Horizon 2020

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Prototyping and demonstration of vehicle identification tool

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Abstract

The usage of remote sensing and robotics addresses at least three challenges for humans: presence in risky locations, presence over time, and reaching difficult locations. There is no single solution that can passively and non-intrusively monitor and detect all ignition sources, but a system of systems approach provides functionalities that collects different types of data and allows for a close interaction and assistance with human operators that can make better decisions.

These demonstrations in LASH FIRE are about the capabilities to identify individual vehicles by the use of signs or placards e.g. license plate and “A Accord européen relatif au transport international des marchandises Dangereuses par Route” (ADR) and “International Maritime Dangerous Goods Code” (IMDG) IMO Dangerous Goods(DG) placards could be detected and verified against the information in the booking.
This is fundamental for both understanding what vehicle/object it is and if a connection to a booking system the position, license plate and ADR/DG then can be forwarded to a Stowage Planning Tool (SPT) as detailed in D08.4 “Stowage planning optimization and visualization aid” for the upcoming voyage but also used to update the current risk level at the terminal if this is of interest. Later the final placement of the vehicle goods onboard the ship is feed to the SPT either by manual input or usage of mobile sensors like a drone or a stationary system like Vehicle Hotspot Detection (VHD). This increases the situational awareness of what cargo/vehicle is booked allows it to be tracked objects from the arrival to departure of the unit from the terminal is possible and also this information can be shared with other systems and users.

The demonstration is based on two systems, one is a stationary sensor arch that is based on SICK AGs Vehicle Hotspot Detection (VHD) concept used for road and rail tunnels and a generic automatic guided vehicle (AGV) drone that can patrol the cargo deck or specific objects such as a row of batter electric vehicles (BEV) charging onboard. The VHD needed to be redesigned and new software functionalities developed to address the Risk Control Measures (RCM) that LASH FIRE is developing. It needed extra sensors, new way of using these sensors and development of new algorithms in the software to facilitate the functions; detection of refrigeration units that could be placed on the truck and/or the trailer, temperature measurement of the refrigeration unit and identify the vehicle, both the truck and trailer. Since many semi-trailers are parked on the terminal as un-accompanied trailers without a driver during the voyage the possibility to identify both are important. The VHD system can also read out the numbers on the dedicated dangerous goods placard if they are visible. The concept of the AGV is that after loading patrol the cargo deck, identifying individual vehicles by license plates, updating the cargo stowage plan and continue to monitor objects during the voyage.

After discussions and evaluations with Stena Line for a suitable location for the VHD system, the final location was Majnabbe terminal in Gothenburg. The measurements for the physical installation started in April 2020 along with the needed new developments and modifications in the software. The physical installation started at Majnabbe in September 2020.
The AGV software for license plate reading was tested on public data sets then onboard the AGV.

The result of the demonstration is presented in D08.11 “Description of prototypes and demonstration for identification of vehicles and ignition sources”.

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Co-authors:	Martin Torstensson, Maria Ulan, Lukas Wallimann, Leon Sütfeld		
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Involved partners

No.	Short name	Full name of Partner	Name and contact info of persons involved
1	RISE	RISE Research Institutes of Sweden	Robert Rylander, robert.rylander@ri.se
13	SCK	SICK AG	Lukas Wallimann, lukas.wallimann@sick.ch
10	STL	Stena Line AB	Martin Carlsson, martin.carlsson@stenaline.com

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Content

1 Executive summary

How a potential ignition source can be detected is dependent on many things, this demonstration focuses on identifying vehicles by their registration plates and also detecting classified goods by the corresponding UN IMO IMDG number places on placards.

Stena Line terminal at Majnabbe was the test site for the VHD system, enhanced for LASH FIRE. And the AGV software was tested on public data sets and physically on the AGV later on passenger cars.

By connecting the data from the booking system, cargo stowage planning and terminal operation -systems the personnel and crew can be assisted in the task of making qualified decisions to lower the risk at the terminal and later onboard the ship. Knowing more about the location of vehicles and cargo in a case of a fire and increase the likelihood of timely and appropriate responses in the case of a fire. Various types of systems with sensors can deliver live feeds and be part of a security system in ports and on ships.

