Summary

BYTRANS: Effects and consequences of capacity reduction in the Bryn tunnel

Per 2016

TØI Report 1566/2017
Authors: Aud Tennøy, Elise Caspersen, Oddrun Helen Hagen, Per Andreas Langeland, Iratxe Landa Mata, Susanne Nordbakke, Kåre H. Skollerud, Anders Tønnesen, Christian Weber, Tale Ørving, Jørgen Aarhaug
Oslo 2017, 286 pages, Norwegian language

In this report, we present analyzes and findings related to impacts and consequences - for transport systems and road users - due to capacity reduction from four to two lanes in the Bryns tunnel. The report addresses the situation before the capacity was reduced as well as the situation after the capacity was reduced until November 2016. The reduction of capacity has made road users adapt to the changes in ways that have resulted in significant reductions in traffic volumes in the Bryns tunnel and on this part of Ring 3. In the two morning rush hours, traffic volumes were reduced by between 3400 and 4900 vehicles per rush, equivalent to reductions between 24 and 41 percent (in different counting points). In the two afternoon rush hours, the reductions were between 2400 and 3900 vehicles per rush, equivalent to reductions of 28 to 34 percent. The delays on this link and a few adjacent links have increased. In other parts of the road system, we only find minor changes in traffic volumes and speeds. Overall, it appears that the number of vehicles on the investigated links is reduced by around 3,000 vehicles in the morning rush hours and 6000 vehicles in the afternoon rush hours (each rush is two hours). The information about the capacity reduction has reached the road users. The travelers have adapted to the situation by choosing other routes, other means of transport, other time of travel and more frequent use of home offices. The delays and adaptions give disadvantages to all types of road users, but not large negative consequences. A main conclusion is hence that halving the capacity on one of Norway's heaviest traffic routes went relatively well - it did not cause crisis or chaos. This is in line with findings in previous research on similar cases.

Background and objectives

A challenge shared by many politicians, professionals and researchers across the globe is: How to develop cities and urban transport systems in ways that ensure efficient mobility while reducing local and global environmental impacts from the transport sector, and making cities more attractive and vibrant? In Norway, clear political goals have been defined for zero growth in car traffic in urban areas, on efficient and environmentally friendly urban transport systems, and on climate-friendly, attractive and vibrant cities.

In the period 2015-2020, major changes will be made to the transport systems in Oslo, especially on the main road system and the rail-based public transport systems. Several individual projects will be implemented, and this can be considered as natural experiments, which provide unique opportunities for developing new knowledge about the effects and consequences of such changes for travelers, transport systems, society, and the environment. This also provides the opportunity to develop knowledge about how mitigation measures and information measures introduced by the authorities work, and how they can be improved. Such knowledge can enable politicians, authorities, and research to develop the more efficient and environmentally friendly urban transport systems of the future. In the BYTRANS project we will document effects and consequences of these changes, for the transport systems, road users, the environment and society, and thus contributing with relevant knowledge.

Here the results of the investigations related to the case Bryns tunnel are reported. The capacity of the tunnel was reduced from four to two lanes in February 2016, and is scheduled to be reopened at full capacity in the summer of 2017. This report addresses the situation before the capacity was reduced, as well as the situation with capacity reduction (until November 2016). In 2018, we will publish a new report regarding the case Bryns tunnel, where we include data from 2017 (when the tunnel has regained full capacity), as well as data and analyzes from the period covered in this report, that we have not been able to analyze yet. Since this is an innovation project in the public sector, we choose to publish the report with the data we have analyzed so far, to bring the information and knowledge to users as swiftly as possible. In 2019, we will publish the final report for this case.

Research design and methods

The main design for the surveys are case studies. To answer the defined research questions, we have collected different types of data in different phases of the individual projects, compared data from the different periods, and analyzed the effects and consequences that can be observed. We collect data in the same weeks of spring and autumn each year, as well as periods immediately before and after changes in the transport systems occur.

Data is and will be retrieved from a variety of actors and sources, and using a variety of methods:

- Data concerning the before-situation on precautionary, measures, mitigation measures and information measures (from responsible agencies)
- Data on car traffic volumes and bicycle traffic volumes, passenger numbers in public transport (from the Norwegian Public Roads Administration, Oslo municipality, Bymiljøetaten, Ruter, NSB)
- Data on speeds and delays for car traffic, public transport, taxi traffic and freight traffic, crowding on public transport, etc. (from the Norwegian Public Roads Administration, Municipality of Oslo Bymiljøetaten, Ruter, NSB, Oslo Taxi, freight transport operators, Telenor)
- Data on road users' travel habits, experience of transport quality, experience of mitigating measures, etc. (surveys and interviews conducted by TØI)

The purpose of using different types of data and analyzes is to investigate the situation from different perspectives, thus increasing the robustness of data bases, analyzes, findings and conclusions.

Answers to the research questions

Through the surveys and analyzes of the case Bryns tunnel we have tried to answer several specific research questions. Below these questions are asked and answered, as short and concise as possible.

Figure S1 shows the location of the Bryns tunnel, as well as important counting points and road links we refer to in the text. We hope the figure can make it easier to follow the discussions.

Figure S1: The map shows the location of the Bryns tunnel, as well as the counting points (E6 Manglerud, E6 Bryn, Rv 150 Hovin and the control point E18 Ramstadsletta) and the links (Grefsen-Teisen, Teisen-Ryen and Ryen-Klemetsrud), as mentioned in the text

Has the capacity reduction in the Bryns tunnel contributed to changes in traffic volumes in the Bryns tunnel and on this part of Ring 3?

