New generation of Vlatacom Multisensor Imaging Systems

November, 2022

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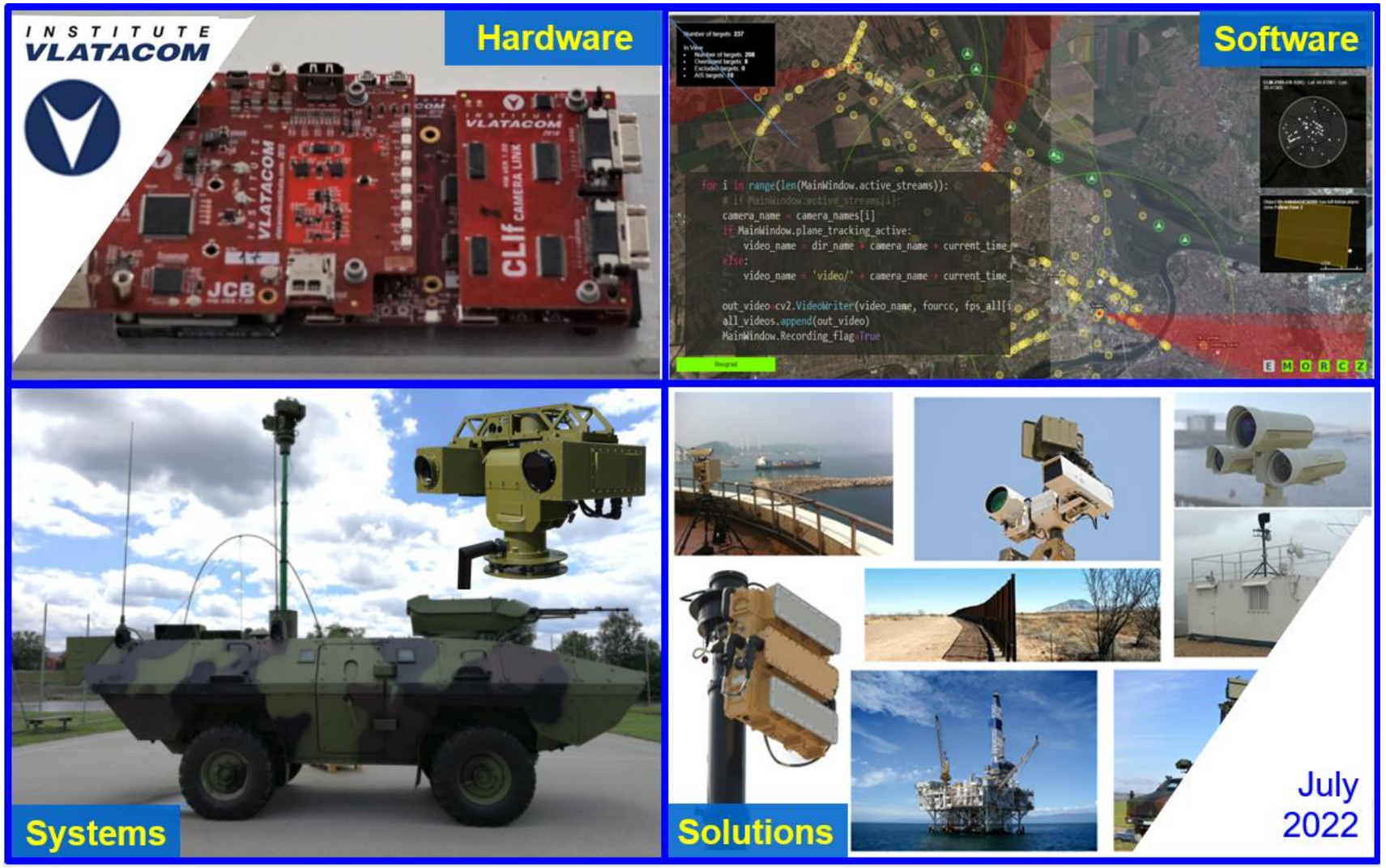
Agenda

- Vlatacom Institute Overview
- Vlatacom Multisensor Imaging Systems Chronology
- Third Generation of Vlatacom Multisensor Imaging Systems
- New flagship model vVMSIS-CHD10-C1000 designed in 2021
- Performance demonstration examples
- Conclusion

Vlatacom Institute Overview



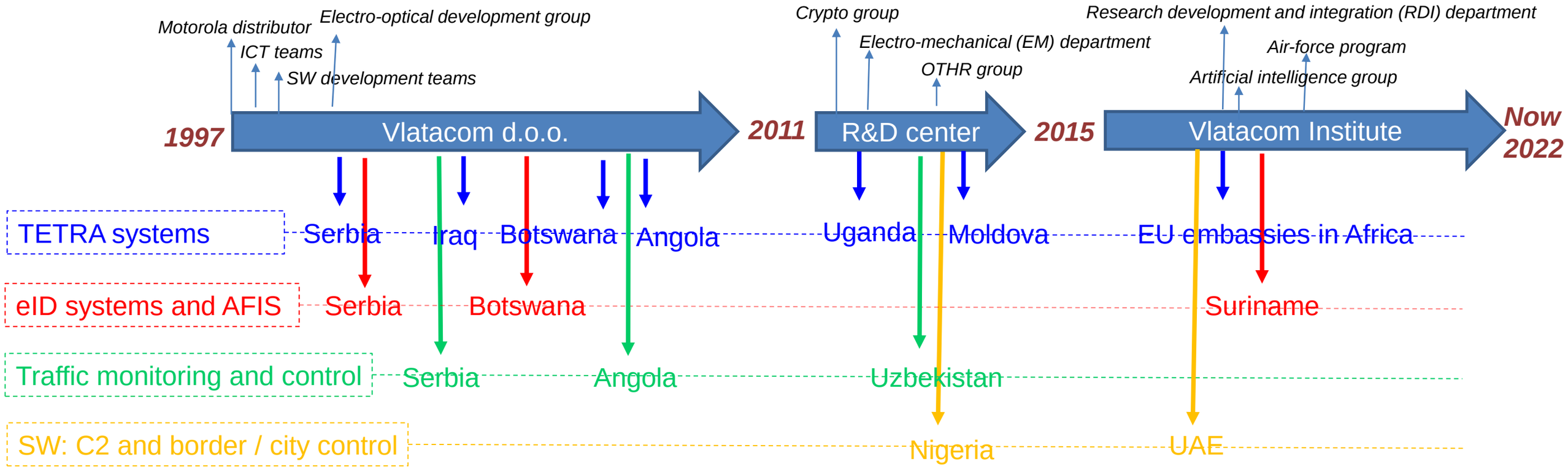
- **1997** Company founded in Belgrade, Serbia
- **2008** First Projects abroad
- **2010** Got license for production & trade in military equipment
- **2011** Accredited as R&D Center
- **2015** Accredited as R&D Institute (reaccredited 2019)
- **2022** there are **151** employees among which
  - **24 PhD**
  - **29 at PhD studies**
  - **95 Master and dipl. ing.**
- Annual income per employee 200 000 USD in last 5 years
- More than 99% income from abroad in last 10 years

Vlatacom Institute Overview

- About **25% of income** achieved from **Projects** and **TOT**, Vlatacom Institute **invests to R&D**.
- Vlatacom Institute collaborates with many Serbian and international academic institutions

Vlatacom Institute Overview - Short history

Complex projects and teams/groups/departments establishing



- Main Vlatacom Institute's driver to ***success*** is permanent investment in ***employees***, ***equipment*** and ***R&D***

Vlatacom Institute Overview - Short history

Certification

Quality Management
Since 2006

Information Security
Since 2012

IT service Management
Since 2014

1997 Vlatacom d.o.o. **2011** R&D center **2015** Vlatacom Institute **Now 2022**

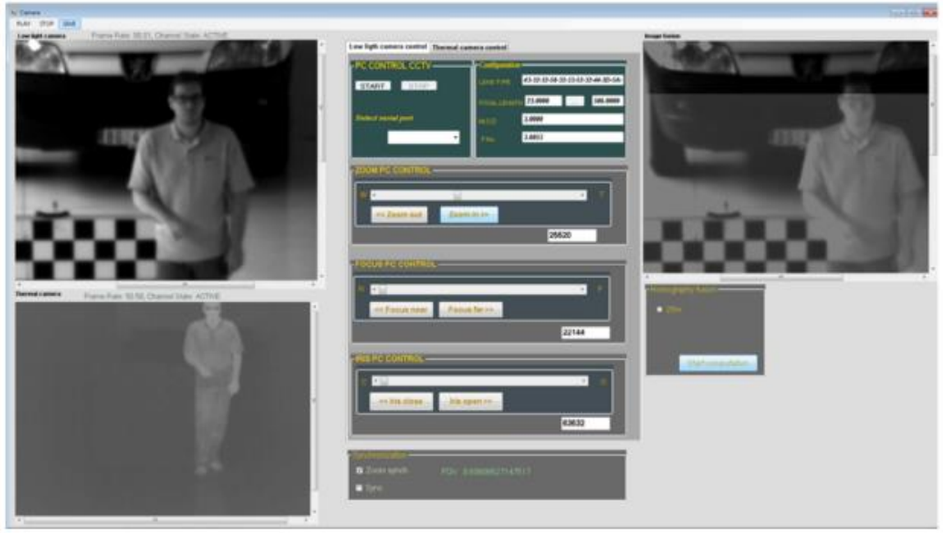
Certificate for trade and production of military products
Since 2010

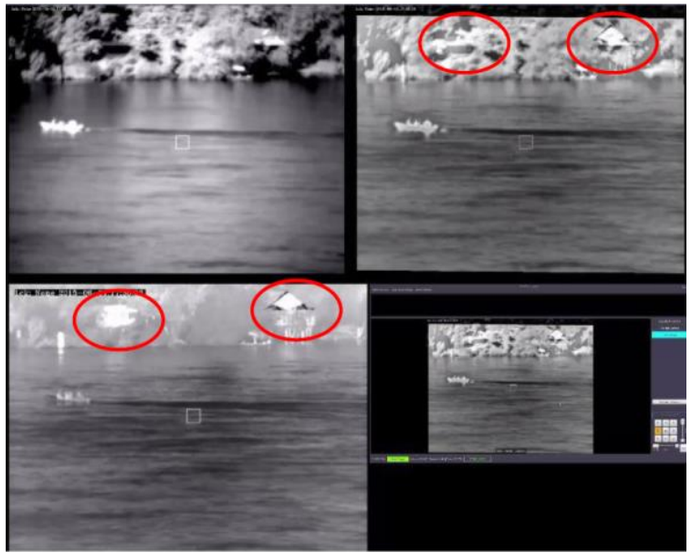
Environment Protection
Since 2016

⇒ This **ensures permanent improvements** of Vlatacom Institute's products, services and organization

