Report ITS pilot
January –April 2021

for

Troms og Finnmark fylkeskommune
Romssa ja Finnmárkku fylkkagielda
Tromssan ja Finmarkun fylkinkomuuni

Nordland FYLKESKOMMUNE

Länsstyrelsen Norrbotten

Länsstyrelsen Västerbotten

Statens vegvesen

TRAFIKVERKET

Kolarctic CBC | CROSS-BORDER COOPERATION

by

CAPIA

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Project description

Challenge

Proper planning of rest periods in response to the availability of parking spaces at rest areas is an important issue for haulage companies as well as traffic and road administrations. To improve road safety, drivers of heavy goods vehicles must comply with strict rules regarding driving time and rest periods. Due to these regulations and contractual delivery agreements, heavy goods vehicle traffic is highly schedule driven. Arriving at a crowded rest area after long journeys leads to drivers exceeding the permitted driving time or having to rest outside of designated areas. Both can lead to increased traffic risk. To avoid these scenarios and to enable better planning, the occupation rate of rest areas needs to be known to drivers in advance. Reducing the number of journeys by eliminating additional trips to find empty parking spaces at other rest areas reduces CO2 emissions and contributes directly to greener transport.

Project goals

The Norwegian county municipalities Troms og Finnmark and Nordland, the Norwegian Public Roads Administration, Kolarctic CBC, the county administrative boards of Norrbotten and Västerbotten in Sweden and the Swedish Transport Administration as part of a Kolartic project *Barents Regional Logistic Transport (BRTL)* have initiated a pilot project with the aim of automatically reporting and forecasting the current and future availability of parking spaces at rest areas in the Barents region. The pilot project ran on two rest areas: Buktamoen in Troms og Finnmark (Norway) 120 km from Tromsø and Töre in Norrbotten (Sweden) 60 km from Luleå. Within the pilot project the equipment, data quality and feasibility of the scientific methods should be evaluated.

Figure 1. Location of the two rest areas in the pilot project.

Project plan

The project running from January until April 2021 was split in several steps.

1. Installation of one camera at each of the two rest areas to record images of the parking spots and set up of video streams.
2. Data collection, training of an image recognition algorithm to identify heavy goods vehicles on the video feed and forecast of available parking spots.
3. Creation of website to display parking spot occupancy at rest areas and further information about the rest area.
4. Evaluation of the service provided on the website.

Project Implementation

Cameras and camera setup

The cameras used were AXIS Q1942-E Thermal Network Cameras with an uncooled microbolometre image sensor with a thermal sensitivity (noise equivalent temperature difference) of <50 mK and a thermal sensor resolution of 640 × 480.

The cameras were installed on existing poles at the two rest areas which allowed the camera to cover the biggest area of the parking spot. On neither of the rest areas was it possible to find a position in which the whole parking area could be overseen by the camera. One of the cameras was installed in front of a pole, which appears as a grey area in the center of the image.

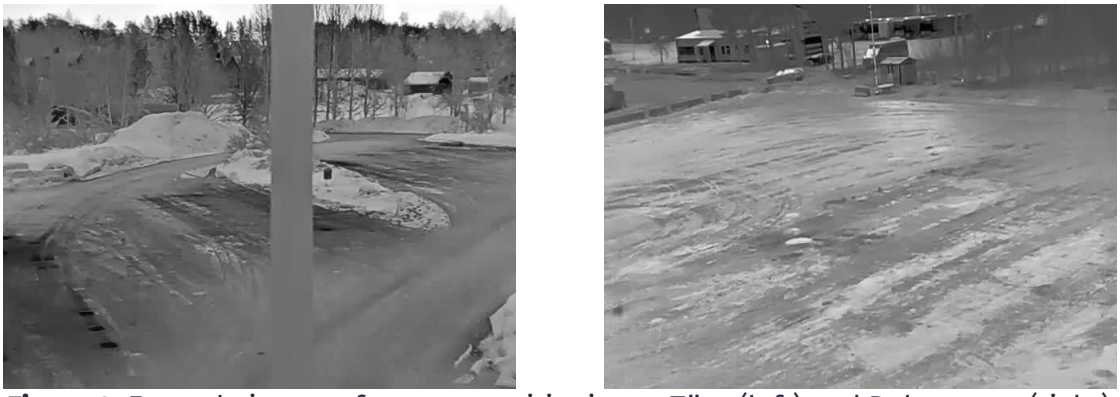


Figure 2. Example image of camera positioning at Töre (left) and Buktamoen (right).

Thermal network cameras fit well to the winter conditions and the polar night in Northern Scandinavia. The camera delivered usable images for all light and weather conditions that occurred during the project period. The image quality was hardly influenced by the light conditions. Weather does influence the image. While light precipitation is not detectable on the camera images, stronger precipitation leads to partly foggy images.