We found that traffic levels in the Bryns tunnel and this part of Ring 3 are reduced when we compare the situations before and after the capacity reduction. In the morning rush hours (7:00 - 9:00), traffic volumes are reduced by between 3400 and 4900 vehicles per rush in different counting points on the link at which the Bryns tunnel is located, which corresponds to reductions between 24 and 41 percent (in different counting points). In the afternoon rush (15:00 - 17:00), the reductions are between 2400 and 3900 vehicles per rush, equivalent to reductions of 28 to 34 percent. The counting point E6 Manglerud illustrates this in Figure S2. Unfortunately, we do not have data that makes it possible to compare with the same weeks in 2015. At the control point E18 Ramstadsletta we did not find reductions in traffic volumes.

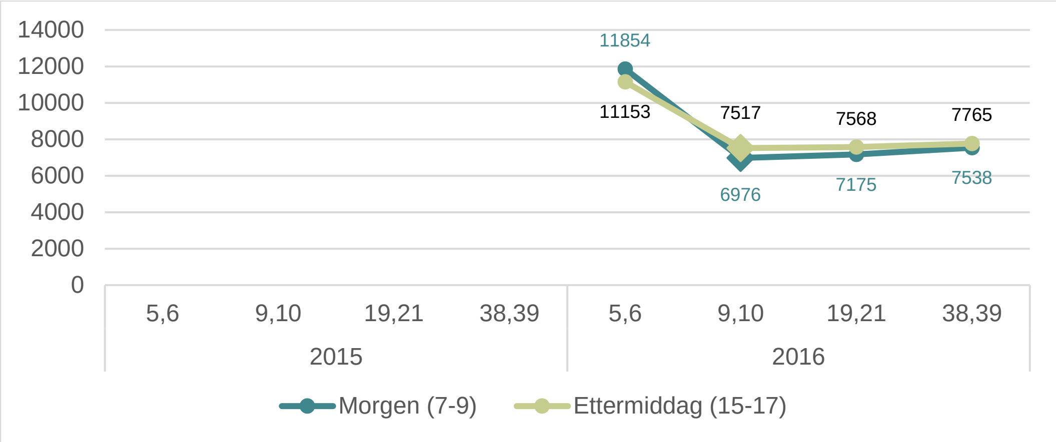

Figure S2: Average traffic volume on E6 Manglerud in morning rush (7-9) and afternoon rush (15-17), sum both directions for selected weeks. Capacity reduction was initiated Saturday in week 7 in 2016. First registration after capacity change is marked. Discrete data is displayed as a continuous line for better readability

We conclude that the capacity reduction in the Bryns tunnel has made road users adapt to the new situation in ways that have contributed to reduced traffic in the Bryns tunnel and on this part of Ring 3.

Has the capacity reduction contributed to increased congestions and delays in the Bryns tunnel and this part of Ring 3?

We analyzed changes in average speeds on the road link which include the Bryns tunnel (Teisen-Ryen), as well as the link north (Grefsen-Teisen) and the link south (Klemetsrud-Ryen) of the tunnel. We have compared weeks 19 and 21 and 38 and 39 in 2015 and 2016.

On the Teisen-Ryen route, speeds decreased from more or less free-flow speeds (around 70 kilometers per hour) in the counter rush directions in both rush periods before the capacity reduction, to an average speed around 30-40 kilometers per hour after the capacity reduction (speed limits are 50 kilometers per hour). In rush direction, speeds decrease from almost free flow in morning rush (around 60 kilometers per hour) to speeds of 30-40 kilometers per hour after capacity reduction. In afternoon rush hours, there were delays before the capacity was reduced (speeds 20-30 km per hour), and these delays remain relatively stable, and increase in weeks 38 and 39 (average speed 16 kilometers per hour). This is illustrated in Figures S3 and S4.

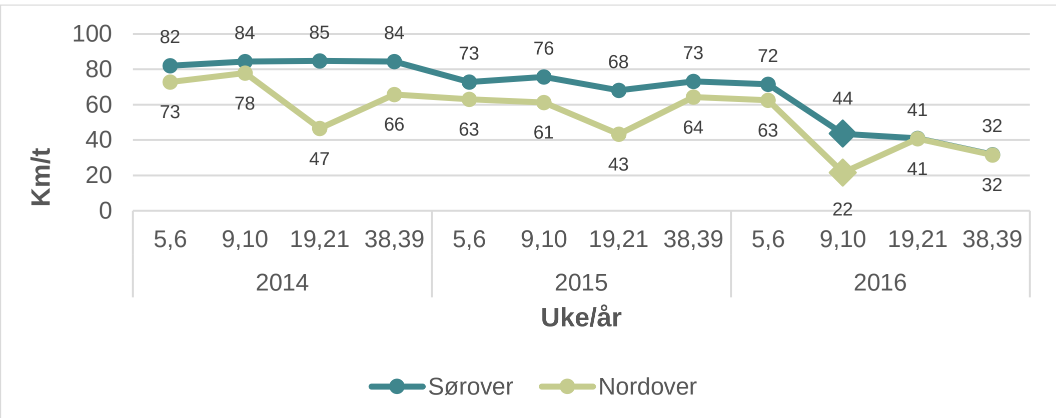

Figure S3: Average speeds of the Teisen-Ryen route in the morning rush (7-9) in selected weeks in 2014. Capacity reduction was initiated in week 7 2016. First registration after capacity reduction is highlighted. Discrete data is displayed as a continuous line for better readability

