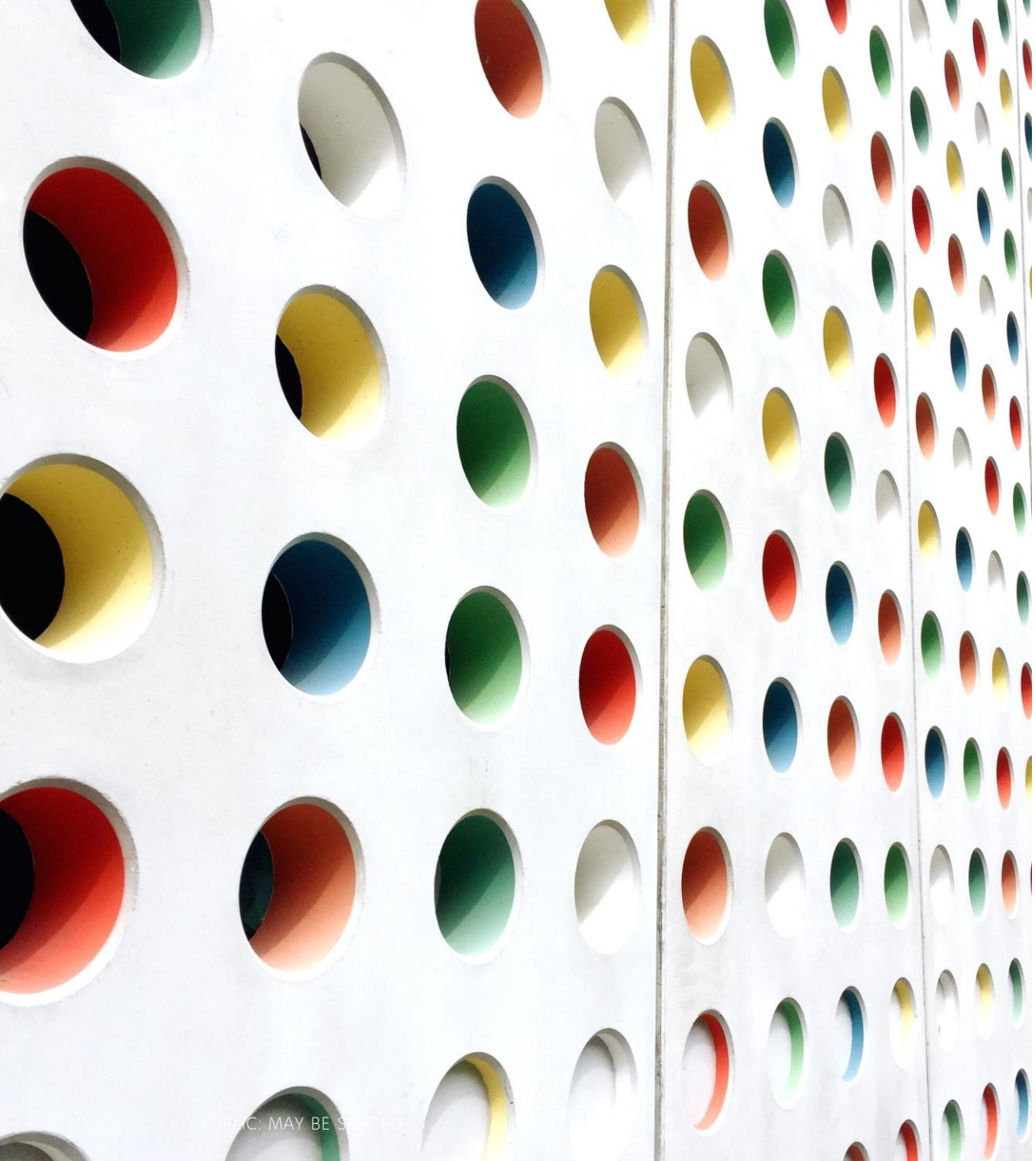

Perception Applications

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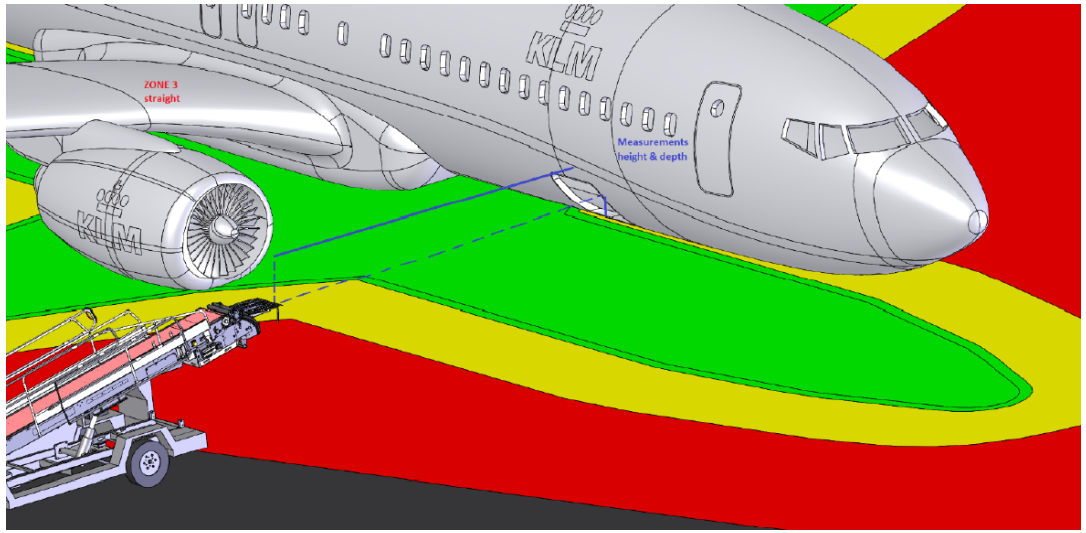
What happens after the automotive boom?

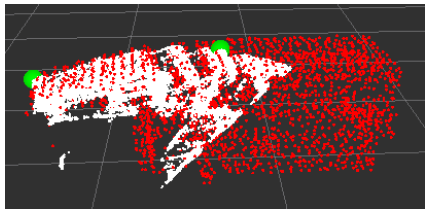
- Lidar and perception field has been dominated by the needs of the Automotive market. However, the world is MORE than the automotive market …
- We addressed a number of possible applications
  - **Airports**
  - **Maritime**
  - **Sports**: Advanced training tools and Player tracking
  - **Industrial**: We built an autonomous collision/incursion avoidance demo platform including a PLC
- Many more applications are out there for further exploration/exploitation, including
  - Mining
  - Construction sites
  - Perimeter monitoring
  - Man-Overboard detection

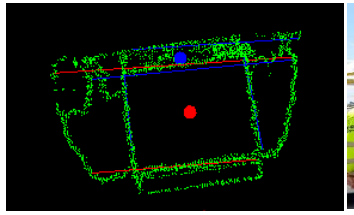
Problem: Accidents at airport aprons are expensive

Airports

- **Mission**: Due to the introduction of carbon fiber planes, a "no-touch" policy has been introduced at the Aprons of airports → GSE may not touch airplane during operations
- **Focus**: Assist baggage handling roller tracks to land inside an airplane with ±~1 cm accuracy
- **Target**: Develop a system to assist the driver to navigating inside the cargo hold of a plane
- **Execution**:
  1. Identify a plane
  2. Identify the cargo hold
  3. Identify and track 5 points inside the cargo hold during approach

