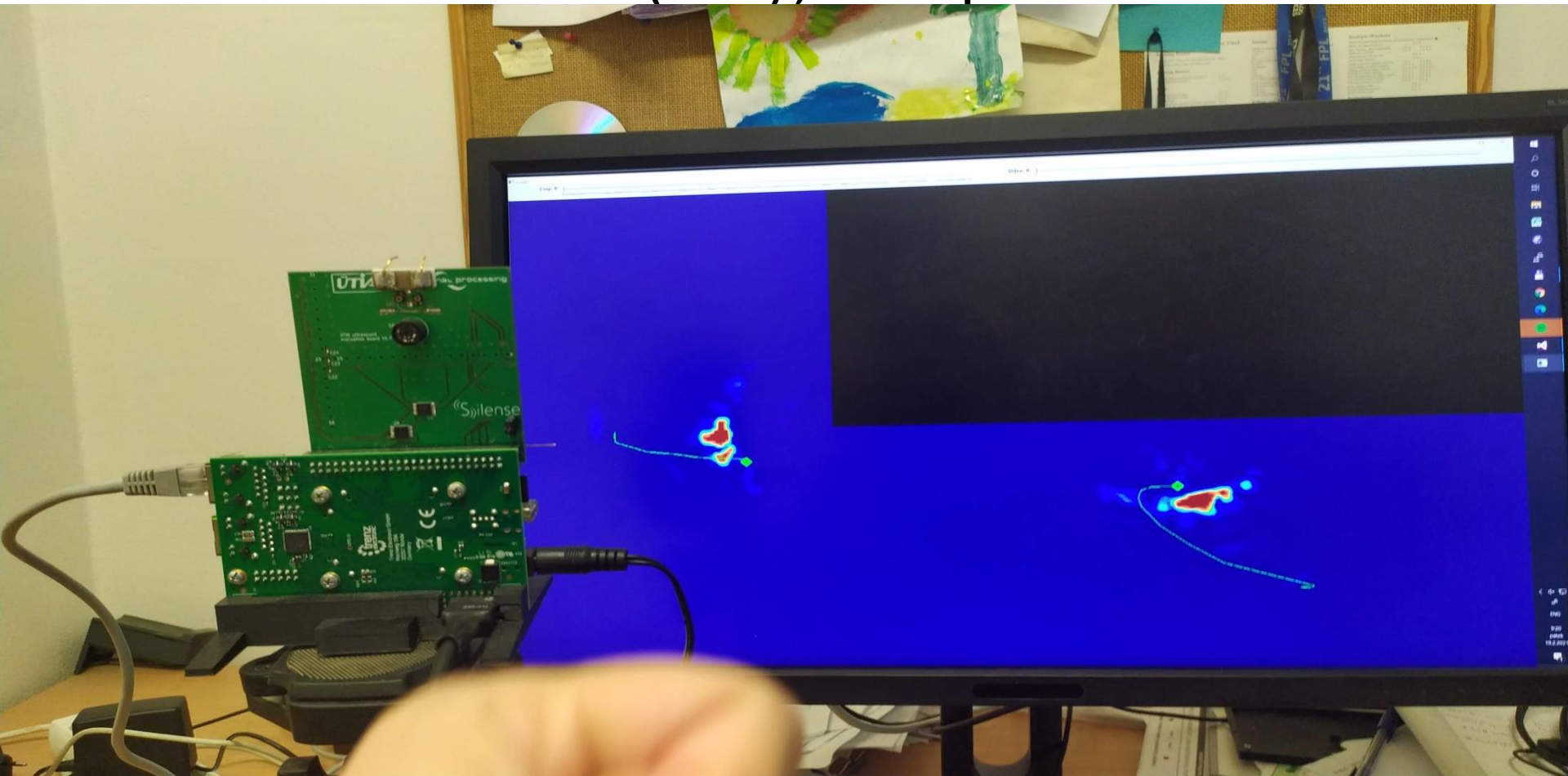
SILENSE –NXP (BE), 31 partners



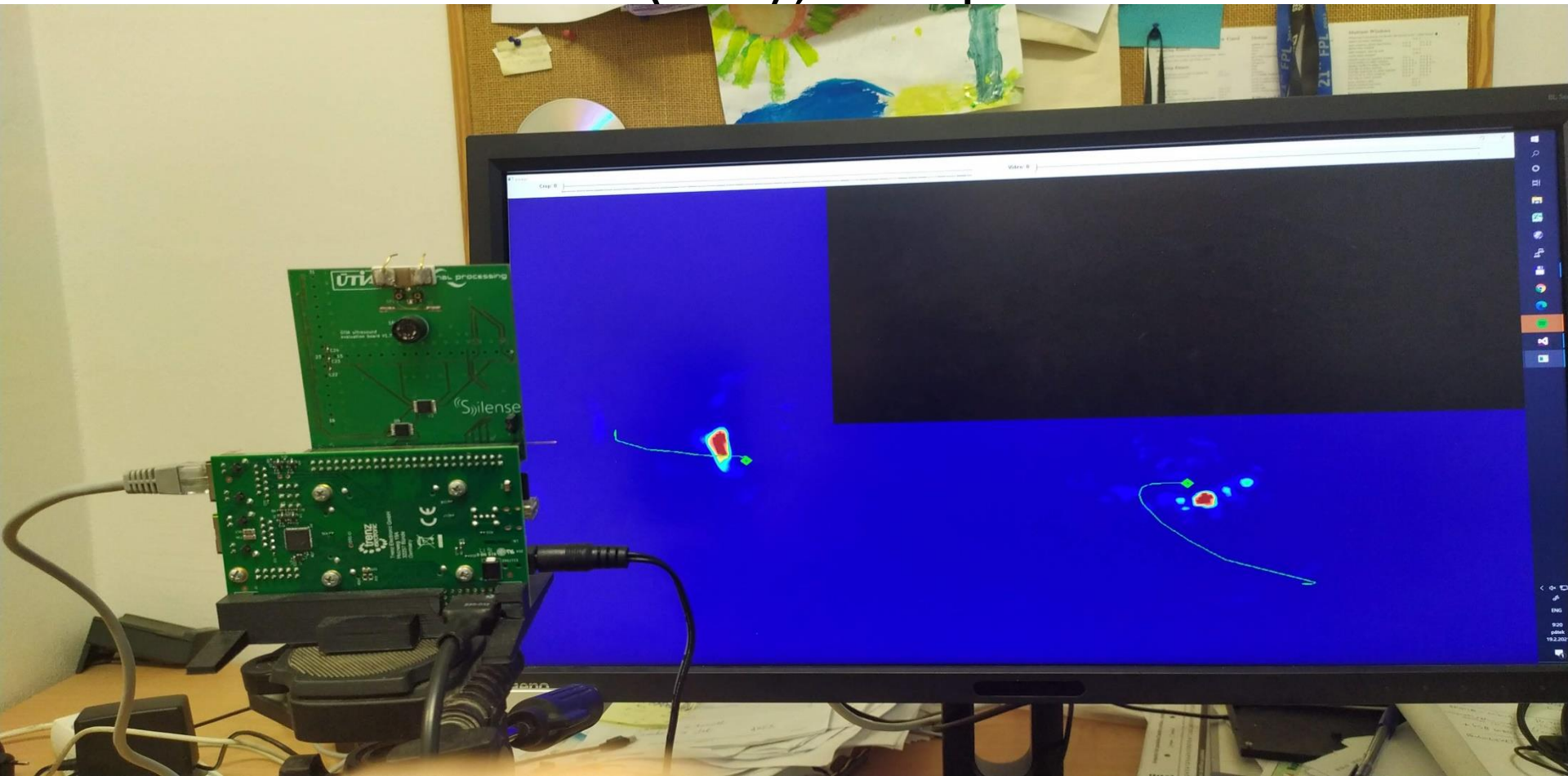
SILENSE –NXP (BE), 31 partners



SILENSE –NXP (BE), 31 partners



SILENSE –NXP (BE), 31 partners

