High resolution solid-state LIDAR with real-time image fusion for autonomous vehicles

Long range use cases

Jordi Riu

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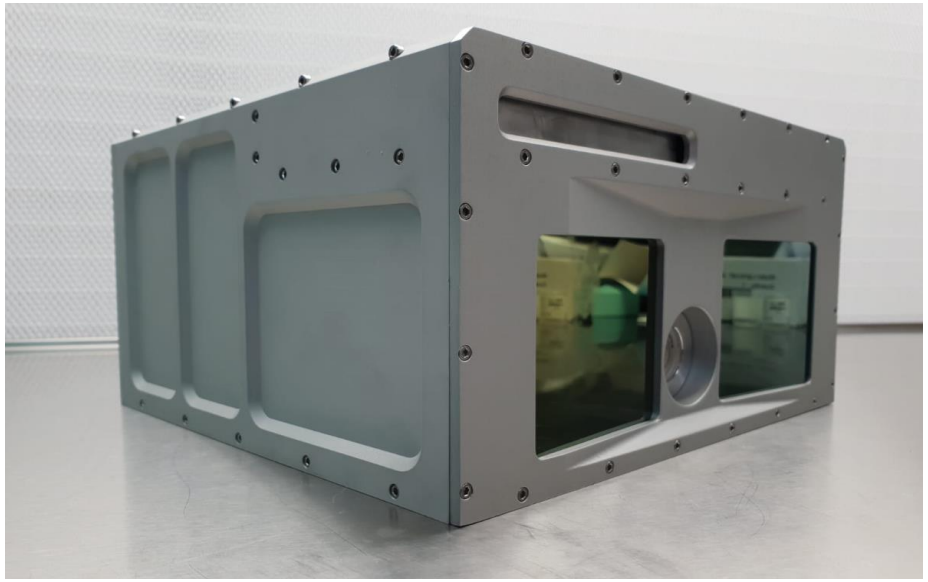
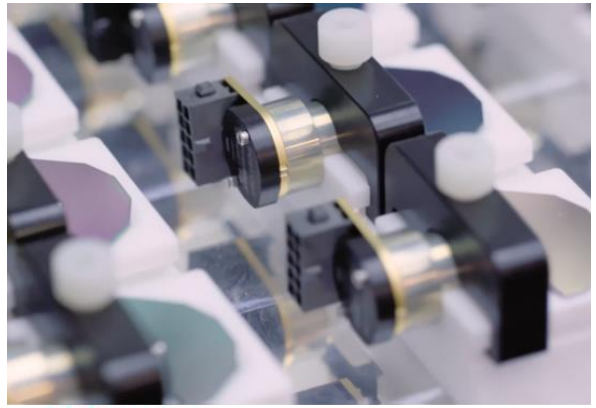
Company overview

- Beamagine was born for commercializing imaging lidar sensors built on proprietary technology awarded by multiple patents granted all over the world.
- The company relies in accumulated knowledge in its engineers accumulated in ten years of lidar, optomechanical, electronics and software development.
- Since then we've been developing innovative solutions and imaging lidar sensors to automotive, railway, maritime and space users, always in applications with demanding point cloud density or demand of sensor fusion procedures.
- We develop robust, high performance lidar imaging solutions for sensing applications, in special related to innovative mobility and transport solutions based on autonomous vehicles and robotics.

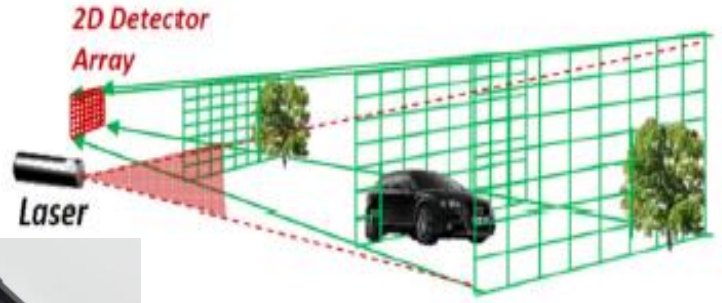


Challenges in automotive lidar

1) MOVING ELEMENTS vs SOLID-STATE

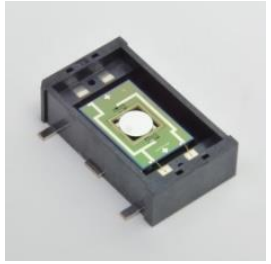


- **Mechanical Scanning**
  - Most of the current imaging LIDAR devices contains macro moving elements like spinning mirrors, galvanometric scanners or rotating heads. Moving parts usually are not a problem in a car, but the ones contained in an imaging LIDAR are **high precision optical elements** that can be sensitive to shock, temperature and vibration. High precision optomechanical elements may not be reliable at mid/long term installed on a vehicle.

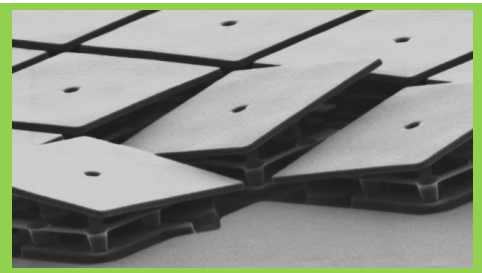


- **Flash**
  - Elegant solution (solid-state also) but impractical for long range because the laser energy is spread over a large area. Low image spatial resolution.