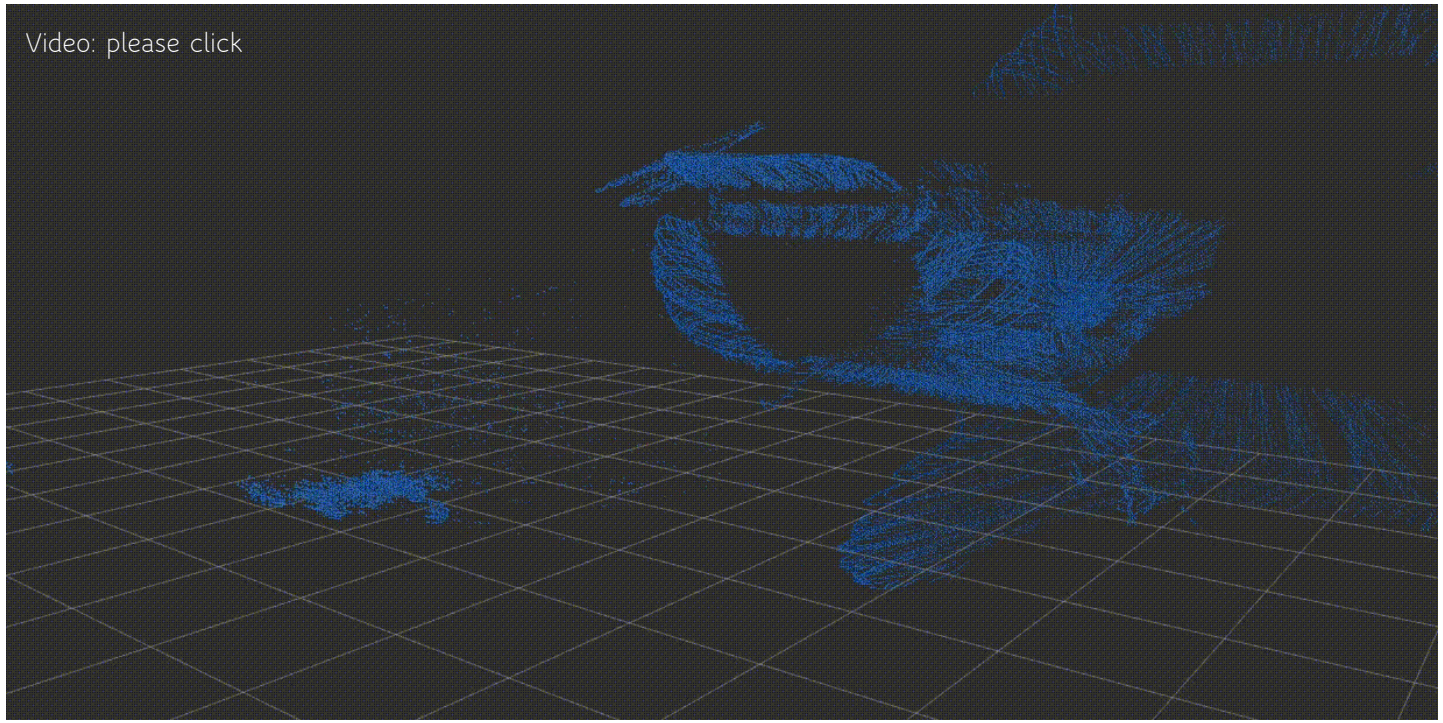


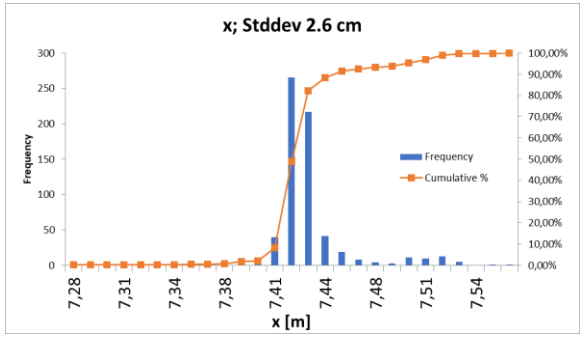


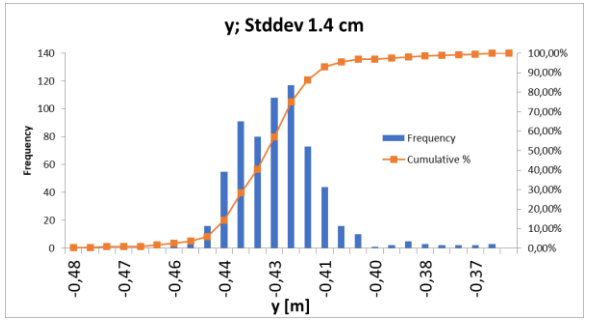


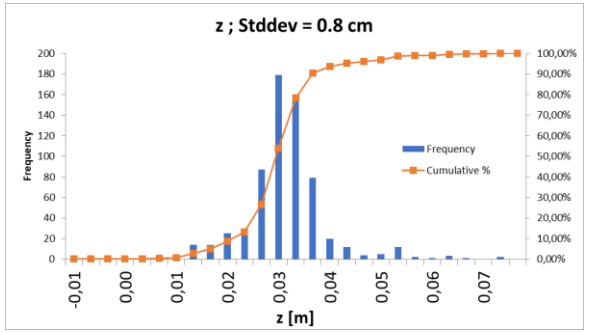
Solution: Lidars + Cameras + Perception

We achieved target performance using **2 x Livox-Mid-40 Lidars & a MYNT-EYE stereo camera** (distribution of center point detection statistic shown in graphs). We simultaneously tracked 5 points in the cargo hold and the head of the roller belt (red point cloud). **The system was retrofitted and tested on a Diesel system from 1994(!!)**. Data set in animation below was recorded during snow.