1.1 Problem definition

As of today, screening of vehicles and cargo is done manually and only for vehicles and cargo that are considered of some kind of risk marked according to rules and codes such as “Accord européen relatif au transport international des marchandises Dangereuses par Route” (ADR) and “International Maritime Dangerous Goods Code” (IMDG). Another example is caravans and mobile homes carrying compressed/liquid cooking gas, which should be labelled, and the gas-system secured e.g., disconnected. The rules and codes inform the personnel at the terminal and the crew from the ship who conduct the screening during the cargo operation. Also for faster and safer firefighting operations, the knowledge of what cargo or type of vehicle is parked at the terminal, on the cargo deck or good stowed in the ship, is crucial.

LASHFIRE investigates whether sensors and systems used in similar domains could be used to assist the personnel at the terminal and ship crew with the task to survey the units/vehicles by providing quantitative measurements that can be used to track if the situation is normal, at a risk level, and if the situation improves or deteriorates over time.
Some of these temperature thresholds are known, e.g. when specific materials can ignite/take fire. Others are currently unknown, eg. the normal temperature range for refrigeration units, or for vehicles running either on internal combustion engine or electrical motor. There is also currently no standard or rule on how hot the surface of a refrigeration unit, or the at surface of a Lithium-ion battery (LIB) during charging.
To be able to track and monitor individual vehicles and goods from gate to ship and possibly to gate, will allow for better understanding of the current level of risk, correct actions depending on type of vehicle and goods and enabling sharing of data between systems and users.

1.2 Method

To address these challenges, two ways of remote sensing have been explored: a stationary system with the goal of identifying the refrigeration unit located on trucks and trailers, and a mobile system for monitoring battery electric vehicles and possibly other types of risks and cargo. Common for these systems is the need to identify the individual unit, either by markings e.g. license plate, ADR/DG placards or fixate its position.
These tests focused on the capability to read license plates or ADR/DG placards numbers.

Vehicle Hotspot Detection system

Based on SICK's Vehicle Hotspot Detection system used to improve road and rail safety in tunnels, the hypothesis is that downward facing long-wave infrared sensors can detect if refrigeration units and map their temperature from the sides and for this project the top side of the unit. This temperature mapping could be collected and processed and, in the future, units with a higher-than normal temperature could be singled out for further investigation and actions taken to mitigate the risk of an overheated unit that might go undetected during the loading processes. Being able to keep track of the individual unit by license plates is fundamental for correct actions in case of a fire and the overall risk management.

Monitoring charging battery electric vehicles

A malfunctioning battery cell is a risk during charging. A heat signature change in the cell is a potential signal of a malfunction. The goal is to investigate if it is possible to run an automatic ground vehicle (AGV) to go underneath vehicles and also other types of vehicles and cargo to provide a heat map or status of the units. This way all units with license plate can be used to update a stowage plan about the position of objects and monitoring would continue throughout the voyage.

1.3 Results and achievements

The main result of this report is the demonstration of the VHD and AGV systems license plate detection systems. Camera and software to identify the units by the license plates. This type of information allows for the tracking of individual units over time, information about the units could be retrieved from booking systems, thus shortening the time needed to find the unit at the terminal or onboard.

1.4 Contribution to LASH FIRE objectives

The work in this report describes the demonstrators in T8.7. In D08.11 more information on the background of the demonstrators can be found along with descriptions of the hardware and software used.

1.5 Exploitation

As this report outlines the demonstration of the contents described in D08.11, please read D08.11 "Description of prototypes and demonstration for identification of vehicles and ignition sources" report for further information on exploitation.

2 List of symbols and abbreviations

ADR	A Accord européen relatif au transport international des marchandises Dangereuses par Route
AGV	Automated Guided Vehicle
ANPR	Automatic Number Plate Recognition
APU	Application-Processing Unit
APV	Alternative Powered Vehicle
BEV	Battery electric vehicles
DG	Dangerous goods
EMSA	European Maritime Safety Administration
HAZID	Hazard Identification
IMDG	International Maritime Dangerous Goods Code
LIB	Lithium-ion battery
LiDAR	Light Detection and Ranging
LOS	Line of sight
LPR	License Plate Reader
LWIR	Long Wave Infrared
RoRo	Roll On -Roll Off cargo ship
SPT	Stowage Planning Tool
TEMS	Traffic Enhanced Monitoring System
VDG	Vehicle Dangerous Goods
VHD	Vehicle Hotspot Detection

3 Introduction

Main author of the chapter: Robert Rylander, RISE

Based on historical data and previous projects; FIRESAFE 1& 2 [3], Lighthouse In-door positioning on RoRo vessels [4], these studies include conclusions taken from the fire cause perspective and highlight the differences in fire sources, from the ship's equipment and the cargo. The statistics regarding the probability related to fires originating in RoRo spaces were performed and subsequently used as input for a Hazard Identification (HAZID) workshop (LASH FIRE, 2020) where the main takeaways were:

- The ship's equipment is rarely the cause of fire, rather the ship's cargo is generally the culprit.
- Electrical faults originating in the ship's cargo are the most common causes of fires in RoRo spaces.
- Although refrigerated units typically constitute a relatively limited proportion of all the carried cargo onboard it is statistically the most fire hazardous type of cargo in terms of probability and severity.
- While electrical failures in internal combustion engine vehicles constitute an apparent hazard, especially if the vehicles are in poor condition, there is little, if any, data that suggests electrical vehicles are more prone to fire than internal combustion engine vehicles.
- Gas leaks in Alternatively Powered Vehicles (APV) that lead to fire are a rare occurrence.

Based on this, automatic remote sensing systems are investigated as a tool to support the personnel and crew at the different phases of the trip: terminal, loading, and during the voyage.

A fixed system based on Vehicle Hotspot Detection and a ground based Automatic Guided Vehicle are the base platforms that were modified for LASH FIRE. The primary goal is systems that can identify heat anomalies as is and quantitative measurements for continuous observation of objects.

This is a step towards a system of systems approach where different systems communicate and collaborate with the personnel and crew to provide quantitative measurements and better situational awareness.

4 VHD vehicle identification prototype

Main author of the chapter: Robert Rylander, RISE

4.1 General description of prototype

To be able to scan as much as possible of a truck and trailer for heat anomalies with a minimum intrusion on the object and the flow of units, a portal with fixed sensors that has line of sight of the sides and top-down view of the object is used. The VHD portal has a front License Plate Reader (LPR) or Automatic Number Plate Recognition (ANPR) and software for identifying ADR/IMDG placards on the cargo. This system is called the Vehicle Dangerous Goods detection system (VDG)

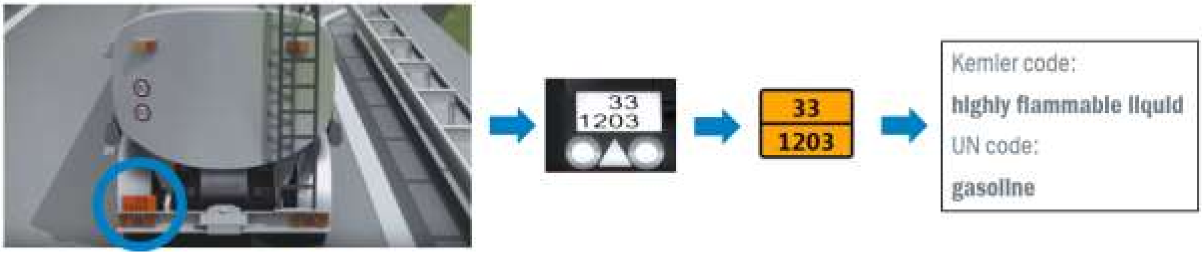

Figure 1Principle of automatic number recognition for ADR/DG goods. (SICK)

Similar systems are in use for road safety at safety critical tunnels at several places in Europe. Three physical modifications have been done in the project to the original VHD system;
- Extra license plate readers were installed so both the truck and trailer could be identified, since many trailers is handed over at the terminal and later loaded by the terminal staff or stevedores.
- A top-down facing long wave infrared sensor (LWIR) was installed to scan the refrigeration units. The hottest item should be the exhaust pipe when the refrigeration unit is running on its combustion engine.
- An extra LiDAR was mounted, so accurate measurements of the object's length could be performed and track the truck and trailer in the compact space available at the Stena Line terminal at Majnabbe, Göteborg.
The necessary hardware modifications were accompanied with software development and incorporated into a prototype version of the user interface and functionality. The system can now identify the trailers' license plate, read ADR/DG placards and segment out the refrigeration units, and set a warning and alarm temperature threshold for all the parts of the object that a VHD system can survey.

4.2 VHD with vehicle identification demonstration

The VHD system had to be modified both hardware configuration and software development, to facilitate the demands from the LASH FIRE as mentioned earlier, to be able to read license plate from the front and rear of the vehicle.

The system needs free line of sight (LOS) of the object: front, rear, sides and roof for the sensors to collect all necessary data; also the distance to the sensors has to be relatively fixed and the object aligned for best performance of the sensors and then later the algorithm for faster computation.

4.2.1 Construction of VHD test site

The planning for the Demonstration started in November 2019 and during the winter and spring 2019-20, the first proposed location was an installation at Stena Line terminal in Karlskrona, Sweden.