- **MEMS based scanning**
  - Good balance between laser energy efficiency and solid-state solution. Limitations related to the mirror aperture (~2mm) that limits the achievable range

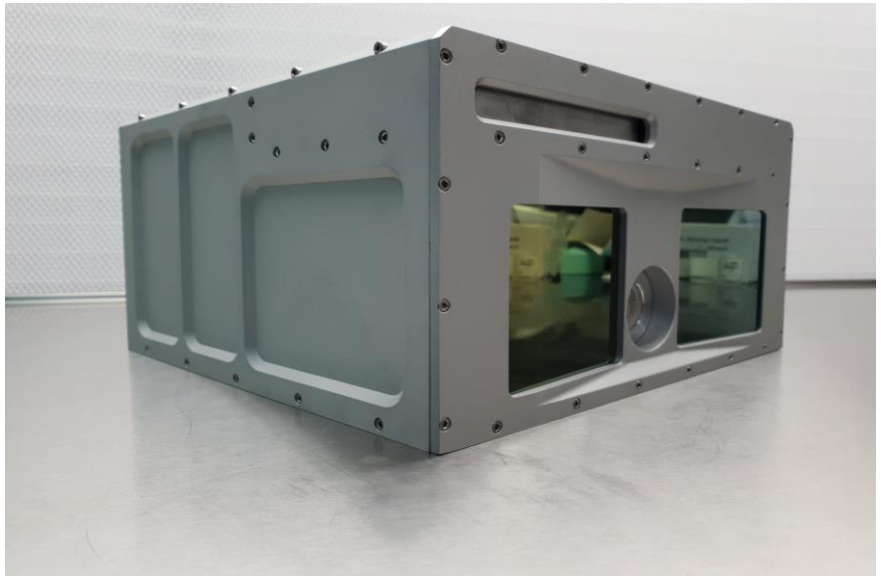


- **Beamagine solid-state scanning**
  - Combines the advantages of a solid-state scanning based on MEMS with a large entrance pupil diameter thanks to a patented double MEMS approach. A large entrance pupil enables long range detection within eye-safe power levels.



Performance figure

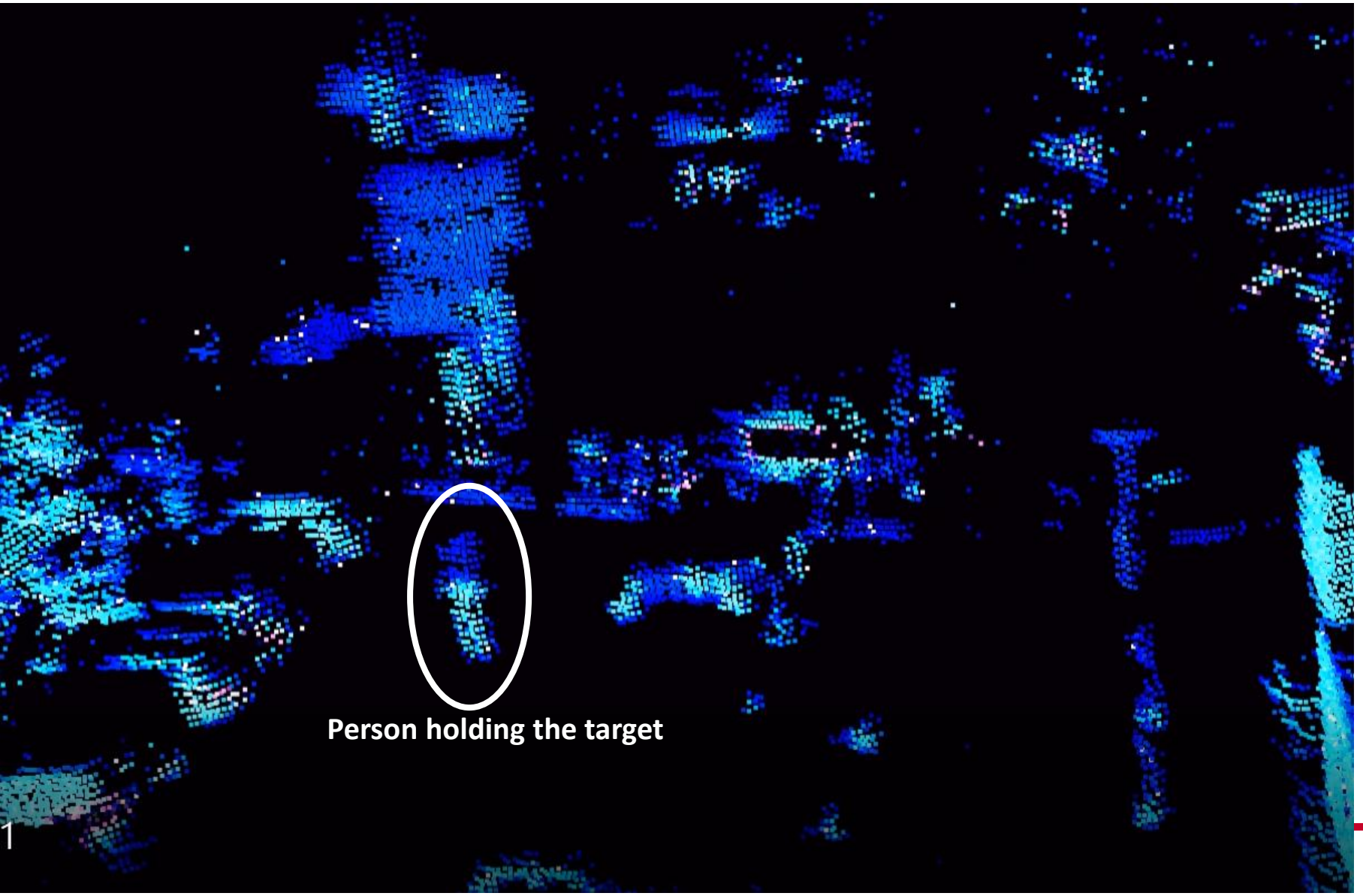
Specifications	CURRENT VALUES	PRODUCT RELEASE 2020
Electro-optical unit		
Wavelength	1064nm – Class 3R	1550nm – Class 1 Eye-safe
Range @ 100klux ambient light	80m @ 10% reflectivity 180m @ 50% reflectivity	120m @ 10% reflectivity 270m @ 50% reflectivity
Point rate	720 Kpx/s	1,5 Mpx/s
Image spatial resolution	600 x 200px	750 x 200px
Frames per second	6 Hz	10 Hz
FOV (HxV)	60 x 20º	75 x 20º
Angular resolution	0.1º H, 0.1º V	
Range accuracy	±2 cm	
Imaging modes	3D: Range, Intensity	3D: Range, Intensity 2D: RGB, NIR, SWIR or Polarimetric
Mechanical / Electrical / Software		
Size (WxDxH)	26 x 23 x 13 cm	13 x 15 x 10 cm
Weight	5Kg	2Kg
Supply Voltage - Power	12 VDC - 30W	
Integration	Linux driver (ROS compatible version also available) DLL for Windows	
Test application	RVIZ and Beamagine Visualizer	