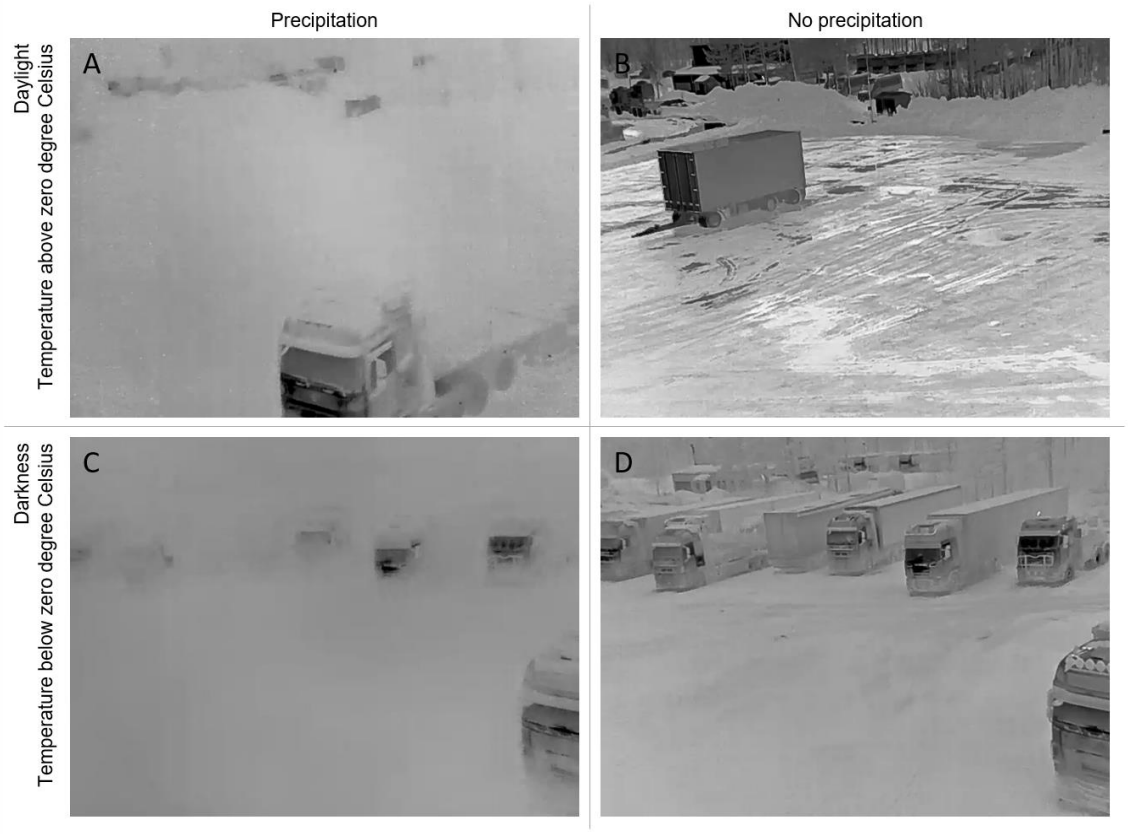


Figure 3. Example images from the thermal network camera taken at daylight (**A,B**), in the dark (**C,D**), when it was raining 1.1 mm (**A**), when it was snowing 1.5 mm (**C**) and without any precipitation (**B,D**).

Furthermore, it is not possible to read number plates, identify detailed human characteristics or see through windscreens in the images hence the data are automatically anonymized. Only in rare cases were labels readable on the heavy goods vehicles.

Figure 4. Example images with view on people, license plates and labels.

NEXT STEPS

Cameras and camera setup

We suggest:

1) using a wider-angle camera to capture more and more complete heavy goods vehicles,
2) avoid obstacles in the camera's field of view and
3) increase the resolution of the images.
4) To cover all parking spots at the rest area, we see two options:
    a. Set up cameras at all entrances and exits of the areas area so that arriving and leaving heavy goods vehicles can be counted
    b. Set up several cameras that combined cover all parking spots.

Data collection

The cameras are connected to the internet through the cell phone network. The video feeds have been downloaded with *ffmpeg*, an open-source solution for video transcoding. It is used to detect slight movement in the stream, and save snapshots as images, for further processing and analysis.

During the project, we experienced network interruptions and instability. The cause of those can be many points along the chain of switches and routers, in central internet infrastructure, that do not handle long standing connections very well. It is out of our reach to impact and improve central internet infrastructure, however it is in our hand to control the receiving end. For a stable connection we can make the receiving end robust and resilient to interruptions.

During the pilot project we dealt network interruptions by closely monitoring it and by *restarting ffmpeg* when needed.

NEXT STEPS

Data collection

Going forward a stable solution to cover network issues in the future, could be:

5) to pipe the video stream through a separate process, which also controls the ffmpeg process.
    a. This helper process can monitor data flow more precisely, and relaunch transcoding with ffmpeg, once the stream is online again.
    b. In addition, we are able to notify services, technicians and end users of the interruption in closer to real time, in case connection can't be reestablished.

Image recognition

To detect heavy goods vehicles on the images from the thermal camera the fifth version of the You Only Look Once algorithm (YOLOv5) was adapted to fit the use case in this project. The main challenge in this image recognition task was the high number of overlaps and cut-offs of vehicles on the images. The out-of-the-box image recognition of heavy goods vehicles and cars showed an accuracy of 42% and 78% resp. with rather low confidence. Therefore, we adapted the algorithm by training it with images from the rest aeras to detect cars as well as the front cabin and the rear of heavy goods vehicles instead of complete heavy goods vehicles. This increased both accuracy and confidence.

A detailed description of the image recognition can be found in the Short Communication "Detecting Heavy Goods Vehicles in Rest Areas in Winter Conditions Using YOLOv5" which Capia published in the scientific journal *Algorithms*.

The training data with images from the thermal cameras showed two types of unbalance. First, due to a later installation of the camera at Töre there were more images from Buktamoen than from Töre and second, cars are highly underrepresented in the dataset, reflecting the fact that the rest areas are mainly used by heavy goods vehicles. Since the algorithm has difficulties to distinguish correctly between cars and cabins it would improve the algorithm to collect more images of cars such that the algorithm can learn to distinguish them better. We also expect further improvement by adding more images to balance the images from the two rest areas.