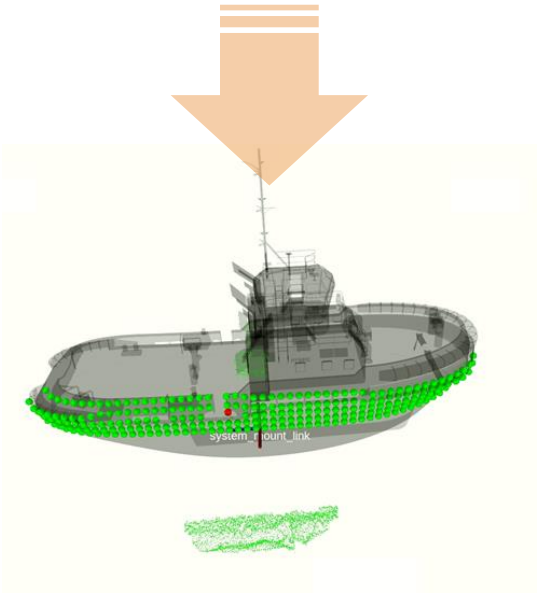
Airport specifications Table

- The system has quite relaxed specifications for Lidar + Camera sensor suite
- Only local data required → no need for GPS, IMU or other sensors (Temp, Humidity, etc.)
- Velocities of moving objects (including self) are rather low
- Data record buffer of up to 20s is required for incident logging
- System must be compact to be fitted on top of (the rather small) airport GSE vehicles

Parameter	Unit	Value	Tolerance
Range	m	25 MAX	± 1
Latency	ms	300	± 100
Accuracy longitudinal (x)	cm	5	± 1
Accuracy in-plane (y,z)	cm	2	± 1
Velocities	km/h	20 MAX	± 5
Weather	N.A.	Snow Rain Sunshine Fog	N.A.
Power consumption	W	Unlimited (Vehicle Power)	N.A.
Lidar	N.A.	Yes	N.A.
Camera	N.A.	Yes	N.A.
GPS	N.A.	No	N.A.
IMU	N.A.	No	N.A.
Interfaces	N.A.	PLC Mechanical Power	N.A.
System Volume	cm	20 x 20 x 20	N.A.
Obstacle detection	N.A.	Must Have	N.A.

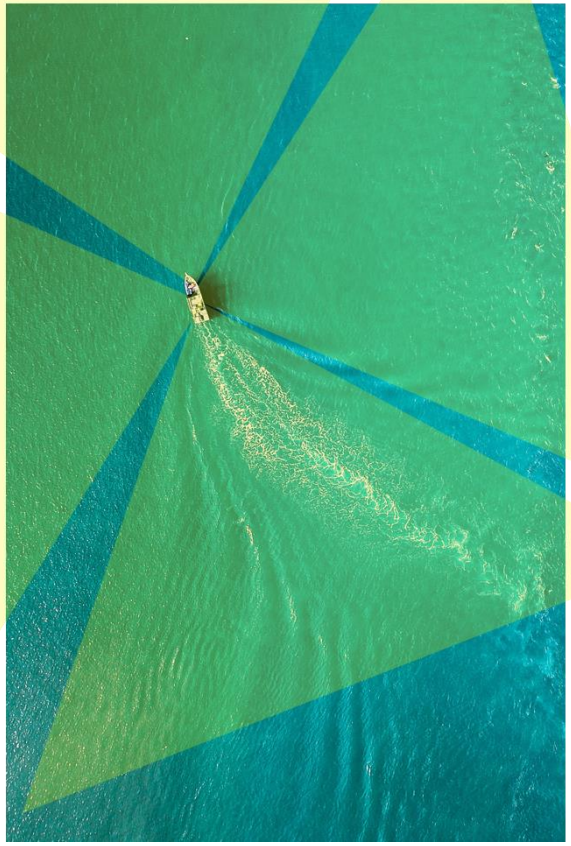
Maritime

- **Mission**: To bring digital technologies to the (currently analogue) maritime sector
- **Focus**: Mooring/Berthing, perimeter security, dynamic near-shore mapping
- **Target**:
  1. Build a vessel wide sensor network
  2. Enable the captain to have a 360° situational awareness
  3. Accurately log incidents for insurance purposes
  4. Build shipping specific applications within the LuxC development framework



A set of Collision monitoring sensors around the vessel

Solution: Enable 360° situational awareness



Rescue Aid

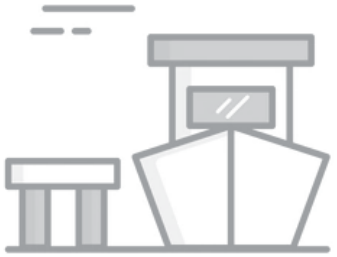
Thermal Cameras – the industry standard- are challenging to use in Northern Waters

Lidar generated 3D point clouds are excellent for Artificial Intelligence based target search