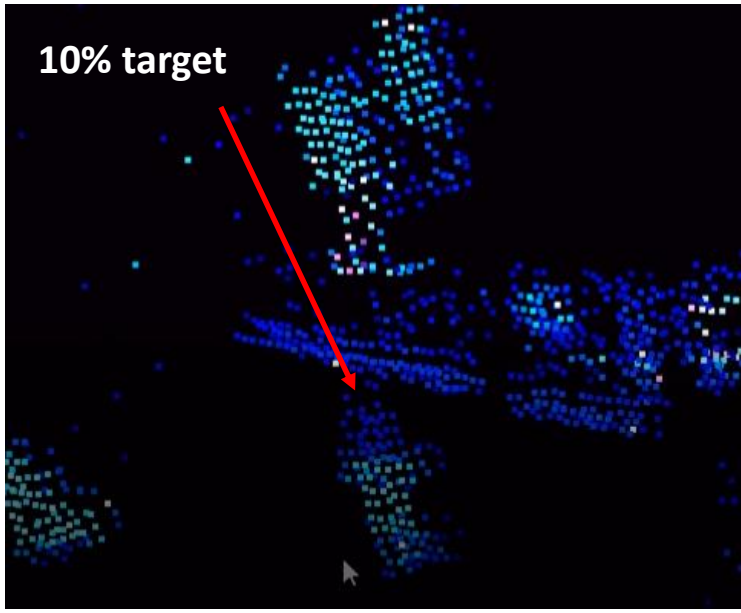


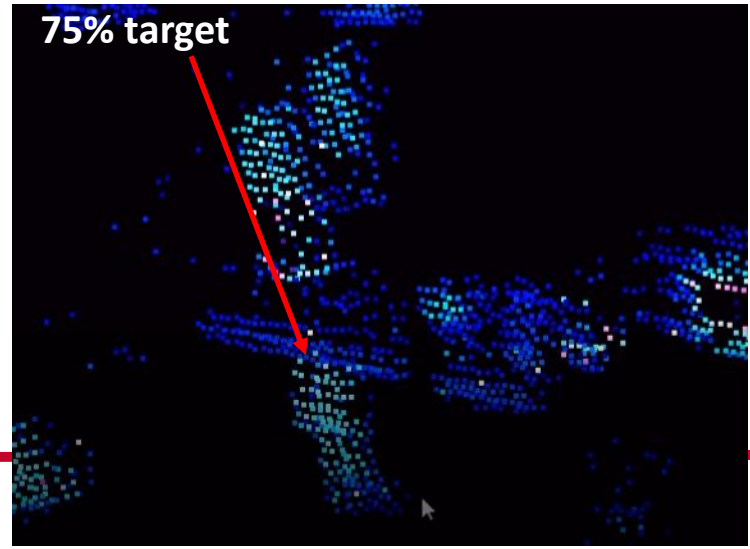
Performance test

- Double reflectivity target (10%-75%)
- Tests up to 80m at 10% reflectivity
- Range and Intensity images obtained
- Some objects (buildings) visible at 200m

