WPI

Breaking the Cycle of Congestion

AN EXAMINATION OF TRAFFIC CONGESTION IN COPENHAGEN

SUPPLEMENTAL MATERIALS

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Submitted to the Faculty of

Worcester Polytechnic Institute

in partial fulfillment of the requirements for the degree of
Bachelor of Science

Date:

May 02, 2017

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Background

To develop strategies to reduce congestion within Copenhagen, we first needed to research the history of bicycle traffic in the city. By understanding the social and technical factors that contributed to bicycle congestion, we could create strategies that would benefit not just the city of Copenhagen, but its citizens as well.

The History of Cycling in Copenhagen

The year 1910 marked the construction of the first cycling infrastructure in Copenhagen in the form of bicycle lanes. By 1912, bicycle lanes measured 35 kilometers of carriage tracks that the cyclists used to avoid the rough cobblestone pavement. Increasing automobile traffic caused concern among cyclists during the 1920s, which led to the separation of car and bike lanes via dividers such as trees or curbs. This bike-car separation was the start of the “Copenhagen style” cycling infrastructure, allowing cyclists and automobiles to travel in their own dedicated spaces, rather than having cars and bikes drive in the same section of road (Carstensen, Olafsson, Bech, Poulsen, and Zhao, 2015).

Historically, this expansion in cycling infrastructure had significant economic impact. People could more readily cycle to jobs in the city, while residing in the low cost suburbs surrounding the city. The oil crisis of World War II stimulated further expansion of bike infrastructure as bicycles became cheaper and thus a more preferred means of transport (Carstensen et al., 2015). The rate of cycling infrastructure expansion declined during the 1950s and 1960s as the City of Copenhagen lifted restrictions on imports and fuel. The percentage of people who used cars spiked from 24% to 46%, while the number of bicycle users in Copenhagen plummeted from 40% to 19% (Carstensen et al., 2015). Consequently, new infrastructure prioritized the increasingly popular automobiles with roadways modified to accommodate. In some traffic intersections, the City of Copenhagen removed bicycle lanes entirely, forcing cyclists to share roads with motorists (Carstensen et al., 2015).

The Danish Cycling Federation (DCF) began advocating for cycling and pedestrian infrastructure in the 1970s in response to high accident rates involving cyclists, joined by thousands of protesters (Carstensen et al., 2015). The DCF promoted most of the early bike infrastructure expansion. The public outcry in the 1970s coupled with the growing cost of oil again made travel by car an expensive and

less popular transportation option. The priority of the state to build car-specific infrastructure decreased. Since 1976, the amount of bicycle infrastructure has been steadily increasing, with the number of cyclists traveling over the Langebro Bridge increasing concurrently. By the 1990s, municipalities began investing in bicycle-exclusive infrastructure innovations such as green bicycle routes, and by 2010, opened bicycle superhighways. The 11-year period between 1974 and 1985 experienced the greatest increase in the number of dedicated bicycle paths, nearly doubling in size at a rate of nearly 9 km per year (Carstensen et al., 2015).

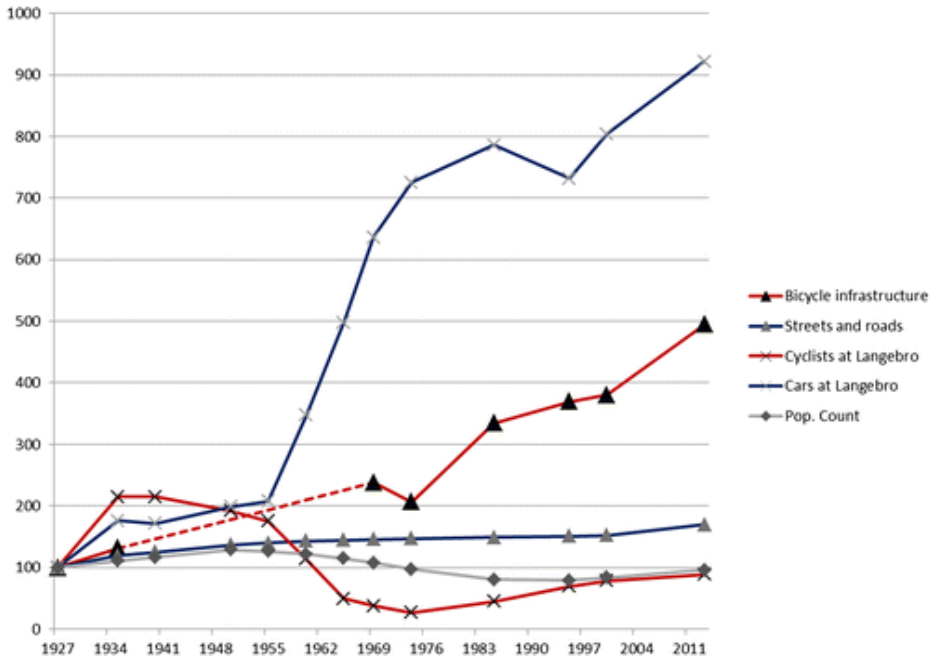

Figure 1: Index numbers for kilometers of bicycle infrastructure and streets in Copenhagen over time, along with numbers of cyclist and cars over the Langebro Bridge, and the population of Copenhagen. The base year is 1927 (Carstensen et al., 2015).

Bicycles have become more widely used as a primary means of transportation in Copenhagen over the past two decades despite the decreasing cycling trend in Denmark as a whole (see Figure 2). Furthermore, Morten Skou of Copenhagen Bicycles mentioned that Denmark has closed many of the smaller schools that used to serve local communities in favor of larger centralized schools (personal communication, 2017). While this is more cost-effective and convenient for the state, often it is further away from students' homes, forcing their parents to drive them to school. Because of

this, Mr. Skou expressed the opinion that it encourages fewer children to ride bikes as a means of transportation, meaning they are less likely to cycle when they grow up. Copenhagen, on the other hand, has places of interest like stores and schools much closer together than in the suburbs of Denmark, making it easier to cycle from place to place, while people in the suburbs have to travel much longer distances.

Copenhagen has styled itself as cyclist-centric city, with many major traffic intersections and roads modified with cyclists in mind (Carstensen et al., 2015). Certain intersections even have footrests for cyclists waiting for the light to change and many stretches of roads have trashcans positioned such that cyclists traveling down the road can easily throw away their trash. The efforts of organizations such as the DCF, the Cycling Embassy of Denmark (a collaboration of private companies, local authorities, and non-governmental organizations) and investments by city government have resulted in 80% of the city's population owning or having access to a bicycle (Nielsen, Skov-Petersen and Carstensen, 2013).

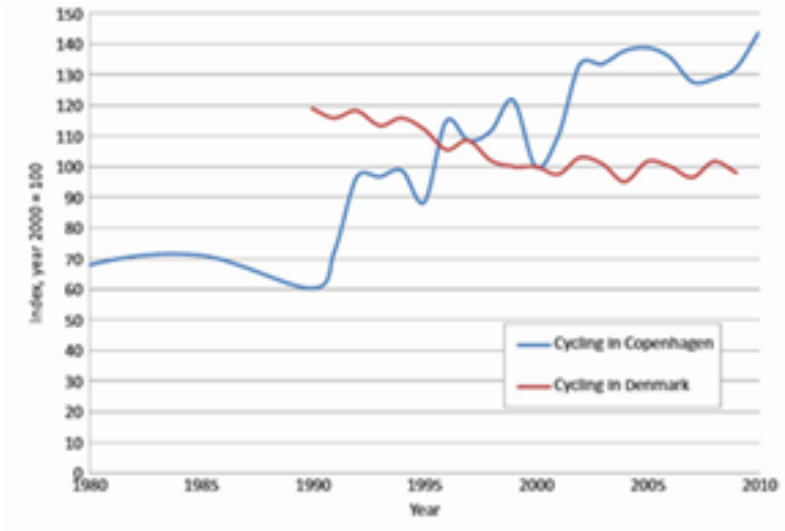

Figure 2: Index numbers for the number of cyclists in Denmark and Copenhagen. The data from 2000 is the base value (100 on the vertical axis). For example, a y-axis value of 110 indicates a 10% increase from 2000 (Nielsen et al., 2013).

The Cycling Goals of Copenhagen

There are several goals for the growth of bicycle traffic put forward by different organizations within the municipality of Copenhagen. The main report we examined was the 2016 Bicycle Report, published by the Technical and Environmental Administration of the City of Copenhagen, the administration that is in charge of all bicycle infrastructure in Copenhagen. The report stated that The City of Copenhagen wanted the percentage of trips made by bicycle in Copenhagen to increase from 41% (in 2015) to 50% in 2025, and also set the goals for 17% increase in bicycle traffic, and 35% increase in bicycle rush hour traffic in 2025 (The City of Copenhagen Technical and Environmental Committee, 2016).

The Benefits of Increasing Cycling

According to Kielgast (2017), the prioritization of bicycles and bicycle infrastructure has reduced Copenhagen's carbon dioxide emissions by hundreds of thousands of tons annually. In addition to making the environment healthier for city residents, the bicycle culture in Denmark is cost effective. In a report published in 2015 in Ecological Economics, authors Stefan Gössling and Andy Choi, in their examination of the economic impact of expanding cycling infrastructure, calculated that a city saves a net $0.18 (1.24 Danish Krone) for every kilometer cycled. By comparison, every kilometer driven by car costs the city a net $0.17 (1.18 Danish Krone) largely due to the infrastructure maintenance and operation fees (Gössling and Choi, 2015). The report argued that cycling cost savings improves population health, which leads to a reduction in medical expenses, as well as reductions in costly motor vehicle related expenses, such as accidents. While the infrastructure adjustments to increase the number of cyclists are significant, there are economic payoffs in the end. Applying the estimates offered by Gössling and Choi (2015), if only half of Copenhagen's 675,000 bikes were used to cycle one kilometer a day for a year, the city could save over $20 million (over 138 million Danish Kroner) in a single year.

Jos Van Vlerken, a project manager in the Technical and Environmental Administration, echoed these sentiments, touching on health benefits and reduced congestion from cycling (personal communication, 2017). However, he also mentioned the benefits of adding bicycle infrastructure to decrease travel time for cyclists: "Let's say widening the bike lane improves travel time by 5 seconds per person. Multiply that by the total number of people going through the intersection, and you have the total

number of seconds saved. Then, associate the total savings per second, and subtract the total savings from the cost of the project." In other words, wasted time spent waiting in bicycle traffic could potentially be spent working and making money with the addition of bicycle-specific infrastructure. Such savings indicate the value of continuing to invest in bicycle infrastructure.

Bicycle Tracks and Lanes

The most common forms of bicycle infrastructure in Copenhagen are bicycle lanes and bicycle tracks. Bicycle lanes are sections of the automobile lane shoulder, dedicated to cyclist use with appropriate markings and white line dividers. Bicycle tracks are roads separated from automobile lanes either by dividers or by raising the track slightly above the roadway curbs (Jensen, 2007). Figure 3 shows a bicycle track on the left and a bicycle lane on the right.

Figure 3: Photos of bicycle track (left) and bicycle lane (right) (Jensen, 2007).

Additionally, bicycle track classifications contain two distinct types: shortened and advanced tracks. Advanced lanes have dedicated traffic lights for regulating traffic flow, which allows cyclists to travel independently of automobiles, allowing for greater flexibility in reducing traffic congestion. Shortened bicycle tracks are tracks that end before an intersection, and turn into lanes that are shared by both cyclists and motorists turning right. Figure 4 provides an example of both shortened and advanced bicycle tracks.

Figure 4: Photos of shortened bicycle track (left) and advanced bicycle track (right) (Jensen, 2007).

A study in 2007 compared accidents (defined as any type of crash, whether involving a single bike, a bike and a car, or a bike and a pedestrian) before and after the implementation of bicycle infrastructure in order to assess the impact of implemented bicycle infrastructure on accidents and overall traffic flow (Jensen, 2007). The analysis revealed that after constructing bicycle tracks intersection, crashes and injuries involving bicycles increased by 18%. By comparison, there was no statistically significant increase in total crashes and accidents in bicycle lanes. Following construction, mileage traveled by bicycles using bicycle tracks increased by 20%, while motor vehicle mileage traveled decreased by 10%, meaning more bikes were using the roads, while fewer cars drove on them. Cyclists using bicycle lanes experienced only a 5% increase in travel mileage, while motor vehicles experienced a 1% decrease overall.

Bicycle Congestion in Copenhagen

Bicycle congestion has become a growing problem in recent years. Figure 5 shows the average volume of cyclists per day in a particular area in congestion bubbles of varying size: the larger the bubble, the more cyclists that pass through. The 2013 traffic bubbles are much larger than the bubbles from 2009, revealing that the

number of bicyclists is continuing to grow in Copenhagen. Many of the areas shown in Figure 5 see over 20,000 cyclists a day, which congests the intersections during rush hour. If the City of Copenhagen meets the goals stated in the 2016 Bicycle Report and the bicycle traffic rises, then the few currently congested intersections will worsen, causing cyclists to avoid them while also congesting other intersections.

Figure 5: Average bicycle counts at Copenhagen intersections in 2009 and 2013 (ArcGIS, 2014).

Danish traffic laws for bicycles add to congestion at troublesome intersections. For example, most intersections do not allow cyclists to directly turn left like cars are able to do, because that would cause them to ride in front of cars traveling straight through the intersection. Instead, as seen in Figure 6, cyclists have to cross the intersection, stop and turn 90 degrees to the left, effectively joining bicycles on the perpendicular street waiting to travel straight through the intersection, and wait for the light of that street to turn green. In very crowded intersections, the line for cyclists trying to turn left can actually take up an entire side of the road.

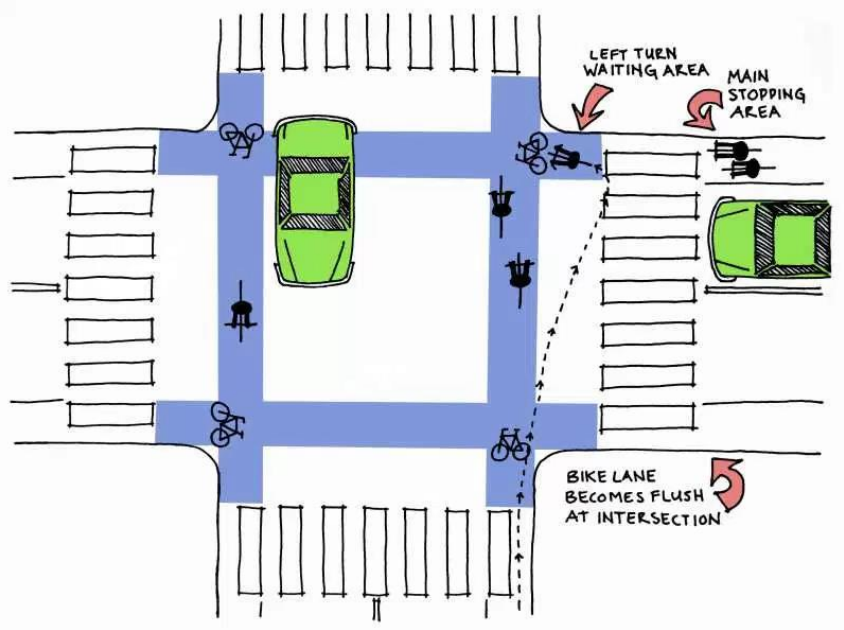

Figure 6: Depiction of the left turn a cyclist takes in Copenhagen (Copenhagen on Two Wheels - Part 1, 2009).

Additionally, cyclists (and motorists) are not allowed to turn right on a red light, further backing up the line waiting for the light, instead of letting a portion of the cyclists turn right, thus alleviating some of the congestion. On top of this, some cyclists will cut across the sidewalk to the bicycle lane they want to use instead of waiting in line. Sometimes cyclists will ride up onto the sidewalk and into the car lanes of the road (Hill, 2011). This has begun to create the negative perception that cyclists are selfish, aggressive, and dangerous, which hurts Copenhagen's goal to continue to increase the number of people cycling in the city (C. Knudsen, Personal Communication, 2017).

Current Strategies to Alleviate Congestion

In addition to the strategies mentioned in the main report, Copenhagen has also implemented other strategies with the goal of improving the flow of bicycle traffic. One of these is the *Copenhagen Intelligent Traffic Solutions* (CITS), an overlapping network of Wi-Fi access points that have the capability of determining the geolocation of Wi-Fi-enabled devices on the street. The system can track smartphones as they move along the road, and consequently, can track the people carrying them. By tracking people,

CITS enables city officials to monitor traffic conditions in real time. CITS analyzes the data to categorize traffic, look for patterns, and identify long-term behavior tendencies of bicycle users (The Energy Times: Informing Customers & Utilities, 2015). Cyclist can access this data using an application, and see the traffic on the streets in real time. Using this information, they identify where the bicycle lanes and roads are congested, and can plan to avoid them. However, it is not clear how many people are using the app to avoid bicycle traffic and if CITS is helping to reduce congestion significantly.

Copenhagen also plans to introduce smart traffic lights throughout the city in the near future. The smart traffic lights will be implemented all throughout the city, and, “by prioritizing buses and bicycle lanes, the smart traffic lights aim to cut bus travel times by up to 20 percent, and bicycle commute times by 10 percent” (Olewitz, 2016). An $8.9 million investment, the traffic lights will be able to view bike lanes and receive electronic GPS information from buses, and will stay green up to 30 seconds longer to accommodate the buses (Olewitz, 2016). Unfortunately, no plans exist to implement these traffic lights, according to Jos Van Vlerken, a project leader at the Technical and Environmental Administration of the City of Copenhagen. According to Van Vlerken, the municipality is currently inputting the sensors for the bikes and buses, but off-the-shelf smart traffic lights would not work for this situation because they favor motorists (personal communication, 2017). Because of this, the municipality will need to create its own smart traffic light program, which could take some years.

The municipality of Copenhagen has also installed LED lights into existing asphalt roadways to widen or narrow lanes temporarily as traffic demand shifts through the day, as shown in Figure 7. Lights also indicate which mode of transportation (bicycles or motor vehicles) has the right-of-way. Sensors within the system determine which changes to make by monitoring vehicle and bicycle traffic and sharing this information with commuters on their smart devices (State of Green, 2017). Using this technology, different components of the roads can have changing functions. For example, if more cyclists use a particular road than cars, then during rush hour the bicycle lanes can be widened to accommodate more cyclists, reducing lines and wait times at traffic lights.

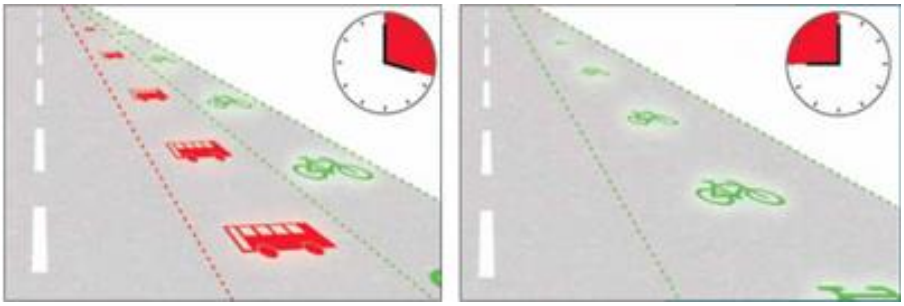

Figure 7: At left, a road that allows both cars and bicycles. At right, a road, widened for only bicycle traffic. This can change during various hours of the day based upon traffic patterns, as denoted by the clocks in the top right of each image (State of Green, 2017).

Copenhagen has also experimented by allowing right hand turns during a red light by cyclists at certain intersections in the city. The city uses signs to inform cyclists that they are able to turn right if safe to do so. City officials are using these intersections as experiments to see if allowing right turns on red will increase the flow of bicycle traffic and if there are any increases in accidents (The City of Copenhagen Technical and Environmental Committee, 2016). Presumably, if all goes well, then the City of Copenhagen will implement this new traffic policy in more intersections.

Cycling Strategies in the Netherlands

Like Denmark, the culture in the Netherlands has ingrained cycling for many decades. International rankings consistently place Amsterdam and Utrecht in the top 10 cycling cities, according to the Copenhagenize Design Company Index (2015). *I Amsterdam* (2017) even reports that bicycles outnumber people in Amsterdam, with 881,000 bikes to 800,000 people. As such, the Netherlands may have developed cycling congestions solutions that could prove useful in Copenhagen.

In the city of Amsterdam, there has been a 40% growth in bicycle use within the last 15 years (Van der Horst, 2014). In response to this growth, the city has built over 1,000 kilometers of bicycle lanes (Van der Horst, 2014). These bicycle lanes include lanes on the side of motorized roadways, and separate, primarily cyclist roads, denoted by their red asphalt. In addition, Amsterdam (and other Dutch cities) converted several streets into primarily cyclist streets. The Dutch cycling blog Bicycle Dutch (2015) reported on how Amsterdam designs its streets and how they improve the cycling conditions of residents. According to the article, a bicycle street "is considered

to be a route in a residential area that is a main route for cycling, but only a minor route for motor traffic" (Wagenbuur, 2015). As seen in Figure 8, these roads are usually constructed (or converted) parallel to major motorways so that cyclists have the same access to the city that motorists do. According to Bicycle Dutch (2015), this design means most motorists will use the main road, and only residents will drive on the cycling street, thus giving more room to cyclists on the cycling street. Furthermore, the city initiated a new bicycle plan in 2011 to encourage more residents to cycle (Van der Horst, 2014).

Figure 8: The Netherlands designs cycling streets (red) to flow parallel to major roadways (blue) (Wagenbuur, 2015).

Given these initiatives, the majority of people in Amsterdam (like in Copenhagen) use the bicycle as their primary mode of transportation within the city. *I Amsterdam*, a tourism guide to Amsterdam, indicates that 58% of residents cycle daily, while 83% cycle at least once per week, a statistic very similar to that of Copenhagen. A primary reason for high proportion of cyclists is the reduced commute time for bicyclists over automobile drivers (Iamsterdam, 2017). Given the rapidly increasing number of cyclists in the Netherlands, considerable challenges arise. The congestion in the Weteringschans district of Amsterdam was explored in a study (City of Amsterdam, 2017), revealing that during rush hour from 14:00 to 18:00 over 3500 cyclists pass through the area creating many traffic jams and congestion. According to the Dutch road safety board *Stichting Wetenschappelijk Onderzoek Verkeersveiligheid* (SWOV), the Dutch organization for road safety, "half of the investigated cycle ways are getting too busy during morning rush hour" (Wagenbuur, 2016). Figure 9 displays this type of congestion, which is very inconvenient for the Dutch residents and creates potentially unsafe situations. According to the study by the City of Amsterdam (2017), a third of all

cycling accidents in Amsterdam occur during rush hour on the aforementioned busy routes (City of Amsterdam, 2017). While the number of cyclists in the city is a factor, the study argued that the main culprit is the shortage of good cycling infrastructure, noting that the “city lanes and paths in the city are too narrow to safely accommodate this enormous stream of cyclists" (City of Amsterdam, 2017).

Figure 9: Cyclists wait during a Dutch traffic jam (Wagenbuur, 2014).

To manage the congestion, more space needs to be created for cyclists, requiring many roads to be changed create this space for bicycles (City of Amsterdam, 2017). The key is to make cyclists the priority and create more infrastructure specifically for cyclists. Ways to accomplish this include widening existing bicycle lanes on the side of roads, or converting side roads into bicycle roads, which will help manage the rush hour traffic that occurs in Amsterdam and other major Dutch cities.

Dutch policy makers are also looking into revolutionizing urban design to prioritize the needs of cyclists. The Royal Dutch Touring Club (ANWB), with the help of experts, published a proposal on how to redesign urban traffic to make it easier for bicycle traffic to get around cities (Wagenbuur, 2016). While widening bike lanes is a good step, in a developed city further expansion of bike lanes is restricted. The ANWB’s proposal aimed to redesign traffic to create more space for bicycles. Currently, the ANWB divided Dutch traffic into three types: motor traffic, cycling, and walking. The ANWB proposed to group vehicles in ’vehicle families’ based upon mass and width (Wagenbuur, 2016). There are six groups, as listed in Figure 10. Group A are pedestrians, Groups B and C include bicycles, mopeds, and motorcycles, and Groups D and E are more traditional cars such a coupe, sedans, and large cargo trucks. The

advantages of classifying traffic this way is that it would allow the government to classify roadways for use by one group primarily, similar to the bicycle streets already in use around Amsterdam. In addition, by classifying vehicles in terms of size and weight, it is easier to understand what types of vehicles could go on each road. For example, Groups A, B, and C would have the right of way on a bicycle street, and Group D might be able to use the street as guests, but size prohibits Group E from using the street. This would make the bicycle street safer as cyclists and pedestrians would not have to worry about trucks and buses driving around them.

Group A	People Walking.
Group B	People cycling on vehicles with a maximum weight of 35 kilograms and a width of 1.5 meters. This includes for the largest part the ordinary person on a pedal powered bicycle.
Group C	A light motorized vehicle up to 350 kilograms with a width of under 2 meters.
	Mopeds, scooters but also motorcycles.
Group D	Cars and "car like" vehicles, coupes and sedans. The weight limit is 3,500 kilograms and that is such that light vans and small trucks will also be included in this vehicle family of vehicles with a maximum width of 2 meters.
Group E	Buses and Trucks, or any cars over 3,500 kilograms or wider than 2 meters.
Group F	Urban vehicles that move on tracks, like a streetcar.

Figure 10: The six groups of traffic proposed by ANWB (Wagenbuur, 2016).

In conjunction with these new classifications, ANWB also proposed four new types of roads for Dutch cities. Each of these types of roads, or "zones," would be for one particular group of traffic, similar to the bicycle street example used in the classification of vehicles described above. They include the Pedestrian Zone, Cycling Zone, Light Motor Vehicle Zone, and Motor Vehicle Zone. In each of these zones, one group of traffic has priority. Any group of traffic can use any of the zones, but only as guest users who yield to the priority group. Figure 11 shows the specifics of each of the traffic zones. Currently there are no intentions to implement this plan but the proposal offers an idea on how to give bikes more priority in a crowded urban

environment. In addition to widening the existing bike lanes, this plan would greatly help the Dutch reduce cyclist congestion.

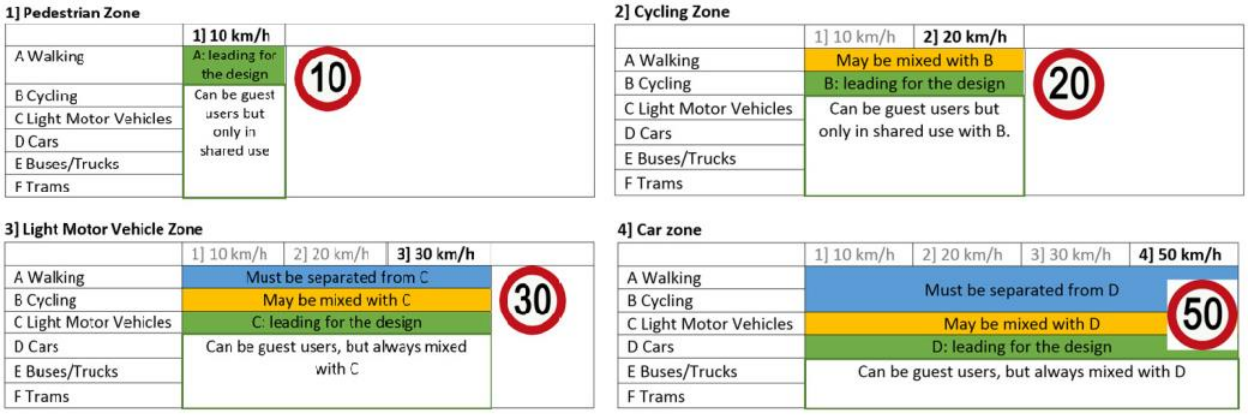

Figure 11: The different traffic zones in ANWB's proposal (Wagenbuur, 2016).

Hovenring

The Netherlands has another innovative piece of bicycle specific infrastructure in the Hovenring, as shown in Figure 12. The Netherlands constructed this aerial roundabout was constructed in 2012, which completely separated cyclists from the 25,000 vehicles that use the road below every day (Wagenbuur, 2012) and connects the bicycle networks of Eindhoven, Veldhoven, and Meerhoven. The 72-meter diameter ring cost approximately €6.3 million to build, as is the ultimate goal of cyclists to allow them to navigate an intersection without having to worry about cars (Wagenbuur, 2012). However, its large size means that constructions like this are only suited for the suburbs, and not the city centers where it would have a greater effect on the higher population.

Figure 12: The Hovenring Roundabout in Eindhoven (Wagenbuur, 2012).