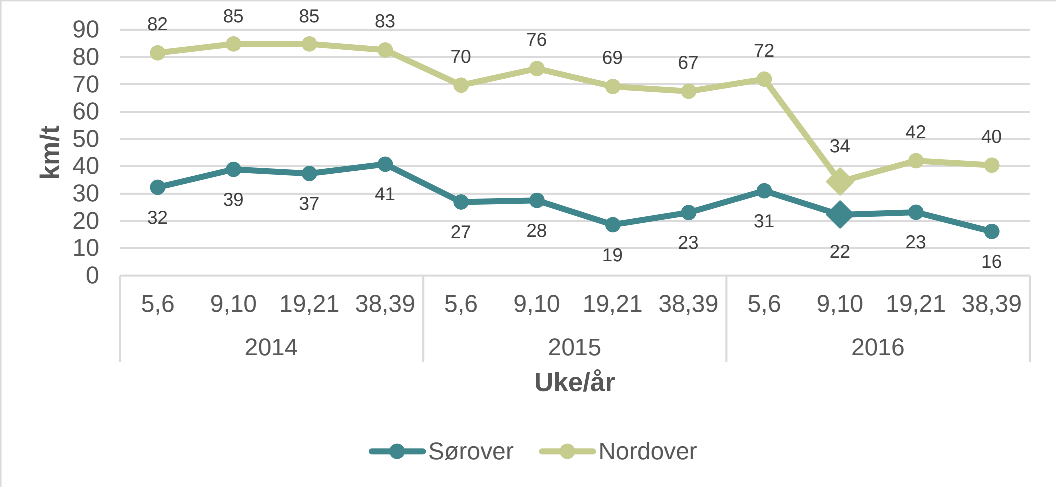

Figure S4: Average speeds of the Teisen-Ryen route in the afternoon rush (7-9) in selected weeks in 2014. Capacity reduction was initiated in week 7 2016. First registration after capacity reduction is highlighted. Discrete data is displayed as a continuous line for better readability

We do not have good explanations regarding why speeds decrease more in the counter rush direction than in rush direction. Traffic volumes are about the same in both directions, both in the situation before and during the capacity reduction, and the capacity is equally reduced in both directions. We will investigate this in more detail in the further work with BYTRANS.

We have also extracted data that shows changes in average speeds in the hours adjacent to rush on this route. Here we found that before the capacity reduction, relatively small delays could be expected. With capacity reduction, one must now expect significant delays also in the hours adjacent to rush hour. Figure S5 shows average speeds on the Teisen-Ryen link in hours adjacent to the morning rush.

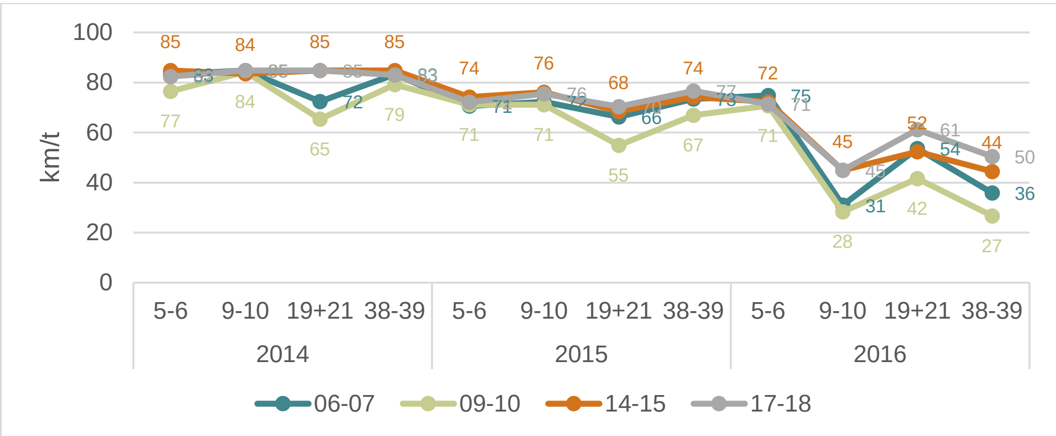

Figure S5: Changes in average speeds in hours until rush on the stretch from Ryen to Teisen (directional). Capacity reduction was initiated in week 7 in 2016. Discrete data is displayed as a continuous line for better readability

Also on the Grefsen - Teisen link, just north of the Teisen - Ryen link, there were free-flow speeds (70-80 kilometers per hour) in counter rush hour direction before the capacity reduction. In the morning rush, the speeds decreased to 40-50 kilometers per hour. In the afternoon, the speeds decrease to 40 kilometers per hour in weeks 19 and 21, and increased back to 75 kilometers per hour in week 38 and 39 2016 (the speed limit is 60 kilometers per hour). In rush direction, the situation has deteriorated somewhat in the morning rush (from around 50 to 40-50 kilometers per hour), while it has gone from bad (30 to 40 kilometers per hour) to worse (all the way down to 12 kilometers per hour in weeks 38 and 39) in the afternoon rush. There are thus block backs on this link from the Bryns tunnel, especially in the afternoon rush.

On the link south of the Bryns tunnel, Klemetsrud - Ryen, we find free-flow speeds in the counter rush direction both before and after the capacity reduction. In the rush direction, we find some increase in delays, from around 30-40 kilometers per hour to 20-30 kilometers per hour in the morning rush hours, and somewhat reduced delays, from around 40 to about 50 kilometers per hour, in the afternoon rush hours.