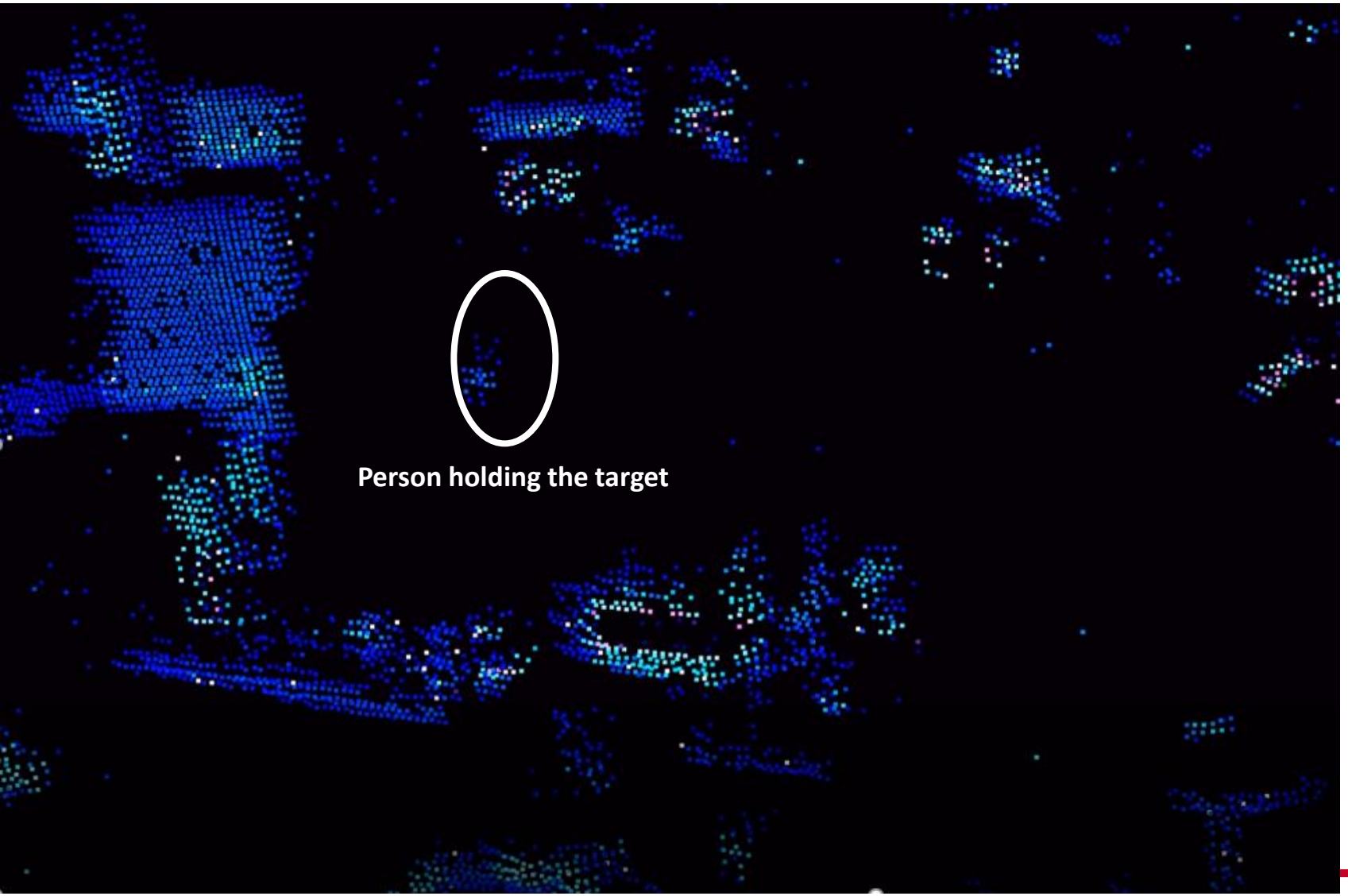
Performance test at 50m

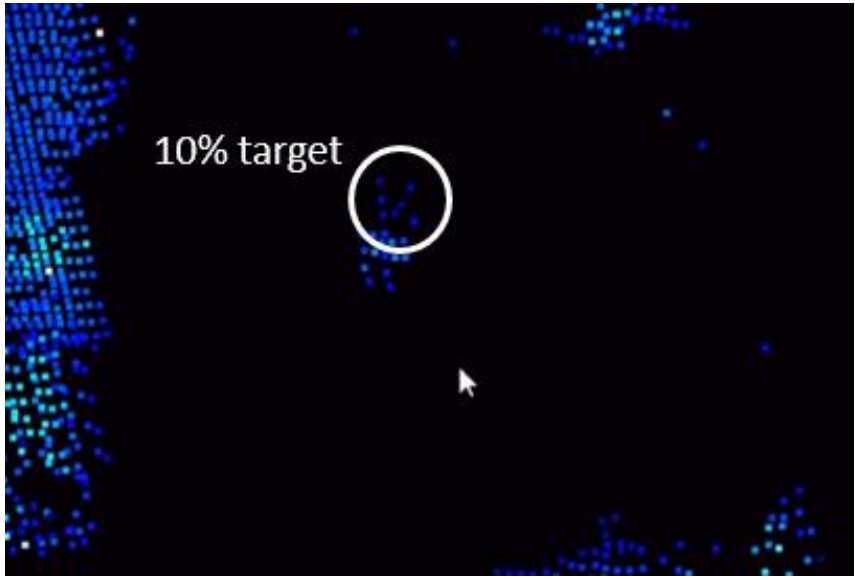


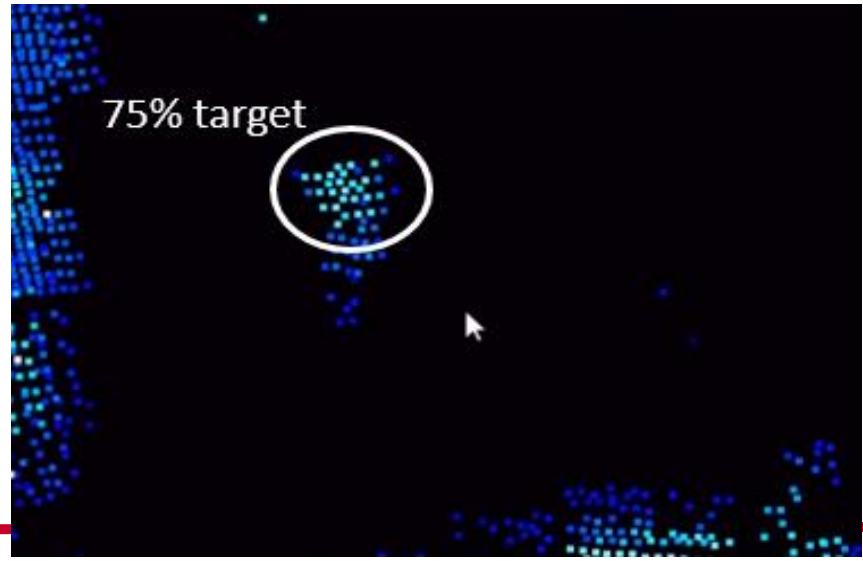




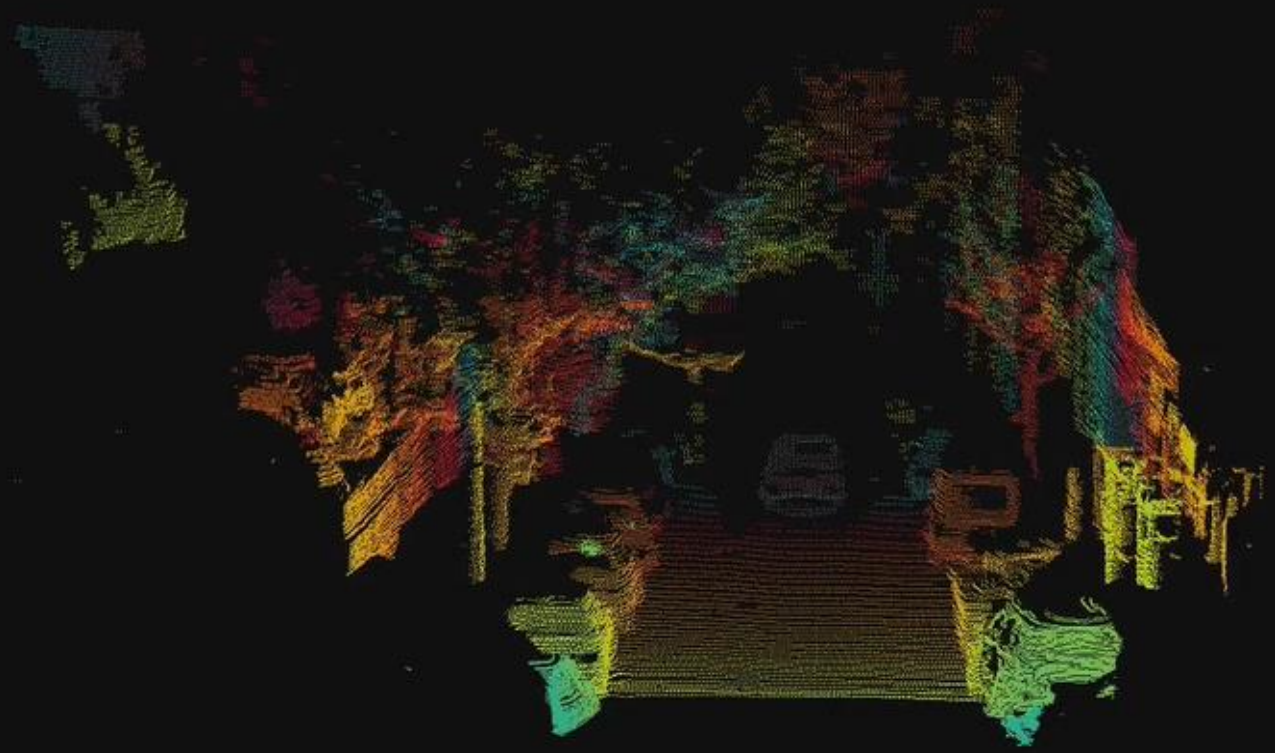
Performance test at 80m







Sample video



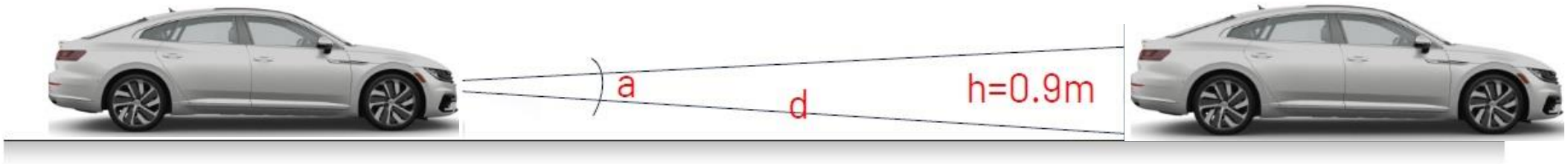
Challenges in automotive lidar

2) VERTICAL RESOLUTION: Range and resolution requirements are connected

- **Range determine how fast you can drive**
- **Resolution determine how small objects can be classified.**
- **Range without resolution is not enough.**

  - Example: Velodyne HDL-64 S3 (64 channels):
    - Measurement range: up to 120m
    - Vertical FOV (Y-axis): 26.9º -> Vertical angular resolution: 0.42º
    - It gives h=120*rad(0.4) = 0.9m

  - Then: Max 2 spots on the height of a tall vehicle (SUV). Probably not enough for classification of a vehicle at measurement range. Not enough for smaller objects.