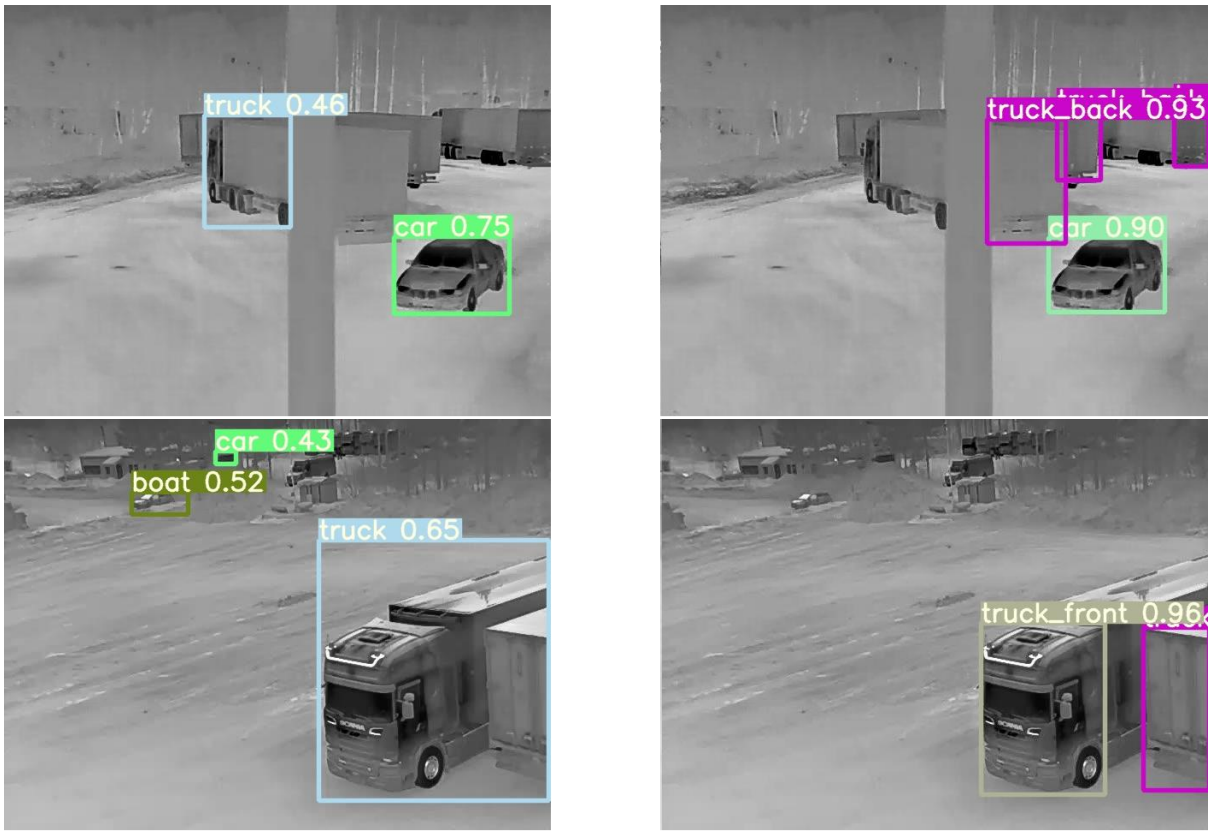


Figure 5. Left column: detection of complete trucks with out-of-the-box image recognition algorithm. Right column: detection of cabin and the rear of trucks with adapted image recognition algorithm. In both columns bounding boxes show which objects were detected by the algorithms and the confidence of the detection.

NEXT STEPS

Analysis – Image recognition

Currently, heavy goods vehicles with both the cabin and the rear outside the image, or which are obscured by other vehicles, are rarely detected by our algorithm. To get closer to the goal of detecting all heavy goods vehicles in the picture, we propose:

6) to further specialize our current model: Instead of training it to detect cabins in frontal and side view, it could be trained to detect only in frontal view (windscreen, front lights and number plate facing the camera).

7) to add an additional model to the analysis for recognition. The additional model could either
   a. detect other characteristic features of heavy goods vehicles that are easily visible from the side, such as wheels, or
   b. it could classify the images into categories indicating the number of heavy goods vehicles.

Knowing how many of the individual features of a heavy goods vehicle are detected in an image enables us to combine this information to estimate the number of heavy goods vehicles in an image and enables us to predict occupancy rates.

Forecast of occupancy

Since January 1st, 2021, the number of heavy goods vehicles detected on the camera images is saved into a database. Based on these numbers an hourly average is calculated for each weekday. This average reflects only the occupancy in the area of the rest area that is within the view of the camera. To be able to make conclusions about the total occupancy on the rest area the whole rest area must be covered by one or several cameras, the entrance and exit must be covered by the camera or for a certain period or for a longer period camera images must be collected with manually counted numbers of vehicles at the rest area.

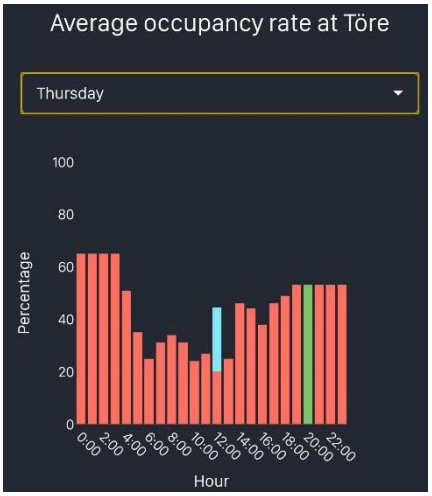


Figure 6. The red bars display the average occupancy rate at a rest stop for the selected day of the week. The green bar displays the usual occupancy rate at the estimated time of arrival. The blue bar displays the current occupancy rate.

NEXT STEPS

Analysis – Forecast of occupancy

Once, data for several months and years has been collected forecasts that take seasonal effects and holidays into account can be made.