We also find increased delays on the Helsfyr - Karihaugen link, especially in the afternoon rush hours, which we assume are due to block backs from the Bryns tunnel. The same applies to the counting point E6 Helsfyr, afternoon rush hours, direction north.

The capacity reduction has thus contributed to more congestion and increased delays in the Bryns tunnel and on this part of Ring 3, especially in counter-rush directions. In rush directions, there have also been increased delays, but these changes are less. Block-backs have also caused speed decreases on adjacent links. The change in average speeds at different times, counting points and directions we have studied, varies from minus 41 to plus 6 kilometers per hour.

Has the capacity reduction in the Bryns tunnel caused rerouting, and by this to changes in traffic volumes and delays on other routes?

In the survey to employees of businesses in the Bryns area (June 2016), 22 percent of respondents and 28 percent of car-drivers answered that they had changed routes to adapt to the traffic situation (the question was asked only for the 450 respondents who had answered that their work trip had either become better or worse due to the capacity reduction). We investigated changes in transport volumes in counting points on links we expected would be alternative routes for motorists who would avoid driving through the Bryns tunnel, and found both increased and reduced traffic volumes on these links. This indicates that some road users have changed their route.

We did not find any significant changes in traffic volumes at E18 Bjørvikatunnel, at Ring 3 Tåsen tunnel or at Ring 2. We found reductions of up to 2300 vehicles per rush at registration points E6 Skullerud and E6 Helsfyr in the afternoon rush, and increases of up to 1040 vehicles per rush in the E6 Svartdalstunnel, E6 Helsfyr morning rush and E18 Kongshavn. We also found increases in traffic volumes of up to 314 vehicles per rush (Østensjøveien) on four of six local roads where traffic overflow was expected. On two out of the six local roads, there was no change or reduction in traffic volumes. On bypass-roads north and south of Oslo, we found only small changes (up to 215 vehicles per rush).

This is summarized in Figure S6, where we show traffic volumes in the counting point Manglerud (just south of the Bryns tunnel), as well as counting points we consider alternative routes for morning rush hours. We see a significant reduction in traffic volumes in the counting point Manglerud, and no distinct changes in other counting points. The pattern is the same for the afternoon rush (see chapter 4.4). Overall, when we summarize all the counting points in the figure, there are 3105 fewer vehicles in weeks 19 and 21 than in week 5 and 6 in 2016 in morning rush hours. In the afternoon rush hours, there are 6092 fewer vehicles in weeks 19 and 21 than in weeks 5 and 6. We have thus lost traffic that we cannot find on other links in what we have defined as rush hours. Unfortunately, we do not have data that enable us to compare traffic volumes in 2016 with the same weeks in 2015.

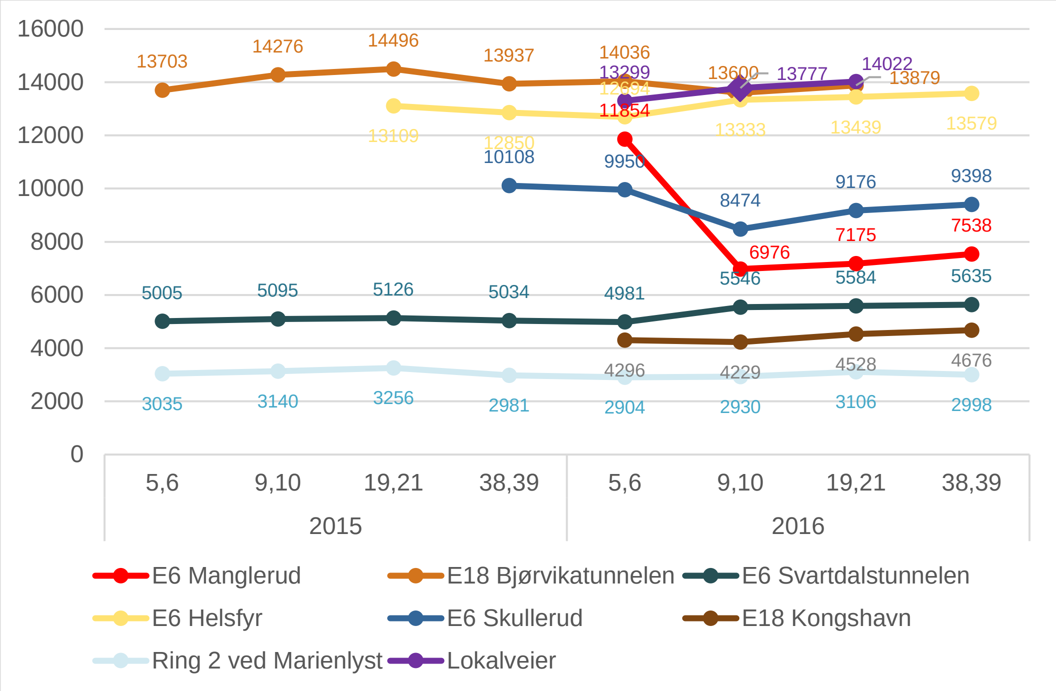

Figure S6: Traffic volumes in different counting points, sum both directions in the morning rush (7-9). "Local roads" consist of the counting points Østensjøveien, Tvetenveien, Vekterveien, Enebakkveien, Lambertseterveien and Plogveien. Discrete data is displayed as a continuous line for better readability

We investigated whether redistribution of traffic has resulted in increased delays in links with increased traffic. We found some decreases in average speeds in one counting point - E18 Kongshavn out of town in the afternoon (we have not analyzed changes in average speeds on local roads).