In Karlskrona Stena Line had a test site for new gates and booking technologies for future automated check in procedures.

4.2.1.1 First Karlskrona then Majnabbe

Preparation was made for an installation illustrated as below underneath a roof and the horizontal and vertical steel beams were the main point for mounting the sensor array.

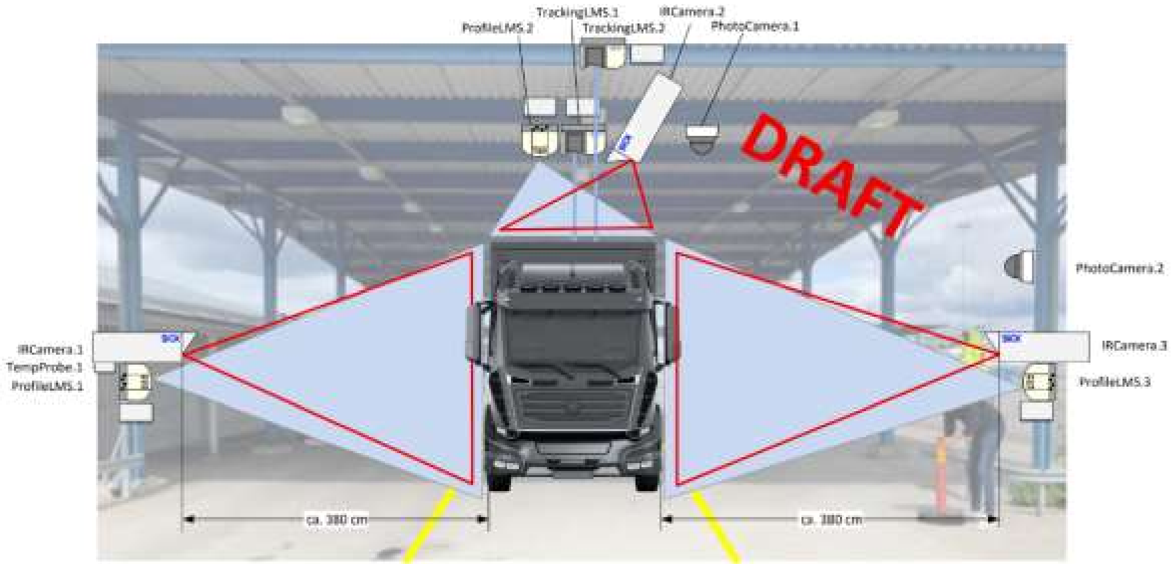

Figure 2 Planned installation at Karlskrona looking from the front. (SICK)

And from above it would look like this

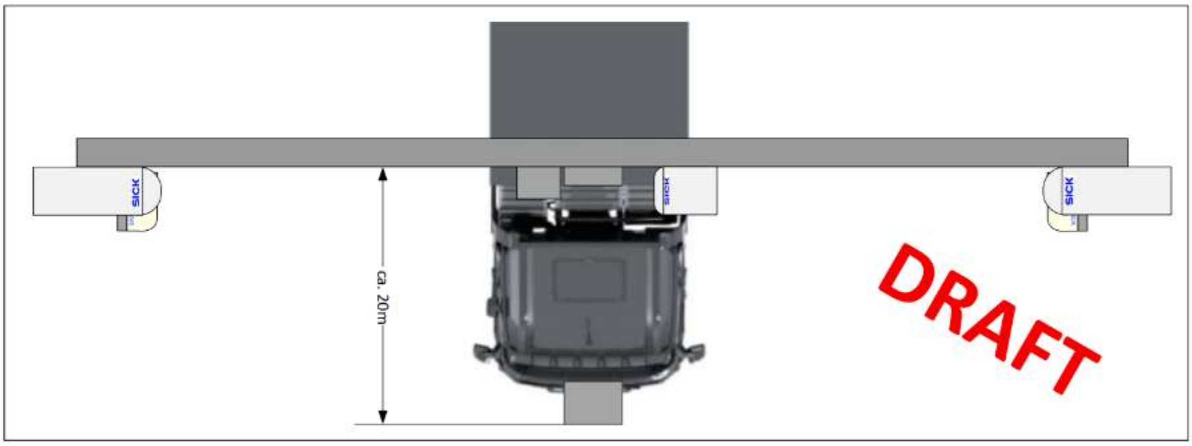

Figure 3 Vertical view of sensor array at Karlskrona. (SICK)

Change of the demonstration site to Majnabbe, Gothenburg

During meetings held in June 2020, reviewing the installation plan and alternatives, the decision was made to make new plans for an installation at the Stena Line terminal at Majnabbe in Gothenburg. The location at Majnabbe offered a better flow of active refrigeration units but a more compact physical installation.