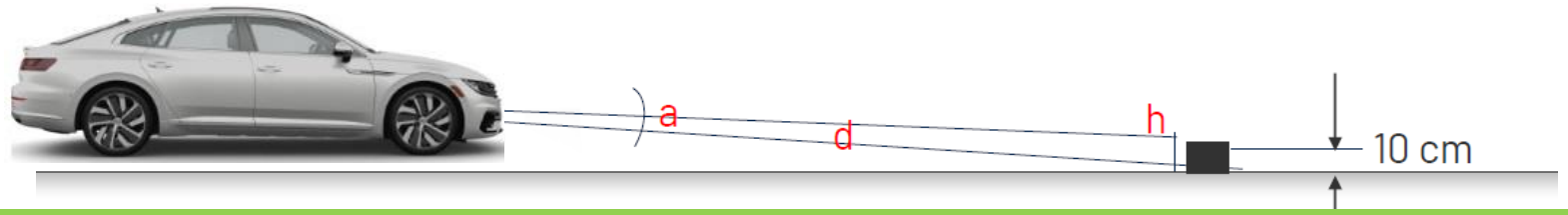


Challenges in automotive lidar

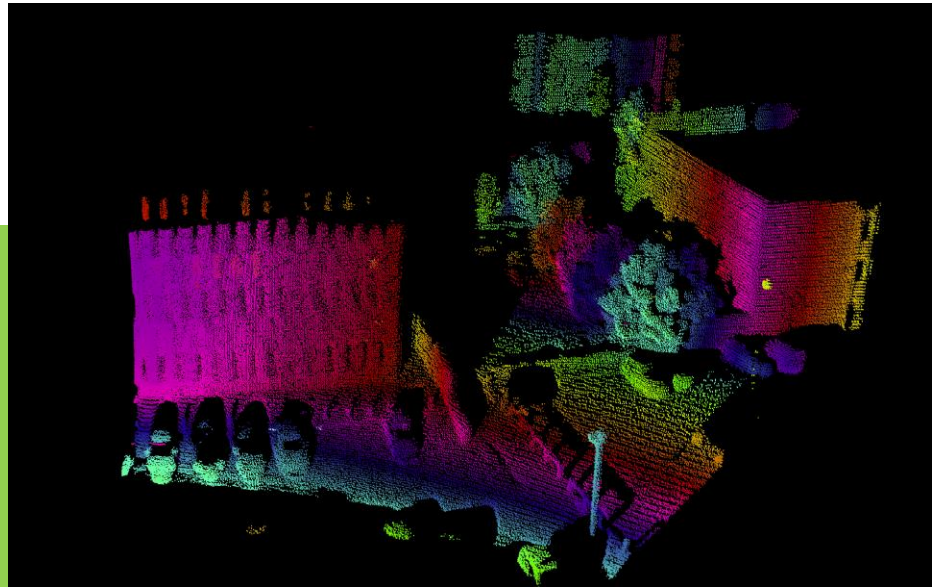
DRIVABLE SPACE DETECION: ROAD DEBRIS USE CASE

Systems mounted in fast-driving cars need to “see” a minimum of 150 meters forward, and detect small objects down to 10cm in height. Translated to resolution requirements:

- Range: 150m
- Vertical **minimum** resolution given by road obstacle: 0.1m
- Then Minimum vertical angular resolution: 0.038º
- Vertical FOV assuming 128 vertical points:
  - vFOV = 128 * 0.038 = 4.9º
  - Vertical FOV < 5º is not enough for various amount of cargo in vehicle or driving in hilly streets

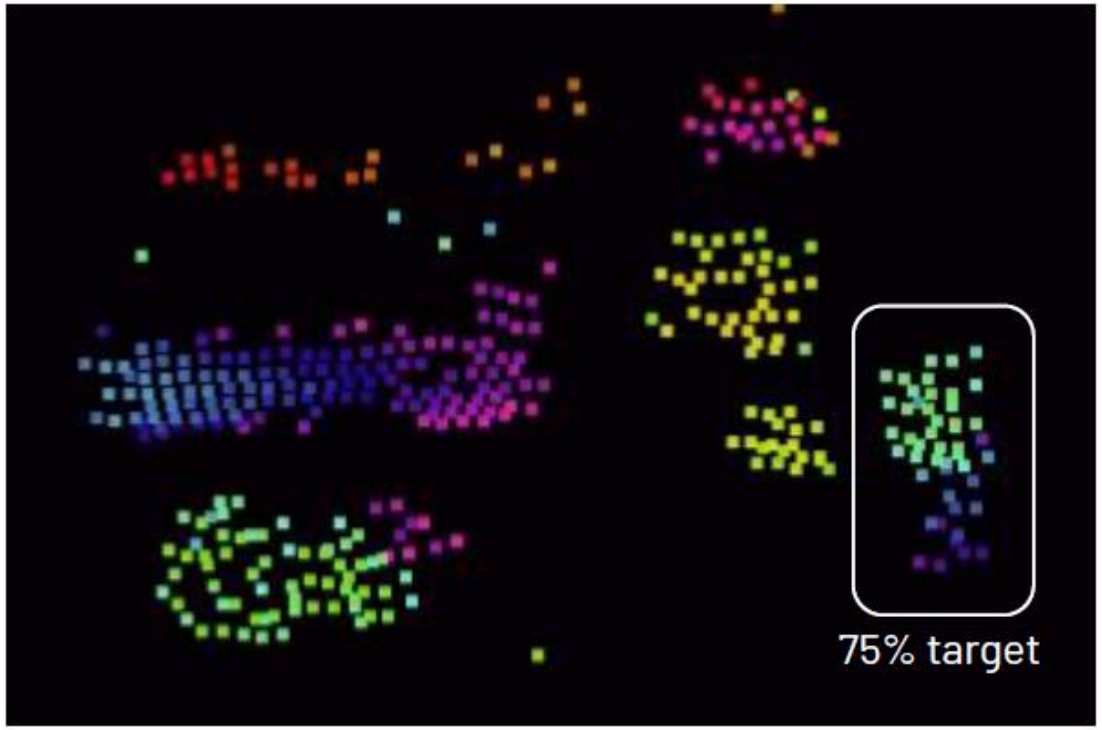


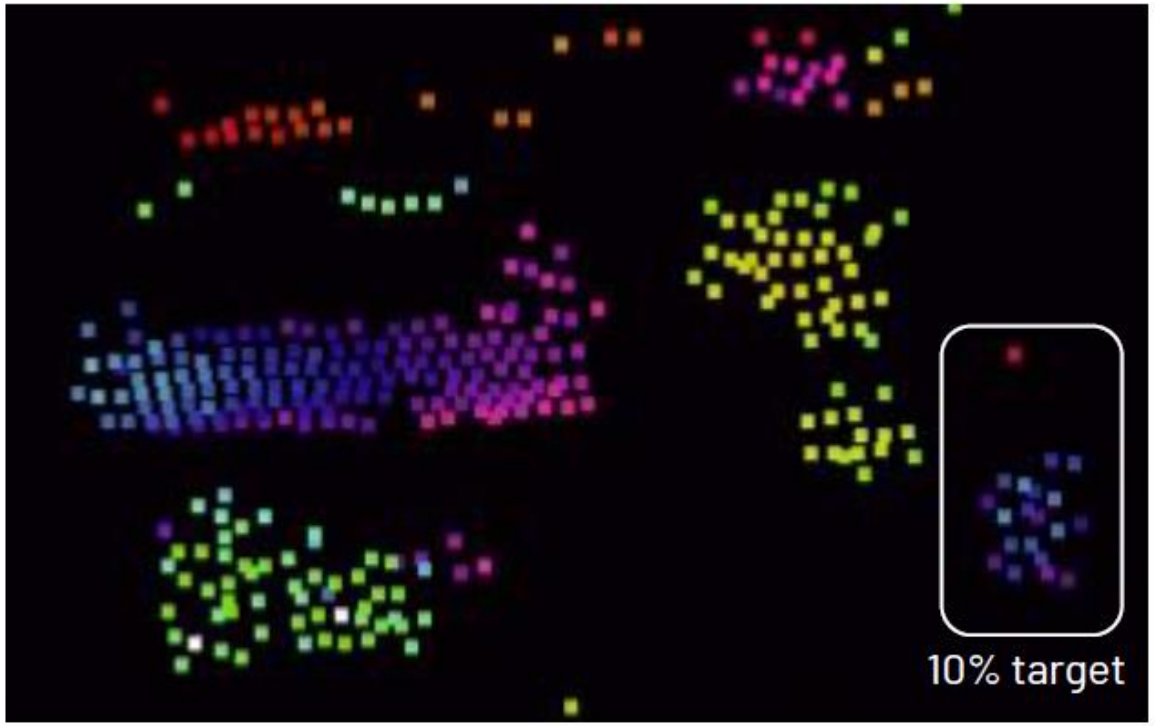
The Beamagine LIDAR provides good resolution not only in horizontal axis, but also in vertical axis. Depending on the OEM specs, it can be customized to achieve an angular resolution down to 0.05º. This ensures the capability to detect low height object that the vehicle can’t override.