We have thus found that the capacity reduction and the increased delays in the Bryns tunnel have contributed to some motorists changing routes. This has not in itself caused increased delays on these links, except for E18 Kongshavn, which has increased delays in the afternoon rush hours.

Has the capacity reduction in the Bryns tunnel caused modal changes?

In the survey to employees in businesses in the Bryn area (June 2016), 13 percent of respondents and 6 percent of motorists answered that they had changed means of transport as an adaption to the changes in the transport system (the question was asked only to respondents who had answered that their work trip has become better or worse due to capacity reduction). When we compared answers about how respondents employed in businesses in the Bryns area traveled the last time they went to work from the surveys in May 2015 and June 2016, we found a decrease from 39 to 29 percent in respondents answering that they had been driving. The share of respondents answering public transport increased from 40 to 45 percent, and for cycling the shares increased from 11 to 15 or 17 percent (depending on the selection), see Figure S7. This indicates that a significant share of the respondents has changed mode of transport due to the capacity reduction and increased delays on the road system. The figure shows two selections for 2016. One (N = 355) shows results from respondents employed in businesses that participated in the survey both in 2015 and 2016, while the second (N = 1029) includes all respondents from the Bryn area in 2016.

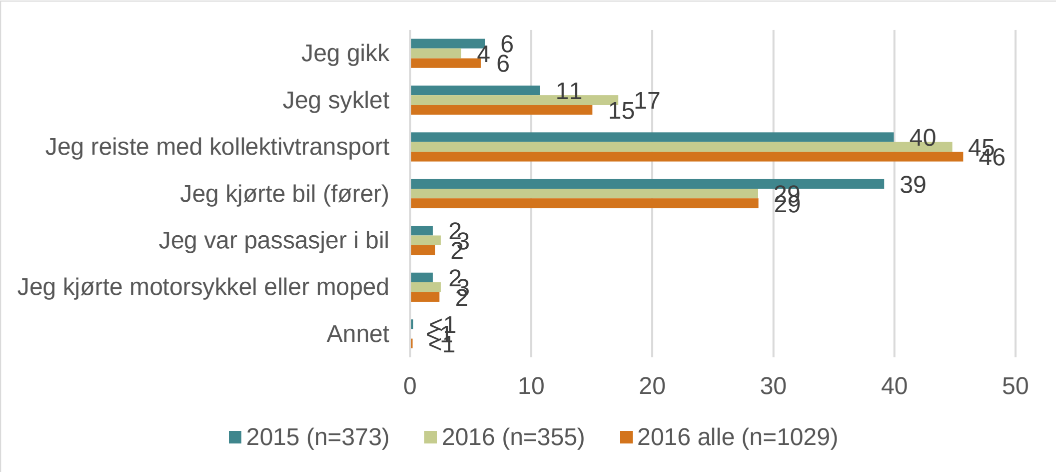

Figure S7: "Which mode of transport did you use the last time you traveled to work and met at your usual work-place?" (N = 373; N = 355; N = 1029). Percentages

We investigated if we also can see this in traffic data. As described above, some road traffic has disappeared from the road system, which is in line with the respondents' responses in the survey. Analysis of passenger data for bus line 23 shows an increase in passengers after the capacity reduction, which may indicate that some motorists have chosen to use public transport instead of travelling by car. However, we will investigate larger parts of the public system, and especially the subway system, before we can conclude more precisely. We expect to have better data and thorough analyzes of public transport in the next report on the Bryns tunnel, in 2018. We found that the bicycle traffic in the Bryns area increased by 15 percent from 2015 to 2016 in the registration points we have figures for. This increase is lower than for Oslo in general, and it is difficult to say whether the capacity reduction in the Bryns tunnel has affected the increase.

These results indicate that some of those who normally drive a car have changed to other means of transportation due to the capacity reduction and the increased delays in the road system in the area.

Has the capacity reduction caused changes in trip-timing?

In the survey to employees in the Bryns business area (June 2016), 33 percent of respondents and 43 percent of motorists answered that they had changed departure time as an adaption to the changes in the transport system (again only respondents who had answered that their work trip had become better or worse due to the capacity reduction were given this question).

We analyzed traffic volumes at the counting point E6 Manglerud in the hours adjacent to rush, to investigate whether changes in trip-timing could be found as increased traffic in the hours adjacent to rush hours here. The results for morning hours are shown in Figure S8. We see a decrease in traffic volumes in the hours adjacent to rush from when comparing weeks 5 and 6 in 2016 (before the capacity reduction) with weeks after the capacity reduction, indicating that there has been no change in trip-timing. There is a slight increase in traffic in the period 5: 00-6: 00, which indicates a small change of trip-timing. Analysis of the afternoon rush hours show the same tendencies - decrease in traffic volumes in the hours adjacent to rush. Unfortunately, we do not have data that allows us to compare with the same period in 2015.