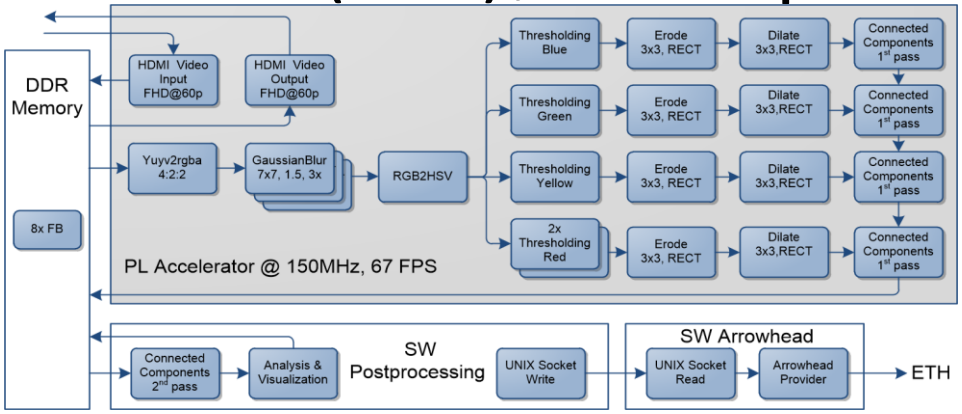


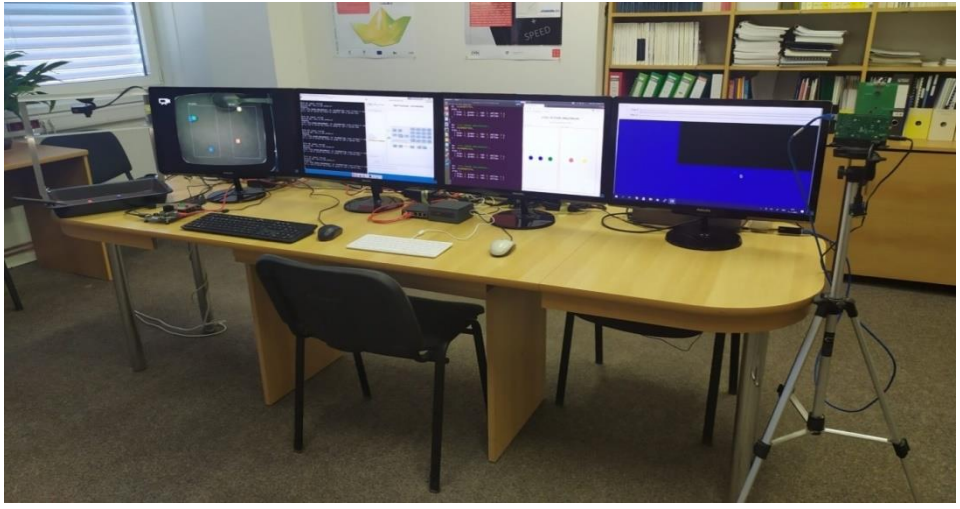
Productive 4.0 – Infineon (DE), 109 p.

- **Research**
  - **Industry 4.0**
  - **Digitalisation**
- **UTIA Results**
  - **Ball tracking from the Full HD, 60FPS Video camera data HW accelerated in the 16nm Xilinx Zynq ZU04-EV industrial module.**
  - **Compatible with ArrowHead 4.0**
  - **PC: 0.5 FPS**
  - **Zynq: 60.0 FPS Accelerated 120x**