Bicycle Politics in Copenhagen

Despite the efforts Copenhagen has made to improve its cycling infrastructure, bicycle congestion remains a very large problem. To understand the problems of bicycle congestion in Copenhagen better, it is important to note the interested parties that are both for and against the increase in cyclists in the city. The Danish Cycling Foundation (DCF), founded in 1905, is a private non-governmental organization, which currently consists of more than 16,000 members. The organization is dedicated to increasing bicycle use and safety through campaigns and receives funding from the Danish parliament to promote cycling (Danish Cyclists Federation, 2017). Another organization is the Bicycle Republic, or *CykelRepublikken*, which is a fund for municipalities to apply for 50% funding of bicycle infrastructure projects. This may include new bike tracks or even bicycle bridges over motorways when new motorways block cyclist's usage. Bicycle Republic works to ensure that there is always bicycle infrastructure in place for cyclists to get to where they need to go. There is also the Copenhagenize Design Company, which promotes cyclist-centric culture and runs a blog dedicated to promoting cycling for Copenhagen as a whole (Anderson, 2013).

Furthermore, several political parties are pro-bicycle, such as the Red-Green Alliance, the Socialist People's Party, and Danish Social-Liberal Party (Anderson, 2013).

However, the party currently in power in Copenhagen is the Social Democratic Party, which has occupied the Lord Mayor post of Copenhagen for over a century (Anderson, 2013). This party has supported bills that prioritize car parking over bicycle parking, and the construction of an expensive harbor tunnel that would allow cars but would exclude bicycles. The Copenhagenize Design Company describes the party as "support[ing] a reversal of the work Copenhagen has done for the past 20 odd years to become one of the world's most livable cities" (Anderson, 2013). These opposing groups, with their established priorities highlight one of the major challenges to implementing significant infrastructural changes to address bicycle congestion.

Much of what the City of Copenhagen accomplishes depends on the agenda of each elected Lord Mayor. Claus Bondam, who was Mayor of the Technical and Environmental Administration of Copenhagen from 2006-2009, mentioned how he was able to get a lot of projects done during his time in office because the Lord Mayor at the time was very supportive of promoting cycling (personal communication, 2017). He also cautioned to get the support of as many administrations and people in the government as possible, so if one person is not re-elected, the projects in place do not fall apart. By having diverse support for bicycle infrastructure projects, the projects are more likely to survive the changings of government.

Methodology

This project intends to assist the Bicycle Innovation Lab in modeling and evaluating viable strategies to reduce bicycle congestion in Copenhagen. In order to accomplish this, we established the following objectives:

1. Analyze intersections with bicycle congestion in Copenhagen and record intersection infrastructure and traffic patterns in each intersection.
2. Assess strategies to reduce bicycle congestion with non-government organizations and government organizations.
3. Model potential strategies that could reduce the volume of bicycle congestion.

To complete these objectives, we used several methods of gathering and analyzing data. These methods included case studies on particular intersections in Copenhagen, the use of traffic simulation software to model potential strategies to reduce bicycle congestion, and interviews with traffic experts and city officials. This section analyzes these methods in depth and explains we chose each.

Objective #1: Case Studies of Intersections

In order to gather current data to model bicycle congestion in Copenhagen, our team conducted case studies on three traffic intersections throughout the city. We analyzed two intersections to provide us with different traffic pattern and infrastructure characteristics to develop strategies that the City of Copenhagen can apply to similar intersections.

We selected the two intersections using the following criteria:

1. The number of total cyclists utilizing the intersection during any given weekday. Most high-level congestion occurs in Central Copenhagen, with the busiest intersection recording 19,000 to 37,000 cyclists on average per day (Average Daily Traffic Count, 2013). We only considered intersections in this range for data collection.
2. Where the intersection is in the city, as many of the recent residential developments are located outside of Central Copenhagen, such as Amager and Nørrebro (C. Knudsen, personal communication, 2017). This will increase the number of commuters from the suburbs to Central Copenhagen, increasing travel on the bridges that connect Central Copenhagen to the rest of Denmark. The locations of these bridges and other major roadways make them susceptible to changing population patterns in the near future, significantly worsening the traffic congestion in the area. For this reason, we only considered locations near major roadways.
3. How complicated the intersection was, or how difficult it was for traffic to move through it. During our first week in Copenhagen, we traveled around the city to look at intersections we had narrowed down to using the first two criteria. From there we looked at (without collecting any data yet) how much the bicycle lanes backed up, if motorists were able to get through the intersection or got stuck in the middle, whether bicycle tracks were separated from motorists or had to share the right turn lane, and if the bicycle lanes had their own traffic light. This criterion was subjective but our initial assessment gave us a first-person account of what the intersection looked like and how the commuters moved through for when we began collecting our data. Because intersections vary in infrastructure throughout Copenhagen, we used these criteria to ensure that the developed strategies would be sufficiently versatile such that the City of

Copenhagen can use them in other intersections. For example, a strategy tested on only four-way intersections may not be effective for a three-way intersection.

From these criteria, the intersections we chose were the Gothersgade-Øster Voldgade and Dronning Louises Bro-Søtorvet intersections, as shown in Figure 13.

Figure 13: The locations of the two intersections studied.

We focused our attention during morning and evening rush hours and conducted data collection from each of the corners of the intersection with an unobstructed view of each portion of the intersection, as shown in Figure 14. We looked at each intersection in depth for two days, and conducted two observations per day, between the hours of 8:00-9:00 and 16:00-17:00. This meant each intersection received four observations in total, all of which used the following methods.

Numbers of Cyclists and Motorists

To model effectively the intersections we had selected, we needed to count the number of cyclists and motorists who passed through the intersection. To do this, we

decided to videotape the intersection and then manually look back through the video to count the cyclists and motorists. To accomplish this, we had one of team member stand at each corner of the intersection, and then film the intersection as shown in Figure 14, so that the cameras recorded all of the traffic entering the intersection, and which way each vehicle turned. We filmed with two Go-Pro video cameras and with our smartphones, and stood back far enough so that we could see the intersection and our designated stretch of road. To get an average of the number of cyclists and motorists, we filmed three five-minute intervals stretching across the hour we were observing the intersection. These intervals were 8:10-8:15, 8:30-8:35, 8:50-8:55 for the morning rush hour, and 16:10-16:15, 16:30-16:35, 16:50-16:55 for the evening rush hour. This meant that for each rush hour we observed, we filmed 12 five-minute videos of the intersection traffic.

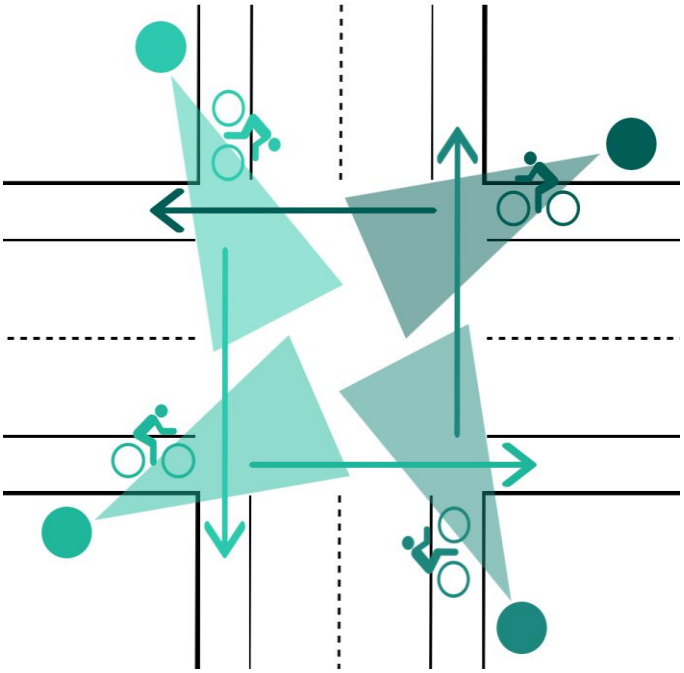

Figure 14: A diagram showing how we filmed the cyclists of an intersection. Filled dots represent each team member video recording the intersection, and wedges of like colors show which person films which lane.

Once we recorded these videos, we uploaded them to an external hard drive so that all team members could view them. We watched each video multiple times by the person who filmed it to count the number of vehicles crossing the intersection to obtain total numbers of cyclists and motorists per hour. We subdivided these counts into morning and afternoon traffic rates, which was then further divided into numbers of

motorists who turned left, right, and straight. For each of the four observation points at the intersection, we calculated the total numbers of cyclists and motorists - each separately - that we counted in the total 30 minutes of recording, and then doubled that number to estimate hourly totals through the intersection during the rush hour. We repeated this process for the afternoon videos to yield the respective rates and these calculations for cyclists, although in those counts we accounted for the fact that cyclists have the option to perform illegal right turns and take alternate turns onto nearby paths, such as cyclists traveling from the west on Nørrebrogade.

Traffic Light Patterns

We noted the traffic light patterns and timed the duration of the traffic lights at a particular intersection via a stopwatch. We measured the duration of the green lights, yellow lights, and red lights. In addition, if there were bicycle traffic lights, we measured those separately from the traffic lights of the main road, as many times the bicycle traffic lights would turn green first to give cyclists a head start. In Copenhagen, traffic lights turned both red and yellow right before switching to green, so we measured the red light duration from when the light first turned red to when it switched to green. We also measured the red light delay of the intersection, when all traffic lights for both the cyclists and motorists had turned red.

In the case that a particular light timing for an intersection varied, we recorded the range of times for the lights in question to make sure we had enough data to model the intersection effectively. We used a database of traffic information throughout Copenhagen provided by Emil Tin from the Copenhagen Municipality to confirm that none of the intersections examined had adaptive signals, which would change the current traffic light cycle based on traffic flow, thus changing the simulation conditions. All three intersections we studied use standard controllers, which do not contain adaptive signals.

Other Observations and Development of Preliminary Strategies

For each intersection, we also made note of how the intersection was structured. This means we looked at how many lanes were on each road, and where each lane turned, and recorded it in a notebook. Once that was completed, we examined the bicycle infrastructure of all the streets, and recorded their position

relative to motorists – whether the roads separated cyclists from motorists, as is the case with bicycle tracks, or if they had to share a lane with motorists turning right.

We also made general notes of problem areas we saw or where the intersection was most congested. We did not include these details in our modeling, but it was useful to understanding the intersection and thinking of how to improve it. From this, we brainstormed strategies to combat the problems and problem areas that we saw at the intersections. Once we brainstormed a strategy, we did preliminary research to understand how the strategy would work and if it would be possible to implement it in Copenhagen. This preliminary research involved looking up the strategy on the internet as well as going through the 2016 Bicycle Report. We investigated past implementation of these strategies in Copenhagen, if so to what effect, and if it required space or laws that would make it difficult to implement in Copenhagen. We used this information later to discuss the strategies with our interviewees.

We developed these four preliminary strategies:

- Widening the bicycle lanes leading up to the intersection. We thought wider lanes would allow more cyclists to make it through the intersection in the given amount of green time from the traffic lights. This seemed like the most obvious solution from our observations, although we were worried taking away space from motorists to widen the bike lanes might increase motorist congestion.
- A designated right turn track on the most congested roads. We came up with this strategy after watching many cyclists ride over the sidewalk at the Dronning Louises Bro intersection, instead of waiting to get to the intersection and then turning right. Our strategy was a right turn track that would cut across the sidewalk to allow cyclists to turn right while not being caught up in the line for the intersection, but also providing infrastructure so pedestrians would be aware that cyclists were turning right at that spot. This track would be separate from the main bicycle lane and implemented only if the lanes were cyclists were very congested, and where there was enough space.
- Adjusting the traffic light patterns at the intersection. We noticed at both the intersections we observed that the longer green times in the light cycles did not favor the direction of traffic that had the most cyclists. We thought that by giving the cyclists-heavy directions of traffic longer green times, we would be able to reduce cyclist congestion. However, we were also concerned that adjusting the traffic lights might increase motorist congestion.
- Allowing right turns on red lights. In Copenhagen, right turns on red lights are illegal, but we thought that by allowing only cyclists to turn right on red, congestion for

cyclists would reduce, as people turning right would no longer have to wait for a green light before turning. However, from our observations we were worried that not enough people might turn right to make a significant difference in bicycle congestion.

Objective #2: Stakeholder Interviews

In order to assess the viability of potential strategies to reduce bicycle congestion, we conducted interviews with stakeholders, specifically government and non-government organizations concerned with the cycling culture and traffic infrastructure in Copenhagen. Our background research and case study observations allowed us to discuss our potential strategies in detail with stakeholders. We presented potential strategies to reduce bicycle congestion to stakeholders, and then we selected strategies to model using the PTV Vissim software based on stakeholder opinions and recommendations. The primary objective of these interviews was to evaluate stakeholder opinions on potential strategies to determine which were realistic before modeling. We interviewed representatives from non-government and government organizations because we sought their professional or educational expertise on the logistical and cultural considerations.

The interviews provided additional qualitative data to determine the effectiveness and practicality of the proposed strategies. We defined effectiveness as the extent to which the proposed strategy would reduce bicycle congestion and practicality as the estimated time and cost of implementation; for example, a more practical strategy required less financial investment. We determined the time and cost of implementing potential strategies from similar infrastructure projects completed in Copenhagen.

We contacted government and non-government organizations, private companies, as well as students and professors studying city planning and traffic congestion. The semi-structured interviews accommodated for various levels of experience provided by our interviewees and allowed us to ask additional questions and facilitate a discussion about which strategy would be most appropriate, if any, to implement.

We contacted fifteen potential interviewees were contacted by e-mail to schedule a time and place to conduct the interview. The following list details the non-

government and government organizations, private companies, and educational institutions contacted for an interview:

- City of Copenhagen Technical and Environmental Administration published *Good, Better, Best: The City of Copenhagen's Bicycle Strategy 2011-2025*.
- Danish Ministry of Transport, Building, and Housing is in charge of transportation, and building and housing regulation.
- Danish Commission on Congestion, created by the City of Copenhagen to reduce car traffic by 30% and minimize car traffic in the future.
- Capital Region of Denmark is concerned with maintaining and improving the availability and efficiency of the traffic infrastructure.
- Cycle Super Highways includes the project managers who collaborated to expand, improve, and link the existing cycle lanes in Greater Copenhagen.
- Cycling Embassy of Denmark is an organization dedicated to promoting cycling and the cycling culture in Denmark, as well as Europe, in areas such as urban planning and infrastructure development.
- Danish Cycling Federation is a non-government organization advocating for Denmark's cyclists through participating in local and national committees and working with transportation policy to create better conditions for cyclists.
- Cykelrepublikken (Cycle Republic) advocated for cyclists, notably in response to the Commission on Congestion investing thirty billion kroner in the harbor tunnel and fifty billion kroner in extending the metro.
- Bycyklen (The City Bike) are public electric bikes available throughout Copenhagen, maintained by the Danish Tourist Offices.
- Donkey Republic is a Copenhagen-based company that provides bike rentals.
- Copenhagen Bicycles makes "bike experiences," through providing bike rentals, guided tours, and repairs.
- Roskilde Universitet Institut for Mennesker og Teknologi (Roskilde University Department of Peple and Technology) professors can assist in identifying relevant problems and qualifying solutions.

We conducted our interviews at a location convenient for the interviewee. Two group members conducted the interview; one group member prompted the interviewee and one group member recorded the conversation with a smart phone and took notes on the key points of the interview. We presented strategies that we had brainstormed to reduce bicycle congestion and demonstrated general use of the PTV Vissim

software, as well as the data obtained from our case study observations. For each strategy, we explained why we brainstormed each one, the benefits we felt each might have, as well as reservations that we had for the strategy. We discussed what the interviewees thought about our reasoning for selecting the strategies, and whether we had overlooked any aspects of our intersections. We then asked the interviewee to identify which of our strategies was most likely to reduce bicycle congestion, including the pros and cons of each strategy, as well as their opinions on the bicycle congestion in general, and what they saw as the most pressing issues for cyclists in the city. As employees and residents in Copenhagen, the stakeholders were able to provide us with additional information on the social implications associated with implementing these strategies. We asked stakeholders to identify the factors we did not consider in our background research, and while forming our strategies to reduce congestion. The interviewer asked additional questions to obtain information, opinions, or clarification from the interviewee. We designed our questions to guide our discussion with the interviewee. The semi-structured interviews allowed us to ask follow-up questions and discuss topics not detailed in our transcript.

The following section describes the procedure and prompts for the interviews.

- Group members will introduce themselves to the interviewee(s).
    - “We are students from Worcester Polytechnic Institute partnering with the Bicycle Innovation Lab, which promotes the cycling culture in Copenhagen. The Bicycle Innovation Lab and Miljøpunkt Amager are non-profit, non-government organizations.”
- Describe the mission and objectives of the project. Describe the objective of these interviews.
    - “This project is intended to assist the Bicycle Innovation Lab in identifying key contributing factors and evaluating viable solutions to address the growing problem of bicycle congestion in Copenhagen. This interview is intended to assess the implementation of potential strategies that could reduce the volume of bicycle congestion.”
- Start to record.
- Ask permission to use name(s) and record interview.
    - “Please state your name. This interview will be audio recorded and your name(s) will be cited as noted. If you do not want to be recorded, we will stop the recording and continue with the interview. You can request to speak “off the record” and the recording will be stopped and then

restarted. Do you have any questions? Do we have permission to record this interview and use your name?"

- Continue or stop recording and start interview.
- Discuss what strategies are in use to reduce bicycle congestion in Copenhagen, and the goals of Copenhagen as stated in the 2016 Bicycle Report
    - Want 50% of all trips made in Copenhagen to be by bicycle by 2025
    - 160 - 260 million Danish Kroner per year budget to build the infrastructure to make this happen.
- Discuss the growing population of Copenhagen and how that will increase congestion, according to the 2016 Bicycle Report.
- Discuss with the interviewees about their opinions on Copenhagen's strategies and intersections in general.
    - Of the ways Copenhagen has tried to reduce bicycle congestion in the past, which do you think has been most effective?
    - What do you think of the current cycling conditions in Copenhagen?
    - If you could only choose one bicycle infrastructure change to make, what would it be and why?
    - What do you think the most troublesome aspect of intersections is for cyclists?
    - Do you think there is a future for bicycle roads in Copenhagen, why or why not?
    - Why are cyclists not allowed to make a right turn on a red light? Would this be something that the municipality of Copenhagen would be open to changing?
    - If you could change one aspect of the intersections to benefit cyclists, what would it be?
- We showed the interviewee a map detailing the intersections we had studied, and then discussed our proposed strategies to reduce bicycle congestion in Copenhagen based on modeling. We presented why and how we modeled specific intersections in the PTV Vissim software by using a laptop we brought with the software running.
    - We saw that at the intersections we watched, cyclists would sometimes make illegal right turns over the sidewalks. We thought that by putting in designated right turn lanes, we could alleviate this problem while also giving cyclists the ability to turn right without having to wait in line and contributing to intersection congestion. What do you think of this strategy?

    - We also thought that widening the bicycle lanes of the particularly congested roads, such as the eastbound lane on the Dronning Louises Bro, could help alleviate congestion. Do you think this would help? Has something like this already been implemented in Copenhagen?
    - At both Dronning Louises Bro and Gothersgade, we saw that the green light duration in the traffic light cycles did not favor the side of the intersection that had more bicycle congestion. We are planning to model the intersections with the traffic light duration flipped so that the direction with the most cyclist will receive the larger green duration. Do you think this would work or could it disrupt car traffic too much to be an effective solution?
    - The last solution that we thought of was allowing cyclists to make a right turn on a red light. Would this be an effective strategy to reduce bicycle congestion?
    - "Based on your experience, how do you anticipate this strategy would affect you and other cyclists, as well as pedestrians, and automobile traffic?
    - What resources would have to be allocated to implement these strategies? Resources include the cost of materials, machinery, and man-hours, as well as construction planning. We will assess how implementing these strategies will affect nearby residents, businesses, and transportation economically and socially. While these potential strategies are intended to improve the bicycle infrastructure, there is a potential cost to the car or public transportation infrastructure that we need to identify. For example, widening the bicycle lanes will narrow the car and/or bus lanes. As a result, we need to determine the financial cost of the construction, for which records from the City of Copenhagen are available to the public, and how detours will affect public transportation routes and use.
    - What resources are being allocated to bicycle infrastructure and city planning currently? What is being prioritized (widening bike lanes, green waves)?
    - What is the political environment that affects what gets changed and when?
- Discuss the interviewee's feedback. Answer additional questions and/or comments. Ask follow-up questions depending on questions and/or comments.
    - "Questions or comments?"

    - “In addition to the City of Copenhagen's objective to increase bicycle use to 50% by 2025, the population of Copenhagen is expected to increase by 10,000 residents each year. As a result, the number of cyclists in Copenhagen will increase. We have identified these strategies are able to tolerate an increase in bicycle traffic. In your opinion, which strategy do you think would be the most effective in reducing bicycle congestion out of the potential solutions we have described? In your opinion, do you think that the financial cost and time of investment would be worth it?”
    - “We described how the strategy will affect cyclists and other modes of transportation based on our modeling. The 2011-2025 Bicycle Strategy is concerned with four objectives for improving the bicycle culture in Copenhagen, including city life, comfort, speed, and sense of security. Do you think our proposed strategies will positively contribute to these objectives?”
    - “In your opinion, are there additional factors to consider to determine how the strategy affects cyclists, pedestrians, public transportation, automobiles, etc.?”
    - “What additional resources, financial or social, are necessary to implement the strategy that we have not considered?”
- Discuss the interviewee’s involvement in the implementation of the bicycle strategy.
    - “To what extent would you promote the implementation of the bicycle strategy? Would you advocate for the implementation of the bicycle strategy to other government and non-government officials and organizations?”
    - “Would you provide additional funding/resources to implement the strategy?”

      “Do you know of any individuals or organizations that would be beneficial to contact for further information?”
- Conclude the interview.
    - “Do you have any more questions, comments, or concerns?”
    - “Thank you for participating in this interview.”

  Stop recording.

Objective #3: Modeling of Final Strategies

Following the feedback from the interviews, we modified our brainstormed strategies for use in our final method.

One strategy we tested was increasing the width of the bicycle lanes. We did this to redesign the streets to handle better the large number of bicycles. We did not reduce the overall width of the street and the number of bicycle and automotive lanes, as doing so would greatly reduce the efficiency of the intersection and the hourly traffic flow, and increasing the overall width of the entire street would be impractically expensive. The bicycle lane widths were changed twice, widened first by 0.5 meters, and then by 1.0 meters. We compared both tests to a control intersection, which was unchanged throughout the test. However, we did not widen the lanes of all the roads of the intersections, only the ones that were very congested with bicycle traffic. For the Dronning Louises Bro-Søtorvet intersection, this was the eastbound Dronning Louises Bro road, and for the Gothersgade-Øster Voldgade intersection, it was Gothersgade on both sides of the intersection.

We also tried allowing right turns on red at the intersections. The traffic laws in Copenhagen forbid bicycles (and other vehicles) from performing right turns during a red light. However, this restriction increases congestion, as bicycles must wait until a green light to turn right. Changing this would theoretically increase the number of bicycles that can pass through the intersection in a given light cycle. In our models of this strategy, bicycles on all roads were allowed to turn right, while no motor vehicles were, as interviews informed us this would be too dangerous.

One additional strategy that accomplished a similar goal to right turns on red was creating dedicated right turn lanes. These lanes already exist in some areas throughout Copenhagen, and are separated from the bicycle lanes and the intersection in general that allow cyclists to turn right without backing up the bicycle lane when the light is turned red. We only simulated these where we had seen cyclists make right turns over the sidewalk, and where there was enough space to do so, meaning we could only create them in the lanes shown in Figure 15. These were on the northwest and southwest corners of the Dronning Louises Bro-Søtorvet intersection, and the southeast and northeast corners of the Gothersgade-Øster Voldgade intersection.

Figure 15: Implementation of tracks for right turns for the Gothersgade-Øster Volgade intersection (left), and the Dronning Louises Bro-Søtorvet intersection (right), shown in red.

Our final strategy was altering the timing of the traffic lights. We tested this because the current traffic lights prioritize motorist-heavy roads over bicycle-heavy roads despite the increasing popularity of bicycles. We tested two variations of this strategy: inverting the light timings, and adding 5 seconds for both motorists and cyclists for the bicycle heavy roads of the intersection. These bicycle heavy roads were Dronning Louises Bro and Gothersgade. We inverted the light timings between each side of the intersection, so that a street travelling in one direction would have its timing switched with the street it intersects. We did all this without changing the time where all traffic lights are red, as this allows cars to clear the intersection before the next road gets a green light. We did these two variations because of feedback from the interviews concerning increased motorist congestion from changing the light timings. Two different variations gave us more options to find the light timing that reduced bicycle congestion while also not increasing motorist congestion by more than twenty percent.

To model the data we had collected from the intersections, and analyze the strategies, we used the PTV Vissim software. This highly developed software package allowed us to simulate many types of traffic, including bicycles and cars, using satellite imagery as a base for simulation (PTV Group, 2017). Roadways, or “links” (blue lines in Figure 16), were constructed manually using the satellite imagery as reference to ensure their accuracy. Then, the links were joined together using connectors (violet lines in Figure 16), which we drew onto the intersections to tell the program the possible ways the traffic could go, such as going straight, turning left, and turning right. Once the intersection was constructed, we added controls. These controls consisted of every type of road sign or signal a motorist or cyclist may encounter, such as a stop

sign or a traffic signal. Furthermore, the rules of the road could be changed by editing the “conflict zones”, as shown as the red/green strips in Figure 16, and defined as locations where vehicles traveling through the intersection may collide, such as a motorist turning left across another lane of traffic that is continuing straight. In conflict zones, the green strip indicates the type of traffic that will have the right of way. The simulated vehicles were told where and when to stop using “signal heads.” These are placed anywhere along a link or connector where a stop is desired. A “signal group” connects these together by synchronizing a group of signal heads. The “signal controller” then controls and times each signal group. We also controlled the density of the car, bicycle, and pedestrian traffic individually, allowing us model the specific intersections we looked at in our case study using the data we collected as part of Objective 1.

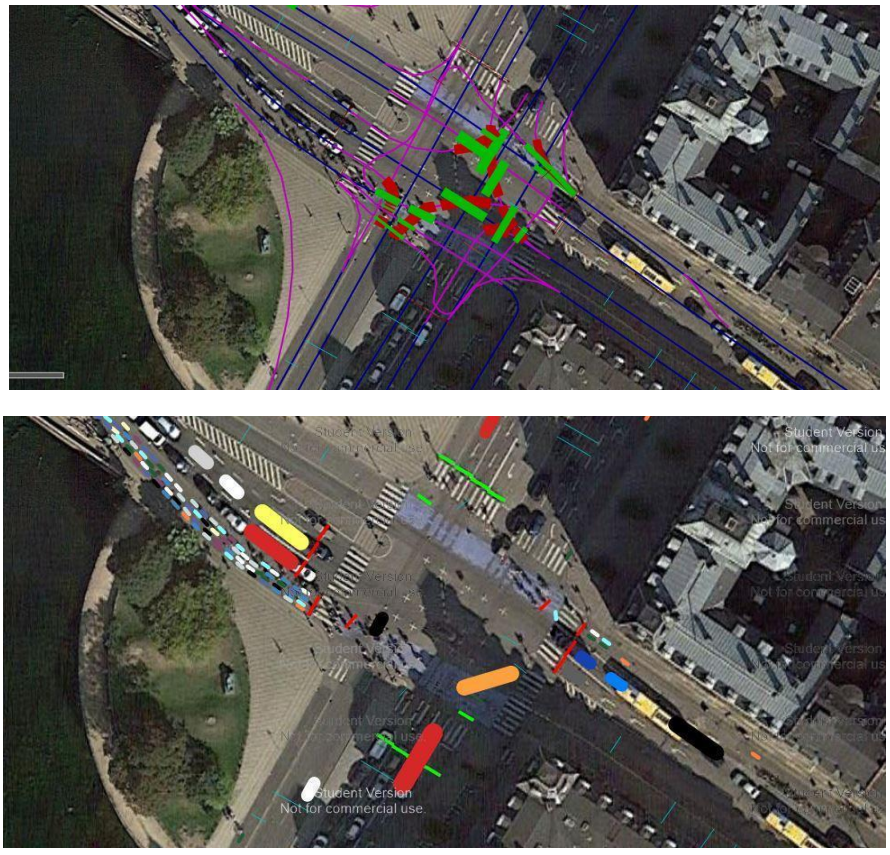

Figure 16: Screenshots of the PTV Vissim software. The upper image shows links, connectors, and conflict areas installed over the background image of the Nørrebrogade intersection. The lower image shows vehicles navigating the intersection.

Once we had set up the general parameters for a given intersection, we inputted the data that we had recorded from our case studies. This included the infrastructure data such as which lanes turn in what direction, the traffic light timings, and the width of the cycling lanes and whether the infrastructure of the streets separated them from the main roadways. We then added the average number of cyclists and cars that passed through the intersection per hour for each individual section of road leading into the intersection, along with the ratios of the cars and cyclists that turned left, right, or took some alternative route (for example a bicycle taking an illegal right turn over a pedestrian walkway). The program used these ratios and determined the number of cyclists and cars that would turn right or left, out of the total traffic per hour; the rest would travel straight. Each intersection had two sets of data, one for the morning rush hour, and one for the evening rush hour, which we modeled separately.

