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Transport operator fatigue in Norway: literature review and expert opinion

Fatigue in Transport Report III

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Summary:

This report uses literature review and expert interviews to assess the need for improved fatigue management in Norwegian land- and sea-based transport sectors. Fatigue is an important safety risk in the road, rail and maritime sectors in Norway. Even so, we know little about prevalence of fatigue in operators. We identify several branches in which operators may be more likely to be fatigued. Systematic programs for the management of fatigue are scarce, and there is no evidence that companies in any sector actually attempt to measure fatigue in their operators. The rail sector may be best at tackling the more serious fatigue problems faced by its operators. We make recommendations for the improved management of fatigue. Promotion of the business benefits of tackling fatigue may be essential for widespread uptake of fatigue countermeasures across transport sectors.

Sammendrag:

Til tross for at trøtthet er en viktig risikofaktor i norsk vei-, bane- og sjøtransport, mangler vi gode date om omfanget av problemet blant operatører. Innenfor vei-, bane- og sjøtransport kan man identifisere spesielle bransjer der risikoen for trøtthet og utmattelse er høy. Det er imidlertid i liten grad satt i verk systematiske programmer for å redusere problemet. I jernbanetransport kan det likevel se ut til at det arbeides systematisk for å redusere trøtthet blant lokførere. Systematiske programmer for å håndtere trøtthet kan trolig først bli realisert på bred basis om nytten av slike programmer kan dokumenteres. Rapporten anbefaler en rekke tiltak for å redusere problemene knyttet til trøtthet innenfor vei-, bane- og sjøtransport i Norge.

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Preface

This is the third report from the project Fatigue in Transport (FiT), carried out within the TRANSIKK programme (*Transportsikkerhet*) of the Research Council of Norway. The main objective of the FiT project is to increase what we know about fatigue in human transport operators in the road, maritime and rail sectors in Norway.

Report I from the FiT project was issued as TØI Report 1351/2014, with the title "What is fatigue and how does it affect the safety performance of human transport operators?". This was an account of how fatigue can be operationalised in order to study its prevalence and effects in human operators of land and sea transport. Report II was issued as TØI Report 1354/2014, with the title "An assessment of studies of human fatigue in land and sea transport". This report reviewed international studies of fatigue in transport operators, and evaluated the studies according to their operationalization of fatigue.

Reports III and IV from the FiT project focus on fatigue in Norwegian transport. By reviewing relevant literature and interviewing experts, the present report – Report III – assembles current knowledge on the prevalence, causes, consequences, management and regulation of fatigue in operators of land- and sea-based transport forms in Norway. Report IV will present the results of a survey of operators working in Norway, structured using the findings from Report III.

The project manager was Ross Owen Phillips. He has written the report together with Tor-Olav Nævestad and Torkel Bjørnskau. Trude Rømming has been involved in editing the report and preparing it for publication. Fridulv Sagberg has quality assured the report.

The authors wish to thank FiT Reference Group – Margareta Lützhöft, Ebba Wergeland, Emma Wadsworth and Anne Kari Rasmussen – for their contribution at the outset of this report. We especially wish to thank the anonymous experts and their employers for the time they gave to us. The following also deserve thanks for helping or reviewing drafts of the report: Elisabeth Vaagen Samsøe, Håvard Gåseidnes and Vegar Berntsen at *Sjøfartsdirektoratet*, Cathrine Elgin Engström and Merete Aass at *Flytoget AS*, Jørgen Aarhaug at *TØI*, Ottar Omstad (taxi owner), Caroline Sagen Paulsen at *Norges taxieierforbund,* and Håkon Willerud and Yogi Samant at *Arbeidstilsynet*.

Oslo, March, 2015
Institute of Transport Economics (TØI)

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Summary:

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An assessment of existing knowledge is needed to help determine whether more needs to be done to tackle fatigue in professional operators of different transport forms in Norway. Data on Norwegian accidents and incidents confirms that fatigue is an important safety risk in the road, rail and maritime sectors. Despite this, we lack quantitative data on the prevalence of fatigue in Norwegian operators. The causes of operator fatigue in Norway are rooted in framework, organisational and working conditions, as well as individual characteristics and life outside of work. Within the road, rail and maritime sectors in Norway, branches can be identified in which operators are likely to have an elevated risk of fatigue. There is little evidence of systematic programs for the management of fatigue in Norwegian transport, and no evidence that transport companies in any sector actually attempt to measure operator fatigue. However, the rail sector may capture and manage many of the more serious fatigue problems faced by its operators. Widespread fatigue management across all Norwegian transport sectors may first require that the business benefits of tackling fatigue are identified and promoted. Several countermeasures are recommended for use in the road, rail and maritime sectors in Norway.

This report charts existing knowledge on fatigue in professional operators of different transport forms in Norway. In particular, it focuses on the prevalence, causes, consequences, regulation and management of fatigue in the following: professional drivers working in road transport, locomotive engineers (train drivers), and watchkeepers at sea. Knowledge is assembled using literature review and interviews with subject matter experts. The aim of the report is to help inform Norwegian authorities and organisations about the need to manage and tackle transport operator fatigue, and to make recommendations about what could be done. This aim is also to inform a quantitative survey of fatigue in different transport operators in Norway, which will be covered by a subsequent report. The current report is the third in a series of reports produced by the project Fatigue in Transport (www.toi.no/fit).

Increasing time-related demands for Norwegian workers

While general working conditions in Norway are favourable relative to many other countries, a recent report shows that time-related job demands, exhaustion, and stressful work have increased in recent years (Bergene et al., 2014). Increasing shares of people work on the weekends, in the evenings or at night. Long working days (over ten hours) are also on the increase. More varied and demanding working time is ultimately the result of increased market liberalisation, but it is assisted by the flexibility afforded by local tariff agreements, negotiated by representatives of companies and workers. In some transport branches, workers are poorly organised such that their interests may not have been fully accounted for in negotiations on

working time. Thus, despite high social standards in Norway, working time arrangements in transport and other branches may be leading to increased exertion and fatigue.

To assess the extent of any fatigue problem in transport operators in Norway, it would be useful to compare their scores on standard measures of fatigue with norms for the general working population. In the general population, other studies show that a little over 20 per cent of people score positively on two standard scales for general fatigue, and 18 per cent are found to have excessive daytime sleepiness.

Gathering current knowledge on operator fatigue

To assess existing knowledge on fatigue in transport operators, we retrieved and reviewed relevant publications on professional transport operations in road, rail and maritime sectors in Norway. We then supplemented this knowledge with findings from a round of 19 interviews with 26 subject matter experts, selected for their insight into (and experience of) fatigue in the main transport operator roles. We then arranged the information from the literature review and interviews according to whether it concerned the prevalence, causes, consequences, or management of fatigue in transport operators working in Norway today.

Prevalence of operator fatigue

We found no studies enabling us to compare fatigue scores for transport operators with those of population norms. However, according to one study 13 per cent of a sample of professional bus and truck drivers report experiencing at least one episode of sleep behind the wheel in the preceding year. Other non-standard measures also suggest that substantial shares of bus and truck drivers in Norway experience other types of fatigue at problematic levels.

There is very little research on train driver fatigue in Norway. While studies in other Nordic countries show that considerable shares of train drivers report experiencing severe sleepiness and acute and chronic fatigue, differences in organization of the rail networks makes us reluctant to generalize these findings to Norway. Research on the prevalence of fatigue in watchkeepers operating in Norwegian waters is also limited. A Norwegian study of seafarer fatigue in coastal freighter crews finds much higher levels of self-reported safety-critical fatigue for foreign than for Norwegian crew members, but the reasons for the differences are not clear. In a separate study of supply vessel crew, about half of those responding to a survey agreed that they felt completely worn out after four weeks at sea. It is hard to draw conclusions from such findings in the absence of normative samples.

According to the experts we interviewed, stress, physical demands and/or lack of sleep can lead to fatigue in most types of professional operator, whether they are carrying out local or long-distance transport of goods or passengers. However, experts identified operators in certain Norwegian transport branches as potentially having elevated fatigue risks. These were drivers working in coach, goods and taxi transport (road sector); drivers working for smaller rail cargo companies; and watchkeepers working on smaller coastal freight transporters and fishing vessels.

While experts from the rail sector did not think severe fatigue was as prevalent among train drivers as for other types of transport operators, they conceded overall that there might still be important areas to address. Most maritime experts thought fatigue and sleepiness was common at sea. Mental exhaustion may be more prevalent

on busy vessels with many port calls operated around the clock, while sleepiness may be more prevalent on well-equipped, larger vessels on long voyages. Fatigue levels are expected to vary a lot, depending on the nature of the voyage, vessel and with the particular phase of the ship's operation.

Causes of fatigue in the different sectors

We identified several possible causes of fatigue in transport operators working in Norway, and the report details these for operators working in each of the main transport sectors. Each sector and branch is a complex system with unique conditions, which will influence the level of exertion required over time by the individual operator, as well as the opportunity to recover from that exertion, through sleep and rest.

In the road transport sector, authorities maintain and enforce national and EU regulations on working, resting and operating hours, in order to help provide rest periods and patterns that allow for *minimum* sufficient recuperation. However, some drivers in the heavy goods, coach and taxi branches in Norway may struggle to get the job done within the confines of working or driving hours regulations, which in some cases may be used as operational norms rather than absolute limits. Ongoing tension between the demands of the job and regulatory limits must be dealt with largely by the driver, a situation that is not helped by a relative lack of driver representation in these branches. The power of the transport buyer in setting delivery terms and conditions in goods transport branches also contributes to increased strain on drivers. Furthermore, while working and driving time regulations provide important boundaries and do a lot to limit fatigue, they do not account for all causes of fatigue (e.g. they fail to distinguish between night and day driving). The tension between framework conditions and the regulations on working and resting time, together with the inability of regulations to account for the wider aspects of fatigue or hold all transport chain actors accountable for driver safety, may mean that many drivers in these branches often do not get sufficient sleep or rest.

Empirical evidence also suggests that professional drivers in all road transport branches may face poor physical and psychosocial working conditions relative to many other occupations, with widely fluctuating periods of workload, in which they often have little control and lack social support. Experts suggest, however, that the extent to which working conditions result in fatigue depends on road transport branch, organisational conditions, and various individual differences and habits. In Norway, winter driving and a relative lack of resting places may contribute to increase fatigue.

While empirical evidence is scarce, the comments of experts from the rail sector suggest that working time (shift schedule) is also a cause of fatigue for train drivers, albeit to a lesser extent than for operators in road or sea transport. Some of the reasons for this are that train drivers work less hours overall, participate in schedule design, and are obliged and encouraged to report when they become fatigued. It is not clear, however, whether the measures taken prevent the build-up of chronic fatigue, or whether overtime and shift swapping by drivers means that actual schedules worked are in some cases considerably more fatiguing than those planned.

In the maritime sector, empirical evidence is again limited, and focuses largely on coastal freight and supply shipping. Findings suggest that the watch system, watch-timings, manning levels, weather, operational characteristics and length of the voyage

combine to influence fatigue. In many cases there will be curtailed opportunity for sleep, such that sleep timings, sleeping conditions and length of the voyage will combine to determine ultimate fatigue levels. There can be large fluctuations in operational demands over the course of a voyage on some vessels, and in more demanding spells some watchkeepers may struggle to get their work done within regulatory limits.

The 6/6 watch system, commonly worked in Norwegian waters, has been shown by international studies to produce curtailed and poor sleep, relative to other systems. However, there may be operative reasons why schedules that are better at limiting fatigue are not opted for, and in some cases watchkeepers may prefer to work 6/6. Again, fatigue-related challenges faced by an operator depend on the branch in which they work. As in the road sector, operational margins and supply chain actors can also influence working conditions.

Possible causes of fatigue that were common to operators working in road, rail and maritime sectors were working and resting time (including occasional discrepancies between planned and actual schedules worked); branch conditions; organisational culture; psychosocial work conditions; sleeping conditions; commuting; non-work life of the operator; operator's life phase; other individual differences, and Norwegian conditions.

Consequences of fatigue

Norwegian research shows that fatigue contributed to the following:

- Seven out of 44 serious road accidents triggered by professional bus and truck drivers between 2005 and 2008.
- 13 per cent of signal pass incidents by train drivers between 2010 and 2012.
- One in ten groundings in Norwegian waters occurring between 2010 and 2013.

This is just some of the evidence that fatigue is a safety problem in land and sea-based transport in Norway. Most expert comments supported this, and also suggest that these figures may underestimate the role of fatigue in incidents and accidents.

Regulation and management

The main way authorities control driver fatigue in the road transport sector is by legislation limiting working and driving hours. However, data suggest that 31 per cent of professional drives in the Norwegian road sector violate the daily rest rule. Over one in four of these violations is serious and reportable. Such data also suggest a discord between demands/logistics of the job and regulatory requirements for many drivers, some of whom may perceive rightly or wrongly that the regulations themselves contribute to stress, time pressure and fatigue.

Comments from our experts supported the need for the existing legislation limiting working and driving hours in road transport, but they too listed a number of problems. These included inflexibility, incoherence, low risk of detection, and failure to hold all transport chain actors accountable. Experts seemed to think that road transport organisations overall could do more to manage and regulate fatigue among their drivers (e.g. sensible shifts, open reporting culture, well-planned operations, health services who understand driver challenges). Some established companies in certain branches do take steps to tackle the problem (e.g. hazardous goods transporters, ISO-39001-certified companies), but in many goods or passenger

transport branches the organisations are often small, such that business owners perceive that there is too little resource to tackle fatigue.

The regulations on working time at sea are less stringent than in land transport, but these too may be perceived as rigid by seafarers, who may simply want to help their colleagues meet the widely varying demands of a vessel's operation. Captains too may perceive some regulations as failing to address the practical realities of modern shipping, with its low manning and increased demands. As a result there can be large discrepancies between recorded and actual hours worked on board, such that transgressions in the maritime sector may be more systematic and serious than in the road sector. We found little evidence of the systematic management of fatigue by shipping companies.

Working time in the rail sector would seem to be more favorable than in either the road or maritime sectors. Furthermore, compliance of working and resting hours also appears to be better. Conditions encouraging the better management and regulation of fatigue include open reporting culture concerning fatigue; highly organized working relations; participative schedule design; and flexible working time. There may be monitoring by the employer of schedules worked for any fatigue-related problems arising, and importance of driver restitution is appreciated by different stakeholders in the transport operation. There are regular health checks and follow-ups by the company health service. Recent regulations require companies to conduct psychological checks following incidents.

While we could find no comprehensive programs devoted to the assessment and management of fatigue, we found several ways in which rail organisations detect and manage fatigue-related issues, including education of new drivers about the risks of shift working, assessment of shift schedules for fatigue risks, and provision of rest facilities at base.

What can authorities and organisations do to reduce fatigue?

We identified areas that each sector could address to improve the management of fatigue risks. Companies could do more to account for life outside work as a cause of fatigue at work, and to assess either actual sleep obtained or the extent to which operators recover from previous work. There is little evidence of systematic analysis of schedules for fatigue risks in the road or maritime sectors. In none of the sectors do companies monitor on-the-job fatigue, or use formal systems to monitor aspects of behaviour or performance that could indicate developing fatigue. In the road and maritime sectors, many companies could do more to legitimize and support the open reporting of severe fatigue. Learning from investigations of accidents and incidents could also be improved.

To address these and other issues, the report structures expert recommendations on tackling fatigue using an expanded version of the fatigue-risk trajectory (Dawson and Fletcher, 2001). The trajectory describes five levels of fatigue risk that organisations or authorities should address in order to tackle fatigue effectively. The results are shown in Table S1.

Table S1. Recommendations on how to improve transport operator fatigue, structured using the expanded version of the fatigue-risk trajectory of Dawson & Fletcher (2001).

Risk level	Description	Recommendation
-	Set preconditions for risk management	• Establish business case for tackling fatigue.
1	Working time, work quality, non-work life quality	• Address any mismatch between hours of work and rest regulations and demands of working. • Systematically assess planned and actual work schedules for fatigue risks.
2	Recovery from work	• Provide facilities and information to help drivers rest, exercise and eat healthily. • Consider assessing need for recovery, recovery + fitness-for-duty tests. • Empower leaders to help subordinates tackle fatigue. • Include fatigue monitoring and reduction as part of company health program. • Promote a home life that allows for optimal recovery from work. • Address commuting risks.
3	Reports of fatigue and behavioural symptoms	• Use standard battery to measure and monitor different forms of operator fatigue at work. • Monitor links between working time and operator fatigue in order to improve schedules. • Legitimise and encourage open reporting of and discussion about fatigue. • Give explicit information about what to do in the event of severe fatigue, including how work tasks should be prioritised in the event of fatigue. • Legitimise informal ways in which operators cope with fatigue that are likely to be effective. • Give operators feedback on personal fatigue tendencies.
4	Fatigue-related errors	• Improve operator and leader knowledge about how to identify fatigue and associated risks in self and colleagues. • Give operators feedback on fatigue-related operational risks.
5	Fatigue-related incidents/accidents	• Standardise reporting on fatigue as part of incident and accident reporting, whether or not investigators believe it is contributory.

Conclusions

We have charted existing knowledge on the prevalence, causes, consequences, regulation and management of fatigue in human operators working in the road, rail and maritime sectors. We need this knowledge to help decide whether more should be done to tackle fatigue in Norwegian transport.

We found a severe lack of quantitative data on the prevalence of operator fatigue. However, qualitative evidence based on expert interviews suggests that operators in certain Norwegian transport branches may have elevated risks of fatigue, and may therefore particularly merit further investigation. These are, in the road sector, coach, truck and taxi branches; in the rail sector: smaller cargo enterprises; and in the maritime sector: smaller coastal freighters and fishing vessels. Use of standard measurement batteries to assess fatigue would provide data to support these assertions. The need to assess fatigue prevalence rates in operators is underlined by data on Norwegian accidents and incidents showing that fatigue is an important safety risk in each of the road, rail and maritime sectors.

While limited by lack of explicit links to actual fatigue levels, empirical and anecdotal evidence from Norway suggests multiple causes of transport operator fatigue, many

of which may interact dynamically. Contributors to fatigue that span the main sectors each contribute to fatigue by influencing sleep or exertion.

Regulation of fatigue by delimiting operating or other working hours is problematic in the road and maritime sectors, partly because certain operators in some branches may at times need to violate the rules in order to get their work done. In the road sector, there is also lack of coherence between regulations, framework conditions and road infrastructure.

We found little evidence of any organisational programs for the management of fatigue in any of the three transport sectors. Even though the major rail companies address fatigue in several different ways, companies do not formally monitor how tired drivers actually are. Organisations in many road and maritime branches, in particular, could do more to address operator fatigue, but may lack resources due to narrow operational margins.

Identifying and promoting the business benefits of tackling fatigue may encourage the implementation of recommended countermeasures, many of which span the road, rail and maritime sectors. Recommended countermeasures resulting from the findings in this report include:

- Measure and monitor different forms of operator fatigue.
- Carry out fitness-for-duty tests.
- Assess links between working time and fatigue.
- Increase open and systematic reporting of fatigue.
- Educate leaders to help subordinates tackle fatigue.
- Feedback to operators on fatigue-related operational risks.
- Fatigue monitoring and reduction as part of company health program.
- Facilities and information to help drivers rest, exercise and eat healthily.

Companies could also promote a home life that allows for optimal recovery from work, and consider addressing risks from fatigue while commuting.

Transportøkonomisk institutt
Stiftelsen Norsk senter for samferdselsforskning

Sammendrag:

Trøtthet og sikkerhetsutfordringer i transportbransjen: litteraturgjennomgang og ekspertvurderinger

TØI rapport 1395/2015
Forfattere: Ross Owen Phillips, Tor-Olav Nævestad, Torkel Bjørnskau
Oslo 2015 129 sider

En gjennomgang og vurdering av kunnskapsgrunnlaget om utmattelse og trøtthet i transportsektoren i Norge er nødvendig for å avgjøre om det er behov for mer kunnskap for å håndtere slike problemer. Data om ulykker og hendelser viser at trøtthet er en viktig risikofaktor i vei-, bane- og sjøtransport, men til tross for det mangler vi gode date om omfanget av trøtthet blant operatører i disse sektorene. Grunnen til at mange blir trøtte er sammensatt; det skyldes rammebetingelsene transporten inngår i, kjennetegn ved organisasjon og arbeidsforhold, individuelle egenskaper blant operatører og livssituasjonen utenfor jobb. Innenfor vei-, bane- og sjøtransport kan man identifisere spesielle bransjer der risikoen for trøtthet og utmattelse er særlig høy. Det er imidlertid i liten grad satt i verk systematiske programmer for å redusere problemet, og det finnes lite dokumentasjon på at transportselskaper faktisk forsøker å registrere omfanget av trøtthet. Innenfor jernbanetransport kan det likevel se ut til at det arbeides systematisk for å redusere problemet med trøtthet blant lokførere. Systematiske programmer for å håndtere problemene knyttet til trøtthet og utmattelse kan trolig først bli realisert på bred basis om nytten av slike programmer kan dokumenteres. Rapporten anbefaler en rekke tiltak for å redusere problemene knyttet til trøtthet og utmattelse innenfor vei-, bane- og sjøtransport i Norge.

Denne rapporten kartlegger eksisterende kunnskap om trøtthet i norske transportsektorer, og er den tredje i en serie av rapporter fra prosjektet *Fatigue in Transport* (www.toi.no/fit). Rapporten fokuserer på ulike aspekter av trøtthet blant yrkessjåfører som arbeider i veitransport, lokførere, og vaktmannskap til sjøs. Kunnskapen er basert på en litteraturgjennomgang og intervjuer med ressurspersoner fra vei-, jernbane- og sjøtransport. Formålet med rapporten er å informere norske myndigheter og organisasjoner om behovet for tiltak mot trøtthet i transport. Rapporten kommer også med forslag om konkrete tiltak. En etterfølgende rapport vil presentere resultatene fra en kvantitativ undersøkelse av trøtthet blant ulike transportoperatører i Norge.

Økende tidsrelaterte krav til norske arbeidere

Arbeidsforholdene i Norge er gunstige i forhold til mange andre land, men en nylig rapport viser at tidsrelaterte jobbkrav, trøtthet og stressende arbeid har økt de siste årene (Bergene et al., 2014). En økende andel av ansatte jobber i helgene, på kvelden og om natten. Lange arbeidsdager (over ti timer) er også i økning. En årsak til dette er økt fleksibilitet i arbeidstiden oppnådd på lokalt nivå gjennom tariffavtaler. I enkelte grener (inkludert noen transportgrener) er relativt få arbeidere organisert. Dette kan medføre at deres interesser ikke er ordentlig regnet med i

arbeidstidsforhandlinger. I noen tilfeller kan arbeidstidsordninger derfor bidra til anstrengelse og trøtthet, til tross for ellers høye sosiale standarder i Norge.

For å vurdere omfanget av trøtthet blant transportoperatører i Norge, er det nyttig å sammenligne trøtthetsskårer for ulike operatører med normskårer for befolkningen generelt (ved bruk av standardmål). Andre studier har vist at litt over 20 prosent av et utvalg av den norske befolkningen skårer positivt på to skalaer for generell trøtthet, og 18 prosent har høy søvnighet på dagtid.

Innhenting av kunnskap om trøtthet

En systematisk litteraturgjennomgang ble gjennomført for å hente publikasjoner om trøtthet i ulike transportsektorer i Norge (vei, jernbane og sjø). Denne informasjonen ble supplert med funn fra 19 intervjuer med 26 ressurspersoner, valgt for sin erfaring med trøtthet i de ulike sektorene. Informasjonen ble kategorisert etter om det handlet om forekomst av trøtthet, årsaker til trøtthet, eller konsekvenser, regulering eller styring av trøtthet blant transportoperatører i Norge i dag.

Forekomsten av trøtthet

Det er ikke mulig å sammenligne trøtthet blant operatører med trøtthet blant befolkningen generelt ved bruk av eksisterende studier. Imidlertid viser norske studier at 13 prosent av yrkessjåfører sier de har sovnet bak rattet minst en gang i løpet av det foregående året. Andre studier viser også at betydelige andeler av yrkessjåfører i Norge opplever ulike former for trøtthet slik at det er et problem. Det er svært lite forskning på trøtthet blant lokførere i Norge. Mens studier i andre nordiske land viser at betydelige andeler av lokomotivførere opplever akutt og kronisk trøtthet, er det ikke klart om dette kan generaliseres til norske lokførere. Forskning på forekomsten av trøtthet blant mannskap som opererer i norske farvann er også begrenset. En norsk studie av arbeidsforhold i fraktefart finner høyere nivåer av sikkerhetskritisk trøtthet blant utenlandske enn blant norske mannskap, men det er uklart hva årsakene er. I en annen studie av norske supplyskip sa halvparten av mannskap og offiserer at de følte seg fullstendig utslitt etter fire uker på havet.

Ifølge ressurspersonene som ble intervjuet, kan stress, fysiske krav og mangel på søvn føre til trøtthet hos de fleste førere som jobber i land- eller sjøtransport, om de jobber i nær- eller langtransport, og gods- eller passasjertransport. Imidlertid kan operatører i visse grener i Norge ha en forhøyede risiko for trøtthet i forhold til de som jobber i andre grener av samme sektor. Vogntog-, turbil- og drosjesjåfører, lokfører som jobber for mindre cargotransportere, og de som jobber i fraktefart og på fiskefartøy kan være særlig utsatt for trøtthet.

Ressurspersoner fra jernbanesektoren mente at trøtthet blant lokførere ikke er et stort problem, skjønt at det gjenstår noen problemer å løse knyttet til skiftarbeid. Derimot mente flere ressurspersoner at trøtthet og søvnighet var vanlig blant mange som jobber i sjøfart. Mental utmattelse kan være mer utbredt på travle fartøy med mange anløp, mens søvnighet kan være mer utbredt på velutstyrte, store skip på lange reiser. Nivået av trøtthet forventes å variere mye, avhengig av reisens natur, type av fartøy, og driftsfase.

Årsaker til trøtthet i de ulike sektorene

Vi identifiserte flere mulige årsaker til trøtthet hos transportoperatører som jobber i Norge. Hver sektor og gren er et komplekst system med unike forhold, som påvirker både nivået av påkjenning for enkelte operatør over tid, og muligheten til å restituere seg gjennom søvn og hvile.

I veitransport er nasjonale og europeiske regler om arbeidstid og kjøre- og hviletid utformet for å gi operatøren mulighet for tilstrekkelig restitusjon. Imidlertid tyder norske data på at mange tungbil-, turbil- og drosjesjåfører sliter for å få jobben gjort innenfor reguleringene. I noen tilfeller må sjåførene strekke eller overskride regulatoriske grenser. Slike problemer forsterkes av utilstrekkelig representasjon av sjåførens interesser i disse grenene, og i godstransport av mektige transportkjøpere som setter leveringsvilkår. Mens reguleringer om arbeidstid og kjøre- og hviletid gjør mye for å begrense trøtthet, tar de ikke hensyn til alle viktige årsaker til trøtthet (for eksempel skiller de ikke mellom natt- og dagkjøring). I noen tilfeller kan transportledere være styrt av transportkjøpere og speditører, slik at de utnytter sine ansatte i den grad at mange sjåfører i disse grenene ikke får tilstrekkelig søvn eller restitusjon.

Undersøkelser tyder på at noen yrkessjåfører står overfor dårlige fysiske og psykososiale arbeidsvilkår, med varierende perioder med over- og underbelastning. Dessuten har de ofte liten jobbkontroll og mangler støtte fra kollegaer og ledere. Ressurspersonene mente at virkningene av slike forhold på trøtthet avhenger av veitransport gren, organisatoriske forhold, og ulike individuelle forskjeller og vaner. I Norge kan vinterkjøring og en relativ mangel på rasteplasser også bidra til å øke trøtthet.

Ved uhensiktsmessig skiftplan kan arbeidstid også være en årsak til trøtthet for lokførere, men i mindre grad enn for operatører i vei- eller sjøtransport. Lokførere jobber mindre timer totalt enn andre typer førere. De deltar i utformingen av skiftplanen, og er forpliktet til å rapportere når dagsformen ikke er forsvarlig. Til tross for gunstige forhold vet vi lite om kronisk trøtthet hos lokførere, eller i hvilken grad hyppig overtid og skiftbytting betyr at arbeidet blir mer trøttende enn det ville blitt med opprinnelig skiftplan.

Innen maritim sektor, er det lite kunnskap om dette. Likevel tyder funnene på at visse kombinasjoner av vaktsystem, skifttid, bemanning, vær, driftsfaser og reisens lengde kan bidra til økt trøtthet. I mange tilfeller vil det bli begrenset mulighet for søvn. Søvntid, soveforhold og reisens lengde vil bidra til trøtthet som bygger seg opp over tid. På noen fartøy kan det være store svingninger i driftskrav i løpet av en reise, noe som betyr at mannskapet av og til ikke får arbeidet gjort innenfor regelverkets rammer. 6/6-vaktsystemet, som vanligvis benyttes i norske farvann, fører til dårlig søvn i forhold til andre systemer, men mannskapet ønsker ikke alltid å jobbe etter den tidsplanen som best begrenser trøtthet.

Mulige årsaker til trøtthet som er felles for operatører fra de ulike transportsektorer er som følger;

- arbeidstid (inkludert avvik mellom planlagt og faktisk tidsplaner jobbet),
- transportbransjens kjøreforhold,
- organisatorisk kultur,
- psykososiale arbeidsvilkår,
- soveforhold for de som sover bort fra hjemmet,

- pendling,
- livet utenfor arbeidet,
- livsfase,
- andre individuelle forskjeller, og
- særnorske forhold.

Konsekvenser av trøtthet

Norsk forskning viser at trøtthet bidrar til følgende:

- Sju av 44 alvorlige trafikkulykker utløst av profesjonelle buss- og lastebilsjåfører i perioden 2005 til 2008.
- 13 prosent av signal passhendelser foretatt av lokomotivførere i perioden 2010 til 2012.
- En av ti grunnstøtinger i norske farvann i perioden 2010 til 2013.

Dette er bare noen av bevisene på at trøtthet er et sikkerhetsproblem i land- og sjøtransport i Norge. De fleste kommentarer fra ressurspersonene støttet dette, og tyder på at disse tallene faktisk undervurderer betydningen av trøtthet i hendelser og ulykker.

Regulering og styring

Den viktigste måten trøtthet styres i veitransportsektoren er ved reguleringer om arbeids- og kjøre- og hviletid. Norske data viser at 31 prosent av yrkessjåfører som ble kontrollert hadde overskredet regelen om døgnhvile. Syv prosent av sjåførene hadde begått et alvorlige og meldepliktig brudd. Disse dataene tyder på at mange sjåfører opplever en konflikt mellom arbeidsgiverens/transportkjøperens krav på den ene siden og myndighetens krav på den andre. Denne konflikten gjør at mange sjåfører oppfatter at regelverket selv bidrar til tidspress, stress og trøtthet. Våre ressurspersoner erkjente at det fortsatt er behov for arbeids- og kjøre- og hviletidsreguleringer, men de listet også opp en rekke problemer. De nevnte blant annet manglende fleksibilitet, lav oppdagelsesrisiko, og vanskeligheter med å holde alle aktører i transportkjeden ansvarlige for sjåførens arbeidstid. De mente at bedrifter i veitransport også kunne gjøre mer for å regulere trøtthet blant sine sjåfører, for eksempel ved risikovurdering av sine arbeidsplaner, åpen rapporteringskultur, godt planlagte operasjoner, og bruk av helsetjenester som forstår sjåførens utfordringer. Noen etablerte selskaper i visse grener har nok tatt skritt for å takle problemet (for eksempel transportører av farlig gods, ISO-39001-sertifiserte selskaper), men i gods- og passasjertransport kan mange av de mindre bedriftene oppfatte at det er for lite ressurser for å takle trøtthet.

Forskrifter om arbeidstid for norsk sjøfart er mindre streng enn i landtransport. I noen tilfeller kan sjøfolk faktisk jobbe opptil 14 timer i døgnet og 77 timer i uken. Til tross for dette kan reguleringene bli oppfattet som altfor rigide av sjøfolk, som kanskje bare ønsker å hjelpe sine kolleger gjennom perioder med høye krav. Også kapteiner kan oppfatte at reguleringene ikke tar hensyn til de praktiske realiteter i moderne skipsfart (lavt bemanningsnivå, økte krav). Som et resultat kan det være store avvik mellom registrerte og faktiske arbeidstimer om bord, og overtredelser i maritim sektor kan være mer systematiske og alvorlige enn i veisektoren.

Arbeidstiden i jernbanesektoren synes å være mer gunstig enn i vei- eller sjøtransport. Overholdelse av arbeids- og hviletid ser også ut til å være bedre. Det er bedre

forutsetninger for styring og regulering av trøtthet, for eksempel åpen rapporteringskultur; høyt organisert arbeidsrelasjoner; deltakelse i planlegging av tidsplan; og fleksibel arbeidstid. Det er regelmessige helsekontroller og oppfølging av bedriftshelsetjenesten.

Selv om vi ikke fant omfattende programmer for måling og styring av trøtthet, fant vi flere måter som jernbanebedrifter håndterte trøtthetsrelaterte problemer på. Disse er blant annet:

- Utdanning av nye sjåfører om risikoene knyttet til skiftarbeid og hvordan håndtere dem.
- Oppmuntring og plikt til å rapportere trøtthet (eller ikke skikket til tjeneste) før og under kjøring. Selskapet er forpliktet til å finne andre ikke-sikkerhetssensitive oppgaver der det er mulig.
- Lokførere oppfordres til å ta opp trøtthetsrelaterte problemer med sine ledere, som også kan se etter tegn på overdreven overtid eller risikabelt skiftarbeid blant sine lokførere. Slike ordninger er i stor grad uformelle.
- Selskapet bestiller selvstendige vurderinger av skiftordninger.
- Overnatting eller hvilefasiliteter tilbys på basen for å maksimere søvnmulighet for lokførere med korte friperioder.

Hva kan myndigheter og organisasjoner gjøre for å redusere trøtthet?

Rapporten diskuterer risikoområder som hver sektor kan fokusere på for å bedre kontrollere trøtthet. I hver av de tre sektorene er lite gjort for å ta hensyn til livet utenfor jobben som en årsak til trøtthet på jobb. Lite er også gjort for å vurdere faktisk søvn eller i hvilken grad en operatør har kommet seg etter tidligere arbeid. I tillegg gjennomføres følgende aktiviteter i liten grad:

- Analyse av tidsplaner for trøtthetsrisiko ved bruk av tilgjengelig programvare
- Måling av trøtthet i arbeidstid
- Overvåkning av aspekter av atferd eller ytelse som kan indikere trøtthet.