Collision Avoidance

Limited visibility at the Wheelhouse can cause collisions due to dead angle

Existing charts and cameras provide only a 2D situational awareness



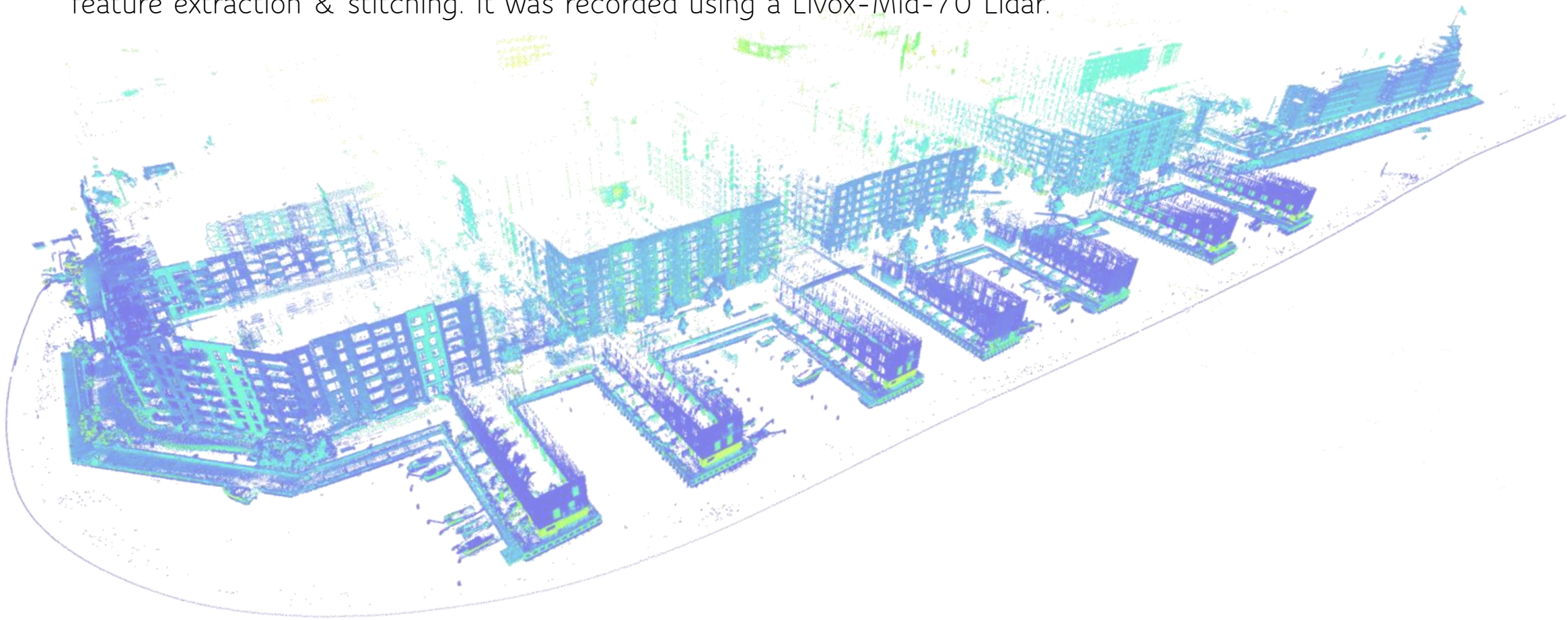
SMART BERTHING

16% of accidents occur during arrival and 21% during anchorage

Bad weather visibility can seriously affect the fuel consumption

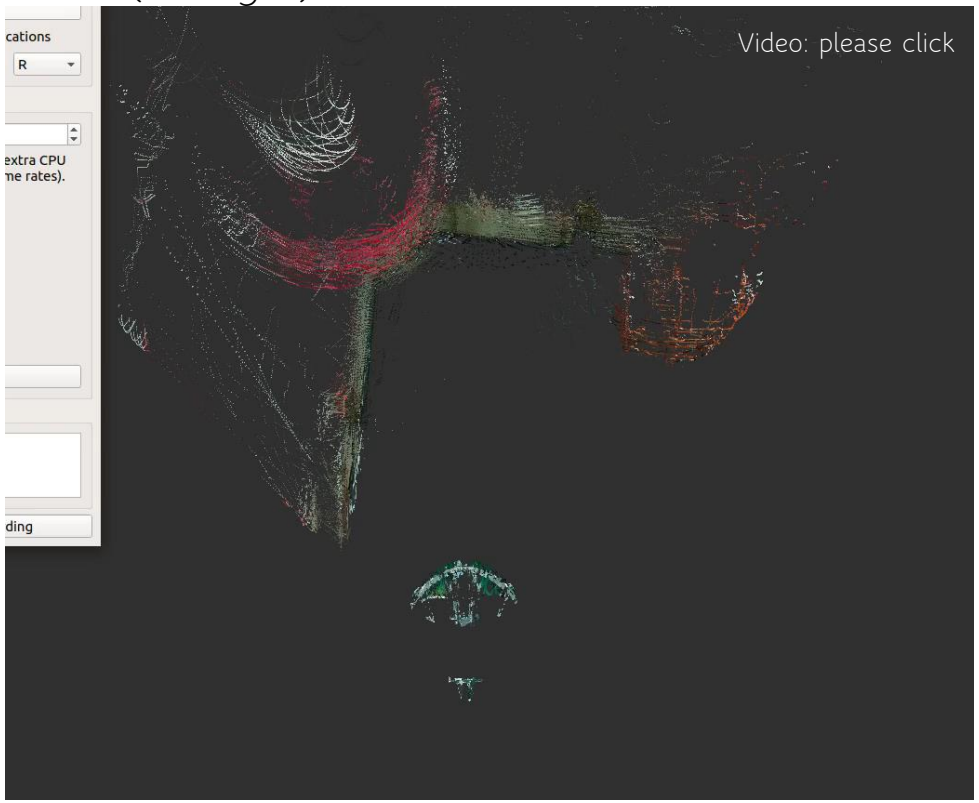
Application example: Mapping