With the intersection configured, we tested our four different strategies intended to decrease congestion in the intersection. We tested each strategy twice for each intersection - once using data from the morning rush hour and once using data from the evening rush hour. We then tried each strategy five times per rush hour period (morning and afternoon) to calculate an average value, as flow rates modeled by PTV Vissim vary slightly among test runs. To obtain a more accurate result, we averaged the results from the five times for each rush hour period per strategy.

We also examined how these strategies would work in the future when Copenhagen's population increased. To do this we increased the traffic flow per hour for each road in an intersection proportionally to the 17% projected Copenhagen population increase stated in the 2016 Bicycle Report, and repeated the same procedure as for current day traffic flow (The City of Copenhagen Technical and Environmental Committee, 2016). In doing so we made the assumption that the numbers of drivers and cyclists would both increase in direct proportion with population increases, even though much of the influx of residents would most likely settle in Amager and other places outside the center of Copenhagen. However, because we did not have quantitative data on projected population increases by region, we were not able to make specific estimates of how geographically uneven population changes would affect traffic at our targeted intersections.

The net change in traffic flow determined the effectiveness of a strategy. An increase in traffic flow meant that congestion had decreased, while a decrease in traffic flow meant that the congestion had increased. We calculated the traffic flow of motorists and bicycles separately, and each road had its own traffic flow of bicycles

and motorists. Because of this, we averaged the four percentages of the cars and bicycles together to get one average percent change in traffic flow for each.

We focused more on an improvement of traffic flow for cyclists, and understood that increasing bicycle traffic flow would likely increase motorist congestion as well. We allowed strategies that did not decrease traffic flow of motorists by more than 20%. This was because favoring bicycles over motor vehicles too much could cause issues regarding air pollution, as forcing a motorist to wait in favor of a cyclist causes them to needlessly spend fuel while idling, according to Suzanne LePage, Professor of Civil and Environmental Engineering at Worcester Polytechnic Institute (LePage, personal communication, 2017). Ideally, we looked for a strategy that increased both cyclists and motor vehicle traffic flow through an intersection.

Results

Objective #1: Case Studies of Intersections

Gothersgade-Øster Voldgade

The first intersection we investigated was the Gothersgade-Øster Voldgade intersection in Nørreport. As seen in Figure 17, the road running from north to south (top to bottom) is Øster Voldgade, while Gothersgade runs from west to east (left to right). All the roads have bicycle tracks that were separate from the road, except the eastbound portion of Gothersgade on the left side of the intersection, which had a right hand turn lane for motorists that merges with the bicycle lane. Only Øster Voldgade had separate bicycle traffic lights that change green for cyclists before the car traffic lights turn green, while Gothersgade cyclists followed the main traffic light.

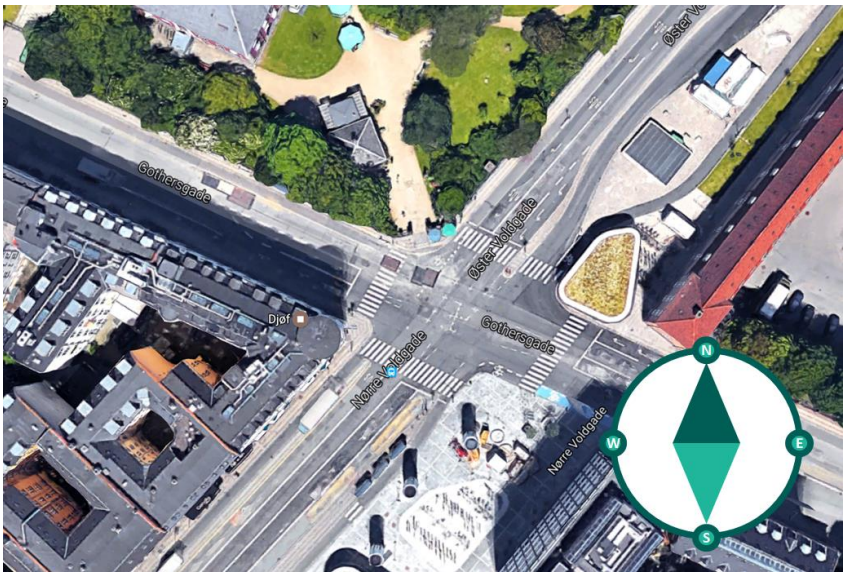

Figure 17: The Gothersgade-Øster Voldgade intersection. Gothersgade runs approximately from west to east (left to right), and Øster Voldgade runs approximately from north to south (top to bottom).

Table 1: Light timings for the Gothersgade-Øster Voldgade intersection (in seconds).

Light Timings (sec)	Green Light (Cyclists)	Green Light (Motorists)	Red Light (Cyclists)	Red Light (Motorists)	Yellow Light
Øster Voldgade	40-45	30	30-35	50	4
Gothersgade	15-20	15-20	60	60	2

In many ways, this was a simple four-way intersection, although a very large amount of vehicle traffic, specifically buses, congested it. This was because Nørreport Station, which serves both the S-train and Metro, is located just below the intersection on Øster Voldgade, and there are bus stops on either side of the road, servicing the station and further congesting the intersection.

Because of this heavy bus traffic, Øster Voldgade had a much longer green light than Gothersgade. This presented a problem because about 2000 cyclists per hour entered the intersection using Gothersgade, which had 20 seconds less green light time. In the morning, the majority of the bicycle traffic traveled eastbound on Gothersgade, and in the afternoon traveled westbound, so the disparity in traffic lights caused congestion for people biking to and from work. Another interesting pattern from the data was that while the bicycle traffic of the intersection was concentrated in Gothersgade, motorist traffic remained constant on all streets in both the morning and the afternoon. Because of this, we believed that the strategy of traffic light adjustment might make a big difference in reducing bicycle congestion at the intersection. It is also important to note that there were periods during the light cycle where all traffic lights in the intersection were red for about 5 seconds. This allowed motorists to clear the intersection and to make right turns they were unable to make because of cyclists riding in the bicycle lanes, but it also increased wait times for both motorists and cyclists.

Table 2: Hourly traffic based on the traffic counts for the Gothersgade-Øster Voldgade intersection.

	# Cyclists	# Cyclists Straight	# Cyclists Right	# Cyclists Left	# Cyclists Illegal Right
Morning					
North (Øster Voldgade)	454	278	28	144	4
South (Øster Voldgade)	716	344	252	16	104
West (Gothersgade)	924	868	4	44	10
East (Nørrebrogade)	852	672	90	36	54
Afternoon					
North (Øster Voldgade)	544	374	80	78	0
South (Øster Voldgade)	592	328	116	42	106
West (Gothersgade)	492	464	8	16	4
East (Gothersgade)	1484	1202	98	86	98

	# Motorists	# Motorists Straight	# Motorists Right	# Motorists Left
Morning				
North (Øster Voldgade)	410	260	26	124
South (Øster Voldgade)	408	320	88	0
West (Gothersgade)	270	174	50	46
East (Gothersgade)	124	56	32	36
Afternoon				
North (Øster Voldgade)	354	232	92	30
South (Øster Voldgade)	316	212	88	16
West (Gothersgade)	252	148	68	36
East (Gothersgade)	0	0	0	0

Dronning Louises Bro-Søtorvet

The Dronning Louises Bro is part of Nørrebrogade, which is one of the most cyclist-heavy roadways in Copenhagen (The City of Copenhagen Technical and Environmental Administration, 2016). It crosses Peblinge Lake, and is one of the few direct ways for cyclists to travel directly to the center of Copenhagen. As seen in Figure 18, Dronning Louises Bro travels from northwest to southeast, and Søtorvet travels from northeast to southwest. There are separated bicycle tracks for all directions of travel except for the westbound Dronning Louises Bro, which is to the right of the intersection. This bicycle lane merges with the right turn lane for motorists.

Figure 18: The Dronning Louises Bro-Søtorvet intersection. Dronning Louises Bro crosses Peblinge Lake (the water in the image) and goes approximately from west to east (left to right), while Søtorvet travels approximately from north to south (top to bottom).

Table 3: Light timings for the Dronning Louises Bro-Søtorvet intersection (in seconds).

Light Timings (sec)	Green Light (Cyclists)	Green Light (Motorists)	Red Light (Cyclists)	Red Light (Motorists)	Yellow Light
Nørrebrogade	20	20	55	55	5
Søtorvet	35	35	40	40	5

We found that the intersection was similar to the Gothersgade-Øster Voldgade intersection in that the traffic light timings do not favor the cyclists. Most cyclists traveled along Dronning Louises Bro, eastbound during the morning rush hour and westbound during the afternoon rush hour, but the green light for Dronning Louises Bro only last 20 seconds, compared to the 40 seconds for Søtorvet. This was presumably because Søtorvet is a major roadway for motorists traveling from the highway into the inner city.

Despite this, over 3600 cyclists cross the Dronning Louises Bro during the morning (traveling eastward). In the afternoon, approximately 2200 cyclists cross back across the bridge from the east, north, and south of the intersection. However, motorist traffic remains relatively constant, the majority of which occurs across Søtorvet and the approximately 2000 motorists are the same between morning and afternoon rush hours. In addition to this, the traffic light cycle for the Dronning Louises Bro-Søtorvet intersection does not change throughout the day. This means that once again changing the traffic lights could greatly reduce the traffic congestion in the intersection.

We also saw several instances in our videos where cyclists would illegally ride over the sidewalk when turning right from Søtorvet to Dronning Louises Bro westbound or from Dronning Louises Bro to Søtorvet southbound. Because of this, we also believed that creating designate right turn lanes for cycling could solve this problem while also reducing cyclist congestion. There was also an alternative right turn where cyclists would cross straight from Dronning Louises Bro before turning right on a separate bike track on the other side to go to another intersection south of Dronning Louises Bro. Despite the data leading us to believe some strategies might work better than others might, we modeled all four strategies for both intersections during both afternoon and morning rush hours.

Table 4: Hourly traffic based on the traffic counts for the Dronning Louises Bro-Søtorvet intersection.

	# Cyclists	# Cyclists Straight	# Cyclists Right	# Cyclists Left	# Cyclists Alt. Right	# Cyclists Illegal Right
Morning						
North (Søtorvet)	798	366	272	66	0	94
South (Søtorvet)	984	824	32	128	0	0
West (Nørrebrogade)	3178	1558	150	368	1000	102
East (Nørrebrogade)	534	500	22	10	0	12
Afternoon						
North (Søtorvet)	1694	588	860	68	0	216
South (Søtorvet)	1132	700	32	400	0	0
West (Nørrebrogade)	1256	660	140	180	262	14
East (Nørrebrogade)	682	620	30	24	0	8

	# Motorists	# Motorists Straight	# Motorists Right	# Motorists Left
Morning				
North (Søtorvet)	1074	1052	0	22
South (Søtorvet)	1044	940	104	0
West (Nørrebrogade)	278	126	124	28
East (Nørrebrogade)	304	206	38	60
Afternoon				
North (Søtorvet)	1000	986	0	14
South (Søtorvet)	932	892	40	0
West (Nørrebrogade)	308	134	116	58
East (Nørrebrogade)	302	208	46	48

Objective #2: Stakeholder Interviews

We contacted fifteen individuals for interviews. We received a response from the five individuals detailed below.

- Klaus Bondam, Director and CEO of the Danish Cyclists' Federation, former Mayor of the City of Copenhagen Technical and Environmental Administration
- Flemming Møller, Danish Cyclists' Federation
- Morten Skou, Owner Copenhagen Bicycles
- Jos van Vlerken, Project Manager for the City of Copenhagen Technical and Environmental Administration
- Helen Lundgaard, Senior Consultant at Capital Region of Denmark

The interviewees are employed by various non-profit, private companies, non-government and government organizations, which provided different perspectives on our potential strategies and how they would affect Copenhagen residents socially and economically. They also provided information on the conditions of cycling in Copenhagen and the main difficulties that cyclists face.

One of the underlying ideas that four out of five interviewees spoke about was making sure that infrastructure accommodated the needs of current cyclists, but also was accessible to any new cyclists. Bondam in particular stated the importance of making the cyclists "feel loved" by listening to them and making changes to infrastructure that would better them (personal communication, 2017). Van Vlerken and Lundgaard also mentioned the goals of the municipality to encourage more people to start cycling. Van Vlerken elaborated that this is the biggest challenge that the city faces when it comes to cycling, as the cramped and crowded nature of rush hour bicycle traffic discourages new cyclists. To reach the goals stated in the 2016 Bicycle Report, "we need to make it so less experienced riders and newcomers are welcomed and are comfortable" (Van Vlerken, personal communication, 2017).

Lundgaard agreed with the importance of getting new cyclists, but looked at it from a different point of view. She saw the problem with encouraging more people to cycle as more of an issue with convenience to individual travelers. Her view was that every day people think about what form of transportation makes the most sense based on what you are trying to accomplish (personal communication, 2017). In other words, which form of transportation is the most convenient to the individual trying to get from

point A to point B? She explained choosing transportation as a convenience hierarchy, as people choose the mode of transportation that is the most convenient for them. So to get more people to start cycling, the convenience of cycling in the city of Copenhagen must be equal to, or greater than, the convenience of walking, driving, or taking public transportation.

We concluded from this line of questioning that we should look for a strategy that makes it more convenient to cycle, and allows newcomers to be comfortable cycling around the city. To understand better the concerns that cyclists have, we asked each of our interviewees (who are all regular cyclists in Copenhagen) what they felt was the most inconvenient or annoying thing about intersections for themselves and others in Copenhagen.

Bondam and Møller both pointed out how traffic light timings do not favor cyclists, with Møller in particular saying that green lights were not long enough for cyclists. Skou, on the other hand, said that not being able to turn right on red legally was his biggest grievance with intersections (personal communication, 2017). However, both Van Vlerken and Lundgaard mentioned something that underlay all of the grievances that our interviewees previously mentioned: the most inconvenient thing for cyclists was to have to stop at the intersection (personal communication, 2017). The light timings and the inability to turn right on red both forced cyclists to stop at the intersection. This is bad since stopping as a cyclist is much different from stopping in a car, and it is much more difficult to get moving again as a cyclist, especially in a crowded lane during rush hour traffic. Van Vlerken also pointed out that he would rather wait through one light cycle that takes 90 seconds than two or three light cycles that only take 45 seconds (personal communication, 2017). Naturally, it is impossible to prevent all stops at an intersection, but judging from the responses of the interviewees a strategy should be able to limit the number of light cycles through which cyclists have to wait.

We then presented the strategies that we planned to use in our modeling. They were creating a designated right turn lane, adjusting traffic lights to benefit cyclists, widening the bicycle lanes, and allowing cyclists to turn right on a red light.

All five of the interviewees were skeptical that the positives of a designated right turn lane for cyclists at an intersection would outweigh the negatives. Bondam and Van Vlerken pointed out that it would just cause conflict between cyclists and pedestrians, because the lane would create another area where cyclists and pedestrians have to be careful not to run into each other. This is because the designated right turn lane would

be separate from the intersection, and cut across the sidewalk to allow the cyclists to turn right without stopping at the main intersection. Skou also stated that Danes are very “right of way oriented,” and will not yield if they believe they have the right of way. He believed that this would cause problems at a right turn lane for cyclists, as pedestrians would cross, believing they were in the right, only to be met by cyclists on the lane who thought they were in the right (personal communication, 2017). Furthermore, Bondam stated he felt that the lane would hurt the aesthetics at the Dronning Louises Bro intersection. Van Vlerken also stated that the municipality of Copenhagen has a goal of getting more people to "hang out" in public places, and that the Dronning Louises Bro in particular is very popular as a spot for citizens to gather for lunch and to talk during the afternoon, as seen in Figure 19. He believed that having a bike lane run through the middle of the pedestrian walkway would discourage people from walking along the bridge (personal communication, 2017). Møller also did not think that the designated right turn lane was a very good option, saying that adding a dashed line to create a right turn lane within the existing bicycle track (like they have for cars on the road) would be a better option (personal communication, 2017).

Figure 19: Pedestrians gathering at the Dronning Louises Bro (Berger, 2015).

Four out of five interviewees thought that the adjustment of the traffic lights could work, but also that there could be some serious drawbacks, in that they would negatively affect car traffic on the roads opposite of the heavy bicycle traffic. Skou and Van Vlerken pointed out that the car traffic on Søtorvet and Øster Voldgade is

particularly heavy (personal communication, 2017). The reason for this, Van Vlerken explained, is that they are both major arteries from motorists going through the city (personal communication, 2017). In fact, Søtorvet is a very high priority motorist road given that it is where most of the people from the highway drive to get to their jobs in Copenhagen (personal communication, 2017). Bondam agreed, stating that while changing the traffic lights would increase bicycle traffic flow, it would congest the car traffic too much, and give unequal priority to cyclists at the expense of motorists (personal communication, 2017). However, Møller pointed out that many cars in Denmark automatically shut off their engines after stopping for 5 seconds, so air pollution from idling engines might not be that much of a concern (personal communication, 2017). However, many trucks and buses take Søtorvet and Øster Voldgade and they are not equipped with such an engine that automatically shuts off. Lastly, Skou suggested that a bicycle bridge would solve the problem without congesting the vehicles, but conceded that building a bicycle bridge would be impossible in the intersections we looked at, because there was simply not enough room (personal communication, 2017).

We noted a similar theme in our interviewees' responses to widening the bike lanes in that it would hurt the already congested car traffic too much. Bondam stated that the lane on Dronning Louises Bro is already so wide that widening it even more would probably force the car traffic on that side of the bridge into one lane, pointing out the inequality it would cause between cyclists and cars (personal communication, 2017). Lundgaard also pointed out that it would not be very effective at reducing congestion either, saying that it would fix the issue for a little while, but it would encourage more traffic to take that route, which would nullify the benefit of the widened lane (personal communication, 2017). Widening the lane would be a temporary fix, but not one that would last, especially with the projected population increases. There is also work already underway on the bicycle lanes at Dronning Louises Bro Intersection. Van Vlerken mentioned that the City of Copenhagen is working to convert the westbound bicycle lane into a bicycle track, so cyclists will no longer have the share a lane with vehicles turning right, which is a dangerous situation in Copenhagen intersections (personal communication, 2017).

Of all of the strategies presented to them, four out of five of the interviewees thought that allowing cyclists to turn right on red would cause the least amount of conflict with other modes of transportation at an intersection. Skou, Møller, Bondam, and Van Vlerken all mentioned that the city is already experimenting with allowing right turns on red at certain intersections (personal communication, 2017). Møller also

worried that because right on red is legal in a few parts of the city, cyclists will believe that it is legal everywhere, and will turn right on red regardless.

All five interviewees believed that allowing right on red was a viable option. However, Møller voiced concerns about making sure that cyclists were educated on when it was safe to make a right turn on red, such as looking to see that the bicycle lane they are turning into is sufficiently clear of cyclists for them to make a safe right turn. Despite this, he believed that allowing right turns on a red light would force cyclists to be much more observant (personal communication, 2017) than they are currently. Skou and Van Vlerken also specified that the City of Copenhagen should only permit cyclists to turn right during a red light, as allowing it for motorists would be too dangerous. Skou explained this as cyclists must be more alert and careful when making a right turn: "If a cyclist hits a pedestrian, then both the cyclists and pedestrian are going to get hurt badly. But if a car hits a pedestrian, only the pedestrian is hurt," so the driver of the car will not be as careful in looking for pedestrians as the cyclists (personal communication, 2017). In addition, cars have to look out for other cars, cyclists, and pedestrians when making a right on red, while cyclists only have to look for other cyclists and pedestrians (personal communication, 2017). This gives cyclists one less thing to worry about and less of a chance to overlook something and cause an accident.

Lundgaard showed cautious optimism for the strategy, saying that while it was a very viable solution, it would not increase traffic flow substantially by itself, and the City of Copenhagen would likely need to implement it in conjunction with another strategy (personal communication, 2017). She also suggested dividing the bike track into two lanes near the intersection, one for turning right and the other for going straight.

Detailed transcripts of the interviews are located in Appendix A of the supplemental materials. Skou did not wish to record the interview, and notes from his interview have been included in Appendix A.

Objective #3: Modeling of Potential Strategies

We used the data collected from the case studies of the selected intersections to model and simulate traffic after modifying them using the advice and feedback from the experts and stakeholders. By collecting data on the timing of the traffic lights and hourly flow rates of motorists and cyclists, we tested strategies to alter the flow of

traffic at each intersection by modifying various attributes, such as the width of lanes and the timings of the traffic lights.

We used the PTV Vissim software to model both of the selected intersections - Gothersgade-Øster Voldgade and Dronning Louises Bro-Søtorvet - as shown below in Figure 20.

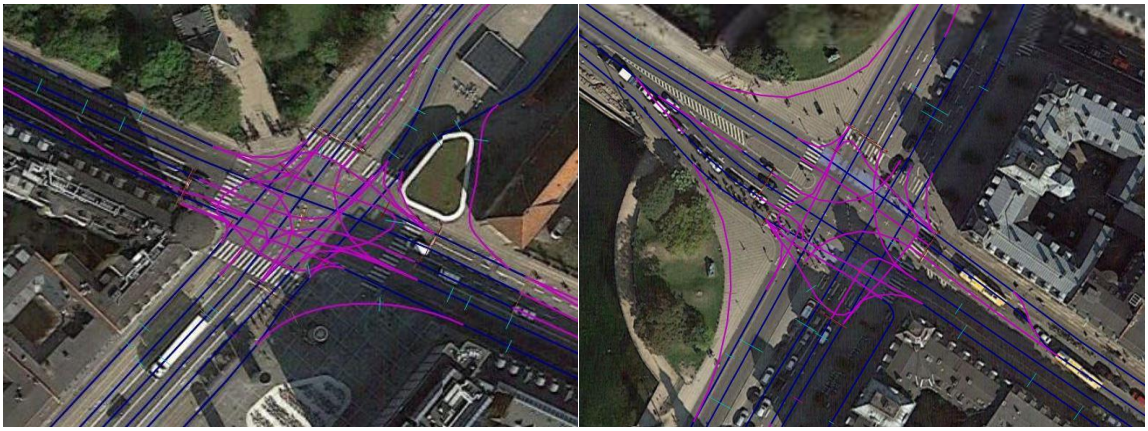

Figure 20: Simulated intersections - Gothersgade-Øster Voldgade (left) and Dronning Louises Bro-Søtorvet (right) - using PTV Vissim.

We tested the following strategies: increasing the width of bicycle lanes, allowing vehicles to turn right during a red light, adjusting light timings and dedicating separate right turn lanes for motorists. Following the interviews, we revised our existing strategies. For right turns on red, we divided the lane in half and allowed one side to go straight, while the other would turn right. This was from concerns from the interviewees that unless the City of Copenhagen implemented a right turn lane, people who wanted to turn right would be stuck in line behind those going straight at the intersection. In addition, due to concerns that both widening the bicycle lanes and adjusting the traffic light timing would increase congestion for motorists, we conducted two variations of each strategy to have more options to find a strategy that did not increase motorist congestion by over 20%.

This section provides the results of these strategies. We tested each strategy or variation of the strategy five times and averaged the results. We then compared them to a baseline data set, which corresponded to the modeled intersection without any modifications, as shown below in Tables 5 and 6.

Table 5: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with no changes.

Unchanged	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Standard Deviation
Morning							
Bicycles (North)	426	408	456	402	348	408	35
Bicycles (East)	726	816	726	642	744	731	55
Bicycles (South)	726	696	618	732	654	685	43
Bicycles (West)	858	720	858	756	690	776	70
Motorists (North)	342	462	360	360	432	391	47
Motorists (East)	210	234	210	204	228	217	12
Motorists (South)	396	414	402	462	426	420	23
Motorists (West)	294	240	246	270	228	256	24
Afternoon							
Bicycles (North)	378	378	414	390	456	403	29
Bicycles (East)	1332	1302	1260	1158	1350	1280	68
Bicycles (South)	624	516	522	594	504	552	48
Bicycles (West)	438	516	432	414	408	442	39
Motorists (North)	354	324	288	264	318	310	31
Motorists (East)	342	378	282	354	306	332	34
Motorists (South)	288	414	342	294	372	342	48
Motorists (West)	186	198	222	180	246	206	24

Table 6: Current numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with no changes.

Unchanged	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Standard Deviation
Morning							
Bicycles (West)	2388	2430	2424	2376	2376	2399	24
Bicycles (East)	456	510	504	612	576	532	55
Bicycles (South)	972	996	984	1044	972	994	27
Bicycles (North)	714	696	762	702	648	704	37
Motorists (North)	1062	984	1032	948	1032	1012	40
Motorists (South)	1074	1068	858	900	942	968	88
Motorists (East)	246	222	312	222	180	236	43
Motorists (West)	252	330	240	288	318	286	35
Afternoon							
Bicycles (West)	618	648	618	648	564	619	31
Bicycles (East)	1038	816	804	930	792	876	95
Bicycles (South)	1092	972	1164	1026	1068	1064	64
Bicycles (North)	1656	1602	1656	1806	1704	1685	69
Motorists (North)	930	918	1014	858	1002	944	57
Motorists (South)	954	954	780	858	1002	910	80
Motorists (East)	246	306	276	294	258	276	22
Motorists (West)	258	288	240	318	300	281	28

We also repeated these tests using an increased traffic flow based on predicted trends calculated by The City of Copenhagen (The City of Copenhagen Technical and Environmental Administration, 2016). We used a flat increase of 17% for all traffic - motorists and cyclists alike -and kept all other strategies the same as before. The results of which are shown below in Tables 7 and 8.

Table 7: Projected numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with no changes.

Unchanged	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Standard Deviation
Morning							
Bicycles (North)	414	432	486	540	444	463	45
Bicycles (East)	822	768	846	762	900	820	51
Bicycles (South)	702	786	702	840	612	728	78
Bicycles (West)	864	918	954	930	864	906	36
Motorists (North)	342	468	354	366	420	390	47
Motorists (East)	228	294	258	198	234	242	32
Motorists (South)	462	456	456	456	408	448	20
Motorists (West)	288	270	264	210	300	266	31
Afternoon							
Bicycles (North)	486	570	534	402	522	503	57
Bicycles (East)	1320	1392	1140	1452	1398	1340	109
Bicycles (South)	822	546	600	594	786	670	112
Bicycles (West)	432	486	456	492	408	455	32
Motorists (North)	414	450	360	426	348	400	39
Motorists (East)	396	384	420	372	390	392	16
Motorists (South)	378	420	390	348	372	382	24
Motorists (West)	240	252	204	228	312	247	36

Table 8: Projected numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with no changes.

Unchanged	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Standard Deviation
Morning							
Bicycles (West)	2580	2454	2412	2604	2376	2485	91
Bicycles (East)	582	678	672	666	630	646	36
Bicycles (South)	960	1068	978	978	1218	1040	96
Bicycles (North)	828	828	924	1032	894	901	75
Motorists (North)	1188	1092	1176	1164	1062	1136	50
Motorists (South)	1176	1224	1212	1122	1026	1152	72
Motorists (East)	252	288	240	258	240	256	18
Motorists (West)	294	378	306	252	294	305	41
Afternoon							
Bicycles (West)	780	660	816	624	786	733	76
Bicycles (East)	972	792	846	822	990	884	81
Bicycles (South)	1314	1266	1422	1194	1290	1297	74
Bicycles (North)	1740	1992	1896	2118	1962	1942	124
Motorists (North)	1116	1056	1074	1032	1074	1070	28
Motorists (South)	978	1158	876	1128	1080	1044	104
Motorists (East)	372	300	342	336	294	329	29
Motorists (West)	282	288	300	258	300	286	15

Increasing the Width of Bicycle Lanes

We widened the bicycle lanes twice, the first time by 0.5 meters, and the second time by 1 meter. Each variation of lane width was run five times and averaged, as shown below in Tables 9, 10, 11, and 12.

Table 9: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with some bicycle lanes increased by 0.5m.

+0.5m	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	366	294	402	396	468	385	-5.59%	56
Bicycles (East)	810	768	804	852	822	811	11.00%	27
Bicycles (South)	738	696	660	690	606	678	-1.05%	44
Bicycles (West)	822	930	774	834	744	821	5.72%	64
Motorists (North)	330	390	408	294	396	364	-7.06%	44
Motorists (East)	234	222	204	174	186	204	-6.08%	22
Motorists (South)	498	408	390	474	426	439	4.57%	41
Motorists (West)	222	258	198	270	276	245	-4.23%	30
Afternoon								
Bicycles (North)	372	402	456	378	414	404	0.30%	30
Bicycles (East)	1194	1308	1374	1224	1296	1279	-0.09%	64
Bicycles (South)	570	522	570	642	498	560	1.50%	49
Bicycles (West)	372	426	402	348	414	392	-12.54%	29
Motorists (North)	402	366	366	336	342	362	14.57%	23
Motorists (East)	330	288	306	324	294	308	-7.78%	16
Motorists (South)	342	312	312	354	252	314	-8.78%	35
Motorists (West)	192	246	258	192	204	218	5.49%	28

Table 10: Current numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with some bicycle lanes increased by 0.5m.