8) With a larger data basis, it will also be possible to include more data to forecast occupancy at the rest areas like
    a. weather data,
    b. data on traffic conditions and
    c. other events as explanatory variables.

Website

On March 3rd, 2021, the website *24 Hour Truck Stop Beta* was launched. The website calculates the route from the current location (if location sharing is activated) to the selected rest area. This route is displayed in a map and the distance in kilometer is shown as well as the driving time and the estimated arrival time, which includes mandatory breaks (of 45min every 4 ½ hour). If the location data is shared and the expected arrival time is known, the average occupancy for each hour on the arrival day is shown in a diagram, the bar of the average occupancy at the expected hour of arrival is colored in green. If location data is not shared the average occupancy at the current day is displayed. The blue bar always displays the occupancy rate at the current hour. If the blue

bar is on top of the red bar, there is higher occupancy than usually, else occupancy is lower. Furthermore, the website gives information about facilities and services available, the current weather at the selected rest area and shows a live picture of the rest area. Automatically, the weather is updated four times a day and the image is updated every 60 seconds if the picture has changed. The website also contained a link to an online survey asking for feedback about the website.

The information about the website was spread through several channels:

- Posters at the rest area in Buktamoen and Töre.
- Information by email to
  - *Norwegian Truck Drivers' Association* (In Norwegian: *Norges Lastebileier-Forbund*) and *Truckers International Association (TIA) Norge* who share the link to the website with their members, e.g. in their newsletter.
  - *Handelskammaren Norrbotten och Västerbotten*, *Region Västerbotten*, *Region Norrbotten* and to the Swedish "*Bärighetsrådet*" who's members are organisations with string interest in transport and infrastructure.
- *The Swedish Association of Road Transport Companies* (In Swedish: *Sveriges Åkeriföretag*) informant about the project at their website: https://www.akeri.se/sv/tyck-till-om-ny-tillganglighetstjanst-rastplatser
- An interviewer advertised the website to truck drivers at the rest area in Töre in a period of four hours. He met 14 drivers from 9 different countries, who shared the link with their colleagues, one with 60 colleagues at once.

NEXT STEPS

Website

For the pilot project the website was well suited, going forward we suggest:

9) an app for mobile devices or a combination of a browser based and app solution could be beneficial.

10) We also recommend making the website / app available in several languages, since there are many international drivers crossing the Barents region.

11) Furthermore, the content and layout should be reviewed in regards to the collected feedback collected from the end user which is described in the following chapter.

12) An official marketing strategy needs to be implemented for the launch of a long-term service across geographical areas.

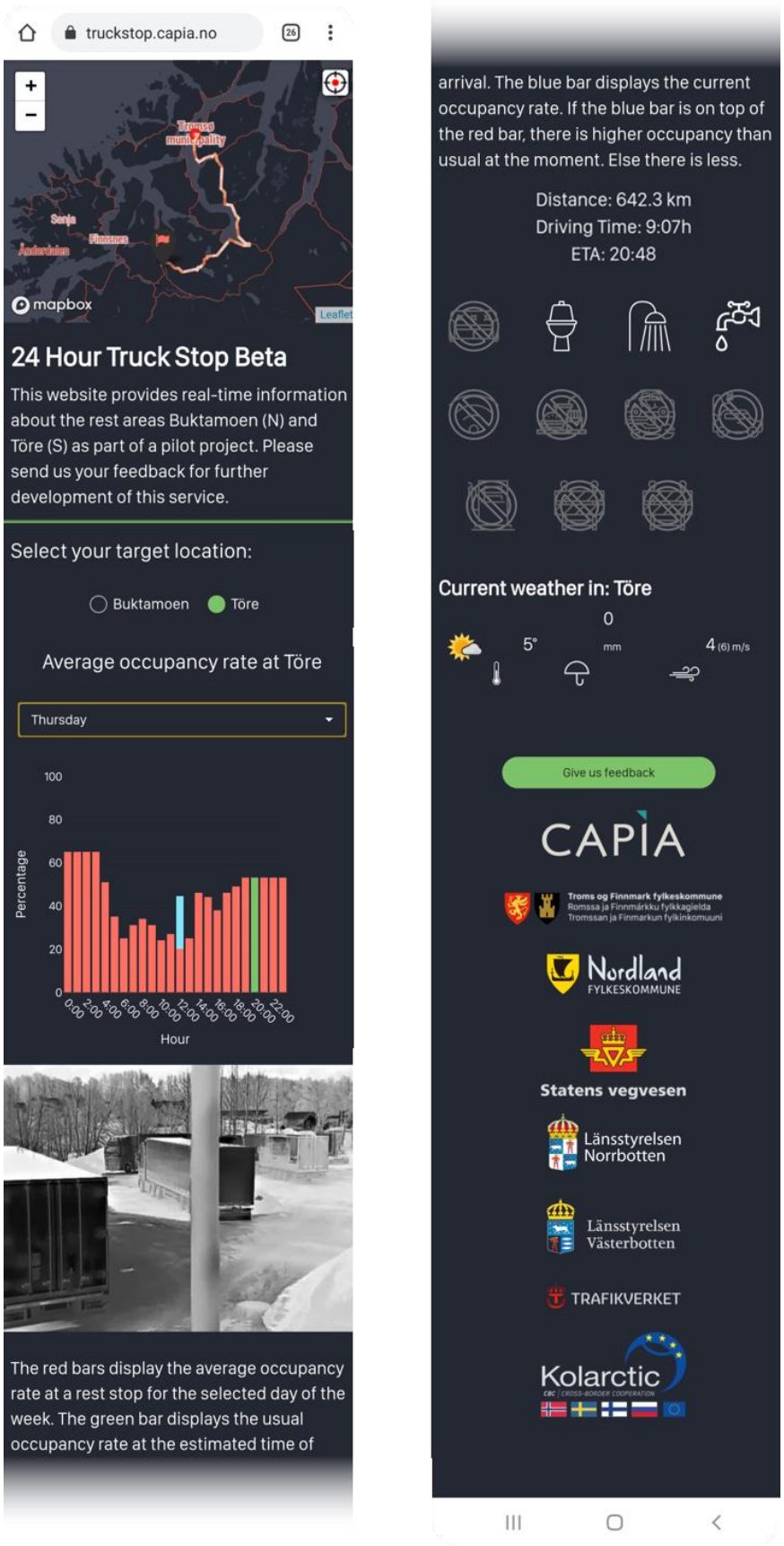


Figure 7. Screenshot of mobile version of website for destination Töre.