Resolution testing

- 0.1º H – 0.1ºV angular resolution: range 100m





Challenges in automotive lidar

3) PARALLAX ERROR IN DATA FUSION

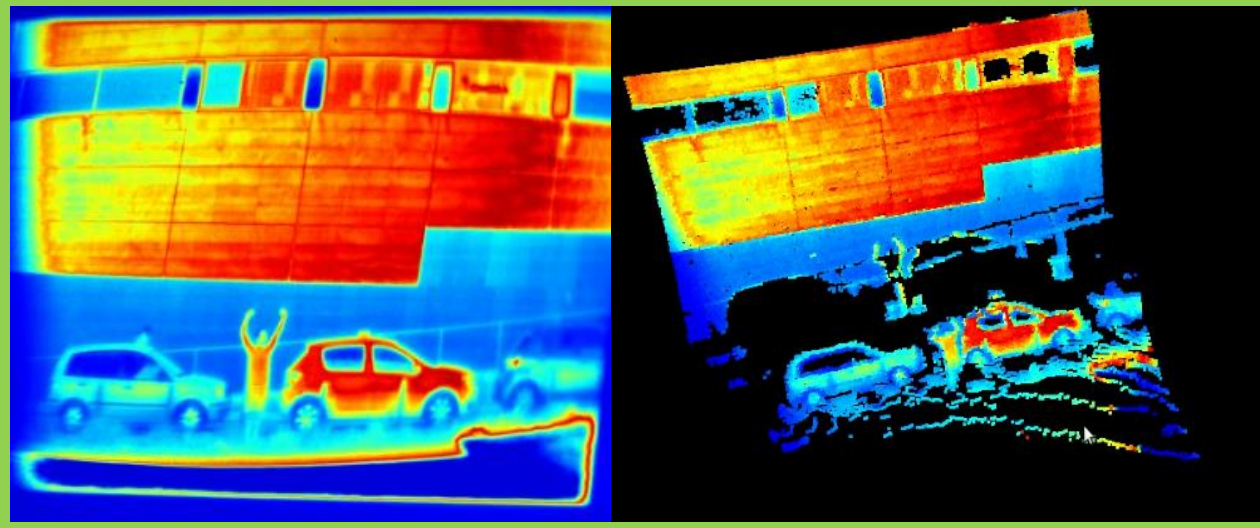
PROBLEM: When different sensors (LIDARs and cameras) are placed on a vehicle in a detached basis, parallax error appears due to:

- Sensors are placed in different locations on the vehicle
- Different FOVs
- Different frame-rates
- Relative misalignments between sensors occurred after calibration

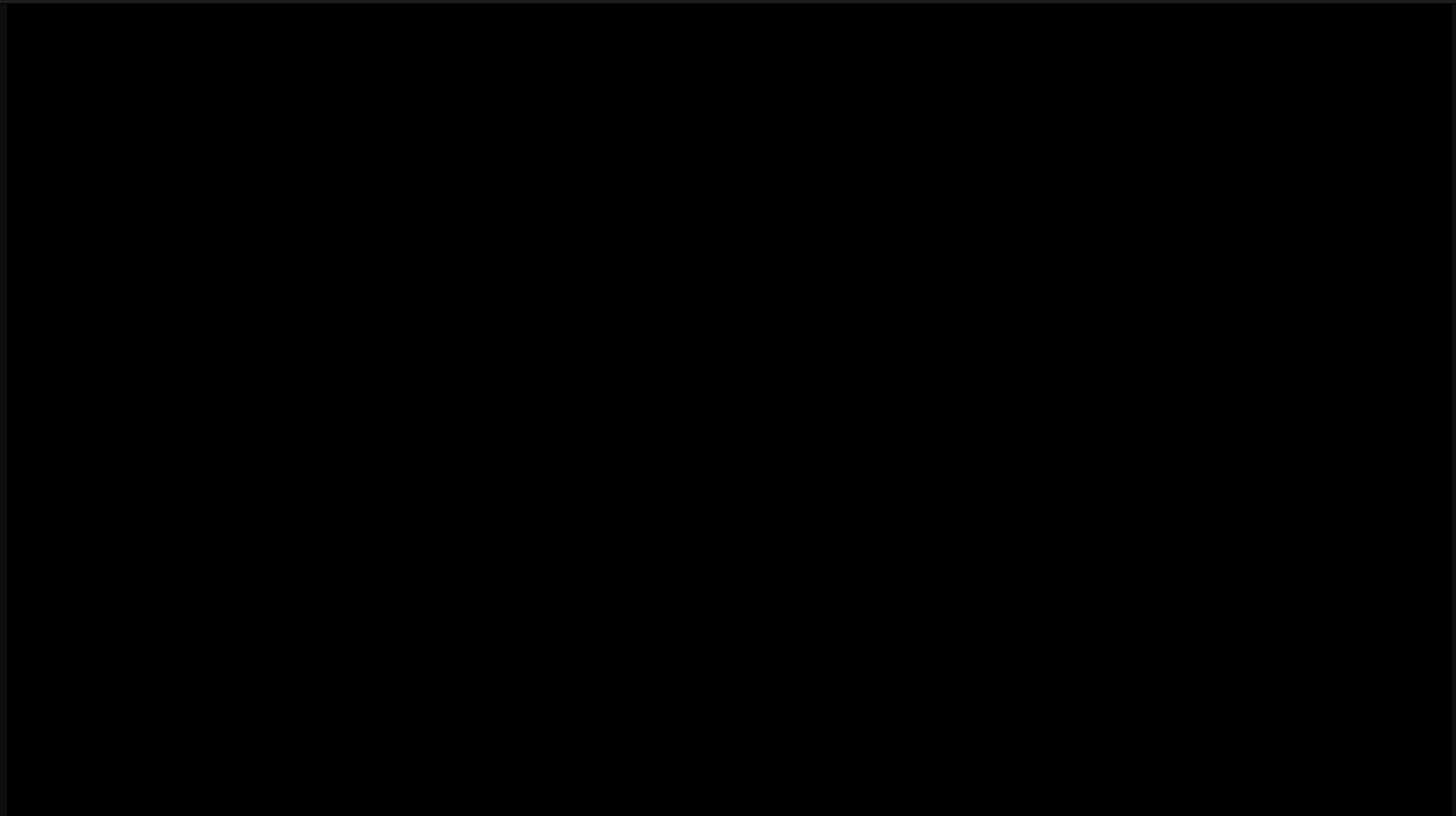
Traditional solutions like transforming the lidar points into camera images don't avoid the parallax misalignments.