+0.5m	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	2658	2556	2568	2538	2664	2597	8.25%	53
Bicycles (East)	534	576	534	516	564	545	2.48%	22
Bicycles (South)	960	870	1038	1002	1098	994	0.00%	77
Bicycles (North)	780	720	858	714	702	755	7.16%	58
Motorists (North)	942	900	894	912	828	895	-11.51%	37
Motorists (South)	1050	858	996	966	840	942	-2.73%	81
Motorists (East)	324	210	240	192	252	244	3.05%	45
Motorists (West)	270	318	264	312	312	295	3.36%	23
Afternoon								
Bicycles (West)	600	714	510	558	606	598	-3.61%	68
Bicycles (East)	1020	1032	1104	1050	1050	1051	16.67%	29
Bicycles (South)	918	1110	1032	1152	1116	1066	0.11%	84
Bicycles (North)	1500	1428	1560	1554	1506	1510	-11.61%	47
Motorists (North)	900	840	936	1026	1074	955	1.13%	85
Motorists (South)	798	870	990	984	828	894	-1.74%	79
Motorists (East)	318	300	330	264	426	328	15.75%	54
Motorists (West)	288	294	276	318	270	289	2.90%	17

Table 11: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with some bicycle lanes increased by 1.0m.

+1.0m	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	378	402	462	456	282	396	-2.94%	65
Bicycles (East)	798	768	888	636	726	763	4.43%	83
Bicycles (South)	666	636	684	624	762	674	-1.58%	49
Bicycles (West)	702	768	768	726	798	752	-3.09%	34
Motorists (North)	420	390	336	366	390	380	-2.76%	28
Motorists (East)	258	252	198	270	204	236	8.84%	30
Motorists (South)	480	372	390	330	408	396	-5.71%	49
Motorists (West)	276	246	264	210	210	241	-5.63%	27
Afternoon								
Bicycles (North)	396	498	282	402	450	406	0.59%	72
Bicycles (East)	1314	1332	1392	1392	1404	1367	6.32%	36
Bicycles (South)	582	570	612	600	648	602	8.37%	27
Bicycles (West)	390	498	378	444	414	425	-3.95%	43
Motorists (North)	306	390	276	342	348	332	6.86%	39
Motorists (East)	300	396	390	366	294	349	4.81%	44
Motorists (South)	354	396	366	390	336	368	7.17%	22
Motorists (West)	150	174	180	294	234	206	0.00%	52

Table 12: Current numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with some bicycle lanes increased by 1.0m.

+1.0m	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	2850	2898	2622	2820	2844	2807	17.01%	96
Bicycles (East)	570	450	564	552	600	547	2.93%	51
Bicycles (South)	1026	978	1074	978	936	998	0.48%	47
Bicycles (North)	948	792	786	768	858	830	17.89%	66
Motorists (North)	960	822	1008	924	942	931	-7.95%	61
Motorists (South)	930	990	978	990	1002	978	0.99%	25
Motorists (East)	210	168	216	216	186	199	-15.74%	19
Motorists (West)	252	222	276	282	300	266	-6.72%	27
Afternoon								
Bicycles (West)	630	612	654	606	570	614	-0.78%	28
Bicycles (East)	1116	1200	1038	1176	1098	1126	22.17%	58
Bicycles (South)	1092	1110	1080	1092	1074	1090	2.31%	12
Bicycles (North)	1674	1674	1836	1698	1656	1708	1.34%	66
Motorists (North)	912	1014	846	936	936	929	-1.68%	54
Motorists (South)	900	864	732	780	918	839	-8.44%	71
Motorists (East)	246	324	360	264	222	283	2.54%	51
Motorists (West)	240	312	294	258	282	277	-1.30%	26

We also repeated these tests using an increased traffic flow using the same increase detailed at the beginning of this section. Tables 13, 14, 15, and 16 detail the results of these increased tests.

Table 13: Projected numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with some bicycle lanes increased by 0.5m.

+0.5m	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	2616	2652	2640	2832	2514	2651	6.66%	103
Bicycles (East)	552	702	684	648	642	646	0.00%	52
Bicycles (South)	1098	1146	1164	1062	1104	1115	7.15%	36
Bicycles (West)	948	966	870	1044	882	942	4.53%	63
Motorists (North)	1020	1080	1212	1032	1092	1087	-4.33%	68
Motorists (East)	1266	1158	1032	1218	1080	1151	-0.10%	86
Motorists (South)	258	258	240	282	300	268	4.69%	21
Motorists (West)	294	324	366	318	270	314	3.15%	32
Afternoon								
Bicycles (North)	588	450	378	486	486	478	-5.28%	68
Bicycles (East)	1650	1554	1356	1650	1500	1542	13.07%	109
Bicycles (South)	654	642	672	612	702	656	-2.01%	30
Bicycles (West)	558	450	462	486	486	488	6.88%	37
Motorists (North)	504	474	474	432	462	469	14.83%	23
Motorists (East)	402	300	372	426	372	374	-4.81%	42
Motorists (South)	408	456	360	408	390	404	5.64%	31
Motorists (West)	258	240	264	258	234	251	1.44%	12

Table 14: Projected numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with some bicycle lanes increased by 0.5m.

+0.5m	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	2616	2652	2640	2832	2514	2651	6.66%	103
Bicycles (East)	552	702	684	648	642	646	0.00%	52
Bicycles (South)	1098	1146	1164	1062	1104	1115	7.15%	36
Bicycles (North)	948	966	870	1044	882	942	4.53%	63
Motorists (North)	1020	1080	1212	1032	1092	1087	-4.33%	68
Motorists (South)	1266	1158	1032	1218	1080	1151	-0.10%	86
Motorists (East)	258	258	240	282	300	268	4.69%	21
Motorists (West)	294	324	366	318	270	314	3.15%	32
Afternoon								
Bicycles (West)	726	726	738	684	648	704	-4.09%	34
Bicycles (East)	1038	1098	930	948	858	974	9.24%	84
Bicycles (South)	1116	1326	1500	1158	1374	1295	-0.19%	141
Bicycles (North)	1824	1932	1896	1860	1878	1878	-3.39%	36
Motorists (North)	1074	996	1056	1014	1086	1045	-2.41%	35
Motorists (South)	906	1074	1050	1152	1026	1042	-0.23%	80
Motorists (East)	372	294	336	294	246	308	-6.61%	43
Motorists (West)	288	282	300	222	258	270	-5.78%	28

Table 15: Projected numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with some bicycle lanes increased by 1.0m.

+1.0m	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	510	510	372	504	486	476	2.8%	53
Bicycles (East)	846	792	744	816	852	810	-1.2%	39
Bicycles (South)	876	804	786	828	858	830	14.0%	33
Bicycles (West)	1056	846	906	990	960	952	5.0%	72
Motorists (North)	240	204	396	450	336	325	-16.6%	92
Motorists (East)	276	222	306	192	240	247	2.0%	40
Motorists (South)	474	450	438	456	522	468	4.6%	29
Motorists (West)	276	234	300	318	354	296	11.3%	40
Afternoon								
Bicycles (North)	528	528	474	456	492	496	-1.45%	29
Bicycles (East)	1488	1728	1548	1620	1674	1612	16.83%	86
Bicycles (South)	624	666	654	774	786	701	4.45%	66
Bicycles (West)	420	528	432	366	468	443	-2.71%	54
Motorists (North)	414	366	402	396	456	407	1.77%	29
Motorists (East)	420	426	342	444	348	396	0.91%	42
Motorists (South)	366	468	414	420	402	414	7.83%	33
Motorists (West)	252	282	246	210	246	247	0.00%	23

Table 16: Projected numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with some bicycle lanes increased by 1.0m.

+1.0m	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	2856	2898	2880	2844	2874	2870	15.50%	19
Bicycles (East)	636	624	570	702	642	635	-1.67%	42
Bicycles (South)	1296	1074	1188	1050	1020	1126	8.19%	102
Bicycles (North)	828	936	786	888	984	884	-1.86%	71
Motorists (North)	1146	1098	1062	1020	1116	1088	-4.22%	44
Motorists (South)	1050	1140	1164	1122	1086	1112	-3.44%	40
Motorists (East)	318	276	198	252	234	256	0.00%	40
Motorists (West)	216	306	264	366	312	293	-3.94%	50
Afternoon								
Bicycles (West)	798	864	780	732	852	805	8.94%	48
Bicycles (East)	1062	1326	1092	1188	1062	1146	22.83%	101
Bicycles (South)	1362	1284	1134	1200	1284	1253	-3.54%	78
Bicycles (North)	1842	1974	1884	1932	1632	1853	-4.79%	119
Motorists (North)	1116	1086	1086	1020	996	1061	-0.90%	45
Motorists (South)	1044	1056	1044	966	990	1020	-2.35%	35
Motorists (East)	258	408	348	300	384	340	3.18%	55
Motorists (West)	186	318	282	258	312	271	-5.31%	48

Allowing Vehicles to Turn Right on a Red Light

We tested this strategy with by permitting all vehicles crossing each intersection to turn right on a red light. Tables 17 and 18 detail the results of these tests.

Table 17: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with right turns on red allowed.

Right on Red	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	426	420	378	354	306	377	-7.65%	44
Bicycles (East)	810	714	756	624	762	733	0.33%	63
Bicycles (South)	708	684	600	642	798	686	0.18%	67
Bicycles (West)	690	906	732	810	690	766	-1.39%	83
Motorists (North)	288	426	300	342	378	347	-11.35%	51
Motorists (East)	252	222	228	258	222	236	8.84%	15
Motorists (South)	456	426	492	426	444	449	6.86%	24
Motorists (West)	264	222	270	156	210	224	-12.21%	41
Afternoon								
Bicycles (North)	354	366	450	348	450	394	-2.44%	46
Bicycles (East)	930	1110	948	1032	960	996	-28.55%	67
Bicycles (South)	510	564	474	576	474	520	-6.24%	43
Bicycles (West)	426	396	402	414	372	402	-9.85%	18
Motorists (North)	360	324	360	270	360	335	7.53%	35
Motorists (East)	348	264	330	324	348	323	-2.97%	31
Motorists (South)	324	354	378	342	432	366	6.56%	37
Motorists (West)	210	162	240	204	228	209	1.15%	27

Table 18: Current numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with right turns on red allowed.

Right on Red	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	2178	1830	1836	1962	2136	1988	-17.11%	146
Bicycles (East)	336	372	342	288	366	341	-35.89%	30
Bicycles (South)	510	498	660	570	690	586	-41.06%	78
Bicycles (North)	852	726	654	918	720	774	9.88%	96
Motorists (North)	954	876	846	840	918	887	-12.34%	43
Motorists (South)	954	876	954	996	786	913	-5.70%	74
Motorists (East)	228	246	282	288	306	270	14.21%	29
Motorists (West)	378	354	318	246	384	336	17.65%	51
Afternoon								
Bicycles (West)	510	666	594	714	666	630	1.71%	71
Bicycles (East)	840	948	660	882	822	830	-5.49%	96
Bicycles (South)	702	828	720	822	816	778	-36.88%	55
Bicycles (North)	1608	1668	1806	1572	1626	1656	-1.74%	81
Motorists (North)	906	912	996	810	930	911	-3.69%	60
Motorists (South)	852	846	816	966	900	876	-3.84%	52
Motorists (East)	258	204	276	306	270	263	-5.02%	33
Motorists (West)	342	312	282	222	306	293	4.10%	40

We also repeated these tests using an increased traffic flow using the same increase detailed at the beginning of this section. Tables 19 and 20 detail the results of these increased tests.

Table 19: Projected numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with right turns on red allowed.

Right on Red	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	372	390	486	510	468	445	-3.89%	54
Bicycles (East)	846	870	966	870	804	871	6.30%	53
Bicycles (South)	954	696	786	978	810	845	15.98%	106
Bicycles (West)	834	948	858	918	942	900	-0.66%	46
Motorists (North)	378	318	360	300	384	348	-10.77%	33
Motorists (East)	324	270	252	228	264	268	10.40%	32
Motorists (South)	516	450	498	480	420	473	5.63%	34
Motorists (West)	276	252	234	264	312	268	0.45%	26
Afternoon								
Bicycles (North)	420	432	462	456	462	446	-12.63%	17
Bicycles (East)	990	972	1086	1074	996	1024	-30.95%	47
Bicycles (South)	612	672	558	600	648	618	-8.35%	39
Bicycles (West)	474	450	486	522	492	485	6.19%	24
Motorists (North)	420	396	366	450	492	425	5.93%	43
Motorists (East)	372	366	354	324	372	358	-9.73%	18
Motorists (South)	390	402	414	426	450	416	8.36%	21
Motorists (West)	204	318	258	264	198	248	0.48%	44

Table 20: Projected numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with right turns on red allowed.

Right on Red	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	1842	1938	1908	2064	2124	1975	-20.52%	104
Bicycles (East)	402	384	396	408	396	397	-38.48%	8
Bicycles (South)	828	690	714	702	876	762	-26.76%	75
Bicycles (North)	864	852	840	924	882	872	-3.20%	29
Motorists (North)	1038	1092	1086	960	1026	1040	-8.45%	48
Motorists (South)	966	1110	978	1098	1038	1038	-9.90%	59
Motorists (East)	336	240	312	288	276	290	13.62%	33
Motorists (West)	456	462	408	354	390	414	35.83%	41
Afternoon								
Bicycles (West)	756	768	648	756	600	706	-3.91%	68
Bicycles (East)	888	924	930	888	864	899	1.60%	25
Bicycles (South)	966	954	900	894	954	934	-38.95%	30
Bicycles (North)	1956	1668	1758	1944	1938	1853	-4.79%	118
Motorists (North)	1038	1020	1002	1080	1026	1033	-3.60%	26
Motorists (South)	972	978	996	996	1056	1000	-4.44%	30
Motorists (East)	312	306	378	324	342	332	1.08%	26
Motorists (West)	228	192	198	240	288	229	-24.61%	34

Dedicated Right Turn Tracks

We only modeled dedicated right turn tracks on the corners of North Søtorvet - East Dronning Louises Bro, South Søtorvet - East Dronning Louises Bro, North Øster Voldgade - East Gothersgade, and South Øster Voldgade - East Gothersgade. Tables 21 and 22 detail the resulting traffic flow rates from these tests.

Table 21: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with right turn tracks.

Right Turn Lanes	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	414	372	414	372	384	391	-4.12%	19
Bicycles (East)	810	714	798	822	738	776	6.24%	43
Bicycles (South)	630	810	738	594	618	678	-1.05%	82
Bicycles (West)	798	924	876	762	876	847	9.12%	59
Motorists (North)	390	366	306	366	360	358	-8.59%	28
Motorists (East)	282	324	216	240	258	264	21.55%	37
Motorists (South)	462	354	444	420	426	421	0.29%	37
Motorists (West)	174	228	288	246	282	244	-4.69%	41
Afternoon								
Bicycles (North)	396	486	480	498	414	455	11.35%	41
Bicycles (East)	1230	1266	1266	1224	1356	1268	-0.95%	47
Bicycles (South)	522	504	558	576	564	545	-1.32%	27
Bicycles (West)	462	456	510	456	462	469	5.88%	21
Motorists (North)	390	384	402	336	366	376	17.57%	23
Motorists (East)	384	258	264	348	426	336	1.07%	66
Motorists (South)	402	330	408	432	276	370	7.47%	58
Motorists (West)	204	222	252	270	288	247	16.50%	31

Table 20: Current numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with right turn tracks.

Right Turn Lanes	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	2514	2568	2718	2544	2460	2561	6.75%	86
Bicycles (East)	594	510	510	546	516	535	0.68%	32
Bicycles (South)	990	1014	1116	918	1020	1012	1.81%	64
Bicycles (North)	810	816	720	690	768	761	8.01%	49
Motorists (North)	990	834	804	900	972	900	-11.03%	73
Motorists (South)	1122	1014	1050	972	1032	1038	7.19%	49
Motorists (East)	192	192	258	270	294	241	2.03%	42
Motorists (West)	324	282	258	192	270	265	-7.14%	43
Afternoon								
Bicycles (West)	636	516	588	696	690	625	0.96%	67
Bicycles (East)	960	900	984	1098	1020	992	11.73%	66
Bicycles (South)	1098	1116	1062	1236	1068	1116	4.62%	63
Bicycles (North)	1680	1656	1620	1518	1662	1627	-3.54%	58
Motorists (North)	924	792	978	870	834	880	-7.37%	66
Motorists (South)	900	948	948	894	822	902	-0.80%	46
Motorists (East)	288	282	294	264	282	282	2.13%	10
Motorists (West)	258	210	276	216	264	245	-14.71%	27

We also repeated these tests using an increased traffic flow using the same increase detailed at the beginning of this section. Tables 23 and 24 detail the results of these increased tests.

Table 23: Projected numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with right turns tracks.

Right Turn Lanes	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	444	462	528	528	390	470	1.55%	53
Bicycles (East)	738	660	768	828	738	746	-8.93%	54
Bicycles (South)	768	852	876	678	738	782	7.41%	73
Bicycles (West)	1038	852	954	870	828	908	0.26%	77
Motorists (North)	402	342	348	378	240	342	-12.31%	55
Motorists (East)	282	300	264	246	270	272	12.38%	18
Motorists (South)	480	480	450	456	486	470	5.09%	14
Motorists (West)	324	270	240	246	234	263	-1.35%	33
Afternoon								
Bicycles (North)	456	480	522	480	438	475	-5.81%	28
Bicycles (East)	1350	1398	1308	1248	1248	1310	-2.29%	58
Bicycles (South)	672	636	792	720	570	678	1.24%	75
Bicycles (West)	462	468	432	528	462	470	3.32%	31
Motorists (North)	408	408	396	300	444	391	-2.15%	48
Motorists (East)	390	342	432	396	384	389	-0.93%	29
Motorists (South)	432	486	456	390	414	436	12.40%	33
Motorists (West)	264	288	192	222	270	247	0.00%	35

Table 24: Projected numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with right turn tracks.

Right Turn Lanes	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	2496	2418	2604	2514	2454	2497	0.48%	63
Bicycles (East)	570	672	564	612	606	605	-6.32%	39
Bicycles (South)	1170	978	1038	1122	1260	1114	7.04%	99
Bicycles (North)	906	924	936	948	846	912	1.20%	36
Motorists (North)	1062	1176	1134	1128	1182	1136	0.00%	43
Motorists (South)	1206	1212	1134	1218	1140	1182	2.60%	37
Motorists (East)	282	240	228	222	192	233	-8.92%	29
Motorists (West)	276	306	240	288	300	282	-7.48%	23
Afternoon								
Bicycles (West)	696	636	756	792	816	739	0.81%	66
Bicycles (East)	972	888	882	900	834	895	1.21%	44
Bicycles (South)	1452	1188	1260	1308	1278	1297	0.00%	87
Bicycles (North)	1842	1776	2082	1806	1896	1880	-3.25%	108
Motorists (North)	1146	1110	960	1062	1110	1078	0.67%	65
Motorists (South)	1116	1116	858	894	924	982	-6.36%	112
Motorists (East)	336	360	372	282	306	331	0.72%	33
Motorists (West)	240	324	342	276	264	289	1.24%	38

Altering Traffic Light Cycles

We tested the two variations of adjusting the traffic light timings five times and averaged the results as done for the other strategies. For the Dronning Louises Bro-Søtorvet intersection, we modeled two variations: inverting the traffic light cycles between the two roads, and giving an additional 5 seconds to those traveling across Dronning Louises Bro. For the Gothersgade-Øster Voldgade intersection, we tested three variations: inverting the traffic lights between Gothersgade and Øster Voldgade, giving Gothersgade an additional 5 seconds, and giving Øster Voldgade an additional 5 seconds. Tables 25, 26, 27, 28, and 29 detail the results of these tests.

Table 25: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with the traffic light cycles inverted.

Lights Inverted	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	408	366	378	384	414	390	-4.41%	18
Bicycles (East)	864	726	702	714	810	763	4.43%	63
Bicycles (South)	696	768	750	798	630	728	6.30%	59
Bicycles (West)	942	792	750	924	798	841	8.35%	77
Motorists (North)	408	324	378	366	390	373	-4.60%	28
Motorists (East)	294	270	198	324	282	274	25.97%	42
Motorists (South)	360	366	450	354	462	398	-5.14%	47
Motorists (West)	264	204	282	228	174	230	-9.86%	39
Afternoon								
Bicycles (North)	426	402	390	390	438	409	1.47%	19
Bicycles (East)	1044	1146	1170	1308	1122	1158	-10.57%	86
Bicycles (South)	552	618	552	570	630	584	5.54%	33
Bicycles (West)	426	420	432	336	504	424	-4.25%	53
Motorists (North)	282	342	408	432	342	361	14.29%	53
Motorists (East)	336	342	318	252	270	304	-9.49%	36
Motorists (South)	372	348	294	420	462	379	9.81%	58
Motorists (West)	228	222	270	192	252	233	11.34%	27

Table 26: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with an additional 5 seconds for Gothersgade.

Gothersgade +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	390	384	390	480	396	408	0.00%	36
Bicycles (East)	744	894	774	810	762	797	9.03%	53
Bicycles (South)	672	756	654	606	720	682	-0.53%	52
Bicycles (West)	810	762	798	816	864	810	4.33%	33
Motorists (North)	384	366	414	378	318	372	-4.91%	31
Motorists (East)	252	228	270	270	246	253	16.57%	16
Motorists (South)	360	324	384	366	372	361	-14.00%	20
Motorists (West)	264	294	204	198	276	247	-3.29%	39
Afternoon								
Bicycles (North)	528	348	456	360	360	410	1.75%	71
Bicycles (East)	1392	1386	1308	1260	1470	1363	6.07%	73
Bicycles (South)	558	642	534	612	576	584	5.54%	38
Bicycles (West)	462	414	486	408	402	434	-1.66%	33
Motorists (North)	348	360	336	318	414	355	12.84%	33
Motorists (East)	312	300	390	288	378	334	0.36%	42
Motorists (South)	294	360	324	318	378	335	-2.15%	30
Motorists (West)	264	198	288	240	222	242	14.85%	31

Table 27: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with an additional 5 seconds for Øster Voldgade.

Øster Voldgade +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	420	402	306	384	372	377	-7.65%	39
Bicycles (East)	924	804	798	612	876	803	9.85%	106
Bicycles (South)	678	648	798	708	660	698	1.93%	54
Bicycles (West)	792	828	750	792	762	785	1.08%	27
Motorists (North)	360	396	264	384	366	354	-9.51%	47
Motorists (East)	180	228	234	216	246	221	1.66%	23
Motorists (South)	426	402	456	456	426	433	3.14%	21
Motorists (West)	246	270	216	174	276	236	-7.51%	38
Afternoon								
Bicycles (North)	366	378	402	414	366	385	-4.67%	19
Bicycles (East)	1110	1008	930	1344	1134	1105	-15.85%	140
Bicycles (South)	576	684	618	492	720	618	10.68%	80
Bicycles (West)	384	384	486	438	366	412	-7.29%	44
Motorists (North)	438	378	336	330	378	372	16.77%	39
Motorists (East)	378	366	390	384	294	362	8.28%	35
Motorists (South)	426	342	378	384	336	373	8.36%	33
Motorists (West)	210	204	186	162	222	197	-4.88%	21

Table 28: Current numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with traffic light cycles inverted.

Inverted Lights	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	3186	2880	3198	3108	3174	3109	29.61%	119
Bicycles (East)	606	552	636	516	528	568	6.77%	46
Bicycles (South)	870	876	666	864	1038	863	-13.16%	118
Bicycles (North)	762	762	684	708	720	727	3.24%	31
Motorists (North)	804	774	774	822	756	786	-22.30%	24
Motorists (South)	822	858	654	876	858	814	-15.99%	82
Motorists (East)	222	336	324	234	282	280	18.27%	46
Motorists (West)	306	300	264	246	276	278	-2.52%	22
Afternoon								
Bicycles (West)	660	660	708	600	624	650	4.80%	37
Bicycles (East)	1332	1248	1434	1170	1008	1238	29.26%	145
Bicycles (South)	960	966	1080	1062	1140	1042	-2.19%	69
Bicycles (North)	1704	1626	1488	1620	1536	1595	-5.64%	75
Motorists (North)	762	798	768	732	816	775	-21.83%	29
Motorists (South)	816	804	894	828	798	828	-9.86%	35
Motorists (East)	312	306	306	318	312	311	11.20%	4
Motorists (West)	324	258	246	306	192	265	-5.88%	47

Table 29: Current numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with an additional 5 seconds for Dronning Louises Bro (DLB).

DLB +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	2916	2832	2922	2892	2976	2908	21.21%	47
Bicycles (East)	522	486	510	516	570	521	-2.03%	27
Bicycles (South)	1092	852	948	996	834	944	-4.95%	95
Bicycles (North)	768	906	738	822	792	805	14.31%	57
Motorists (North)	834	912	1020	774	822	872	-13.76%	86
Motorists (South)	918	972	1062	828	1110	978	0.99%	101
Motorists (East)	246	234	264	264	174	236	0.00%	33
Motorists (West)	270	252	276	276	270	269	-5.88%	9
Afternoon								
Bicycles (West)	624	672	714	600	636	649	4.62%	40
Bicycles (East)	1038	1212	1134	1128	1038	1110	21.08%	66
Bicycles (South)	1056	984	1116	882	1104	1028	-3.50%	87
Bicycles (North)	1596	1692	1566	1536	1602	1598	-5.41%	52
Motorists (North)	1050	828	924	1020	732	911	-3.69%	119
Motorists (South)	882	882	738	840	774	823	-10.50%	58
Motorists (East)	336	312	282	234	300	293	5.74%	34
Motorists (West)	240	210	252	252	318	254	-10.38%	35

We also repeated these tests using an increased traffic flow using the same increase detailed at the beginning of this section. Tables 30, 31, 32, 33, and 34 detail the results of these increased tests.

Table 30: Projected numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with the traffic light cycles inverted.

Lights Inverted	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	486	378	456	486	474	456	-1.55%	41
Bicycles (East)	612	714	654	1014	714	742	-9.52%	142
Bicycles (South)	864	852	912	750	768	829	13.84%	61
Bicycles (West)	924	726	912	774	876	842	-7.02%	79
Motorists (North)	402	492	312	324	408	388	-0.62%	65
Motorists (East)	258	234	180	156	246	215	-11.39%	40
Motorists (South)	480	474	468	456	474	470	5.09%	8
Motorists (West)	294	336	252	264	270	283	6.31%	30
Afternoon								
Bicycles (North)	468	396	450	498	498	462	-8.83%	38
Bicycles (East)	966	1326	894	930	1086	1040	-28.84%	157
Bicycles (South)	678	678	768	726	654	701	4.45%	41
Bicycles (West)	522	462	564	546	522	523	13.07%	34
Motorists (North)	330	522	438	504	408	440	9.26%	69
Motorists (East)	372	300	396	492	372	386	-1.55%	62
Motorists (South)	390	456	408	450	420	425	10.17%	25
Motorists (West)	252	306	252	318	330	292	15.23%	33

Table 31: Projected numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with an additional 5 seconds for Gothersgade.

Gothersgade +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	504	492	606	474	522	520	12.18%	46
Bicycles (East)	708	786	804	666	738	740	-9.66%	50
Bicycles (South)	870	720	792	840	822	809	11.04%	51
Bicycles (West)	876	1068	930	960	798	926	2.25%	90
Motorists (North)	390	270	408	264	414	349	-10.46%	68
Motorists (East)	246	270	252	270	252	258	6.44%	10
Motorists (South)	396	384	378	378	348	377	-15.82%	16
Motorists (West)	348	300	360	294	318	324	21.62%	26
Afternoon								
Bicycles (North)	438	474	420	474	390	439	-14.48%	32
Bicycles (East)	1422	1452	1524	1506	1482	1477	9.26%	37
Bicycles (South)	570	714	660	624	618	637	-5.08%	48
Bicycles (West)	510	534	486	516	474	504	9.76%	21
Motorists (North)	444	348	450	396	414	410	2.63%	37
Motorists (East)	384	384	438	408	258	374	-4.81%	61
Motorists (South)	384	360	288	348	360	348	-9.66%	32
Motorists (West)	282	294	288	270	246	276	10.43%	17

Table 32: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with an additional 5 seconds for Øster Voldgade.

Øster Voldgade +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (North)	504	516	450	420	474	473	2.07%	35
Bicycles (East)	756	846	750	750	852	791	-3.51%	48
Bicycles (South)	798	762	858	888	864	834	14.50%	47
Bicycles (West)	930	882	1002	888	888	918	1.32%	45
Motorists (North)	360	384	228	402	396	354	-9.23%	65
Motorists (East)	288	294	276	342	354	311	28.22%	31
Motorists (South)	474	438	504	426	456	460	2.68%	28
Motorists (West)	318	336	252	258	240	281	5.41%	39
Afternoon								
Bicycles (North)	384	414	432	474	450	431	-16.71%	31
Bicycles (East)	1248	822	1158	1206	1116	1110	-20.76%	151
Bicycles (South)	696	618	636	678	816	689	2.79%	69
Bicycles (West)	546	330	432	384	564	451	-0.80%	91
Motorists (North)	462	348	426	516	480	446	10.48%	57
Motorists (East)	324	414	384	402	426	390	-0.62%	36
Motorists (South)	396	354	438	336	462	397	3.93%	48
Motorists (West)	210	270	282	162	282	241	-2.49%	48

Table 33: Projected numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with traffic light cycles inverted.