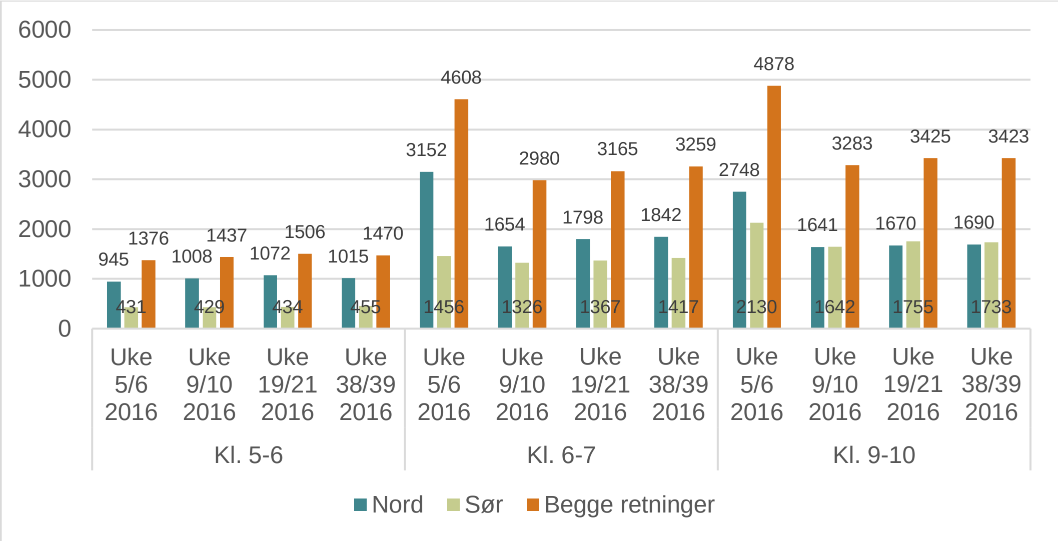

Figure S8: Traffic volumes (vehicle per hour) in the hours 5-6, 6-7 and 9-10 in the counting point E6 Manglerud, divided by direction and total. Capacity reduction was initiated in week 7 in 2016

Based on this, we cannot conclude whether there have been any changes in trip-timing. Respondents in the survey indicates that they have changed their departure time, but we do not find this in traffic figures at the counting point we have analyzed. We have not analyzed other counting points regarding rush hour sliding. We will do thorough research on this in the next round of data collection and in the next report on the Bryns tunnel, which will be in 2018.

Has the capacity reduction reduced travel frequency?

In the survey to employees of businesses in the Bryns area (June 2016), 7 percent of respondents and 11 percent of motorists answered that they more often worked from home as an adaptation to the changes in the transport system (again the question was asked only to respondents who answered that their work travel had become better or worse due to capacity reduction).

When we compare answers from responses employed in the two companies that participated in the survey both in 2015 and 2016, we find an increase from 11 to 18 percent among those who responded they worked from home at least one day every week. This indicates that some have adapted to the changes in the transport system by having a more frequent home office, thus traveling less frequently.

In interviews, some informants told that their employer had improved the opportunity to use home office and flexible working hours. Others stated that they use home offices, among other things, to avoid long work trips. However, those who mentioned that they used home office, also expressed limited use.

What effects and consequences has the capacity reduction caused to different parts of the transport systems?

Based on what has been discussed, it seems that the effects and consequences for the road traffic are mainly limited to the Bryns tunnel and this part of Ring 3. Here, and on some adjacent links, the delays have increased significantly. This has caused road users to adapt in several, including choosing other routes and other means of transport, and traveling less frequently. This has resulted in significant reductions in traffic volumes in the Bryns tunnel and on this part of Ring 3, which has contributed to make the delays and disadvantages caused by the capacity reduction of the Bryns tunnel less than they would otherwise have been. The adjustments have caused some changes in traffic volumes on alternative routes. This also applies to municipal, local roads where one does not want increased traffic. The redistribution has not resulted in significantly increased delays in the links that have received increased traffic.

Roadworks on local roads in the area around Bryn (especially on the road Østensjøveien, which is on top of the Bryns tunnel), as well as some increase in traffic volumes on local roads, have (according to interviews and open answers in the survey) resulted in disadvantages for pedestrians and cyclist. Those bicycling express that they are "pushed" up on the sidewalk, which is a disadvantage for both pedestrians and cyclists. The public transport system and the bicycle infrastructure also appear to have increased loads because some road users have switched from car to these means of transportation. Several mentioned that they experience deficient bicycle paths on their route, and that some are of poor standard.

What adjustments have commuters made?

In the survey, we asked all respondents employed in businesses in the Bryns area if they experience that their work trips have been affected by reduced capacity in the Bryns tunnel. 44 percent responded affirmative to this. Those who answered that their work trip has improved or worsened due to the capacity reduction was asked how they had adapted to the changes. 41 percent of respondents and 34 percent of motorists responded that they had not made changes to their work trip to adapt to the situation in the Bryns tunnel. As mentioned above, 33 percent of respondents and 43 percent of motorists answered that they had changed travel time, while 22 percent of respondents and 28 percent of motorists indicated that they had changed their route. 13 percent of respondents and 6 percent of drivers said they had changed means of transport, while 7 percent of respondents and 11 percent of drivers worked more often from home.

Above we have seen these responses in the context of analyzes of other data, and mainly found compliance. The exception concerns changes of trip-timing, where traffic data does not show such changes (as we should have seen if many have changed travel time).

What are the consequences for commuters of the capacity reduction, and of their adaption to the changes?