5 Eval. Packages:
http://sp.utia.cz/index.php?ids=projects/productive40

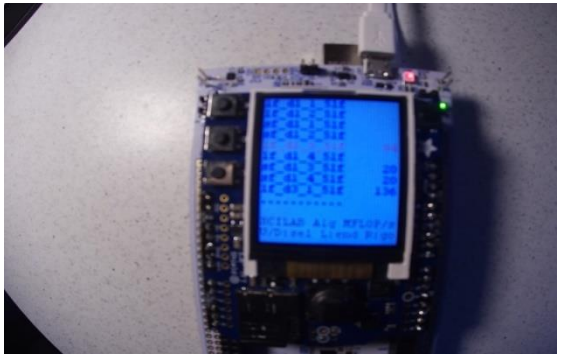
Video 1: P4.0-balls.mp4

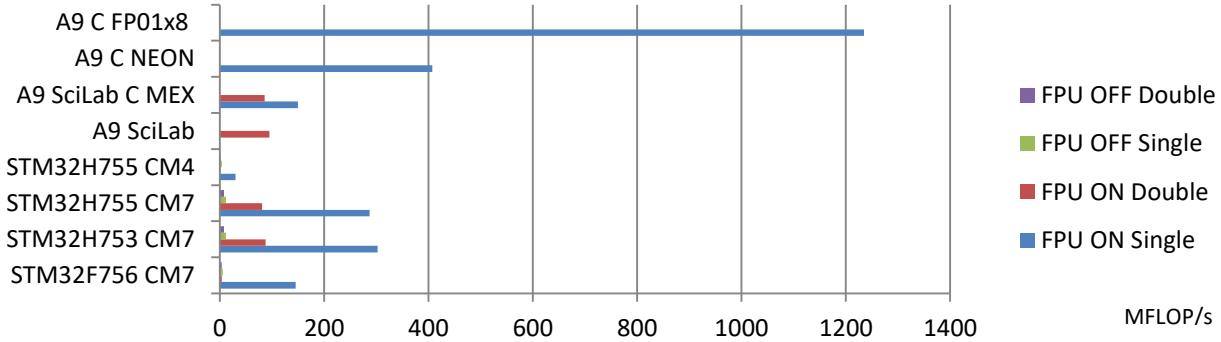




WAKeMeUP – STM (FR) ,18 partners

- **Research**
  - **STM32H MCU benchmarks**
- **UTIA Results**
  - **UTIA developed STM32H MCU based terminal with Zynq Debian Linux OS, SciLab and 8xSIMD FP HW accelerator**
- **FP and DP benchmarks:**
  - **Base:STM32F7 MCUs**
  - **New: STM32H7 MCUs**
  - **ARM 2xA9: zcu0710-1c**
  - **HW encryption bench.**
  - **DMA benchmarks**





4 Eval. Packages:

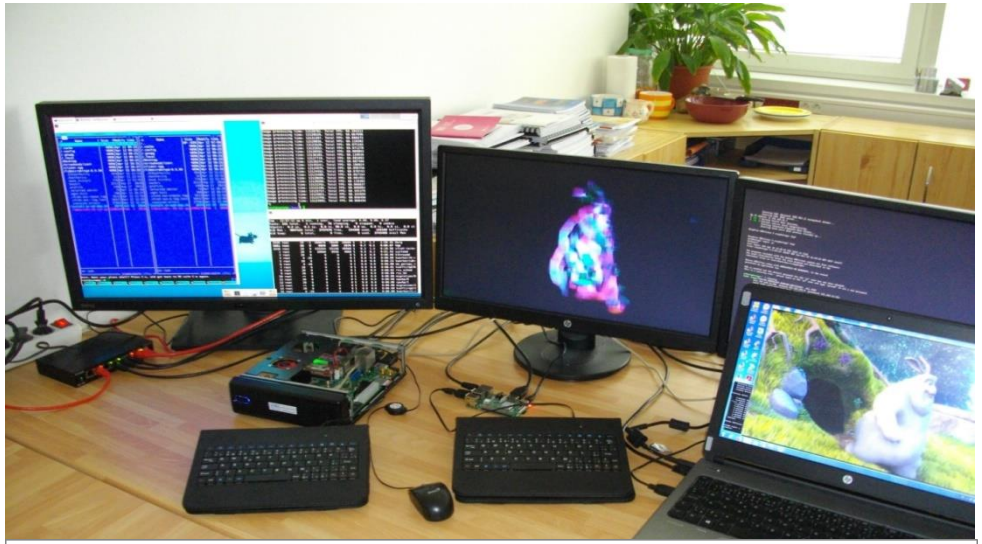
http://sp.utia.cz/index.php?ids=projects/wakemeup