An example of 2 km long, ±10 cm accuracy 3D map of the Copenhagen harbor that was built using feature extraction & stitching. It was recorded using a Livox-Mid-70 Lidar.

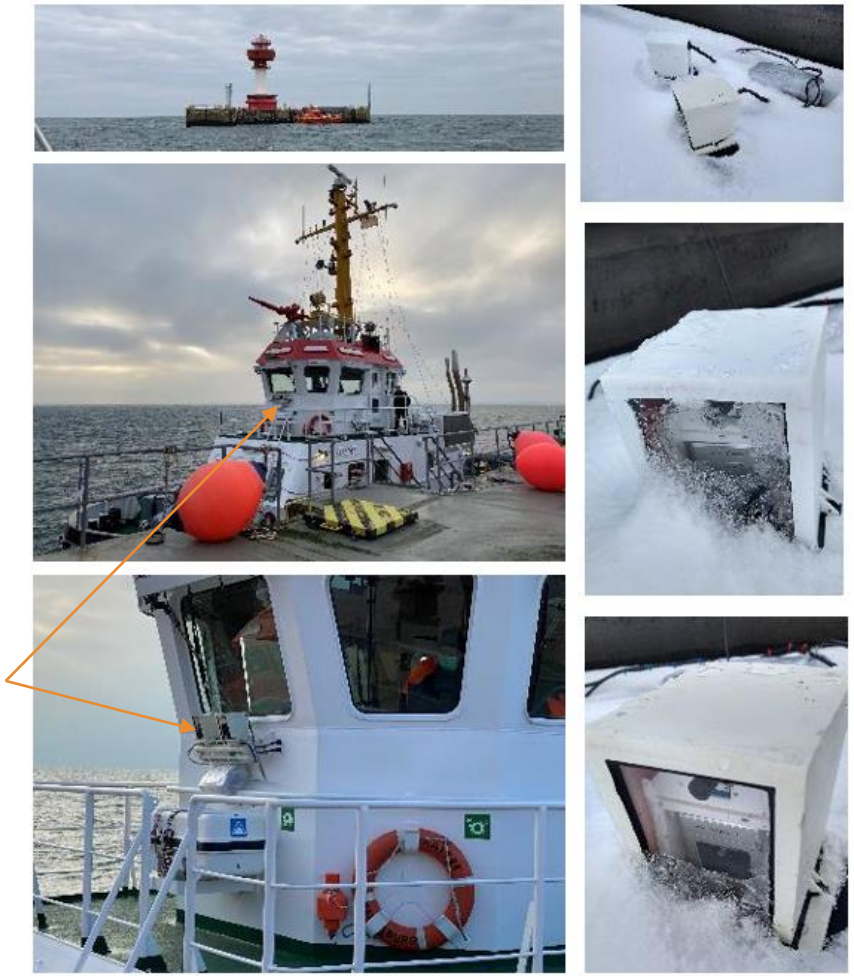


Application example: Sensor fusion (Camera + Lidar)

A top-view of a 3D Lidar & camera fused data set during approach to a light house in rough waters near Keil, Germany. Sensors were mounted in front of the vessel (see right)