In the survey to employees in businesses in the Bryn area, in 2015 and 2016, we asked all respondents about how satisfied they are with their work trip (before we introduced questions about the Bryns tunnel). The shares that answered 'satisfied' or 'very satisfied' is the same in 2015 and 2016 (72 and 73 percent). The shares that responded 'very satisfied' is higher in 2016 (30 percent) than in 2015 (26 percent). The proportion that replied 'neither nor' is similar. Thus, the percentage of respondents who responded 'dissatisfied or 'very dissatisfied' (13 percent) is also un-changed. The shares of respondents answering 'very dissatisfied' is lower in 2016 than in 2015. We may understand this as if the capacity reduction in the Bryns tunnel, or other changes in the transport system, have not contributed negatively to the commuters experience of the quality of their work trip. On the contrary, results show a higher satisfaction in 2016 than in 2015. It is also interesting to note that a large majority is satisfied with their work trip, both in 2015 and in 2016. We also asked (both in 2015 and in 2016) if they felt that their work trip had improved or if it was worse than it was at the same time the year before. Here we found a higher proportion responding much better and slightly better in 2016 than in 2015, and a higher proportion responding somewhat or much worse in 2016 than in 2015. A lower proportion answers 'unchanged' in 2016 than in 2015.

Further on in the survey, we focused on the effects and consequences of the capacity reduction in the Bryns tunnel. 19 percent of all respondents employed in businesses across Oslo, and 44 percent of respondents from the Bryn area, answered that they experienced that their work trip has been affected by the capacity reduction in the Bryns tunnel. 37 percent of all respondents from the Bryn area report that this has led to a poorer work travel experience than before. We asked these respondents which negative changes they have experienced. The drivers answer that congestions have increased (68 percent) and that travel time has increased (62 percent). Those who use public transport emphasize that travel time has increased (39 percent), that it takes more time to travel with public transport (37 percent), and that punctuality has deteriorated (34 percent). The cyclists, as well, answer that the travel time has increased (36 percent) and that there is more car traffic and/or pollution where they walk or bicycle (58 percent). This was also emphasized in qualitative interviews. Few of the respondents indicated that the capacity reduction had resulted in positive changes for their work trips. Some drivers, especially those arriving at E18 just before the Bryns tunnel in the southbound direction, stated that their return trip had become faster than before the tunnel works started.

Half of those who drove or were passengers in a car last time they went to work, indicate that they spend longer time travelling to work due to the tunnel works, in average 9 minutes. Of those who used public transport last time they went to work, few (13 percent) experienced changes in time spent.

12 percent of (all) respondents employed in businesses in the Bryn area report that the capacity reduction and/or their adaptation to the situation have led to changes in responsibilities, routines or other changes in the household. 5 percent answered that it had resulted in changes in responsibility/routines to bringing children to and from kindergarten, school, etc. In qualitative interviews, more emphasis was placed on the fact that a surprisingly large increase in traffic in their local areas caused problems. Driving for example, to their grocery shop, or to recreational activities after school and work, took longer time. This is interesting in the light of the traffic data, which show only small increases in traffic volumes on such roads.

The answer to the research question is that 37 percent of all respondents employed in the Bryn area report that their travel to work has been worse (26 percent) or much worse (11 percent) as a result of the capacity reduction in the Bryns tunnel, and that users of different modes of transport report different negative effects. Increased travel time is reported as a negative effect by all groups, although there is a significantly higher proportion of car-drivers than others who report this. 12 percent (of all respondents) state that the changes in the transport system and /or their adaptations to these have led to changes in responsibilities, routines or otherwise in the household.

What adjustments have freight traffic made?

In interviews, truck drivers and transport planners express that it primarily is trip-timing and routes they can change (and have changed) to adapt to the traffic situation. Truck drivers who do not have sufficient flexibility to change route or trip-timing are most affected by the capacity reduction and increased delays. Truck drivers who can make changes, do to a greater extent find alternative solutions, and avoid being stuck in congestion.

What are the consequences for freight traffic of the capacity reduction, and of their adaption to the changes?

The survey shows that truck drivers are more dissatisfied with the transport system in Oslo in 2016 than in 2015. In the interviews, truck drivers and transport planners generally express that they have experienced only a marginal deterioration of the transport situation. This is mainly due to slow traffic through the Bryns tunnel, especially in the morning rush hour.

The truck drivers do as far as possible try to avoid congestions in the Bryns tunnel, but do anyhow report that they use somewhat more time on deliveries than before. Truck-owners experience lost revenue and increased costs due to increased time spent on deliveries.

What adjustments have taxis made?

The capacity reduction in the Bryns tunnel has reduced driving speed and increased tour lengths for taxi traffic only marginally. Drivers do not report (in interviews) that they have made significant changes to adapt to the situation. The largest taxi center has not made any adjustments.

What are the consequences for taxi traffic of the capacity reduction, and of their adaption to the changes?

Taxi drivers say in the survey that their working day has become worse due to the tunnel works, and they are less satisfied with the traffic situation in the Oslo area in 2016 than in 2015. However, in the qualitative interviews, taxi drivers gave a clear impression that the capacity reduction has affected their situation only marginally, if at all. The taxis can use the public transport lanes in the Bryn area, and the delays are perceived to be so moderate that those we interviewed do not pay particular attention to them. However, there was a consensus that traffic is slower, especially on some ramps leading to E6. The work was perceived as a burden by some of the drivers.

Did the mitigation measures work as intended? What can improve?

Several mitigation measures were implemented to reduce the inconveniences for road users and residents due to capacity reduction in the Bryns tunnel: Speed reductions, closing ramps, warning of congestions, signs informing about alternative routes, temporary public transport lanes, restrictions on electric vehicles in public transport lanes, closing of local roads during rush hours, and temporary commuter parking.