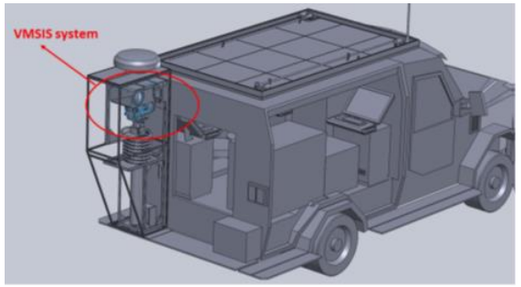
vMSIS Vlatacom Multisensor Imaging System Concept (2013)

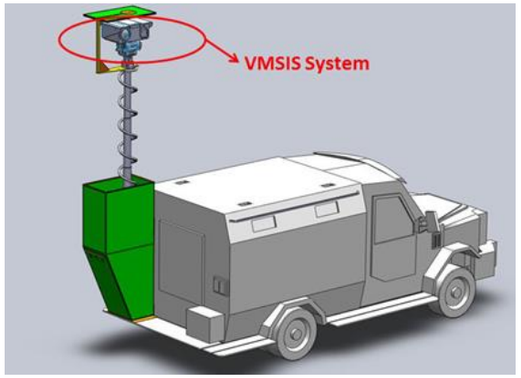
- Unique monitoring and surveillance system
- Various imaging sensors for 24 hours vision
- Image fusion of digital uncompressed sensor outputs
- Preprocessing anti-vibration / filtering
- All outdoor, extended temperature range
- Integrated pan/tilt platform
- Suitable for stationary and mobile installations
- Remote control and monitoring

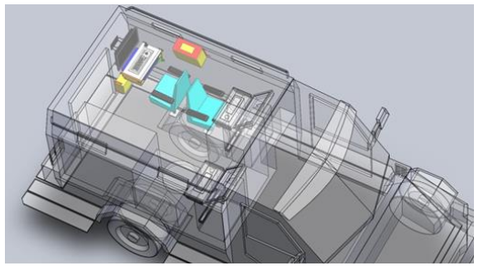


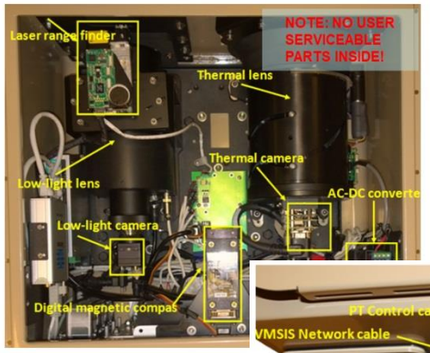


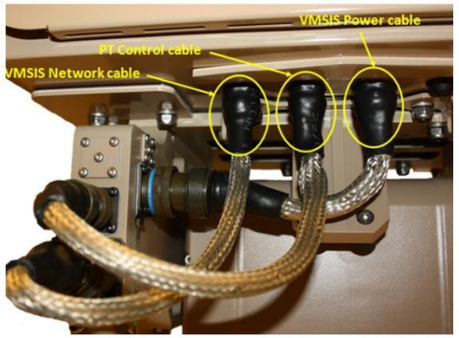
Project Implementation Nigeria EO (2014) 11+2 vMSIS

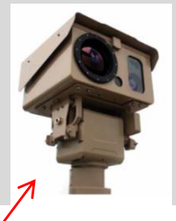


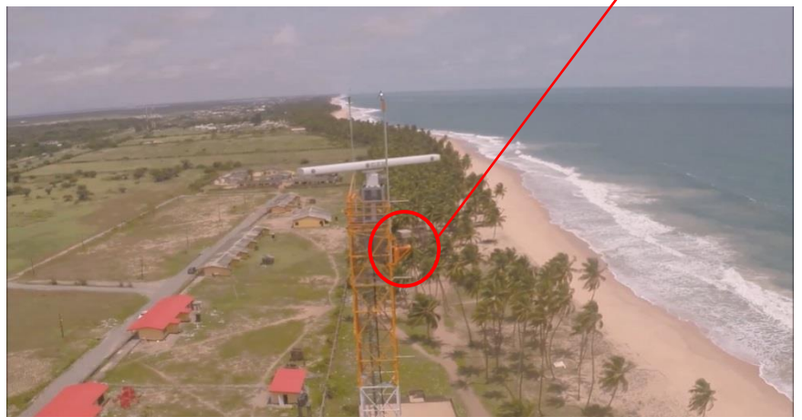






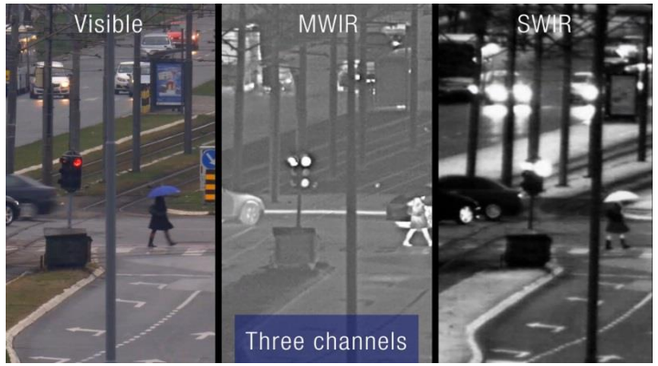






- System integration with other sensors (radars etc.) into C2 center
- Data fusion and representation to end user
- Mobile installation and customization of the vehicle (turn key solution)
- All outdoor, extended temperature range
- On site electro optical sensors and LRF calibration

vMSIS2 (2015) (2nd gen.)



- **Long range** vMSIS comprises **color lowlight**, **HD MWIR** thermal **and SWIR** cameras with **LRF**
- Modularity, possible exchange of different video channels each in its own mechanics
- All outdoor, extended temperature range, first version with aluminum enclosure and passive cooling and second generation with composite enclosure and active thermo-electric cooling
- Video processing algorithms for image stabilization, image enhancement
- Environmental tests in Certified Laboratories and Faculty of Mechanical Engineering
- In Vlatacom Institute installed modern electro-optical laboratory for system production and calibration
- Extensive on-site tests
- Visibility on major exhibitions in UAE

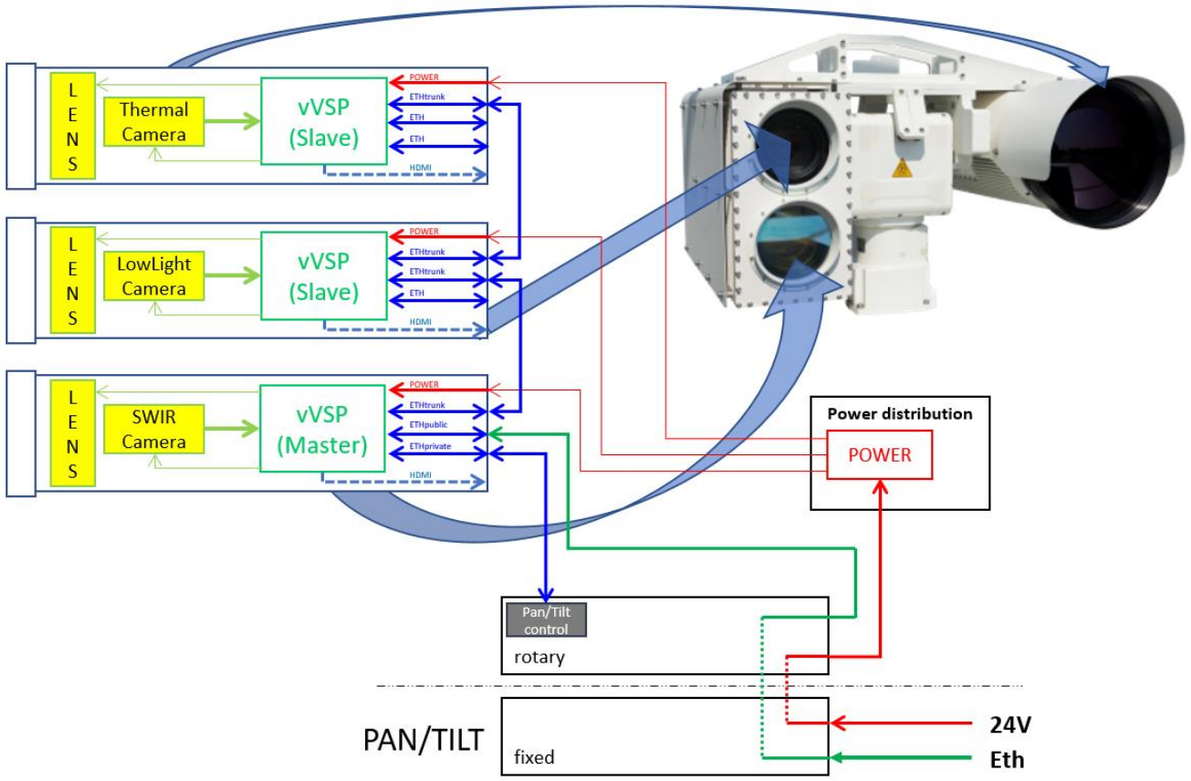
vMSIS-VTI (2017) – vMSIS 3rd generation

- Designed for armored vehicle integration (**officially approved for use in Serbian army**)
- Performance and SWaP optimization with Vlatacom Video Signal Processing module (vVSP)
- It is important to provide 24hours, wide-area, all-weather surveillance capability in order to detect and identify men and vehicles that are within a confirmed distance from defined perimeter.
- Includes Laser Range Finder, GPS receiver, Digital Magnetic Compass
- High performance sensor positioner with continuous rotation in azimuth plane and gyro-stabilization

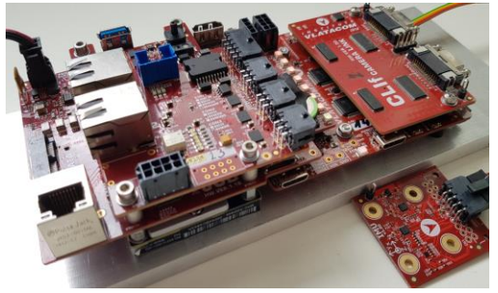
Vlatacom Video Signal Processing (vVSP)

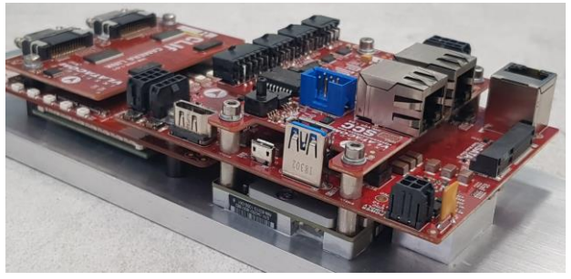
- vVSP module enables management of all key system components, solve all communication issues, receives data from all sensors and use efficient pipeline for video signal processing that minimizes delays and applies advanced algorithms accordingly.