Inverted Lights	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	3606	3444	3690	3438	3240	3484	40.2%	155
Bicycles (East)	648	630	618	678	660	647	0.2%	21
Bicycles (South)	930	1044	882	1002	1002	972	-6.6%	58
Bicycles (North)	894	816	768	942	1032	890	-1.2%	93
Motorists (North)	834	798	810	750	786	796	-30.0%	28
Motorists (South)	888	924	924	858	906	900	-21.9%	25
Motorists (East)	234	330	270	288	282	281	9.9%	31
Motorists (West)	312	294	318	246	312	296	-2.8%	26
Afternoon								
Bicycles (West)	762	744	828	654	744	746	1.77%	56
Bicycles (East)	1578	1446	1536	1392	1392	1469	39.79%	76
Bicycles (South)	1002	1212	1176	1146	1296	1166	-11.21%	96
Bicycles (North)	1884	1728	1830	1566	1716	1745	-11.28%	109
Motorists (North)	828	792	798	780	810	802	-33.53%	16
Motorists (South)	888	882	900	864	936	894	-16.78%	24
Motorists (East)	330	282	330	342	408	338	2.84%	40
Motorists (West)	336	294	312	354	234	306	6.67%	41

Table 34: Projected numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with an additional 5 seconds for Dronning Louises Bro (DLB).

DLB +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	2886	2970	2784	2898	3048	2917	17.38%	88
Bicycles (East)	654	546	750	636	630	643	-0.37%	65
Bicycles (South)	1050	1200	1044	1128	1044	1093	5.07%	62
Bicycles (North)	1068	924	792	870	804	892	-1.07%	100
Motorists (North)	1032	1038	1020	954	1068	1022	-10.03%	38
Motorists (South)	1224	1086	1074	1260	1176	1164	1.04%	74
Motorists (East)	216	270	240	222	288	247	-3.29%	28
Motorists (West)	312	366	330	264	288	312	2.36%	35
Afternoon								
Bicycles (West)	780	720	762	678	690	726	-0.99%	40
Bicycles (East)	1056	1122	1230	1020	1086	1103	19.80%	72
Bicycles (South)	1326	1290	1242	1296	1278	1286	-0.84%	27
Bicycles (North)	1938	1764	1806	1848	1836	1838	-5.61%	58
Motorists (North)	1056	1116	1008	1080	1020	1056	-1.36%	39
Motorists (South)	978	1236	936	900	1038	1018	-2.59%	118
Motorists (East)	444	360	306	294	396	360	8.67%	56
Motorists (West)	306	294	324	282	378	317	9.85%	34

Combining Strategies

In addition to the strategies outlined above, we tested an additional strategy that was a combination of two previously modeled strategies: widening the width of bicycle lanes and altering traffic light cycles. In this case, we widened the same bicycle lanes modified above by 0.5 meters and added 5 seconds to specific lanes of traffic, as done in the original strategies. Tables 35, 36, and 37 detail the results of this strategy.

Table 35: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with bicycle lanes widened by 0.5m and an additional 5 seconds added for Gothersgade.

+0.5m, +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	384	360	276	420	414	371	-9.12%	52
Bicycles (East)	594	750	642	828	648	692	-5.25%	85
Bicycles (South)	618	606	564	636	582	601	-12.26%	26
Bicycles (North)	798	834	774	888	804	820	5.56%	39
Motorists (North)	372	354	360	330	288	341	-12.88%	30
Motorists (South)	222	174	150	264	276	217	0.00%	49
Motorists (East)	378	348	318	354	348	349	-16.86%	19
Motorists (West)	270	252	252	246	204	245	-4.23%	22
Afternoon								
Bicycles (West)	354	366	450	342	384	379	-6.33%	38
Bicycles (East)	1404	1314	1344	1356	1392	1362	5.99%	33
Bicycles (South)	516	576	492	576	492	530	-4.07%	38
Bicycles (North)	468	426	432	438	444	442	0.00%	14
Motorists (North)	354	318	354	264	330	324	4.44%	33
Motorists (South)	354	264	336	324	330	322	-3.36%	30
Motorists (East)	318	336	366	300	336	331	-3.26%	22
Motorists (West)	216	186	252	234	222	222	7.03%	22

Table 36: Current numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with bicycle lanes widened by 0.5m and an additional 5 seconds added for Øster Voldgade.

+0.5m, +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	366	426	426	312	318	370	-9.41%	50
Bicycles (East)	642	642	504	492	738	604	-17.41%	93
Bicycles (South)	726	702	654	660	756	700	2.10%	39
Bicycles (North)	786	732	756	684	888	769	-0.93%	68
Motorists (North)	366	408	342	366	450	386	-1.23%	38
Motorists (South)	252	234	276	168	162	218	0.55%	46
Motorists (East)	438	294	432	492	432	418	-0.57%	66
Motorists (West)	222	240	210	282	252	241	-5.63%	25
Afternoon								
Bicycles (West)	384	474	420	312	378	394	-2.44%	53
Bicycles (East)	1278	1206	1224	1374	1272	1271	-0.76%	58
Bicycles (South)	510	618	522	552	630	566	2.54%	49
Bicycles (North)	444	402	396	414	372	406	-8.88%	24
Motorists (North)	402	342	438	342	312	367	15.69%	46
Motorists (South)	312	402	336	330	336	343	3.15%	31
Motorists (East)	372	420	396	342	354	377	9.24%	28
Motorists (West)	234	234	162	180	258	214	3.37%	36

Table 37: Current numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with bicycle lanes widened by 0.5m and an additional 5 seconds added for Dronning Louises Bro.

+0.5m, +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	2838	3132	2958	2850	3042	2964	23.56%	112
Bicycles (East)	516	510	492	588	498	521	-2.03%	35
Bicycles (South)	990	1008	924	954	786	932	-6.16%	79
Bicycles (North)	744	756	858	804	696	772	9.54%	55
Motorists (North)	936	948	918	1026	1008	967	-4.39%	42
Motorists (South)	990	954	1020	990	972	985	1.73%	22
Motorists (East)	294	210	210	258	288	252	6.60%	36
Motorists (West)	270	246	222	330	270	268	-6.30%	36
Afternoon								
Bicycles (West)	684	684	666	648	654	667	7.19%	15
Bicycles (East)	1092	1098	1134	1140	1128	1118	21.67%	20
Bicycles (South)	1110	1092	1068	1062	1056	1078	1.22%	20
Bicycles (North)	1668	1566	1572	1554	1560	1584	-6.36%	42
Motorists (North)	858	870	870	864	876	868	-8.85%	6
Motorists (South)	792	810	804	810	810	805	-12.97%	7
Motorists (East)	270	264	276	282	294	277	0.43%	10
Motorists (West)	258	234	252	246	252	248	-13.04%	8

We also repeated these tests using an increased traffic flow using the same increase detailed at the beginning of this section. Tables 38, 39, and 40 detail the results of these increased tests.

Table 38: Projected numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with bicycle lanes widened by 0.5m and an additional 5 seconds added for Gothersgade.

+0.5m, +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	564	414	510	474	438	480	3.63%	53
Bicycles (East)	810	750	906	792	840	820	0.00%	52
Bicycles (South)	846	798	720	864	828	811	11.37%	51
Bicycles (North)	792	930	906	852	1038	904	-0.26%	82
Motorists (North)	408	324	342	282	276	326	-16.31%	48
Motorists (South)	252	246	288	216	240	248	2.48%	23
Motorists (East)	372	378	354	378	378	372	-16.89%	9
Motorists (West)	342	372	294	270	312	318	19.37%	36
Afternoon								
Bicycles (West)	564	420	438	378	498	460	-9.40%	65
Bicycles (East)	1554	1686	1584	1518	1488	1566	14.41%	68
Bicycles (South)	654	708	666	534	636	640	-4.69%	58
Bicycles (North)	552	510	528	570	528	538	15.40%	21
Motorists (North)	450	348	468	414	450	426	6.20%	43
Motorists (South)	384	360	444	432	384	401	2.10%	32
Motorists (East)	312	354	318	336	384	341	-11.97%	26
Motorists (West)	258	228	276	246	276	257	3.74%	18

Table 39: Projected numbers of vehicles passing through the Gothersgade-Øster Voldgade intersection with bicycle lanes widened by 0.5m and an additional 5 seconds added for Øster Voldgade.

+0.5m, +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	558	480	420	462	360	456	-1.55%	66
Bicycles (East)	690	852	792	714	732	756	-7.76%	59
Bicycles (South)	690	762	840	726	804	764	4.94%	53
Bicycles (North)	972	846	942	954	852	913	0.79%	53
Motorists (North)	438	456	438	402	420	431	10.46%	18
Motorists (South)	288	294	288	294	324	298	22.77%	13
Motorists (East)	492	492	450	456	486	475	6.17%	18
Motorists (West)	324	240	330	360	192	289	8.56%	63
Afternoon								
Bicycles (West)	456	504	456	468	528	482	-4.23%	29
Bicycles (East)	1458	1374	1302	1458	1488	1416	5.34%	69
Bicycles (South)	732	750	546	696	618	668	-0.18%	76
Bicycles (North)	426	396	450	342	492	421	-7.98%	51
Motorists (North)	438	390	402	408	426	413	3.20%	17
Motorists (South)	450	372	438	396	414	414	5.22%	28
Motorists (East)	384	354	414	342	432	385	0.93%	34
Motorists (West)	252	192	324	288	228	257	3.74%	46

Table 40: Projected numbers of vehicles passing through the Dronning Louises Bro-Søtorvet intersection with bicycle lanes widened by 0.5m and an additional 5 seconds added for Dronning Louises Bro.

+0.5m, +5s	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Net	Standard Deviation
Morning								
Bicycles (West)	3258	3270	3288	3162	3288	3253	30.90%	47
Bicycles (East)	648	576	630	552	576	596	-7.62%	36
Bicycles (South)	876	1212	1116	1164	1128	1099	5.65%	116
Bicycles (North)	816	900	906	936	894	890	-1.20%	40
Motorists (North)	1020	1038	930	1056	1038	1016	-10.56%	45
Motorists (South)	1158	1110	1152	1128	1176	1145	-0.63%	23
Motorists (East)	258	210	204	300	276	250	-2.35%	37
Motorists (West)	312	270	318	246	282	286	-6.30%	27
Afternoon								
Bicycles (West)	762	732	690	780	732	739	0.81%	31
Bicycles (East)	1224	1272	1104	1230	1182	1202	26.45%	57
Bicycles (South)	1236	1296	1290	1368	1218	1282	-1.22%	53
Bicycles (North)	1908	1692	1848	1908	1926	1856	-4.59%	86
Motorists (North)	906	984	1080	1152	972	1019	-5.06%	87
Motorists (South)	990	1098	906	960	936	978	-6.75%	66
Motorists (East)	276	330	354	462	354	355	7.43%	61
Motorists (West)	300	264	306	258	270	280	-2.15%	20

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Appendix A: Interview Transcripts

Below are the transcripts and notes for the individuals we interviewed. We removed selections of the conversation in cases in which the interviewer is speaking from the prompt detailed in the methods section.

Transcript of Interview with Klaus Bondam

Interviewee: Bondam, Klaus (Director)
Tuesday, 4 April 2017 1100-1200 (00:58:17)
Cyklistforbundet (Danish Cyclists' Federation)
Rømersgade 5-7, 1362 Copenhagen K
Interviewer: Koubeck, Adam
Attendee: Hunt, Alan

KOUBECK: What do you think is the most troublesome aspect of intersections for the average cyclist?
BONDAM: I would probably think the most troublesome aspect is sorta the stop and go aspect of an intersection because of course what - not a necessity, but what is really a commodity of a cyclist, is basically have the flow which was one of the reasons other amounts of other places in Copenhagen, but on that stretch also, we introduced the Green Wave. We basically, if you peddle 20 kilometers per hour you basically go through all the green lights. That is where we do get annoyed by intersections because they basically stop your flow, they put you in a position where you need to use more energy to get started again
KOUBECK: And it's harder for cyclists to get started again
BONDAM: yeah you have to find your way in that pattern that a group of cyclists is also moving together, also is you basically have to re-establish that order. I mean, who goes what speed? Where do I fit in?
KOUBECK: Well especially since there, for example, cars they have marked lanes for turning right and left, but for bicycle lanes is just
BONDAM: Not all of them, you see. I think you see more and more different infrastructure
KOUBECK: That's true.
BONDAM: But I think that one of the most annoying things, but again, it's not also not annoying, because it's also nice sometimes, you know, just to stop to have a rest. One of the things that has been instituted basically in the first two months is the handrails, which I think is a, it's really, you can, you can argue "oh what a waste of money and is that really necessary," but on the other hand it's, I mean it's extremely comfortable if you're at a red light and you don't have to go to the ground, you just lean against the bar. And finally, which is probably the most important thing about most bicycle policy

in Copenhagen - a lot of bicycle policies in Copenhagen - is you want to send a very clear signal to the cyclists that we actually do like you, we think you are really good people in our city, we think you really contribute positively to a lot of the agendas that we're working within the city when it comes to mobility, when it comes to sustainability, when it comes to CO2 reduction, when it comes to noise reduction, when it comes to public health, when it comes to livability. All these kinds of things.
KOUBECK: So would you say they are the priority?
BONDAM: It's about making them laugh, it's about giving them the feeling that they are actually seen and acknowledged. And I think you see a lot of - you see a lot of urban construction, city construction, city planning and you do especially - it's also changing, but you also see it in the states where you really see a very car centric, car dominated planning culture. And I think Copenhagen has managed to move away from that and show - it's not because cyclists are more important or better people or whatever - but it's a matter of saying, that I mean you are a part of the entire traffic system in the city and you are a completely equal part.
KOUBECK: Just not prioritizing one of the others - making them know they are equal to cars in the form of transportation
BONDAM: But of course, of coarse in sometimes, in some places they are always - you do prioritize. Having been a politician, I mean politics is about prioritizing. It's about saying that I prefer this from this.
KOUBECK: That's true.
BONDAM: You can say, you have a residential area where you are allowed the garbage trucks to come in there three o'clock at night - no because you prioritize people's ability to sleep higher than the picking up of garbage. So it's basically sorta that prioritizing of course [] is a very good example because they've basically prioritized bicycles in public transport and stopped the ability for cars going through. And the important thing to recon is that before that was done there were around twelve thousand cars per day and there were thirty five thousand bicycle riders and there were about thirty three thousand - as far as I remember - people using public transport. So for me it is to be honest. I mean I took a lot of criticism for it and it was a lot of [] but for me, prioritizing the accessibility for almost seventy thousand people to the accessibility of twelve thousand people, for me it was
KOUBECK: It's a numbers game
BONDAM: It's also a numbers game, yeah.
KOUBECK: Yeah, also we say the new traffic lights that are being implemented all over the city that will stay green for buses and stay green for cyclists. So basically prioritizing that.

BONDAM: That is because, the funny thing to sorta see from - not the outside of just in Europe, part of the business right now - but to experiment over the development of intelligent traffic systems in the last ten years. I mean, now we are realistically talking about things we couldn't dreamed about ten years ago. And that is - of course - the integration of mobile devices, the integration of chips, the on-the-spot control of traffic lines. All these kinda things and I think it's very interesting. Of course we're gonna use it to help answer your question.
[demonstrating the Vissim software for Norrebrogade]
BONDAM: The one's taking the little path there, that's actually quite a good example.The one's going here. Because that was actually, that was a thing a lot of people did before illegally because you probably know - going here and then down that street - you basically reach that access that go all through the inner city. Whereas when you went down here - especially when the metro was constructed, it was closed down here - so it was basically taking something a big portion of people did, making it legal by actually fitting the construction in.
HUNT: That makes sense.
BONDAM: I mean it doesn't give you speed as a cyclist, but it's an indication, a signal that you are - it's ok to go here - we've actually build a bicycle track for you and it's fine. And that we are also seeing what you are doing. Then of course you can ask why don't we open for it here - I'm the city council so I don't have any opinion about it - but that's of course an aesthetic point of view. You have a statue there, you have sorta little square there, there is a nice sorta aesthetic view to it.
KOUBECK: That's true.
BONDAM: Do you want to ruin that a lot?
HUNT: Right.
BONDAM: My personal point is no 'cause I think sometimes you also have to leave some things and say - I mean it's nice - Do people harm anybody by crossing over? No. Should the police spend tons of resources stopping it? No.
HUNT: Right.
BONDAM: But I think it's also important that you do send some signals saying the boundaries here.
KOUBECK: Yeah that was one of things we were thinking of suggest, is putting dedicated - the right turns - like a dedicated lane. So we've seen that in a lot of other, other places.
KLAUS: But it will actually come about, I'll show you that later. But that is a, that is a actually a good way for discussing this because you are probably familiar with the works of [] Anderson - Mikael [] Anderson - and talks a lot about - he's the guy from

Copenhagen [] - he talks a lot about desires. I mean, if you look into where people desire to go. And I mean, I don't care much about him because he forgets there are also aspects of aesthetics for example.
KOUBECK: That's true.
BONDAM: There are also aspects of saying no. We actually prioritize pedestrians here. We actually say, even though cyclists desire to go there. I mean if you live a life only farming your desires.
KOUBECK: Yeah, we also have to look at what pedestrians want too.
BONDAM: Yeah, exactly.
KOUBECK: Right. It's like you mentioned before, it's almost a balancing act. So I believed we talked to someone at the debate a couple of weeks ago and he had an interesting point of treating - right now we are almost treating cyclists as sorta pedestrians, but to rather treat them as vehicles themselves, to like, give them their own lights.
BONDAM: But there is actually a plan of reconstruction at the intersection - I'll have to show it to you. I don't know if you are aware of that, but there was in the news the other day.
KOUBECK: The Norrebrogade core renovations? Yeah. Yeah we were actually looking at that, because of the things we were actually thinking of was widening intersections, but they've already - they're already planning to do that, but I'm not sure of the specifics of that plan per-say.
BONDAM: [video] This is a ... this is a film made by the newspaper []. But this one will be prolonged before and after. But that's not []. The bicycle path on here will become broader.
KOUBECK: Ok
HUNT: Ok
BONDAM: And will give the arriving - yeah.
HUNT: I like it.
BONDAM: So changes will occur.
HUNT: OK
KOUBECK: Yeah that was one of the things we say with the people coming up to the bridge. They had to contend with the cars who wanted to turn right.
HUNT: Right, because one of the things that I've seen is there aren't actually that many people that turn right here, but there are quite a few that will turn right here. And, in fact, I think we saw more people taking this pathway over here then at the light.
BONDAM: I think one of the reason is - I think when one discusses bicycle planning there's also a very very strong element of culture because we are very - when you are a

cyclist you are very exposed, in the send that you're not sitting in your own little
KOUBECK: There are no air bags.
BONDAM: No, there are no air - No, but not only that, but you're also - you are very visible as a citizen you are. And as you've probably recognized from being here sometime is that Denmark is an extremely homogeneous society. We have a very very very social control. I mean we very much look to what other peoples are doing and sort of - we're not that open to diversity and so the reason is probably here that you have so many cyclists here, especially in the morning, and if you do that, all the other will look at you "oh there somebody breaking the law. There's somebody that we know that is illegal. I can do that. I be good citizen, I don't do that." Where as here there are hardly so many people coming here - so here, "uh! Nobody sees me. I can do it." It's a very cultural thing. I think is a very cultural thing and I think when we talk about cycling it is important to integrate those kinds of things in the cost. If you drive a car in Denmark - if you go on the highway - you'll find a lot of people sticking to the speed limit, but staying in the outer lane - not sort of keeping to the right - why? Because it's apart of the Danish culture. You say, "Oh! If the law is I can drive a hundred and ten, everybody has to drive a hundred and ten. I'll just stay here and I don't care that other people want to pass me because I'm driving the proper speed." It's a very very very Danish sorta [] this sort of righteous... Yeah, I'm staying on my right and I'm not doing anything legal and others shouldn't do that either. So there's a cultural aspect to how we behave in traffic also. And then again, a lot of surveys in Copenhagen show that cyclists has a tendency to - and I don't know the English words - there is a Norwegian - kinda little mountain mice which is called a lemming, and it's called the lemming effect.
KOUBECK: If one goes the others follow.
BONDAM: If one goes, all the others follows. And you see, if you - I mean now you have a technical background - but if you work with the anthropologists or ... in this country, they will say that you see a lot of that behavior within cyclists. I mean they basically, they do what the one in front of them do. Which is quite understandable because you're also - because you're driving so close that there's congestion so you're very dependent on the others so you have to - I mean you have to be apart of a... yeah.
KOUBECK: You see that a lot - when we've been cycling around we see that a lot with the delays where it is red for everyone, but you know that the green light is coming so you'll see one person start biking out and then everyone else will follow even though the light hasn't turned green.
HUNT: But if that first person doesn't go, then nobody goes.

BONDAM: But it's interesting - it is quite interesting.
KOUBECK: Getting back to the green wave, do think that that's - how well do think that's worked to - I understand that you probably don't have any technical data, but how well do you think that's working?
BONDAM: The city probably has technical data about it because they actually have data about quite a lot of things. And I do think that is one of the really positive things from a planning, policy making perspective in Copenhagen, that there is - we come very much from the traditional [] the danish urban planner, the urbanist - what's it called - cities for people, it's sorta his major work. And he works a lot about counting - I mean you have to count because when you actually know how many people does certain thing or what percentage, you can actually start planning after that. So there is a very strong tradition for counting, there's also a quite broad political consensus that what - talking about news and everything or fake data - but there is - at least in my time - there was a consensus in the committee from the far left to the far right, but if the administration came with some numbers... I mean, they're the numbers, you don't start argue the numbers at all we don't' say "oh I counted myself and I actually found that there were not two-hundred, there were two-hundred and fifteen." I mean we don't go there. So, has the green lane worked? Yes, I do believe it's worked. Also, in connection with some other installments, making the bicycle paths wider - because twenty kilometers for some - I mean for an older, middle aged man - like me - it's a good speed. If you're an old lady in your seventies, it's quite a good speed. On the other hand, if you're riding on an e-bike twenty kilometers is nothing. So the whole concept of making the bicycle paths broader and, also at the bus stops making sure that we have what we call - we refer to them as islands.
KOUBECK: Yeah for the people to wait for the buses.
BONDAM: Yeah, and the law is if there is an island you have to wait as a bus passenger. But if there is not an island the cyclists has to wait. No everybody knows that rule, but that's another thing. But... so I think, I mean, I don't think that green waves just work everywhere. They work with - like a lot of other things - in conjunction with other infrastructure changes. And I think that is probably one of the key messages about planning for cycling is that it's not enough just to say "oh we want people to cycle. I'm the mayor, I'm sitting here bicycling. Everybody should bike." It doesn't work that way. I mean, and it doesn't work with - and a lot of other cities has painted a lot of white - you know have painted bicycle lanes with white paint - and I know they say it's an OK start, but the ones that really benefit from that are people who have shares in white paint factories because it's not bicycle infrastructure. It's something that very disappointingly resembles what should be proper constructed, built segregated bicycle

infrastructure.
KOUBECK: Yeah that's the one thing we've seen as that the...there's a lot more of a push towards segregating the cars with the bicycle bridges, superhighways
BONDAM: That is where you find one of the big differences between Denmark and the Netherlands because the Netherlands - even though they higher percentage of cyclists
KOUBECK: The bicycle roads...
BONDAM: They have a much stronger tendency actually to mix cars and bicycles and pedestrian than we do. We hardly never do that. The thing I'm thinking here is that if you do it in one intersection it does have effects in other places of the city also. And for example, you have Norrebrogade going up here. The one going by the lakes is basically the [] from the highway through the university area down
KOUBECK: So it would involve - it would back up some cars.
BONDAM: Yeah so I'm pretty sure if you prolong the green time going that way you will basically - making even harder congestion on the highway coming in where there is already really heavily congested. So the point is of course, when you move green lights you're always - it's like domino... As far as I know that - they do have this close to the bicycle snake - there's this new round building called the Traffic Tower, which is the Danish director [] that together with the City of Copenhagen, so it's basically state and national government and local government working together, but it's the idea of - as I understand it the traffic tower - is to basically monitor the entire traffic - public, private bicycle traffic - in the entire entire greater Copenhagen region, to basically make the flow better and also to get more knowledge and experience.
KOUBECK: Yeah because we also - we also saw at Gothersgade and Ostervolgade. Sorry my pronunciation still needs work. But we saw that there are a lot - that while a lot of cyclists are on Gothersgade and it's almost a similar situation where the cyclists have a lesser green time, but looking at you can almost understand why because you have Norreport station right on the opposite road and you have buses coming through constantly. So you could - like we were thinking you could make the longer green time for the cyclists, but at the same time you would back up bus transportation so you'd only - you'd elevate cyclists, but also diminish the public transportation.
BONDAM: I think one of the challenges is, at least in Copenhagen - one of the challenges is also to identify alternative routes to make alternative routes accessible. I don't have a map here, but - I mean, because again as I talk about the culture before, we have a tendency to everybody goes the same way. But there are alternative routes and we can find alternative routes and how can we actually nudge people to go with alternative routes. Take the new - that's quite interesting - the new bridge between the Royal theater and the paper island. That was opened last August and the interesting

this is that has actually created a interior through the city. So it has moved some of the traffic away from the first bridge and it has sorta moved it to another one. So it's a matter. Then of course has - part of that was also...
HUNT: So is this bridge by - you said was by Paper Island, is that the one that leads up to the triangle bridge or...
BONDAM: Yes. That bridge up here at Nyhavn, it is this one here.
HUNT: Right, yes.
BONDAM: Triangle bridge is right here.
HUNT: I actually take that one every day.
BONDAM: But this is basically a kind of new bridge. A lot of construction were done here to create a bicycle lane here. This was opened so you could go - it was before it was only a one-way street, now you can actually - cyclists go that way also. So what you did here was basically open a new interior in going through the city. So it's - the point is to maybe sometimes try to see how can we - through construction, through notching - having people go all the ways because there is simply too many in some places.
KOUBECK: As we saw a lot of green route construction, like Carlsberg and the Harbour area, but we personnel think that is the best way to go, but the problem is really for what we're doing right here we're not really able to model that. So we're trying to get the quantifiable data with the intersections - that's why we're specifically looking at that.
BONDAM: But also - I mean - we're working with habits, we're working with peoples - I mean - I think people's' transport habits are just like their eating habits - I mean- they are difficult, or their smoking habits, or - I mean - I think they are extremely difficult to move and work with. And I mean, I think that goes for cyclists also. If I'm use to going this exact way, I will keep going that even though that there are tons of cyclists. So how can we actually, threw other means
KOUBECK: Encourage them to...
BONDAM: To either go other ways or changing the light time or building flyovers or whatever because of course if, at the end of the day you feel the congestion is unbearable, that you maybe choose mode of transportation is ok, you say "I mean I'm just waiting here to cycle. I don't get []. I'd rather sit on the bus and read my book or I'd rather sit in my car and listen to the radio." I mean that's - because congestion takes away one of the things that probably more - most important for a cyclists, and that is the feeling of freedom. That is the feeling of controlling your own speed. That is the feeling of flow and accessibility.
KOUBECK: Yeah and that is what we looked at for - for the next slide. What we did is

we then projected, with the projected increase from the cycling report, so this what - so right here we have the projected general bicycle increase of eighteen percent and then the rush hour increase of three to five percent. And we looked at that and we wanted to - when we came up with strategies that we used, such as the light timings or widening the bicycle lanes. We wanted something that would work, not just now, but also in the future because we don't want to have - put - like make this report, give out suggestions, and have them be useless and five years.
BONDAM: But I'll give you an interesting input because I talk more and more about Denmark being a homogenous society. I remember one day I was standing out at the Bicycle Snake here doing an interview with a Belgian journalist. And suddenly around a quarter to four tons of cargo bikes started arriving, sorta going down. And the journalist, "Oh! What happens? What happens?" and I say, "Quarter to four, it's kindergarten. Parents are picking up kids at kindergarten." We are a very, very - I mean - basically everybody does the same at the same time in Denmark. So you have huge congestion here in the morning between eight and nine-thirty. Quarter to ten it's quite. That is why - that's because we have a very strong day care system - public day care system and you're suppose to bring your kid to daycare before nine o'clock and all these kinds of things. One of the things that was talking about in mobility management in Denmark is also to see can we make basically expand the hours that the institutions are open? Can we work with - like I have an office here. At four o'clock, nobody left. I mean all the parents are gone. They're gone, they're picking up their children because I mean if you're the last parent picking up your children - your child in the kindergarten - everybody looks at you "Oh! We have an issue with you. Apparently very bad parent, being so late picking up your child." So we also have a society to work with that, you're not a bad parent if you don't pick up your child until six o'clock. Maybe, if you don't do that three days - we basically have to because having the same problem with the highways. We basically have to expand the amount of hours were we can use it. But it's a huge, huge fight with the union on - and of course also with the municipal administration if we keep kindergarten longer open - but that is a part of our problem.
KOUBECK: Yeah it's not just an infrastructural problem.
BONDAM: And one of - and I mean, you're the future generation of planners so one thing I would really encourage you to is that there has been a tendency in mobility management always to sorta make it a technical discuss or a technical debate or a technical solution - but we do also work with other policy areas like when is our welfare accessible for the citizens? It's their culture I speak to. There are aspects of habits and all these kinds of things, but how do you work with that? So my encouragement to you will really be to engage other disciplines in your work. That's is really important.