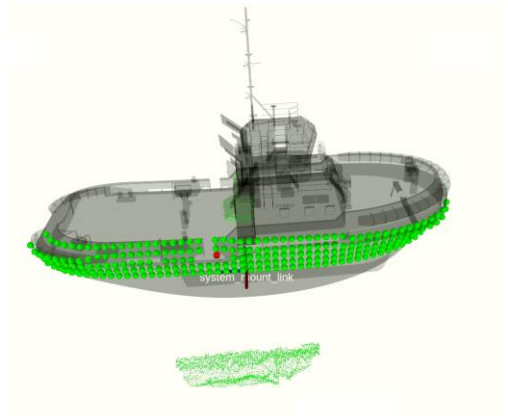


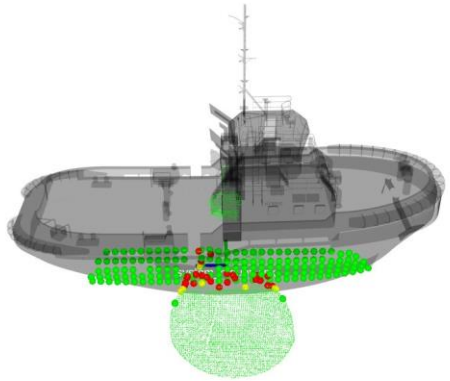
Our sensor nodes



Application example: SMART Berthing

- Current solutions rely on (uncorrected) fisheye camera images
- With LIDAR and virtual collision sensors around the ship, the captain achieves 360° situational awareness
- We built a two-node system, where each node had
  - One Livox mid-70 Lidar
  - One fisheye camera
  - One IMU
  - One Raspberry-PI4 for preprocessing





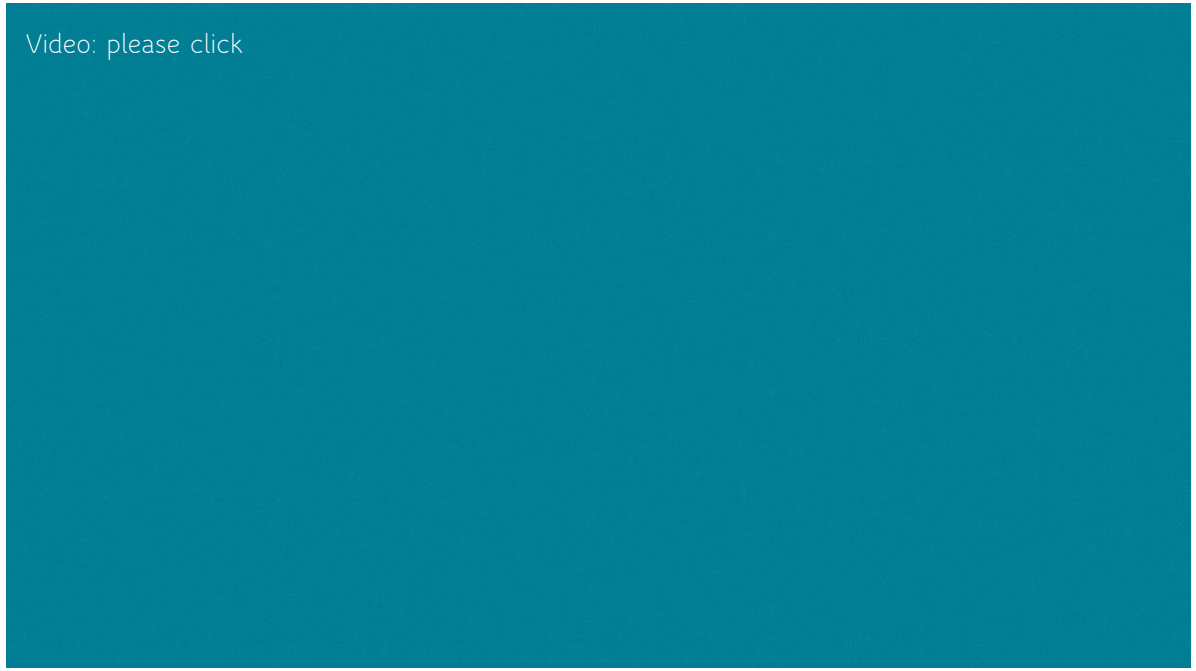
Maritime specifications Table

- Data density is very important → Multiple Lidars with overlapping fields are preferred
- Real-time analysis is required → Higher density points are preferred
- IMU is a MUST to compensate for wave motion
- Velocities of moving objects (including self) are rather low as compared to automotive
- Data record of up to 100s is required for incident logging
- Range requirements are complex and must be tailored to individual vessel dimensions

Parameter	Unit	Value	Tolerance
Range	m	25 to 1000	± 1 to ± 10
Latency	ms	500	± 100
Accuracy longitudinal (x)	cm	20	± 1
Accuracy in-plane (y,z)	cm	10	± 1
Velocities	km/h	1 to 20	± 0.5 to ± 1
Weather	N.A.	Snow Rain Sunshine Fog Splash	N.A.
Power consumption	W	Unlimited (Vessel Power)	N.A.
Lidar	N.A.	Yes	N.A.
Camera	N.A.	Yes	N.A.
GPS	N.A.	Yes	N.A.
IMU	N.A.	Yes	N.A.
Temp & Humidity	N.A.	Good to have	N.A.
Interfaces	N.A.	Mechanical Power	N.A.
System IP rating	N.A.	Ipv8	N.A.
System Volume	cm	Unlimited	N.A.