- For supporting several cameras in the system, vVSP modules are cascaded. Complete video signal processing is performed only on the vVSP module.

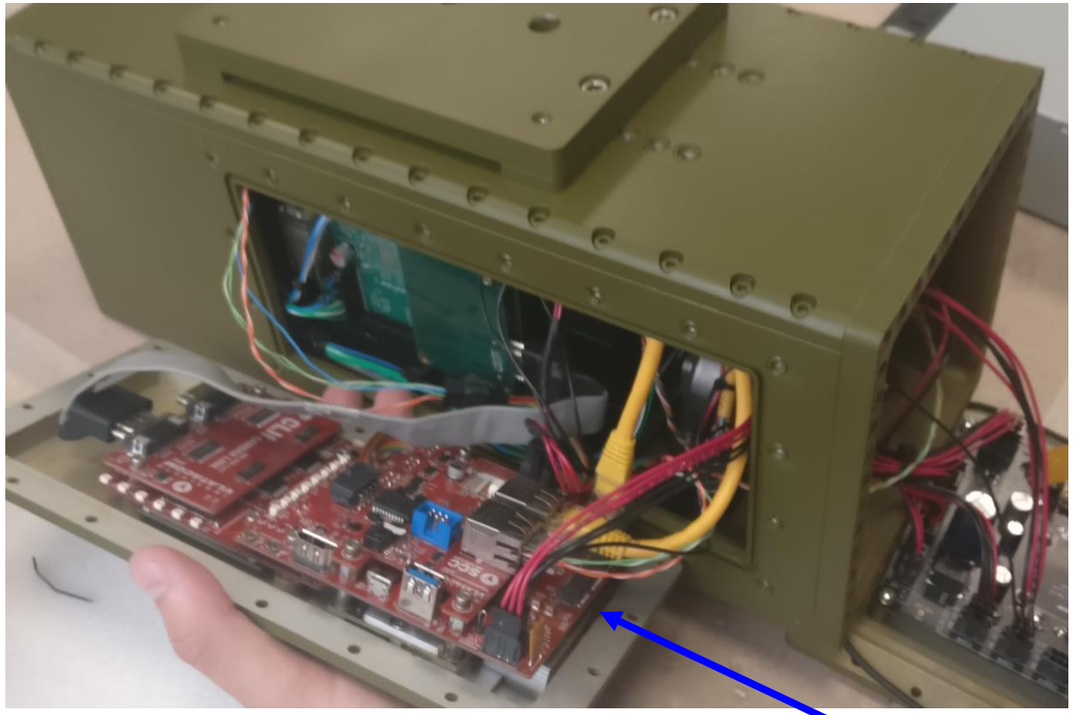


- Application processor – quad-core ARM + 256 GPU cores and FPGA
- Interface to HD-SDI (up to FullHD), Camera-link, composite PAL
- Control for camera and lens parameters, GPS, compass, calibration lid
- Dedicated interface for IMU
- Integrated 7-port manageable GbE switch to support distributed architecture

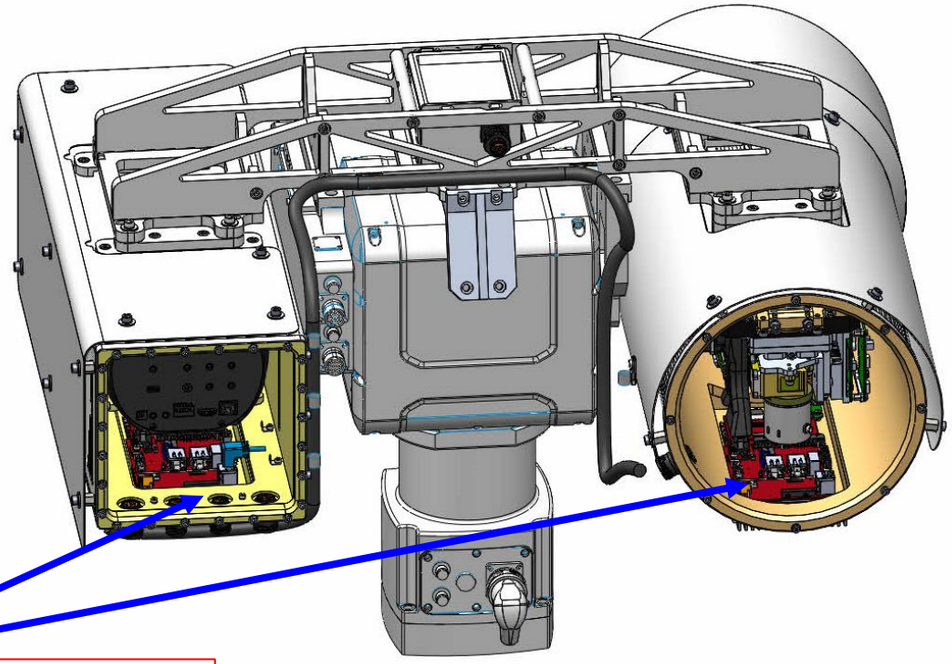




vVSP integration



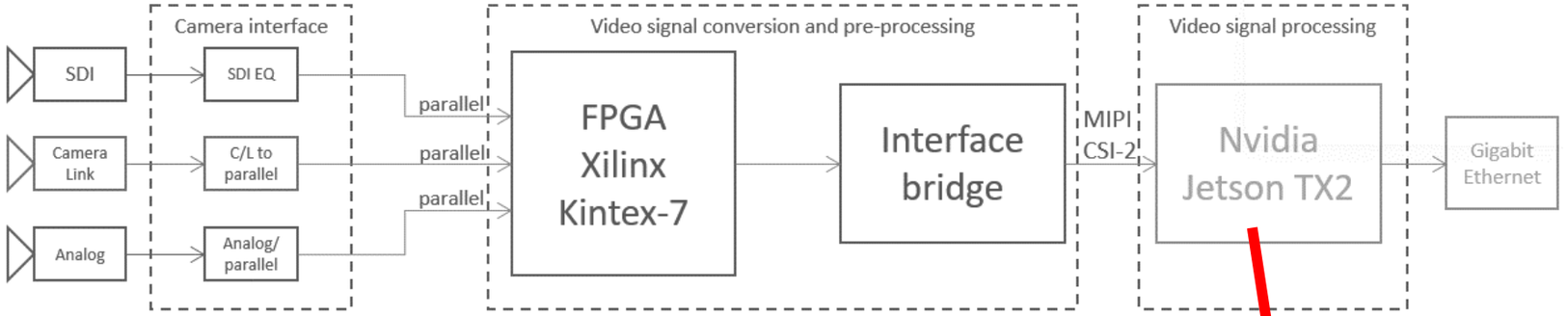
- All wirings between the vVSP and other equipment are realized inside the housing, there are no external cables.
- Wires for power supplies and communication of the vMSIS3 system pass through the pan-tilt slip ring, so that the system movement of the N x 360° is enabled.

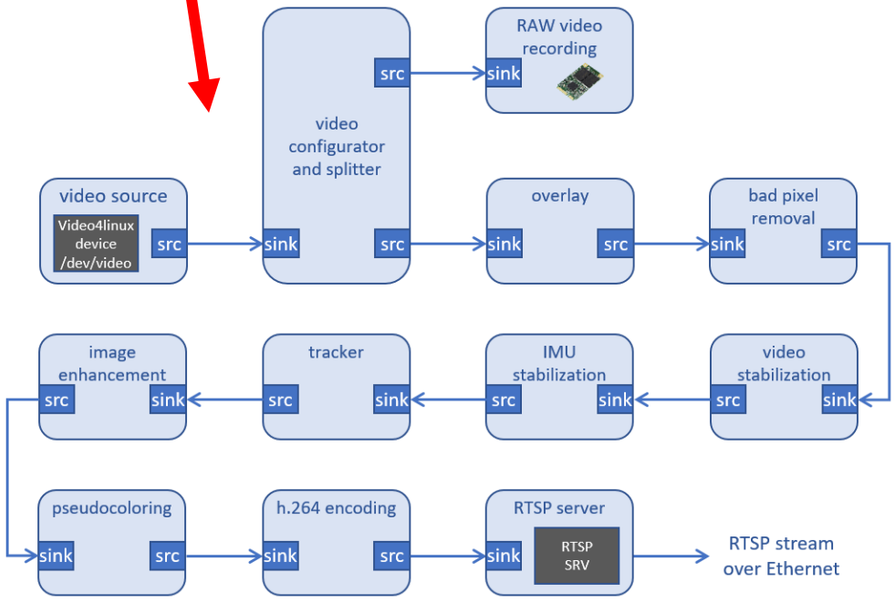


- Passive cooling
- Hermetically sealed
- Integrated in stationary and mobile applications installation in vehicles, where it is mounted on a telescopic mast.