4.2.1.2 Majnabbe

In September the final measurement for Majnabbe was conducted and the planning for the needed fastenings for the sensor-installations was conducted as illustrated below.

Entrance for heavy vehicles to the Majnabbe terminal. In the picture the raisable barrier is visual behind Jan Engquist from SICK.

Figure 4 Gate and building at Majnabbe. (RISE)

Prior to the actual gate there is an office building, the lower floor windows are visible to the left in the picture and the first floor of the office building is barely visible at the top of the picture above. The front edge of the first floor is shown in the picture below.

Figure 5 Front edge of office building in front of the gate. (RISE)

The low vertical clearance of 490cm obscured the line of sight for the traditional placement of the length and position measuring LiDAR. It was decided to develop a new array and sensor layout with two LiDARs for length and positioning to be able to track the front and rear of the vehicle as illustrated below with two downward facing LiDARs.

4.2.2 License plate sensor placement

Inside the gate house the sensors looking at the sides of the vehicle are placed as far from the vehicle as possible; they were fitted on the vertical beam of the house. Illustrated by the two pictures below are the right-side wall and the vertical beams that were decided to use as mounting points for the sensors.

Inside the gatehouse, Stena Line has a system for documenting all vehicles that pass the gate. We had to adapt to the situation, so our system did not interfere with its functions, and so our system got free line of sight too. But our project also benefitted from the present system's light arrangement.

Figure 6 Looking out towards the entrance of the gate looking south. (RISE)

The vibrations from heavy vehicles had to be considered and choosing the location for the sensors was done with extra caution, maximizing the field of view for the sensors they could have been mounted on the wall but that was too weak and prone to vibrate as the vehicles passed by.

4.2.2.1 Installation of license plate cameras

The system uses camera sensors from Micropak, called Micropak 3, both for license plate reading and ADR/DG placard numbers

Rear license plate cameras mounted in the south side ceiling.

Figure 7 Two rear license plate cameras mounted in the south side ceiling. (STL)

The rear license plate cameras were mounted in the south side of the building in the ceiling facing north.

Front license plate readers

Figure 8 Front LPR and ANPR readers on each side of the LiDAR. (STL)

The front LPRs are placed at the north side at the exit of the building, facing south.

Figure 9 Side view of front LPR/ANPR and positioning LiDAR. (STL)

Above is the cut out in the house visible for the second tracking LiDAR (light grey) and to the right the two LPRs (dark grey).

4.2.2.2 Control cabinet

From the sensors, via junction boxes that provide connectivity and power for the sensors, the signals/data is processed in an Application Processing Unit (APU) that runs the TEMS software. The

APU has an uplink with Internet connectivity. It also contains power and visual indication on operation status shown below.

Figure 10 Exterior of TEMS cabinet. (STL)

Figure 11 Interior of a TEMS cabinet. (SICK)

Interior of a cabinet

At the bottom of the cabinet, power and signal cables are routed. The cabinet was placed inside the gate house.

Figure 12 Visual indicator of VHD operational status. (STL)

The Traffic Enhanced Monitoring System (TEMS) software needed to be modified in the code to allow two more cameras. Also, the client's software, TEMS Analyzer and VHD Client, needed to be configured. The system was commissioned with two new cameras and updated software in April 2022, later two new ANPR sensors and added software functionally were added to the TEMS.

4.2.3 Test design

Using the regular flow of units passing the VHD portal, data for development and evaluation of the software was carried out and a functional solution implementation used in the demo. After each step of development, the functionality was confirmed by manual sampling of the recorded vehicles.

4.2.4 Scenario description

As a unit passes the VHD portal, license plate information and ADR/IMDG placards are read from the units and presented via the TEMS software to the operator at the terminal. This allows the operator to verify, if needed, booking information versus the vehicle as it passed the VHD system.
In general, trailers are either accompanied by a truck and driver or handed over to the operator and loaded on to the ship by Stena Line personnel a.k.a. un-accompanied trailer. This is why the license plate from both the truck and the trailer is of importance, if the truck and driver leave the trailer at the terminal.
Vehicles carrying ADR/DG goods should have the mandatory placards visible on all four sides of the vehicle.