I vei- og maritimsektorene er det lite tegn på at selskaper legitimerer og støtter åpen rapportering av alvorlig trøtthet. Gransking av ulykker og hendelser kan også bli bedre, slik at hver gren kan lære av dem.

I rapporten har vi strukturert anbefalinger om trøtthetshåndtering ved hjelp av en utvidet versjon av *fatigue-risk trajectory* (Dawson og Fletcher, 2001). *Fatigue-risk trajectory* beskriver fem nivåer av trøtthetsrisiko som organisasjoner eller myndigheter bør ta hensyn til for å takle trøtthet effektivt. Resultatene er vist i tabell S1.

Konklusjoner

Vi har kartlagt eksisterende kunnskap om forekomst, årsaker, konsekvenser, regulering og styring av trøtthet blant menneskelige operatører som arbeider i vei-, jernbane- og sjøtransport. Slik kunnskap trengs for å vurdere behovet for å takle trøtthet i norsk transport.

Det er en mangel på kvantitative data om forekomsten av trøtthet blant norske transportoperatører. Likevel tyder kvalitative bevis på at operatører i noen transportgrener kan ha forhøyet risiko for trøtthet. Dette gjelder lastebil-, turbil og drosjesjåfører; lokførere i mindre cargobedrifter; og offiserer som jobber i fraktefart

og på fiskefartøy. Bruk av målebatterier for å vurdere trøtthet ville gi kvantitative støtte for disse funnene. Behovet for å tallfeste forekomsten av trøtthet understrekes også av data om norske transportulykker og -hendelser, som viser at trøtthet er en viktig trussel mot sikkerheten.

Tabell S1. Anbefalinger om hvordan forebygge trøtthet hos transportoperatører, strukturert ved hjelp av en utvidet versjon av Dawson & Fletcher (2001)s Fatigue-risk trajectory.

Risikonivå	Beskrivelse	Anbefaling
-	Forutsetninger for risikostyring.	• Etablere business case for å takle trøtthet.
1	Arbeidstid, arbeidskvalitet, livet utenfor arbeid.	• Redusere konflikt mellom reguleringer om arbeidstid og arbeidskrav. • Systematisk vurdering av trøtthetsrisiko knyttet til planlagte arbeidsplaner og faktisk arbeidstid.
2	Recovery fra arbeid.	• Gi fasiliteter og opplysninger som kan hjelpe sjåførene til å hvile, trene og spise sunt. • Vurdere måling av *need-for-recovery*, *recovery* og *fitness-for-duty*. • Utdanning av ledere for å hjelpe underordnede med å takle trøtthet. • Sjekk for trøtthet, utbrenthet, for mye overtid osv. i helsesjekk. • Fremme et liv utenfor arbeid som gir optimal recovery fra arbeid. • Ta henysn til pendling.
3	Atferdsmessige eller andre tegn på trøtthet.	• Bruk standard målebatteri for å måle og overvåke ulike former for trøtthet på jobb. • Kontinuerlig forbedring av arbeidsplan ved å se på koblinger mellom arbeidstid og trøtthet. • Legitimere åpen rapportering og diskusjon om trøtthet på jobb. • Gi eksplisitt opplysning om hva som kan gjøres når trøtthet oppstår. • Legitimere uformelle trøtthetshåndtering der det er effektivt. • Gi personlig tilbakemelding om trøtthet.
4	Trøtthetsrelatert feil.	• Gi operatørene og lederne kunnskap om hvordan identifisere trøtthetsrelatert atferd og symptomer. • Gi operatører tilbakemelding om operative risikoer knyttet til trøtthet.
5	Trøtthetsrelatert hendelser / ulykker	• Standardisere rapportering på trøtthet for gransking av hendelser og ulykker, uavhengig av om det er medvirkende.

Forskning og anekdotiske observasjoner fra Norge tyder på flere årsaker til trøtthet i transport, hvorav mange kan samhandle dynamisk. Regulering av trøtthet ved å avgrense arbeids- eller kjøretid er problematisk i vei- og maritimsektorene. Enkelte operatører i noen grener føler at de til tider må bryte reglene for å få arbeidet gjort. Dette skyldes mangel på sammenheng mellom regelverket og rammebetingelsene. I veisektoren er det også mangel på sammenheng mellom regelverket og veisystemer.

Vi fant lite bevis for programmer for trøtthetsstyring i noen av de tre transportsektorene. Selv om de store jernbaneselskapene håndterer trøtthet på flere forskjellige måter, er det ingen av bedriftene som måler hvor trøtt deres lokførere faktisk blir. Organisasjoner i mange vei- og sjøgrener kan gjøre mer for å kontrollere trøtthet, men mange mener at de mangler ressurser på grunn av trange driftsmarginer.

Identifisering av de konkrete fordelene av å takle trøtthet kan derfor trengs før implementering av anbefalte tiltak blir mulig. Anbefalinger som gis omfatter blant annet måling og overvåking av ulike former for trøtthet, måling av *fitness-for-duty*, vurdering av sammenhenger mellom arbeidstid og trøtthet, etablering av åpen rapportering på trøtthet, og utdanning av ledere for å hjelpe underordnede med å takle trøtthet. Selskaper kan også fremme et hjemmeliv som gir mulighet for optimal avkobling fra jobb, og vurdere trøtthetsrisikoene knyttet til pendling.

Abbreviations

AIBN – Accident Investigation Board Norway (*Statens harvarikommisjon for transport*)

ATC – Automatic Train Control

BNWAS – Bridge Navigational Watch Alarm System

ESS – Epworth Sleepiness Scale

FMP – Fatigue Management Program

ILO – International Labour Organisation

IMO – International Maritime Organisation

ITF – International Transport Workers Federation

KSS – Karolinska Sleepiness Scale

MAIB – Marine Accident Investigation Branch (UK)

MARPOL – International Convention for the Prevention of Pollution From Ships

MLC – Maritime Labour Convention

NLF – Norwegian national train driver union (*Norsk Lokomotivmannsforbund)*

NLIA – National Labour Inspection Authority (*Arbeidstilsynet*)

NMA – Norwegian Maritime Authority (*Sjøfartsdirektoratet*)

SOLAS – International Convention for the Safety of Life at Sea

STCW – International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

WEL – Work Environment Law (*Arbeidsmiljøloven*)

1 Introduction

Fatigue has been found to contribute to a substantial share of accidents involving professional drivers in road transport, navigational officers at sea and train drivers, and its detrimental effect on vigilance is a potential threat to security operations (Sagberg et al., 2004; Gertler, DiFiore, & Raslear, 2013; Raby & Lee, 2001). The implications of severe sleepiness for transport operator performance can be as serious as those caused by high alcohol levels (Dawson & Reid, 1997; Williamson & Feyer, 2000).

One particularly promising way to tackle the problem is for regulatory authorities to encourage the systemic management of fatigue and sleepiness by individual transport organisations, which are well placed to effectively design, implement and monitor measures to tackle fatigue according to the specific needs of its operators. Some regulators, especially in the air sector, are promoting the management of fatigue within the framework of existing occupational health and safety legislation, where fatigue is treated as any other risk factor to be controlled within an ongoing Safety Risk Management System (Moore-Ede, 2010; Stewart et al., 2010). Attempts to do this are also increasingly evident in rail and maritime sectors (Starren et al., 2008), and more recently in the road sector (Wallington et al., 2014). In the Australian road and international air sectors, regulatory opt-outs have been offered to companies shown to demonstrate effective Fatigue Management Programmes (FMPs), which combine complementary measures to tackle fatigue, such as training, schedule management or health monitoring (Jackson et al., 2009; NTC Australia, 2008). Despite this, the dominant regulatory approach among the road, rail and maritime sectors of European countries, including Norway, is still proscriptive legislation based on hours-of-work.

To advise authorities about the need to encourage the active management of fatigue by transport organisations, we need to know more about the prevalence, causes, outcomes of fatigue in different types of transport operator (Phillips & Sagberg, 2010a). This applies especially to Norway, where knowledge on fatigue in different transport sectors is relatively scarce. Recognition of this resulted in the project "Fatigue in Transport (FiT)", funded by the Research Council of Norway (2012-2015), of which this report is part.

A major part of the FiT project aims to compare and contrast prevalence, causes and outcomes of fatigue in operators of different land and sea transport forms in Norway. By doing so, it hopes to identify challenges across and within different types of branch, organisation and job role, and ultimately inform the future regulation and management of fatigue. This report is the first of two reports describing the results from this part of the project, and it assesses the prevalence, causes and outcomes of fatigue in Norwegian operators using literature review and expert interviews. The

second report will describe the results of a two-part questionnaire survey on fatigue in operators of different land and sea transport forms (Phillips & Sagberg, 2015)[1].

The findings of the current report are presented in three main chapters, which follow the Introduction and Methods. These deal, respectively, with road driver fatigue (Chapter 5), train driver fatigue (Chapter 6) and fatigue among watchkeepers at sea (Chapter 7). Each of these chapters starts by giving some relevant background to the relevant transport sector in Norway, before presenting findings on the prevalence, causes, outcomes, management and regulation of fatigue among operators for that sector, both from the literature review and expert interviews. Findings on operator fatigue in different transport sectors in Norway are compared and contrasted in Chapter 8.

We begin by giving some general background for the report.

[1] Other relevant reports in the project include one that sets out our view of the operationalization of fatigue (Phillips, 2014a), and another that reviews international studies of the prevalence, causes and outcomes of fatigue in land- and sea-based operators (Phillips, 2014b). A doctoral study examines the risks of fatigue at sea, and an oncoming report reviews fatigue countermeasures that can be used by transport organisations (Akhtar & Utne, 2012, 2013, 2014). The FiT project also includes an evaluation of a Norwegian company FMP (see www.toi.no/fit).

2 General background

This chapter provides some information to help understand the problem of fatigue in transport operators in Norway, as well as our approach to studying the problem. The authors of any account of fatigue would do well to explain what they mean by the term, so we begin with an account of how we understand fatigue, especially in relation to sleepiness. This account is effectively a summary of an earlier report, which can be referred to for further guidance (Phillips, 2014a). Having operationalised terms, we go on to describe some trends in Norwegian working life, which give important contextual understanding concerning the problem of fatigue in transport operators working in Norway. Finally, we review what is known about the prevalence, causes and consequences of fatigue in the general and working populations in Norway. The normative information presented in this chapter can be reflected on in subsequent chapters, when considering our findings on fatigue in transport operators.

2.1 Fatigued, sleepy or tired?

There is a vast research literature on tiredness, drowsiness, fatigue and sleepiness, and these terms are often used interchangeably. According to Lützhöft et al. (2007: 14), definitions of fatigue generally hold that fatigue concerns the inability or disinclination to continue an activity, because the activity in some way has been going on "too long". Fatigue can also be conceptualized as a condition with several different sub-components. First, we may conceive of local physical fatigue, e.g. in a skeletal muscle. Second, we may conceive of general physical fatigue. A third sub-component of fatigue is mental fatigue that may be induced by a long-lasting high mental workload. A further form of fatigue may be termed "central nervous system" fatigue, normally referred to as sleepiness (Lützhöft et al., 2007: 14). There are also other ways to conceptualize fatigue. For instance, it can be acute or chronic, or can manifest itself as an experience, as physiological change or as performance decrement (Phillips, 2015). The experience of fatigue itself has several dimensions, with fatigued people reporting that they are cognitively, emotionally or physically tired to different extents.

These are just some of the ways in which fatigue has been operationalized in transport research. In a previous report, we argued that broader consensus on operationalization is needed in applied studies of fatigue, to improve how much we know about its causes, occurrence and effects, and thus what should be done to tackle it (Phillips, 2014a). We also argued that a good way to progress towards consensus is to recognise that exertion appears to be central to everyday understanding of the term, i.e. fatigue is often conceived as tiredness caused by exertion (Phillips, 2015). In other words, in general use fatigue is tiredness, not caused simply by an activity going on "too long", but by the person performing the activity being driven to carry on or exert themselves, either consciously or subconsciously. The reasons people carry on are many and varied, as for other

workers carrying out time-pressured, safety-sensitive tasks, transport operators will perceive that they need to maintain performance levels even when they are tired. There is evidence that some operators can maintain performance of the primary task successfully for at least several hours without a break (Dorrian et al., 2007). Nevertheless, when fatigued operators strive to maintain performance, there are inevitably hidden costs, including severe momentary reductions in cognitive performance, or over the longer-term, health and cognitive decrements (Marquié et al., 2014). Such hidden costs are known as latent performance effects, and many are a threat to health and safety (Hockey, 1997). Thus exertion to conserve the primary operating task may often precipitate fatigue in transport operators, and it will be very important to attend to both motivational aspects and latent performance effects when we consider the problem of operator fatigue.

One aspect of fatigue that we have not addressed yet, and which operators are less successful at resisting in order to conserve performance, is sleepiness. Sleepiness is mainly determined by the "body clock" and "sleep homeostasis" (Jackson et al., 2011: 21). The body clock is governed by 24-hour rhythms, known as circadian rhythms, which control sleep and wakefulness. The peaks in sleepiness occur between 02:00-06:00 h and 14:00-16:00 h. Indeed, fatigue-related road accident risks tend to vary in line with this, although the main nighttime increase is somewhat earlier than expected if the circadian dip alone was responsible, i.e. risk peaks at around midnight rather than between 0200-0600 h. This may partly be due to the influence of sleep homeostasis, which refers to the balance between how much sleep a person has had and how long they have been awake (Jackson et al., 2011: 21). After 17-18 hours of wakefulness (i.e., around midnight for the average sleeper) neurobehavioural performance begins degrade to levels approaching BAC levels of greater than .05 (Williamson & Feyer, 2000).

Because of its undoubted importance in serious transport accidents, many researchers have narrowed their operationalization of fatigue to the concept of sleepiness, some arguing that it is by far the most important contributor to fatigue-related accidents (Dawson & McCulloch, 2005). Indeed, standard experiential measures of sleepiness are widely used, and have been shown to be a valid indicator of safety outcomes in different types of operator (Williamson et al., 2011; Åkerstedt et al., 2008). Despite this, the term *fatigue* still abounds. It is used especially in the driver context in the USA (Dinges & Mallis, 1998). Some authors do not believe that this is a problem, since both terms – fatigue and sleepiness – have generally been used to describe operator wakefulness (Lützhöft et al., 2007:14; Anund et al., 2011: 7). However, we have argued that studies should consider a broader concept of fatigue in transport operators for the following reasons (Phillips, 2014b):

1. We wish to understand the effects of sustained *work* and working while tired on performance, and sleepiness models say little about this.
2. Even though they may not be *sleepy*, human operators may still be tired such that performance or latent performance is affected, and exertion will be a major contributor of "non-sleepy tiredness".
3. Vigilance is a central task for all transport operators, and task-related fatigue can have strong effects on vigilance (Kribbs & Dinges, 1994).
4. We are interested in accounting for how cumulative fatigue may lead to performance reductions by interacting with stress, lack of sleep and health (Phillips & Bjørnskau, 2013).

In line with a broad operationalization of fatigue that is due to exertion, we have defined fatigue as follows (Phillips, 2015):

Fatigue is a suboptimal psychophysiological condition caused by exertion. The degree and dimensional character of the condition depends on the form, dynamics and context of exertion. The context of exertion is described by the value and meaning of performance to the individual; rest and sleep history; circadian effects; psychosocial factors spanning work and home life; individual traits; diet; health, fitness and other individual states; and environmental conditions. The fatigue condition results in changes in strategies or resource use such that original levels of mental processing or physical activity are maintained or reduced.

This definition captures all major aspects of work and non-work life that influence operator fatigue. It accounts for sleepiness as part of the broader concept of fatigue, in that: (i) sleepiness may increase fatigue by causing one to exert oneself more in order to conserve performance; and (ii) sleepiness can be a dimension of fatigue because increased sleepiness can result from exertion (for further explanation, see Phillips [2014a]). However, since sleepiness also arises "naturally", in the absence of exertion, we regard the sleepiness as only partially encompassed by the concept of fatigue.

Of course, operators themselves will simply feel *tired* ("a felt need for sleep or rest"), and may not be able to distinguish these different aspects of fatigue and sleepiness. Such a distinction is nevertheless important, because it helps us understand the most important work-related contributors to tiredness and how these influence operator health and performance.

In the current report, we use the terms fatigue and sleepiness in line with the above operationalization.

2.2 Working conditions and the Norwegian model

In comparison with other EU countries, most people in Norway are satisfied with their jobs, and tend more to see them as meaningful (Bergene et al., 2014). They view challenges more positively, and fewer than in other countries work under hard physical conditions. One problem, however, is that time pressure at work has remained high in Norway relative to many other EU countries. Bergene et al. (2014) find that time-related job demands, a feeling of being exhausted after work, and stressful work are the main challenges in Norwegian working life, but that these challenges have only increased in recent years.

In line with EU law, Norwegian Work Environment Law (WEL) stipulates a general maximum limit on formal work time of 40 hours a week. However, the law affords a deal of flexibitity in order for employers and employees to account for varying local conditions. Even though average contracted work time for full-time employees is 37.8 hours a week, employees in Norway actually work an average of 40.8 hours a week (Bergene et al., 2014). Men in particular work more than contracted hours, working a total of 41.5 hours a week on average. Bergene et al. (2014) point out that WEL appears to be based on an assumption that the interests of workers are best protected by limiting the quantity of work in terms of length of time spent working each day or week. It accounts for neither characteristics of the tasks to be completed nor the pace of work, even though such factors may cause stress and fatigue and be detrimental to health and safety. This is important because the share of workers experiencing pressure to produce more in a shorter time has increased over the last 5 years in Norway, to reach its current level of 69 per cent.

For several years, reports have recognised that compared with many EU countries, Norway has a higher share of workers who work in the evenings (between 1800 h and 2200 h) and nights (between 2200 h and 0500 h), and who work shifts and long working days (over ten hours) (Bergene et al., 2014). This may be the result of the change in WEL in 2005, allowing a greater degree of flexibility through local agreements between parties, and it has been pointed out that the normal working day is under pressure in terms of total hours worked, when those hours are worked, and compensation received for non-social hours (before 0500 h and after 1800 h). Working non-social hours is widespread, with over 40 per cent of workers working over ten hours or on the weekends at least sometimes, and 50 and 15 per cent working evenings and nights, respectively, at least sometimes. Three out of every four workers report that they must work at a high tempo, undoubtedly related to the increase in target-driven rather than clock-driven work.

Conditions for most employees in Norway are evolved through local "tariff" agreements. These agreements are obtained and evolved through regular collective bargaining between organs representing the interests of companies, unions or other parties involved in the transport work. This so-called "Norwegian model" is valued as a way of evolving businesses in a way that best caters for the interests of all parties (Bergene & Underthun, 2012). As an EEA member, Norway has therefore attempted to comply with EU legislation in a way that maintains a sufficient level of flexibility to maintain the power of these local negotiations in setting working conditions. For collective bargaining to be successful, however, requires (i) effective representation of workers and managers' interests; and (ii) arrangements that allow for the general application of collective agreements (*allmenngjøring*). According to Bråten et al. (2013: 12), "the quality of cooperative work [in setting working conditions] depends on the nature and level of organisation of the sector"[2], presumably because effective representation requires a certain degree of organisation. Sectors that are highly exposed to the effects of liberalisation and globalisation processes appear to have reduced levels of organisation, and there are claims that this may have been detrimental to working conditions (Bergene & Underthun, 2012). One such sector is the transport sector, large parts of which were poorly organised to begin with. In seeking to understand fatigue in Norwegian transport operators, it will therefore be important to consider how working conditions are developing in different sectors and branches[3], and how liberalisation processes may have reduced the extent to which demands on transport operators and the effects on fatigue have been considered.

2.3 Fatigue in the Norwegian population

Much of the research focus in Norway has been on health-related aspects, in particular severe sleep disorders and the chronic fatigue that may result from serious health conditions such as cancer or depression. Prevalence rates for fatigue in the general population have been given, but one must take care to consider the particular measure of fatigue used (Phillips, 2014b). Loge et al. (1997) attempted to alleviate the problems caused by different studies using different measures, by providing a

[2] Translated from Norwegian.

[3] In this report we use the term "sector" to denote a main transport branch, i.e. road, rail or maritime, while we use the term "branch" to describe a subsector, e.g. livestock transport by road or international freight transport by sea.

Norwegian population norm for scores on the 11-item Fatigue Questionnaire, a measure of chronic fatigue for use in epidemiological studies. Substantial fatigue was found for 22 per cent of a representative sample of 2353 respondents, and can be compared with a prevalence rate of 33 per cent in England (Lerdal et al., 2005:123). About half of the people classified as fatigued in the Norwegian sample reported that they had been so for at least six months. It was found that women scored higher than men, and there was a weak positive association between fatigue and age. The study found no links between fatigue and either occupational, marital or educational status.

The Fatigue Severity Scale has also been used to measure fatigue in the general Norwegian population (Lerdal et al., 2005). It is based on a definition of fatigue as "a sense of physical tiredness and lack of energy, distinct from sadness or weakness" (Lerdal et al., 2005: 124). In this case the prevalence rate was 23 per cent (n=1893), based on a scale score of 5 or more. More women (26 per cent) than men (20 per cent) experienced high fatigue ($p=0.004$). Using this scale, an inverse correlation was also found between fatigue and level of formal education ($r=0.20$, $p<0.001$).

Severe sleepiness in general populations is often measured using the Epworth Sleepiness Scale (ESS), which asks respondents to report on the likelihood of falling asleep in various common life situations (e.g. at the cinema, while talking to someone) (Johns, 1991). The ESS score of a sample of 72 "healthy" Australian workers (i.e. reporting no signs of sleep disturbances, such as heavy snoring) was found to be 4.6 (Johns & Hocking, 1997). Furthermore, because ESS scores for these healthy subjects was found to range from 0 to 10, the authors argued that the percentage of ESS scores in any given sample that are above 10 can be used as an indicator of excessive daytime sleepiness (EDS). It should be noted, however, that these data are almost 20 years old and sleepiness seems to be increasing in the Western populations (Pallesen et al., 2005: 619). It should also be noted that studies of general sleepiness in general populations rarely find such low scores in practice, because many people have problems sleeping. An ESS score of 6.95 and EDS of 18 per cent have been recorded in a sample representing the Norwegian population (n=2301) (Pallesen et al., 2007). The authors consider these scores as high, since about 1 in 6 respondents reported subjective sleepiness in the pathological range (Pallesen et al., 2007). However, similar scores have been found for populations in Spain and New Zealand (Izquierdo-Vicario et al., 1997; Gander et al., 2005), supporting our observation that high levels of general sleepiness in general populations are not unusual.

In contrast to the findings on general fatigue, men were reported by Pallesen et al. (2007) to have higher levels of sleepiness than women. Being younger was also associated with increased sleepiness. This may be surprising given the reduced sleep lengths that are known for older people, but it probably reflects that younger people tend to need more sleep than they get, i.e. there is a greater sleep debt among younger people. Working nights, being depressed, and living in Southern Norway were also associated with increased sleepiness in the Norwegian sample (Pallesen et al., 2007). An earlier finding by the same group, based on a 1-item measurement of insomnia, found that insomnia was greater in the summer in Northern Norway, but greater in the winter in Southern Norway (Pallesen et al., 2001).

2.4 A Norwegian perspective on fatigue

The following is a general commentary on prevalence, causes and consequences of fatigue in the general Norwegian population. It is based mostly on an interview in 2012 with Bjørn Bjorvatn, Professor of Medicine at the Department of Global Public Health and Primary Care at the University of Bergen.

Prevalence

Apart from population studies, there have been many studies in Norway on clinical populations, and on populations experiencing sleep difficulties. As in other countries, nurses working night shift have been a subject of concern. In Norway, studies suggest that as many as 30 per cent of these workers have been found to have elevated levels of general sleepiness (Epworth Sleepiness Scale scores above 10[4]), although the share scoring positively for Chronic Fatigue Syndrome was somewhat lower (12 to 13 per cent) (Natvik et al., 2011). While this may reflect different scale sensitivities, the two scales also measure qualitatively different aspects of fatigue. Although there is not as much research on other occupations as there is on nurses in Norway, anyone with a safety-critical job that involves sitting still while working at unusual times of the day is of concern as regards vulnerability to fatigue. Those who have been active and must drive home afterwards are also of concern (Phillips & Meyer, 2012).

Although there may be considerable variation in fatigue and sleepiness scores according to occupation and working time, the variation within occupations is probably larger. A series of studies has been carried out based on the self-reports of private car drivers in Norway (Phillips & Sagberg, 2013). According to these studies, the share of drivers reporting that they have slept or dozed off behind the wheel at least once in the preceding 12 months varies between three and eight per cent.

Causes

Working and sleeping time

As for other countries, we may expect fatigue-related performance problems to manifest themselves especially during circadian lows, between 0300 and 0600 h, with a less substantial dip at some time during the afternoon, such as between 1400 and 1600 h. We can expect those working early shifts and night shifts to experience high levels of sleepiness at work, not only due to circadian dips but due to problems getting sufficient sleep beforehand, i.e. having to sleep at times of day that are not physiologically conducive to sleep. Regular evening shifts may be less of a problem, although problems caused by lack of social interaction may contribute to fatigue- and stress-related problems in the longer run. In terms of general driving, research supports that there is a much greater risk of falling asleep between the hours of midnight and 0600 h on Norwegian roads (Sagberg & Bjørnskau, 2004). In Norway, as in other countries, working and driving time regulations account for the time of day when one is working only to a limited extent, and the regulations fail to consider either job factors or the recent sleep quantity and quality of workers.

[4] See Phillips [2014a] for an explanation of this scale.

Organisational causes other than working time

As in other countries, very high or low work demands may cause fatigue. Although this might not be a problem in the short term, this can lead to chronic fatigue in the long term. Psychosocial causes of fatigue in relation to work-related safety risks are not well documented in Norway. There is, however, work on psychosocial factors linked to health (Lie et al., 2014).

Individual causes

As we have said, there is a large individual variation in fatigue prevalence within occupations. Increased weight and BMI is linked to sleep disturbances, in Norway as in other lands. Sleep problems and sleepiness appear to be worse among men in Norway, while *fatigue* may be higher among women (see Section 2.3). Other individual variations in fatigue and sleepiness are caused by medication; sleep-related disorders such as sleep apnea or narcolepsy; or a host of other diseases that can cause fatigue- and sleep-related problems (e.g. depression or cancer). Such health-related problems may be less common for young men, but the latter may be more willing to prioritise social activities above sleep. According to the series of studies on private car drivers in Norway, self-reported accidents involving sleepy driving were more likely for drivers with fewer years with a driving licence (Phillips & Sagberg, 2013). Incidents of sleep behind the wheel were more likely for men, younger drivers, and those with sleep-related health problems.

Norwegian causes

In terms of causes that are unique to Norway, or at least to Nordic countries, the seasonal variation in light levels in the north of the country influences fatigue-related hormonal profiles, and there is increased sleepiness and depression in the north of the country. There is also a tendency for people in many jobs in Norway to be more stressed at work in the period from October to the end of December. A final point is that while many occupations are demanding, employers are not obliged to account for fatigue that may occur on the drive home after a spell of work. In Norway the drive to and from work can be long and demanding, and the sleep-related problems this can cause is evident in analyses of fatal accidents (Phillips & Meyer, 2012). Nevertheless, workers in Norway may be less fatigued at work than those in many other countries, because work is relatively well organised and employee interests well-represented. The risks may be greatest in occupations where employee interests are poorly represented due to a low level of work organisation (see Section 2.2). Foreign workers in particular may be under great pressure to exceed working time limits.

Consequences

Generally, employees may be poorly aware of the potential of fatigue to cause safety problems at work. While they may be aware of the danger of sleeping behind the wheel in traffic, they may not really believe that this would happen to them. Research on fatigue in drivers in Norway suggests in fact that most drivers are not able to predict incidents of falling asleep while driving, even though they know they might be tired (Sagberg & Bjørnskau, 2004: 27). Even when drivers know they are sleepy, they are often reluctant to stop and delay the journey in order to rest. Instead, they tend to attempt ineffective countermeasures, such as winding down the window or switching on the radio.

Apart from research on general driving population, little has been done to understand the problem of fatigue as a safety problem in transport operations. Most people who work in a relevant occupation will know of serious incidents at sea or on the roads that have been caused by tiredness, but this knowledge is rarely captured systematically. What we do know comes mostly from the road sector. For instance, one report suggests that two to four per cent of accidents (all types) reported to a major Norwegian insurance company involved fatigue or sleepiness at the wheel (Phillips & Sagberg, 2013). In the period between 2005 and 2013, the share of fatal accidents on Norwegian roads where the driver was believed to have slept was 12 per cent (Vaa et al., 2014). The latter figure does not account for accidents caused by forms of fatigue other than sleepiness.

Finally, in terms of health outcomes of fatigue, there is research on the effects of shift work on health (Lie et al., 2014).

Management and regulation

It is probably fair to say that Norwegian society and the organisations it contains do not really question the need for increasing amounts of night work, especially in terms of the consequences for safety and health. Part of the reason for this is that it is difficult for organisations to capture a problem that is traditionally seen as being associated with individuals. On the other hand, fatigue is being seen more and more as an organisational problem, especially in countries like Norway, which prioritises worker health and safety highly relative to some other countries. One catalyst for this is the highly successful oil industry, governed by strict safety standards, and which may be able to provide "best practice" examples of how to account for worker fatigue.

3 Aim

This is a report on part of a project on fatigue, the aim of which was to assemble knowledge on the prevalence, causes, outcomes and management of fatigue among professional drivers in different organisations in different transport sectors (road, rail and sea) in Norway.

The part of the study covered by this report uses two main methods to assemble knowledge on fatigue:

(i) Literature review;

(ii) In-depth interviews with representative experts from the road, rail and maritimes.

Results from each analysis have been combined in order to produce the results of this report. The report concerns the main types of operators of goods and passenger transport by road, and rail and sea, within and around Norway.

4 Methods

4.1 Literature review

We conducted a literature review to assemble knowledge on the prevalence, causes, outcomes and management of sleepiness and fatigue among professional drivers in road, rail and sea transport in Norway. Table 1 shows the Norwegian and English search terms that we used.

Table 1. Norwegian (in italics) and English search terms used in the literature study. In each search, each general term was used in combination with one of the sector terms.

Transport sector	Search terms:
General	*trøtthet*/tiredness, *søvn-*/sleep-, fatigue, transport
Road transport:	*sjåfør(er)*/driver(s),
Rail transport:	*lokfører*/train driver, rail
Sea transport:	*sjøfart*/maritime, sea

A search was also made using the term "transport" and the Swedish terms *trötthet* (tiredness) and *sömn* (sleep). The literature search was conducted in the following websites, online libraries and search engines: the Google search engine: www.google.no, the website of the Institute of Transport Economics (TØI) (www.toi.no), the website of the Norwegian research institute "SINTEF" (www.sintef.no), the website of the Norwegian research institute "IRIS" (www.iris.no), the website of the Norwegian research institute "Studio Apertura" (www.ntnusamfunnsforskning.no), the Norwegian research institute "FAFO" (www.fafo.no), the Norwegian Work Research Institute (AFI; www.afi-wri.no), Institute for Social Research (IFS; www.samfunnsforskning.no), *Møreforskning* (www.moreforsk.no), *Vestlandsforskning* (www.vestlandsforskning.no) , Unifob AS (*Stiftelsen Universitetsforskning Bergen*) (www.uni.no), *Agderforskning* (www.agderforskning.no), *Telemarksforskning* (www.tmforsk.no) and *Østlandsforskning* (www.ostforsk.no). We also searched the websites of the Swedish road traffic research institute, VTI (www.vti.se), Norway's National Institute of Occupational Health (www.stami.no), the Norwegian Labour Inspection Authority (www.arbeidstilsynet.no). Finally, we used the international research database "Sciencedirect" (www.sciencedirect.com), and the international research database "ISI web of knowledge".

To sum up, we conducted six literature searches. The first, general Google search generated 39 relevant results. The second search, using the websites of 13 Norwegian and Scandinavian research institutes generated 23 relevant results, although some of these overlapped with the results from the previous search. The third search, using

search engines from websites of Norwegian Labour Inspection Authority, generated 6 relevant results. The fourth search, using VTI's Transguide database, generated 11 results, although most of these had been identified in previous searches. The fifth search, using Sciencedirect generated 60 results, but none of these presented Norwegian data. The last search, using ISI web of Science, generated 42 results, but no Norwegian data.

In addition to the peer-reviewed literature, an attempt was made to retrieve important documents from each sector pertaining to fatigue, such as rules or regulations or inspections related to fatigue. Available resource limited the extent to which this could be done systematically. Significant data retrieved by this part of the search included results of roadside and company inspections carried out by the Norwegian Public Road Authority (NPRA; e.g. Nygaard, 2009), and a report on fatigue in Swedish carried out for the train company Flytoget (Kecklund & Ingre, 2006).

The Norwegian data retrieved from these searches are discussed in the context of international findings on fatigue. The latter come from existing articles in the authors' database (available on request), and from the Introductions of the Norwegian articles retrieved.

4.2 Expert interviews

An interview schedule was used in semi-structured interviews with sector or subject matter experts. The schedule was designed based on an initial literature review and advice from the project Reference Group. (The actual e-mail invitation and interview schedule used are given in Appendix 1.) Briefly, interviewees were asked about the following:

- Interviewee background and experience.
- Major safety risks facing operators in their sector, and the role of fatigue.
- Prevalence of fatigue, including which role types, tasks, operations and branches are most affected.
- When operator fatigue is most likely to occur, including time of day, shift patterns, day of week and seasons.
- Causes of fatigue, including individual (health, gender, age, experience) and task-related factors, those related to shifts and shift schedules, organisational factors, framework conditions specific to (a) particular branch(es), non-work factors, and geopolitical influences.
- Consequences of fatigue for safety
- Management and regulation of fatigue, by the authorities (working and driving time regulations), or by transport, rail or shipping companies.

In total we interviewed 26 experts in 19 interviews (Table 2). Thirteen of the interviews were carried out face to face, and five by telephone. Each interview lasted between 80 and 120 minutes. They were conducted during the autumn of 2012, spring of 2013, and January 2014.

The experts were recruited by e-mail through existing contacts and advice from the project Reference Group.

Table 2. Categorisation and description of interviewees, selected to give insight into fatigue as a problem in Norwegian transport. Anonymity was guaranteed in order to encourage openness during the interviews.