We have not conducted thorough investigations as to whether all these measures have worked as intended. In the survey to employees in businesses located in the Bryn area, 12 percent agree that temporary public transport lanes and restrictions on electric vehicles in public transport lanes have contributed to reducing the inconveniences for road users to a high degree, while 3 percent answered the same for the temporary commuter parking. 60 to 70 percent of respondents do not know or feel that the question is not relevant for them. We analyzed the effects of a temporary public transport lane in southbound direction just north of the Bryns tunnel, and concluded that it has had a mitigating effect and reduced the delays for the buses using them. Taxi drivers state that public transport lanes are an important reason why the capacity reduction has not produced significant negative consequences for them.

The Norwegian Public Roads Administration had prepared action plans A and B for mitigation measures. Plan B was to be implemented if the measures in Plan A were not sufficient, but decided not to implement the Plan B. This can be understood as they perceived that the mitigation measures functioned as intended. They adjusted the mitigation measures somewhat along the way, and these experiences will be useful in similar situations in the future.

Have the information measures worked as intended? What can improve?

The Norwegian Public Roads Administration implemented an information strategy with several elements: Interest analysis, local information (written), dialogue with schools and FAU[2], advertising and editorials in traditional media, posts on their own websites, posts and advertisements on social media, competitions and campaigns.

Surveys and interviews among commuters, truck drivers and taxi drivers show that the Norwegian Public Roads Administration managed to get the information out. Most commuters (61 percent), truck drivers (75 percent) and taxi drivers (54 percent) responded that they had received sufficient information. Only 3 percent of the commuters, 6 percent of the truck drivers and 5 percent of the taxi drivers replied that they had not received information about the capacity reduction. The most important sources of information were employers, editorials in newspapers, on radio and television, newspaper advertisements and colleagues, friends, and acquaintances.

Figure S9: Example of ads from the Norwegian Public Roads Administration. Source: Norwegian Public Roads Administration

Social media is indicated as an important source of information by a lower share of respondents. The Norwegian Public Roads Administration's use of the Facebook page 'Bryns tunnel' is nevertheless an interesting development. They used it to communicate with users and to answer questions, and this communication replaced some of the communication they normally would have done by email and phone.

Hence, we conclude that the information measures worked as intended - the information reached large shares of the intended audience.

[2] FAU: Parents Council Working Committee in schools.

Has the capacity reduction caused increased local air pollution in the area around Bryns tunnel?

Local air pollution was measured before and after the capacity reduction was implemented. It seems that the meteorology has had the greatest impact on the results. The analyses still concluded that the capacity reduction and changes in traffic patterns had caused less impact on local air pollution than previously assumed.

So what? What can we learn from the case Bryns tunnel?

This could be summarized as that halving capacity in the Bryns tunnel, with AADT of 66,000 vehicles per day, did not have major consequences. Road users have made various adaptions, and the delays have increased on affected parts of the road system, but overall, this went quite well. It did not cause chaos, crisis, or intolerable conditions or consequences

How can this knowledge be useful in developing the more efficient and environmentally friendly urban transport system of the future? As we understand this in the project, it concerns to develop cities and urban transport systems in ways that ensure efficient mobility and accessibility, while at the same time reducing local and global environmental impacts from transport, and making cities more attractive and vibrant.

Current discussions about development of urban transport systems concern among other things to prioritize between various means of transport. This regards how to best utilize current road capacity, trade-offs between car traffic and the local environment, and how planning resources and investments should be used to achieve defined societal objectives. In such discussions, the actors' understanding of effects and consequences of reducing road capacity will to a high degree affect which possibilities and alternative solutions they understand as relevant. Our findings concerning effects and consequences of halving the capacity of the heavily trafficked route that the Bryns tunnel is part of, may contribute to expanding the understanding of opportunities and alternatives. This can strengthen public authorities' ability to transform today's urban transport systems into the more efficient environmentally friendly urban transport systems of the future.

The knowledge developed through studying the case Bryns tunnel, can be useful in at least five ways:

- It can increase the possibilities for implementing measures that can improve accessibility and transport quality for other means of transport than car, the urban environment, etc., which requires that road capacity is reduced
- It points to the possibilities for investigating the effects of mitigating measures for freight traffic
- It can contribute to more efficient investments with respect to achieving objectives concerning more efficient and environmentally friendly urban transport systems (including the zero-growth target)
- It can be a useful contribution to improving current transport models
- It provides a better knowledge base for future temporary changes in urban transport systems

The knowledge generated in this case study can contribute to accelerate and to increase investments in, and implementation of, measures that contribute to future urban transport systems becoming more efficient and environmentally friendly. This could for instance concern to transforming car lanes into public transport lanes. Furthermore, the results question the need to build alternative road capacity in cases where the road capacity for ordinary traffic needs to be reduced, which may cause delays for such projects and make them more expensive. This knowledge can also contribute to reducing investments in measures (such as increasing urban road capacity) that counter-act defined objectives. If so, it may contribute to more efficient investments with respect to achieving objectives related to more efficient and environmentally friendly urban transport systems (including the zero-growth target).

Big and New Data

In the BYTRANS project, we explore how we can use different types of mobile data and GPS data in research and planning, which we expect to provide new types of information and understanding of changes in traffic flows (all transport modes) in Oslo. So far, we are at an experimental stage, and data and analyzes have not yet contributed to answer research questions in this project. We have been working hard to develop a digital platform for efficient data sharing in the project. It is now in operation and has been used in the work of the case Bryns tunnel.