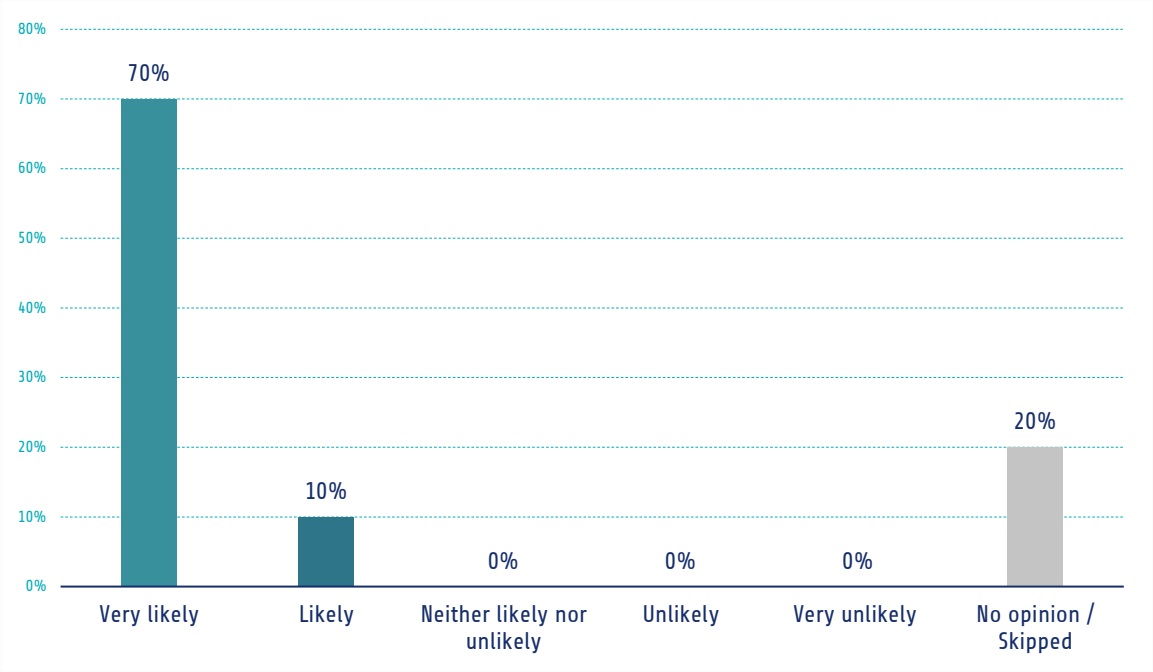
Evaluation

The evaluation of the website and the service was done by collecting feedback from end users. Therefore, feedback was collected via an online survey directly from the website. Furthermore, truck drivers were interviewed at the rest area in Töre, by e-mail and by phone. The consistent message in the feedback was that the website was considered very useful and that this service should be rolled out on all rest areas.

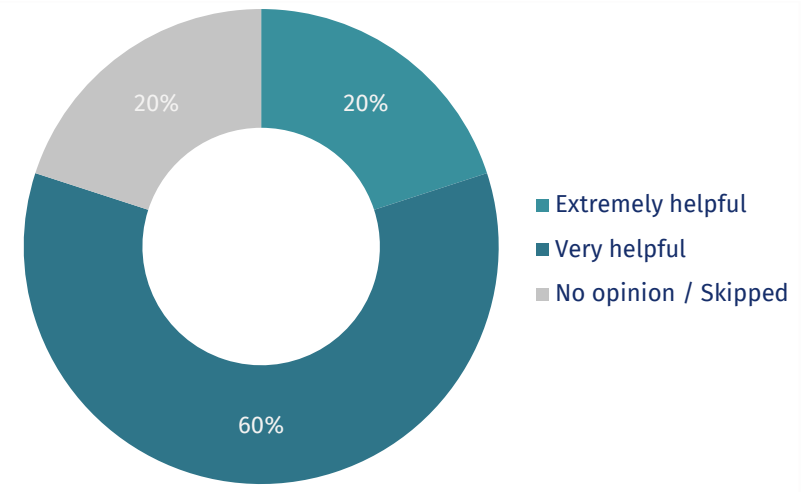
Online survey

The online survey consisted of five questions (see Appendix C for online questionnaire). Within the period of the pilot project 10 people responded to the questions.