Sector	Interview no.	Description of subject matter expert
Road	1	Leading representative of national driver union. Has also considerable experience as a goods driver.
	2	Advisor for Norwegian Labour Inspection Authority and expert on driving and resting regulations and professional drivers. Experienced as driver in goods and passenger transport.
	3	Experienced bus driver and researcher into framework and working conditions for taxi and bus drivers.
	4	Head of road section of Accident Investigation Board Norway.
	5	Experienced goods driver and investigator at AIBN.
	6	Advisor in professional goods transport, as driver (8 years, goods transport), researcher and employee of the Public Roads Administration.
	7	Fatigue researcher who has studied fatigue in passenger and goods drivers.
Rail	1	Locomotive engineer, over ten years' experience in passenger (Flytoget, NSB) and goods transport (CargoNet).
	2	Accident investigator with AIBN. Has worked in Oslo as underground train and tram driver.
	3	Locomotive engineer with over 25 years of experience (mostly NSB). Currently represents employee interests on behalf of driver union.
	4	Leader of company health service at NSB, the Norwegian state railway. Expert in worker health and wellbeing.
	5	Six were interviewed from Flytoget AS: Head of safety, staff representative/train driver, train driver, head of staff planning (including shift schedule planning), train driver manager, HR head; and a former driver responsible for follow-up of safety-related issues.
	6	Locomotive engineer, over ten years' experience in passenger (Flytoget, NSB) and goods transport (CargoNet).
Maritme	1	Two safety experts from the Norwegian Maritime Authority, one of whom is an expert in the physiology of fatigue.
	2	Bridge watch officer, has worked over 20 years in various maritime branches.
	3	Captain, with over 30 years of experience of the Norwegian maritime sector, having worked at all sailor and officer ranks, on both goods and passenger vessels.
	4	Two experts: i. Member of sea section of national organisation representing shipping company/employer interests, and expert on regulations pertaining to working time at sea. ii. Watchkeeper, union advisor on working time arrangements, over 25 years at sea, mainly on passenger vessels.
	5	Researcher who has studied safety on board cargo ships and offshore, as well as the effects of different watch types on watchkeeper fatigue and sleepiness.
	6	Human factors consultant with PhD on fatigue in watchkeepers.

Two researchers were present for twelve of the interviews, taking turns to ask questions and probes based on the interview schedule. Each researcher took notes during the interview. After each interview, one of the researchers sorted his notes into category headings, based on the questions in the interview schedule. The other researcher then used their notes to verify, modify and supplemented these notes. Finally, the notes were collected in a table for each sector, and the table used in the writing of this report.

Since they were obtained from researcher notes and translated from Norwegian to English, statements attributed to individual resource persons do not reproduce what they said word for word. The meaning of what was said has, however, has been conserved as much as possible.

5 Professional drivers in road transport

This chapter presents findings on fatigue in professional drivers in the Norwegian road transport sector. It begins with some general background on the framework conditions, working conditions and working time for different branches in the road sector. Findings on the prevalence, causes, consequences and management of fatigue are then discussed.

5.1 Background

5.1.1 Framework conditions

Goods transport

As in most countries, there are usually three or four main types of actors involved in the transport of goods by road: the product owner, the shipping agent, the transporter and the product receiver. The product owner wishes to transport their goods to the product receiver[5]. Larger companies may have their own transporters, but usually they either hire a transporter to do this for them, or enter an agreement with a shipping agent. Shipping agents are used typically when the logistics of the transport operation are more complex. Shipping agents can hire a chain of different transporters to carry the product owner's goods, but they can also have their own transporters. A further possibility is that a transport hub, which does not own vehicles but is an organised collection of independent transporters, takes on contracts from product owners or shipping agents. In Norway, there is increasing recognition that the product owner and shipping agents play an important role in helping set the working conditions of the drivers. Product owners, in particular, will vary in the extent to which they set conditions for the purchase of services, in terms of pay, delivery or even HSE standards for the drivers that they hire.

Goods transport can thus be carried out by independent transporters, shipping agents, or the product owners themselves, and as such the sector is extremely fragmented, comprising a complex mosaic of company types, with relatively few large, and many small transport enterprises (there are only around three employees per goods transport company in Norway on average; Jensen et al., 2015). Many of the smaller concerns deal directly with only one or two product owners, who for them are permanent customers. Drivers may not only work for transporters, but may work for staffing agencies, who hire out their drivers to transporters. Thus, what was once a simple employer-employee contract, is often now a three-way contract –

[5] It is best to avoid the term customer, since confusion often arises as to whether we are talking about the product owner's customer, the shipping agent's customer (i.e. the product owner) or the transporter's customer (the product owner or the shipping agent)!

between contractor, employer/agency, and the driver-employee (Bergene & Underthun, 2012).

The way that goods transport is organised does not nurture effective representation or workers. Indeed, working conditions in goods transport in Norway are thought to be especially vulnerable to fluctuations in framework conditions, partly because representation is not sufficient for the successful negotiation of tariff agreements according to the "Norwegian model" (see Section 2.2). Only ten to 20 per cent of lorry drivers are union members. Historical reasons have been given for this (e.g. the transfer of many unemployed Norwegian sailors into road transport in the 1950s), but an important reason is also that organisation in the many small enterprises is low, with operations often being driven on a basis of trust and loyalty (Askildsen, 2011). Many drivers are also independent business owners and thus managers, but relatively few of these are members of a formal trade organisations that represent their interests. Effective representation is hindered further by increasing fragmentation of the parties involved, through practices such as subcontracting, especially where it involves the hiring in of independent or foreign drivers. Hiring of drivers from "low-cost countries" also threatens the working conditions of Norwegian drivers because companies employing them must restrict wage levels to be able to compete. Increasing participation of foreign transporters in international transport is evidenced by the increased number of border crossings by foreign-registered vehicles (Bergene & Underthun, 2012). These transporters are also increasingly participating in legal and illegal domestic deliveries ("cabotage"; Nævestad et al., 2014). These developments have led to claims that EU legislation, which has relaxed the restraints on open competition in the international and domestic goods transport market, seems to have failed to consider or control the consequences of this on working conditions in individual countries (Bråten et al., 2013:19).

Despite claims of deteriorating framework conditions, there is little systematic evidence to date, either of the precise nature of poorer working conditions, or whether there are detrimental effects on drivers. A recent survey of over 200 heavy goods vehicle (HGV) drivers did find, however, that over half reported either little or only a moderate amount of control over their own work time (Bergland & Gressnes, 2014). One in five respondents classified their work as stressful, and 1 in 4 experienced a near-miss while driving traffic at least once a week. The authors take their findings to be a sign of a worsening work conditions in the sector.

Framework conditions for the Norwegian heavy goods vehicle operator are otherwise well described by Moe & Øvstedal (1997), while conditions for operators in the goods branches are more recently described by Bråten et al. (2013) and Jensen et al. (2015). Jensen et al. (2015) describe goods transport organisations in Norway as follows:

- 14 per cent of companies employ temporary drivers.
- Almost half of the companies hire drivers.
- Over 40 per cent of companies adjust working time of their employees depending on the contracts that they are working on.
- Widespread use of overtime reinforces an impression of a branch controlled by external actors / contract providers.
- The share of organisations with staff safety officer elected to represent the HSE interests of staff is low.

Jensen et al. (2015) also describe conditions for the goods driver:

- 95 per cent of drivers are permanently employed.
- Over half perform local deliveries.
- One in four drivers do not have a fixed wage.
- Different forms of fixed wage combined with some form of bonus is more common among long-distance than among local delivery drivers.
- Working time varies depending on the type of work done. Local delivery drivers tend to work days, while shift and contract-dependent working time is more the norm for long-distance drivers.
- In addition to local and long-distance drivers, there is a third category of driver, characterised by a high degree of contract-dependent working hours and flexibility.
- One in three drivers reports that their work situation causes stress (although this is not assessed psychometrically). Stress is reported more by local delivery drivers than long distance drivers.
- Time pressure is the main cause of stress for those drivers that report it.
- One in three drivers work in an organisation that does not have a safety officer.

Passenger transport

There are several different types of passenger transport in Norway, including local bus, express bus, charter coach and taxi services. According to Bråten et al. (2013), the main challenges in the passenger transport sector, in terms of working conditions, are for coach and taxi sectors, although conditions in these sectors are also less well studied.

Public bus services

The level of organisation in public transport is generally higher than in goods transport, both among employees and managers; about 4 in 5 bus drivers are union members (personal communication, *Yrkestrafikkforbundet*). Relative to the chartered coach and taxi branches, there are fewer conflicts about working conditions in local public transport. This is in part due to a relatively high degree of organisation and effective representation, but also because it is harder for international competitors to establish themselves in the scheduled transport sector (Bråten et al., 2013). In local public transport, in particular, the district council controls the quality of services provided by different operators through strict tender contracts.

Nevertheless, the need for companies to participate in bidding competitions has had its effects. While it has not been detrimental to wage levels or general working conditions, there is evidence of increased time pressure, job insecurity and health complaints among bus drivers (Longva & Osland, 2008; Longva et al., 2007). Drivers also seem to have less influence on their working day. Personal communications with unions also suggest that there may be increased tendency for schedules to be driven by economic considerations, with the result that fatigue may be less accounted for.

Companies also compete increasingly by asking their drivers to work split shifts, where the working day of a single driver is split into two periods to correspond with rush hour traffic (Phillips & Bjørnskau, 2013). In split-shift arrangements, the formal working hours are not long, because in theory the drivers are free to do as they please between split shifts. In practice, however, drivers may be far from home or feel that they are still on duty, and effectively experience a very long working day, in which intense bouts of driving are interspersed by long periods of monotony. Bus

drivers working split shifts have been found to report the worse working conditions, in terms of having insufficient time to carry out tasks, pressure from route timetables, work/non-work life balance, shift-related sleep problems and health problems (Phillips & Bjørnskau, 2013).

Chartered coach and express bus services

In the chartered coach branch, as in goods branches, there is relatively poor representation of party interests required to ensure the quality of working conditions through collective bargaining. Organisation has been reduced by contracting out of parts of the operation, the use of temporary contracts, an increasing number of independent business owners, increased competition for fixed-term contracts to carry out routes or activities, and an increasing share of international actors entering the market (Bråten et al., 2013). The chartered coach sector in Norway can be run by any of the following:

- large companies, where chartered operations are only part of the larger business;
- large, reputable companies devoted to charter operations; or
- small enterprises with few staff.

There are reports of increasing international competition leading to the loss or acquisition of Norwegian operators, who claim that they cannot compete due to constraints related to wages and work conditions (Bråten et al., 2013:37). Smaller enterprises are particularly affected.

Chartered coach operators are subject to more competition than the express bus sector, partly because operators in the latter require a strictly regulated operating licence, and partly because a permanent base in Norway is necessary to operate regular routes (Bråten et al., 2013). There is also a higher degree of cooperative understanding in the express bus market.

The Norwegian coach branch is experiencing tough competition from foreign operators (Bråten et al., 2013). There is a marked difference in wage costs between Norway and many other EU countries, and wage expenses make up a substantial share of the cost of transportation in the coach sector. This gives Norwegian companies employing drivers based in Norway a distinct disadvantage. Jensen et al. (2015) describe the following working conditions for coach drivers.

- Twelve per cent of drivers do not have permanent employment
- Only 14 per cent of drivers are younger than 46 years old; most are male.
- One in five drivers report that they receive a permanent wage.
- Most drivers with variable working time do not have work plans longer than 16 days in length.
- One in three drivers reports being stressed, and time pressure and traffic conditions are the main causes.
- One in three drivers do not have a safety officer.

Taxi services

There are many different market forms and segments in Norway's taxi branch. Taxis can operate in street markets (hailing and taxi ranks), through a pre-booking system (by telephone, text/sms or internet), or can be contracted out (Aarhaug, 2014). Taxis can also be contracted to carry out routine passenger transport on behalf of a public body or organisation, and this part of the taxi branch is increasingly exposed to competitive bidding in the same way as the chartered coach branch.

There are few taxi companies in Norway. Rather, the taxi business may best be viewed as a collection of licensed one-man enterprises, driven by taxi-owners owning one or two cars. Individual drivers can also lease permits from license owners. A change in the law in 1999 led to some taxi-owners acquiring several licences, up to 20 or 30, according to one taxi owner we spoke to. Traditionally, taxi operations are run by central operative centres, which are cooperative organisations jointly owned by the taxi owners and run on a non-profit basis (e.g. *Oslo Taxi, Bergen Taxi*). These centres are often important for drivers' working conditions, in that they help run training courses and other work-related activities. Newer operative centres are driven so that the owners of the centres can profit from them (e.g. *Norgestaxi*, *Taxi 2*). It should be stressed, however, that all operative centres are based on taxi-owners who run their own independent businesses, and who employ taxi drivers under their own terms. The result of this is that there is a very low level of organisation in the Norwegian taxi branch, and working conditions depend very much on individual taxi-owner/taxi-driver relationships. Working conditions are being further threatened by competition from mobile telephone applications (e.g. *MyTaxi, Uber*) helping those who would normally be customers of licensed taxi operations arrange rides by other means.

5.1.2 Working conditions

The problems of attempting to summarise working conditions in the transport sector are well expressed by Bråten et al. (2013:7), who summarise the road transport sector as "complicated and fragmented, organisationally, functionally and geographically…with many markets [each with its own set of working conditions]." A follow-up report by the same group reaches similar conclusions (Jensen et al., 2015). Since the sector comprises disparate occupational areas and groups, the problems and challenges associated with working relationships, and working and employment conditions vary widely in the different branch segments. This must be borne in mind as we attempt to summarise some main challenges, below.

Goods transport

Working conditions of those involved in goods transport in Norway have been considered according to whether the drivers are involved in local or long-distance transport. Some challenges for each are summarised in Table 3.

Table 3. Summary of main challenges for local versus long-distance goods transport.

Local (Enehaug & Gamperiene, 2010)	Long-distance (Askildsen, 2011; Bråten et al., 2013)
• High demands placed on driver in terms of traffic jams, traffic negotiations, turning and parking. • Driver exposed to stressful situation when delivering goods; there can be time pressure, a need to break the law (e.g. park on pavements), and absence of signatory to receive goods, concerns about theft from parked vehicle. • Severe manual handling challenges e.g. twisting while lifting awkwardly shaped, heavy goods from vehicle or onto shelves. • Delivery times that do not account for local driving conditions, vehicle restrictions or delays. • Driver must deal with customer on employer's behalf.	• Monotony. • Irregular, long, antisocial hours including night driving. • Many nights away from home. • Poor conditions for eating, sleeping, maintaining hygiene. • Lack of resting places required for drivers to accord with driving and resting time regulations. • Delivery times that do not account for driving time regulations, driving conditions or delays. • Narrowing operational margins increase pressure for round-the-clock operation. • Large number of small "copy-cat" companies = stiff price competition, lack of information sharing. • Risky manual operations during loading / unloading, coupling/decoupling of trailer, securing loads etc.

There can also be concerns about the effects of pay systems on safety, especially when drivers are not given a permanent wage, but paid by the hour, per delivery or given a percentage of the value of the delivery. We might expect this to influence fatigue by increasing the amount of time a driver is motivated to work when feeling tired.

Passenger transport

Working conditions that can present fatigue-related challenges are considered in Table 4, according to whether the drivers are involved in local or long-distance bus transport or taxi.

5.1.3 Working time

For those involved in long-distance goods and passenger transport, the main legal restrictions on driving hours will be the driving and resting time regulations (*Kjøre- og hviletidsbestemmelsene*), together with a special law on the working hours of professional drivers (of 10th June, 2005). The latter is based on an EU law (2002/15/EF of 11th March, 2002), and is largely in line with working hours laid out in Norwegian WEL, which applies to most workers. Table 5 serves to illustrate driving and resting time regulations.

Table 4. Some challenges for operators of bus and taxi transport in Norway.

Local bus (e.g. Phillips & Bjørnskau, 2013)	Long-distance / rural bus (express and coach) (e.g. Jensen et al., 2015)	Taxi (e.g. Jørhaug, 2014)
• City drivers face high demands in terms of traffic jams, negotiations, pulling out in traffic etc. • Time pressure. Increasing need for punctuality, can be stressful in heavy traffic or when there are other delays. Time pressure also during maintenance and administrative duties. • Role conflict: passenger service, safety and punctuality. • Often work split shifts (see text for explanation), early shifts, night shifts. • Poor rest facilities, change in support available from colleagues. • Fixed sitting position. • Health complaints common, especially musculoskeletal disorders • Insecurity from threats of abuse	• Monotony • Irregular, antisocial hours, night driving. • Nights away from home. • Poor conditions for eating, sleeping, maintaining hygiene. • Can be much waiting. • May lack support. • May also be severe time pressure from need to be punctual. • Fixed sitting position, possibly psychosomatic issues.	• Much waiting between jobs can lead to boredom and a very long working day; often not clear whether driver is working or not. • Passengers can be difficult to deal with, perceived threat may lead to insecurity. • If driver is also owner, may work long hours. • Antisocial hours. • Large fluctuations in demand (e.g. very busy on Friday and Saturday nights versus Monday night). • Large variation in supportive infrastructure, e.g. provision of rest facilities.

Recently, a rule was passed to adapt working time set out in general WEL for professional drivers subject to driving and resting hours legislation, in order to bring Norwegian regulations in line with EU law (*forskrift om arbeidstid for sjåfører; FATS*). This rule does not change what WEL says about working time substantially, but it is important because it makes shipping agents or those contracting drivers (via their employers or recruitment agencies) co-responsible for ensuring that the drivers are able to comply with the regulations. Furthermore, working time is now the total sum of all time worked in the branch, i.e. even if it is for different employers. This means

that the driver employee has to inform each employer about all of the work that they do, such that total time worked (not driven) on any one day is never more than 13 hours when overtime is included.

*Table 5. An illustrative excerpt from a summary of driving and resting hours rules by a professional driver union (*Yrkestrafikkforbundet*). The rules do not apply to buses on routes of less than 50 km or to drivers of vehicles with fewer than 13 seats (most taxi drivers)*[6].

Driving time	• 9 hours daily driving time. • Can be extended to 10 hours up to 2 times a week. • Up to 56 hours a week if working time legislation allows it. • Up to 90 hours over two weeks.
Breaks	• No driving *or other* work during breaks. • A break of at least 45 min must be taken after 4.5 hours driving. • Can be split into one break of 15 min and one of 30 min, but only in that order.
Resting time	• Normal daily rest: at least 11 hours of non-work time per 24 h. • This can be split into 3 + 9 h. • A driver can have a maximum of three reduced daily rests between 2 weekly rests • The 3-hour rest period cannot be split up.
Weekly rest	• Normal weekly rest: at least 45 h. • Reduced weekly rest: under 45 h, but no less than 24 consecutive hours. • There must be normal weekly rest every other week. • 2 normal weekly rests in 2 wk period, OR 1 normal + 1 reduced weekly rest

The regulations on driving and resting time and the special rule on working time do not apply to drivers of vehicles weighing less than 3.5 tonnes (including trailers), buses on routes of less than 50 km, or passenger transport vehicles with less than eleven seats. In other words most bus and taxi drivers in Norway are exempt from them[7]. The working and driving time of those who are excepted is regulated by Norwegian WEL, in turn based on EU law, and local tariff agreements.[8] The latter, which are too many and comprehensive to cover here, will normally result in more flexible working arrangements.

Box 1. Work Environment Law (WEL) and working time.

WEL's limitations for "normal" working time are nine hours during 24 hours and 40 hours during seven days. Weekly hours described by normal working time can also be increased for any single week, up to 48 hours for any single week, because the law allows working time to be taken as the average over long periods (up to a year). If the employer is a partner in a local tariff agreement, it is possible for employees who do not work nights to work up to ten hours in any single day, and up to 54 hours in any single week, as long as the average does not exceed *normal* working time in the long run. In fact, as long as normal working time is not exceeded according to time averaged over 16 weeks, it is possible for employees to work up to 60 hours in any single week within the confines of local agreements. Those working shifts, nights or Sundays, however, are limited to a *normal* working time of 36 to 38 hours during seven days, again subject to exceptions and local agreements.

Note that so far we have only addressed *normal* working time, which does not include overtime. Overtime may be imposed on the driver by the employer in addition to normal time, if temporary business needs justify it (no more than 200 hours in a calendar year). As long as there is written agreement with the employer, drivers who wish to may also work extra overtime (total overtime cannot exceed 400 hours in a calendar year). Whatever the case, total working time (normal and over time) must never exceed 13 hours on any single day (ten hours for night work), or 48 hours a week on average. As long as the average over 16 weeks is 48 hours a week or less, it is possible to work 60 hours a week.

[6] There are also other exceptions, including road maintenance vehicles, fire engines, livestock transport, and rubbish trucks.

[7] There are also other exceptions, including road maintenance vehicles, fire engines, livestock transport, and rubbish trucks.

[8] http://www.arbeidstilsynet.no/fakta

In effect, WEL allows drivers to regularly work over nine hours on a single day, and over 40 hours in a single week, but never more than 13 hours of total work a day, or 60 hours a week, whether overtime is worked or not (See Box 1). The law gives employees the right to at least one break when their working day exceeds between 4.5-6 h[9], and if the day exceeds eight hours, the break must be at least half an hour long. Those working over nine hours a day, or 40 hours a week must be compensated with an overtime rate that is at least 40 per cent greater than ordinary pay. An example of the results of a local tariff agreement based on WEL is given in Table 6.

Finally, it is worth noting that across the road transport sector, questions have been raised about the quality of regulatory supervision and control required to enforce fatigue-related legislation on working time or driving and resting hours. Across an increasingly open European market, there is lack of cooperation, understanding and information sharing between national authorities responsible for inspections (Sitran & Pastori, 2013). Lack of regulatory cooperation at national and international level may weaken the ability to control the impact of less reputable actors on safety standards in Norway (Bergene & Underthun, 2012).

Table 6. Working time of employee taxi drivers is controlled by a tariff agreement and WEL (TAXI, 2012). *This does not apply to business owners who drive.*

Daily and weekly working time	• No more than 9 hours work in any 24-hours. • No more than 8 hours a day if 3 or more of those hours are worked at night. • Can be an average, but must not exceed 13 hours a day or 48 hours a week. • The rule of 48 hours a week can be averaged over 8 weeks, but must never exceed 60 hours in any one week. • Overtime must be approved according to WEL
Breaks	• At least half an hour during a shift

5.2 Prevalence

International research shows that the share of private drivers saying that they have fallen asleep behind the wheel one time or another is between 23 and 52 per cent, compared with between 36 and 64 per cent for professional drivers (Sagberg & Bjørnskau 2004: 2). The higher share among professional drivers is usually explained by the fact that they drive longer distances than private drivers.

More reliable data on sleep behind the wheel is obtained by asking drivers to recall incidences for a fixed period. When asked if they have fallen asleep in the last 12 months, the share of private drivers answering "yes" varies internationally from between 8 and 29 per cent (Sagberg & Bjørnskau 2004; Phillips & Sagberg, 2013). The shares of professional drivers reporting the same can be higher, depending on branch. For instance, a Finnish survey (n=317 male drivers) showed that 40 per cent of long distance drivers reported dozing while driving at work in the past three months, with 25 per cent reporting that this had happened twice in the same period (DaCoTa, 2012). Only 15 per cent of local delivery drivers reported to have dozed off. Other international data on prevalence is also summarised by DaCoTa (2012).

[9] For those who are covered by driving and resting time legislation, they must break after 4.5 h. Otherwise they must break after 5.5 or 6 h, according to WEL and special law on working time for drivers, respectively.

5.2.1 Previous research in Norway

The Hordaland Health Study includes a cross-sectional survey study carried out in Norway between 1997 and 1999. An analysis of this study by Ursin et al. (2009) examined the relationship between different occupations and sleep, sleepiness and insomnia in shift workers (including night workers) aged 40 to 45 years (n=7782). When adjusted for shift work and working hours, professional drivers had an 1.8 times greater risk of daytime sleepiness, compared to leaders, and their odds of falling asleep at work was two-fold greater.

Nordbakke (2004) examined private and professional drivers' experience with falling asleep behind the wheel. Two separate surveys of 1531 private drivers (response rate 54 per cent) and 1169 professional drivers (72 per cent bus and 28 per cent truck drivers; response rate 41 per cent) were conducted. Nordbakke confirmed that falling asleep behind the wheel is a widespread phenomenon also for professional drivers in Norway. Forty-five per cent of the private and 36 per cent of professional drivers reported to have fallen asleep behind the wheel while driving at one time or another, while 11 per cent of private and 13 per cent of professional drivers reported to have dozed off behind the wheel at least once during the preceding 12 months. The share reporting to have slept behind the wheel over the preceding year was greater for truck drivers (16 per cent) than bus drivers (12 per cent). Nordbakke explains the higher risk of falling asleep among truck drivers by the fact that they drive longer distances (most bus drivers were local drivers).

Enehaug and Gamperiene (2010) document the results of a study of the working day of urban local transport drivers in Oslo, Bergen and Trondheim (Enehaug & Gamperiene 2010). The report examines various aspects of the drivers' working conditions, traffic conditions, delivery conditions, health, environment and safety. Although the report does not focus heavily on sleepiness/fatigue issues, the questionnaire that was used in the study includes two questions on fatigue. Reviewing the results of this study, we should bear in mind that it focuses on local drivers, and that the fatigue challenges faced by these may be different from those of long distance truck drivers. The respondents in the study were all employed by the Norwegian company ASKO. The study relied first on in-depth interviews with ASKO personnel, field-work, and a survey including 230 local transport drivers.

Drivers were asked, "In the last month, how often have you experienced the following problems?". When it comes to fatigue, 28 per cent answered that they were not bothered by fatigue, 30 per cent answered that they were bothered by fatigue a couple of days a month, ten per cent were bothered by fatigue about one day a week, 15 per cent were bothered by fatigue a couple of days a week, while 14 per cent were bothered by fatigue on a daily basis. Thus, about a quarter of the local transport drivers were bothered by fatigue a couple of days a week or more.

The second sleepiness/fatigue-related question in the study of Enehaug and Gamperiene (2010) was: "Below, you will find a list of different [sleep-related] problems. Have you experienced any of these during the course of the last week (including today)?" Fifty-eight per cent answered that they were not bothered by the sleep disorder symptoms listed, while 42 per cent of the local transport drivers were somewhat bothered or worse by sleep disorders. The study did not include data on fatigue causes, outcomes or management.

In a survey of 2133 bus drivers from 44 Norwegian bus companies, Moe (2006) examined Norwegian bus drivers' experience of their work situation with respect to

safety, emergency preparedness and working environment. The following items were used to make up the composite measure "exhausted and tired" in Moe's (2006:15) analysis of the work situation of bus drivers in Norway, where each statement was weighted according to their importance for the factor (weights were given from 0-1, and the closer to 1, the more important is the statement to the factor):

1. "I have considered quitting as a driver because the work is too exhausting" (0.8),
2. "I am tired of being a driver" (0.8),
3. "I am very tired and sleepy while driving" (0.7),
4. "I have fallen asleep behind the wheel" (0.5) and
5. "I have experienced anxiety with respect to my work" (0.5).

Analyzing responses for "exhausted and tired", Moe (2006) found that most variation was explained by bus driver experience, i.e. the more experienced the bus drivers got, the more exhausted and tired they felt. He suggested that this could be an effect of fatigue accumulating over many years in service (Moe, 2006: 15). Finally, Moe (2006: 39) found that 20 per cent of the bus drivers were so exhausted and tired that they had considered quitting their job as a bus driver.

A more recent article highlights a trio of studies on sleepiness in Norwegian drivers conducted in 1997, 2003 and 2008 (Phillips & Sagberg, 2012). Together the studies sampled over 7,000 Norwegian drivers who were not at fault for an accident they were involved in during the preceding year. These drivers were used as a "best proxy" for drivers of private light vehicles on Norwegian roads. The studies excluded drivers of heavy vehicles, but are nevertheless interesting because questions are included on the prevalence of sleep behind the wheel among drivers of company cars. Across survey years it was found that ten per cent of the company car drivers (n = 198) reported sleeping behind the wheel in the preceding 12 months, a share that was significantly higher than the five per cent of the drivers of privately owned cars.

In summary then, data on the prevalence of sleepiness behind the wheel in the Norwegian transport sector find that:

- Daytime sleepiness is elevated for professional drivers compared to leaders (Ursin et al., 2009).
- Thirteen per cent of a sample of professional drivers (and 16 per cent of the truck drivers) report to have fallen asleep behind the wheel during the preceding year (Nordbakke, 2004; vs. 11 per cent of private drivers).
- Ten per cent of company car drivers have slept behind the wheel during the last 12 months vs. five per cent of private car drivers.
- Fourteen per cent of local goods drivers working for a large company are bothered by fatigue on a daily basis, and a further 15 per cent a couple of days a week (Enehaug & Gamperiene, 2010).
- Between 15 and 25 per cent of a large sample of bus drivers, from a range of companies, are sometimes exhausted and tired, depending on experience.

Studies use several different measures of fatigue, and often therefore cannot be cross-validated. Only one of these studies (Nordbakke et al., 2004) measures the prevalence of sleep episodes per unit of time (12 months) in occupational drivers during occupational driving. This confirms episodes of severe sleepiness behind the wheel is widespread in truck drivers (16 per cent over 12 months), and greater than for private drivers (11 per cent). Given available Finnish data, showing that 40 per cent of long-distance truck drivers report nodding off at the wheel over 12 months, there is a need to report prevalence for different types of goods driver in Norway.

Finally, there are no objective measures of the prevalence of sleep behind the wheel among transport workers in Norway, for instance using naturalistic video analyses.

5.2.2 Findings from interviews with experts

Despite qualitative comments, most experts did not quantify sleepiness or fatigue for different driving populations in their branch, despite that several had heard many stories of drivers nodding off behind the wheel. When considering the prevalence of fatigue in transport workers, several experts commented that it is important to be clear about the sort of fatigue one is measuring. Sleepiness is an important safety problem for professional drivers, but less is known about general fatigue, which can also cause severe somatic problems over the longer term. As one expert explained:

> "Tiredness and exhaustion will eventually stay in the body. Drivers often get neck and back problems that are the result of mental exhaustion, it's not just physical problems. In this respect it is important to consider stress, in addition to fatigue."

Experts thought that fatigue resulting from stress, physical demands and lack of sleep was commonplace, and that most drivers, whether local or long-distance, goods or passenger drivers, would have experienced it as a problem. As a serious problem, however, sleepiness behind the wheel is probably more confined to certain types of driver. One expert commented that physical fatigue due to loading duties was more of a problem for local delivery drivers, who will not tend to experience problems related to sleepiness behind the wheel, since they are always in and out of the truck. For these drivers, fatigue was more likely to result in workplace injuries for those who carry out loading operations.

When asked who is more likely to suffer from fatigue, several experts identified truck and taxi drivers. Whether fatigue is perceived as a risk by those in the industry in relation to other health and safety risks, may also say something about the prevalence of fatigue in the road transport sector. Most experts placed fatigue in the top five risk factors for accidents involving professional drivers, and most pointed out that it was most risky when occurring together with other factors such as distraction, speed and stress.

5.3 Causes of fatigue

According to our operationalization in Section 2.1, the level of exertion that results in fatigue is influenced by sleep drives, time-on-task and task nature. International studies of fatigue in road transport have identified many causes, both direct and indirect, especially sleep history, schedules, night- and shiftwork and organisational factors (Phillips, 2014b). A study of long-haul American truck drivers identified the following six independent risk factors associated with self-reported instances of falling asleep behind the wheel (McCartt et al., 2000, in Jackson et al., 2011):

- daytime sleepiness,
- long work hours,
- limited rest opportunity,
- older drivers with more years of service,
- night-time drowsy driving,
- poor sleep on the road, and
- symptoms of a sleep disorder.

A British literature study asserts that dangerous levels of fatigue are produced by driving goods vehicles on monotonous inter urban roads that provide fewer stimuli to the driver, as they are more likely to be driven when the effects of sleepiness are most severe, and driven by male drivers who are more likely to suffer from obstructive sleep apnea (Jackson et al., 2011: 41). Other studies of professional driver fatigue have focused on more indirect causes, such as time pressure, pay structures, customer/consumer demands, loading or delivery queues, inadequate drivers numbers, poor shift schedule planning and management (Jackson et al., 2011: 45).

5.3.1 Previous research in Norway

Sleep history

Occupational factors are thought to be a predictor of daytime sleepiness, insomnia and sleep duration, which suggests that the organisation can influence driver fatigue by helping determine sleep history (Kronholm et al., 2006). In the analysis by Ursin et al. (2009) (see 5.2.1), it was found that professional drivers in Norway slept less than leaders (in different occupations) and service workers. Rise times, but not bedtimes, were also earlier for drivers than for service workers and leaders. Twenty-four per cent of drivers, versus only seven per cent of leaders, had less than six hours sleep on a normal weekday night.

Age

Nordbakke (2004) finds that the risk of falling asleep behind the wheel decreased with increasing age for professional drivers. She concludes that more work experience seems to enable professional drivers to become aware of fatigue, and deal with it effectively. Interestingly, on the other hand, Moe (2006) found that the more experience bus drivers had, the more exhausted and tired they reported to be. One explanation may be that even though older drivers are more tired, they are better at preventing tiredness from affecting driving performance.

Branch

As we have already discussed, Nordbakke (2004) found that the risk of falling asleep behind the wheel (at any time in career) was higher for long distance drivers (42 per cent) than for local transport drivers (34 per cent). Reports of falling asleep behind the wheel were also higher for truck drivers (44 per cent) than for bus drivers (31 per cent). This may be due to the monotonous nature of driving that the truck drivers in the sample were exposed to, since 83 per cent of the bus drivers drove local transport.

Pressure to carry on driving when tired

When it comes to why professional drivers exert themselves in the face of increasing fatigue, and violate hours of work regulations, factors found to be most important were: pressure from management (49 per cent) and an aspiration to follow time schedules (44 per cent) (Nordbakke 2004: 61). Interestingly, Anund, Kecklund and Åkerstedt (2011) also cited time pressure as a reason why drivers do not stop driving even when they are sleepy. It may also help explain why Nordbakke found a tendency for professional drivers who are employed by a transport company to have a somewhat higher risk of falling asleep behind the wheel than professional drivers who are self-employed.