KOUBECK: Yeah, that's actually really helpful because that's what we've been trying to do, but we've had very little success so far.
BONDAM: The way that Copenhagen is governed is a bit different from other Danish cities. You have elections every four years - it's a fixed term. Just after the election, the Lord Mayor and six Deputy Mayors are appointed - they are appointed by the City Council of Copenhagen, so they are members of the City Council. It normally goes as the biggest party choses first, so they chose the Lord Mayors post, and then through a quite complicated system the size of your party and the coalition's you are able to make, but only coalitions on election night. Basically dividing up who takes which mayoral post and all the other - what we call paid posts on the board of the development company that does this the board of the public transport company - all these different posts there are. So, basically that whole cake is sorta cut up on election night, but in the days to follow. So you have a Lord Mayor, but the Lord Mayor does not have any power other than what a majority in the city council gives him. So a Lord Mayor cannot - he can maybe start a little campaign or he can say something - but he cannot start a huge investment scheme without him having the backing of the City Council or majority of the City Council. On contrary to the US we have a multi-party system, we have seven, eight different parties so the way it works in Copenhagen is that every year the budget for the coming year is agreed. So it very much depends on - and of course what happens is that, when you're the mayor of the technical and environmental administration you come with a huge package of bicycle infrastructure plans, if you're the mayor for social affairs you come with a whole package of investment schemes for houses, for mentally ill people, if you're the school mayor it comes with a reconstruction of school packet. I mean, you basically put in all these things. The good thing about cycling policy is that - and that's probably one of the big success of the, not only Copenhagen, but Danish cycling policy that it's not considered a especially left wing thing to do. You can find a lot of right wing politicians contrary to the US because the right side is blue to us and the left side is red for us.
KOUBECK: Yeah, more conservative.
BONDAM: Yeah, but you can find a conservative people who are very pro cycling. And it - I think everybody will agree that cycling is a completely integrated, essential part of mobility in Copenhagen. Their discussion about closing Norrebrogade - there's huge discussion about that. There's huge discussion about taking away parking places - all these kinds of things, but there's no sorta disagreement for that. What I did - and there was a big change when I started as a mayor - I mean, sometimes people are referring to me as the "Bicycle Mayor." I made everything happen - that's not true because there was a historical tradition, but what I did - and not me alone - but together with

the Lord Mayor at that time - and she was new - she had in her election campaign - she's from the labor, she was from the labor party like the present Lord Mayor is - Copenhagen has the Lord Mayor of Copenhagen has been been from the Labor Party for the last hundred and twenty years. But she had already in her campaign, she had talked about cycling infrastructure. And from a smaller party, a smaller social liberal party, and I picked that up already in the election campaign and she and I were a very good team, worked very well together. So what we basically did was taking and already existing bicycle policy and already existing not-so-big investment scheme in bicycle infrastructure - taking it from somewhere down on one of the bottom cells, lifting it up on the top of the mobility agenda in the city. Introducing the whole "I bike Copenhagen" scheme could really communicate to the Copenhageners "year you are our best friends and we love you and..." and you have to understand that all of this from 2006 to 2009 was leading up to the cut fifteen in Copenhagen. Copenhagen was the whole city of the UN Climate Summit. What happened in Paris at the Paris Agreement was suppose to have happened in Copenhagen in 2009, but that summit went completely mad, but it was a very, very, very important stepping stone for the City of Copenhagen to basically really work on a lot of these sustainability policies. And of course highlighting the cycling was an extremely low hanging fruit because it was there already but we just, you know, polished, made it nice. And then - from my first year in office - I came with a huge packet which is in city government is referred to as the Bicycle Package No. 1 - I think they reached Bicycle Package No. 12 now - but I came with a huge investment package. I remember the leaders from party - she said to me - she was in Parliament - she said - she's a very old lady now and she said, "You'll always have to be content when the Prime Minister has an interest in your area." And that was basically was about - I mean I was work with the Lord Mayor who really liked cycling so cycling is a solution and I'm pretty sure if you ask some of my male colleagues and some of the other - they were a bit envied of me - they sorta, "Oh the Lord Mayor always gives Claus money" and really sort of - they always have highly idealized cycling, but it wasn't - that was a change maker for Copenhagen and it is important to understand that political leaders here - and I'm not talking about myself - I'm talking about the Lord Mayor - but taking on that political leadership is essential because if you have on the highest level political leadership you also see the sorta []...
KOUBECK: Yeah they make it a priority, then everyone else gets in line.
BONDAM: Yeah, exactly. And that was what basically happened. So you came with these huge investment schemes and you saw the priority plan from up to 2025. It was packages like that saying "Oh the next four years we would like to do this and this and this and this - and then of course it's always a political discussion should we prioritize

this bridge from this bridge or making this one broader. That's political negotiation. They are sometimes, they are bound in good, sound reason and other times they are bounded in personal interest - not financial because there's basically no bribe in Denmark - but they can be like "Oh I'm elected to this area, so I want to...I want it in my constituency."
KOUBECK: Yeah, they want - they also probably want to get reelected too.
BONDAM: So, and of course - that is of course all the - you can find very good people that say "Oh no, no. I don't want to bicycle lane here because means they're taking away parking spaces. Oh and I don't want that fight up the election with the constituency." But that is the really, really bad thing about politics is that you very, very often end with the second best or the third best solution
KOUBECK: Yeah you have to compromise.
BONDAM: You have to compromise, there's a lot of factors. That is what's extremely frustrating about politics also. So that's how it works, that you basically - and I think - I talked about the counting before, but I think another thing that is very important is to have these plans and visions and also funding that sorta goes. You maybe have not set aside money until 2025, but you have some kind of - I mean the seed has been planted in your head that the next ten years you're - you should invest this amount of money.
KOUBECK: Yeah, they actually mentioned between one-hundred sixty and two-hundred sixty million kroner. Now that is to reach the goal, but it's to maintain it they said a hundred million kroner a year.
BONDAM: And that is of course also to work with the public - making the public aware - if you come to a completely bike estrange city and say, "oh we wanted this - a hundred million dollars for bicycle infrastructure." "What on earth are you thinking of?" But if you start preparing people saying "that in the next ten years, we will every year set aside." I've very often use the term that things have to be politically sustainable. That you make sure that you have as broad a coalition as possible to make sure it can survive changeability.
KOUBECK: Make it as broad and appeal as possible.
BONDAM: But also to make sure it can survive change of leadership to make sure that you have not only people on the technical and environmental committee on board, but you basically have all the people elected from different parties aboard. So a lot of my work - and I believe I was pretty good at that - a lot of my work was also to persuade some of the people who did not work because the worst thing that can happen, even though you have funding, you have the lord mayor from the labor party begging, but then somebody - some back bencher from the labor party start shouting up and "uh!" Then the press starts and the "ugh." So really sorta working with everybody and all the

parties - you know making them - I use the term that it's very important that they have the common language that they know what we're talking about - when we're talking about being a cycling city or the number one city for cyclists in the world - that they basically know what we're talking about.
KOUBECK: Yeah, yeah makes sense. Well especially making sure that it has as broad of an appeal as possible so no matter what happens it's - what's the word - like, it's - it wouldn't be politically smart to do away with it.
BONDAM: I think what we need in Denmark is - what we need is - we've had a tendency to believe that as long as we build a proper segregated bicycle track - that was fine and everything was wonderful and that was a ways to do it. Then, I think we learned with the construction of the bicycle snake - this one here - I think we learned that there can be different or higher ambitions to bicycle infrastructure. That bicycle infrastructure is more than just building a segregated bicycle lane.
KOUBECK: No matter what people are still gonna have to use the main roads probably.
BONDAM: Exactly, exactly, but what is also sorta understanding that investments are a little bit higher sometimes. What one of my favorite projects - and I have to say I haven't seen it, I've only seen it online - but one of my favorite projects is the Dutch structure. This is called [] the ring above [] but as you can see here it is basically a huge intersection where you have this first floor round about for cyclists. It's - I mean it's - I think it's really cool. And I think - of course not in the inner city area - but in some of sorta the subway-suburbs
KOUBECK: More open areas.
BONDAM: More open areas, I mean - things were you could actually - I mean really create a very nice flow. And why do I prefer this - for example to tunnels - well because tunnels have a tendency to become extremely unsafe.
KOUBECK: Or they just seem unsafe to be honest.
BONDAM: They seem unsafe yeah. Because of course you can work with lining, but I'm pretty sure that this is cheaper than building a tunnel. I mean...
KOUBECK: That's something that we can look up.
BONDAM: And I think we see more and more of these structures - I saw one yesterday which is also really cool.
HUNT: The things that I see with this is that something like this will actually encourage cyclists to actually cycle more - it's sorta like the Bicycle Snake - not just because it's convenient, but because it's actually a very interesting structure as well.
BONDAM: Yeah, but having said that we are also - we haven't even touched that question, but we are seeing more and more people working with using e-bikes. This is

another examples - this is in the Netherlands also it's in the school [] - were you basically see here it's combined with a school - this area here is a public school. It does create some problems I have to say, but the point is we are now in a place where in some places we really need a high level of investment to build
KOUBECK: More specialized
BONDAM: More specialized construction []. And I'm not talking about building a big one here because that would be - I mean really
KOUBECK: It's just not possible
BONDAM: It's not just possible. It is not possible. But i may be possible in other places.
KOUBECK: Yeah it's definitely something - yeah especially at the [].
BONDAM: And the good thing about segregation is also that you are basically making - you're making the car [] that has to go there can actually also pass
KOUBECK: Yeah they don't have to worry about waiting for cyclists
BONDAM: They don't have to worry about cyclists that pass. So and another thing - I mean constructions like this - this is called Green Road - it's basically an old train track you find that probably also in US cities, but you find it in a lot of European cities. You find tons of these abandoned train tracks. They're basically sorta - they're lying in that part of the city that was built hundred-hundred and fifty years ago in the old industrial areas or the old - through the industrialization people from the countryside came in. So they're just lying there like sorta open wounds in the city. And I think it's a good way to sorta use an old train track like this. We do have - there are some more out here that really have been used for that and I'm pretty sure that that's going to be one of the next things we're going to do. But again there are also security issues of these because how do you make it - how do you create a feeling if you go with your bicycle in the night, in a pretty abandoned area that you as a young female or a child or a parent actually feel that it's ok - I mean, and we can work that out today through lights. I think we can work it out with temporary lights, we can work it out with surveillance, we can - I mean, yeah...
KOUBECK: I think it would be a lot of lighting to be honest. Just making...
BONDAM: You can make light today that it basically only light where you are going. It does exist. I mean, you can put sensors in so the lights ahead basically start.
KOUBECK: Yeah, to save energy so they're not just all on all the time.
BONDAM: I remember there was a young lady in city council and I think she said, [] We talked about security and feeling secure on a bicycle and - you know - being assaulted and then she said, "I always feel safe on my bicycle." Cause she felt she that she could always get away on her bicycle. Whereas when she was walking, she didn't- she

sometimes didn't feel comfortable. But actually when she was on here bicycle she always felt - I mean - her chances of getting away was []...

Transcript of Interview with Jos Van Vlerken

Interviewee: Van Vlerken, Jos (Project Leader)
Thursday, 6 April 2017 1400-1500 (TIME)
City of Copenhagen Technical and Environmental Administration
Njalsgade 13, 2300 København S
Rømersgade 5-7, 1362 Copenhagen K
Interviewer: Koubeck, Adam
Attendee: Hunt, Alan

KOUBECK: So, the first thing we wanted to ask was, in this job or just as a citizen in Copenhagen in general, when do you think bicycle congestion became a serious problem in the city or do you think it's not a serious problem in the city yet.
VAN VLERKEN: Well the thing is for me personally, I think, as a cyclist, I have one view as a cyclist, one view obviously as an employer for the City of Copenhagen with a focus on this. As a cyclist for myself, personally, I don't view congestion in Copenhagen as large problem as such. There are always - I've lived in Copenhagen for multiple/for many year, I know the routes that are congestion, I know the routes that aren't, I know the times when the different times are congested and how to come from point A to point B. And I only cycle, I don't use any other means of transportations. And so, I personally don't feel congestion at all. When I do I know of course, I see that there are a lot bicyclists in the bike lane, but it doesn't bother me much.
KOUBECK: You are use to it.
VAN VLERKEN: I'm quite use to it, yes. And, but I also, in the last ten years, I can see that of course as the bike lanes have been widened, as the cycle infrastructure has been improved, this has also attracted a lot of cyclists. The thing is, everybody that can cycle, that has easy access to cycling physically and also mentally, you know it's often quite - you have to keep a lot of things in mind when you are cycling there, the traffic as such. Everybody that can cycle, that is capable of cycling easily, is already cycling in Copenhagen. The thing the City of Copenhagen want to invite more people to cycling, new bicyclists that aren't that experienced, children, older people need to be able to cycle and for them the level of congestion in the city is high because for them the stress of being biking quite closely to other people around you, being able to react, to swerve by other bicyclists or to other traffic related situations -
KOUBECK: It's a lot at first.

VAN VLERKEN: It's a lot at first and that's why the more people that cycle, in let's say the infrastructure is given - it's fixed, everything else being equal, the more people that cycle, the harder accessibility to cycling ti becomes for - because first of all the abled population is already - you know it's not anymore like easily accessible bicycles. And for the rest, it's hard to get into bicycling because there are so many -
KOUBECK: It's such a high number already.
VAN VLERKEN: Exactly, yes. And that's - and this is my professional view of it. It's - cycling now is - could be easily - when doing infrastructure projects we try to do them for the people that are not yet cycling.
KOUBECK: Make it easily for the beginners to understand -
VAN VLERKEN: Exactly and to let - to have mothers and fathers feel comfortable with having their children in traffic cycling themselves, sometimes you see children down to four or five years of age cycling. That should be not only possible, but encouraged. And parents should feel safe to do that. And as well as the elderly for example, having a three bicycle with like a little more steadiness should be - and at a slower pace - should be allowed and totally acceptable in the bike lanes.
KOUBECK: That's where the wider bike lanes help because they can stay on the right and people that want to go faster can go too.
VAN VLERKEN: Exactly. And it's always been like that - that the bike lanes, more or less in the city of Copenhagen, the bike lanes - most of them have always been able to accommodate one broader bicycle, like the cargo bikes, or for that matter a tricycle kind of thing, with people overtaking. So this has always been the case. Now the bike lanes have been expanded even further so now it's to accommodate people riding side-by-side and for example taking and having a conversation, which is - I don't know if you know [] from the Bicycle Program on the fourth floor here, she calls is - it's kind of a pun on - in Denmark we have something called the "conversation kitchen." So it's a big kitchen where you can have a conversation. She calls it the conversation bike lane, where you can ride the bike lane and have a conversation with your friend or family member or whoever. And still let other people overtake obviously.
KOUBECK: One of the things that we are looking at for the strategies that we are going to try is how much they would cost to implement. With the projects that you do, what exactly do you guys look at to estimate it will cost?
VAN VLERKEN: It depends on the business case. It depends on how much it's socially-economically, what are the benefits going back into the system in some way you know. Not for us necessarily, but for - if we can see that there is travel time reduction on a certain corridor we can - that the unit minute travel time or second travel time reduction has a value in these - this is the transport ministry has these

models. And if we -
KOUBECK: Is there someway that we can access those models?
VAN VLERKEN: I think you can try contacting the - I know that this firm called "Incentive," they have done some work for the transport ministry and they've done some work for us, they have some insight into it. They - I don't know if these models are easily - these are quite complicated also - statistical models and stuff and economical models and - I don't know the economics, but you can ask -
KOUBECK: It's always worth a shot.
VAN VLERKEN: Yeah, ask the Transport Ministry, I think it's them who has them or at least go through this "Incentive." I don't have access to myself. We never use them ourselves really, we always get consultants or - to help.
KOUBECK: They tell you the summary of it.
VAN VLERKEN: Exactly, yes. Well and anyway, let's say some improvement makes a -
KOUBECK: Like widening the bicycle lanes -
VAN VLERKEN: Widening or whatever - makes an improvement of letting people get somewhere - let's say half a minute faster even or maybe ten seconds faster - you multiply that by the amount of people that - first of all, the amount of people that already ride in the bike lane, then you further - you add the people that are being transferred. Because of this it makes the trip faster. They prefer the trip compared to driving a car for example. You add them on top of it, you add the health benefits, you add the benefit of cars not polluting. And that way, if that - and you add a lot different - whatever the models have of course - so and, take all that into account and then you hold it up to the cost of the project basically. Smaller project, they're - the transport model on bicycling is of course - it's because the Transport Ministry doesn't - it has a pretty good model, but it only recently - these models are basically the - they were initiated originally for cars and now they've been adapted for bicycling and this has only happened in the last ten years or something like that. So they are quite new and many of the variables are unknown so many -
KOUBECK: Yeah they're still trying to figure it out.
VAN VLERKEN: There's still a lot of improvement into these models that can happen, but - well the basic of doing these kinds of infrastructure projects is the socio-economic business case behind them. As the municipality we of course, we serve the public and society itself so we don't have to earn money obviously, but it needs to have like some kind of like social or economic effect on - positive effect on society. And sometimes we do, if there is absolutely - we of course also do smaller pilot projects which we just try out and then evaluate them afterwards on qualitative measures -

KOUBECK: Like the right turns on red or the bicycle roads.
VAN VLERKEN: Yeah, exactly. The right turns on red are evaluated with looking at accidents in that - in those places depending on the project of course, but it needs to have within its own like framework it needs to improve what it tries to improve obviously. In the real sense as well. So yeah - so we look at - we always look as the - we look to evaluate the project and if it's deemed to be beneficial in some way -
KOUBECK: They'll expand a little -
VAN VLERKEN: First you'll try like one intersection or two intersections - one street or something - and then you'll try a couple of more, see if this is scalable and if the results show to be good you then - on the basis of the initial things you do a - then you do a socio-economic analysis and try to see how it works to a city-wide solution.
KOUBECK: One of the things we've been looking at actually is the 2016 Bicycle Report, which I think is made by the same administration.
VAN VLERKEN: Yes, correct. Another department though.
KOUBECK: Ok. I'm not sure if you can answer this then, but one of the things that we thought was very interesting was that they projected that bicycle traffic would increase by 17% overall and 35% in rush hour by 2025, do you know how they got this or -
VAN VLERKEN: This is - I think I'm not certain - this is more a goal and not so much a projection, as I remember. We don't do projections that much. We - of course we see - because some of these things fluctuate. Last year we had a higher - this is - we're still within the margin of error it's called, but last year we had - the year before actually, we had a higher amount of cyclists, now it's gotten a little bit low. So it fluctuates a little bit, but the goal is to reach what is -
KOUBECK: seventeen and thirty-five
VAN VLERKEN: Ok now I remember. But yeah, it's more of a goal, it's not a projection of such. So we are working towards that goal. We don't believe it will happen of itself.
KOUBECK: Okay yeah that's actually very helpful to clarify. As a cyclist yourself, what do you think is the most troublesome part of intersections, just specifically intersections?
VAN VLERKEN: Let's see, well of course obviously there is the issue of cars not - in Denmark there is rule you have to be certain that there is space for you on the other side -
KOUBECK: They're getting stuck in the middle of that light.
VAN VLERKEN: They're getting stuck in the middle. And this is not only for bicycle traffic, but sometimes this deadlocks the whole area and that is - right now I think that is the biggest issue with bicycling with the intersections and such. In relations to what cyclists are doing - and of course I do this myself, everyone does this - but when you

need to go diagonally - you go forward and then you do the turn - but if it's red for you, then it's green for the pedestrian thing obviously because that's the way - so people cycle over and then cycle over again in the pedestrian crossings and then they they go diagonally that way, that's also quite a big problem.
KOUBECK: So they cycle straight and then they cycle -
VAN VLERKEN: No, the thing is let me draw it for you because quite - you need to know. Let's say this is the intersection - I want to go from here - I come here and I want to go here. The proper way to do this is - if it's red here - is stop and then cross afterwards and then it's red here, and then you go. But the thing is, when you're coming around here and it's red, then it's green this way, so and you have the pedestrian thing here, so you bike over here - wait here, because it - and then it will get green here and then you go this way over.
KOUBECK: Yes we've seen that.
VAN VLERKEN: Yes of course. And this - everybody - not everybody, many people do this. I even do it myself and I know I shouldn't.
KOUBECK: Yeah a lot of people also do the - they'll cut across the sidewalk.
VAN VLERKEN: Yeah, exactly. But because going this way over and then that way will save you time compared to waiting here and then waiting here and then going - going over. So that's - that's kind of a problem in intersections for pedestrians, not for bicycles -
KOUBECK: You don't the interference between the bikes and the pedestrians.
VAN VLERKEN: Yeah you want to keep them separate because like - bicycles I consider it towards pedestrians - cars I consider it towards bicycles and pedestrians as well basically sometimes - and you know it's like a hierarchy of inconsiderateness. So that's - but that's - I think those two issues in intersections, those two are the biggest I would say. Of course not looking at people that run the red lights and stuff. That's of course obviously also a problem.
KOUBECK: Yeah, one of the things we saw with that was - it's a touch on the social aspects - was we were talking to Klaus Bondam, who the former mayor of the Technical and Environmental Administration, but he was saying a lot of how cyclists will basically will do a lot of following. Say someone is doing an illegal right turn they be like, "Oh okay, I can do that." Do you think that - because he was saying something about how Danes are very - I can't remember what the exact term was, but I think it was it's more -
HUNT: Oh he was like saying something about like a lemming train or something like that.
VAN VLERKEN: I think that this is - in my sociology studies I studied like behavioural

psychology, a little thing called nudging at some point and stuff - so and of course there is this concept of social proof in a way. If you see that it is acceptable to do something because other people are doing it, then you will be more likely to do it yourself. So that's - I don't if he exactly means like in the exact moment you see someone do it you're going to do it yourself. That is -
KOUBECK: It puts something in the back of your mind.
VAN VLERKEN: Yeah of course it would. This is like - this is the whole concept of culture you know. The idea of culture is that some people do something and it gets reproduced and reproduced and in the end it's - it's like it's the same for - this is both good and bad obviously because it's the same you have for bicycle as such. In Denmark we have a bicycling culture, which means that somebody started doing it and then others did it afterwards and now everybody is doing it. So that - this is a natural human behavioral thing. And of course if you can somehow, if it's negative cultural aspect of say run red lights or cutting corners and stuff - if you can reach the first mover person - the first person that does something - obviously you'll keep more people back. I don't know of ten you know this, but I - experience this - but you stand at a read light with friends of yours. You're having a conversation, somebody starts walking and you - without looking at the red light, you start walking your self. I don't know if this is familiar to you, but it's - and if they - if this person that you're just following walks the red light - you look up, you start taking step - you look up, "oh it's red" and then you stop. So it's - it's kind of a - this is how we are as people I think so and this is something that in making solutions, I think one must take into account the more or less natural behavior of people to look at these things - taking behavioral aspects into consideration when making solutions, that's a pretty good start I think.
KOUBECK: Yeah because our natural instinct is to follow the group.
VAN VLERKEN: Probably, yes.
KOUBECK: One more thing. What do you think of the infrastructure implementations that have been made by the city in the past, such as the bicycle highways, the only bicycle bridges, the green routes, the green wave. What do you think has most effective at increasing the - or decreasing I should say the travel time of cyclists trying to get around the city?
VAN VLERKEN: Well I think all of it really. It depends on - it's not like one solution that does the trick. The thing you should look at is what do all these solutions have in common? And what they have in common is really that they
KOUBECK: Segregation of the traffic?
VAN VLERKEN: Yeah, no - well not really. Yeah of course that also because - but what they have in common really is they break down barriers - like for example, the cycle

bridge down at [] down at the harbor. It - you use to have to take your bike and then take your bike on your shoulder or drag it up - depending on which kind of bike you have - up two flights of stairs and then you were - then you could carry on biking. The most annoying thing for any bicyclist is having to put their foot down, having to stop in any way or even dismounting. So having a - creating a smooth flow through the city - this is what bike lanes do, this is what bridges do - cutting across stuff - ramps. Whatever - anything we do is to make bicycling - to make traveling through the city by bicycling more attractive because of convenience - mostly just because of convenience, maybe also because of travel time, but convenience is what it is about.
KOUBECK: So it's convenient that they also think making sure the traffic flows -
VAN VLERKEN: Flows, yes smoothly from that - that you don't have to go
KOUBECK: You don't have to like start and stop or get off your bike.
VAN VLERKEN: Yeah, exactly. I'll go - I'll even take too big a - what's it called -
KOUBECK: Detour?
VAN VLERKEN: Detour. Yeah, exactly. Though just - I think the convenience aspect is the what binds all these solutions together.
KOUBECK: And that's what will encourage more people to -
VAN VLERKEN: Exactly because that is we are lazy as people. We do the easiest thing we can get away with. And if you make bicycling that and then people will automatically start biking.
KOUBECK: At the same time people don't want to like - people are comfortable with the old ways, like they're used to cars. What you want to do is you want to make the convenience factor almost outweigh.
VAN VLERKEN: Yeah, of coarse. And I think in Copenhagen it's sometime ago we crossed the - for people living within like in the city in - let's say within five kilometers of the city center - their biking is like the most convenient way to get around. And we keep - you can do it by two ways - you can make it more convenient to bike or you can make it very less convenient to ride a car.
KOUBECK: Yeah, one of the people we talked to was mentioning how in a lot of places in Copenhagen there are not enough parking spaces for people to park their cars without people having to pay the toll or fine.
VAN VLERKEN: Yeah we - as in my work - we don't take those decisions, we let those decisions be up to the politicians. So is a political question. We just - whatever they want us to do - we don't do anything with parking either - we only to with ITS technology and the infrastructure and also signaling so -
KOUBECK: For the signaling, what exactly do you work on?
VAN VLERKEN: There - yeah again I'm not a traffic engineer - those are the guys doing

the signaling -
KOUBECK: Yeah, but just the general.
VAN VLERKEN: For example making Green Waves bicycles so having like a corridor being consecutively - I don't know - in sync, if you travel at a certain sort of speed you don't need to stop at any traffic signals. This is extremely convenient. I can really go - I can go from my place on Norreport into the inner city, only stopping at like one intersection or something like that if I go in the morning for example. I can get from [] where I live and down here to [] with two to three stops at intersection. This is a five kilometer trip that I can do without stopping, of course I take a route which allows me to do this, but this is also the fastest route.
KOUBECK: And also we saw stuff about the new smart traffic signals that are being placed around the city that I think the concept is they'll stay green for buses and also identify when the bikes are there.
VAN VLERKEN: We're working on this. Right not we are installing sensor technology which will ultimately allow us to be able to do that.
KOUBECK: Yeah because we saw that they have been announced, but we hadn't seen anything on when it was going to be implemented.
VAN VLERKEN: Exactly and it's something we're working on and it's something that will come. But we - right now we're working on sensor technology and because what you need to be - we're laying all the ground work to be able to do that at some point and then we can - at some point we can flip a switch and then this will be possible.
KOUBECK: Yeah you want to make sure everything is setup before.
VAN VLERKEN: Yeah, exactly, yes. So this is some years into the future, but we are laying the groundwork now. Finding out good sense of technology which can - which of course can be scaled - needs to also be quite not too expensive because it exists, but it doesn't exist and a price range that makes its accessible for city wide solution. We are trying out the different types of technology that can allow us to do that ultimately, but we need to find something that really works you know. And often those off the shelf solutions which are - which people - which accessible to us which people - those don't really work often. So we need to find something - create something that is distinctly Copenhagen-ish you know.
KOUBECK: And that'll work in the environment.
VAN VLERKEN: Yes, exactly.
[present our objectives and methods, including demonstrating the PTV Vissim software]
VAN VLERKEN: You know there are -
KOUBECK: There are counters on the bridge.