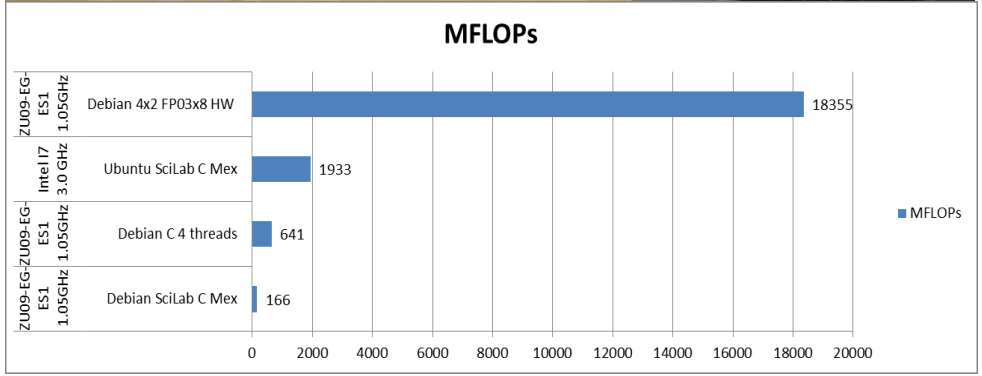
FitOptiVis – Philips (NL), 30 partners

- **Research**
  - **From embedded to cloud-based Video Processing**
- **UTIA Results**
  - **Design time support for 28 nm Xilinx Zynq and 16 nm Zynq Ultrascale+ devices with Xilinx SDSoC C/C++ to HW system-level compiler.**
  - **Support for UTIA 8x 8xSIMD FP FP32 reconfigurable HW accelerators**
- **Lucas Kanade Dense Optical Flow, SW/HW:**
  - **Arm A53, 1.05 GHz SW: 0.1 FPS**
  - **Zynq zu15-eg-1e 250 MHz HW: 60.0 FPS** **600x**
    In paralelel with HW accelerated Matrix Multiplication FP32: **110x**