vVSP positioning in vMSIS3 systems

Application of Algorithms in vMSIS3 Systems on vVSP module

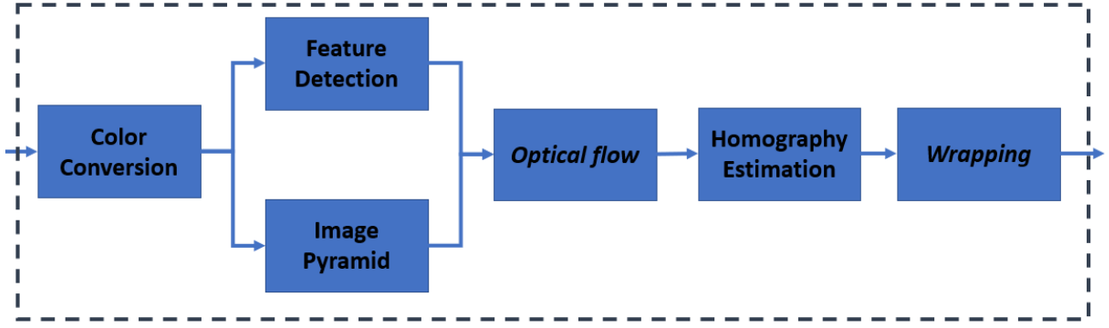


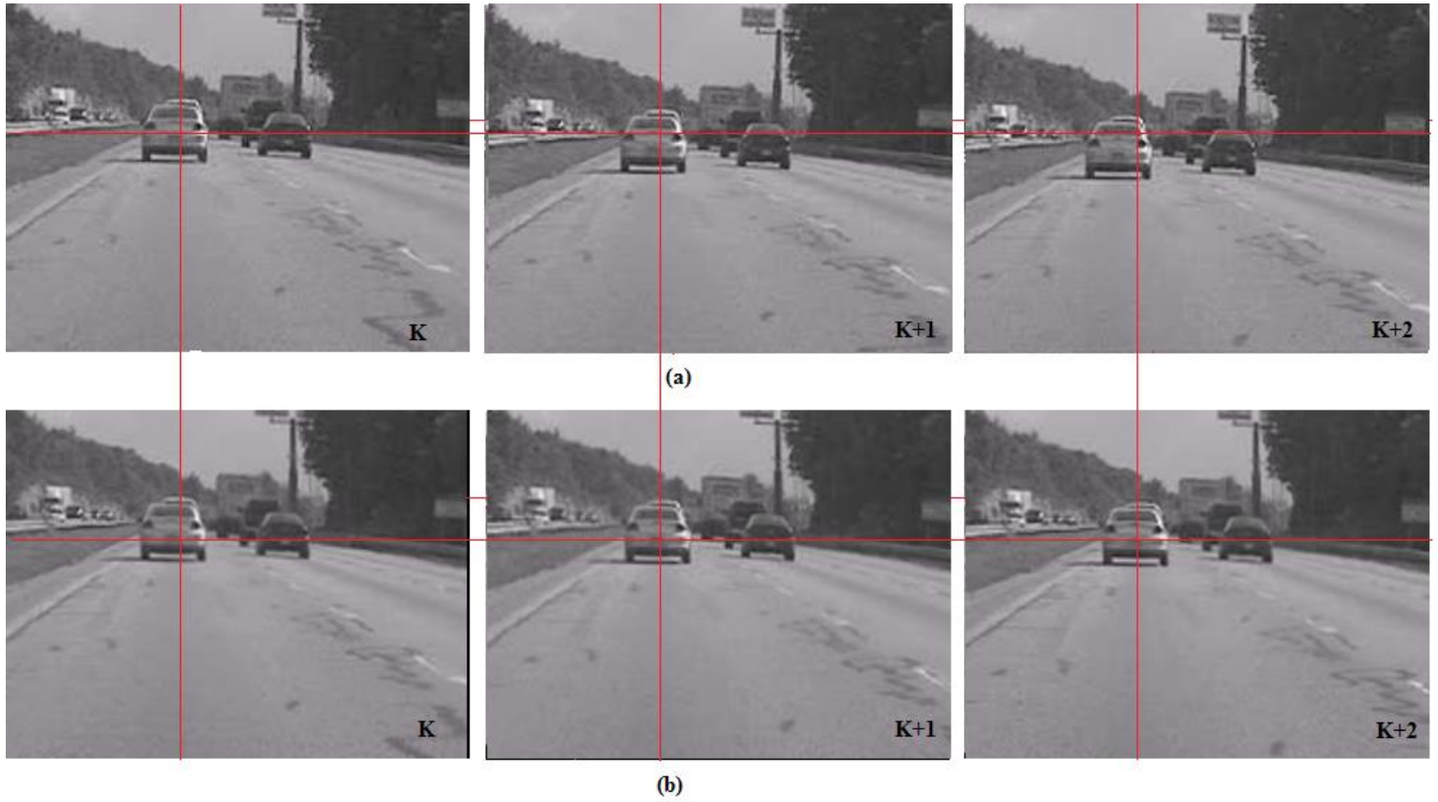


- Each algorithm is implemented as a Gstreamer plug-in
- Video signal processing algorithms optimized for **real-time operation**
- **Maximum resolution** 1920x1080@30fps

Digital Video Stabilization

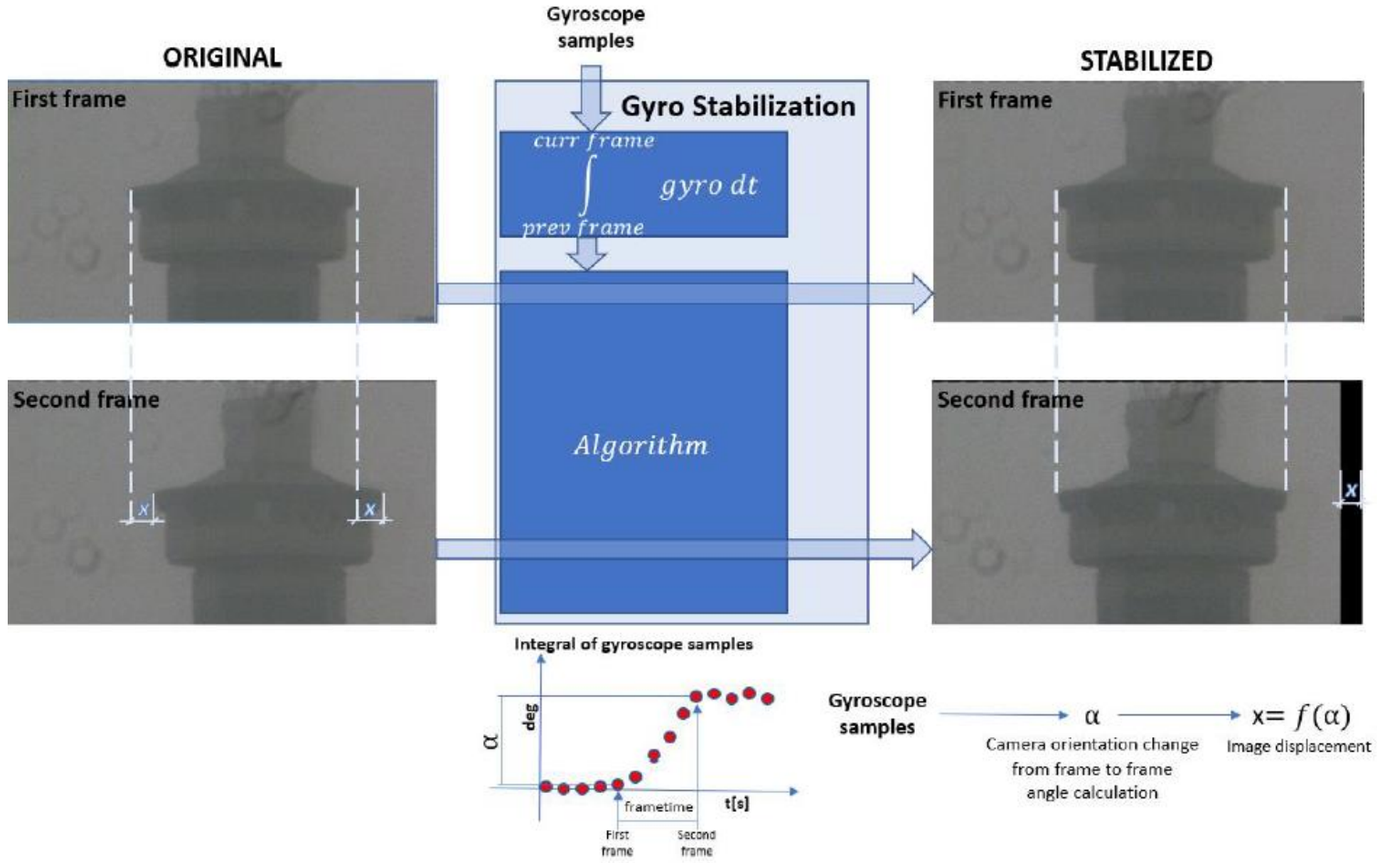
- The goal of digital video stabilization is to **improve video quality** by **removing** the effects of the **unwanted** camera **movements**
- **Preserving** the motion of **moving objects** in the video sequence
- Movement assessment based on characteristic points (Harris features and Optical flow)
- Motion compensation using the appropriate global homography transformation matrix
- An affine transformation with 6 parameters is applied