VAN VLERKEN: Yeah and there are restrictions on what you can do there because there's a car coming from either side you can't turn as - or one of the sides
KOUBECK: We also marked down which - yeah because I don't think they turn right there.
HUNT: Right because you can't turn - the only way they can way you can get to where are going is this way.
KOUBECK: That's also what we did, we - I think I can show you the diagrams which showed which way everyone can turn. Because like you mentioned, the bridges do count the traffic that goes through, but part of the modeling software we're using is you're able to put in the ratio of people that turn right or left.
HUNT: We might as well move right into this. This is the software we use, it's PTV Vissim.
VAN VLERKEN: The engineer guys use that as well.
KOUBECK: Yeah I know they used it in the past for the Green Wave.
30:03 - 30:20
HUNT: So this is the modeling software that we use.
KOUBECK: Are you familiar with it?
VAN VLERKEN: Not really. I've seen it, but I'm not familiar with it myself.
KOUBECK: Basically you take a google maps picture of the intersection. Unfortunately right now we've only been able to fully model out Norrebrogade. But basically the dark blue lines you see are the road ways and the pink is where the cars or bicycles are able to turn. So you can see we included the -
VAN VLERKEN: Are they able to or allowed?
KOUBECK: Able to because they are not do the right turn.
HUNT: That was one of the things that we took down when we analyzed our video is we counted how many people were actually taking the illegal right hand turn. And so if we actually run this we can see that every now and again you'll see someone take that legal right hand turn.
KOUBECK: This is for the morning as well.
HUNT: Yes, this is morning traffic because in the afternoon it wasn't nearly as bad.
KOUBECK: One of the things that we also looked at was we increased the traffic on this intersection by I believe it was the seventeen percent that was the goal. And the problem that we saw was the traffic beings backing up a lot more.
HUNT: Right, so I think if we increase that - our original figure was thirty-two hundred per hour coming across the bridge and if we increase that to thirty-eight hundred right here -
VAN VLERKEN: And this is for bikes or for cars?

HUNT: This is for bicycles.
KOUBECK: We assumed that the cars would stay constant just to simplify everything and also because if the goal was met that more people are cycling it would be safe to assume that the amount of cars would grow as much.
HUNT: Right. So, just fast forwarding to get the simulation going. As soon as we increase this number, we can see the line of traffic moves further and further back. And if we fast forward even more it - as time goes on it backs up all the way across the bridge.
KOUBECK: So this goes back to the thing that -
VAN VLERKEN: And this is a model for lets say the scenario - the 2025 scenario?
HUNT: Right.
KOUBECK: This is the 2025. So what we wanted to do was we wanted to - we wanted to try a strategy that would lessen that so like - to mention again - to just make it convenient to keep cycling through. So one of the things - we had increasing the bicycle lane widths, which I think actually is already - it's already one of the things because it already they have on the 2016 report- renovating the Norregale corridor, so from Dronning Louises Bro -
VAN VLERKEN: Actually, the only thing they are going to renovate within the next year is a corridor going this way though.
KOUBECK: Oh just that one side.
VAN VLERKEN: Just that one side. They can't do anything here because - well you can take the right turn lane from the cars, then you will have more capacity and give it to the bicyclists and you will have more capacity for bicyclists, but only right onto the intersection. It's still -
KOUBECK: So it would only be right at the intersection that they would benefit from that?
VAN VLERKEN: Yes, exactly. Because this is just one - two lanes. So one going up and one going down for cars. You can't take much more space from that. Here you see a right turn lane and this you could remove the whole right turn lanes, but this one has consequences for cars. So I don't think they are going to expand the bike lanes to be like six meters wide or anything like that, this seems unrealistic at this given time - at this time. And the expansion of the bike lane is only here going upwards. It's not really an expansion because right now there isn't bicycle lane.
KOUBECK: It's basically making a separate bicycle track so they won't have to share with cars turning right.
VAN VLERKEN: Exactly. All the way out to the intersection. Like this on the other side of the road.

KOUBECK: So is it just making that one part - just making that separate?
VAN VLERKEN: Yeah and there's a separate right turn signal when you are coming upwards and then going into the bridge. There they will be like a divided lane where there is a - its own - I think it will have its right turn signal which will come into play sometimes. I don't really remember how it's suppose to be. But yeah, so those are basically the improvements, maybe one more improvement, but not really - nothing going from the bridge and into the city.
KOUBECK: Ok that's good to know because in the report it just listed widening the lane, improving - so there's some talking point words in there.
VAN VLERKEN: Yeah, exactly. That's what that means basically.
KOUBECK: So yeah, another thing that we looked at was creating right turn specific turns for the cyclists
35:48 - 35:59
KOUBECK: Basically making those into designated bike lanes to not only allow the cyclists to do that, but also to give basically the pedestrians a heads up - like this is where bikes might be going through.
VAN VLERKEN: This has been taken up at some point, but it was rejected and it is - I've hear it mentioned sometimes and it's usually rejected because pedestrians also have a high priority in Copenhagen. Copenhagen is known as a cycling city, but pedestrians are harder to model. Pedestrians are harder to get data from, but they still have a very high priority where they can. So I - if - I don't think you will get away with taking pedestrian space to make bike lanes because I think every time they take - you can take car lanes and make either - often both widening the pedestrian sidewalks and the bicycle lanes, but never the one on the account of the other. That's - right now it's not like politically how the landscape is right now. So right now it's pedestrians and bicycles, not either or.
KOUBECK: Yeah and putting in the cyclist only lanes would - yeah because it could force the -
VAN VLERKEN: Exactly, but where - they did this further down as - you know -
KOUBECK: Is it the alternative right?
VAN VLERKEN: Yeah and that is - they did that. That was controversial, but that was also very necessary because -
KOUBECK: Yeah a lot of people actually - I think what was it like a thousand people took that in the morning?
38:07 - 38:30
VAN VLERKEN: This is because if you go back to the map - this is because by [] this is congested and especially, this - not not this, this one. This intersection here is often

very congested so two things happened -
KOUBECK: And if you go to the alternate right you can avoid the congestion at Norrebro.
VAN VLERKEN: You can avoid the congestion because the parallel street here does not have a bike lane so it is much less - it has much less car traffic. So here, this has much more capacity because the bicyclists can fill out the whole car lane in principle. So this right turn here, it [] - it both alleviated the intersection further down and the congestion going up to it as well as accommodating something because this was something that many people were doing.
KOUBECK: Yeah, they would do it illegally.
VAN VLERKEN: They were doing something good illegally. What if you make a bike lane here will - people that just go over here instead of waiting are not doing - are doing something illegally without alleviating anything really. So this will not be a - this will probably not be accepted I think, but again it depends on the political situation. It depends on a lot of stuff.
KOUBECK: And to go along with that, one of the things that we talked about was making - allowing the cyclists in the intersection to make a right on red providing that they are able to do so.
VAN VLERKEN: This is a more viable solution I think because if you - this is being tested now and will be implemented more broadly I think - I don't know, we don't have to do, this is not our department again, we have many departments in the Technical and Environmental Administration. But having conditional red lights - right turns on condition that the pedestrians are respected is a much more viable way of doing it because -
KOUBECK: Well you're not taking any space away -
VAN VLERKEN: Exactly, you're not taking space away from pedestrians. You're putting a clear hierarchy that the pedestrians not come first. And then - because if you were making a designated bike lane going through there.
KOUBECK: The cyclists would -
VAN VLERKEN: You kind of - you can make the small white triangles you know - which in principle, which means stop unconditional and if there is anybody, that those are respected less than an actual red light where you - it is acceptable to go. So I think it'll have a bigger behavioral impact on bicycles. They will tend to respect pedestrians more if they are allowed to cross with red on that condition instead of having a bike lane just for themselves where the pedestrians are kind of a nuisance on their bike lane. Do you see the distinction?
KOUBECK: Yeah it's the ownership, it's their bike lane.

VAN VLERKEN: Exactly, yes. And it depends - in this intersection it very []. You can see it's a beautiful spot, it has a lot of space for pedestrians as well, and it's a place where people also hang out. So you want that to be a place where - it's a goal of Copenhagen. When you see the goals for bicyclists you can also see the goals for pedestrians, but there is also goal that people - like it's very broadly formulated - it's like people hang out more outside and this - people on the way from point A to point B, that they stop and like enjoy themselves for some time. It's a much more qualitative - quality of life kind of thing.
KOUBECK: Yeah, that's one of the things that Klaus mentioned about the designated right turn lane because he was saying that it would almost ruin the aesthetic appeal because people would not be able to mostly hang out in those areas.
VAN VLERKEN: It will become too busy. Where will you hang out you know? You will hang out in that green spot there -
KOUBECK: Yeah a little island in a sea of bicycles.
VAN VLERKEN: Yeah exactly. That will never be used for anything. They should actually put benches up there, I don't know why they don't.
KOUBECK: Yeah there are only one or two.
VAN VLERKEN: Yeah that's a shame, but anyway. It's something different. But yes, so that won't be viable I think, but the allowing the right turn - even though it's red - that will be more acceptable I think.
KOUBECK: Yeah and we're thinking about allowing that for bicycles and not for cars.
VAN VLERKEN: Yeah, of coarse. You shouldn't allow the cars, only for bicyclists.
KOUBECK: Why not for cars? I'm just curious. Because in America it's traditional that cars are allowed to turn right on red.
VAN
KOUBECK: One of the things that we were thinking about was changing the light timings in the morning. So as you can see, the Dronning Louises Bro has a lot more cyclists in the morning, but it has almost half of the green time. So what we were thinking of doing was switching that for the morning - say before noon - so that Norrebrogade will get -
VAN VLERKEN: The thing is with that it affects the cars and that a big problem. That stretch of road is prioritized Copenhagen has different priority levels for each corridor or many corridors. You can see it in - I don't know if this is actually in English -
KOUBECK: I mean we can translate it.
VAN VLERKEN: It's called "[]," the Administration - it's the basis for administration for traffic management. It divides many of the essential corridors in Copenhagen into what is the prioritized modes of transportation. How should the intersections, the signals in

those corridors - what should they be - what should they prioritize. And the way down from Osterport and down [] Boulevard, [] which it's called - that is prioritized for cars. And like
KOUBECK: Okay because that's what we - we looked at that one too. We saw similar things where the longer green time was contradicting the direction where the majority of cyclists were traveling.
VAN VLERKEN: Exactly, but not the majority of cars.
KOUBECK: And the buses especially.
VAN VLERKEN: Exactly yeah. And don't want cars to be - to have too long - like idle -
KOUBECK: Yeah because that creates a lot of pollution.
VAN VLERKEN: Exactly and that's a big problem so you also need to like - we need to improve the flow for cars as well as the bicycles, but as long as still have cars and they are not electrical - all of them. Then we need to also get the cars through the city otherwise they're just stuck in the city polluting the air, more or less.
KOUBECK: I actually found this out yesterday about car, but if you are stationary for more than five seconds than your engine will shut off.
VAN VLERKEN: Now there is that and maybe that will be taken into account, but it's still not
KOUBECK: You still don't want to increase the bicycle flow at the cost of an enormous -
VAN VLERKEN: It depends. Well it depends on the political priority of the specific corridor and this is stated in that document. And it depends of course also on the circumstances of course. I think, being that there are so many bicyclists in that area - I think it would be good idea to improve the flow that way, but then again on the other hand, then we've had - bicyclists have a green wave all the way from Norreport station, all the way down to that point. So, kind of, you can't give bicyclists Green Wave anywhere they want. That they have it from that point, then maybe they can wait like one or two cycle times in that traffic signal. All in all it depends more on having bicyclists stop less times and not so much because once you've put your foot down on the ground, then you stay that way for however long. It's the actual action of stopping and putting your foot down and having to decelerate and accelerate again, not the actually amount of time you are waiting, I think in my opinion. This has not been research as much obviously, but I think it's acceptable to have people wait a certain amount of time if they had like a whole - if they've been able to ride 1-1/12 to 2 kilometers through 7-8 intersections without having to stop than yeah, okay. Having to stop one or two minutes, it evens out. And the annoying part is stopping, not actually waiting. This is what - there has been some study that made that most annoying thing

for bicyclists is having to stop because of the - you use energy when you accelerate again. And if you have good flow then - so I think that will be - that trade off is acceptable. So wherever - so the reason for that in any case for the intersection being as it is - is because it prioritizes the car go south-west bound.
KOUBECK: Yeah especially the Gothersgade intersection we saw - it's basically where all the buses are going to get to Norreport station.
VAN VLERKEN: Yes that's a priority for the person there.

Transcript of Interview with Flemming Møller

Interviewee: Møller, Flemming
Tuesday, 4 April 2017 1700-1800
Cyklistforbundet (Danish Cyclists' Federation)
Rømersgade 5-7, 1362 Copenhagen K
Interviewer: Koubeck, Adam
Attendee: Hunt, Alan

KOUBECK: What do you think is the most troublesome aspect of an intersection for a cyclist?
MØLLER: For me and for many of my colleagues, the main problem should be the green time.
KOUBECK: So just the amount of green? Because that actually something we saw as well. Because if you look, the west Norrebrogade, that's the one with the thirty-two hundred, but if you look up top - sorry it's a little small, but they only get twenty seconds of green versus the perpendicular street gets thirty-five seconds.
MØLLER: Yes and twenty seconds is not unnormal, that's probably seen in many crossings.
KOUBECK: Yeah we also saw that at Gothersgade as well. But the problem that we saw was, regardless of the light timinings, there's still a lot of car traffic so it's important to also look and see - make sure that even if you solve some of the bicycle congestion, you don't want the car traffic to become overwhelming because that's actually going to increase pollution. One of the things that we were thinking was to swap these green times for the morning because that's when traffic is at its peak over Dronning Louises Bro.
MØLLER: At eight or nine or something -
KOUBECK: Yeah and keep it the same for the afternoon because, as you can see, a lot more cyclists -
MØLLER: In the same direction or the opposite direction?
KOUBECK: So basically - so during the morning Norrebrogade will get thirty-five seconds of green and then in the afternoon - during the afternoon rush hour - they would get twenty seconds instead because we would flop it - or flip-flop it - so that people with the most cyclists - or the road with the most cyclists would get the greater green time.
MØLLER: Have you noticed whether the period, the interval time changes during the

day so that you have longer intervals during the rush hours and shorter during the main hours of the day?
KOUBECK: Not at Norrebrogade, but we have seen something like that at Gothersgade. Yeah, especially with the new smart traffic lights they are putting out - you know about those?
MØLLER: Oh yes.
KOUBECK: So that will let the bikes and buses through rather than - or it will prioritize.
MØLLER: Yes and in other respects the municipality is working on making alternative signing for bicycles you've probably heard.
KOUBECK: Yeah where you can track the cyclists.
MØLLER: Here's some points which are put here in this area, [] - here. But it's on a basis of a experiment.
KOUBECK: So ok, they are testing it out? Do you have any idea how that is going or just - ?
MØLLER: No, not yet because they haven't quite managed to put it up - it's some technical difficulties.
KOUBECK: Ok, so it's a very recent thing that they've tried. Because when we were talking - we talked to Klaus earlier this morning and one of the things he mentioned was the social aspect of all of this. Of how a lot of people - or how people in the morning trying - or there's always going to be a lot of congestion in the morning because people are trying to get their kids to daycare at a certain time or in the afternoon one of the more fascinating things I saw or I heard from him was people want to leave work earlier so they can go pick up their kids from day care because because they don't want to be the last ones to come and pick-up their kids. And that's something that we hadn't even thought of before.
MØLLER: They have definite times in the afternoon which are really tough, seventeen is normal.
KOUBECK: Seventeen? Okay. Do you know of any other social aspects or social ways or - I'm sorry I'm not saying this right - social aspects of Danish culture that may affect the congestion times.
MØLLER: No, not in the afternoon I think because most are busy getting home to make food and to get their children to make their homework for school and such things, but in the morning hours there could be some gather of bicycles who are aiming the same spot. They have maybe negotiated and said we'll meet here and then we'll proceed to our working place -
KOUBECK: Of dropping their kids off at school or something like that.
MØLLER: That should be afterwards.

KOUBECK: Another one of the things that we were looking into was the widening of the lanes. We'd also seen that - we saw that actually the city is already planning a lot of renovations, especially for the Norrebrogade corridor.
MØLLER: Yes, the road is called something with -port. Amagerportgale, Norreportgale, Osterportgale, which are still the main roads also for bicyclists. Osterport is still a little narrow so it will probably not be the last one, but Osterportgade - where I live in fact - has already on this part a so broad a cycle lane that you have parted it in lane for those - what's called overhaul - they have overtaking places here and they have in Norreport and some other places where the traffic is hard. They'll probably more of the in the future. It would have to be co-worked with the police because they still the remains of responsibility of making the traffic flow. And they always vote with motorized traffic.
KOUBECK: And we were also looking at a lot of the stuff Klaus mentioned was the separation of bicycle traffic and car traffic. Especially with the superhighways -
MØLLER: Oh, yes. It's possible to do it some ways - some places where there's place enough - space enough. But in the center of Copenhagen you would rather do this way - that you say this road is not for cars, it's only for pedestrians and bicycles - and we already have many street here in the center of Copenhagen where you may go by bike in the opposite direction of a one-way road. So the one way road is only for cars, but some places bicyclists are allowed to get in the opposite direction and it's working fine. But the police were very, very upset about this yes, but even then - even they have - what's it called - noted it. That it should be possible with proper signing.
KOUBECK: Because when we were researching the topic of bicycle congestion, one of the things we saw in the Netherlands was the bicycle roads - the roads where the cyclists have the right-of-way. And it was actually interesting to see Copenhagen is actually trying out one in Valby and one in Vesterbrogade. And actually, in the Bicycle report, they said they were making a couple more, do you think that would be a viable option - do you know what the bicycle road is?
MØLLER: Oh yes. I should say where the technical aspect of the road itself hasn't been changed yet. Maybe they are planning to do it, but I don't think they are doing it all over the route - so they say we should have route C99 coming in from here and all the way inside to main center - the main station - it would be impossible to do it everywhere. The space is too narrow - we can't do it. Of course when you are outside - in fact outside the municipality - you see many examples of making separate lanes for bicycles away from the other traffic.
KOUBECK: Yeah that was one of the key things that we saw or at least that Klaus mentioned before. I just wanted to ask you one more question about the intersections -

if you could change one aspect of like the intersection to benefit cyclists what would you change?
MØLLER: Depends on where it is.
KOUBECK: Well then I mean, what would you change depending on where it is? Because honestly the more data we can gather, the more it would help us.
MØLLER: I would still say this aspect with the right regulating should be more in favor of the bicyclists and the pedestrians.
KOUBECK: The right turns? The right-hand turns? Is that what you said?
MØLLER: No, in fact more the direct head way because many have already - they are going to their working place, they chose the direct way. They use as few turns as possible, so it's more about to find a way to make the signaling in favor of those going directly.
KOUBECK: Okay, yeah. So it comes back again to the light timings.
MØLLER: If you think of the way the surface is or stones or markings and so - it's a minor importance apart from the granite stone - they are very popular anywhere.
KOUBECK: Because it doesn't matter the markings or the lanes if you - if there's not enough time to get through the intersection.

Transcript of Interview with Helen Lundgaard

Interviewee: Lundgaard, Helen (Chief Consultant)
Monday, 10 April 2017 1400-1500 (01:10:23)
Capital Region of Denmark
Nordre Frihavnsgade 106, 2100 København Ø
Interviewer: Koubeck, Adam
Attendee: Hunt, Alan

LUNDGAARD: How much do you know about the Capital Region?
KOUBECK: I know it's about - it's Copenhagen and the outskirts, but I'm not - I wouldn't say very knowledgeable on it.
LUNDGAARD: Well you don't need to. It's a regional authority and it's primarily a health authority.
KOUBECK: Yeah, I saw that.
LUNDGAARD: And I am in the secret services of the Capital Region. Nobody - it's not actually - we don't have any authority to plan or to build or like - all traffic authority is local or state central so I'm in kinda of a think tank or strategy section that is trying to look at regional challenges and find regional solutions to those with problems. So and when you're talking about traffic you often can't solve traffic challenges on the local scale and that's is our mandate - is try to coordinate and try to make local municipalities cooperate. And the municipality of Copenhagen is a big and powerful municipality and it's got Frederiksberg - do you know? So there were two central authorities, but since a lot of commuters each day travel into the municipalities and like I commute forty kilometers north of Copenhagen each day. So you can't as a local authority only deal with your own stuff, you can't solve problems with congestion in one without looking at the regional picture. So that's what we deal with and bicycling is a political - has a political focus as well as other issues.
KOUBECK: So what specifically have you looked at with regarding bicycle traffic or infrastructure in the past year or so?
LUNDGAARD: Our - what we do is primarily is to sponsor projects - development projects. We don't have an authority, but what we are concerned with exactly is that oh we actually we also see the bicycle as a solution to a lot of challenges - health, environment and climate, congestion of coarse. And you can sum up a lot that solve it - like economically numbers - what does it cost for society to
KOUBECK: Yeah it saves money to have more cyclists.

LUNDGAARD: Yeah. So there is a social economical argument to work with bicycling so this is a - the reason why our - the 41 elected politicians are steering the regional council, this is why they want focus on the bicycle because they see it as a solution, but also it's because it's a popular issue. A lot of citizens would like the authorities to better the conditions for cycling. So that's also a good argument to work with it.
KOUBECK: Yeah because I saw on your website - on the regional website it had a figure I believe sixty percent of people in the region cycle or use cycling like every day to travel.
LUNDGAARD: Uh sixty percent
KOUBECK: It was something with sixty percent, but I've also seen fifty percent and forty.
LUNDGAARD: Around the first of May we publish the second regional cycling account. So when we have that we will have the newest statistics about cycling in the region. So maybe you should get in touch with me around that account to give it to you now because it's not finished. We are working on it each time, but we have it finished when we get to the first of May. We have an old account - I can't remember the name - sixty percent is a lot.
KOUBECK: Yeah I thought - from the numbers we saw it was more - we've been looking at the 2016 Bicycle Report from the municipality of Copenhagen.
LUNDGAARD: Ah that's different story.
KOUBECK: Yeah it's different because it’s not the
LUNDGAARD: This is the big news the last - I think couple months ago something - that went the world round that there are now more bicycles than cars in Copenhagen - that's in the local authority. That doesn't count when you're on a regional scale where you have twenty-eight municipalities.
KOUBECK: Yeah because I feel like a lot of the outskirts, it's easier to use a car to get - or especially if you have a job inside of Copenhagen it's easier to use a car because it's almost just too far to bicycle.
LUNDGAARD: See and that's - so that's our focus I think that's what you ask me. The focus is also to try to make it easier to go for longer distances on the bicycle. You can either do that by making the infrastructure better to try to make it - the highway high quality. And you can work with combination trips. So to get people - more people to combine with bicycle with public transportation. And then you can also - we work with electric bikes which is also a way of making your - making people capable of biking more to go distances. So with the big problem is that when you get away from Copenhagen you don't have these great number anymore. There is car ownership increases when you get to the suburbs and the activity of public transport is not as

great and of course if you have thirty kilometers to work you cannot just got by bike. So there is a good reason why people - there are more cars when you get outside Copenhagen and of course if you have a car you will use it. So and from the perspective of the Capital Region, we are not car haters - we do not hate cars. This kind of like a political point of view that in order to strengthen economic growth and development good frame work conditions for business, society, and for people in general it should be possible to use a combination of vehicles - modes of transportation. So but we encourage people if possible walk or bicycle because it's good for your health, it's also good for the environment and so on, it's good for everything more or less. So but sometimes on not all trips can be done by bicycle or as a pedestrian. So the second advice, then use public transportation. So if that is also not an option, use the car. If you use the car consider e-cars, electric cars. So this is the optimal situation. People always think like that and not maybe not just as - you should think about it all the time. So that's also that we work with, that the behavior part of it.
KOUBECK: Almost like a hierarchy of your options or I should say the administration would prefer people to - like think of using bikes, walking, and public transportation, try to see if those are possible first and then if none of them, use the car.
LUNDGAARD: And if you - during your week you - like me, I work forty kilometers north of Copenhagen, but I often have works at my meetings in Copenhagen and sometimes I don't go to my work place. I take a meeting and I work at home. And other times I need to go to Sweden or anything, so everyday consider what would be the optimal way of transportation. So it's just about trying to do something else now and - so this is also a thing that we work with. I don't know - maybe I am a moving away from your question so
KOUBECK: Oh no, that's fine. We know that the decision making hierarchy thing is very interesting. So also couples on - we talked to someone from the Technical and Environmental Administration and what he was saying was...
LUNDGAARD: Who did you talk to?
KOUBECK: Jos van Vlerken.
LUNDGAARD: Ah, I don't know him.
KOUBECK: Okay, but what he was saying was a lot about making bicycle as convenient or possibly more convenient for cars. Because like you say, when people are deciding how to they are gonna move around the city, if it's more convenient to use a bicycle then they'll use it, but if it's not they will probably chose one of the others or the car.
LUNDGAARD: So that's - it's easier said than done to make the decision about

bicycling more using form of transportation as attractive as possible so that's - I think probably what we work for, but at different scales. In Copenhagen they work primarily with their own citizens. So, but they can't' - they have high ambitions about being carbon neutral and they want to do a lot of things, but they can't control what's happening about commuting and all the people that -
KOUBECK: Okay yeah that's true.
LUNDGAARD: So they need to cooperate with the municipality and the Super Cycle Highways is one of those projects that we sponsor as a regional authority because we see it as a - you know - a regional project. It's a project where municipalities they cooperate so that - to make better considerations for the bicycle, also on the long distance.
KOUBECK: So it doesn't just help just central Copenhagen, it helps the outskirts as well.
LUNDGAARD: Well I think it probably - it helps everywhere. So, but they can also - if more people didn't take their car each day to work it would also - it can also be felt in Copenhagen. I also think as a citizen it's - now my personal opinion - that it's annoying with all those cars. So I think a lot of citizens here would like less cars. On the other hand, everybody wants a car and a place - a parking place - and so on. And they want the option of a car now and then.
KOUBECK: That's fair. One of the things we wanted to ask was do you feel bicycle congestion is a serious problem in the central city right now or - and if you do, when do you think that started?
LUNDGAARD: Now I think I need to answer as a - it's my person perspective, but it probably it would be because I don't know - we don't have any studies or anything about that, but as person that bicycles myself I think congestion is a problem at certain times...during the rush hours. And I especially feel it in the S-trains because my way to work is typically to be to go down to Newhaven station and hop on a train and then go to Hellerup, to the end station at - I think it's the A line. And I would take my bicycle with me on the train and then because I three kilometers from Hellerup station and then to my workplace I would on the bicycle on the last three kilometers. But it's really a big problem with the congestion in the trains.
KOUBECK: Okay yeah, because there's only a certain amount of racks for the bikes.
LUNDGAARD: Also only in rush hours. I see both and sometimes and when I have meetings in Copenhagen it's - I get really surprised how many bicycles is on the road. It's really wild. And it can be dangerous also.
KOUBECK: Yeah that one of the things we see.
LUNDGAARD: So [] must go to work everyday on the bicycle. And he works in

Copenhagen and I often hear him complain and that's because there are a lot of cargo bikes in Copenhagen and at a special time - at around eight/eight-thirty all the mothers and fathers need to take their children to the child care - to the schools. And it makes - after that it's not a problem anymore though.
KOUBECK: Okay, that's actually the second time we've heard that too in our interviews as well. We were talking to - I don't know if you know him - Klaus Bondam, but he - on top of that he had mentioned that a lot of parents will leave work almost at the same time, like around four because they don't want to be the last parent to pick their kid up at the daycare as well.
LUNDGAARD: Well I think it's a problem, but I think maybe you are the first people studying that topic so I don't know - I haven't heard about - I haven't heard that there are a lot of studies about congestion.
KOUBECK: Yeah that's one of the things because our sponsor Claus Knudsen he was telling us that this past bicycle report was the first time that they listed bicycle congestion as a major issue. Yeah, that's one of the things that we saw because - what we are looking at is also the report they said - they had the goals on increasing the - I don't want to say the congestion, but the amount of people in the traffic. So I think they said seventeen percent in overall - increase in overall bicycle traffic and thirty-five percent in rush hour traffic by 2025. So one of the things that we were looking at was trying to find strategies to make it - to keep bicycling as convenient or improve it that when these - the increase people come it doesn't make up traffic everywhere. Because right now there's - it's really only congested in certain places but we don't want that to spread as the number of people riding bikes increase.
LUNDGAARD: I don't know if - what happens because some places , especially with like bicycle supercycler highways and the concept of broad bicycle lanes, what happens is that just as it happens when you put another lane on the highway for cars it solves congestion for a while and then you can see all measures of around Copenhagen on the major traffic routes - you can see that whenever you put more - a lane more than after a while you will have even more cars. So I don't know if the same things is counting for bicycle lanes. When you make them broader and more attractive you will have more bicycles and eventually you will have just as more congestion.
KOUBECK: That's true, but it's also taking people from other routes as well.
LUNDGAARD: It's both because of new people who didn't bicycle before, but because they also chose another route.
KOUBECK: Yeah that's true. Also - actually I can show you the map that we - by the lakes was where we looked at the intersections.
LUNDGAARD: So you looked at the intersections at the lakes?