Beamagine technology enables a singular feature:

- Self-registered 3D lidar image with another 2D imaging mode (**RGB, NIR, SWIR, polarimetric, hyperspectral and even thermal**).
- Parallax free data fusion.
- Immunity to misalignments generated by chassis deformations.

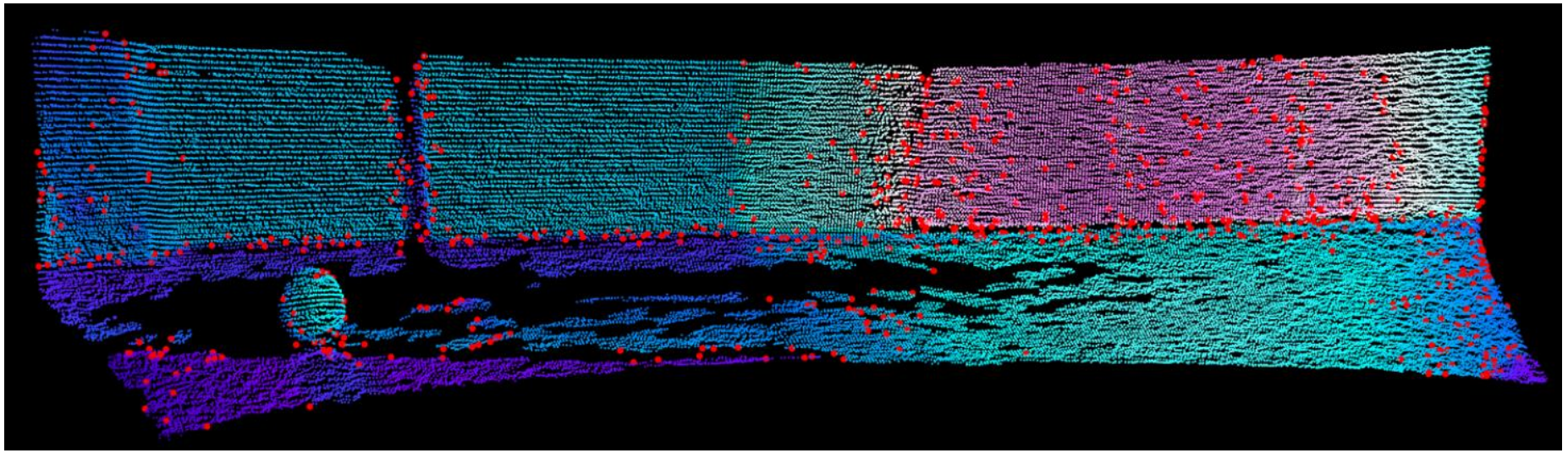


Sample video: LIDAR + Polarization



Point cloud processing software

- Since its creation, Beamagine has been focused on the hardware side of the LIDAR sensor. However, we started developing software also for point cloud processing to provide complete solutions to our customers.
- In addition, we stablished a stable collaboration with the Image Processing Group of the Technical University of Catalonia.



Vision, Identification, with Z-sensing Technologies and key Applications

See more at: www.vizta-ecsel.eu/

OBJECTIVE

Develop innovative technologies for **optical sensors** and **laser sources,** for short to long-range **3D-imaging,** and **demonstrate their value** in several key applications

MAIN TARGETS

- Develop innovative technologies for 3D-imaging depth map high resolution sensors and associated IR light sources
- Exercise new 3D sensors and light sources in key applications with various ranges: Secured access, driver monitoring, object recognition, few cm to several meters, up to LiDARs systems with hundreds meters range
- Build partnership ecosystems foreseeing future competitive European products for Automotive, Security, Smart Cities and Industry4.0 and anticipate normative requirements

DURATION 3,5 years - May 2019 until Oct 2022 **FUNDING** 21 M€

COORDINATION STMicroelectronics Crolles (France)

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THANKS FOR YOUR ATTENTION!

Contact information

C. Bellesguard, 16
E08755 Castellbisbal
Barcelona (Spain)

phone: +34 659706005
email: info@beamagine.com
web: www.beamagine.com
twitter: @beamagine

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