Job demands

Job demands and job control have been cited as predictors of health status, poor sleep and fatigue in general workers (De Croon et al., 2003; De Lange & Kompier, 2009; Duijts et al., 2007). We found no Norwegian studies attemting to link these psychosocial factors to fatigue levels in road transport workers. Indeed, even the evidence for high job demands *per se* among transport operators in Norway is mixed. While the 2011 Norwegian work environment monitoring survey finds that both transport operators and drivers working in road haulage, construction and shipping have above average job uncertainty, the demands experienced by transport workers are reportedly among the lowest of any profession (STAMI, 2011). These findings are probably quirks of the categorisations used, since Norwegian studies of both long-distance and local goods transport imply strongly that demands can actually be very high (Longva, Osland et al., 2007; Enehaug and Gamperiene, 2010; Askildsen, 2011). The bus drivers in Moe's study also described a demanding work situation, entailing (Moe, 2006: 39):

- Harassment and passenger trouble (experienced by between 10 and 15 per cent).
- Time pressure and a demand for high concentration levels.
- Perceived high demands for vigilance.
- Risk taking.
- Higher stress loads in winter than summer.

Several demands may be unique to Norway, such as demanding road dimensions, poor resting facilities (especially in the winter), poor weather conditions, undersea tunnel driving, and the adjustments and maintenance that need to be made to vehicles to keep them safe in poor conditions.

Job control

In terms of job control, there is little doubt that transport operators the world over experience poor decision latitude (low task variety and little social authority), with clear links demonstrated between level of control and musculoskeletal complaints. Norwegian research confirms that even where it is possible, control in the form of participative decision making (e.g. route planning, choice of equipment) is low (Enehaug and Gamperiene, 2010). Uncertainty due to low autonomy is exacerbated by lack of performance feedback from the work environment. In Norway, the share of transport workers reporting that they lack information that they need to do their job is among the very highest, and bus and train drivers are highlighted for low levels of performance-related support and feedback, especially from leaders (STAMI, 2011).

Job support

Transport operators also receive little social support from colleagues, staff representatives and leaders. The ability of the latter to gain insight into the challenges faced by workers on the road is as important as it is challenging, given the remoteness of the transport operator's role, and there is little evidence of success. The Norwegian survey of short-distance goods drivers by Enehaug and Gamperiene (2010) found in fact that the customer was the main source of social support and feedback. In light of this, it is not surprising that the introduction of teams in Norwegian bus companies with self-elected leaders coincided with greater job satisfaction and a drop in sickness absence (Longva et al., 2007).

Other factors

In addition to the above factors, sleep and fatigue will of course also be influenced by working time (e.g. insufficient rest breaks and long work shifts) in addition to leisure time stressors. Although we know little about the effect of shift schedules on sleep and fatigue in Norwegian transport workers, there is no reason why we cannot apply international evidence about shift characteristics causing poor sleep, and increased exertion and fatigue as a consequence. Such evidence shows, for instance, that if there is too short rest time between shifts, the speed and direction of shift rotation is unfavourable, or if shifts afford little chance to adapt to sleep at unusual times of day, then sleep will be poor (Sallinen & Kecklund, 2010).

Summary

In summary, there are gaps in Norwegian research on the direct causes of fatigue at work for transport operators in the road sector. Existing studies suggest mixed results for driver age and experience, probably explained by the fact that younger drivers take more risks with their sleep and fatigue while driving, while older drivers may be more prone to daytime sleepiness than younger drivers working the same schedule. Driving longer distances without stopping is also thought to increase the risk of sleeping at the wheel, and international studies support this. Time pressure may also be a risk factor in Norwegian professional driving (Jensen et al., 2015). Otherwise, Moe (2006) discusses the high levels of demands faced by bus drivers may lead to fatigue, especially during the winter months in Norway. Little has been done to provide an overview of shift schedules and actual hours worked in different transport branches in Norway. More is known about what international research suggests are organisational causes of fatigue, in terms of too high or low demands, and a lack of control and support. As in other countries, little is known about how such work stressors interact with work schedules to influence fatigue. Moreover, we know little about the sort of shift schedules that are worked in many branches of the main transport sectors, and therefore cannot conclude anything about associated fatigue risks. In addition, more studies are needed, both in Norway and internationally, to determine the extent to which specific work stressors of different types predict poor and inadequate sleep, and elevated levels of fatigue.

5.3.2 Findings from interviews with experts

The main causes of fatigue discussed with experts can be grouped according to whether they are related to schedules and problems sleeping, the task, organisation, branch or nature of supply chain, or individual drivers and their lives outside work. Comments on each cause type are given below.

Shifts and schedules

Most experts concurred that driving between 0300 and 0600 h was most problematic for sleepiness, especially if a driver had driven through the night and had to drive through dawn. Time of day and when the drive started together formed the most important effects on sleepiness, according to one expert. One expert claimed that fatigue was worse for drivers starting late shifts, while another claimed double shifts may be an important cause of severe fatigue in some branches. Another expert pointed out that fatigue will be a particular challenge for those working shifts that rotate earlier and earlier against the clock – so-called backwardly rotating shifts.

Importantly, backwardly rotating shifts may be encouraged by the nature of driving and resting time regulations for some long-distance drivers. The regulations typically limit driving to nine or ten hours a day with a minimum rest period of 11 hours (cf. Section 5.1.3). Thus the typical "day" for drivers on long journeys can be 20 or 21 hours rather than 24 hours. In order to minimize delivery times, drivers on longer journeys must inevitably drive through the night. Regulations do not prevent this because they say nothing about the need for regularity of driving from day to day, and do little to discourage night driving. Another expert pointed out that:

> "rest time regulations effectively say that you cannot stop when you are tired [but when you have driven for a certain amount of time]. They should be more flexible so that you can rest and sleep when you are tired, and then drive for longer afterwards if necessary."

Difficulties sleeping

Experts noted that problems obtaining sufficient quality sleep at "unphysiological" times of the day could be exacerbated by drivers dreading having to drive while exhausted the next day. Some drivers feel stressed and isolated at the prospect of having to drive alone through the night. Many things often go wrong (delays, queues, technical problems, having to stop and sleep), and thinking about this can make it difficult to sleep.

Task-related causes

Several experts identified that professional drivers faced two main types of task-related challenge:

1. *Monotonous driving tasks causing underload*, which experts associated more with sleepiness. A driver working alone, with long work hours and who must drive for long periods on good roads will be most prone to this problem. Lorry drivers with comfortable vehicles with low frequency noise, which can produce a sleep-inducing effect, will also be prone. One must consider the extent to which the driver is mentally engaged in the driving and aware of developing situations, in the sense that less engagement may contribute to increased monotony. Automatic gear and cruise control may not be beneficial in this respect. Drivers' jobs are becoming less demanding, mentally and physically, and more comfortable, such that the driver is becoming less an engaged actor, and a more detached monitor of the system.
2. *High demand tasks causing overload*, associated with exhaustion. Bus drivers in the city, for example, may be more prone to fatigue-related problems related to physical exhaustion and lack of concentration. According to one road sector expert, bus drivers "may enter a negative stress loop, where they become mentally exhausted and lose concentration, don't get enough sleep, get even more exhausted and so on."

Both tasks cause fatigue that results in increased frequency of driver errors, say the experts. Moreover, exhaustion and sleepiness influence each other, and in the real world, drivers may have jobs containing a mixture of both types of task (i.e. 1 and 2). For instance, those who drive long hours not only face problems from monotony and having to work at unusual times of day, they are more likely to have to deal with intense, unfamiliar environments as they near their destination.

Organisational conditions

For many goods drivers working in small independent outfits, considerations of issues such as safety culture or employee support will be seen as irrelevant, not least due to lack of resource. In such cases, all available human and financial resources may be focused on what makes the business run in the short term. Driver professionalism may be conceived as the loyalty they have to the business, and the extent to which they are concerned about competing and the survival of their company. This is nurtured by a long-standing occupational pride and "lone cowboy" mentality among drivers, where getting the load delivered on time is everything[10] (Askildsen, 2011). One union expert pointed out that certain employers, contractors or shipping agents may exploit this attitude by setting unrealistic delivery schedules (see below under Branch conditions).

For those drivers employed by more formal organisations (some goods and coach drivers, and many bus drivers), culture and internal training courses play an important role in the driver's awareness of and ability to tackle fatigue. Much depends the quality of middle management, and in particular the relationship between the driver and their line manager. Good organisational conditions can often improve the experience of drivers and driver fatigue, in some cases simply by planning the work properly, such that drivers do not spend as long on the roads. One way in which organisational culture concerning fatigue and safety manifests itself is in driver's willingness to adjust the digital trip recorder such that it does not appear that they have exceeded working or driving time regulations, even though they have. This can be done, for example, by changing the name of the driver to which hours are recorded for, or by inserting another driver's card into the recorder for part of the journey. Some organisations will check the recorders, while some will never look at them.

Branch conditions

Apart from transport forms reflecting the two tasks above (i.e. long-distance and local transport), conditions influencing operator fatigue can vary according to what is being transported.

Goods transport

Many goods jobs entail a working day that can be very broken up, such that drivers do not rest properly, or are forced to rest at times of the day that are not physiologically conducive to sleep. Several experts picked out fish transport as a branch in which drivers were likely to be most fatigued. Drivers in this branch were perceived as more likely to be young with long driving hours, and having to drive top-heavy trucks at high speed due to considerable time pressure. In addition, fish can be bought and sold several times while they are under transport, something which also gives drivers a very unpredictable working day. One expert contended that although fish transport has a reputation as an unsafe branch, there have been improvements. This expert, who had driven in several branches, claimed that other goods branches, such as bulk transport, can be more exhausting.

[10] According to one expert this attitude was also encouraged as a result of outflagging in the maritime sector, which resulted in many Norwegian sailors off the sea and onto land, where many became truck drivers.

It may be less exhausting to drive container transporters, because there is less loading to be done than there is with other trucks, and in this sense construction and waste transport may be particularly exhausting. Other experts agreed that loading duties were problematic, especially when carried out late at night and when followed by long drives. Although regulation has reduced the extent to which drivers in the EU load and unload, many domestic drivers still have loading as part of their duties. Drivers at terminals may not wish to wait for those whose job it is to load and unload, or may wish to help out simply to pass the time or as a means of social interaction.

Several experts pointed out that hazardous goods transporters had less fatigue-related problems, especially while subcontracted to oil companies, receiving training courses, better hours, pay, and pay arrangements as a consequence. One expert said that these drivers can even get telephone call asking whether they are tired, i.e. the employer or contractor follows-up and shows active concern for these drivers. They are allowed to take an extra break, or at least ask for one. They are regarded as elite drivers, and they feel supported, according to our experts. Some hazardous transport operations have limited the speed of their vehicles to 80 km per hour, with the result that the drivers are less exhausted, and they drive more economically, something which supports a link between rushing/stress and perceived fatigue. In contrast to hazardous goods transport branches, other branches overall seem not to *involve* themselves as much in safety.

Experts commented that goods transport branches most exposed to liberalization of the market need to compete more than ever, with one company informing one expert that their drivers need to work 50 hours a week to be able to compete with foreign competitors, whose work time may be less well regulated.

Several experts claimed that transport buyers and shipping agents pressured transporters (organisations, truck owners and independent drivers), such that many drivers drove far too much. The situation led one expert to claim that

> "the shipping agents and truck owners steer the truck, not the driver. They are the ones that can pressure drivers and say when the load shall be delivered."

For example, the schedules to be followed may not sufficiently consider break times set out by driving and resting legislation or the availability of rest stops. Delivery times may also be set that do not allow for any traffic delays, unless the driver breaks driving hours regulations. Even though the new regulations make buyers and shipping agents co-responsible for ensuring drivers do not exceed driving and working time regulations in theory, in practice these actors are rarely punished. More often than not, it is still the driver who is punished for driving too long in order to meet unrealistic delivery deadlines. A different expert, also referring to the pressure drivers are given, pointed out that although drivers no longer have incentives to drive longer (because as explained below, most are paid per day of work rather than e.g. distance driven), the transporters and transport buyers do, and therefore the driver gets pressured instead by them. This expert explained how this might be done in some cases:

> "It is not unusual that the company keeps a low profile, such that the driver becomes personally responsible for fulfilling the customer demands. They give the driver the responsibility, and say to them "see what you can manage", "you have control, we don't have control" or "just do the best you can". Drivers are all too willing to interpret this responsibility as part of the freedom they enjoy in their work. An illusion is created that they have a stake in the way their work is carried out. But [in reality] the work of the truck driver is under surveillance."

Competition conditions in the transport market may mean that there are many small companies who are not in a position to negotiate with the shipping agent or transport buyer, in order to win better terms for their drivers. One expert commented that while there are many small enterprises in Denmark, as in Norway, truck owners were better at working together in order to say what is acceptable in terms of delivery costs (i.e. higher level of organisation).

Although more common for foreign drivers, some Norwegian goods drivers are still paid per kilometer, according to one expert. "When the vehicle stands still, so does the driver's income." The low level of organisation makes this hard to tackle. Another expert commented that such payment arrangements are rare, since there has been a development away from payment based on a share of the value of the goods transported, towards payment per day. The effects of accord payments (e.g. pay per kilometer or per load delivered) may, however, live on in goods transport culture.

Passenger transport

Several experts though that sleepiness was more a problem for goods than passenger transport, but bus transport has its own problems in terms of waiting time, psychological loads, shifts at unusual times of the day, and overtime. It was also pointed out that drivers may feel more obliged to continue when fatigued if they are driving a bus (i.e. they cannot just stop and sleep with passengers on board).

Overtime is widespread in local bus operations, with one expert commenting that this can often result in working time transgressions ("the shift schedule shows how long drivers have driven, not the tachograph"). Drivers drive overtime out of a sense of duty, but also to earn more. Another expert added that "pay and driver loyalty are the reasons why fatigue is widespread [in the bus branch]". Councils increasingly award contracts to transport providers after bid rounds. Price is an important factor, and the company that can operate their services most economically may not be the one who can best manage driver fatigue. Risk of fines and the need to report delays means that there is a lot of pressure on drivers to keep to a tight schedule. There may be little time to consider and tackle fatigue.

In coach or express bus transport, traffic queues or other delays can often cause fatigue by extending time behind the wheel. Competition has increased most in these branches, and coach companies who before would have had two drivers on a route, now choose one in order to win the contract. This can mean that the driving hours regulations are "stretched now and then".

Individual-level causes

One expert reported having heard reports about older drivers struggling with sleepiness in the daytime, and had also talked to many and got the impression that older drivers were "damn fed up" with driving. Another pointed out that age is a problem due to health-related issues causing sleeping difficulties. Age-related problems may be exacerbated by an increasing average age in the truck driving branch.

Poor eating habits and obesity were also highlighted as causes of fatigue, both because of sleep-related problems and because of the effects of large variations in blood sugar throughout the day. A bus expert referred to a union member survey showing that 1 in 3 drivers reported health complaints, most commonly back and neck problems and high blood pressure. The union runs roadside driver health

checks along with NPRA and the police, and has sent several drivers directly to the hospital. Poor eating habits and not having eaten for a long time were common findings from these checks. Others pointed out that the framework conditions of the industry discouraged healthy eating and exercise.

Use of alcohol and drugs and medication by individuals can also exacerbate the effects of fatigue, but is hard to measure the after-effects, and there were few indications that this was prevalent.

One expert pointed out the need for some drivers to have several employers, or drive in different branches, perhaps because a bus job does not pay well enough. Some also work in other sectors or are students, in addition to having a driving job. Second jobs are hard to capture in inspections by the Labour Inspection Authority, and put onus on individual drivers to manage their own time.

Carrying on when tired

Experts referred to the lack of available stopping places, and many stopping places that are perceived as undesirable by drivers. A scarcity of stopping places – especially in the winter months – makes planning stops to comply with driving resting time regulations difficult. Some long-distance drivers who have driven in the night might recognize the need to sleep towards the end of a tour, but rarely stop even when there are resting places. According to one expert:

> "If there is just an hour left, it's difficult to stop. You think: *I'll manage to stay awake for an hour or so*. Pride can also play a role, it's important to show others that you can cope with the demands of the job. You don't want to be the last man to arrive to deliver at a train or ferry. It's a macho environment in that way. If you are the last to arrive, you also go later to bed, get up and leave later. There are many reasons to get where you are going on time."

Another expert explained that "alertness shows that you can cope with this sort of work. You play down how tired you are, because you are saying indirectly that you cannot master the job."

Life outside work

One expert noted that "driver fatigue is regulated by working life and home life". Several other experts agreed that the whole lives of drivers must be considered to completely account for fatigue-related risks. Demands on time outside of work may impinge on the time one has to sleep. There may be social activities or hobbies – especially among younger drivers – or care obligations at home. One expert pointed out that since long-distance drivers are away from home a lot, how they use their non-driving time may be important. Bus drivers in particular may suffer from problems with work-home balance, especially the considerable share that work split shifts, where they work during the morning and evening rush hours but not in between. Several experts commented on commuting as an important fatigue issue. One expert commented "it is much more demanding to drive a heavy vehicle, so you relax or perhaps drive faster in your car on the way home, you think the risk is the same because the vehicle is less dangerous." At the end of the day this may be a problem. When one considers that time spent performing the main work task (driving) outside work inhibits recovery from work, problems may accumulate for those who have regular long commutes. Thus an important question is whether activities at home add to or relieve the burden from work, with beneficial free time giving restitution and recovery from work.

Norwegian causes

When asked if there were particular Norwegian causes of fatigue, the extreme variation in light levels between summer and winter in Norway, especially in the north of the country, were cited as a potential problem by several experts. Periods without light are worse, since the lack of light leads to hormonal profiles that induce increased sleepiness in operators. On the other hand, in the summer when the periods of darkness are very short, drivers may be tempted to exploit daylight hours to the full. A different expert concurred that this could help explain why, according to his private (unofficial) data records, there are more heavy vehicle accidents in the summer.

One expert commented that while the lorry pool in Norway was generally of a high standard, the roads were not, i.e. the condition of roads in Norway may contribute to fatigue. Another agreed commenting that,

> "at times the ferry times, weather conditions and topography in Norway can control the amount and length of driving a driver does more than driving and resting times."

Several experts commented that the standard and quantity of resting places in Norway was not conducive with driving and resting time regulations (cf. section on working time above). For goods transport, there are fewer resting places during the winter (due to closed roads), when they are needed the most.

It was implicit from expert comments that several interacting factors caused particular problems in the winter. Most concurred that winter driving was most challenging, both because of the mental and physical demands of driving in poor weather conditions (e.g. need to fit snow chains) or on slippery roads in the dark, because of the effects that lack of light has on physiology, and the relative lack of resting places. One expert who had worked as a bus driver pointed out that the effect of winter on tiredness could clearly be seen on the faces of the passengers, and that sleep was socially infectious, i.e. it was easy to feel tired in the winter when all the passengers were dozy.

One expert thought that Norwegian driving conditions were only a problem because they were more likely to cause fatigue in foreign drivers.

Summary

In summary, the comments of our experts confirmed international research findings that the reasons for fatigue can be found at individual, task, organisational, branch and regulatory levels. However, together the comments of experts seem to place more emphasis on branch-level (framework) conditions than previous research would suggest. As one expert said "it is not just driver attitude, the system is the problem". This is a system that is often hard for regulators to understand, and at times even for drivers and managers (e.g. loads which change owners during transport).

5.4 Consequences

International research indicates that fatigue is a considerable risk factor related to road accidents, and that fatigue-related accidents are more frequent among professional than private drivers (Sagberg & Bjørnskau, 2004: 3). When considering all kinds of accidents involving all types of driver, studies indicate that the share of accidents caused by fatigue varies between one and six per cent (Sagberg & Bjørnskau, 2004: 3). However, fatigue-related accidents generally occur in main roads with high speed limits, and their consequences tend to be severe. For this reason the share of fatal accidents caused by fatigue is higher, varying between three and 15 per cent according to Sagberg & Bjørnskau (2004:3).

There are considerable Norwegian and Nordic data on sleepiness and accidents for private drivers. These confirm international findings that fatigue is a substantial cause of traffic accidents. In a Swedish case-control study of drivers who were hospitalized after car accidents (N=408) and car drivers stopped by police who had not experienced an accident (N= 2308), it was found that accident-involved drivers reported a higher frequency of falling asleep before the accident (3.5 per cent) than the control group (0.1 per cent) (Anund et al., 2011). In an in-depth study of 119 lone vehicle accidents (N=53) and collisions (N=66) that occurred on straight roads in Norway with speed limits of 80 and 90 km/h, Moe (1999) found that sleepiness was the most frequent cause. Thirty per cent of the accidents were caused by drivers falling asleep behind the wheel, consistent with other findings that fatigue tends to cause accidents on straight roads with higher speeds. Moe's (1999) study found driver sleepiness to be a more important cause of these accidents than alcohol impairment.

Since 2005, the regional Accident Analysis Groups (AAG) have carried out in-depth analyses of fatal accidents in Norway involving private and professional drivers (Statens vegvesen, 2014). Annual reports are available that draw conclusions about factors linked to these accidents. Fatigue is one of the main driver-related factors considered, alongside speed, driver ability, and alcohol/drug intake. As found elsewhere, it is difficult to draw links between fatigue and fatal accidents. Even so, evidence of driver sleepiness, the lack of skid marks on the road preceding the accident, or evidence of driving out of lane over a longer distance are taken as signs of fatigue. Fatigue was influential in 15 per cent of all fatal road accidents in Norway in 2013, and averages at 14 per cent for the years 2005 to 2013 (Statens vegvesen, 2014). These figures are for all drivers – private and professional – and the AAG reports do not break down causal factors for professional drivers.

We also know from Norwegian research that there are many more incidents of sleep behind the wheel than there are sleep-related accidents. Focusing on 9200 private drivers in Norway, Sagberg (1999) found that only four per cent of the incidences in which drivers fell asleep while driving resulted in a crash, mostly caused by driving off the road. In many cases (64 per cent), drivers who fall asleep wake up when they cross the edge line or rumble strips (Phillips and Sagberg, 2010b). According to driver recall, rumble strips are present in only about 1 in 3 cases of sleep behind the wheel in Norway (Phillips & Sagberg, 2010b).

The following figure from Sagberg et al. (2004) is worth considering alongside these data for private drivers. It is useful when thinking about the consequences of fatigue and sleepiness.

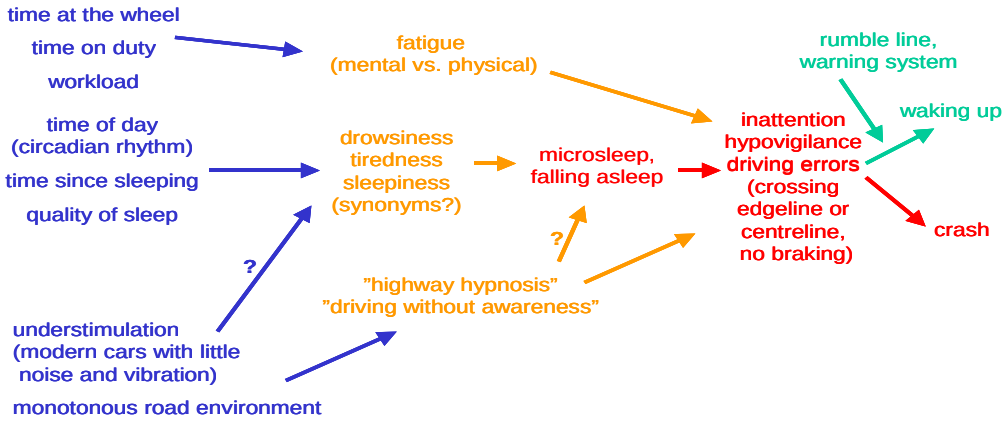

Figure 1. A conceptual map of fatigue, sleepiness and related phenomena, and their possible precursors and consequences. Source TØI report 739/2004.

What is clear from this figure is that we know little about the consequences of forms of fatigue other than sleepiness, such as driving without awareness, microsleeps (of which drivers are often unaware), or fatigue-related inattention, hypovigilance or cognitive slowness. Reasons to believe that non-sleepy fatigue is also a safety problem for transport operators are outlined in Phillips (2014a).

In addition to immediate safety consequences, the health-related consequences of chronic fatigue are especially important for professional drivers. In industrialized nations, the risks of sickness and disease among bus, truck and other land-based transport operators and workers have long been recognized as higher as they are for most other workers, and there may be safety consequences of which we know little about (Benavides et al., 2003; Winkleby et al., 1988).

We now turn to consider what is known about consequences of fatigue for professional drivers in Norway.

5.4.1 Previous research in Norway

Nordbakke (2004) finds that 1.3 per cent of the professional drivers (N=154) who fell asleep in the last year experienced an accident when they fell asleep. This roughly accords with results reported by Sagberg (1999) for private drivers, above, but suggests that professional drivers sleeping behind the wheel may be less likely to have an accident. Nordbakke (2004) found that when the professional drivers woke up after falling asleep, they did the following:

- Continued driving without stopping (36 %)
- Had a short break (36 %)
- Parked and slept for a while (32 %)
- Stopped to eat and drink (9 %)
- Stopped and drove further the next day (5 %)

The professional drivers who fell asleep (N=154) and other drivers who had experienced being afraid of falling asleep (N= 453), noticed the following characteristics, respectively:

- Misperception of the road or traffic: (22 %; 16 %)
- Slow reaction to traffic events: (33 %; 29 %)

- Driving too slow or fast: (39 %; 30 %)
- Swerve out on the road shoulder: (12 %; 12 %)
- Swerve into the wrong lane: (19 %; 4 %)

Fifty-six per cent of the bus drivers in Moe's (2006) study had been involved in accidents or near misses (not just due to fatigue) in the last three years. Bus drivers listed lack of attention, tiredness and distraction among the causes of the accidents they had experienced. About five per cent ascribed great importance to the fact that they had been tired, or had fallen asleep (Moe, 2006: 31). Bus drivers who reported that they often were exhausted and tired (nearly 30 per cent) had experienced more accidents than the drivers who seldom were exhausted and tired (nearly 20 per cent) (Moe, 2006: 33).

An analysis has been conducted of the AAG reports on 130 accidents involving heavy vehicles occurring between 2005 and 2008 (Assum & Sørensen, 2010). Professional drivers were identified as triggering, or possibly triggering, 44 of these accidents. Tiredness or sleeping was identified as a contributory factor in 7 of these 44 accidents (16 per cent). Only the factors "high speed" and "inattention" were identified more frequently as contributory, factors that often can be caused by tiredness. Tiredness or sleeping contributed to five out of 15 accidents in which trucks drove off the road and no other vehicle was involved. The study also examined "time pressure" and "driving and resting time regulation transgressions" as contributory factors, and found them to be contributory in five of the 44 fatal accidents that may have been triggered by the professional driver.

In 2011, the Norwegian Ministry of Transport and Communications commissioned research to improve knowledge on the causes of work-related accidents occurring in traffic. The first report, also based on the AAG reports (this time from 2005 to 2011), found that of those professional drivers *involved* in fatal accidents, six per cent were fatigued and six per cent were stressed, while most of the remainder were in a "normal condition" (Phillips & Meyer, 2012). A second report looked more closely at professional drivers involved in the fatal accidents who had triggered them (Nævestad & Phillips, 2013; Nævestad et al., 2014). Apart from momentary driver error, the biggest contributory factors for accidents involving these drivers were high speed (major or decisive role in 52 per cent of cases), lack of driving skill (14 per cent) and fatigue (12 per cent).

In addition to the work by the National Public Roads Authority (NPRA), the Accident Investigation Board Norway (AIBN) has in recent times investigated road accidents with serious implications for Norwegian society. An AIBN report on a recent serious bus accident at Dombås highlights the serious implications that operator fatigue can have for safety in the Norwegian road sector (AIBN, 2014). The accident happened as the driver fell asleep at 0400 h. Although he had not broken the driving and working hours rules, he had slept very poorly in the days leading to the accident. As a result of this report there has been commentary that driving and working hours regulations alone are not sufficient to control operator fatigue, and that the organisation has an important responsibility to monitor possible influences on fatigue in their employees (Grønli, 2014).

An important source of road safety data in Norway is the accident database maintained by Statistics Norway. A preliminary analysis of this database shows that it is only of limited use as regards assigning fatigue or sleepiness as a cause of the accident. Table 7 shows an analysis of the database, for the share of person and

material injury accidents involving drivers at work occurring between midnight and 0600 h (as an indicator of sleepiness), from 2007 up to and including 2012.

Table 7. Percentage of road accidents involving drivers working at night (midnight to 6 am), according to the type of vehicle driven. Data are from Statistics Norway, based on person/material injury accidents occurring from 2007 up to and including 2012. Per cent.

Vehicle type		
HGV (n=2241)	Bus (n=611)	Taxi (n=219)
6.4	5.1	24.7

The analysis shows that 1 in 4 accidents involving taxi drivers occur in the hours between midnight and 0600 h, a share that is far higher than for any other driver at work. While this may largely be due to the fact that taxi drivers drive during the night hours more than any other type of transport operator, it raises important questions about the contribution of fatigue to accidents involving these drivers.

So, international research shows that fatigue is a substantial cause of road accidents for private and professional drivers, and that the chance of fatigue being involved in an accident increases with accident severity. Norwegian research supports these findings, and shows that only one in every 70 incidents of sleep-behind-the-wheel incidents result in an accident. On waking, over one in three professional drivers may simply continue driving. These findings suggest that many serious incidents of professional drivers sleeping behind the wheel go unreported. Of bus drivers reporting involvement in any type of accident, five per cent ascribed fatigue as the main cause. Norwegian accident investigating teams find that tiredness is contributory in 1 in 3 accidents in which trucks drive off the road and no other vehicle is involved, while an in-depth investigation of a serious bus accident suggests that drivers can become dangerously tired despite following driving and resting time regulations.

5.4.2 Findings from interviews with experts

In line with research findings, most experts were of the opinion that fatigue played a role in a substantial share of traffic accidents. Some estimated a share based on their knowledge of the research (centred on 15 to 20 per cent). Most experts had heard of stories or incidents involving driver sleepiness. Several thought that statistics on fatigue underestimated it as a cause of accidents, because drivers often do not report it, being unwilling to admit what they see is a sign of not coping with the job. However, investigators of more serious accidents suspecting fatigue look at the driver's driving and resting history, work environment, and sleep history, and therefore would probably be able to identify serious fatigue as a cause.

Experts stressed that it is important to be clear about what is meant by fatigue when assigning it as cause. One expert commented that he did not think sleepiness was a major safety problem for professional drivers, but that the problem of mental fatigue and its effect on decision-making and rapid response was greater. Another expert testified to the large individual variation in fatigue, by commenting that he had only slept two times behind the wheel during 20 years as a professional driver, but that he knew of others who could nod off behind the wheel at least once a week.

One expert from the National Labour Inspection Authority (NLIA) reported that he and a colleague had collected "private statistics" on accidents involving heavy goods vehicles in 2009 and 2010. They found that over half were lone vehicle incidents, implying that fatigue plays a major role in these accidents. Most involved drivers driving off the road on the left-hand side of the road, possibly because sleepy drivers may overcompensate when they realise they are about to drive off the road on the right-hand side of the road. The expert stressed that this was just a theory.

Concerning other consequences, one expert commented that fatigue was more likely to result in workplace injuries during loading operations, and another commented that the most serious fatigue-related safety risks may occur after work, on the commute home. Driving without awareness may be more of a problem than sleepiness for local goods or bus drivers.

Experts from driver representative organisations reported that fatigue was an issue mainly in relation to long working hours, health and welfare. These organisations attempt to make it ok for drivers to stop when they are tired, as the law obliges them to do (*Vegtrafikkloven*), but they doubt whether many drivers feel that they can do this.

5.5 Regulation and management of fatigue

An account of the general regulation of road transport at EU and Norwegian level is given by Bergene & Underthun (2012:20). As far as fatigue goes, this addresses mainly working, driving and resting times (see Section 5.1.3 in this report), driver education and further education (which only addresses fatigue to a very limited extent) and health (professional drivers must pass a medical test every five years).

Most of our knowledge on attempts to control or limit fatigue in professional drivers in Norway is limited to those attempts carried out by authorities. The NPRA and, to a lesser extent the NLIA, conduct roadside and workplace inspections in accordance with EU social legislation. The EU legislation goes beyond resting and driving time rules, and includes for example:

- Requirements for tachographs and driver cards, which together record on paper or increasingly digitally, the history of driving and resting times for both the vehicle and driver.
- Requirements for the authorities on inspections and reporting to the EU.
- Requirements for companies to keep records of employee working and driving hours for several months up to a year.

Along with the police, the NPRA has also been responsible for conducting a major national campaign, "Stop and Sleep" ("*Stopp og sov*") in the 2000s, although this was targeted at all types of driver. As far as we know there has been no evaluation of the effects of this campaign. In 2012 of the road safety management standard, ISO39001, was launched in Norway to improve the extent to which road and other organisations account for the risks faced by employees who drive. There have also been attempts by organisations such as road transport companies, driver unions or bodies involved in worker safety or health promotion, to promote driver restitution, often in the context of driver health. There have also been campaigns for more and better resting facilities along Norwegian roads.

According to Phillips and Sagberg (2010a), alternative ways of regulating and managing operator fatigue at the organisational level, so-called fatigue management programmes, are gaining international momentum. Fatigue management may be incorporated into safety management, route scheduling, work time arrangements and other aspect of work organisation aimed at preventing fatigue related accidents (Sagberg & Bjørnskau, 2004; Phillips and Sagberg, 2010a). However, few fatigue management programs were found for organisations involved in road transport in Norway.

5.5.1 Previous research in Norway

Adherence to hours of work / driving legislation

A driver in Norway is far more likely to be caught speeding, driving without a seatbelt, drink-driving or using a telephone while driving than they are exceeding the driving hours regulations. Worse still, a recent report by Elvik & Amundsen (2014) finds that the actual risk of being detected for violating driving hours regulations has fallen slightly. In the period from 2006 to 2008, there were 1.5 offences detected for every million kilometers driven in excess of the rules, but for the period 2012 to 2013, there were only 1.1 offences detected.

Examining professional drivers' adherence to hours of work legislation, Nordbakke (2004) found that 57 per cent of the professional drivers reported violating hours of driving or work rules at least sometimes. The study also showed that the more often the drivers violate hours of work rules, the more often they tended to fall asleep behind the wheel. Nordbakke concludes that this indicates the importance of the hours of work rules. When it comes to why professional drivers violate hours of work legislation, the factors considered most important are: pressure from management (reported as a reason by 49 per cent) and an aspiration to follow time schedules (reported by 44 per cent) (Nordbakke, 2004: 61). This indicates the crucial importance of the organisation for managing fatigue and accident risk among professional drivers.