9 Eval. Packages: **Video 2:** video2.MP4

http://sp.utia.cz/index.php?ids=projects/fitoptivis





FitOptiVis – Philips (NL), 30 partners

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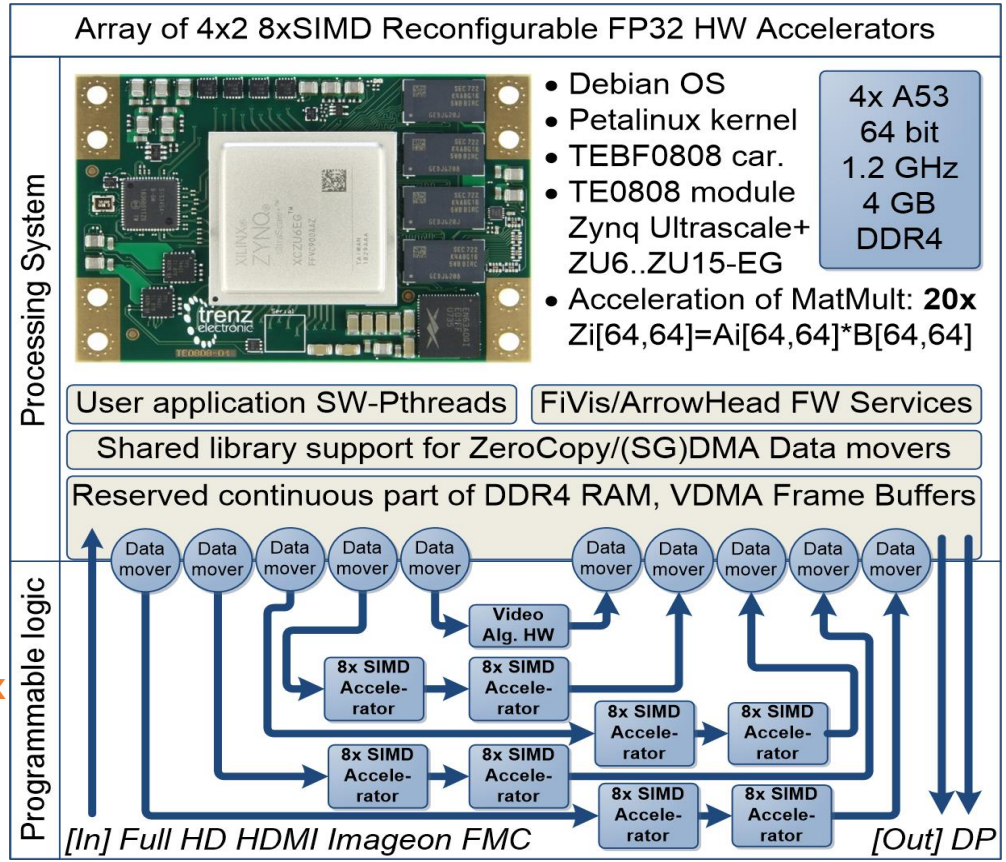
9 Eval. Packages:
http://sp.utia.cz/index.php?ids=projects/fitoptivis