1. How likely are you to visit this website again when you pass one of the two rest areas?



2. How helpful would it be to you to extent this service to several 24 rest areas?



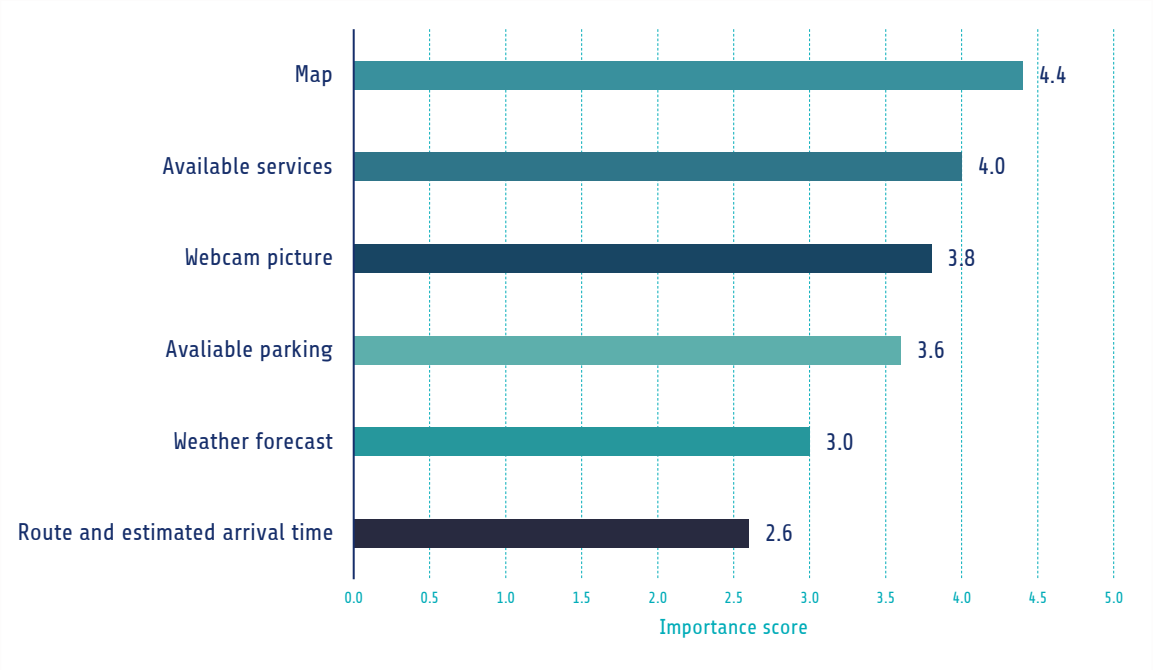
3. How likely is it that you would recommend this website to a friend or colleague?

Net Promoter® Score "How likely is it that you would recommend ... to a friend or colleague?" is a standardized question. The respondents are categorized in one of the following three groups based on their reply to the Net Promoter® Score.

	Distribution of Responses
Promoters Loyal enthusiasts who will keep using the service and urge their friends and colleagues to do the same	55.6%
Passives Satisfied but indifferent and unenthusiastic website visitors	33.3%
Detractors Unhappy website visitors who can hurt your brand and service through negative word-of-mouth	11.1%

4. Please rank the following elements of the website in order of importance – 1 being the most important to you.

Five respondents ranked the six website elements by their importance. Based on the ranking of those five respondence, an importance score was calculated:



5. What could we do to improve this website?

Three people replied to this open text question. They entered:

- Implementere på alle stoppesteder *(In English: implement at all rest areas)*
- It's perfect
- More places

Interviews

In total, 21 truck drivers provided feedback about the website and the offered service. Amongst those were 14 truck drivers, which were interviewed at the rest area in Töre, 5 which were interviewed by telephone and 2 who sent their feedback by email.

General feedback

- This service is needed for all rest areas. From several drivers the expression used for the service was “Djævelsk bra” (in English: devilish good). Most of the drivers we talked to did seldom use the 2 areas in the pilot, but the info given was considered important and very useful for route planning. Changes to the driving plan, due to full rest areas, do not only cause delays due to longer driving times but also require additional documentation. This additional effort and time for this paperwork adds to delays.
- With the camera in place, the rest area became safer. Theft on rest areas amongst drivers would be a common problem. However, in areas with camera surveillance, theft would not occur that often.
- The drivers used the images of the rest area as main indication of occupancy of the rest area and for deciding if changes to the driving plan would be necessary.
- The drivers had not used the graph showing the occupancy at the rest area because they did not know how to read it. After an explanation, the graph was evaluated positively and as important information. In combination with the image, they wanted to use the graph for future route planning.
- The information of what kind of services were found at or near the rest area, displayed as icons was considered very useful. The most important services to know about would be information about if there was electricity, WC, shower, foodservice and/or a store.
- General information about the primary use of the rest area (sleeping, parking of trailers, moving cargo etc.) was missed by the drivers.
- When asked if pre-ordering parking spots on rest areas would be a service which they would like to have, the drivers denied since it would not be possible to implement it at areas with open access and they appreciate the flexibility of closed areas, where the numbers of trucks often exceed the official number of parking spaces, e.g. at Buktamoen the official number of parking spaces is 12 however we recorded up to 20 parked trucks during the pilot project.

Website specific feedback

- The webpage felt a little slow on the cellphone.
- The image should cover the whole parking area.
- The image from the rest area on the webpage was too small.
- The map was too big, since all drivers had GPS and the route information was less important.

NEXT STEPS

Implementation of feedback

13) Rewrite explanation of graph which shows the average occupancy. To ensure best understanding and usage of website translate it into several languages. Find most common languages by interviewing truck drivers, logistic companies or big companies that use many different haulage companies.

14) The map was evaluated both as important and unimportant, this could be due to different usage of the map. It could be rated as important for selecting a rest area by location instead of by name but as unimportant for seeing and following the route to the rest area, since the drivers already use different routing systems.

15) Find data about how rest areas are classified in primary use and add this information to the website.

16) Review and implement features to improve website speed.

Outlook

Extension to other truck stops

The successful test of equipment, approach and methodology confirms that the project can be rolled out on a larger scale. Furthermore, the positive feedback shows the need for such a service.