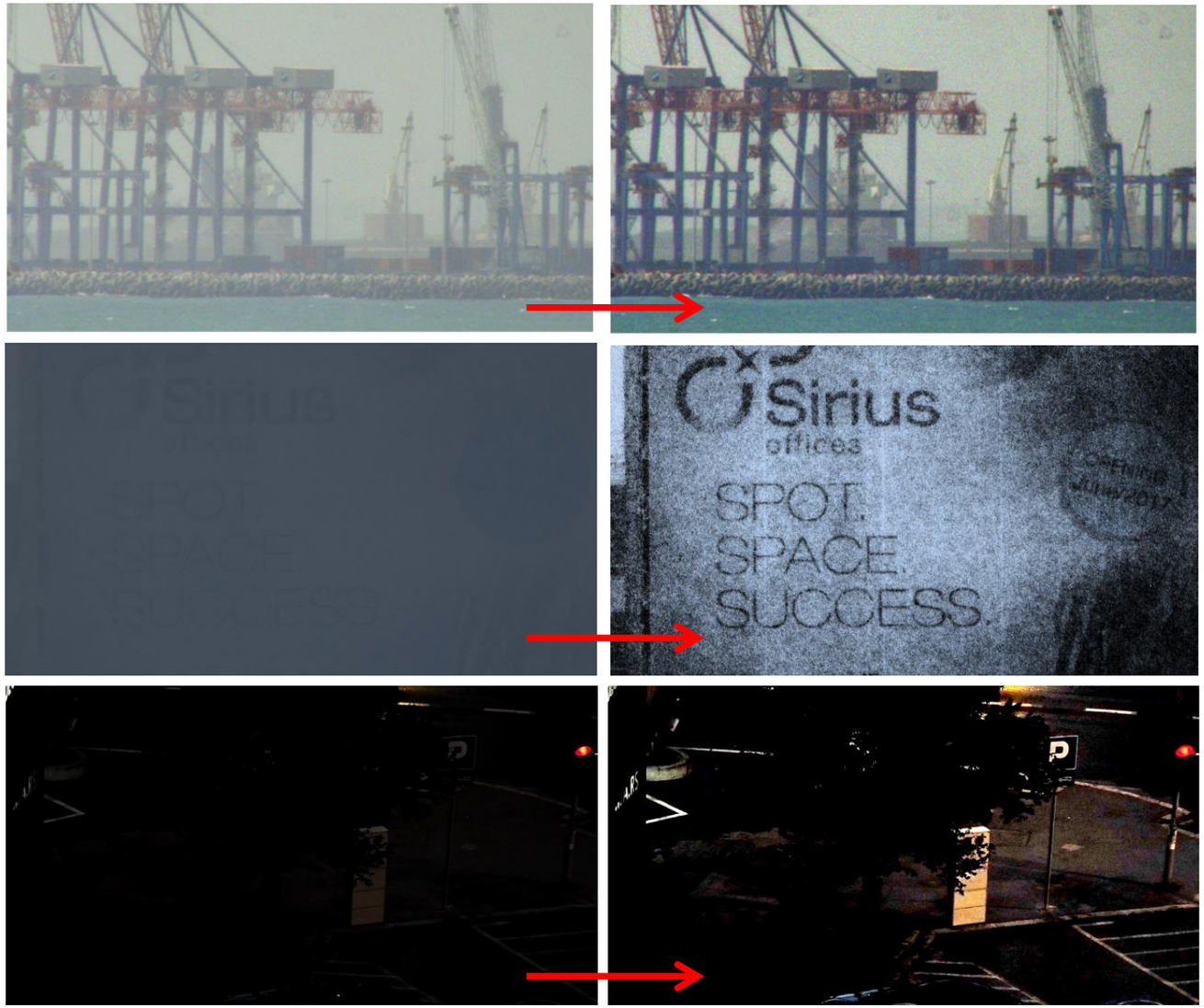
IMU Based Digital Video Stabilization

- System **displacements in 3D space** are measured by reading data from the **gyroscope** (FPGA interaction with the CPU)
- **Displacements in 2D** image space are estimated **based on** the **measurements** from **3D space** and camera parameters
- Estimation of the corresponding transformation (homography)



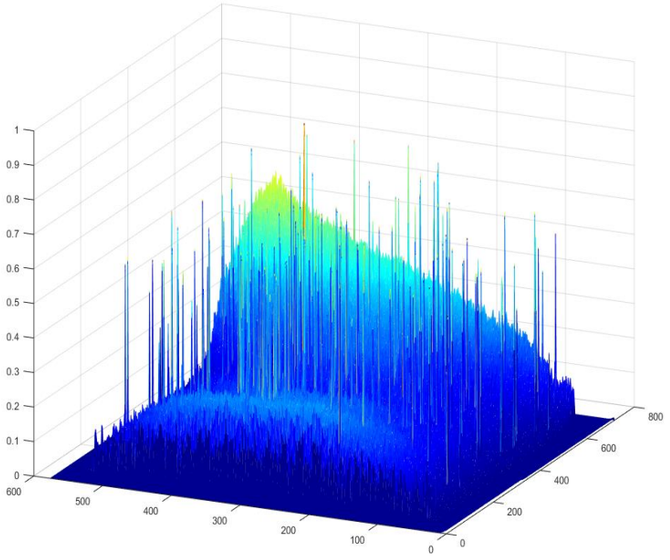
Video Enhancement

- The process of **revealing hidden information** from an image in order to **improve the user's perception**
- Loss of visibility on the video signal has three different manifestations:
  - **Haze** effect due to different types of particles: fog, dust, smoke, rain, snow
  - **Low contrast**
  - **Night imaging** (low illumination)
- Removing the "haze" effect involves modeling the disturbance (haze transmission map) and removing it
- Night images are considered on a similar principle when their inversion is performed
- Enhancement of low-contrast images is based on adaptive histogram adjustment
- Infrared imaging enhancement algorithm is based on edge preserving smoothing and image sharpening methods, applicable to multiple sensor types.



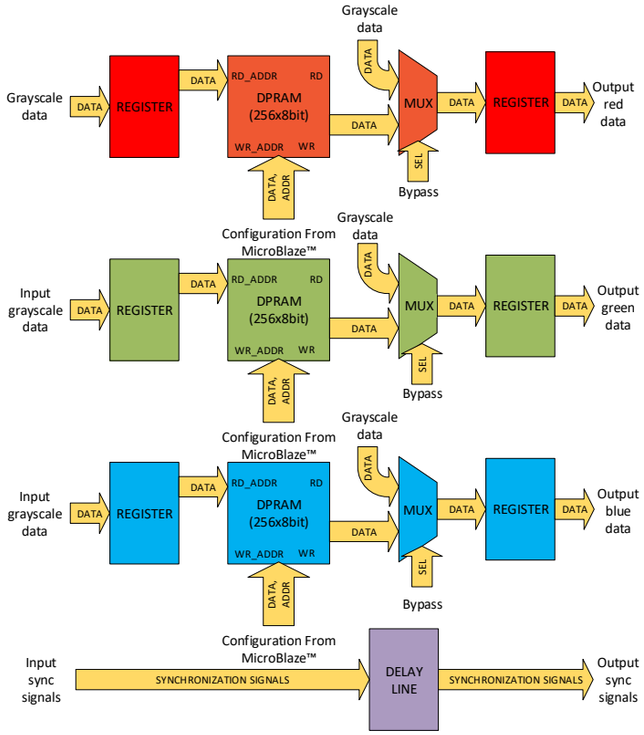
Dead Pixels Removal

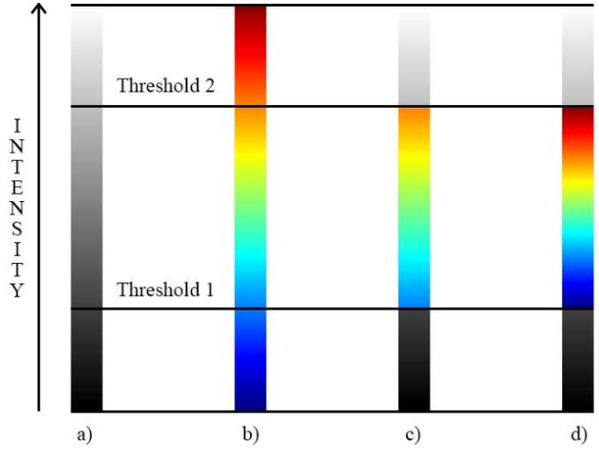
- Thermal sensors are affected by the common problem of unresponsive pixels - termed “***Dead Pixels***”
- Type of ‘salt’ noise problem
- Detection by estimating average pixel value for each pixel using set of frames contaminated with dead pixels
- **Inverse Distance Algorithm** for removal of dead pixels

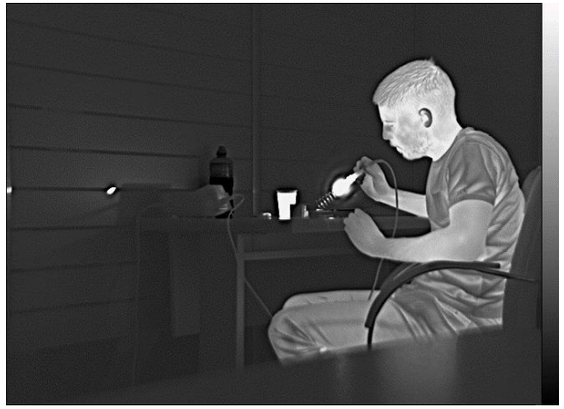


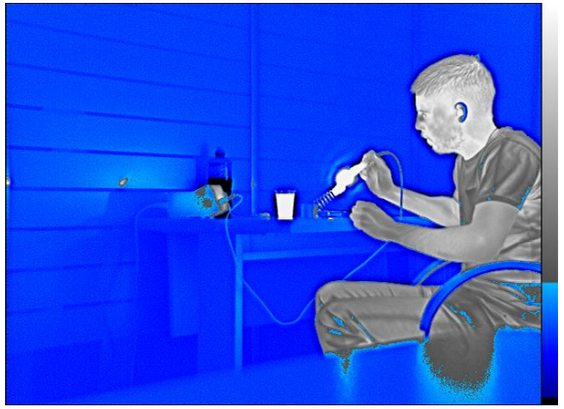
Pseudo Coloring of Thermal Image

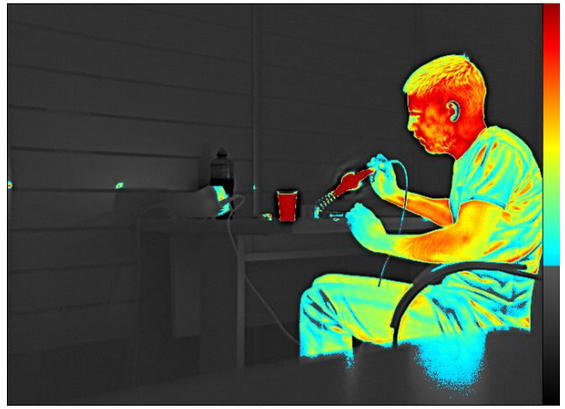
- Pseudo coloring of the entire image
- **Selective pseudo coloring**
- FPGA implementation
- Different color maps