Another Norwegian study, which included roadside inspections of 3032 trucks chosen randomly, found that 25 per cent of the drivers had violated one or more of the rules in the EEA regulations (Ragnøy & Sagberg, 1999). The rule that was most frequently violated by the drivers was the main daily rest period. The NPRA (2003) undertook a roadside study of hours of work adherence in 2002. In random roadside checks on compliance with hours of work regulations, the NPRA controlled 4700 vehicles, and found that seven per cent had committed a reportable violation of the daily rest rule. More recent surveys by the NPRA suggest that this latter figure remained largely unchanged in the years from 2004 to 2013 (Nygaard, 2014). However, this figure does not include "minor transgressions" of the main daily rest-period rule, committed by an additional 24 per cent of drivers in 2013. The share of drivers driving in accordance with the daily rest regulation was only 69 per cent in 2013. The NPRA reports also show a substantial regional variation in serious violations of the daily rest rule, varying from 4 per cent in the mid-Norway (*Region midt*) to 13 per cent in Western Norway (*Region vest*) (Nygaard, 2014).

Transgressions of other driving hours regulations are given respectively for 2013, as follows:

- Violations of daily driving hours: 17 % minor, 3 % serious transgressions.

- Incorrect use of tachograph or driver card recording hours worked and driven: 11 % minor, 3 % serious transgressions
- Illegitimate tachograph: 6 %

Driver opinion of driving and resting time regulations

Recent evidence suggests that lorry drivers in Norway are on the whole supportive of driving and resting hours rules, and almost all drivers are familiar with the rules (Bergland & Gressnes, 2014). Drivers also largely recognise that driving hours regulations are necessary to control exploitation of drivers and limit driver fatigue (Bergland & Gressnes, 2014). Interestingly, although 80 per cent thought that the rules influenced traffic safety, only half of these thought the influence was positive. Together with evidence that driving hours are experienced as too inflexible (by over 60 per cent of drivers), the implication is that drivers may have to drive when they are tired in order to exploit the rules to the full, or may have to drive faster in order to reach a destination without exceeding the driving time allowed by the legislation. Support for the latter comes from reports that 1 in 3 drivers often drive too fast to get home or to keep the driving hours regulations (Bergland & Gressnes, 2014). Another problem with the regulations is that they say when breaks must be taken, and do not consider where the driver is at the time, and what quality of facilities there are. Not surprisingly, Bergland & Gressnes (2014) found regulations contributed to stress in 1 in 4 drivers. According to reports by local goods drivers, 1 in 5 say they have very little say in when they take a break and cannot carry out their work tasks within their formal working hours (Enehaug & Gamperiene, 2010).

Norwegian companies with a publicised approach to driver fatigue

The bus drivers in Moe's (2006) study do not report explicitly about any fatigue management programmes. Moe (2006: 33) concludes, however, that the least accident prone bus drivers work in bus companies with high competence on emergency preparedness, safety focus, good HSE-work and positive relations between employees. This may indicate that companies with a clear focus on safety, good HSE-work and so forth may prevent driver fatigue and experience fewer accidents.

In our literature search, we found one Norwegian company with an explicit and public approach to driver fatigue, "Boreal Transport Norge" (previously Veolia). This company has 2000 employees, and transports 83,000 people each day by means of buses and ferries. This company includes fatigue among its five ground safety rules, stating "Fatigue and exhaustion can induce failure of concentration that may cause serious accidents. I stay fit and maintain my health, for the safety of EVERYBODY"[11]. This statement indicates the importance of health and fitness when it comes to fatigue, and it stresses the responsibility of the driver for staying fit. It would be interesting to learn more about how the company facilitates this. On the company's website, fatigue is treated as a crucial threat to safe transport operations together with four other hazards (assaults/harassment, inattention, intoxication, falls).

There are probably other companies who implement systemic measures to address fatigue among their driver employees, but these may be difficult to identify where

[11] http://www.boreal.no/sikkerhet/category388.html. Downloaded 04.01.2012. The statement has been translated into English by the author.

fatigue is assimilated along with other important risks to consider. Fatigue will, for instance, be addressed to a certain extent by company health services, or by companies certified in the road safety management standard ISO39001.

Information campaigns unlikely to succeed

Nordbakke (2004) found that respondents drove while tired even though they were aware of the risks related to drowsy driving. She also found that drivers have fairly good knowledge of the risk of falling asleep while driving, and that they know about the significance of sufficient sleep. In spite of this, few drivers actually get sufficient sleep for a longer period of time before a longer drive, and only a few drivers stop to take a nap while feeling tired. Professional drivers state that time schedules (62 per cent) and pressure from management (40 per cent) make them ignore symptoms of fatigue and sleepiness while driving (Nordbakke, 2004: 57). This again indicates the crucial importance of organisational conditions for professional drivers' tendency to drive while fatigued. Thus according to Norwegian research, campaigns aimed at raising awareness of fatigue that simply give information on how to tackle fatigue may not succeed in limiting the frequency of drowsy driving, unless there is first a change in driver culture or attitude related to driving while fatigued (Phillips & Sagberg, 2010a).

In summary, there is evidence that while Norwegian professional drivers see the need for regulations on working, driving and resting time, they are seen as inflexible to the extent that many drivers need to exceed the legal limits in order to do their job. According to Norwegian authors, the risk of fatigue-related accidents among professional drivers may be reduced by means of the following organisational measures: reduce driving hours where the risk of falling asleep is high, maintaining sufficient periods of rest before driving, and preventing long periods of continuous driving (Sagberg & Bjørnskau, 2004: 7). Clearly, given the limited control that they have, companies need to help drivers implement these measures. Despite this, we know little about what organisations such as road transport companies actually do to help drivers prevent fatigue. In particular, we know little about how employers manage their risk of fatigue among their employees, as they are obliged to do by work environment as well as traffic legislation. We know more, in fact, about attempts by professional drivers themselves to control their own fatigue.

5.5.2 Findings from interviews with experts

Working, driving and resting time rules

Experts recognised that getting a good sleep at night is maybe the most important factor in preventing driver fatigue, but pointed out that this is not really regulated for. There were also comments that existing regulations on driving and working hours are not always easy to understand and interpret alongside each other.

Flexibility and day vs. night

The perceived relevance of the rules to the driver may depend on how much flexibility is required in the particular transport job they do, and how much support or pressure they experience from their employer and other transport chain actors. In some cases inflexibility of the regulations is a source of frustration. This is illustrated by a quote we received from one truck driver:

> "It happens often – every day in fact – that I have to take a break in the middle of the day, when I am wide awake with nothing to do but sit and wait for the break to go so that I can drive on. What's the point of that? When I drive distribution in a local area, I am the only one with a 7.5 hours working day who has to take a rest, even if I feel I don't need it. If I drop the break, or take a couple of minutes less, I risk as much as 8000 Norwegian kroner in a fine. And nobody checks what I do with my resting time, there is no guarantee that I have actually rested. Everything is based on a piece of paper that shows nothing except how long the wheel on my truck has stood still."

Rather than drive a bit further to enjoy a little peace, a shower, toilet, food and shops, compliant drivers often have to settle for the next nearest stop, where the facilities may be poor, or there may be road noise. One expert commented that drivers also feel insecure about sleeping at certain stops due to concerns about theft of the load they are carrying. Another expert added that the rules say you must drive for 4.5 hours and then rest for 45 minutes, but "you get tired of looking at the clock, and when you get to your obligatory break time you may find you are 300 km from the next resting place or toilet".

Referring to long-distance goods driving, one expert said that "the biggest problem with driving and resting rules is that drivers lose control of their day. Shift work is heaven in comparison […], because then at least you know when your work begins and ends". This is further explained by the following quote from a long-distance driver:

> "With things as they are, I often have to stay awake through the night and sleep in the day to exploit the driving time I have such that I can get done what I need to do in time. One example of this was when the ferry from Kristiansand to Hirtshals had arrived in Denmark around midnight. If you then had to unload in Hamburg on Monday, a little before midday, and had to drive, say, a couple of hours after that, you are then ready for your main sleep in the middle of the afternoon. If you don't have much time to the next delivery place, such that you can delay the main sleep until the night, you'll be tired for the whole week. You can imagine how tired you were by Thursday-Friday."

In the express bus sector, there were comments that the rules need to allow for the fact that drivers will always serve their passengers, and therefore will never stop and rest while passengers are waiting.

Supporting the above comments, several experts thought authorities could improve the rules to (i) better distinguish between the effects of day and night driving, (ii) allow increased flexibility.

Enforcing the rules

An expert from a regulatory authority commented that it is often difficult to inspect and control drivers' working time because drivers can work for different employers, although this is easier to detect now that electronic driver cards have been introduced. Using driver cards it is now possible to see how much the driver has worked and driven altogether, even though they may have driven different vehicles. However, for drivers with other non-driving jobs, driver cards will not help detect total working time. Also, if drivers who are exempted from driving hours legislation sometimes carry out long-distance tasks, authorities will have problems detecting their total working time. This problem of "double working" was also exemplified by an expert with experience as a professional driver.

> "I drove during the day in Oslo (about 7 hours driving exempt from driving hours legislation), followed by a car trip between employers, and then an 8.5 hours driving stint (subject to driving hours legislation). The total time at work, including loading and unloading

> and transport between employers was over 20 hours within a 24 hour period. This was exceptional, but it was not the only time it happened during my career."

Another problem is that the digital or paper recorder is set to "rest" even though the drivers may be loading and unloading. In reality some goods drivers can perform non-driving tasks for five or six hours before setting off on an eight-hour drive. Because of extra non-driving work, many drivers in Norway may break working hours rules, even though the new rules introduced in 2005 are meant to cover both physical and driving work. When carrying out inspections, the NLIA often finds that working hours are not recorded on the digital recorder, even though this is required. The system for recording working and driving time can be manipulated, and unless drivers are inspected while they are manipulating the system, it can be difficult to detect. Irregularities between working schedules and actual working hours can be revealed, however, by inspecting wage slips.

Supply chain actors do not share responsibility

A further problem with existing legislation is that in practice, it does not appear to have resulted in transport buyers and shippers taking greater responsibility for goods driver fatigue. The way the rules are interpreted and enforced means that the driver remains mainly responsible for compliance, even though in many cases they have been pressured to exceed the limits by other actors in the transport chain. Several experts commented on the pressure put on goods drivers and truck owners by shipping agents and transport buyers, with little thought for driver fatigue. The drivers were seen as having to hold out as long as they could, because fatigue is just part of the job, something to be tolerated:

"It is important to understand the role of the shipping agents here, some of whom are seen as "mafia" in some respects. There are many small companies in the road transport sector, and the shipping agents like it like that, because they can let them compete against each other, and squeeze the price down. I don't know. The employees take the brunt, they can only turn up, take the pressure, try to manage as best they can. And they have varying success."

Such conditions are also made worse by temporary contracts and payment systems that encourage longer driving spells, e.g. payment per km driven rather than by the hour. While this is discouraged by existing legislation, it is allowed as long as it does not influence safety, something which is difficult to prove.

One expert commented that:

> "a systemic approach to regulation – where all take responsibility for driver fatigue – is important. But there's something strange about the regulations that makes them ineffective. Like we're waiting for a court case so that what is written in the regulations [about each transport chain actor taking responsibility for driver fatigue] actually applies in practice."

Better than nothing

Despite these problems, all experts agreed that there was a need for working, driving and resting time rules, and several said that they provide "concrete boundaries" that are clear for everybody. Driving and resting regulations were perceived as effective at curbing many of the worst offences, and enforcement was perceived by experts as having improved. One expert commented that Norway, Sweden, Germany and France were among the countries that inspected compliance with driving time regulations most effectively. Germany and France were also mentioned by another expert as a country with strict rules and effective enforcement. Despite Norway's high ranking, experts commented that drivers may perceive little danger of being caught exceeding driving or working hours, though this may depend on the branch in

question. One expert also mentioned that authorities should be better at detecting serious, systematic transgressions of driving and working hours rules.

The taxi driver

In preparation of this report, we received some comments from an expert not included in the original study, about the difficulties of controlling working hours in the taxi branch. These are included in Box 2.

Box 2. Regulating working time in the taxi branch in Norway.

The Norwegian Labour Inspection Authority (NLIA) often inspects hours worked and employment contracts for taxi drivers according to records of the responsible taxi owner. Although taxi owners often do a large share of the taxi driving, their working hours are not in focus because their working time is not restricted by Work Environment Law (WEL).

Many owners use an electronic data system that their drivers register into and out of when they start and finish operating, and data from these systems is used by NLIA for inspections. However, there may be a discrepancy between what the authorities and drivers or taxi-owners perceive as working time. For instance, a driver who is tired may settle down in a quiet spot outside a taxi stop to rest, or even sleep, even though he or she is technically registered by the system as working and waiting for a customer. Some drivers may not wish to leave the data system because they would lose their place in the "digital queue" of drivers waiting for customers – they may even leave the car while they remain registered in the system. For many drivers, long hours between the start and end of work, made up of periods of working and waiting may be viewed as necessary to compensate for fluctuations in taxi demand throughout the day. (Given this situation one might ask whether the amount of work done by taxi drivers may therefore best be measured in terms of both distance driven and registered time working.) It is also not unusual that part-time drivers, for instance working only on the weekends, work intense and long hours, and little is known about whether their weekday activities allow them to recover. Such issues may help explain revelations in Norway in 2012, that taxi drivers regularly break working hours regulations laid down in WEL (TAXI, 2012).

Perhaps more than any other branch, the taxi branch illustrates how rigid working hours legislation may not reflect the realities imposed on operators by the framework conditions of their branch. To be able to survive, drivers may need to be flexible about when they work from day to day. The important question for us is whether this way of working results in increased fatigue, or whether drivers really are able to recuperate between jobs. Whatever the case, the taxi branch remains poorly researched despite bouts of media coverage suggesting extremely long working hours[12].

What do organisations do?

Experts commented that the organisation can do much to address fatigue among drivers, once framework conditions are put aside. The drivers of hazardous goods vehicles were cited by several as a good example. These drivers "do everything at their own speed, have a different culture". They are respected, and get to set the agenda. Well-organised work conditions, sensible shift arrangements and open reporting culture were named as important factors for these drivers. A key aspect is the role of oil or other hazardous goods company as employer or contractor with high standards of health and safety for all who carry out tasks (Nævestad & Bjørnskau, 2014).

One expert who had been a bus driver up until 2008 said that drivers had talked about fatigue at company training courses, as a new driver and then after two and four years. Interestingly, fatigue was talked about in terms of losing concentration during difficult parking manouvres, rather than sleep at the wheel, probably reflecting that this was a local bus company running urban routes. In coach driving it may be more common to talk about sleepiness, but in either case formal ways of reporting fatigue may be rare, unless there is an accident that must be reported. Bus

[12] http://www.rogalandsavis.no/index.php?page=vis_nyhet&NyhetID=97494

organisations can also encourage drivers to take breaks, according to the same expert. They may not always be motivated to do this out of concern for the driver, but rather to comply with inspections. One expert commented that HSE is viewed by many transport companies as too expensive, but they have "missed the whole point" (i.e. that there are business benefits).

Talking about goods transport companies, one expert stated that organisations perceived, rightly or wrongly, that safety is expensive, and so leave the management of fatigue to the driver. Worse still, some branches may be implicit in hiding fatigue, because there is often little accept for saying that you are tired. "To arrive later than agreed because you are tired is not good." How drivers experience how open they can be about fatigue may depend a lot on local relations. For example, it seems some drivers can tell their line manager that they are exhausted on reaching a depot, and may even get loading delayed so they can sleep a little.

According to accident investigators, internal inspections of goods transport companies for compliance with WEL show that there is room for improvement. Among recommendations made by accident investigation reports are that they must not ask more of the driver than they can legally do.

Finally, one expert pointed out that firms of a certain size must have a company health service, but that this excludes most goods transport companies, which are very small. General health service providers may also struggle to understand the demands of working in transport.

Accident investigations

One way a society learns about road safety problems is via accident investigations. Experts from the Accident Investigation Board Norway (AIBN) commented that Norway has focused more on alcohol and drugs than fatigue, in relation to many other countries. They also gave two reasons why using investigations to learn lessons from fatigue-related accidents may be difficult. Firstly, most fatigue-related accidents will involve lone drivers, and in this sense may not be interesting to investigating authorities, who are focused on using available resources to investigate the most catastrophic accidents. Secondly, there is underreporting by drivers and difficulties in obtaining data charting the development of driver fatigue. Investigators also have to account for ethics when questioning drivers, or the families of drivers, involved in serious accidents.

Summary

In summary, experts recognised both the usefulness and limitations of working, driving and resting time regulations. Here, there was a paradox however: at the same time as providing clear and necessary boundaries for working and driving time limits, they were experienced as inflexible in some branches. According to the analyses carried out here, taxi and long-distance goods branches face particular challenges when applying the existing regulations to the realities of their jobs. Legislation passed that gives all supply chain actors responsibility in preventing fatigue does not seem to be functioning as anticipated, possibly because they are not perceived as enforceable. Because they may be limited by framework conditions of a particular branch, it is not clear how much individual organisations may have room to manoeuvre in order to tackle fatigue among their driver employees, but it was implicit from comments that where driver health and safety is seen as beneficial for the business (hazardous goods), working conditions can be positively geared towards preventing fatigue.

Perceptions by organisations that they are obliged by regulators to prevent fatigue may not be optimal in terms of preventing fatigue, as long as there are perceived business benefits of not doing so. Finally, regulations are often altered to better improve conditions for drivers when those conditions are seen to play a role in serious accidents. The extent to which regulators in Norway can learn about the role of fatigue in accidents may be limited by a focus on catastrophic accidents and the difficulties of assigning fatigue as a cause.

5.6 Expert recommendations on what to do to improve fatigue

Recommendations made by experts to tackle fatigue, or recommendations implicit in their comments, were as follows:

- Improve reporting of fatigue. It is only reported when there is "serious trouble" at the moment, i.e. rarely. Effective reporting requires a good, open dialogue with the drivers. We need to change the culture where you need to show managers that you are wide awake and ready for work when you are not.
- Impose minimum rest period following loading and unloading.
- Reduce night driving, but assess alongside risk from increased traffic volumes at other times of the day.
- Plan the transport schedule to account for systematic evidence of fatigue risks.
- Make it ok for shipping agents and transport owners to hear "no" more often. On a related point, one expert said that the law should be changed to give transport buyers and shipping agents more concrete responsibility for looking after the driver. (The parallel example of master builders in construction was given, i.e. they have responsibility for the activities of subcontractors in the same way that shipping agents should.)
- Legislation should be introduced that better allows drivers to follow their biological clock to a greater extent, and which takes account of the need for "a little flexibility and freedom" for the drivers. There were also comments that increasing their flexibility would increase the level of respect that drivers and companies have for regulations.
- Consider better coverage of fatigue at driver training courses, although bear in mind that such measures would place more emphasis on driver responsibility. Focus particularly on educating drivers from "low cost" countries.
- Assistance could be given to increase drivers' ability to know when they are in what one expert called "fatigue-risk mode". Give feedback to drivers about the risks of their operation, and personal feedback about when they tend to get more tired.
- Improve learning from fatigue-related incidents and accidents by improving the extent to which accidents are investigated, and by improving knowledge about the causes and nature of fatigue-related accidents.
- Increase perceptions of the risk of detection for transgressions of driving and working hours.
- Companies should strive to get an overview of driver fatigue – there may be best practice examples already.
- Increase use of speed-limiters set at lower speeds e.g. 80 km/t instead of 90 km/t as set by the EU – again there are best practice examples.

- Give time to sleep and a place that is conducive to sleep, when it is allowed. Need more facilities in companies and on roads ("there are only 15 approved facilities in Norway, as opposed to 110 in Denmark").
- Take better care of driver health.
- Consider the role of life outside work in fatigue. Improve work-life balance by increasing driver participation in work planning.

5.7 Summary of findings on fatigue in professional drivers

Background

When attempting to understand the problem of fatigue for different types of driver, one must bear in mind that the road transport sector in Norway is extremely fragmented, with diverse market segments liberalized for competition to varying degrees. Within individual branches, there can be extreme and dynamic diversity, and fluctuating time pressures, with actors in goods transport chains, for instance, changing from day to day. Within the bus sector, framework conditions depend a lot on the need to compete for contracts, while in the bus and taxi branches there is variation depending on the nature of the service offered. Levels of organisation in goods, taxi and to some extent coach transport are low, since operations in these branches can be based on small independent enterprises with few employees. This means that the interests of drivers can be poorly represented when local working conditions are negotiated.

Background research shows that fatigue-related working conditions in goods and passenger transport can depend to a certain degree on whether the transport is local or long-distance. Local transport drivers (of lorries, taxis and buses) can face high mental demands from time pressure, the need to negotiate busy traffic environments while maneuvering, and the need to keep customers happy. For some there may also be physical demands from manual handling tasks. Long distance drivers (mostly of buses, coaches and lorries, but also taxis) can work irregular, long hours and face long periods of monotonous driving at times of day when the body normally sleeps. They may also face nights away from home, and lack social support. All drivers may suffer from long spells in a fixed sitting position, and musculoskeletal complaints are among the highest of any occupation.

Regardless of branch, driver fatigue in Norway is controlled mainly by EU regulations limiting the number hours per day and week that drivers can drive and work. The particular rules that apply depend on the type of vehicle and distance driven, and in more organized branches, such as local bus transport, vary subject to local tariff agreements.

Prevalence

Of the different elements of fatigue, we have most knowledge on sleepiness. The data we have support international research findings that episodes of sleep behind the wheel are not uncommon among professional drivers in general (13 per cent of one sample having experienced at least one episode in the preceding 12 months). Thus fatigue among professional drivers in Norway is within the range given for other countries, where between 8 and 29 per cent report to have fallen asleep behind the wheel in the preceding 12 months. Although it is hard to generalize based on the

few other (non-standard) measures of fatigue used in Norwegian research, these also suggest that other types of driver fatigue are not uncommon.

Prevalence rates for Norwegian drivers must be considered to vary according to the type of professional driver surveyed. This is reflected by data showing that the share of drivers reporting falling asleep behind the wheel (at any time) is higher for long distance drivers (42 per cent) than for local transport drivers (34 per cent) (Nordbakke, 2004). Thus sleepiness rates among long-distance bus and truck drivers may be higher than for local drivers. Rates of mental or physical exhaustion – which we know little about in Norway – may also vary within road transport, according to particular job tasks. Despite qualitative comments, experts generally could not quantify rates of sleepiness or fatigue for drivers in different branches.

Causes

Surprisingly little has been done by researchers to relate schedules worked to sleep and fatigue in the Norwegian road transport sector. Available Norwegian studies do suggest, however, that professional drivers (who arguably need it most) get substantially less sleep than some other occupations, with almost 1 in 4 drivers getting less than six hours sleep on a normal week night. Again, there are probably large variations among the particular transport branches.

Norwegian evidence supports international data showing that older professional drivers in Norway tend more to be sleepy behind the wheel and more fatigued from working (especially in the longer term), but this does not mean that they are more at risk than younger drivers for a fatigue-related accident. Indeed a greater share of younger drivers have been found to report incidences of sleep behind the wheel, in Norway and internationally.

Some indirect organisational causes of fatigue have also been investigated by Norwegian studies, if only qualitatively. These suggest that for bus drivers diverse aspects of the work situations (e.g. time pressure, insecurity, mental demand) may be experienced as fatiguing. Norwegian studies have also documented work conditions that may lead to – but have not been linked to – fatigue, finding that job demands vary widely for different transport branches, and that job stress may be important to consider alongside fatigue for bus drivers. They also suggest low job control (for local drivers) and low levels of job and social support. Thus there is ample indirect evidence to suggest that working conditions contribute to fatigue for transport workers in Norway.

However, expert comments suggest that a far broader range of factors may contribute to cause fatigue in the Norwegian transport sector than have been charted by researchers. In addition to limited sleep, age/experience and generic job factors (control, support etc.), experts explained how the following could cause fatigue in different branches:

- Time of day or night driving task is performed.
- Shifts (night work, late shifts, very early shift starts, split shifts, double shifts and backwardly rotating shifts are fatiguing).
- Driving time regulations, which can prevent driving when alert, or effectively "force" long-distance drivers who have stringent delivery times, to sleep during the day and drive through the night.
- Monotonous and high demand tasks, or both
- Organisational training

- Driver-line manager relationship
- Branch culture and occupational pride, which prevents drivers from stopping when they need to
- Branch framework conditions:

  In goods transport:
  - Increasing competition may be leading to increased pressure to work longer, not helped by low level of organisation in branch.
  - Many small enterprises run on loyalty and reliant on driver's occupational pride and "get-the-job-done-whatever-it-takes"-attitude, further exploited by shipping agents and transport buyers in setting unrealistic delivery schedules.
  - Load transported (goods) can determine working conditions (perishable versus hazardous goods) or the amount of physical work to be done.
  - Pay systems influential, though improving

  And in passenger transport:
  - Single driver arrangements promoted by bids for tender (coach)
  - Overtime commonplace (local bus)
  - Need to cover rush periods results in long days (local bus)
  - Need to consider passengers – can't just stop and rest
  - Time pressure on drivers encouraged by system of fines for poor punctuality (bus)
- Double working
- Lack of accounting for life outside work, including commuting
- Causes that may be particular to Norway (or Nordic countries), including poor roads, difficult roads to drive on, ferries along routes, and poor weather and light driving conditions for driving in the winter.

Consequences

Norwegian data for professional truck and bus drivers support international data showing that the occurrence of sleep behind the wheel is far greater than the occurrence of sleep-related accidents, with an accident occurring only one in every 70 times a driver recalls sleeping. One study suggests as many as one in three Norwegian bus and truck drivers continue driving when they are sleepy.

The following Norwegian data supports that sleep behind the wheel is a main cause of accidents:

- Bus drivers ascribe fatigue as an important cause of 1 in 20 traffic accidents (all types) which they had been involved in.
- Tiredness or sleeping was found to contribute to 7 of 44 (16 per cent of) fatal accidents triggered by professional drivers in Norway, between 2005 and 2008; a different study on the same types of accident (but from 2005 to 2011) found fatigue to be contributory in 12 per cent of cases.
- Tiredness or sleeping was found to contribute to 5 of 15 fatal lone-vehicle accidents involving professional drivers, between 2005 and 2008.
- Fatigue and stress were the most frequent explanations for the "abnormal condition" of professional drivers who became involved in fatal accidents in Norway, between 2005 and 2011.

Expert estimates of the contribution of fatigue to serious traffic accidents ranged from 15 to 20 per cent, but that fatigue may be underestimated as a cause. Experts

stressed one must be careful about what is meant by fatigue when assigning it as cause. Experts from bodies representing drivers were also concerned about the longer-term health effects of fatigue for drivers in addition to its safety effects.

Regulation and management

Norwegian data suggest that violations of hours of work legislation are common among professional drivers. This is important because a relationship is also shown between violations and falling asleep behind the wheel. As many as 65 per cent of the drivers who often/regularly violate hours of work legislation report to have fallen asleep behind the wheel. Time pressure is a clear cause of violations, according to the drivers. It is not clear what sort of drivers are responsible for violations. Research also shows that most drivers see the need for driving hours legislation, but most do not think it influences traffic safety positively. This may partly be explained by findings that the regulations contribute to stress, and that many drivers admit that they drive too fast in order to get home or comply with the driving time regulations. Regulations are experienced as too inflexible by over half of drivers. One in five local delivery drivers have commented that they have little control over break times, and cannot carry out their work times within formal working hours.

We found little evidence of regulation or management of fatigue at the organisational level, although this may be because such information is difficult to find. At the individual-level, there is evidence that drivers have too little control over their work situation to be able to manage their fatigue effectively.

Comments from experts supported the need for working and driving time legislation, but they too listed a number of problems. These included:

- Inflexibility can prevent the ability of drivers to manage their fatigue effectively (by enforcing breaks during alert periods, or bouts of sleep during the daytime).
- Incoherence between regulation, supportive infrastructure (e.g. nowhere to stop when it's time to stop) and framework conditions (e.g. schedules that allow insufficient time for breaks in reality, especially when delays).
- Drivers remaining largely responsible for compliance, even though the drivers have little control over their working day.
- Risk of detection of transgressions is perceived as low.
- Ways of evading detection are common knowledge (although prevalence of evasion is unknown).

Experts seemed to think that organisations can do a lot to manage and regulate fatigue themselves (e.g. sensible shifts, open reporting culture, well-planned operations, health services who understand driver challenges), but in some branches the organisations are often too small with too little resource to do this.

6 Train drivers

6.1 Background

6.1.1 Organisation of the railway

All passenger and cargo train operations in Norway were run by the state-owned NSB until 1996, when a number of specialized companies were established. NSB still runs most passenger services through its regional units (e.g. NSB Riks has nearly 300 drivers and NSB Øst has over 650 drivers). In addition to NSB, however, drivers can drive for CargoNet, Flytoget, Cargolink, Malmtrafikk or Hector Rail. All train operations are still influenced by the effects of state ownership, and most if not all staff remain highly organized and well represented.

In 2011, passenger trains were responsible for 37 million kilometers driven on the railways, versus 8.5 million kilometers driven by cargo trains (AIBN, 2013). Passenger rail operations occur at the local, regional, national (intercity) and international level. In addition to NSB AS, the main passenger train companies are Flytoget AS and NSB Gjøvikbanen AS. They are both linked to the old state-run NSB, but now operate as separate companies at regional level. NSB also has a daughter company, Nettbuss AS, employing 3000 bus drivers, which recently became the first transport company in Norway to be certified in the ISO39001 standard on safety management in road transport. While there are an increasing number of actors in rail cargo operations, it remains dominated by CargoNet AS (derived from the old goods division of NSB). CargoNet employs over 900 staff, including almost 200 drivers. CargoNet carries out a lot of combined transportations, carrying a lot of containers, timber and fuel. There is a lot of night work to exploit the extra capacity on the rail network, but cargo work is scaled down somewhat on the weekends.

Almost all train drivers are union members. This, together with a strong sense of loyalty to the union, means that the rail sector may be better suited to the Norwegian model than the road transport sector, where the level of organisation is lower and where loyalty is more to the employer (cf Section 2.2). The Norwegian train driver's union, NLF (*Norsk Lokomotivmannsforbund*), is one of the two main rail employee unions, and works closely together with the Norwegian railway union (*Norsk Jernbaneforbund*) to give strong representation of worker interests. NLF in particular has had substantial negotiating power within the rail sector, partly because of national driver shortages and partly because of a strict safety regime in Norwegian railway operations (Seip, 2009: 35).

6.1.2 Safety aspects

The Automatic Train Control (ATC) system operates on most rail stretches in Norway[13]. ATC is a system that gives information to drivers on current speed and signal status for the current and subsequent block of track. The train driver's signal

[13] Exceptions include Gjøvik line, north of Roa, and the Ski-Rakkestad-Sarpsborg line.

approach speed is compared to a braking curve using a digital algorithm, and if the speed is too high, a visual alarm (flashing light) shows for a few seconds on the driver's panel, followed by an audible warning sound. If the driver fails to cancel either alarm, automatic braking is applied to the train on signal approach. This braking can slow the train to appropriate operational speed for signal approach; in more severe cases there may be emergency braking. ATC is an important safety barrier in the context of driver fatigue, and, together with the dead man's lever (which stops the train when the driver is incapacitated), forms a double-barrier against drivers sleeping. However, ATC is not available on all stretches of track, particularly in station areas and during shunting operations, which are more prone to accidents. In addition, large stretches of track in Norway only have partial ATC, which means there is no monitoring and automatic adjustment of speed in relation to speed limits (i.e. only on signal approach). Another exception is on the underground train, where it is possible to pass a red signal at 15 km per hour, in order to be able to pack trains together. There are plans to replace the ATC system in Norway with the European Train Management System, which will give the driver information on speed limits[14].

Open reporting of incidents and accidents by drivers is encouraged in most cases via the Synergi system, in which accident reporting forms are filled out and fed into a national database. There is little knowledge about the extent to which drivers and managers report different types of incidents. There is some evidence that drivers may be reluctant to certain report minor incidents that they feel management will not address (Phillips & Sagberg, 2010b). According to one expert we spoke to, a total of 10,000 to 12,000 incidents of different kinds are reported to the Norwegian Rail Authority every year. Serious incidents on the rail are train collisions, which are extremely rare, and derailing, level crossing and signal pass incidents. Level crossing and derailing incidents are relatively rare, and although signal pass incidents do not happen often, they are more common. In the period from 2002 to 2010 there were between 70 and 99 reported signal passes every year in Norway (AIBN, 2013). It is possible to pass a signal when ATC intervenes (due to high train momentum), but passes also happen in areas not covered by ATC. Signal passes are seen as a very serious incident by companies in the rail sector, and involve the driver being taken out of service with immediate effect.

6.1.3 Working conditions

Some of the challenging working conditions for train drivers are presented below (Phillips, 2014a).

- Main task is classic vigilance task, i.e. driver can be monitor of system for long periods of time.
- Long spells of low arousal and monotony, and underload for those driving long stretches of good track.
- Monotony interspersed with periods of complexity, where driver must anticipate, observe, interpret and react to signals, speed limits and other messages in the track and cabin environment, and act as a link between different actors in the system, such as the train controller, conductors, maintenance staff and passengers.

[14] For more on ATC in Norway see Phillips & Sagberg (2014), which also describes complex ways in which fatigue may influence train driving.

- Many simultaneous demands e.g. need to be punctual in face of delays, control engine overuse on slippery tracks, check safe passenger embarkation, visualise the aspects of dirty signals, find signals in unusual positions, take incoming telephone calls from train managers, communicate with the conductor or other drivers in the cabin.
- Adverse weather such as low sun, fog or heavy rain causes engine handling and visualisation problems.

Thus, though the introduction of technology such as ATC has increased periods of monotony, train driving is often complex, involving multitasking and higher-level thinking. It often requires continuous constant alertness (vigilance) and continual object detection and recognition, recall, planning, decision-making and workload management (Dorrian et al., 2006). Risk is ever-present. While serious accidents are rare, the transport of a large number of passengers or hazardous cargo can mean that they are catastrophic when they do occur. Alongside safety performance demands, there are demands for punctuality, which can mean that delays in busy periods are stressful. Multiple search tasks in taxing signal environments are an additional demand (Phillips & Sagberg, 2010b). Note also that the cargo train driver will tend to work more at night, carry out more shunting operations, and possibly be involved in more physical work.

6.1.4 Working time

Working time is regulated through WEL, the Railway Law (*Jernbaneloven*), associated rulings, and main and local tariff agreements. Each union has its own agreement with each employer, making it difficult to summarise different working time arrangements. There are, however, some notable differences. For instance, NSB and CargoNet have retained an "old" system giving a gradual reduction in average weekly working hours, the more one works nights and on weekends (Seip, 2009). Those with more years of service have a greater say in which shifts and tours they carry out. In contrast, Flytoget does not compensate for night and weekend work, but instead limits average weekly working time to 33.6 h. It also distributes shift schedules independently of years of service.