FitOptiVis – Philips (NL), 30 partners

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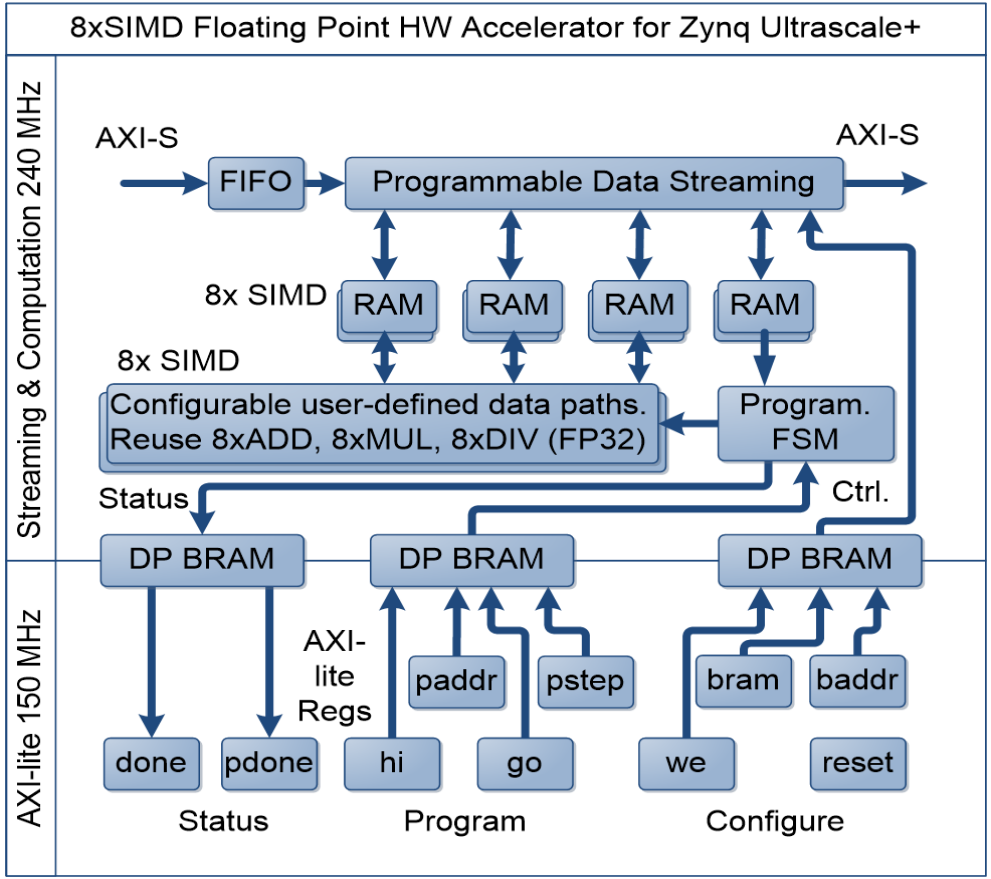
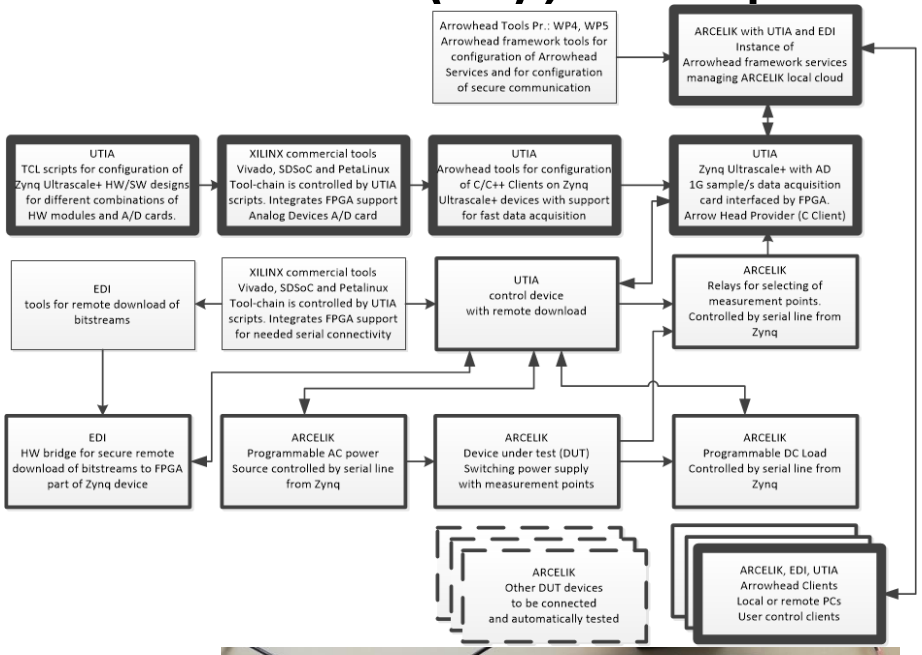
9 Eval. Packages:
http://sp.utia.cz/index.php?ids=projects/fitoptivis

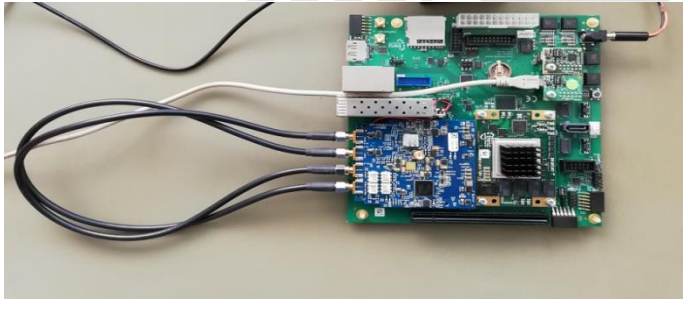


Arrowhead Tools – TU Lulea (S), 81 p.

- **Research**
  - **Tools for systems of systems**
- **UTIA Results**
  - **2x 1G sample/s data acquisition for automated detection of errors of switching transistors in power suply units.**
  - **Use Case: Tester of power-supply-units, for TVs for export to the Far-east.**
  - **Partner company: Arcelik, Istanbul.**
  - **Implementation of SW services for secure connectivity in a local cloud based on ArrowHead Framework middleware.**

Project description:
http://sp.utia.cz/index.php?ids=projects/ahtools





Cooperation with ŠKODA AUTO a.s.