Feature example: Virtual proximity detection sensor grid

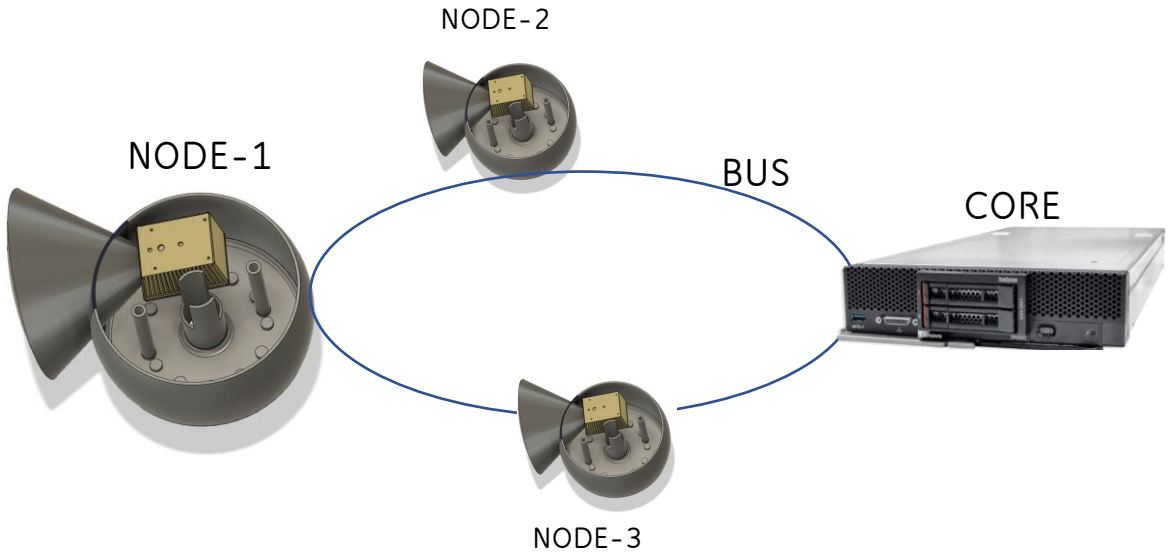
- Using functions of our library, higher level product features can be developed
- As an example, we have developed “Virtual proximity detection sensors”
  - Perimeter is defined by a virtual grid
  - Object for detection must be within the FoV of sensor suite
  - Lidar & Camera required
- Markets
  - Military
  - Construction sites/Marinas/Law enforcement
  - Security/Safety

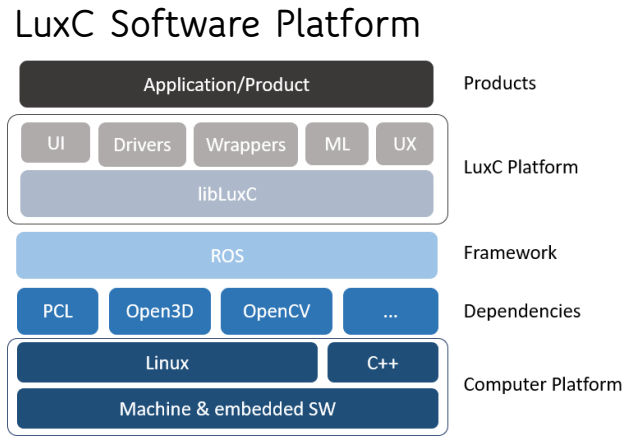


Architecture

NODE

- ✓ Lidar
- ✓ Camera
- ✓ GPS & IMU
- ✓ IPv8 Housing
- ✓ Power Distribution
- ✓ PCB
- ✓ Mounts
- ✓ Node Network





Our system architecture has 3 main parts: (I) **The sensor node**, which contains all the sensors, a local network and may even have a local CPU for pre-processing; (II) **the BUS**, which is TCP/IP based and has a ring architecture that supports POE and the (III) **the CORE** which runs the perception software. This architecture can be complemented with a User Interface and a display.

Deliverables

- User Journey/Exploration → System and product specifications
- Solution analysis and requirements engineering → Specifications
- Consultancy based
  - support for system design → System Architecture
  - support for adaption of core architecture and system design
- First Steps
  - Consultancy
  - Product definition/Technology-product-matching
  - Team training/development/recruitment
  - Full system development until customer hand-off
  - Advise on future development & Road mapping
- Technology and market analysis
- Strategic development/deployment
- Execution / Interim management

Summary

- Proven software
- Proven System & Concept
- IP & Source available → Scalable
- Our software is a result of ~100k manhours of design, development, testing and verification cycles
- Lean Development mindset used to build key functionalities suitable for edge computing

Thank you for your time.

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