A main summary of working time for drivers of NLF are:

- A working day of no more than ten hours.
- A maximum of 5.5 hours continuous driving, with 40 minutes break in an approved rest room.
- Minimum 11 hours rest at the driver's home-station, with a minimum 8 hours rest at an away-station.
- No more than two consecutive nights worked.

According to WEL, the minimum rest time between work periods should be 11 h. With local agreements, this has been negotiated down to a minimum nine hours rest if a driver is required to rest at an "away" station, but in most cases this can be reduced further, to eight hours if there are delays.

There is a long-standing tradition of cooperation when shift rotations are worked out, about once a year. According to Seip (2009), there are three phases: deciding train routes; deciding shift schedules; and deciding how shift schedules are distributed. The interests of drivers are strongly represented in each of these phases. According to NLF, this has advantages also for the employer, in that they avoid

disagreement down the line, and run a safer operation by ensuring that nightwork and stays away from home are fairly distributed. Involvement of the unions also helps ensure that working time laid down by local tariff agreements is not exceeded. After the shift schedules are distributed, a local service office in each region helps drivers deal with any problems. The offices are flexible if there is a need for drivers to swap shifts or part of a shift schedule.

6.2 Prevalence

There have been some interesting Nordic studies on train driver fatigue.

Swedish studies

In a Swedish study from 1983, 11 per cent of the train drivers reported to have dozed off while operating the train (Åkerstedt et al., 1983, in Härmä et al., 2002). These findings are cited by Härmä et al. (2002), who do not clarify whether the incidents referred to one time or another or within a given period of time, for instance in the last year.

A Swedish study of 288 train drivers documents various sleepiness/fatigue issues, focusing on train drivers' working hours, sleep, stress and safety (Ingre et al., 2000). The results of this study indicated that train driver workload was relatively high and that their working hours were very strenuous. A key finding of this report is that the prevalence of fatigue at work and sleep disturbances was high. The train drivers reported more stress, poorer sleep quality, more sleepiness, less satisfaction, less time for family, friends and social activities than the comparison groups. The study also found that:

- Two per cent of the train drivers stated that they were physically exhausted at least once a week,
- Seven per cent were mentally exhausted at least once each week,
- Nine per cent were exhausted/burned out at least once each week
- One in four experienced chronic fatigue at least once each week

Analyzing the relationship between the variable "chronic fatigue" and other relevant variables, Ingre et al. (2000) found that indicators of stress and restitution explained 43 per cent of the variance in chronic fatigue. Insufficient sleep alone explained a third of the variable's variance (Ingre et al., 2000: 50). Finally, half of the train drivers who reported problems with continuous tiredness met the criteria for insomnia.

Finnish studies

A Finnish study examines the prevalence of severe sleepiness in shifts among male train drivers (N=126) and railway traffic controllers (N=104), by means of questionnaires and sleep-wake diaries used for 21 days (Härmä et al., 2002). Thus the study examined 2482 shifts during a three-week period. The study also examined which shift and sleep-related factors associated with severe sleepiness in an irregular shift system. The study defined severe sleepiness as a score of 7 or higher on the Karolinska Sleepiness Scale. Severe sleepiness was reported by 50 per cent of the train drivers working night shifts, 20 per cent working morning shifts, 4 per cent working day shifts and six per cent working evening shifts. The risk of severe sleepiness was between six and 14 times higher in the night shift compared with the

day shift, and about twice as high in the morning shift compared with the day shift (Härmä et al., 2002).

6.2.1 Previous research in Norway

We found no studies directly documenting the prevalence of fatigue in train drivers in Norway. However, a secondary finding reported in one of our own studies was the fact that fatigued driving was rated as an important issue by 75 per cent of the drivers (Phillips & Sagberg, 2010c: 40).

Thus, we can say little about fatigue in train drivers in Norway. The above Nordic studies suggest, however, that substantial shares of drivers suffer from sleepiness while operating, and experience mental exhaustion on a weekly basis (7 to 9 per cent). The Finnish studies are of particular concern. It is particularly interesting that 1 in 4 drivers in Sweden regularly experience chronic fatigue, since it indicates that a considerable share of the train drivers are unable to restitute themselves properly between their work shifts. However, since working conditions in Sweden and Finland are unique to those countries, it is not clear whether we can generalize their results to Norway. In Sweden, for instance, there may be less challenging (and more monotonous) driving stretches, and ATC coverage is better, but a higher degree of rail privatization may lead to more fatigue-related problems for drivers than in Norway.

6.2.2 Findings from interviews with experts

Generally, the experts could say little about the prevalence of sleepiness or other aspects of fatigue in train drivers, but they thought that fatigue-related problems were less prevalent among operators of rail transport than among operators of other forms of transport. Two thought that fatigue was not widespread in the rail sector, especially in comparison with drivers in the road sector who work under more demanding conditions, including double shifts. Two of the experts thought that fatigue was quite common even if the consequences were not, because of the technological and organisational safety barriers in place. One expert estimated that a driver reported being too tired to work once every one or two weeks in CargoNet. No experts seemed to think that fatigue was a severe problem for train drivers. An important reason for this could be that, where driver fatigue does become severe, drivers are encouraged and obliged to report it.

Of different fatigue aspects, train drivers seem to be most concerned with the lack of sleep and sleepiness, according to experts. One expert said that train drivers talk openly about being tired and having had too little sleep. A different expert said that the focus was on sleep problems and restricted sleep, sleep in relation to the regulations, and the problems it may cause. Lack of sleep is easier to work with and help drivers tackle than mental exhaustion (e.g. through company health service), and the latter may be somewhat overlooked by companies. Experts perceived important differences between the two concepts, however. Thus while sleepiness may be well controlled in the rail sector, it is more difficult to conclude about other forms of fatigue such as mental or chronic fatigue.

Most experts regarded both sleepiness and cognitive fatigue as risks, even though most drivers get enough sleep. There was recognition that short moments with little room for error can be decisive, and fatigue may play a crucial role. Experts concurred that falling asleep was not a main risk, because of the double barrier that is often in

place, but that more subtle effects of mental exhaustion on shunting operations, decision-making, multitasking and prioritization were probably more important. In such situations, the effects of fatigue are difficult to distinguish from distractions or "driving without awareness", and thus fatigue as a risk is difficult to assess.

6.3 Causes

International research supports that working shifts can cause some train drivers to experience reduced duration and quality of sleep, which leads in turn to elevated fatigue levels (Dorrian et al., 2006, 2007; Härmä et al., 2002). Sleep after night shifts is often curtailed and poor in quality, and sleep before early morning shift often involve a fear of oversleeping. Consequently, train drivers working such shifts often fail to get more than five hours of sleep, and sleep loss accumulates across working periods. (Persson et al., 2005).

Härmä et al. (2002) finds that train drivers' shift schedules are often irregular and include early morning shifts and relatively short time-off intervals between the shifts. Shift length increased the risk of severe sleepiness with 15 per cent for each hour of the main shift, while each additional hour of the main sleep period decreased the risk of severe sleepiness by 15 per cent. Härmä et al. (2002) also found that the length and timing of the shifts varied a lot, and that this made shift combinations difficult and short sleeps common. Persson et al. (2005) have also found that irregular working hours disturb train drivers' sleep/wake rhythm, and limit their abilities to plan leisure time and family life.

A Swedish report has also shown that the working hours of train drivers are very irregular (Kecklund et al., 1999). Train drivers were working all hours, shifts could start and stop at any time, could rotate backwards, and vary considerably in duration. Almost 1 in 3 shifts were early morning shifts (starts between 03:00 and 06:00 h), and 14 per cent were night shifts. There was considerable variation in time off between shifts.

Other research documents similar problems. An Australian diary study (n=253) shows that the quality of train drivers' restitution between shifts depends a lot on time of the day their shift ends (Roach et al., 2003). Rest periods of 12 hours between shifts, for instance, were associated with sleep periods of 5.2 hours in average, while rest periods of 16 hours between shifts, for instance, were associated with sleep periods of 6.5 hours in average. However, sleep duration also depended on when the train driver's shift ended. If the shifts of train drivers with 16 hours restitution period ended between 0400 and 0600 h, their sleep period was reduced to 4.8 hours in average. If the shifts of train drivers with 16 hours restitution period ended between 1800 h and 2000 h, their sleep period increased to 7.7 hours on average (Roach et al., 2003).

A Danish literature study on the safety consequences of train drivers' working hours concludes that irregular working hours, a high prevalence of night and early morning shifts, insufficient rest between shifts and a relatively high prevalence of sleep away from home, caused insufficient sleep length and quality in some drivers (Persson et al., 2005). Sleeping away from home, for instance on the train, is common for train drivers who drive longer distances and Australian and US research shows that the quality of such sleep is often poor (Persson et al., 2005).

Increased age has been associated with a reduction of risk for severe sleepiness among Finnish train drivers (Härmä et al., 2002). Paterson et al. (2012) assess factors other than working time that influence sleep behaviour. The authors did not find that BMI, commute time, age and partner's employment status predicted sleep behaviour (Paterson et al., 2012). They found however, that smoking and timing of sleep predicted sleep quality of rail workers.

In summary, Nordic and international research on the causes of train driver fatigue have focused a lot on the effect of shift duration, timing and patterns of sleep and sleepiness. There is good evidence that varying shift lengths, irregular shift timings, and a high prevalence of night and early morning shifts, disturb train drivers' sleep/wake rhythm, and may cause fatigue. In particular, sleep after night shifts and sleep before early morning shift is often too short (less than 5 h) and of poor quality, causing insufficient rest between shifts. The fatigue that results appears to be confounded by sleeping away from home, and particularly by backwardly rotating shifts.

6.3.1 Previous research in Norway

We found no peer-reviewed Norwegian research on the causes of train driver fatigue. However, Flytoget gave us permission to review an internal report commissioned by them in 2005 to assess the role of train drivers' work schedules in fatigue (Kecklund & Ingre, 2006). No actual measurements of driver fatigue were conducted, but the likelihood that different driver schedules would cause fatigue was assessed, based on existing knowledge of the effects of different shift lengths, timings and patterns on fatigue. Few work shifts at Flytoget were found to be at risk for high fatigue, but there were some schedule-related conditions that might have contributed to increased fatigue. These were short rest times (less than 12 h) between some shifts, and discrepancies between actual and scheduled work hours[15]. The authors of the report also pointed out the need to consider factors affecting fatigue that are not related to work hours or conditions.

6.3.2 Findings from interviews with experts

We identified the following causes of fatigue for train drivers in Norway, from expert comments.

Shifts

In addition to split shifts, shifts rotating against the clock may also be a problem. Although these are rare, they are desired by some drivers, particularly towards the end of a week, because they allow them to have a longer weekend. According to one expert, another problem was that:

> "The worst shifts are the best paid ones, and are often sought after for that reason. Drivers with longer service are prioritized when these shifts are given out. This could be a problem, but on the other hand older drivers can get the best routes and this can place a greater load on the younger driver population, who have least experience with unfamiliar routes, and a more challenging home life."

One expert, ranking situations causing fatigue, identified split-shifts as problematic:

[15] The company has since implemented an action plan as a result of this report.

> "The worst is night train. The next is working split shifts at night. You can begin just before midnight, drive until 3 or 4 in the morning, have 2 or 3 hours break, and then begin again in the morning. The third worst is overnight stays at hotels. For example, you drive from Oslo to Dombås or Ål and sleep away until you have to drive back to Oslo again. It happens that drivers don't get much sleep like this and have reported that they can't drive back because they are too tired."

Another expert commented that risks from split shifts are limited by dispersing them among more favourable shifts.

Experts pointed out problems of sleeping in periods between shifts of 12 hours or less, especially for those facing long commutes before arriving home.

Finally, several experts said that drivers could struggle with getting sufficient sleep in advance of early shifts. Indeed, concerns about not being able to get enough sleep itself causing lack of sleep was a known problem.

Medicine / drugs

Drivers have been taken out of service because they have taken medicines that they shouldn't have, but this is not common. Two experts mentioned that use of alcohol and medicine could be an important factor in the most serious cases of fatigue.

Monotony and time of day

When you have worked the whole night, and drive through dawn, you can feel very fatigued. Collectively, experts identified that both fatigue and driving errors are greater between 0200 and 0600 h than earlier on in the night. Several experts named monotony on long journeys in the cargo sector as a potential problem, where you often have to drive alone through the night (typically from 2000 or 2100 h to 0800 or 0900 h), or on certain passenger services involving a lot of night work and straight stretches and much routine (e.g. Flytoget). One expert explained that this is especially a challenge if the last stretch is undisturbed and straight, and especially if you have had a busy day. Other experts also commented that drivers also got tired at the end of long days, especially when not finishing until 2000 h or 2100 h.

Time pressure

One expert comment suggested that a train driver's time has become more regulated, and this may be more tiring in terms of the extra demands and lack of control experienced by the driver.

> "NSB has done an analysis of how long everything takes for drivers, to get from a break room to the wagon set, for instance. Everything is stipulated beforehand. The results of this is that drivers have to meet up in advance of their starting time. There can be time pressure, in terms of drivers being asked what they were doing in a two-minute window."

Branch conditions

Branch conditions influence fatigue to a much lesser extent than in the road sector[16]. It can be implicitly more difficult to say no to a shift because one is tired if the operating company is smaller, because there are less drivers to provide cover. One expert recalled "a period in rail cargo where there was a lot to do and a shortage of

[16] Interestingly, however, since road haulage is a main competitor for rail cargo, increased competition in the road sector may influence how much the rail cargo companies need to compete.

drivers. There was a lot to earn from working overtime, and in such periods you can push the limits, but only as far as it is legal."

Problems from a combination of monotony and time of day may be more common for cargo than passenger train operators. One expert mentioned that several applied to work at NSB rather than continue in cargo transport, because of sleep problems encountered. Passenger train operations tend to occur more in the daytime, and local operations especially are more stop-start, with lots of people around, where support is more accessible. However, monotonous, straight stretches can also cause problems in the passenger branch. In particular, the stretch operated by Flytoget, between Drammen, Oslo and Gardemoen, operates through much of the night, until 0200 h and starting again at 0400 h. There is considerable routine, since it is an express service with few stops, taking only 60 minutes to drive from one end to the other. However, other factors play a role. For instance, one expert pointed out that Flytoget may be less tiring than NSB, because there are few or no night shifts that extend into the morning, the latest ending at 0730 h.

It was pointed out that tram-driving was made difficult by mental exhaustion from the busyness and noise of the city. For one expert, tram drivers faced the greatest problems from fatigue in relation to other track-based transport forms. A main challenge for underground train drivers was queueing for platforms, when there can be little distance between trains. There is a lot of shift work and early starts on shift and underground.

One expert claimed there has been a systematic improvements in NSB that have not occurred in the cargo sector. Competition also makes its presence felt more in the latter branch. "In goods transport you are aware that there is a guarantee that you get the train to its destination on time. The transport buyer can be compensated up to 35 per cent of the value of the freight if you are late." There is also probably more pressure on smaller cargo train companies than NSB or CargoNet, who have a well-established operational culture.

Individual-level reasons

There is a deal of individual variation, with some drivers working the same shifts striving to get enough sleep with others relatively unaffected. One expert claimed that older drives appear to suffer more, with another adding that after the age of 50 years, many drivers can feel more sleepy in the afternoons. Several said that it was harder for older drivers to work through the night. However, there were also comments to the effect that younger drivers may place more importance on social life, and this may influence how tired they are at work or the type of shift schedules they choose. There were also comments that older drivers are experienced in how to limit the effects of fatigue on job performance, through strategies such as stretching or standing while operating the train.

Life phase is also important, especially for those who must care for small children (see below). Another factor is how good the drivers are at getting to bed early enough. Such factors are important but difficult to account for.

Life outside work

All experts saw life outside work as important. For most experts, social conditions surrounding the job were at least as important as organisational conditions. One expert explained that the social context can be complicated.

> "For a parent of small children, you can get up early, take care of the kids all day, then begin an evening shift and finish at 0300 or 0400 h. That is a long working day. A lot depends on how much support you get to look after the kids, how old the kids are."

Thus the interaction between individuals, their life contexts and working time is important.

Commuting

One expert thought that night driving caused problems on the commute home, for those who drive. "It happens that you sink your shoulders, think that you had a good night, and then fail to take care on the way home in the car."

Norwegian causes

Although there were no serious problems recognized, one expert mentioned that there are less monotonous stretches in Norway, so it might be easier to stay awake, although a more demanding track environment may cause more exhaustion. There were few indications that this resulted in systematic problems. The dark winters did not appear to be a particular issue, with one expert claiming that the increased use of young inexperienced drivers in the summer months may cause more fatigue-related problems. One expert mentioned that slower driving and greater vibrations in the northern part of Norway might possibly cause more sleepiness.

Experts generally saw working conditions in Norway as better than they are in Sweden, which has three large unions who do not cooperate as well, and so cannot influence working time in the same way. A high level of cooperation among Norwegian unions means that they have a greater say in working time. Another advantage over Sweden is that the latter is more similar to goods transport in Norway, with a larger number of smaller outfits, even with independent drivers who own their own trains. Organisation comes with a cost, however, and things may be heading the same direction in Norway.

Finally, experts also mentioned that the following characteristics of Norwegian rail may cause more problems for mentally exhausted drivers:

- Short distance between signals and junctions.
- Partial ATC coverage.
- Inconsistent and therefore confusing track environment and rail infrastructure.

6.4 Consequences

Research on the consequences of train driver fatigue has been done in other Nordic countries (Sweden and Finland). Kecklund et al. (1999) studied 79 accidents and near-misses in the period 1980 to 1997, in order to examine the work situation factors (e.g. working hours, sleepiness) underlying accidents and near-misses among train drivers. They selected cases based on two criteria:

- the train driver was in some way involved in the accident (e.g. accidents caused by technical failures were excluded); and
- the investigation report included substantial information about the causes of the accident.

Given the lack of information on sleep and fatigue in several cases, the authors used both direct and indirect indicators of sleepiness/fatigue (Kecklund et al., 1999: 33).

Indirect criteria were that the accident occurred between 03:00 and 06:00, or that the shift was preceded by insufficient sleep (less than five hours) or an insufficient rest period (less than eleven hours). When defining accidents as sleepiness/fatigue-related the authors used direct criteria (driver reports that sleepiness or sleep was the cause or that the investigator concludes that the accident in question was due to sleepiness); or the two indirect criteria in combination with a last criterion:

- accidents caused by missed signals, inattention or loss of memory (which the authors claimed are usually related to sleepiness).

Only four per cent of the accidents were due to sleepiness according to the direct criteria, while 13 per cent were sleepiness-related according to the indirect criteria (Kecklund et al., 1999: 34)[17]. Comparing the sleepiness-related accidents to other types of train accident, the authors conclude that the former were more likely to be caused by train drivers' failure to notice signals (Kecklund et al., 1999).

Studies of fatigue show that critical incidents are more likely to occur at certain times of day and at certain times within a duty period (Buck & Lamonde, 1993). When it comes to when the accidents occurred, Kecklund et al. (1999) found that two peaks occurred: one 09:00, and one 17:00. In accordance with previous studies, the authors found that the frequency of accidents increased up to the third hour of the shift, before decreasing again. Seventy-five per cent of the accidents occurred during the three first hours of the shifts. Kecklund et al. (1999) also found that fatigue-related accidents seemed to occur more often in the dark months (October -March) of the year.

A Finnish study by Härmä et al. (2002) asked train drivers to report whether fatigue impairs work performance on different shifts (Härmä et al., 2002). Between 21 and 37 per cent of the train drivers working night shifts found that fatigue impaired their work performance, while between four and eight per cent of the train drivers working morning shift found that fatigue impaired their work performance. During night shifts, drivers over 43 years were more impaired by fatigue than younger drivers, while the tendency was the opposite during the morning shifts.

There are many international studies on the consequences of driver fatigue. For example, a Japanese study finds that 26 per cent of the train drivers have dozed off while operating the train (Kogi & Ohta [1975] in Härmä et al., 2002). Other studies find:

- crews involved in accidents are more likely to have been exposed to fatiguing schedules (Raslear et al., 2013);
- there is a strong link between fatigue and health complaints for train operators (Ku & Smith, 2010); and
- the probability that a schedule will cause fatigue is positively linked to inefficient fuel and brake use, and speed violations (Dorrian et al., 2007).

However, an Australian study of sleep and performance of train drivers across a 106-hour rail operation between the Australian cities of Adelaide and Perth indicates that despite cumulative sleep loss across the duration of the operation, the drivers were able to sustain vigilance performance across the operation (Darwent et al., 2008). Another Australian study examined 16 four-day trips, and found that designated rest

[17] Reviewing these results, we must however bear in mind the methodological uncertainties induced by these criteria, the relatively low number of accidents in the material, and the fact that individual differences when it comes to how people respond to lack of sleep and monotonous working situations may occur (Kecklund et al., 1999).

periods of eight hours seemed sufficient to reduce fatigue to levels recorded prior to departure and to prevent the accumulation of fatigue during the trip (Jay, Dawson, Ferguson & Lamond, 2008). The same group has identified critical fatigue-zones among train drivers, finding that less than five hours of sleep in the 24 hours prior to work and/or more than 16 hours of wakefulness can significantly increase the likelihood of fatigue-related impairment and error at work (Dorrian et al., 2011).

International studies also tell us about the consequences of fatigue other than for safety. A national US survey found that fatigue led to more mood-related problems, dissatisfaction with family life and poorer social relations for train drivers than many other occupations (National Sleep Foundation, 2012). The share of train drivers saying sleepiness affected their job at least once a week in this study was higher than for truck drivers (26 per cent versus 15 per cent). Alarmingly, the study also found 39 per cent of train operators reported that they drove while drowsy when not at work at least once a month, indicating that commuting might be problematic for train drivers.

6.4.1 Previous research in Norway

A report by the Accident Investigation Board Norway suggests that fatigue played a role in 13 per cent of signal pass incidents reported by drivers (AIBN, 2013). Furthermore, 88 percent of incidents occurred on a stretch of track that was routine for the driver, possibly implicating the role of routine and monotony in signal passes. Phillips and Sagberg (2010c) surveyed 115 train drivers on three occasions over an 18-month period about their involvement in signal approach incidents to find relevant incidents to study in-depth. They chose to do in-depth studies of ten railway incidents to identify limitations in the way surrounding systems of organisational and technical factors support train drivers on their approach to signals. One of the main findings from this study is that routine assumptions are a great hazard for rail drivers, as such assumptions may make them overlook signals, especially when they are fatigued or distracted.

Overall, we found little evidence about the consequences of fatigue for train drivers in Norway.

6.4.2 Findings from interviews with experts

One expert said that dropping off while driving probably happened quite often, especially at night, but other experts did not know or thought that this happened rarely. This same expert remembered one episode when he had nodded off over the previous ten years.

One expert said that there are several incidents linked directly to driver fatigue, and many more near misses. However, they also said that it was often difficult to link fatigue to incidents or accidents, and much depend on reports by individual drivers. One expert mentioned a train collision involving a sleeping driver having driven a monotonous straight stretch of track. The accident investigation expert cited a collision involving a tram collision and an exhausted driver, but also admitted that underreporting probably limits the extent of knowledge about more minor fatigue-related incidents. Another expert knew of a signal pass incident that occurred because of driver fatigue, and resulted in a near miss. One expert reckoned that fatigue was responsible for 20 to 25 per cent of signal pass incidents involving

human error. On the other hand, one expert we spoke to who was involved in incident analysis did not think that driver fatigue played such a large role in incidents.

An important safety risk for train drivers is failure to observe or comply with a signal. According to one expert, fatigue can affect the extent to which drivers can *prioritise* such safety-central tasks correctly e.g. focus on an approaching signal rather than answer the train manager in the telephone. Similarly, one expert commented that "Mental exhaustion or cognitive slowness due to drowsiness, medication or illness is more important than sleeping, because of dead man's lever, which means that the train will stop when the driver is motionless." Individual drivers may use technical support systems (ATC) in different ways, and one expert claimed that younger drivers tend to rely on it more, "even though it can let you down at any time". For instance, in a previous study there were indications that some drivers seemed to consider that the visual alarm emitted by ATC (when speed limits are exceeded) could be triggered simply in order to find the maximum speed for a stretch of track. According to the expert comments, drivers employing such a strategy may be more vulnerable to the effects of fatigue, since they become used to seeing or hearing alarms. Level crossing incidents have also become an increasing concern in Norway, where there are 3500 crossings, many of which have short distance between signal pass and collision zones. The effects of fatigue and darkness on driver's ability to attend to pre-signals (which warn about the status of the next subsequent signal) to crossings is important, and in this sense fatigue is an important risk.

The effects of fatigue may to some extent be branch-specific. For instance, one might expect the consequences of driver fatigue in cargo transport to be less severe than in passenger transport, because there are often less train traffic and fewer passengers around. On the other hand, shunting operations are most vulnerable to misunderstandings, and are often carried out in the early morning, with conductors on the ground.

Summary

Fatigue plays a role in a substantial number safety-related incidents occurring on Norwegian railways, contributing to 13 per cent of signal pass incidents in the first half of 2012 (AIBN, 2013). Nordic and international research suggests that fatigue plays a role in 17 per cent of train accidents, and has the greatest affect performance during night shifts. While substantial shares of drivers in different countries report being affected by fatigue, other studies show how able drivers are to conserve performance much of the time. Australian research claims critical thresholds for fatigue risks have been set for the number of hours of sleep in the preceding 24 or 48 hours (less than five and 12 hours sleep, respectively), and the number of hours awake since last sleep (16 hours).

There are mixed opinions about the occurrence of sleepiness or sleep while operating the train. Nevertheless, fatigue-related signal incidences do seem to occur, and may be due not only to sleepiness but suboptimal higher level thinking, such as task prioritization on signal approach. It is not clear whether passenger or cargo operations in Norway are more or less at risk from the effects of driver fatigue.

6.5 Regulation and management of fatigue

There appear to be few studies considering the impact of working or operating hours regulations on train driver fatigue, and few studies considering violations of the regulations. This might imply that the regulations are less problematic in the rail sector.

The management of fatigue at organisational level by rail companies is discussed by Phillips & Sagberg (2010a), but it is not clear how widespread such programmes are, or indeed whether fatigue is managed in any other ways by drivers or their organisations. There are, however, recommendations on better fatigue management in other Nordic and international literature (see Section 6.6.1, below).

6.5.1 Previous research in Norway

We identified no peer-reviewed research. We were, however, granted access by Flytoget to an internal report commissioned not long after Flytoget was established as a separate company (Kecklund & Ingre, 2006). The report, which was written by the authors of the TRAIN study, recommended that a program for fatigue and performance management be implemented as part of safety management (Kecklund & Ingre, 2006). Recommended measures for inclusion in the program included: staff training related to fatigue; criteria and rules planning of shift schedules and manning of schedules; increased quality of breaks during a driving tour; increase variation of work tasks; measure and follow up tiredness / alertness levels; and a review of light levels in tunnels. Concrete measures recommended for consideration (with the aim of minimizing fatigue and increasing alertness) are given in Table 8 in Section 6.6.1.

6.5.2 Findings from interviews with experts

Working hours regulation

Experts thought that drivers generally adhered to working hours rules in the rail transport sector. Experts did not see the rules as a problem, but rather as essential. Experts viewed well-organised relations between organisations and employees as key in being able to capture and address fatigue.

Shift schedule design

A committee selected to take care of driver interests (*Tjenesteutvalget*) is involved in planning of shift schedules. One expert claimed that the employer decides when the trains will depart, but who shall depart and how the shift schedules are put together is largely decided by bodies representing staff interests. However, the employer may review shift schedules and alter them as necessary. The employer may also monitor shifts to identify any drivers working risky schedules. The organisation discourages working shifts against the clock, and does not allow double shifts, at least in passenger transport. A driver survey carried out by Flytoget in 2012 showed that most drivers preferred shifts that changed with the clock.

Experts thought that that it was beneficial for drivers to have a say in which shift schedules they work, in that they afford the driver a level of control over their fatigue. That is, the individual driver knows which schedules best suit them, as individuals and given their current life circumstances, and enabling them to choose schedules helps limit fatigue by balancing the demands of work and non-work life.

However, experts recognized that in some cases drivers might choose schedules with a high frequency of night shifts because they provide financial compensation. Alternatively, drivers may wish to maximize non-work activities that may lead to more fatigue at work. In addition, drivers with young families often opt for early shifts that fit well with the family's living pattern. However, the problems such drivers might face sleeping at night (i.e. family disrupts sleep) may exacerbate the difficulties of getting enough quality sleep before an early shift start.

A problem recognized by employers in the rail sector is that it can be difficult to schedule work with the sole purpose of minimizing fatigue, since drivers often want the schedules to account for other practical issues that they face. For example, Flytoget commissioned an independent analysis of its shift schedules, in order to generate recommendations on how to improve them in order to optimize the health of its drivers. The analysis showed that only 30 per cent of drivers wanted to introduce the new system, partly because it produced what they saw as less desirable free periods. As one expert put it, "longer free periods means longer shifts". A driver survey confirmed that most drivers wish to work several days in a row in exchange for longer free periods. NSB also pointed out that drivers often wished to work more intensely towards the end of a week in order to get a longer weekend. One expert cited examples of drivers working schedules in which 50 or 60 per cent of shifts were nightshifts. Drivers were only given such shift schedules if they wanted it, and the evidence suggested that sickness absence levels decreased for drivers after they began to work such shift schedules (fatigue was not measured, however).

Finally, an expert from one company pointed out that drivers are able to swap shifts after schedules have been issued, and that some drivers can do this to such an extent that the "shifts worked have almost nothing to do with the shifts scheduled". While this may help the driver control periods of fatigue, drivers often swap shifts for social reasons. Drivers who swap often may be exposed to fatigue, because since drivers cannot choose which other drivers they can swap with, and may end up with unusual and challenging shift patterns, albeit within working time regulations set out in WEL and local agreements. These comments imply that freedom of choice may not always be beneficial in terms of fatigue, since drivers have other considerations than just fatigue.

Reporting culture

Experts commented that there is a culture of openness in the rail sector, which helps prevent drivers operating while they are fatigued. Data from Flytoget supports this, showing that the two reasons that drivers most agreed on as reasons for sickness absence were (i) shift work and (ii) not being fit for duty due to having slept poorly. As one driver commented,

> "There is an open culture – it has become ok to say that you are tired. It is up to the driver to speak up if they are getting exhausted, and most recognize this and feel that they can do so. Managers can always get hold of another driver if they need to, and there is a willingness to help out to share the load."

Another commented that:

> "It is the individual driver's responsibility to speak up if they are too tired to work. There is awareness of the need to report if you are tired, for example if you are exhausted for private reasons or because of work."

Another expert said it was ok to be relieved from service because of difficulty sleeping; in fact, the employer has an obligation to find less safety-central tasks for

the driver to do where this is possible. A union expert gave an account of the historical reasons for open reporting of fatigue.

> "We have worked to get accept that it is ok to report being unfit to drive. It began in 1992, when a sick driver rang to report being ill, but got pressured into going to work. He missed a signal and there was almost a collision. Then we took hold of the issue, and expanded it to cover fatigue. Now there are resting rooms at Oslo central, and it is ok to say you are tired. That is not to say there will be someone to take over in the middle of the night in [the middle of nowhere]."

An expert from company health service suggested that the organisations have also worked towards greater openness:

> "Drivers are obliged to speak up and say that they are unfit to drive, no matter what the reason: tiredness, alcohol or medicines. We have been trying to get this established, but we are trying to get the leaders to make clear that there should be no fear about speaking up. It will not be necessary to be absent."

Framework conditions may make train drivers more likely to report severe fatigue. As one expert commented, "it is easier for all drivers to say no to a job than it is for a truck driver, because the train driver gets his wage in any case."

Is severe fatigue always reported?

Expert opinion was mixed about the extent to which drivers report mental fatigue. Several experts said that even in the middle of service, drivers can stop the train and call someone to say they are feeling exhausted, and that it is part of their job to do so. These experts also thought that the reporting threshold for a given level of severe fatigue was the same whether the driver became fatigued before or during active service.

However, other experts made more qualified comments about reporting fatigue: "You see drivers report themselves for misunderstanding a signal or making mistakes, but not for being sleepy or exhausted." Another said that, "there is respect for drivers who speak up, but on the other hand an unwritten code that you don't want to burden other drivers too much." One expert said that occupational pride that may limit the extent to which they always report that they are very tired. The prevailing attitude for some drivers may still be that "the train must go". We also found another comment, suggesting grey areas concerning the reporting of fatigue :

> "[Drivers] take a calculated risk or speak up only if they know they can easily be replaced by another driver. As a rule it goes ok if they do this, and so it goes on."

As one expert emphasized, whether a driver reports a given level of fatigue may vary a lot individually, depending on both the driver's interpretation of their safety responsibilities, and their own subjective threshold for what is a dangerous level of fatigue.

Reporting and investigating of fatigue-related incidents

Reporting of serious incidents using the Synergi system was widespread and systematic, according to one expert. Questions about recent shift patterns, shift swaps, and quality of recent sleep are routinely put to drivers after they are taken out of service following a serious incident. Information on work schedules of train drivers also appears to be readily available to investigators of the most serious rail incidents in Norway (Accident Investigation Board Norway, AIBN), who look at between ten and 15 incidents a year. Obtaining shift schedules worked for the preceding three days is rarely a problem, and it is often possible to investigate other

factors that could cause fatigue, such as stress, illness in the family, sleep and workload. Drivers and families appear to talk openly to investigators, who are able to capture fatigue in subtle ways, such as its manifestation as emotional stress, or increased sign of mental shortcuts taken. AIBN has been developing its human factors competence, which is playing an important role in rail investigations.

Despite these positive aspects, investigators have not always distinguished between sleepiness and mental exhaustion, and one expert claimed that there could be more focus on this. One expert thought there was room for improvement in the way the organisation learns internally about fatigue-related incidents, i.e. that it could focus more on human, and not just the technical aspects. For instance, Eurostar (UK/France) monitor and follow-up the time it takes for drivers to cancel audible warnings from the ATC system, which could be an important indicator of fatigue.

Company health service

Company health systems cannot measure fatigue, so they do not focus on it as much as e.g. blood pressure or heart rate. In one rail company, an internal company health service looks at chronic fatigue as an indicator that driver is not coping with a shift system, or as a sign of poor work-life balance, a sign that driver needs help for their own health and safety. There is also a focus on helping drivers with sleep problems and sleep disorders. This is of paramount importance, but there also needs to be a focus on other causes of fatigue. Poor health does not mean that you lose your job as a train driver, "there are always other things to do". After 55, drivers get a health check every year and after 45 every three years. In 2011 after new driver ruling, the company health service also got stricter demands on psychological follow-ups of drivers involved in serious incidents (e.g. signal passes).