- **Research framework**
  - **Framework agreement about realization educational activities between ŠKODA AUTO a.s. and ÚTIA AV ČR, v.v.i**
- **Research Topics**
  - **Adaptive Decision-Making under Information Demanding Conditions**
  - **Multiple Participant Decision Making**
  - **Predictive Control for Industrial Robots**
  - **Bayesian Approximate Recursive Identification and On-line Adaptive Control**
  - **Learning Methods Applicable to Quantitative and Qualitative Data**
  - **Multi-level Control of the Traffic in Large Urban Transportation Networks**
  - **Modelling, Prediction and Simulation for Vehicle Systems for Assistance and Safety**

Cooperation with ŠKODA AUTO a.s.

- **Research results**
  - **Roboted autonomous driving (accelerator, brake, gear selector (floating)) on predefined circuit (length approx. 40 km) including development of HMI**
  - **Regulator and „efficiency control model“ controls the accelerator, brake and gear selector to reach minimum consumption of energy**
    - **Optimal vehicle speed profile**
    - **HMI to assist the driver**
    - **Available energy management**
  - **HW/SW subsystems for the autonomous parking**
- **Video 3:**

Utia Autonomous Parking – Testing Presentation_0121_61s.mp4

Future projects with ŠKODA AUTO a.s.

- **USP - Urban Smart Park (EIT Urban Mobility)**
  - **Urban Smart Park focusses on the development and pilot demonstration of automated vehicles that simplify driverless on-street inner-city parking.**
  - http://sp.utia.cz/index.php?ids=projects/usp
- **TIE - Transportation Innovation Ecosystem (EIT UM)**
  - **Creating a strategic infrastructure for urban policy management in the field of urban mobility. The overall objective is to define a set of policy recommendations provided to municipal leadership.**
  - http://sp.utia.cz/index.php?ids=projects/tie
- **DTN – Doctorand Training Network (EIT UM)**
  - **Doctorand longer-term research stays abroad.**
  - http://sp.utia.cz/index.php?ids=projects/dtn
- **Other HW systems with our SW support.** **VIDEO 4:** VID_20210211_085843.mp4
  - http://sp.utia.cz/index.php?ids=results

Future Extern Funding

	2020	2021	2022	2023	2024
SILENSE (ECSEL JU)					
PRODUCTIVE 4.0 (ECSEL JU)					
WAKEMEUP (ECSEL JU)					
FITOPTIVIS (ECSEL JU)					
ARROWHEAD TOOLS (ECSEL JU)					
STORAIGE (ECSEL JU)					
DTN (EIT Urban Mobility)					
TIE (EIT Urban Mobility)					
USP (EIT Urban Mobility)					
External funding ECSEL (Mil Kč)	8,934	8,672	5,491	4,000	2,000
External funding ECSEL 2020-24	29,097 Mil Kč = 1,077 Mil €				

Future of the team 2020 – 2024

- In 2021, Department have invested into this 7nm Equipment:
  - Versal ACAP AI Core Series VCK190 (400 GPU, 10 TFLOP/s peak)
  - Versal ACAP Prime Series VMK180
- We plan to build on our current strengths:
  - Design of custom board support packages for advanced computing architectures targeting single-chip, HW-accelerated DSP aps.
  - IP design for SoCs with FPGA. UTIA licensed IPs.
  - Mapping of recursive DSP/AI/ML algorithms to HW (StorAIge proj.).
  - Design of normalized, QR DSP fixed-point algorithms as HW IPs.
  - Clustering/Classification by recursive mixture estimation as HW IPs.
  - Teaching of Bc/MSc/PhD students at the CTU, Faculty of Transport.
  - New concepts of HMI systems in cooperation with Skoda Auto a.s.

Thank you for your attention.

department of signal processing