4.2.5 Final demonstration results

The sensor array and software could identify the units with license plates, on both the trucks and trailers and ADR/IMDG placard are captured too. This allows for the possibility of tracking and classifying vehicles by their shape and to being a cornerstone in a future vehicle/goods tracking system from gate at the terminal to leaving the gate at the destination. The results are presented in D08.11 "Description of prototypes and demonstration for identification of vehicles and ignition sources".

4.3 Using the VHD Client in the demonstration

April 2021 the VHD portal was turned on with only initial calibration done and no LASH FIRE project software development done. The view of a vehicle in VHD client looked like below.

Figure 13 TEMS information in VHD client prior at start up.

Left row (light blue), is recorded vehicles. When a unit is selected, the center pane is populated with recorded data. In the grey column of the center pane, 2D & 3D thermographic images. To the far right a column shows all images captured by LPR/ANPR and CCTV.

4.3.1 Captured license plate during test and demonstration.

In April 2022 the front LPR came online, and information could be presented in the VHD Client and TEMS Analyzer

Figure 14 First vehicle with LPR displayed in VHD Client.

In the picture 14 above, the left column now also shows recorded vehicles LPR/ANPR in light blue icons, when a unit is selected the center pane is populated with recorded data. In the grey column of the center pane, more information from the sensor is presented.

4.3.1.1 Front and rear license plate readers

In January 2023 the functionality to read license plate from both truck and trailer was available in the VHD client and TEMS analyser. This will allow easier communication and tracking of units, unaccompanied trailers and accompanied vehicles.

Front license plate readers

Figure 15 Truck and trailer license plates.

In the picture above, the read LPR readouts can be seen in the left pane on the icon, then as the unit is chosen, more details are shown in the second column and also 2D/3D view. Then the actual captured images by the LPR can be seen at the far-right column and are accessible one by one.

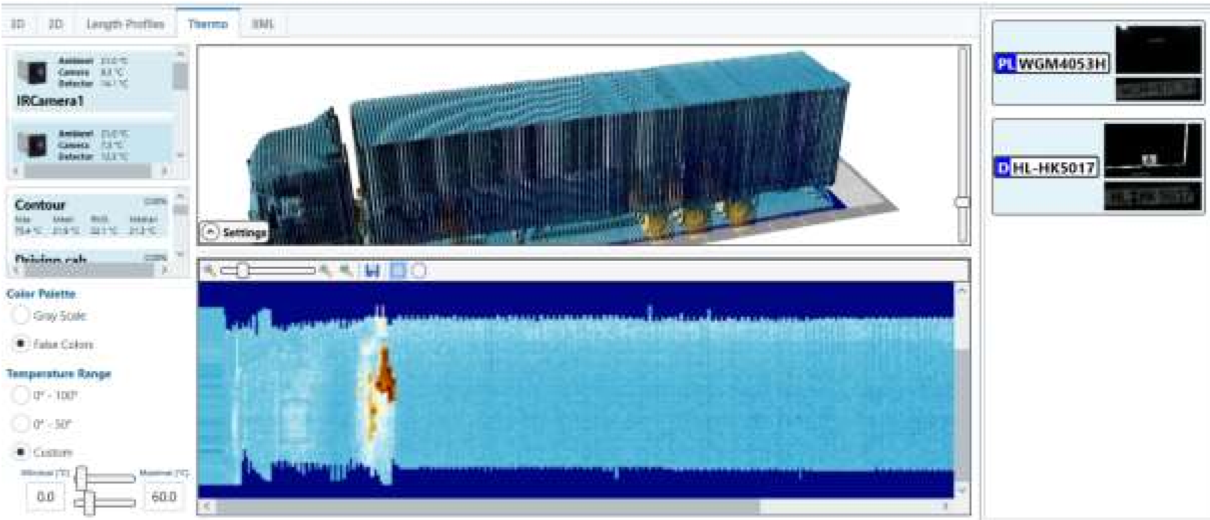

Figure 16 Truck and trailers license plates are read and presented to the operator via TEMS Analyzer interface.

In the picture above, the LPR and ANPR read outs for truck and trailer displayed in the VHD Client.

4.3.2 ADR/DG placard readers

When the forward ANPR came online in April the numeric part of ADR/DG placards could be presented in the VHD Client and TEMS Analyzer. Later, January 2023 when the rear ANPR also came online, performance increased.