Training

An expert informed that new recruits in one train company only received one day's training on HSE issues. This implies that there is little time to learn about sleepiness and fatigue that builds over the longer term, and how drivers should report and deal with such problems.

Life outside work

Talking about the problems of drivers with young families, we asked about the flexibility drivers have to choose shifts that suit.

> "You can ask for a shift that best suits to a certain extent. Drivers are keen to look after each other in that way, but there is also recognition that those without kids should not take on an unfair load."

Lone parents can apply to not work nights, and it is possible to change your work tasks to ones that are not safety-sensitive if you are tired.

Organisational management of fatigue

There do not appear to be formal, systematic programmes devoted to the management of fatigue in the rail sector. Neither were there any suggestions from interviewees that fatigue was handled systematically as a risk within a broader risk management system. That is not to say that organisations are not aware of fatigue, or do not implement measures to control it. This is illustrated in the case of Flytoget AS, who explained that they address fatigue in the following ways:

- New drivers are educated about their responsibility to be rested for work, and in various aspects of shift work
- Drivers have a clear and long-standing obligation to report if they are not fit to perform their shift
- Drivers have a certain say in which shift schedules and shift types they work, and are able to swap shifts after they have been dealt out (and thus a certain degree of flexibility is afforded that in theory helps drivers control their fatigue).
- Drivers can raise difficulties they are having with working their shifts with their leaders
- The company health checks deal with shift work and should capture fatigue-related health problems
- At a higher level, the organisation has commissioned independent analyses of its shift schedules, which include recommendations on how the company can improve fatigue.
- Drivers are offered rest facilities at base, hotel facilities to maximize sleep during shorter off-duty periods, and parking facilities to minimize commuting time and maximize time at home.

6.6 What to do about fatigue?

6.6.1 Literature

Addressing the causes of train driver sleepiness (irregular working hours, high prevalence of night and early morning shifts, insufficient rest between shifts, sleeping away from home on longer trips), Persson et al. (2005) suggest the following improvements:

- Give train drivers more influence over their schedules to improve the length and quality of their sleep
- Prolong rest between shifts
- Prevent sleeping away from home (e.g. in the train).

The authors of the Swedish TRAIN study (Kecklund et al., 2001) assert that the work situation of train drivers will always include irregular working hours and that a total absence of sleepiness/fatigue is an unrealistic goal. The TRAIN study has the following recommendations aimed at preventing train driver fatigue:

- Reduce the length of train drivers' working week by 3-5 hours (from 38-40 hours in Sweden) to compensate for fatigue/sleep loss and make it easier for train drivers to deal with irregular working hours.
- Longer rest periods between shifts (minimum 12 hours). No instances of early morning shifts after evening shifts.
- Avoid concentrated work periods, as these involve accumulation of fatigue. More specifically, train drivers should not work more than 5 days consecutively.
- Educate train drivers on how to deal with work schedules. Train drivers have a responsibility when it comes to organizing sleep and restitution in their spare time. Managers should inform drivers about how to do this, and then provide support and feedback to help them do it.
- Rehabilitate risk groups, e.g. train drivers suffering from chronic fatigue.

- Work schedules should rotate clockwise, i.e. from a morning shift to a day shift and from a day shift to an evening shift etc.
- Reduce the number of nights sleeping away from home, as these nights involve poor sleep quality and restitution.
- Accident and incident investigators should consider information about the working hours of the involved train driver(s) at least a week prior to the accident, whether overtime has occurred, whether fatiguing working hours have occurred (e.g. early morning shifts and night shifts), whether insufficient resting hours have occurred, the incidence of stress and so forth.

The Finnish study by Härmä et al. (2002) suggests that managers should adjust shift timings (i.e. when shifts end and start), reduce shift lengths and increase off-duty time to extend the main sleep period and reduce fatigue.

Finally, the Australian research by Dorrian et al. (2011) would also suggest that sleeps of less than five hours in the preceding 24 hours, a total of less than 12 hours in the preceding 48 hours, and working while having been awake for 16 hours or more should be avoided.

Flytoget recommendations

Recommendations made by a report commissioned by Flytoget were classified as those relating to education, scheduling, strategy and technical aspects of organisation (Kecklund & Ingre, 2006). They are given in Table 8.

Table 8. Concrete recommendations for minimizing fatigue in train driving (Kecklund & Ingre, 2006).

Domain	Recommendation
Education	• Inform drivers about how to live healthily (nutrition, exercise, sleep), and look for ways to help them do this. • Use experienced drivers as mentors for younger drivers to help them maintain fitness for duty. • Specific training program to inform about fatigue and how to cope with it.
Scheduling	• Limit number of consecutive nightshifts worked to a minimum. • Avoid early morning starts as far as possible. • Increase the number of breaks on early morning trips. • Avoid resting times between shifts of less than 12 h in duration. • Minimum rest of 36 h in any 7 day period. • Avoid periods of more than 4 h work without a break. • Attempt to set in “minibreaks” where possible, with opportunity for fresh air, talk with conductor, for example. • Discuss measures to avoid lengthy overtime and many changes to shift schedules. • Ensure forward-rotating shifts.
Strategic	• Measure train driver fatigue at individual level. • Explicit procedures for what a train driver must do if suddenly tired. • Limit the extent to which drivers who have had an early morning trip can take an extra run to help out in unusual situations. • Avoid manning problems, which can lead to perceived pressure to go to work when not rested. • Fatigue management program with leadership engagement.
Technical	• Fit radio to help stimulate drivers on monotonous runs. • Improve tunnel lighting.

6.6.2 Expert opinion

Expert comments on how to improve fatigue in train drivers are collected below.

- Have rules that make clear what is expected of drivers in risky situations, i.e. which tasks must be prioritized.
- Eurostar (UK/France) have a points system where passengers give feedback on issues that can be influenced by driver fatigue (e.g. sudden braking). If a driver gets enough points, he is brought in for discussion.
- Increase focus on and concern about mental exhaustion (i.e. in addition to sleepiness).
- The extent to which companies account for fatigue in planning transport operations could be improved.
- Companies could also provide better facilities for sleeping, healthier food, and promote physical activity.
- Exploit data on driving style (braking, speeding, alarm cancelling).
- Leaders have to be better at detecting fatigue in their drivers, and dealing with it in a helpful way. Psychologists could help instruct how to do this.
- More regular checks of fitness-for-duty.
- Strike the right balance between shift schedules that are optimal in terms of fatigue and those that are desirable for drivers in practice.
- Limit excessive overtime.
- Companies could better help drivers eat healthily, exercise and give information on how to do this. Independent assessments of fatigue or schedules can help them do this.

6.7 Summary of findings on fatigue in train drivers

Background

There are relatively few companies responsible for rail transport in Norway, and the roots of the largest can be traced to the state-owned NSB, which remains by far the largest rail company in passenger transport. As a result of this the Norwegian rail sector is characterized by less competition and a much higher level of employee and management organisation than in the Norwegian road sector, although the cargo sector may soon witness increasing fragmentation and competition. Due to a united union front, employee interests, have traditionally been well represented in negotiations of working conditions with employers, and this applies particularly to train drivers. Despite this, the nature of train driving means that there can still be challenging working conditions, including demanding schedules, periods of monotony interspersed with periods of intense complexity, and time pressure.

The ATC and "dead man's lever" system act as a double safety barrier to prevent sleep resulting in accidents on the railways. This may mean that the main fatigue-related safety challenge for train drivers relates to higher level cognitive tasks involving prioritization of several simultaneous tasks, decision-making, or the use of inappropriate mental schemas. Signal pass and level crossing incidents are main safety-related challenges on Norwegian railways.

Prevalence

Working conditions for train drivers in Nordic countries can be less favourable than for many other occupations, and that sleepiness and acute and chronic fatigue is not uncommon for considerable shares of train drivers. The findings include that 1 in 4 drivers in a Swedish sample reported feeling chronically fatigued, and half of drivers working night shifts in Finland experience severe sleepiness on night shifts (Härmä et al., 2002; Kecklund et al., 1999). The fact that there may be important differences between Norway and other Nordic countries underlines the need for Norwegian research into train driver fatigue. This is also reflected by differing views of Norwegian experts on the prevalence of fatigue in drivers, which also suggest that less is known about the prevalence of mental fatigue than sleepiness.

Causes

Nordic and international research on the causes of train driver fatigue have focused on the effect of shift duration, timing and patterns on sleep and sleepiness. There is good evidence that varying shift lengths, irregular shift timings, and a high prevalence of night and early morning shifts, disturb train drivers' sleep/wake rhythm, and contributes to fatigue. In particular, sleep after night shifts and sleep before early morning shift is often too short (less than 5 h) and of poor quality, causing insufficient rest between shifts. The fatigue that results appear to be confounded by sleeping away from home, and particularly by backwardly rotating shifts.

Little empirical research has been done in Norway, but the comments of our experts suggest that the following may be worth investigating in addition to the above, as causes of fatigue: split shifts, backwards rotating shifts, time pressure, various branch conditions, early morning driving at the end of a night shift, driver age and life phase, driver's care obligations outside work, commuting, and use of medicines or drugs.

Consequences

In 2012, drivers reported that fatigue played a role in 13 per cent of signal pass incidents occurring in Norway. Swedish research suggests that 17 per cent of train accidents are related to fatigue/sleepiness, and that performance may be most affected during night shifts. While substantial shares of drivers in different countries report being affected by fatigue, other studies show how able drivers are to conserve performance much of the time. Australian research claims critical thresholds for fatigue risks have been set for the number of hours of sleep in the preceding 24 or 48 hours (less than 5 and 12 hours sleep, respectively), and the number of hours awake since last sleep (16 h).

Fatigue-related incidents may be due not only to sleepiness, but suboptimal higher level thinking, such as task prioritization on signal approach. It is not clear whether passenger or cargo operations in Norway are more or less at risk from the effects of driver fatigue.

Regulation and management

Experts described several conditions that favour the effective management and regulation of fatigue in train drivers in Norway:

- Widespread compliance of working and resting hours.

- Open reporting culture concerning fatigue.
- Highly organized working relations (nearly all drivers in union and unions work together).
- Driver participation in shift schedules and working time.
- Monitoring by employer of schedules worked for any fatigue-related problems.
- Driver taken care of systematically following serious incidents.
- Drivers respected by all stakeholders in the transport operation.
- Regular health checks and follow-ups, psychological checks following incidents, by company health service.

Given these conditions, many of the recommendations from Nordic studies on how to reduce fatigue in train drivers may be redundant. Nevertheless they are worth reviewing. One could consider better adjustment of shift timings to reduce fatigue, for example, in Norway.

According to our experts, much has been or is being done to tackle severe problems related to fatigue or sleepiness before a tour of duty in Norway. However, some uncertainties remain surrounding what a driver does if fatigue develops while driving, which may be worth some further research. There may also be further scope to consider mental fatigue, as opposed to sleepiness, especially over the longer term. Experts also listed a number of other ways in which fatigue might better be accounted for, including use of braking/ATC parameters as indicators of driver fatigue, more promotion of healthy eating and living, and development of leaders who are more equipped to help their drivers discuss and tackle their fatigue.

7 Watchkeepers at sea

7.1 Background

Vessels operating in Norwegian waters[18] have been ranked, in order of distance sailed in 2011 as (Kystverket, 2012):

- Cargo or dry goods transporters, including bulk and container ships (33 % of distance sailed);
- Passenger transport, including fast vessels, ferries, coast services, and offshore supply (21 % of distance sailed);
- Fishing vessels (18 % of distance sailed);
- Tankers (7 % of distance sailed); and
- Others (22 % of distance sailed).

Between 80 and 90 per cent of the distance sailed is by smaller ships, weighing less than 5000 tonnes (Kystverket, 2012:15). Most of the sailing distance in Norwegian waters is by ships run by Norwegian operators. Nevertheless, the number of ships registered under the Norwegian NIS/NOR system[19] has decreased considerably, such that most of the larger ships (over 5000 tonnes) operating in Norwegian waters are now foreign-registered (Nævestad et al., 2014). Generally, ships with Norwegian watchkeepers will tend to operate in domestic waters and be smaller vessels – particularly supply vessels, smaller cargo vessels, fishing vessels and ferries.

7.1.1 Safety aspects

The Norwegian Maritime Authority (NMA) is especially concerned with groundings, collisions and fires onboard in terms of potential for loss of life. Collisions and groundings are the most common serious incidents reported to NMA, but there are also a substantial number of fires on board, which also have large potential for catastrophe on passenger ships. Quay collisions happen relatively often, but since the consequences are less serious, they are of less concern to the authorities. The sort of serious accident a ship is most at risk for depends a lot on the vessel in question (see Table 9). For instance, for cargo ships, the main risk is grounding, but for ferries, quay collisions are the main risk. In terms of fatalities, most serious accidents in Norwegian waters occur on fishing vessels. There are typically six or seven fatalities a year on fishing vessels, compared with between ten or twelve for all other types of vessel combined (personal communication with NMA safety person).

[18] Coastal and inland waters and parts of the North sea, Norwegian sea and Barents sea.

[19] See below under "Working Conditions" for explanation of NIS/NOR system

Table 9. Variety of working environments in the Norwegian maritime sector.

Vessel type	Illustration	Comments
Fast vessels		Mostly used as ferries, coastal transport, sightseeing. Relatively small crew. High speeds require attentive bridge crew.
Normal ferries		As above but slower. Includes *Hurtigruten*. Can be high level of routine. Tendency for older crew to migrate to ferries, since less demanding than some other maritime environments, and possibly less time away from home.
RoRo		Roll-on/Roll-off ferries for transport of cars and lorries.
Supply vessels		Many Norwegian officers work on these. Most supply personnel and equipment to oil platforms, but also other sea stations up to 100 km from the Norwegian coast e.g. wind parks. Conditions on board are relatively comfortable, and crew are relatively well paid.
Cargo (container and bulk) ships		Relatively large crew, can be physically demanding work involving long distances. There are also a number of “mini-bulkers” operating along the coast. Conditions on these can be demanding.
Tankers		Carry end-products like fluid chemicals, fuel, food oil or gas in specially lined tanks. Safety standards should be high.
Research vessels		Hard to categorise, since many different vessel types, but most sail in extreme conditions, containing specialised laboratories and equipment.

As of July 2014, all ships were to be equipped with a Bridge Navigational Watch Alarm System (BNWAS) (Anund et al., 2014). When the autopilot is switched on, the BNWAS is automatically engaged, requiring the officer to signal his or her presence (e.g. by pressing a button) every three to 12 minutes, in response to a visual, and then audible alarm. If the officer does not respond to the alarm after 30-60 s, an alarm will sound in the captain's and the first officer's cabins. One of them must then go to the bridge and cancel the alarm. If neither the captain nor the first officer cancels the alarm within a specified period, an alarm will sound in locations where other personnel are usually available.

Ship owners and companies are obliged to report certain types of incidents and accidents to the NMA using a standard reporting form, which the NMA extract data from to construct their accident database (formerly known as "DAMA"). NMA have received reports of 2053 accidents of different types on working vessels from 2010 to 2013 (Appendix 2 gives a breakdown of different accident types).

As a safety risk, the main ways in which fatigue are regulated are by regulations on hours of work, adherence to watch practice, and manning levels, each of which will be addressed below. Employers have the normal obligations for ensuring that health and safety of employees is not put at risk, and seafarers also have a responsibility to report if they are in an unfit condition to work.

7.1.2 Working conditions

"Flagging out" is a practice where a ship owner or shipping company registers their ship in a country other than their country of residence in order to avoid taxes or regulations seen as overly restrictive, including those concerning the crew's working conditions and pay. Flagging out is a long-standing, common practice, that has helped make the shipping industry a highly internationalised sector, with pressure on companies to cut wage, manning levels and/or other social costs for crews to survive (Bergene & Underthun, 2012). Along with economic conditions triggered by the oil crisis in the 1970s, flagging out has contributed to a large reduction in the share of Norwegian crew operating in Norwegian domestic and international waters (Pape, 2003).

Norwegian shipping policy has been steered largely by attempts to conserve its historically strong international shipping profile (Pape, 2003). As part of this effort Norway was one of the first to introduce an alternative international register (Norwegian International Ship register, NIS) in addition to its domestic register (Norwegian Ordinary Register, NOR), in an attempt to discourage flagging out by Norwegian ship owners. NIS is meant to ensure that the Norwegian ships can maintain international competitiveness while sailing under Norwegian jurisdiction and maintaining Norwegian standards. Shipping companies registered with NIS can man vessels with foreign crew, according to the tariffs and conditions that apply in their home countries, even though they may work alongside Norwegian crew on Norwegian salaries. There are claims that international registers like NIS have paved the way even more for social dumping[20] by increasing accessibility to lower standards than conventional home country registers would allow (Bergene & Underthun,

[20] "Social dumping" describes use by companies of labour that is less expensive than that which is normally available to them in their own countries. This can mean employing foreign workers or moving transport company headquarters to a low-wage country. As a result, governments may be tempted to enter a so-called *social policy regime competition* whereby they would reduce their labour and social standards in order to ease labour costs on enterprises and, eventually, to retain business activity within their jurisdiction. (Based on an entry on Social dumping on Wikipedia.)

2012). Another effect of flagging out and NIS is that arrangements that ensure the general application of local tariff agreements, and thus promote equal conditions for all, are difficult to apply in the Norwegian maritime sector (Bråten et al., 2013).

While NIS-ships are less tightly bound than NOR-ships to certain parts of Norwegian law, including those covering crew pay and work conditions, they cannot carry goods or passengers between Norwegian ports, or carry passengers on routes between Norwegian and foreign ports[21]. Norwegian-registered ships on domestic routes (on coastal and inland waters, and between Norway and oil platforms at sea) will thus be NOR-ships. Pape (2003) claims that Norwegian shipping policy has overlooked the interests of domestic shipping, creating a situation in which Norwegian-owned, NIS-registered ships are prevented from operating domestic routes, but where Norwegian- or other-owned foreign-registered ships are not (Pape, 2003).

International wage differences for officers and engineers are lower than those found for less qualified crew. Thus Norwegian vessels can feasibly be run by Norwegian officers with a large proportion of foreign crew. One pitfall of this, as pointed out by Bergene and Underthun (2012), is that Norwegian seafarers are having increasing difficulty getting enough on-the-job experience to be able to rise in the ranks. Another increasing problem in the maritime sector – particularly in offshore and international shipping – is that ship-owning enterprises do not employ the crew, but hire them through recruitment agencies. Under such arrangements, the working conditions for the crew are less visible to the ship owners, and there is less job security. A further disadvantage is that crew must often pay recruitment agencies to find work, and spend some weeks or months on board paying back their debt (Bergene & Underthun, 2012: 32). The extent of foreign crew working on board varies substantially among different branches of the maritime sector. Relative to container or bulk transporters, there are far fewer foreign crew working on ferries, coastal passenger routes, or on the better-paid oil supply vessels.

7.1.3 Governance

International law is paramount in the maritime sector. As a specialized agency of the United Nations, the International Maritime Organisation (IMO) is according to their own website,

> "the global standard-setting authority for the safety, security and environmental performance of international shipping. Its main role is to create a regulatory framework for the shipping industry that is fair and effective, universally adopted and universally implemented. In other words, its role is to create a level playing-field so that ship operators cannot address their financial issues by simply cutting corners and compromising on safety, security and environmental performance. This approach also encourages innovation and efficiency. Shipping is a truly international industry, and it can only operate effectively if the regulations and standards are themselves agreed, adopted and implemented on an international basis. And IMO is the forum at which this process takes place."

IMO achieves its aims through publishing and promoting acceptance on an international level, of documents and conventions on safety standards. At international level, working standards at sea are also upheld by International Labour Organisation (ILO) conventions. Member states who sign up to these conventions have responsibility for ensuring that shipping companies registered with them

[21] www.snl.no

maintain minimum standards. In the EU, directives are issued which effectively implement these conventions. The Maritime Labour Convention (MLC) of the ILO was adopted in 2006, and came into force in August 2013. As of October 2014, the convention had been ratified by 65 states, representing 80 per cent of global shipping.

Thus the MLC is now part of international law at sea, along with:

- The International Convention for the Safety of Life at Sea (SOLAS).
- The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW; www.stcw.org) (see 7.1.5 below).
- International Convention for the Prevention of Pollution From Ships (MARPOL).

The MLC and other treaties apply to all ships entering the harbours of parties to the treaty, as well as to all ships flying the flag of a member state. Fatigue-related aspects of the MLC are included in the non-mandatory "section B" of the MLC convention. The IMO/ILO has issued "Guidelines for the Development of Tables of Seafarers' Shipboard Working Arrangements and Formats of Records of Seafarers Hours of Work and Rest, 1999", to help ship owners and seafarers meet their obligations under the MLC and STCW. The guidelines provide standard formats, for shipboard working arrangements, for recording seafarer's daily hours of work and rest, and for the monitoring of compliance with hours of work regulations.

At international level, international seafarer unions (particularly the International Transport Worker Federation) have thus helped shape the conditions within which shipping companies must operate (Bergene & Underthun, 2012:17). At the national Norwegian level, regulations basically seek to enforce the international minimum standards that become conditional on registering with the NIS/NOR registers. Norwegian WEL does not apply at sea, but it has its parallel, originally in the form of The Seafarer's Law (*Sjømannsloven*) of 1975, which regulated working hours, conditions and pay in similar ways. The Seafarer's Law was eventually replaced by a new law on working on ships (*Skipsarbeidsloven*), and in 2007 work and rest time regulation was moved from the *Skipsarbeidsloven* to the ship safety law (*Skipsikkerhetsloven*). The aim of the latter was to show that working hours are above all a question of safety at sea (personal communication, NMA).

Because the maritime sector has traditionally fallen under the domain of the Ministry of Trade, Industry and Fisheries, and not the Ministry of Work, the NMA rather than the NLIA has been responsible for regulation of working hours in the maritime sector. There is thus less of a profile for employment rights and tariff agreements, and general application of those agreements either do not apply or have less power.

7.1.4 Working time

The EU Directive 1999/63/EC implemented the International Labour Organisation's convention on the Hours of Work of Seafarers (ILO180, Anund et al., 2014), and later the MLC and Chapter VIII of the STCW Code (see below). The Directive applies to seafarers on board every sea vessel registered in the territory of a member state, whether publicly or privately owned, which is ordinarily engaged in commercial maritime operations.

Under these rules, either the combined hours of work must not exceed

- 14 hours in any 24-hour period, and

- 72 hours in any 7-day period;

or the combined hours of rest must not be less than

- Ten hours in any 24-hour period; or
- 77 hours in any 7-day period.

Hours of rest can be divided into no more than two periods, one of which must be at least six hours in length. The interval between consecutive periods of rest must not exceed 14 hours.

According to Anund et al. (2014),

> "The master of a ship must take all measures necessary to ensure that the conditions relating to hours of work and rest are met. The master shall keep a record of the daily hours of work and rest of seafarers. Furthermore, the national authorities may request the ship-owner to provide information on the watch keepers and night workers. In addition, regarding age, it is stated that seafarers under the age of 18 are not permitted to work at night and that no person under 16 years of age is allowed to work on a ship. Night is defined as *a period of nine consecutive hours at least, commencing at the latest at midnight and ending at the earliest at 5 a.m.*"

Hours of work as described by the MLC are essentially identical to these rules. Slightly stricter guidelines are formulated for young seafarers under the age of 18, but these have just the status of a *guideline* rather than a *regulation*. The MLC applies to ships "other than ones which navigate exclusively in inland waters or waters within, or closely adjacent to, sheltered waters or areas where port regulations apply". Ships that travel within Norway and outside the coast within one nautical mile from a port are not included, and in such cases WEL will apply subject to local negotiations. ITF have a special agreement for seafarers employed by offshore industry, which covers areas including working time, overtime, rest time and minimum manning levels. However, these standards are not necessarily as high as those negotiated by traditional tariff agreements that apply for Norwegian territory. There is no arrangement for generalising these agreements so that they apply to everyone operating in Norwegian waters, in parallel with practice in some land-based transport (*allmenngjøring*).

There is also national regulation of pay and work conditions via the two Norwegian ship registers. The Seaman's Law of 1975 is parallel to the Work Environment Law, but according to Bergene & Underthun (2012) is "30 years behind". The fact that NMA and not NLIA inspect and enforce the regulations, seems to have led to less focus on employee rights than in land-based industry (Bergene & Underthun, 2012: 21).

7.1.5 Watchkeeping arrangements

An appreciation of the STCW rules on fitness for duty and watchkeeping, laid out in chapter VIII of the code, may help the reader understand the pressures involved in arranging working hours at sea. Firstly, Rule VIII/1 describes obligations to ensure that those on duty are well-rested[22]:

> 1. Each administration shall
>   - seek to prevent fatigue by establishing and enforcing rest periods for watchkeeping personnel (…), and
>   - demand that

[22] The STCW rules have been translated from Norwegian by the author, but checked for accuracy.

- watches are arranged such that the effectiveness of watchkeeping personnel is not reduced by fatigue, and
- arrangements in place to ensure that watchkeepers on the first watch of a voyage, as well as those on subsequent relieving watches, are sufficiently rested and otherwise adequately able to perform their duties.

2. Each administration shall seek to prevent alcohol and drug abuse by ensuring that appropriate measures are implemented, in accordance with the provisions of section A-VIII / 1, taking into account the guidance in section B-VIII / 1 of STCW code.

However, obligations to ensure fitness for duty must be balanced with a second rule presented in STCW chapter VIII, which describes obligations centered on continuous watchkeeping:

1. Each administration shall make companies, masters, chief engineer officers and all watchkeeping personnel aware of the requirements, principles and guidance of the STCW Code necessary to ensure proper, continuous watch(es) appropriate to the prevailing conditions are maintained in all seagoing ships at all times.
2. Each administration shall require each ship's master to ensure that watchkeeping arrangements are acceptable with regard to keeping acceptable, uninterrupted watch(es), once prevailing conditions are accounted for. Under the master's supervision:

1. Duty officers are responsible for the safe navigation of the ship while on watch, when they shall at all times be physically present on the navigating bridge or in a directly associated location such as room or control room on the bridge.
2. Radio operators are responsible for maintaining a continuous radio watch on appropriate frequencies during their guards.
3. Engineer officers on watch, under the leadership of a Chief Engineer, are immediately available and ready to attend the engine or, as required, physically present in the engine room while on watch.
4. Appropriate and effective watch(es) must be kept at all times for safety reasons, either when the ship is at anchor or moored or if the ship carrying dangerous cargo (…)

5. Where relevant, effective watch must be maintained for the sake of protection.

There are many different watchkeeping arrangements while at sea, as exemplified in Table 10. These may be different while a ship is in port.

Watches worked must be considered alongside lengths of duty and free time ashore. On ships sailing *Hurtigruten,* the seafarers work 6/6 with two or three weeks on and off, according to one expert that we interviewed. On ferries seafarers work more limited tours of duty, such that the 24 hours rest they get is taken ashore (see 24-hour watch system in Table 10).

Table 10. Examples of common watch systems used in Norwegian and international waters.

Name	Description
4-on/8-off "three watch" system.	This is a three watch system because three groups of people rotate to ensure there is 24-hour coverage of different role types. First officers or captains typically work from 0400-0800 h and 1600-2000 h, while second officer takes the midnight-0400 and 1200-1600 watchs. If there is a third officer, they take the 0800-1200 and 2000-2400 watchs (because a superior officer is likely to be awake while they are on watch). Third officers are becoming rare in Norwegian seafarers, due to the type of vessels they work on and reduced manning in the industry. Captains may not take a watch, but rather be on watch or standby all the time.
6-on/6-off "two watch" system.	This is the most common type of watch arrangement worked by Norwegian officers. One watch covers 0000-0600 and 1200-1800, and so on. 6/6 systems are associated with decreased sleep lengths and increased fatigue and sleepiness among bridge officers than 4/8 (Härmä, Partinen, Repo, Sorsa, & Siivonen, 2008).
24-hour watch (*døgnskift*); 12-on/12-off "two watch"	E.g. Work from 1000 h to 2400, rest for 5 h, and then work again from 0500 to 1000 h. This is followed by a period of 24 h rest, before another 24-hour watch begins. Mostly on ferries, where it is possible to return home in the free period.

7.1.6 Navigation at sea

One difference worth mentioning in relation to our consideration of drivers in road and rail transport sectors, is that navigation at sea is more team- and technology-oriented. Although on smaller ships and ferries, the "driver" is also the person responsible for navigation of the vessel, this is often not the case on larger vessels. The following is from Wikipedia[23].

> "The bridge of a ship is the room or platform from which the ship can be commanded. When a ship is underway the bridge is typically manned by an officer of the watch, aided usually by an able seaman acting as lookout. During critical maneuvers the captain will be on the bridge supported, perhaps, by an officer on watch as an extra set of hands, an able seaman on the wheel (helmsman) and sometimes a pilot if required (harbours, difficult stretches of water)."

On some vessels the helmsman also acts as lookout, but on others there is no helmsman. However, the regulations stipulate that in most cases there should always be a lookout. The officer on watch has three fundamental duties: navigate the ship, safely avoid traffic, and respond to any emergencies that may arise. The ability to smartly handle a ship is key to safe watchstanding, and requires that the officer is alert. A ship's hull, trim, speed and under-keel clearance all affect its turning radius and stopping distance. Other factors include the effects of wind and current, squat, shallow water and similar effects. Ship handling is key during avoidance manouvres, and anchoring and mooring of the ship.

For NOR-ships a directive on bridge watchkeeping applies, which again consolidates international practice (*Vaktholdforskriften*). The directive states that there should normally be three people on the bridge: a responsible navigator, a lookout and a helmsman. Where autopilot is available, it may replace the helmsman, as long as the navigator and lookout monitor the autopilot's settings and activities. The lookout can

[23] http://en.wikipedia.org/wiki/Bridge_(nautical)

only be relieved of bridge duty under certain conditions, when the water is open, easy to navigate, there is little traffic, the weather is good and it is daylight.

7.2 Prevalence

When considering the prevalence of fatigue, it is important to remember that working conditions faced by seafarers on different vessels and in different branches, vary widely depending on what is transported and where, crew nationality, flag of registration, rules that apply and so on. Nevertheless, seafarers share several important work characteristics influencing fatigue so it makes sense to consider the prevalence of fatigue for watchkeepers in general. These include long working hours, sleep disturbances, due to for instance motion and noise, and night work (Allen et al., 2008: 84). Evidence is accumulating from international studies that fatigue is a problem for many watchkeepers at sea. For example:

- The Bridge Watchkeeping Study of the Marine Accident Investigation Branch (MAIB) concludes that seafarer fatigue is a fairly common phenomenon along the UK coastline, causing considerable numbers of collisions, near collisions, groundings and contacts (MAIB, 2004). This study concludes that a third of all the groundings involved a fatigued officer alone on the bridge at night.
- A questionnaire study of masters and mates working on New Zealand inter-island ferries found that 61 per cent of the officers stated that they were often or always affected by fatigue on duty (Gander and Le Quesne, 2001 in Allen et al., 2008).
- Three per cent of watchkeepers studied in a Swedish survey reported severe sleepiness (scores of 8 or 9 on the Karolinska Sleepiness Scale) during a duty, and scores over 5 are common (Lützhöft et al., 2007).
- One third of officers working 6/6 in a Finnish study report were identified as having excessive daytime sleepiness, using standard measures (Härmä et al., 2008).

Data from comprehensive studies such as the Cardiff Sea Study and Horizon project, are also consolidating this picture (Smith et al., 2006; van Leeuwen et al., 2011).

7.2.1 Previous research in Norway

Coastal freighters represent a considerable share in the statistics of ships running aground along the coast of Norway. Although the Norwegian Maritime Authority seldom detects violations of the hours of work regulations on these ships, there are indications that transgressions are not uncommon, and that the quality of sleep on these ships is poor. A Norwegian study was therefore carried out examine in a safety context, the work life of crews of ten ships sailing cargo routes along the coast of Norway (Størkersen et al., 2011). The study excluded passenger ferries. The study used fieldwork, in-depth interviews (N=54) and a crew survey (N=77), and involved crew members with different national origins: Norwegian, Filipino and Russian/East European. The ships were owned in Norway and abroad, and they transported different kinds of cargo. The study did not focus on watchkeepers, but they were included in the survey as crew members. Fatigue was operationalized quantitatively in the survey as what the authors termed "safety critical fatigue". Four per cent of Norwegian crew agreed somewhat with the statement that "I am sometimes so tired in my work time that safety is at stake", but none agreed totally. Among two foreign

crew groups, however, around 60 per cent agreed somewhat or totally. These large differences might be explained by the differing working conditions and tour lengths faced by Norwegian versus foreign crew groups surveyed (e.g. one of the foreign groups worked more overtime and got less sleep). Qualitative findings by the same study also suggest that prevalence may vary a lot depending on factors such as the phase of a tour, length of tours along the coast, weather, port call frequency and season (for more on this study, see Causes.)

The same research group surveyed 382 persons of different seniority working on Norwegian platform supply vessels contracted by the same oil company (Kongsvik et al., 2011). The sample worked mostly 6-on/6-off, and about 40 per cent were officers. About half of the total sample, agreed partially or completely with the statement "After four weeks on duty I feel completely worn out" (Kongsvik et al., 2011).

Otherwise published Norwegian research on watchkeeper fatigue is scant, and there is little empirical knowledge about the prevalence of fatigue.

7.2.2 Findings from interviews with experts

Six of the maritime experts thought that fatigue and sleepiness at sea were common on many different types of vessel sailing in Norwegian waters, but especially on busy ships or ships with many port calls. One expert did not think that fatigue was a problem on ships that only operated in the day, while another did not think fatigue at sea was at all prevalent. Overall, most experts viewed fatigue as fairly common, with the degree of fatigue varying depending on particular situations.

According to experts, seafarers seem to talk most about sleep and problems sleeping, when they talk about tiredness. Exhaustion from continuous shifts and difficulty concentrating is also discussed. One expert pointed out that there is a lot about fatigue in the literature that officers may read, such as the Norwegian Maritime Authority's *Navigare*. Most experts agreed that there is general understanding among officers and crew that fatigue is a risk at sea, especially in situations involving routine and monotony. All crew, from seamen to captain, will have an appreciation of the effects of fatigue and lack of sleep, because they will have experienced fatigue and its effects personally, and observed it in colleagues on board. While this implies that fatigue is not uncommon, it also suggests that it may be perceived as something to be tolerated, part of life at sea. According to one of the experts, this is an attitude that may be nurtured by a long-standing occupational pride, an attitude among seafarers that "I can cope with this myself".