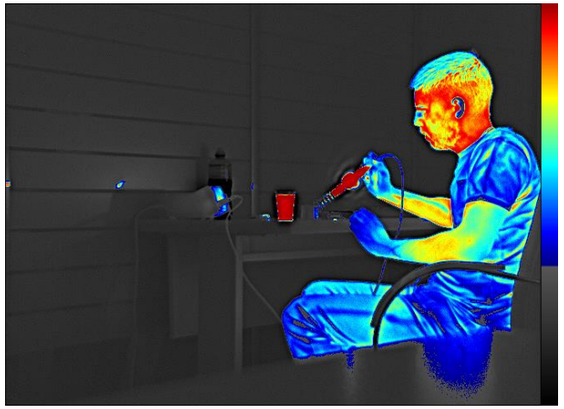








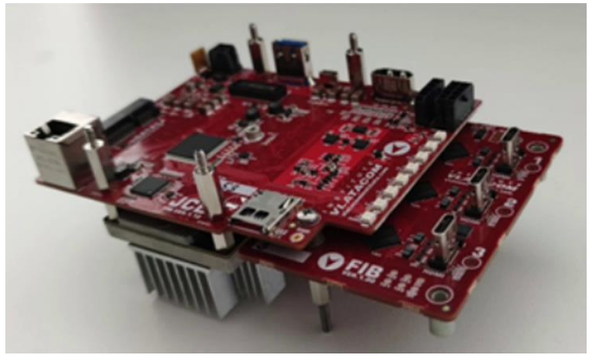


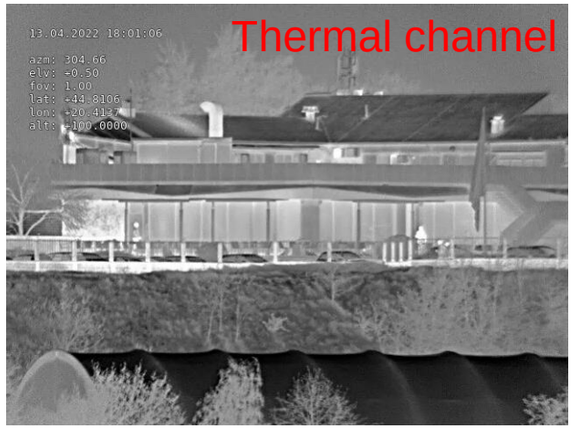


Video Fusion

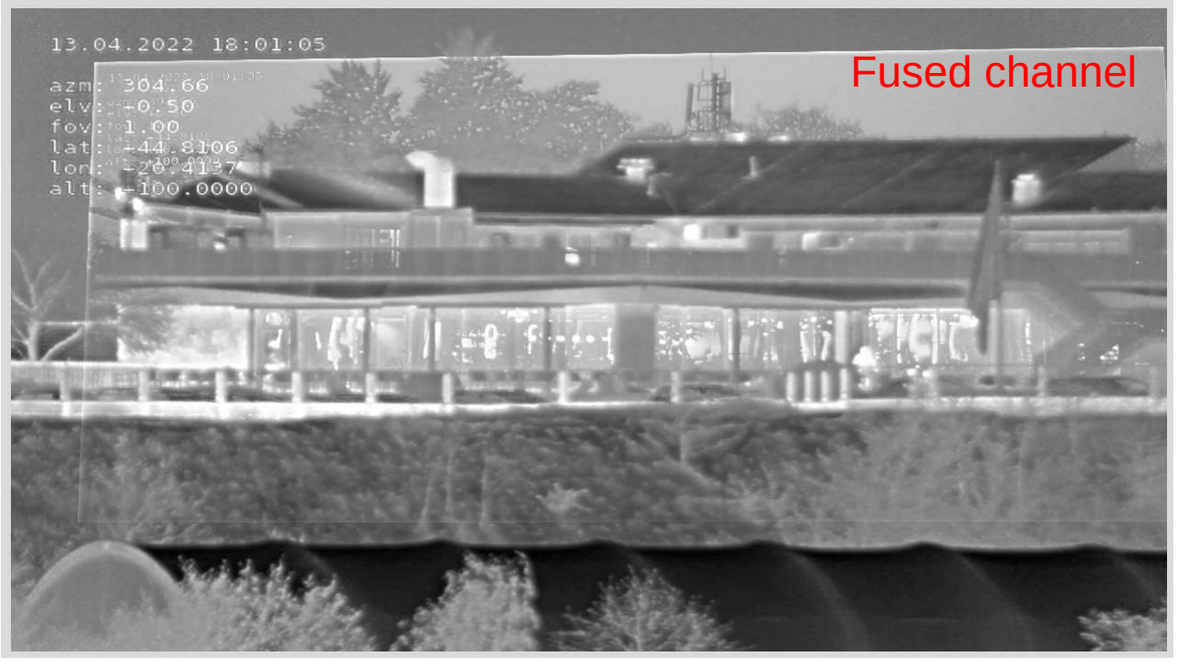
- Video Fusion:
  - Implemented in GStreamer framework
  - Selectable resolution
  - Grayscale fusion or color from low-light channel
  - Algorithm accelerated with OpenVX standard
  - Predefined homography matrix

- Dedicated fusion module:





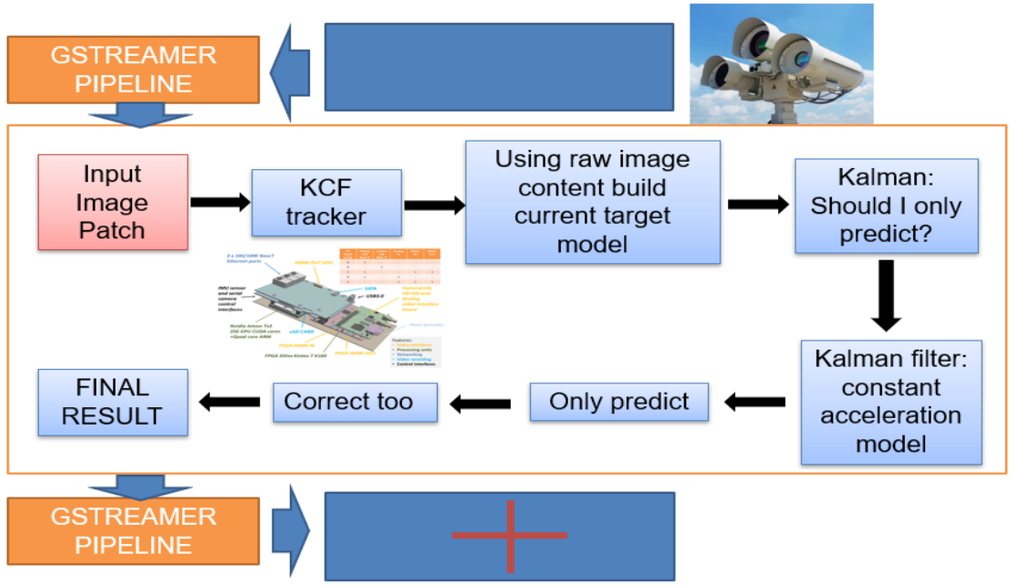
Fusion algorithm



- Fusion method: Laplacian pyramids
- Fusion color space: grayscale
- Video output: 1280x720 pixels
- Distance: 2km

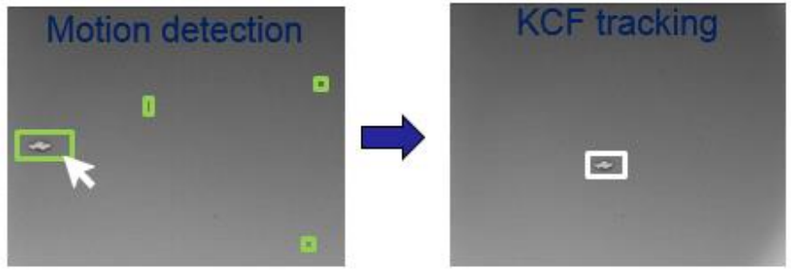
Video Tracking

- The PTZ platform should move the EO system so that the **target** remains **in the center of the image**
- **KCF** (**Kernelized Correlation Filters**) is used as the basic technology - demonstrates high accuracy and robustness in visual tracking tasks, with very low computational complexity
- The algorithm **overcomes partial occlusions** well
- Minimum bounding box 10x10, preferably 30x30 pixels

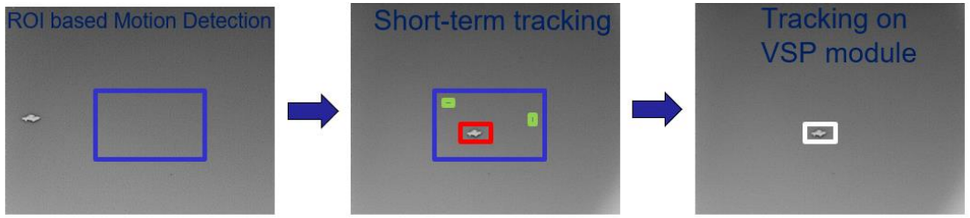


Automatic Tracking Activation

- Select based Motion Detection
  - *Gaussian Mixture-based Background/Foreground Segmentation*
  - Morphological operations