KOUBECK: Yes.
LUNDGAARD: Yeah okay.
KOUBECK: So the ones that - near the lakes, but those are the three that we circles are the ones that we chose.
LUNDGAARD: Yeah okay. That's also a very a good place to study.
KOUBECK: Yeah because since we only had essentially three weeks to gather the data, so we chose the intersections because it gave us the best opportunity to get quantitative data of how.
LUNDGAARD: So what did you do? You just count?
KOUBECK: Yeah we can actually move into that now. Yeah it's confusing without the visual aids. So what we did is we went there during the morning rush hour and the evening rush hour and we - each of the group members stood at corner so we could videotape the flow of traffic going in and we took three videos of five minutes each and what we did was play those back and we individually - we counted the cars going through as well as the cyclists, but not just that, but also which direction they turned because they do have counters on the bridges that does
LUNDGAARD: I know there is a counter right there. Yeah exactly.
KOUBECK: But what we were trying to do is we have this modeling software - that actually the city is used in the past with the green wave initiative - we've been using that and to accurately impute the data it requires which direction people are turning. So we were able to gather that as well. And if you have any questions feel free to stop us if you want.
LUNDGAARD: No, so far it's interesting.
HUNT: Yeah so we might as well move right into the modeling software - I just have to get this open real quick.
KOUBECK: So essentially what this does is it takes google maps photo of the intersection and then you can draw in the - road ways you'll see in the dark blue and the pink I believe is the directions that people can turn. So we were able to input that. And what we can do is from the data - from the data in the videos that we watched we were able to put in the ratios of people - say making an illegal right-hand turn or making a left-hand turn.
HUNT: Right so - yeah so each of these blue ones is where someone can enter or exit the intersection and all these pink ones are the different route they can go on. And so if we get this running real quick it will take a second because all of the traffic starts at the very ends of these. Where are they?
KOUBECK: Skip forward a little bit I think it will.
HUNT: We'll fast forward a little bit. Here they come. So yeah, we can see these green

and red are the stop lines and so we have the intersection traffic controller timing recorded. And so, at the moment our model seems to be pretty accurate with the amount of people going through and so we can see - and this is for the morning data, by the way - so this the most congested part in the morning and in the afternoon it's going the other way. That is what it looks like at the moment.
KOUBECK: Yeah and so what we can do with that - we are trying to come up with strategies that we could use to possibly run it through because...
LUNDGAARD: So that's my strategy to solve that particular intersection...
KOUBECK: Yeah we are looking at it from a micro level because - to be completely honest - it was the most doable in the time span that we had and to still get quantitative results that we could - instead of just saying "oh we think that you could do this" we can say "oh we modeled it and it increased traffic flow by this percentage."
LUNDGAARD: So maybe that's also good to look at the hotspots of problems and then solve them instead of - because I think most places it's pretty okay. We have a few places that are already now problematic and the demographic development and so on and we can only expect it to increase.
KOUBECK: We actually can model for the increase. We model - I believe you have the...we modeled the data of the eighteen percent increase I mentioned before - the goals of the - just the traffic in general. And we can just do that by changing the flow of the people going through.
HUNT: Right, so each of these has an input, like a number of people per hour so we have some for bicycles and some for cars, this one is for the bicycles coming this way and I believe I actually already had the eighteen percent increase in there. And so if I actually put that back you'd see a little bit less traffic. But we can see even if it increases - like let's put it to four-thousand-two-hundred per hour- it doesn't take very long after the simulation starts to actually back it up pretty far. So let me fast forward just a little bit. We can see with just one light cycle they are all the way back here at this point and by the time we get through a couple more light cycles they'll pretty much back up all the way across the bridge.
LUNDGAARD: And then you start to find another route.
HUNT: Right, so at this point the model wouldn't even be accurate.
KOUBECK: Other people other places get backed up as well. That's one of the flaws with looking at these approaches, you can't really look at the grid as a whole.
HUNT: Right. But anyways that's what we see if we just say more people are coming this way we can see that it's not going to work.
KOUBECK: And also we wanted to keep - we kept the car's constant even as we increased the bicycles because the goal of the Bicycle Report is to increase the bikes

and even with the increase people coming in we assumed - we thought it was pertinent to assume that the cars would stay about the same, and maybe not drop off that much, but stay even.
HUNT: Want to look at this?
KOUBECK: So for strategies that we were thinking, we were thinking about mixing up the light timing because - I don't know if you can see - but the Norrebrogade has almost a fifteen second less of a green,but it also has almost three times the amount of cyclists in the morning. So what we were think was if we flipped the times in the morning it will allow more cyclists to get through and then keep it back in the afternoon because Sortrovet - but yeah that has more bicycle traffic in the afternoon, so if we keep it like this in the afternoon - we thought that that was - we thought it might work, but the problem would be that the cars coming in from the highway also - used as one of their primary access points. So we would have to see if it - how much it increased the car traffic in the morning by because at the same time we are looking to increase the flow of bicycle traffic, but we don't want to do that at the expense of extreme car congestion. Because that almost causes as much pollution as it would save by having more cyclists.
LUNDGAARD: Yeah, it is already bad here in the morning. But I saw a report about the different bicycle ideas solutions and there was one solution that I think they used in Holland where they
KOUBECK: Was it the bicycle road by any chance? Where they had the cars and bikes on the same part of the street?
LUNDGAARD: No I think it was that they changed - instead of you have an intersection with many different - then you make it green for these and then this and then you then you have many you know different changes then you give the bicycles a change more so you make it green for the bicycles and then you leave someone else. And then instead of making everybody - give everybody a green light then you give the bicycles twice green light during the whole...so that's more - I think that's
KOUBECK: So was that twice the duration or that turn twice green twice in the cycle? So green...
LUNDGAARD: I don't actually, actually I don't know maybe you can do either thing so - but I don't know if you thought about that.
KOUBECK: I don't think we had the double or at least the two times per cycle, that would be something good to look at.
HUNT: Do you know where you saw it?
LUNDGAARD: Because I'm not an engineer so I'm not, that was into the technical solutions, but I thought that was quite clever to - you can do that for cars also.

Whatever lane or whoever you want to favor you can favor by give them green light twice. So - and maybe you can even with the intelligent traffic steering you can even you can change that during the day show the rush hour direction, you can give it a green light twice. I don't - I just that as a solution that has been - I don't know if it's even done in Denmark, but I've hear they at least tried to do it as a test in Holland.
KOUBECK; Okay. Yeah because we also
LUNDGAARD: Did you speak to the Super Cycle Highways - the Secretariate of the Super Cycle Highways?
KOUBECK: I don't believe so - I don't believe we've spoken to him.
LUNDGAARD: So, but they are the ones that made the report on bicycle ideas. Maybe it's one year old or something like that, but that was a collection of different solutions that could be implemented or that could be worked with that has not been done. I think maybe it was both known solutions and unknown solutions in Copenhagen.
KOUBECK: Yeah. Going off the traffic light was also saw that - I believe Copenhagen is trying to implement smart traffic lights at all intersections where they'll stay green for busses and favor the cyclists as well, but I don't - when we talked to Jos at the Technical and Environmental Administration he - they still didn't know the timetable because I think they are still working on that so that could be some years away. So going back to the - sorry, how do I go back?
HUNT: Oh you want to go back to the Vissim?
KOUBECK: Yeah, Vissim. So going back another - another one of the things we saw was increasing the bicycle lane widths, which I think they actually are- they're already doing I think just right here because that's not a separate bicycle lane, you actually have to merge with the car traffic to turn right.But we though possibly expanding this lane even - it's already very wide to begin with, but possibly expand
LUNDGAARD: Yeah it's one of the widest places in Copenhagen.
KOUBECK: Possibly expanding that more might help, but it almost has that same cons as the traffic lights where it leaves less space for the cars trying to get through. And unlike the traffic lights you can't change it during the day, it's a fixed, permanent thing. But I think a lot of around Copenhagen they are doing a lot with expanding the bicycle lanes, no?
LUNDGAARD: I think they do - there is a will to work with it, but the financial, the municipal projects are bad and there is no municipality - what Copenhagen is a rich municipality and they spend a lot of money on bicycle infrastructure. Some municipalities around Copenhagen also do - had done a lot and have plans, but the investment - intensity of investments in bicycle infrastructure is - could be better. So because in the municipalities they need to prioritize between you know school and

child care and old people's' homes and they have so many priorities
KOUBECK: And it's hard to fit cycling infrastructure in there.
LUNDGAARD: Yeah so, but I definitely think on the long term - both short and long term - you can you can save - it was my argument in the beginning that you can help Copenhagen with the congestion problems by helping the municipalities if you can - it's not maybe you know the municipalities are authorities and they can invest in infrastructure and they can make - they can put incentives to make their citizens go by - take something else than the car, but in the end it's about you and me, it's about people - human beings. So you need to talk to the people. You need to change something in the software and so - and I even think there is also some very non-technical solutions if you have - maybe you've looked into car, there's one person in each car. What if you fill up the cars and make - you know - carpooling more attractive and how you can solve problems in Copenhagen city by filling up the cars.
KOUBECK: Yeah, so there's less traffic on the roads.
LUNDGAARD: So yeah.
KOUBECK: Yeah so for supporting outlining municipalities like you said that's more - would it be more of an infrastructure support or like more of a social like...
LUNDGAARD: Well that's a good questions. That's probably why it's - there's not authority where - there's no place that has a responsibility for that. So I think it's also for many politicians, municipalities, it's - they don't like to tell people what to do because they don't want to interfere with people's privacy. The same thing counts to workplaces, business. This is something that is coming up and that is getting bigger and bigger than municipalities want to cooperate with big workplaces in the neighborhood and their industrial quarter and so on. So that also - see this is something about corporate social responsibility that employers also maybe have a point of view on how their employees travel, transport themselves to and from work.
KOUBECK: Incentivize the bicycle travel possible or...?
LUNDGAARD: That - you need - when you don't have money any - nobody has money for this so maybe you should make some partnerships between workplaces and authorities. So, but it's - nobody - not also - also the workplaces they don't - employers don't like to interfere with their employs' possibilities because people - they are not just a lazy or people they take the car for reasons because they have - you know they need to - not all people - the Copenhageners they can maybe take the cargo bike and get their children to work and then they can go to their workplace one kilometer away, but if you live in the outskirts you have longer distances and you have many - you may have many errands that you should take care of on your way to work.
KOUBECK: Yeah the reason why people aren't - or why a person isn't using a bike

isn't because they don't want to physically exert themselves...
LUNDGAARD: People would like to bicycle, there are people that don't want to, but you can't force any - you can get everyone, everybody to bicycle. You can get - there are a lot of people that we know that from surveys - that a lot of people that go by car each day, they hate it. They really would like to do something else -
KOUBECK: There's almost more of a freedom when you're on the bike than when you are stuck in the car in the city.
LUNDGAARD: Plus you get some exercise and some fresh air and for a lot of people it's a way - to increasing life quality, so but it's not just easy for them to take that decision because they have too many day- they don't have time and - you know there are a lot of excuses good and bad excuses - so but that's also a solution that is in a more social, nontechnical area when you make - when workplaces interfere with their employees' choice of transportation and should the authorities - local authorities interfere with the citizens and ask them please help us make cleaner - the air cleaner and the roads less congested and so on by taking - letting your car stay at home. That's - I think there are some political difference whether you want to work with that. I think the more socialistic or the more social democratic you are, the more green you are, the more you would like to interfere. If you are liberal or conservative you don't want to interfere. So you have these differences.
KOUBECK: Ok. When you're cycling, what do you think is the most inconvenient part of an intersection for not only yourself, but cyclists in general?
LUNDGAARD: Well I think it's inconvenient that I have to stop. I wish I could just go ahead and - because there's a lot of energy put into stopping and starting. So what -
KOUBECK: It almost goes along with the -
LUNDGAARD: I don't know if there's something that annoys me especially or - I haven't thought about that. No, I don't know.
KOUBECK: Because when we were talking to Jos at the - he said a similar thing that the most inconvenient part was stopping and he mentioned it would almost be - it's not the wait times are the most inconvenient thing, but it's that actual fact that you have to stop. And he was pointing to the green waves where if you travel at the speed you'll hit a lot of green lights.
LUNDGAARD: That's also what they work with in the super cycle highways that conception of the people -just the flow - the conception of flow so that you don't - I think it's probably no different if you're in a car you would like to have a flow and you don't care if it takes one minute longer or not, but it's just as long as you can have flow you don't mind your distance or time a little bit.
KOUBECK: Well especially in the intersection the last thing you - it's not as bad to be

stopped once and have to wait then per say have to get stopped once and then move a little bit forward and stopped again and be stuck in the line for two or three light cycles. That's what we are trying to get rid of.
LUNDGAARD: That's what happens sometimes there.
KOUBECK: Yeah, especially in the morning.
LUNDGAARD: There are - but this is very expensive solutions when you have built bridges and you separate the traffic from each other. I think that's really a solution. It's very - it's ideal and possible more in the suburbs or outside the city center, but a city center like this it's not possible and the simple fact is no matter how much bicycle specific infrastructure you make, if you're going - say like you're jogging the city, there's going to come a time where you're going to have to interact with other cars or pedestrians in an intersection. Because that's another reason why we want to put focus on the intersections because everyone has to go in there eventually. And then the last strategy we had that we though actually might be good was allowing the cyclists to turn right on red because I know that's already being tested in certain parts inside Copenhagen, but what is your opinion on allowing cyclists to do that?
LUNDGAARD: I think it's a good solution. I think it's maybe not the only solution. You probably need to look at different strategies that in together solve the problem. So that could be part of it, but I think at that place probably most people need to go straight ahead. So - and actually that's - now I remember a thing that annoys me. That's when you have a right to go to - if you need to go right and people they -
KOUBECK: They block it?
LUNDGAARD: They block it, yes. Exactly. So -
KOUBECK: Yeah so possible creating - almost like a car lane where there's a designated right turn lane and then there's a straight lane.
LUNDGAARD: So - and that's because people come from this way and they block when they come here and they stop because they need turn here -
KOUBECK: Yeah they are trying to turn left.
LUNDGAARD: Yeah, so they stop here and they block the right lane because I think people come from here, they are - they follow the rules and they stay in the straight lane, but then people come from here, they sort of -
KOUBECK: Yeah clog it up -
LUNDGAARD: Yeah. So -
KOUBECK: Yeah that's why a lot of or several people use the road just right over the sidewalk. Which isn't ideal.
LUNDGAARD: So, but I think you may just as well allow people to turn right because you've probably seen that people do it no matter if they are allowed to or - they do it.

The bicyclists - the people on the bicycle, they don't respect the rules. So not a lot.
KOUBECK: Well especially in that case to - not so much like riding across the intersection on red, but -
LUNDGAARD: But I think you hear about accidents so why should you not allow people to turn right. I think it's not dangerous.
KOUBECK: Well especially with common sense because it's not they're just blindly turning right - they are looking and making sure that there's space.
LUNDGAARD: I've head of a lot of old ladies that don't like it.
KOUBECK: Yeah I feel like old ladies will get mad not matter what you do.
LUNDGAARD: Yeah they don't like it. They like the rules and they are very upset about the behavior of people on the bicycles. I think they are partly right, but also -
KOUBECK: Yeah a lot of cyclists do act like they are the only people on the road.
LUNDGAARD: Yeah and they think they can - they are allowed to. If car - people in the car they don't follow the rules you know - that's really bad. So -
KOUBECK: One of the other things Jos also - was it, I think it was Jos - what he mentioned was - one of the - the difference between cars and bikes is, a car - I wouldn't say you're not as worries about hitting someone, but if you do hit someone there's not as much of a danger to you. While if you're in a bicycle you're always on the look out to not hit someone because if you do you'll probably get extremely hurt as well.
LUNDGAARD: You're the soft person.
KOUBECK: You'll get hurt as much or probably even more if you get thrown off your bicycle.
LUNDGAARD: Are you - do you have bicycles in Copenhagen?
KOUBECK: Yes.
LUNDGAARD: So what do you think about it? Is it - was it scary to bicycle here?
KOUBECK: A little bit at first because you don't really know the turn lanes, especially when someone's just stopping and you realize that like a couple seconds too late because you're not use to it.
LUNDGAARD: So well that's part of your study, to try it on yourself.
KOUBECK: Honestly the hardest part is when you're in a pack of cyclists and the light turns green and you try to get your bike going forward without wobbling or bumping into anyone on the side.
LUNDGAARD: Did you - how did you find it?
HUNT: I found it fairly easy to get use to because I bicycle a little bit back home on some bicycle paths, but I definitely was not accustomed to the amount of bicycles going through, especially I tried - like when we started collecting data for Norrebrogade

- I actually tried, "Oh let me just try going with the bicycles and see what it is like to go through the intersection and - yeah the hardest part is getting started again without -
KOUBECK: The stopping and starting is very, very annoying.
LUNDGAARD: You need to - when you have a lot of congestion on the bicycle lanes, then you really need to be careful, be observant about the intersections because if they just - you know make a small - if they do something that you didn't expect then suddenly you are in twisted and you have an accident. So you need to read the other people. I think I have a special capability of identifying tourists on a bicycle. You can see if that they are much more insecure -
KOUBECK: Very wobbly.
LUNDGAARD: And you take like a big bow around them when you are - when you pass them.
KOUBECK: Yeah we as a - we're with twenty-four other students here.
LUNDGAARD: Ah you're twenty-four?
KOUBECK: Yeah so we are split into five different projects and ours is focused on bicycle congestion, but I think another is congestion is Prinsessegade, down here.
LUNDGAARD: So it's all bicycle -
KOUBECK: It's actually - it's not - we're the only one that bicycle, but it's all - they're all basically split into different things. We all went to Amager Beach and one of our friends - when we were riding back one of our friends rode back with us, Nelson. And I don't think he's ridden a bike in a very long time because as soon as he got on the bike he was - well he almost hit - he almost ran into signposts on two different occasions, but you can definitely tell when people are not accustomed to it.
LUNDGAARD: So and you're not here in the high season for tourists but from May, June, July, August, September you will - you have a lot of tourists and also because cycling has been used to advertise for Copenhagen as a tourist destination. Like everyone - everyone wants to - it's part of the experience to go to Copenhagen as a tourist, is to use the bikes. So you - a lot of them in the summer.
HUNT: I imagine the City Bikes get quite a bit of use in the summer as well.
LUNDGAARD: Yes they do.
KOUBECK: We talked also the - I don't know if he's - is he the owner or the - he's like the head of Copenhagen bicycles which is a rental where -
LUNDGAARD: GoBike? Or -
KOUBECK: No. Is it Copenhagen - I think it's Copenhagen Bicycles.
LUNDGAARD: But the Director is a woman.
HUNT: Right, yes.
LUNDGAARD: Her name is Tina. So there is a foundation called [] - it's city and

commuter cycle foundation. It's more or less - they are - they have
KOUBECK: I can't - yeah I don't know if he was one of the people who ran it, but I don't know if he was the head person. They're right down near the harbor, but they basically - the point was that they rent a lot of bikes to tourists and one of the things -
LUNDGAARD: Oh so it's not the white -
KOUBECK: No it's not. It's a private business, it's not with the city.
LUNDGAARD: Oh so it's private rental of bicycles. Oh I don't know them. I know there is the Donkey Republic and the white, [], as we say City Bike.
KOUBECK: Yeah, but what he was saying was a lot - at some points in the city there's bicycle lanes that look pedestrian paths or I think I have a picture of it, but right down by the bridge there is a bicycle path, also a pedestrian lane that they are basically merged and he was saying how - especially with the tourists - they're not very familiar with the infrastructure. So there's a lot of - like right here you can see the lane turns into cobble stone because aesthetically it looks nice, but it's very confusing because right here I think there's supposed to be a cross walk. He was saying the company they keep going out drawing - like spray painting white lines so that accidents don't happen right outside their door.
LUNDGAARD: Ok I think I know where it is. I think I've seen that solution maybe somewhere else.
KOUBECK: I thinks it's - it's by a bridge somewhere down there.
HUNT: Yes this is by the -
LUNDGAARD: Is that -
KOUBECK: Down here.
LUNDGAARD: The bridge to the Opera and -
HUNT: Yeah so it's right on this corner with the green and the purple.
KOUBECK: This was another picture we took of the front - this is from the bridge.
HUNT: There.
LUNDGAARD: Ah okay. Okay, now I know exactly where it is.
KOUBECK: It's just like the tourists come and they think that the cobble stone is a pedestrian path, but they don't - they're not looking for the bicycles coming down -
LUNDGAARD: I can't blame them. This is just a place where everybody has to be extra aware.
KOUBECK: When you said the tourists that just - that came to my mind. That they are just not use to all the infrastructure.
LUNDGAARD: I have had several bicycle accidents. And I've broken my bike, I've broken my arm, I've broken my - you know I've broken a lot of stuff. So it's not - it's not always safe to go on the bicycles. Even if you are - you've bicycled all your life. So

sometimes you aren't okay and you couldn't have done anything. So, but anyway, it is a risky business sometimes. So yeah.
KOUBECK: What is your opinion on the Green Wave, do you think that helps the cyclists or it decreases the travel time.
LUNDGAARD: I think - well not it's a personal reply - it doesn't make a big difference for me.
KOUBECK: Ok. So - is it just because you don't really use it? Because I know it's only specific places
LUNDGAARD: Specific places if you keep a certain pace if that's what you mean? Twenty kilometers an hour, then you make - you are - you can have a Green Wave.
KOUBECK: I believe it's along here or there's one of them along that.
LUNDGAARD: This is exactly the trip that my husband, he takes when he goes to work here - so he goes that way. Ask him - then ask him. No I think you need to - if you go that - if you everyday had to go that direction and that route everyday, then of course I would be aware of it because I know it would - I just said that flow - the experience of flow is important for me. So, but I probably not always think about it so I should be more aware of it or maybe they don't -
KOUBECK: Yeah because that's one of the things -
LUNDGAARD: I don't know maybe the signs are not good enough because I don't think so much about it. And then again, if you have too much - too many other bicycles on the lane you can't always control your own pace.
KOUBECK: That's true yeah.
LUNDGAARD: So I think it's a nice feature. I think the most important thing and I know as people - on behalf of most people is that you have broad lanes, you have nice asphalt with no bumps and so one - and so the good infrastructure is the most important thing.
KOUBECK: I think that's all the questions we had. Is there anything else you want to ask us?
LUNDGAARD: No I think it is interesting there are a lot of people come to Copenhagen to study bicycles and - I think, it's not so often that I'm asked because you know it's Copenhagen city that does - for most people is interesting. So it does happen now and then. I also have a group of visitors who want to know about the regional perspective of cycling.
KOUBECK: Yeah because it's also interesting to see that the changes you make in Copenhagen, they have a ripple affect almost to the entire region.
LUNDGAARD: Yeah exactly. So I think what you are studying here is quite important. So it is interesting, to me, somebody is looking into a problem that is there and that is

unsolved. We want to - Copenhagen want more people to bicycle, but you are reaching a limit now where people don't want to bicycle anymore because it's not safe anymore.
KOUBECK: Or it's not convenient to -
LUNDGAARD: They can't go - they can't even the go the pace they want to because of all the bicycles and so on. So maybe just as you're looking into strategies, people - as a citizen - you always need to consider your strategy. And as I said to you, each day you should consider what would be the best option for you. Not just automatically take the car. The car or the bicycle. And if it gets too much hassle to go on the bicycle maybe people they find other ways. So and yeah. Because I have that regional perspective I'm not so interested in - I'm not so occupied with the challenges in Copenhagen as a professional, but as a citizen in Copenhagen, of course it's interesting for me. So, and I think the City of Copenhagen is so - such good they are investing a lot and they are very concerned about this. I'm not so concerned about Copenhagen because they are rich and they would like to do something for bicycling. But when you get outside Copenhagen -
KOUBECK: Yeah, it's less favorable for more cyclists.
LUNDGAARD: Yeah exactly. So this is from professional view - the regional view - we have much more focus on how to change behavior and patterns outside Copenhagen.
KOUBECK: That makes sense.
LUNDGAARD: And when it comes to that, Copenhagen is a big inspiration. They have - there is - I don't know - I don't think there is anywhere in the country and maybe not in the world where you have a whole section of traffic planners only working with bicycling. That is so pertinent.
KOUBECK: Yeah I think really the only other country - the only other country that is similar is the Netherlands.
LUNDGAARD: So that's - in other local authorities, municipalities - you have maybe for big municipality - not that it has a big geography but not a big a area, but not so many citizens maybe because it's not so densely populated. They have one engineer in total to take care of all the roads. And so how much time can they spend on improving conditions for bicycling? Not a lot of time. So Copenhagen is very privileges.
KOUBECK: Well especially cities in general are a lot more favorable for cycling.
LUNDGAARD: Of course, it makes sense to go on the bicycle. It's the easiest and the fastest way.
KOUBECK: Yeah and we want to keep it that way.
LUNDGAARD: So yeah. Ok but if you have any - if you get - if you suddenly think of something then you can contact me. And I thought maybe, did you ever see the

regional - you're talking about the end year report for Copenhagen - did you see the regional count?
KOUBECK: I don't - I'm not certain.
LUNDGAARD: Because we have it in English. So that might be interesting. We don't - not the whole report, but the - we have a small summary in English - in both Danish and English. And, unfortunately, it's getting old, but as I told you, we have a new one that will be published in one month or something. So I will just send, maybe the link to that one and then just so you can see what it's about and then remember contact me for the new one that will also be translated into English. But I think by the first of May have it in English.
KOUBECK: Unfortunately, I think that may be a little too late for us.
LUNDGAARD: Ah ok.
KOUBECK: I think our final report is due the - I want to say the twenty - somewhere around the twenty-third of April.
LUNDGAARD: Ah ok. So then take a look at the old one you have you know the statistics - it was published in 2014 and 2015, but not the statistics are back to 2012. That will just give you a small look into the regional differences into how much do they bicycle in Copenhagen versus the suburbs and the countryside and so on. All these difference that you have.

Notes for Interview with Morten Skou

Interviewee: Skou, Morten (Owner)
Wednesday, 5 April 2017 1030-1130
Copenhagen Bicycles
Nyhavn 44, 1058 København K
Interviewer: Koubeck, Adam
Attendee: Hunt, Alan

- In the 1930s, bicycles dominated, just look at any picture of Nørrebrogade in that era, there are no cars.
    - The rather late industrialization of Denmark led to the movement to cars
- In this day and age, the bicycle is the last thing of freedom for the people - bicyclists don't like to be told what to do, where to park, etc. It is a very difficult culture to alter.
    - If, for example, an underground parking garage was created for cyclists, it would never be used, even if it provided more space. Why? Because cyclists are stubborn, and will park their bike wherever it is most convenient.
- Doesn't think of Danes as very healthy people
    - Bicycling helps, but Morten has the opinion that Danes drink too much beer, smoke too many cigarettes, and eat too many pastries.
    - "Danes are generally unhealthy"
    - The CEO then interrupted our conversation to say that Copenhageners are much more healthy than outsiders. She also pointed out that there are not nearly as many cyclists outside of Copenhagen. This may have to do with the fact that city goers are much more driven by self image, hence they are healthier.
- A social issue is that many smaller schools are closing in favor of fewer larger schools.
    - This increases traffic, because more people will be heading to the same place at the same time to pick up their children
    - This is likely to lead to more car use, as parents don't have the time to bicycle to pick up their children, when they still need to run errands, pick up groceries, etc. "There is no room for biking in that life."

- Morten used to own a car.
    - When you are a resident, you need to apply for a parking ticket if you own a car. This gives you access to park in your residential area for the cost of the ticket. Anywhere else in Copenhagen that you park has an additional cost on a per-time basis.
    - However, in many areas, parking is not available for residents, due to the high number of cars. This is causing many residents to get tickets for illegal parking.
        - Some think that this is intentional, to encourage Copenhagen residents to give up their cars in favor of bicycles.
- Thinks that rules of the road need to be adjusted for cars.
    - We should make city rules designed for bicycles, and if cars want to drive down the roads, they have to follow cyclist rules
    - One idea is to make the speed limit for all roads 25km/h, so that no form of traffic can go faster.
    - Bicycles have been forced to follow car rules for too long.
- There will always be conflict between different modes of transport.
    - Especially between bicycles and pedestrians.
    - There is a resemblance to road rage for some cyclists.
    - Danes are very “right oriented”, and will block other traffic intentionally if they have a green light. They do not believe in yielding if they have the right of way, unlike some other countries in Europe that mix all types of traffic, and rely on the people to make the traffic flow.
- Opinion on Right on Red
    - These experiments are not good for the city, as it increases the illegal actions that happen where the experiments are not. Once people see that a right on red is legal some places, they will start doing it at all the intersections.
- Nørrebrogade Notes:
    - Main issue at this intersection is the Søtorvet car traffic.
    - Most effective solution would be to build a bicycle bridge over the intersection for all the cyclists trying to go straight.
- Biggest issue for cyclists is that they aren’t allowed to make a right turn on a red light. It is just too tempting for a cyclist to go when they can see that nobody is obstructing their turn, but still have to wait at a light
- E-Bike users are very annoying for hardcore riders that can ride faster than the regulated speed of 25km/h.

    - Oftentimes tourists will use the City Bikes, and think that they are the fastest bike on the lane, so will default to staying on the left, getting in the way of faster riders.
    - Serious bikers will then sometimes resort to using the roadways to pass these annoying cyclists.
- Two main models
    - Danish Model
        - Separate the traffic, so that they don't have to interact
        - Leads to an organized system, where people believe that they have the right to go whenever there is a green light.
        - Can lead to conflicts when different forms of traffic meet.
    - Dutch Model
        - Intentional mixing of traffic
        - Relies on the people to work out who goes when
        - Would never work in Copenhagen - Copenhageners already have expectations for how the lanes work, so changing the system so drastically would just lead to confusion.