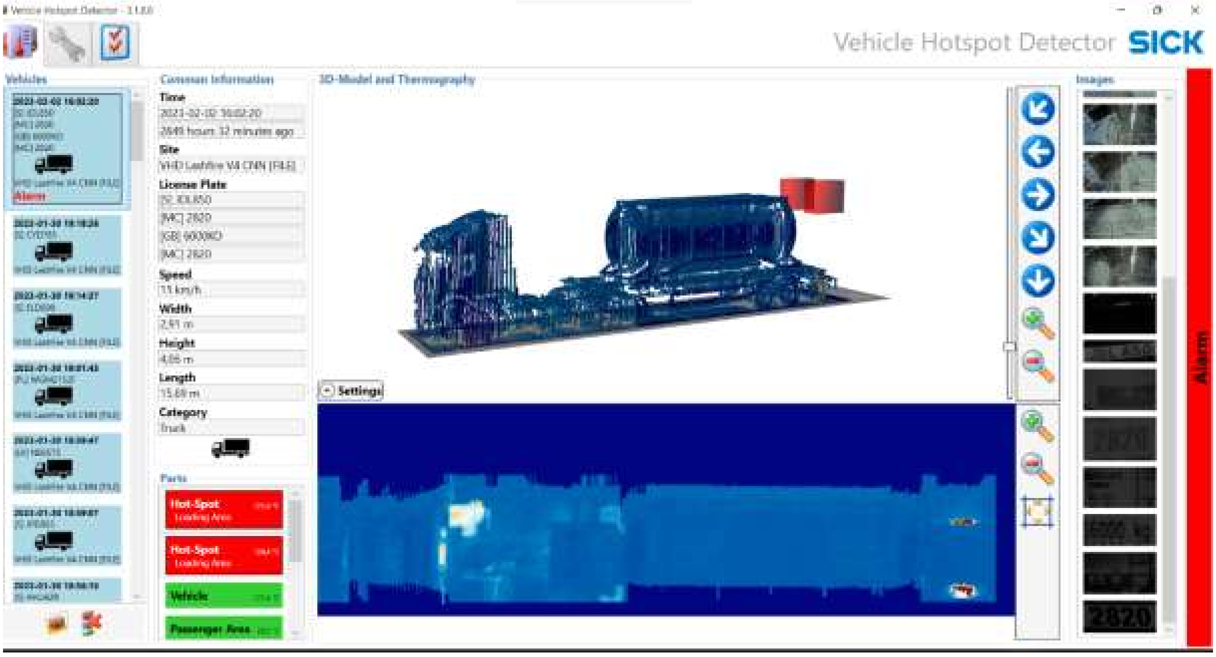

Figure 17 Overheated brakes on trailer with ADR/DG goods.

Above is a cargo of ADR/DG 2820 Butyric acid, the alarm indicated in the VHD Client is the two overheated rear brakes of the trailer.

Below is the rear of the trailer showing a lot of signs and placards.

Figure 18 Rear of the trailer showing signs and placards.

Algorithms scan the picture for known groups and combinations, this is a challenge when other signs and placards are visible to the system.

Figure 19 ADR/DG 2280 placard singled out.

Visual confirmation

The CCTV placed on the sides can be used as visual confirmation as illustrated below.

Figure 20 ADR/DG placard visible via CCTV.

At the moment the ADR/DG information is handled manually e.g. if the personnel at the terminal is aware that this unit is an ADR/DG they can inspect the unit for the compulsory signs. An automatic system could verify that booked ADR/DG vehicles have or don't have the compulsory placards visible, it could also update the SPT developed in LASH FIRE. Currently there is no such connections and for full functionality all sides of the object should be covered by ANPRs.

5 AGV vehicle identification prototype

Main author of the chapter: Martin Torstensson, RISE

5.1 General description of prototype

License plate detection - Description of implementation.
The license plate detection was implemented as a continuously running detection algorithm that detects whether or not a license plate is present in the frame, and in true cases it returns the detected symbols. The AGV can detect and recognize the license plates in real-time. The implementation uses an RGB camera that is plugged to a NVIDIA Jets via an USB port. The method called OpenALPR [1] was tested.

5.2 Test design

To test the functionalities of the license plate detection algorithms, a dataset of European license plates was used. This is to test the performance of the algorithms in a more general setting. To measure the performance two metrics are used. The first is the accuracy of how often a complete license plate has been correctly classified, that is the number of correctly read license plates divided by the total number of license plates. The second measure is the accuracy of detecting any license plate regardless of the classification being correct or not. Therefore, both the classification (detection and reading) and the detection of the license plates are evaluated.