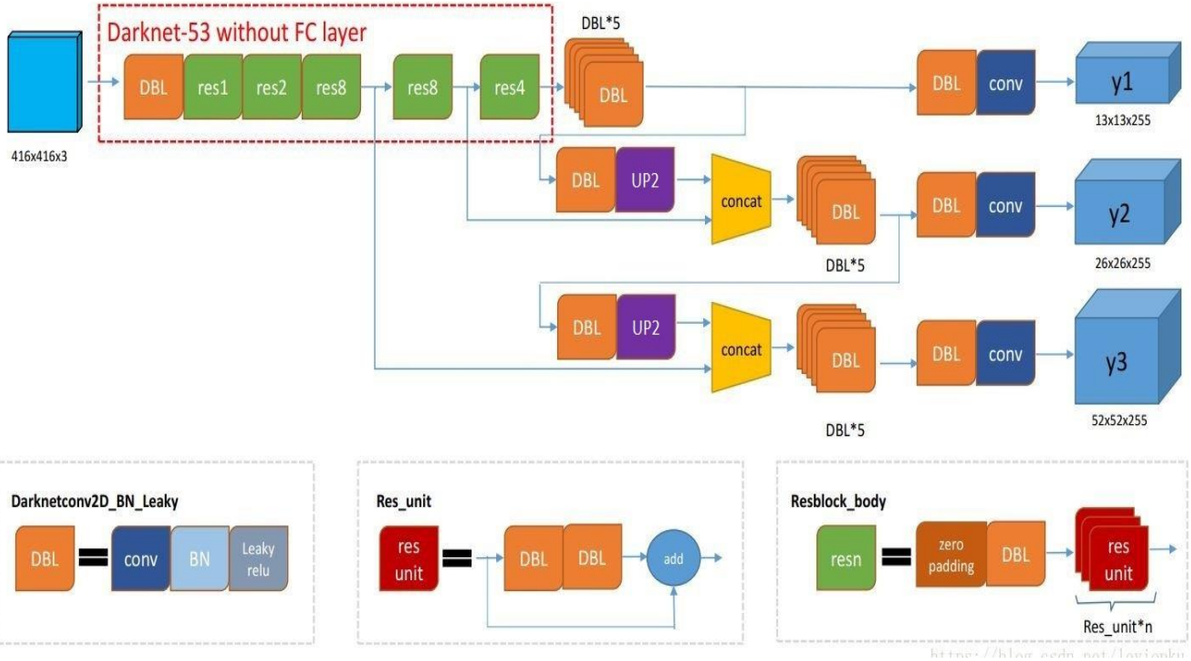


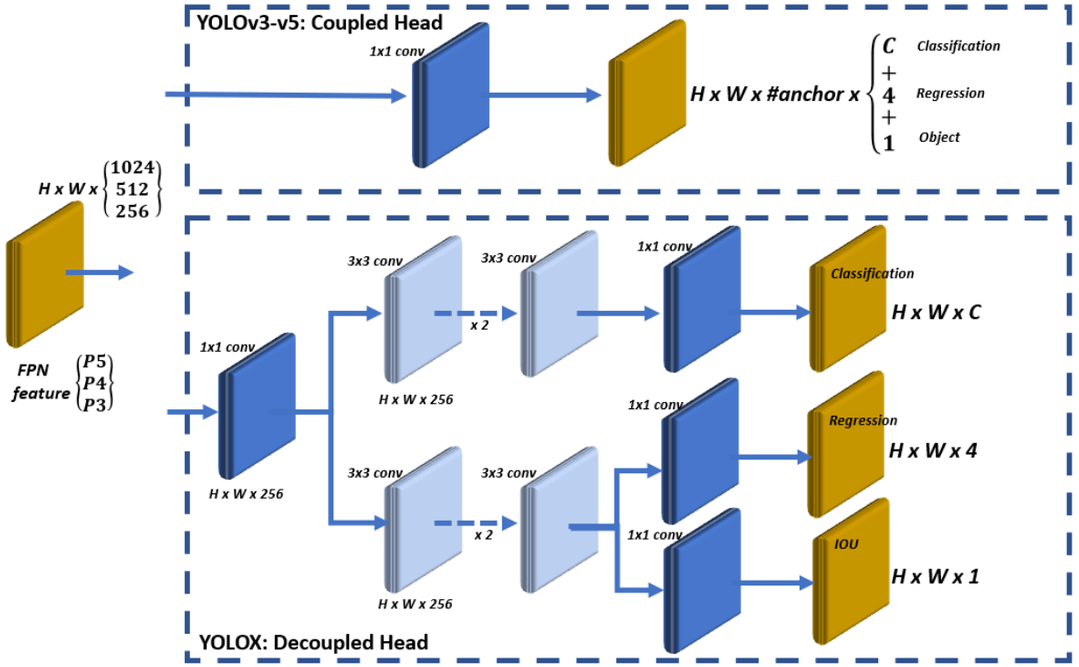
- ROI based Motion Detection
  - Defining the region of interest (ROI)
  - The first or the largest area object
  - Filtering by size
  - Short-term tracking for *n* frames



Object Detection

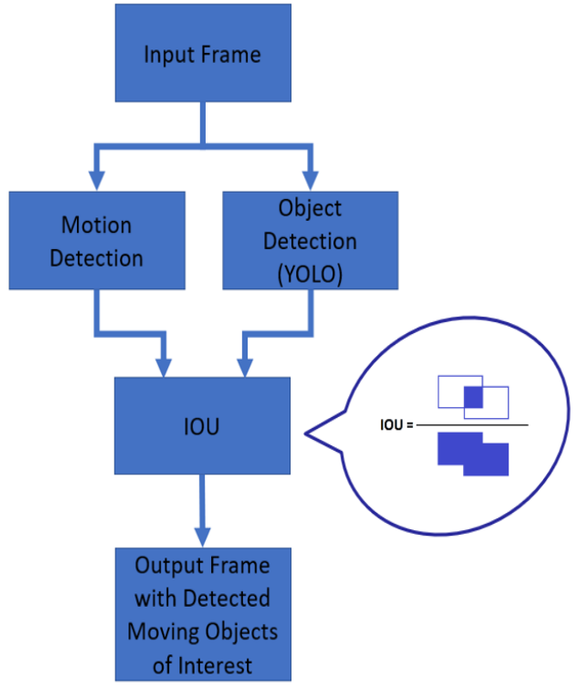
- Provide "human vision" to the VMSIS
- An integral part of the algorithm for tracking objects of interest
- **Deep Learning** based model
- High precision
- **Real-Time**
- **Detection on Visible, SWIR and Thermal** images





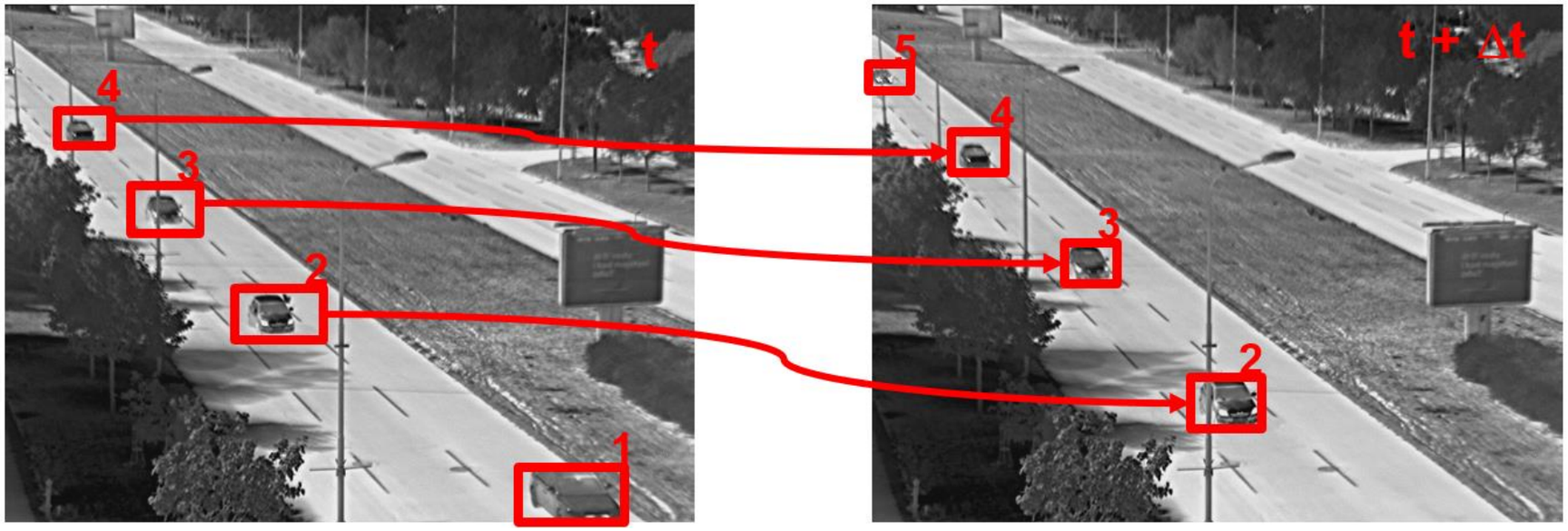
Moving Object of Interest Detection

- Combination of the method for motion detection in images - Optical flow with morphological operations and deep learning method for detecting objects of interest – YOLO
- Short-term tracking with Kalman filtering
- Detection on visible-light, SWIR and thermal channel
- **Automatic activation of target tracking algorithm from EDGE platform** for the moving object of interest



Multi-Target Tracking

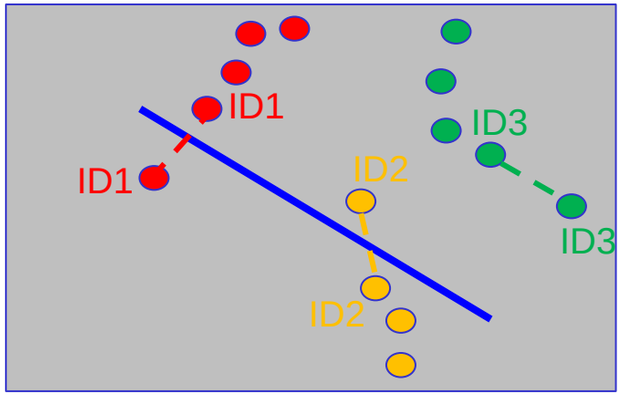
- The process of **estimating** over time **the location and trajectory** of one or **more objects** using a camera
- Challenges in video tracking: clutter, occlusions, noise, changes in pose



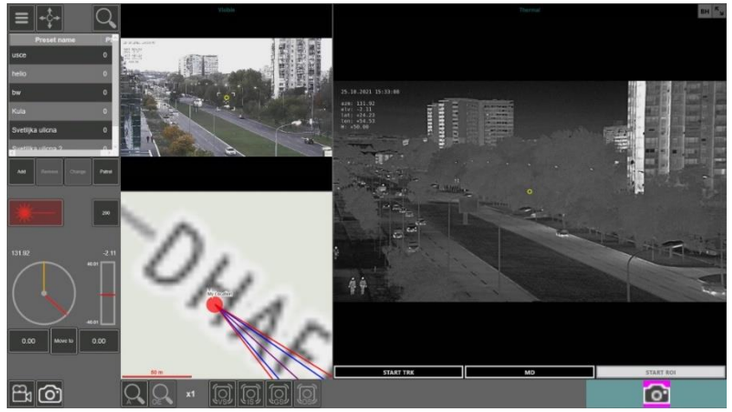
- ***Tracking-by-Detection***
  - **Strong framework**
  - Deep learning based object detector
  - Multi-object trackers rely on the output of the detector in order to create, delete, or correct a track