The extension of a pilot project from two rest areas to all rest areas can be implemented as a several step project which can also run in parallel. A starting point would be a prioritization of rest areas. Rest areas could be added one after the other or in batches. A schematic workflow per rest area could include the following six tasks:

Learnings from the project documented in the Next Steps block in the section *Cameras and camera setup* could be implemented while setting up new cameras and could be adjusted at the two rest areas of the pilot project depending on the prioritization of those two rest areas.

Other learning points from the pilot project and the collected feedback could be implemented into the data collection process, the algorithm, and the app/website in parallel to the setup of new cameras at additional rest areas.

Based on the service created in the pilot project, changes and improvements could be implemented organically, replacing the existing version adding one by feature by the other, and adding new rest areas one at a time. Throughout the whole project, we recommend including drivers, haulage companies and organizations. This way feedback could be collected continuously from the end user ensuring that the service stays relevant and fulfills the needs of the truck drivers.

Green transport

The service could also be used to share information about green transport and to raise awareness for green transport. Examples for relevant information are information about access to (green) electricity for trucks / cabins for heating and cooling, information about recycling at the rest area, information about nearby fuel stations and which fuel types are available as well as information about close by (food) supply stores. Knowing where to find fuel stations and supply stores, also enables better planned driving and reduces emission as a result.

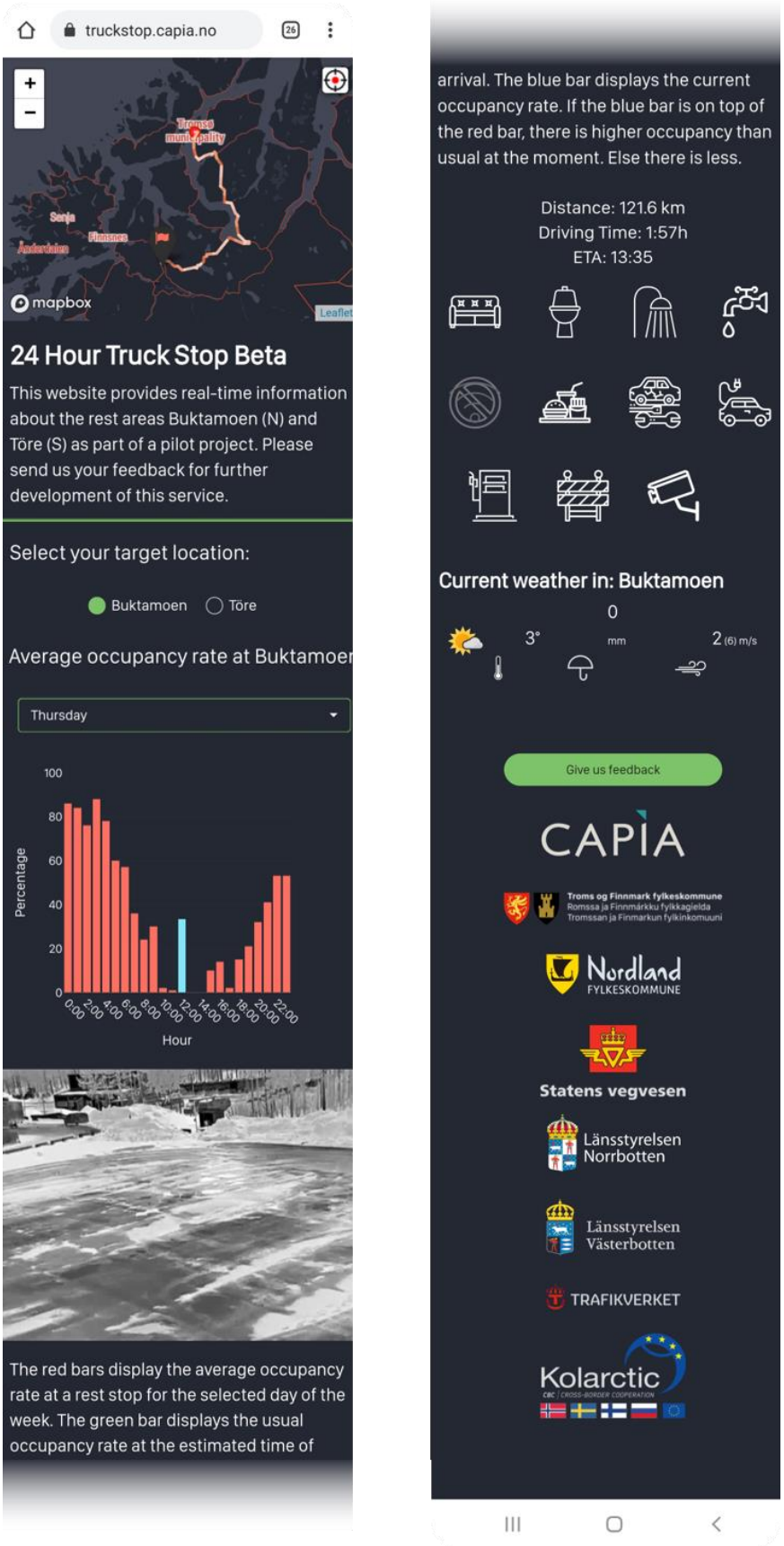
Knowledge transfer

The knowledge gained in this per project can be leveraged for several computer vision questions within traffic. Amongst those are:

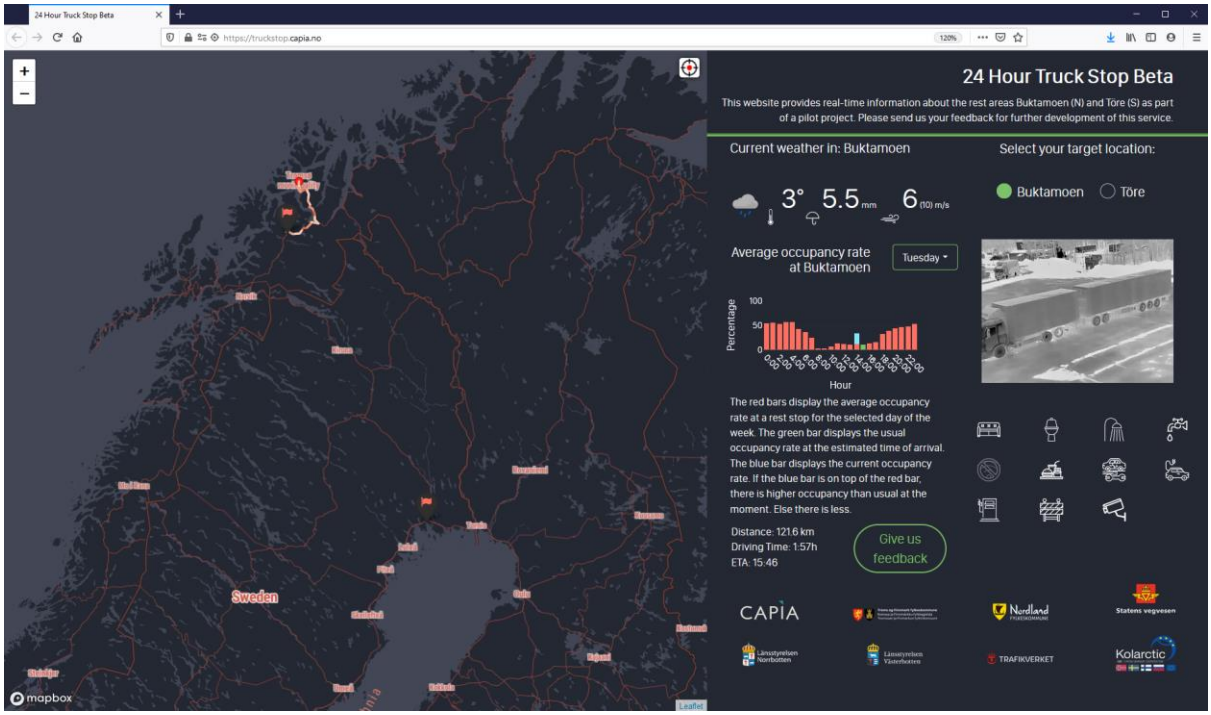
- Detecting, counting, and tracking of traffic participants in different environments e.g., highways, crossroads, roundabouts, tunnels, bridges.
- Detection of violation of traffic and parking rules.
- Vehicle speed monitoring.
- Parking spot monitoring for big events and / or shopping centers.

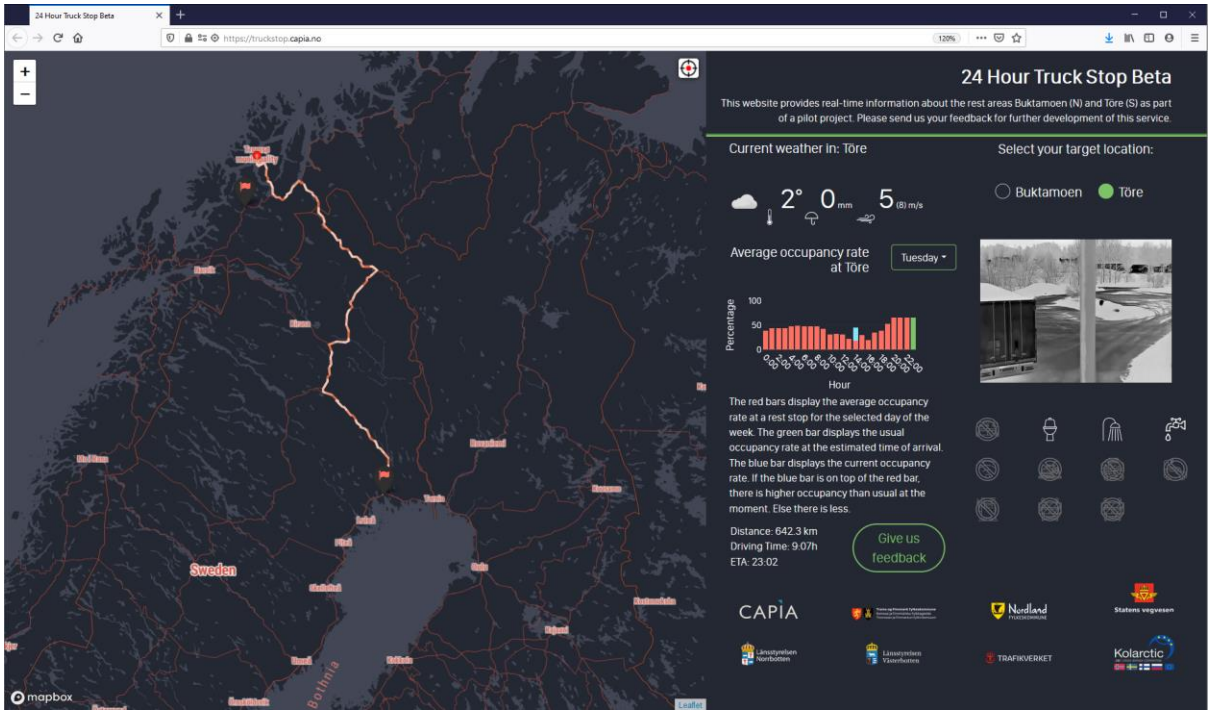
Appendix

A Mobile version website with destination Buktamoen



B Desktop version website





C Online survey