5.3 Scenario description

There is a surprising lack of available license plate datasets with images of vehicles and not just the plates. While images of only plates could be useful for the classification part of the task it is also vital to be able to detect the plates in the first place. Therefore, a dataset provided by [2] was utilized as it contains a variety of images of cars with license plates in different situations. There are in total 108 images with the corresponding annotations of plate numbers. Larger datasets of Chinese license plates are available, but for the purposes of this study the selection was limited to European plates.

5.4 Final demonstration results

Out of the 108 images the algorithm managed to make correct classifications and detections in 78 of the cases resulting in an accuracy of roughly 72%. In 28 of the cases a license plate is detected but read incorrectly, giving an accuracy of detection alone at roughly 98%. Finally, in the remaining two cases the license plate is not detected at all.

5.4.1 Successful samples

In Figures 2 and 3 two cases of correctly detected and classified plates, which reads as RK715AA and RK776AI respectively by the algorithm.

Figure 21. Correctly classified vehicle by OpenALPR. *Image modified from [2].*

Figure 22 . Correctly classified vehicle by OpenALPR. Image modified from [2].

5.4.2 Detected but incorrect samples

In Figures 23 and 24 two cases of correctly detected, but incorrectly classified plates. The plate in Figure 23 is GWAGEN, the algorithm however missed out on the W and read only GAGEN. In the case of Figure 24 the plate reads BA302OZ and the algorithm found BA3020Z. The difference is small and the “O” that is next to last was replaced with a zero. This is an error easy to make for a human as well, unless you also take into account the specific structure of the letters and numbers based on the country.

Figure 23. Correctly detected, but incorrectly classified vehicle by OpenALPR. Image modified from [2].

Figure 24. Correctly detected, but incorrectly classified vehicle by OpenALPR. Image modified from [2].

5.4.3 Failed samples

In two of the cases shown in Figure 25 and Figure 26 the OpenALPR algorithm completely failed to detect a license plate.

Figure 25. Failure to detect vehicle by OpenALPR. Image modified from [2].

Figure 26 Failure to detect vehicle by OpenALPR. Image modified from [2].

5.5 License plate detection in relevant environment

The environment most similar to a ferry's cargo deck that was accessible and practical for testing was the parking garage at Lindholmen, Gothenburg. It had dirty cars and floor and similar lighting conditions as a cargo deck. A small section of the garage was used as the test site, with two passenger EVs parked in a row. This test was conducted with the drone statically placed behind the vehicles and inside the calibration rig. The readout and logging procedure for license plates were activated. The log file outputs show repeated readouts such as the following:

```
detection: RKW36G
```

In this example, the license plate was read out correctly, and the license plate readout system was thus determined functional. However, some inconsistency in the readout was detected; In a significant fraction of repeated reads, it was recognized as “RKW6G”, thus missing the “3”, despite the favourable viewing angle and occlusion-free line of sight. While relatively simple post-processing (e.g., closest match in database, majority vote over time, etc.) could be applied to achieve a more stable readout of license plates, we rate this test as only partially successful. In particular, readouts in less favourable conditions are likely to be less accurate than what was observed in this test.

Figure 27. Test setup for test of license plate readout in relevant environment.

6 Conclusion

Main author of the chapter: Robert Rylander, RISE

Two demonstrators have been developed: one for an AGV patrolling underneath vehicles to continuously scan license plates and a VHD system scanning vehicles passing through. Both systems have license plate recognition systems that have been evaluated and found promising.

The choice to investigate long wave infrared (LWIR) sensors in combination with cameras allows not only non-intrusive, effective, and precise measurements it also allows the system to operate at some distance. This allows the systems to survey different types of cargo and vehicles or that the objects are not perfectly aligned, stowed, or parked. It has good performance in different lighting and can also perform well in headlights.

High precision measurements of the objects using LiDAR allows for successful identification and segmentation of the refrigeration unit on truck and trailers. This allows for quantitative measurement on a high-risk ignition source without interfering with the flow of units and the possibility to monitor units over time, either as the unit passes another gate at the terminal, at the ramp or by a system onboard the ship.

The AGV license plate identification system showed the ability to detect roughly 98% of license plates it was tested on and correctly read them in roughly 72% of the cases. The OpenALPR method shows a great ability to detect the plates and a good ability to read them, with minor errors. This shows a proof of concept, but for a smooth operation onboard an increased accuracy would be required. One of the major hindrances from improving these numbers for now are to find datasets with large quantity of license plates that are publically available.

7 References

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8 Indexes

8.1 Index of figures