Danish consulting engineering company, COWI, is among the first in Denmark to use advanced UAV technology for monitoring and analysing traffic flow. Monitoring from above literally presents new perspectives in optimizing road traffic systems which are experiencing growing congestion problems.

New challenges call for new solutions. This is also the case with an increasing level of traffic on the Danish roads. Expanding a traffic system by building new roads is expensive and therefore road authorities demand advanced solutions that can optimize existing traffic systems. These advanced solutions however require comprehensive and detailed data inputs and analysis in order to point out the exact issues in a given congestion area. Therefore, COWI has initiated the use of UAVs (drones) for monitoring and analysing traffic flow. The use of drones as an alternative to manual inspections as well as semi-automatic traffic-data collection methods placed on the ground has many advantages including the ability to detect drivers, who act inappropriately and why. In addition, it is possible to analyse several...
traffic streams at once and their impact on each other. Finally, video recording using a drone obviously secures a unique documentation of traffic observations that we just cannot obtain when standing on the ground.

COWI is among the oldest and most respected consulting engineering companies in Denmark with more than 45 years of experience conducting traditional mapping from airplanes. We have been using drones for various purposes for the last four years including 3D mapping and modelling, high-resolution photography, visualizations etc. In 2014, we began using drones for traffic monitoring, which has proven to be a valuable tool, especially after finding solutions to some of the built-in limitations that come with UAVs themselves.

**Case no. 1: Congestion in roundabout in Randers, Denmark**

The municipality of Randers in Denmark has experienced high levels of congestion in one of the city’s central roundabouts, and they are assessing different solutions. Before making a decision on which solution to implement, the municipality needed a thorough analysis of both the level of congestion as well as the reasons leading to congestion i.e. traffic backing up from other nearby intersections.

COWI organized a non-stop UAV-recording of two hours during the morning and afternoon peak in June 2015. We conducted the recordings from a flying height of approximately 60 meters, and we recorded the video footage in Full HD allowing us to present videos on high-resolution screens giving the possibility to see even small details within the footage.

We determined the position of the UAV for the recordings based on two conditions. First of all we needed to keep the necessary safety distance and second of all we wanted to be able to follow the traffic flow going south to and from the roundabout in direction of the bridge crossing the river that runs through the city.

**Roundabout in Randers, Denmark. Congestion allows no traffic to get through and causes traffic to back up all incoming roads.**

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An in-depth analysis of the footage showed that a number of different conditions each contributed to the congestion in the roundabout. In addition, it was clear that the congestion in the roundabout caused traffic to back up on all roads leading to the roundabout, thereby resulting in a classic gridlock spreading throughout the city. We conducted our analysis in several steps, starting with a vehicle count that documented the amount of traffic passing through the roundabout. We compared the count with the expected capacity of the roundabout. The difference between these two, we used as an expression of the level of congestion.

Combining this detailed knowledge with another of our key business areas, traffic management, enabled us to design a solution addressing the documented issues. Hence, using a UAV for collecting traffic data basically made the difference.

Case no. 2: Lane change analysis on motorway, Denmark

The Danish Road Directorate has established a pilot project, replacing the emergency lane with a parallel traffic lane, which drivers should consider an extended entrance/exit road. This means that road users who enters the motorway should leave the parallel lane at the beginning of the stretch unless they plan to use the coming exit.

To evaluate whether drivers use the parallel lane as intended, COWI used a drone to monitor traffic on a section of the motorway. On the recorded footage, it is possible to register whether drivers leave the parallel lane after entering the motorway or stays in it.

We did the recordings from a maximum height of roughly 65 meters, since we wanted to be able to analyse the longest possible stretch in one recording. In this given case, the recording covers close to 500 meters of the motorway. This is the longest distance we have analysed in one recording so far. We chose the position of the drone by considering the legislative limitations.
combined with a request to capture both the weaving sections of the motorway as well as the regular sections.

We have started the initial analysis of the footage. This part of the analysis involves registering the number of vehicles using the parallel traffic lane as intended and unintended respectively.

COWI conducted the recordings in June 2015 and we have not yet concluded the results of the analysis. It is however clear by now that the use of drones allows us to evaluate the project. This simply could not have been carried out doing a manual inspection on the ground or by car due to the large area, we needed to monitor simultaneously.

**Current Challenges**
The use of drones for traffic monitoring and analysis is not without challenges. The most important challenges in Denmark are in regards to Danish legislation, which is very strict on this subject. Legislation prohibits flying closer than 150 meters to large public roads and densely populated areas, unless obtaining an exemption. Even having the exemption, licensed pilots must never pilot a drone closer than 50 meters to i.e. public roads. Obviously, this limits the use of drones for traffic monitoring, as most roads are in urban areas. Also not being able to record footage directly above e.g. intersections also limits the use. During 2016 a new set of rules within the use of
drones is expected to be implemented in Danish legislation.

There are also technical challenges. COWI currently uses a specially designed UAV for our traffic monitoring assignments. The drone weighs in just short of 7 kg, as we need a high degree of stability when flying also in windy conditions. Consequently, the needed power is rather high. The known balancing of battery capacity versus weight gives us roughly 20 minutes of flying. 20 minutes however is just not enough when conducting proper traffic analysis. Flying and recording non-stop dictates powering the drone using a ground-based power supply connected to the drone using a power cable. Due to cable weight increasing proportionally with its length, this limits the flying height to approximately 65-70 meters.

**What will the future bring?**

In COWI, we expect the use of UAVs to increase dramatically over the coming years. Competition will grow, and we anticipate cheaper, low-quality solutions to flood the market.

As for now, we find that we have obtained a very good, balanced solution for using UAVs in obtaining traffic data. However, the need for increasing usability and quality for traffic monitoring at the same time as reducing costs means that we are constantly on the lookout for bettering overall performance.

In COWI, we believe UAVs will allow us to monitor traffic relations while at the same time collecting traditional traffic data such as traffic counts. We are currently close to being able to conduct fully automated counts using specially designed software. The software detects all vehicles entering an intersection and registers their following exit. This allows us to both count the amount of traffic as well as work out an O-D analysis (origin and destination).

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