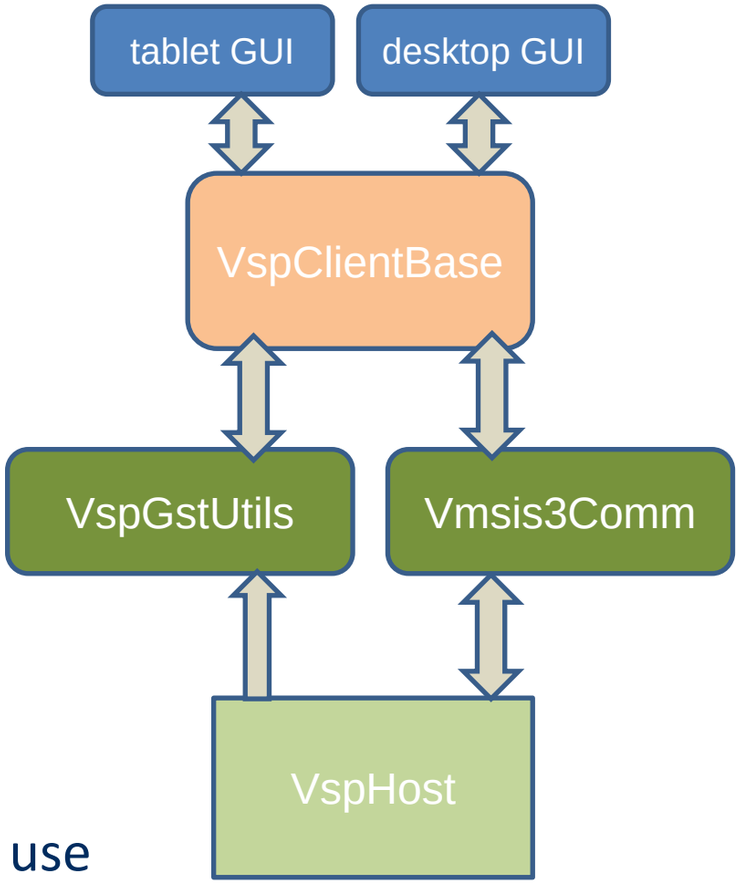
Object Counting

- Based on Multi-Target Tracking
- Crossing line detection
- General algorithm



vSPScout Control and Monitoring Application

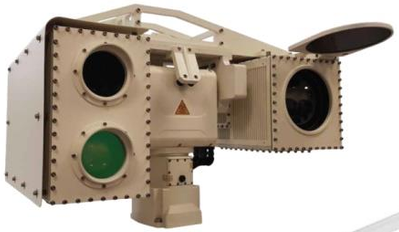




– Novel desktop application with GUI for vMSIS family with new architecture:

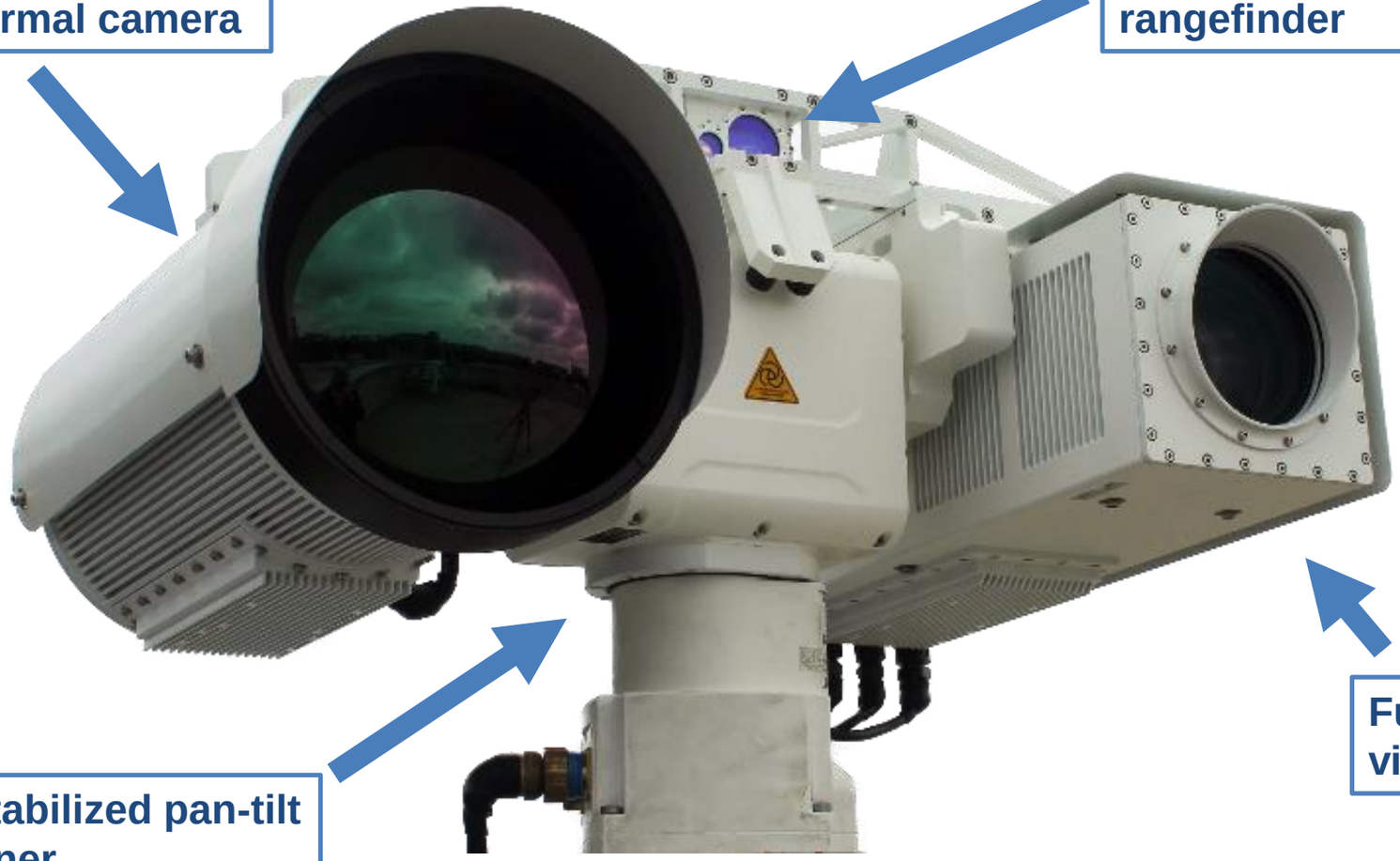
1. *VspClientBase* – the backbone; an abstraction of the EO device
2. *Vmsis3Comm* – a communication channel with the EO system
3. *VspGstUtils* – a *C++* library for handling *gstreamer* pipelines
4. tablet *GUI*, desktop *GUI* – different GUI implementations for different use cases

vMSIS3 Further Development (2019)



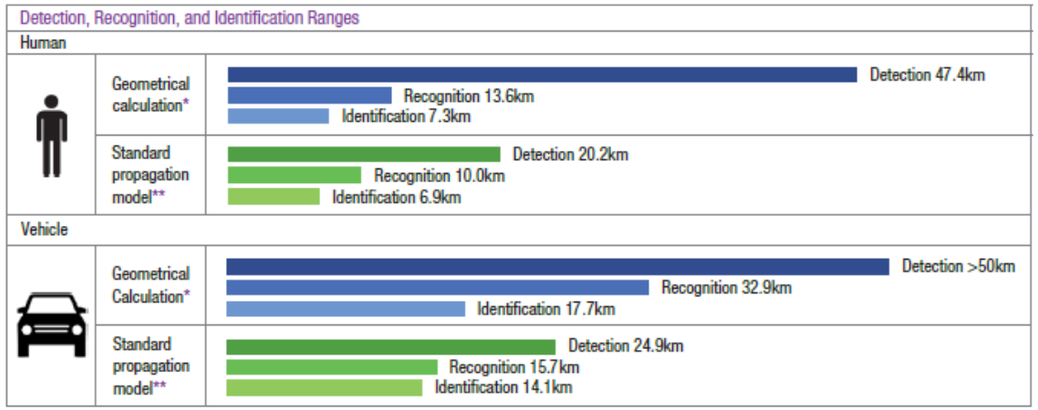
- Various customized solutions for different applications (ultra long range surveillance for coastal and land border protection, stationary and vehicle installation, fast objects tracking etc.)
- Real time implementation of algorithms on vVSP module (RTC synchronization, hybrid video stabilization, tracking, motion detection, etc.)
- Development of digital image stabilization based on **IMU sensors**
- Development of very robust **tracking** algorithm with target position prediction that works well even in cases of occlusions
- Integrated cleaning systems optionally available

Flagship model vVMSIS-CHD10-C1000 designed in 2021



Optical Sensors Characteristics and Ranges

vMSIS3-CHD-C1000-T



(*) Geometrical calculation for system IFOV (pixel size / maximum focal length).
(**) Calculated with NVThermIP model, according to STANAG 4347: 50% probability at 0.2/km atmospheric attenuation factor and 2K temperature difference.
Actual range may vary depending on environmental conditions, camera set-up, type of display and user experience.

Disclaimer: Subject to change without notice.

MWIR InSb FPA 1280x1024
NFOV: 0.74°
Digital zoom can be applied on HD format for smaller NFOV
(e.g. x2 gives NFOV 0.37° with 640 x 512 resolution)

Color Day
Cont. zoom to NFOV: 0.55°
Min illumination 0.0017 lux

Optional **SWIR** (1280x1024)

LRF 1.54 μm, up to 39km (Class 1)
Continuous Measurement
Mode (CMM) rates up to 200 Hz

Range calculation refer to thermal imager

For range calculation we used:

NVThermIP software (Night Vision Thermal and Image Processing), based on TTP (Targeting Task Performance) metric and MODTRAN for atmosphere description.

Performance demonstration examples

[redacted]

INSTITUTE VLATACOM

vMSIS3 Advanced EO System
vMSIS3–CHD10–C1000–T

[redacted]

Conclusion

New Vlatacom Institute EO system vMSIS3-CHD-C1000-T has strong advantages.

Here is the summary:

- MWIR high resolution sensor with continuous zoom lens extends detection, recognition and identification ranges
- Superior low-light colour day camera with continuous zoom lens
- Optional high resolution SWIR with continuous zoom lens (FOV matched with thermal imager)
- Superior LRF range and high firing rate in continuous mode measurement
- High performance of pan/tilt and stabilization parameters
- Provides built-in software features (video processing algorithms)

Thank you for your attention!

Any questions?

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