7.3 Causes

A variety of interacting causes of watchkeeper fatigue have been found by international studies (Phillips, 2014b). Sleep is almost always studied in relation to watch systems. The 6/6 system in particular is found to result in curtailed sleeps that cause fatigue, with sleeps of 4.5 hours not being unusual, according to one study (Lützhöft et al., 2007). The effect of watch systems on sleep also depends on the time of day at which watches start, and the extent to which a routine sleep at night is possible. The latter also applies for three-watch systems (e.g.4/8), which generally produce less fatigue than 6/6 systems.

Very poor quality or curtailed sleeps may produce acute fatigue, but even a slight sleep debt will also produce chronic fatigue during the course of longer tours of duty. Several studies suggest that sleepiness generally peaks in watchkeepers between 0400 and 0600 h; and alertness over time increases over the course of morning watches, and decreases over the course of afternoon and evening watches. Working hours (not just watch hours), tour length, vessel/transport type, perceived job demands and support, position on board, and physical environment have each been found to predict fatigue in watchkeepers (Smith et al., 2006). Branch conditions will also influence fatigue by determining length of duty tours, common watch systems used, manning levels, crew acceptance of fatigue, port call frequencies, time pressure, and so on. Coastal freight transport has been studied for its fatiguing conditions in several countries, but many other branches will also have particular causes of fatigue (e.g. physical exhaustion on fishing vessels) (Phillips, 2014b). Finally, at the individual level, physical activity, diet, health status, demographics and life on-shore also play a part (Phillips, 2014b). A study of crew aboard a naval vessel stresses that there are noticeable inter-individual differences when it comes to how we experience and tackle fatigue (Goh, 2000, in Allen et al., 2008).

Studies are beginning to recognize that many of the above factors will dynamically interact to influence fatigue, such that fatigue may build and vary within and across tours of duty (Wadsworth et al., 2008). Thus one must account for whole systems of factors including sleep, watch systems, on board culture, role, length of duty, port calls, non-watch tasks, time of day and individual differences when assessing the causes of fatigue in watchkeepers.

7.3.1 Previous research in Norway

Again we retrieved relevant data from the Norwegian study of working conditions aboard short sea cargo vessels sailing along the coast of Norway (Størkersen et al., 2011). This found that sleepiness accumulates over the course of a voyage. Crews in this study worked for periods of 4 weeks or 6 months, and during these periods, crew members stated that they became more and more fatigued. As the crews were fairly small, crew members often filled several different functions aboard (e.g. function as a cook, sailor and machine operator), and they had several port visits during each 24-hour period. As a consequence, time for restitution and sleep was scarce. The workload was also greater in bad weather, especially during the winter.

Although they worked 6/6 on paper, this was not necessarily followed in practice. During port visits, for instance, all crew members had to lend a hand with loading and unloading work, which could be considerable. On one of the ships, a crew member worked consecutively for 30 hours (Størkersen et al., 2011: 17). It was also not uncommon that crew members worked consecutively for more than 12 hours. Manning levels were simply too low to allow some crew members to rest during important operations. Thus because of practical considerations, few crew members followed hours of work regulations (Størkersen et al., 2011: 17). The navigators usually followed their work schedules to a greater extent than other crew members, but they usually worked for longer hours than their official work schedules implied. Their opportunities to rest and work according to hours of work regulations were influenced by: the number of navigators on the ship and on duty, the use of pilot and the number of officers certified to navigate along the coast, the number of port visits, time of port visits, the frequency of corrective maintenance operations, the number of crew members, their experience and their competence (Størkersen et al., 2011: 19).

In addition, bridge officers often liked to use up half an hour of their rest periods for what they saw as essential "hand-over" discussions with incoming watch officers beginning their watch. Størkersen et al. (2011) also found that certain groups of foreign crew members were especially vulnerable to working long hours and that crew members rest periods were filled with administrative tasks.

When asked to assess their agreement with the statement that "I get sufficient sleep and rest aboard", 94 per cent of the Norwegian respondents somewhat or totally agreed, compared to only 63 per cent in one group of foreign crew members. Clearly, this indicates important differences between nationalities when it comes to work-rest patterns aboard and fatigue. This was also found in interviews.

Crew members often talked about the accumulation of fatigue during their work periods (both crew members working four weeks and crew members working six months) (Størkersen et al., 2011: 21). Crew members working on ships registered in foreign countries were generally more dissatisfied with fatigue. They asserted that their lack of rest was due to small crews and too much work.

Finally, Størkersen et al. (2011) also found that navigators at sea can feel pressure from the shipping company, shipping agent or transport buyer, even receiving phone calls that lead to promises about delivery times that are not easy to keep, for instance. This is interesting in light of similar comments found for drivers of goods transport by road, in Chapter 5.

Another study on platform supply vessel crew (cf. Section 7.2.1) found that seafarers with lengths of duty of 4 weeks and working an 8/8/4/4 regime had significantly better sleep efficiency, more continuous sleep and experienced more sufficient sleep than a corresponding 6/6 group, but there were no differences between the two groups regarding fatigue (Kongsvik et al., 2011).

7.3.2 Findings from interviews with experts

According to our experts there are several interacting causes of fatigue in watchkeepers at sea in Norway, reflecting international findings. These are grouped below as:

- watch systems,
- time of day,
- branch conditions,
- physical work,
- manning and equipment,
- other organisational aspects,
- sleeping conditions,
- individual differences and non-work life,
- use of off-duty time while on board, and
- Norwegian- or weather-related causes.

Watch systems

Experts pointed out that officers and crew on shorter tours, and especially ferries, sometimes want to work as much as possible while on board in exchange for more time onshore at home and with the family (cf. train driver requests for shorter weeks). In the case of ferry crew this has caused a preference for 24 h-watch systems over 12/12 systems, since the latter can mean that crew must be away from home for

longer. However, 24 h-watch systems are also far from perfect as regards fatigue. One ferry captain said:

> "I sail a round trip on the bridge for 90 minutes. I swap with someone and then it's paper work of all types (salary hours, maintenance duties, e-mails) when you are not navigating. I don't have time to make food, and get more tired because of that. Everything is so intense in the 24 hours you are on. A short rest at night, and you are exhausted when you go off."

8/8/4/4-type "two-watch" systems are used on oil supply vessels and certain other ships.

Experts claimed that most seafarers prefer the alternative 6/6 "two-watch" system, even though evidence suggests it leads to poorer sleep. When asked why this was, our expert commented that:

> "It's tradition. 6/6 has always been the way. Some seafarers even carry on with a 6/6 arrangement when they are at home! Some also like to work through the last rest period on board so that they can begin the weekend earlier."

However, not everybody prefers 6/6. One first officer said:

> "I worked a 6/6 watch system for many years, before changing to 12/12. Now I get a chance to sleep fully almost every day, and don't get disturbed sleep patterns. In my opinion 6/6 should be banned. It's impossible to sleep enough and have time to look after yourself. I've never been more tired than when I worked 6/6."

The overall verdict from "neutral" experts (researchers and authority representatives) was that 6/6 were less desirable in terms of fatigue, especially for fatigue accumulating on longer tours of duty. As put simply by one expert, "When you need seven hours sleep to replenish completely, 6/6 cannot be good." One expert added that 6/6 systems are also preferred by some employers, especially if they fit better with the vessel's schedule or task distribution.

In terms of chronic fatigue, watch systems and length of tour were the major factors, according to several experts. For example, one said that:

> "if you are on duty for four weeks and work 6/6, you start to get stressed about getting enough sleep. You think *now I really need to sleep,* and lie there a long time, awake."

Several experts commented that 12/12 systems were disliked by some, and were too long for those with navigational duties or hard physical work.

Another expert, commenting on watch systems worked on fishing vessels said, "fishing vessels practice all types of insane arrangements, there is no organisation round them. They get to decide a lot themselves."

Time of day

Experts claimed that time of day interacts with watch systems worked to cause fatigue. Working a challenging system like 6/6, between 0400 and 0600 h in the morning, will therefore be problematic in terms of sleepiness and physical weariness. One expert pointed out there is no reason why conclusions from international research should be different in Norwegian waters in this respect. One captain pointed out that several on the bridge say they get tired after eating a meal.

Branch conditions

The longest domestic ferry route in Norway is no longer than an hour in duration, and ferries can dock 60 or 70 times a day, often to and from the same two quaysides. Ferry operation can thus become extremely monotonous (cf. signal passes in the rail sector), even though the demand for skill during docking operations remains high.

One ferry officer explained, "There is a lot of back and forth, but the need to be aware at all times in open sea and take extreme care in and out of the quay does not get any smaller." Ferries and fast vessels with many quay arrivals will be subject to time pressure, and officers may be conscious of the need for punctuality in an increasingly competitive branch.

Each vessel type has its own operational pattern, time at sea, number and frequency of port calls and so on. This can influence watch systems, sleep, and the consequences of fatigue. Port calls in particular may contribute to fatigue by disrupting work and rest patterns, requiring most or all crew to be active, or responsible watch officers to supervise lengthy loading operations. The nearer to the coast a ship operates, the more a ship will be loaded and offloaded, the more severe the potential consequences of fatigue may be. A responsible bridge officer on such ships working 6/6 watches will have limited chance to sleep. Some freighters have only two crew, one in charge of loading, one in charge of navigation.

Where there are many port calls, the person loading will find it especially hard to rest. One expert went as far as recommending that anyone interested in fatigue on crews sailing in Norwegian waters should focus on cargo vessels with many port calls sailing close to a difficult coastline, many of which sail under flags of convenience. Other experts added that the relatively narrow operational margins of smaller cargo vessels leads to pressures to cut costs, by minimal manning, poor maintenance of resting facilities, etc., and this also leads to fatigue.

The crew on ships that sail longer distances without many port calls may have more time to rest and look after themselves, but for quiet ships with long spells with not much to do, sleepiness may become a problem. Some other vessels that are out at sea for long periods, such as fishing vessels, can cause mental and physical exhaustion due to disturbed, demanding work, but within the fishing branch there is considerable variation, from two-man enterprises to factory vessels. Other crews (on anchor ships for example) have a lot of waiting around with periods of intense work, so it is difficult to say how much of a problem fatigue is for them.

One expert explained that oil supply vessels were often required by oil companies to set minimum standards on safe manning, but that health and safety standards were not necessarily high across the board in this branch. They did not necessarily always fulfil the need for two navigators on the bridge, for instance. The expert did not think that anyone was especially better at dealing with officer and crew fatigue, but rather that some branches were especially bad:

> "If they can get an extra tour, they will, it's the same for everyone. But you have to remember that [the NMA] see the back side of things. There can be good things, but they don't look at it because it's not directly important to [them]."

Another expert stated that offshore employers are very concerned that shipping companies they use have a focus on fatigue. They added that perhaps it was because they had the resources to do something about it, which for other branches was often not the case.

Although mainly manifest as manning levels, narrower economic margins also affect safety attitudes and culture, safety procedures and training for example.

> "A one-man fishing enterprise cannot be expected to have the same resource as a larger vessel on a mission for Statoil. He needs to do a lot himself to be able to compete, and that means more physical work and more hours at work."

Contracts make a big difference (cf. road sector). Some seafarers can work four weeks and are paid the whole time they are away, whereas others are not paid for the hours they are not actually working.

An understanding of the risks from fatigue also appears to vary with attitude to safety, which in turn varies with culture and nationality, and therefore branch. In some branches, such as fishing, where fatigue may be perceived as a necessary part of the job, there may be an increased *acceptance* of fatigue risks, but this does not necessarily mean that there is less understanding of the risks that fatigue causes.

Physical work

With less people on board, seafarers increasingly have to help out with other duties on board. Physical work carried out before a navigational watch may increase fatigue. The extent of other operations to be carried out depends a lot on vessel type. Loading of shuttle tankers, for example, can take 24 hours or more. Fishing vessel operations can be extensive, with crew working in intense spells from 0500 h to 2200 h, even midnight.

Manning and equipment

Manning level was the key determinant of fatigue for several experts, because it determines both the watch worked, how much work there is to do on board, and how much cover there is in deviant situations. Some ships have too few crew for docking operations, and there is simply too much to do, especially when things go wrong. Manning also affects fatigue via watch arrangements. Norwegian vessels with Norwegian crew have the lowest manning levels, according to one expert (although we have not seen any data confirming this).

Another of our experts had conducted a doctoral study showing that equipment introduced to allow fewer people to navigate the ship did not result in sleep problems for the staff who were left. However, there were more microsleeps due to the monotony of having to monitor the equipment. The expert commented that bridge officers have become more like drivers on the road in this way, especially if they also have to help out with loading, unloading or other physical duties on board before having to stand watch. Another expert commented "There is a danger that you just sit there with a load of systems and nothing to do, this makes the monotony worse." Several experts also pointed out that monotony-related fatigue may play a role in increasing the risk of incidents in open, calm waters in good weather.

The view of experts whose interests may align more with those of shipping companies was not in line with those of other experts (neutral experts and experienced officers). It was rather that more people on the bridge was not necessarily always a good thing. They pointed out that some ferries have just one navigator, yet incidents are rare. Another point made was that more people on the bridge often leads to confusion, and mistaken assumptions about who is taking care of navigation at critical moments. They added that there are no incidents that NMA have said are influenced by the crew size. Since these comments come from only two experts, we must be careful about attributing these comments to shipping companies in general.

Other organisational aspects

Perceived organisational support from the shipping company is important. Dare they get in touch if there are problems with the crew or equipment? Manager attitudes are

important, and the captain's attitude means a lot for the atmosphere on board, even influencing sleep patterns. It is also related to culture on board, which affects all aspects of safety.

Sleeping environment

Cabin quality, noise and motion was mentioned as a problem by some, and it was pointed out that this depends a lot on vessel type.

Position

The captain often does not have proscribed resting hours. The captain and chief machinist are on standby to a greater extent than others in the free periods. There can be a lot of office work for officers in the free periods, and the administrative burden is increasing. First and second officer roles are associated with certain watch start times and other responsibilities (e.g. for safety or loading operations).

Individual differences

People have different tolerances for fatigue at sea, and some struggle with night work, but according to one expert seafarers generally are poor at knowing how tired they are. Two experts with considerable seafaring experience commented on the large variation in proneness to fatigue. "I have never knowingly slept, but I have seen colleagues falling asleep on watch almost every week."

Commenting on age, one expert claimed that experience with severe fatigue helps you know where your limits are, which may mean that older seafarers can predict the danger signs and cope with fatigue better. On the other hand, younger seafarers seem to appreciate the links between nutrition, exercise, and other health-related habits and fatigue to a greater extent than older seafarers do.

Medicine and alcohol

According to one expert, "use of medicine is not controlled in reality, a lot is left down to individual responsibility. If you take a sleeping pill, and something happens on board, an emergency situation, it can be dangerous." Knowing that you can be called out of a rest duty at any time therefore limits the opportunities you have to manage fatigue.

Alcohol use can be an issue. According to one expert:

> "When the vessel goes into harbour, the crew can have two days ashore. Many drink together, have a laugh. The shipping companies turn a blind eye to this, but some have alcohol testing on board. There is a certain accept for drinking on land. Of course this can affect fatigue on board, but I don't know how much. But you can suddenly get two hours warning to leave. Then you come on board in a bad way."

Apparently, NMA do not check for alcohol when they conduct inspections on board.

Onboard free time

Rest periods can be disturbed by non-watch work, noise or the need for extra hands due to deviant situations. When there is time to rest, the facilities that are available to relax and disconnect may be paramount. New technology makes it easier to communicate with home, but this may actually increase stress while on board. One expert stressed this was an important point that should be emphasised. One expert

claimed that "if there is a little storm, you can lose all your sleep, so it is important that everything else is right when conditions allow for sleep and relaxation."

Life outside work

Commuting and the demands of family life may be more influential for those working on domestic ferry routes, who are at home during rest periods. One expert said,

> "For those that work 12/12 or 24-hour watches, the rules say nothing about what you do in your free time. You can drive 2.5 hours to and from a 12 hour watch, spend 7 hours at home resting, and do the same again. The drive in the car home is something many talk about."

In other branches there may be very long commutes to meet up with some ships, and there is often uncertainty about whether this is counted as work or not.

Norwegian causes and weather

The Barents and Norwegian seas are dark and cold, and it can be more tiring to sail them in the winter, especially when there is bad weather. When the ship docks, bad weather often means more hands are needed on deck, and officers too may be called out of a rest period to help. Fishing work in bad weather can be extremely taxing. However, according to one expert, there is no evidence that there are more accidents in the winter. Several experts also commented that sleepiness was a problem in the summer months, when the seas are calm and the watch is monotonous. In the summer there are also more frequent dockings in some branches, with fewer incidents. One expert said that a shipping company thought that this was because semi-retired officers are used to fill in, and that they steer the vessel more carefully.

A challenging coastline, poor weather and poor light in the winter may make it especially difficult for foreign crew to adjust to, according to some experts, and they might get more fatigued because of this. The problem may be worsened by the fact that they apply to the vessels that have limited resources, and they come directly from their home countries or a ship in another part of the world, typically from the Philippines, Poland, Croatia, Russia, Pakistan or India. The international laws that apply to these crew (who are largely on outflagged ships), do not take account of Norwegian conditions.

Summary

In summary, then, limited empirical research and interviews with experts suggest that the findings of international studies on fatigue at sea apply also to Norwegian domestic shipping, in that fatigue takes on several different forms at sea, each of which has a system of interacting of overlapping influences. Coastal freight transport in particular may have fatigue-related challenges, with small crews, crew members filling several functions, fatigue accumulating during long work periods, and periods of work of over 12 hours commonplace. Moreover it has been found that in this branch, the work aboard the ship decides the work/rest pattern of the crew, and hours of work regulation seems secondary in this respect. Officer fatigue in coastal freight shipping may be further exacerbated by short periods between port visits, and many administrative tasks. Expert interviews support that coastal freight shipping may be problematic, and the situation is exacerbated by narrow economic margins.

Other comments show that shipping is a complicated sector, and each branch has its own fatigue-related challenges, and even its own unique profile with respect to the differing dimensions of fatigue. In domestic shipping, coastal freight transport, ferry

work and fishing seemed to be of most concern in relation to fatigue in Norwegian domestic shipping. Comments also suggest that the sleep afforded is not the only factor deciding which watch system is chosen, and that watch systems are often dictated by the nature of the work performed. The most common system, 6/6, also appears to be one of the most fatiguing. Other comments largely reflect international research findings, that factors such as port call frequency, individual differences, organisational approaches or onboard facilities may each contribute to influence fatigue. Finally, there may be aspects of Norwegian domestic shipping that foreign crews, with limited resources, may find fatiguing.

7.4 Consequences

There is ample international evidence that fatigue is responsible for a substantial share of ship groundings. For instance, the UK's MAIB concludes that a third of all the groundings involved a fatigued officer alone on the bridge at night, and fatigue was found to be a contributory factor in 82 per cent of the groundings occurring between midnight and 0600 h (MAIB, 2004: 8). While it may be more difficult to demonstrate the role of fatigue in other types of ship accident, such as collisions and quay crashes, research on the whole suggests that fatigue is a main safety risk at sea. For instance, a questionnaire study of masters and mates working on New Zealand inter-island ferries found that 26 per cent of the respondents recalled being involved in a fatigue-related incident or accident in the last 6 months (Gander & Le Quesne, 2001 in Allen et al., 2008). A 1996 United States coast guard analysis found that, of 279 incidents, fatigue contributed to 16 per cent of all critical vessel casualties and 33 per cent of all personal injuries (cited in Lützhöft et al., 2007: 17).

7.4.1 Previous research in Norway

Data from NMA's accident database, requested for this report, confirm international findings that fatigue plays a major role in groundings in Norway. Groundings were responsible for 41 per cent of a total of 2151 ship accidents reported to the NMA between 2005 and 2013[24]. Most of the other accidents were contact accidents (with quay, bridge etc.), ship collisions, or fire or explosions on board, responsible for 18, 12 and ten per cent of accidents, respectively. Sleeping on watch was responsible for 11 per cent of groundings, but essentially no other type of accident. In addition, it is apparent from the NMA's website that poor watchkeeping practice (lone officer on bridge) has been linked to sleep-related groundings in several cases.

Officer fatigue manifests itself in many other ways than being asleep (e.g. drowsiness, severe mental exhaustion), and while they may also lead to accidents, it is unlikely that they are captured by the reporting system employed by NMA. While the NMA do collect data on "fatigue" as an indirect person-related cause of accidents reported to them, NMA can only register fatigue as a factor where it is reported by those responsible in their descriptions of the accident, and it is almost always reported only when "sleep on watch" is given as a direct reason for the accident. Moreover, the NMA suspect that fatigue is often underreported (see expert comments below).

[24] This figure excludes work-related accidents involving injuries to persons on board, but includes all other types of accident including those involving fire or machinery.

AIBN only has the resource to investigate five to ten of the most serious accidents in Norwegian territorial waters per year. A search of AIBN's website for "fatigue", "sleepiness", "sleep" revealed only three relevant accidents since 2000.

The report by Størkersen et al. (2011: 21) states that when they are asked directly, most seafarers assert that they have sufficient time to rest and that they do not perceive themselves as too tired when they work. Nevertheless, crew members assert that all cases of ships running aground that they know about occurred when crew members fell asleep (Størkersen et al., 2011: 21). While this is anecdotal evidence, it suggests that the role of sleepiness in groundings may be underestimated by official figures. As reported in the section on Prevalence, there were also marked differences between foreign and Norwegian crews on safety-related fatigue, although study limitations should be considered when interpreting these differences.

7.4.2 Findings from interviews with experts

Experts emphasized that Norway has more groundings than countries with less coastline. Thus, because it is a major cause of groundings, fatigue may be a greater risk in Norwegian shipping. However, experts thought that fatigue is one of the most important risk factors for collisions too. Some experts thought that fatigue was also a frequent influence in more frequent minor incidents, such as quay collisions, even though technical factors are more dominant. Experts pointed out that technical problems are often due to human factors, but fatigue is difficult to trace as a cause, as it is more likely to result in safety problems when there is time pressure. All experts were easily able to relate serious and sometimes very costly incidences they knew of – many involving colleagues – that had been caused by sleepiness. Overall, fatigue plays a major role in the most common types of accident in Norwegian waters.

Only one of the eight experts interviewed did not think that fatigue was a notable risk factor. While recognizing that risks were somewhat elevated under certain conditions (monotony, calm seas), they thought that the arrangements put in place by shipping companies (e.g. frequent change of navigation officer) ensured that the risks were small. This expert thought that undue care and attitude of personnel was a bigger risk than fatigue.

An interesting aspect that came up in our discussions with maritime experts was the difference between fatigue prevalence and fatigue risks. There seemed to be general acceptance that sleepiness and fatigue may be most prevalent in the maritime sector (versus the road, rail or aviation sector), but for several experts, the risks of something happening should one become fatigued were lower. As one expert said "the ship can go by itself".

That those ship types with most accidents are those with smallest economic margins supported the contention that manning leads to accidents via fatigue, according to one expert.

7.5 Regulation and management of fatigue

The MAIB study of 2004 concludes that the current requirements of hours of work, manning and look-out are insufficient to manage fatigue in the maritime sector. It claims that due to the global nature of shipping, any effective regulation requires that international maritime legislation be changed:

> "To be effective, any action to reduce levels of fatigue, increase a master's ability to discharge his duties, or to improve the standards of lookout, must be taken on an international basis, and must be mandatory. This can only be achieved via the IMO by amending current legislation or by introducing new measures." (MAIB, 2004: 28).

Allen et al. (2008) assert that fatigue is only likely to be tackled as a serious issue in the maritime industry once a reliable picture on its prevalence is established. They conclude that it therefore is unfortunate that it is only possible to present a reliable picture of the prevalence fatigue in the maritime sector once fatigue is taken seriously enough to deserve an accurate reporting system (Allen et al., 2008: 82-83).

A study of New Zealand fishermen during the New Zealand "hoki" (deepwater fish) season, concludes that avoiding fatigue totally in the maritime sector may be an unrealistic goal (Gander et al., 2005, in Allen et al., 2008). The authors suggest that systems that respond to fatigue should be established. Such systems could provide good contingency planning for situations where factors combine to produce high fatigue levels among crew members (Gander et al., 2005, in Allen et al., 2008). This assertion is important, as we have seen in the foregoing that although work-rest schedules may be followed under normal, calm conditions aboard ships, various circumstances (e.g. bad weather, maintenance work) often create a lot of work and considerable amounts of overtime. The idea of fatigue-responsive systems is also outlined in a recent article on fatigue-proofing (Dawson et al., 2012).

7.5.1 Previous research in Norway

Størkersen et al. (2011: 24) points out that the regulations on working time allow for considerable overtime, and beyond this, it is common for all role types aboard coastal freighters to work for longer hours than the work schedules imply. The main reasons for this are small crews and fluctuating work demands that often become too large to be met within legal working time limits. Hours of work regulations are, however, adhered to when the weather is good and things work according to plan.

Størkersen et al. (2011: 20) found that the answers of the crew members were more positive in the surveys than in the interviews, when the crew members were asked to assess to what extent crew members adhered to the hours of work regulations. The qualitative findings of the Størkesen et al. (2011) study suggest that what is recorded as working time in the deck book that is subject to NMA inspection, may not reflect reality, where the length of work and rest periods are subject to wide deviations, as required to make the ship function.

7.5.2 Findings from interviews with experts

Framework conditions and manning levels

One expert thought that framework conditions do not encourage the international maritime industry to improve safety, including fatigue. "Insurance arrangements are such that shipping companies do not lose out economically if there is a grounding, as long as you can show you have followed the IMO's rules, which are not strict in the first place, and people have not died." Unfortunately this means that small companies with tight economic margins will not solve a problem of crew exhaustion by adding an extra man. There is no business incentive to do so, whatever the effect to health and safety of crew on board.

A captain and member of an officer's union explicitly blamed the NMA for letting the shipping companies reduce manning to unacceptable levels.

> "Some years ago there were eight people running a ferry. Now there's half that number. This is because bids for tender were introduced in the ferry business. Where you save money is by reducing the number on board. Those with fewest crew win the contract. And the unions do not know why NMA approve all this. They protest formally, all three unions. It's obviously a long way from a desk in Haugesund [where NMA are based in Norway] to reality, because they accept lower and lower manning levels on board."

Regulations allowing too low manning levels were also seen as a fatigue problem in other branches, particularly because they made fulfilling directives on bridge watch manning levels impractical. As a result there can be no officer to swap with when an officer becomes tired. Having two navigators is the most obvious way to avoid fatigue-related accidents, according to one captain. "You have to know something can be done when you are tired." Another officer said,

> "There is often a team spirit which means that it happens [that an officer is on the bridge alone. They] can work longer than they should because another has asked if he could just finish eating for example."

Guidance on bridge manning levels were criticized for reducing bridge manning levels at time when sleepiness is more likely (good weather, open water, calm seas). They were also criticized for not applying in Norway:

> "IMO rules state that there must be two navigators on the bridge unless it can be defended from a safety point of view. The rules stipulate that in bad weather, dark, or busy waters there must be two, but it is dark the whole time in winter in [northern] Norway!"

In contrast to these comments, the shipping company representative did not see manning levels as a safety problem, as much as other framework conditions in some domestic branches. In particular the system of bids for tender and punishments for delays were seen to cause rushed arrivals at quays and stress, which were a greater threat to safety than fatigue.

Several expert emphasised the importance of organisation in mitigating fatigue effects. For example:

> "It's undoubtedly the most important factor. The organisation is supposed to be the buffer against framework conditions, weather, individual error, length of tour and so on."

Mismatch between regulatory requirements and job demands

There were several indications from expert comments that regulations are necessarily down-prioritised by many seafarers. Indeed, there may be a view that duties are sometimes carried out in spite of the regulations (cf. goods transport by road). One researcher expert said:

> "Seafarers don't refer to the authorities. There is a feeling that they have to manage things themselves, because the rules do not help them when they need it in practice. You have to do the best you can no matter what the rules say. Some have rules that suit their job, but others find them too rigid. Crew often don't have enough knowledge of the rules, but the focus is on being a good seaman. This can depend on the approach of the ship owner and employer."

Other comments suggested the need to "read between the lines" of the regulations, and manage fatigue informal ways given the realities of shipping. For instance, a captain reported that he had on several occasions allowed people to sleep, when the regulations said they should have been on the bridge. He viewed this as an important "judgment call", where there is a need to weigh the risks of less manning on the

bridge now versus severely fatigue personnel on the bridge later. Another expert added that,

> "Each company wants to get the most out of its staff. So in practice, a lot is done informally, it is left up to those on board to ensure that they arrange things so they don't get too tired, and that they talk openly about the possibility of swapping navigator before people get tired."

The need to bend the rules in shipping is also supported by several comments that the standard timesheets (*hviletidskjemaene*; forms on working and resting hours to be filled out for officers and crew members, subject to inspection by NMA) are filled out with varying accuracy. One researcher expert perceived a one-sided view on ships where "watches are seen on the one side as inflexible, that you cannot leave your watch, but when it comes down to writing your hours on the timesheets, you don't fill out all the hours you work." Other industry experts concurred: "when [NMA] inspect the timesheets they are completely perfect – [they] have even found sheets filled out for the future!" When asked whether they looked at wage slips to see if they were in agreement with timesheets filled out (as done by NLIA in the road sector), one expert pointed out that NMA do not have the resource for it. A different expert was nevertheless adamant that NMA should have a more specific focus on the issue, especially while companies "played tricks" to avoid detection:

> "Resting time arrangements do not work. For instance in theory double watches are not allowed and are not recorded in the watch listings, even though they are still practiced."

The expert recommended that the deck diary should be inspected to get a better idea of reality than timesheets.

> "One reason why Statoil had a good reputation, was that they inspected the deck diaries continually, they get emails twice a day, they are engaged."

Another expert pointed out that despite their problems, the timesheets were helpful because they made the shipping companies aware that staff must not work too much. In contrast to other experts, the expert from the body representing company interests thought current reporting systems worked well.

Reporting of fatigue

Regulations stipulate that seafarers are obliged to report if they are unfit for duty, but expert comments suggested that conditions may not encourage open reporting of fatigue. An expert commented that a lot depends on the shipping company and local union strength as to whether a seaman feels able to report that they need help with fatigue, but that even then seafarers may be too embarrassed to speak up. "Good seamanship is about not blaming others, and not being shown to be weak." One officer agreed, saying that you do not want to ask to get relieved, because you know that would result in resting colleagues being disturbed. This makes it particularly unlikely that seafarers will report fatigue in the middle of a watch, a view supported by another expert.

> "First and foremost, the way to handle fatigue is to bite your tongue and get on with it the best you can. The seaman can say to his line manager that he is too tired to work, but then they are sick. It is more likely then that he will wait until the watch is over, ask to miss the next watch, rather than say in the middle of a watch."

One expert pointed out that each company will have a staff representative, who is meant to take up concerns of the crew and officers, but also stated that fatigue is rarely taken up relative to other issues. Even then, something can only be done in the longer term, such as getting an officer onto a different watch arrangement.

One expert was quite confident that almost all incidences in which a ship is damaged are reported by NIS/NOR ships (due to the penalties incurred on failing to report). Despite this, they believed that fatigue could be underreported as a cause. Several experts commented on NMA's belief that fatigue is influential in a large share of ship damage accidents, more than current statistics would suggest. It seems that if the NMA can prove sleepiness or fatigue as a cause, it does so, but in many cases it is suspected, and cannot be proven. Certain framework conditions may also dissuade seafarers from reporting fatigue as a cause when accidents are reported.

> "If they write *inattention* [on the reporting form], there are no consequences. If they write that an accident was due to *sleeping on watch*, however, the individual concerned will get 30,000 Kr in fines."

One seafarer, who agreed that the problem was underreported, saw things slightly differently:

> "If you report fatigue, the authorities or company ask why there weren't two of you or why you didn't ask to be relieved from duty, but you don't want to disturb colleagues."

Several experts commented that reporting was flawed in the extent to which it accounted for fatigue, and that there were a lot of "hidden statistics" concerning fatigue. The expert representing shipping company interests, however, again disagreed, claiming that fatigue was not reported often as a cause of accidents because it rarely is a problem. One expert said that if fatigue was a clear cause, it was reported as such. If it was a grey area, it wasn't reported.

Accident investigation

One expert commented that AIBN is probably best at getting to the underlying causes of an accident, due to the competence and resources they can devote to one analysis. Another expert commented, "the investigators are good, they cover everything, wife and all." According to one expert, the NMA accident data "must be taken with a pinch of salt", because of the difficulties of assigning fatigue as a cause, the available information and competence available to do so. Another expert explained that "NMA gets 400-500 incidents reported each year, and 240 of these are groundings, 75 serious. [They] only look at between ten and 15 of these because of limited resource." Thus only a small share of incidents can be analysed in any depth, and this means there is a lack of evidence regarding how often fatigue causes accidents. One captain thought that the Coastal Service did a good job of inspections, and were "cleverer than NMA" in that they record a vessels speed and route, and then catch up with it a day later to inspect its certification against how far and how long the vessel has sailed. If there is only one person with certification on board, for instance they will be able to tell if they have rested enough.

Stakeholder cooperation

Another expert commented that relations between NMA and the shipping companies could hinder the extent to which fatigue has been tackled.

> "It's the shipping company's responsibility, and NMA depend on the shipping company's good will. NMA detect that fatigue is a big problem in the sector, but they lack concrete documentation to prove it. […] NMA think that the shipping companies tend to hold information from them, I mean that NMA have indications that there is a problem but no documentation. And the shipping companies report that they experience that NMA suspect them for holding back information. The dilemma is that the international rules are not very strict, and if NMA impose stricter rules, the Norwegian shipping companies say it affects their ability to compete."

7.6 What to do about fatigue?

Implicit in the expert comments was a need to solve mismatch between what the rules say, on the one hand, and how officers and crew must deal with realities of sailing a vessel, on the other.

Almost all experts mentioned explicitly that increased manning would help tackle fatigue, despite recognising at the same time that this was unlikely to happen for commercial reasons. Several stated that there was too much room for interpretation about what levels of manning were defensible in terms of safety.

Experts also gave the following direct comments on what could be done.

- An important way to prevent risks at sea is having clear procedures that are followed, that there is enough time to follow the procedures, especially in deviant situations. On a related point, system resilience could be increased, such that the disturbances and deviations that happen so often do not cause fatigue. There could be better planning in advance to allow for the possibility of fatigue at times and during phases of operation when it is most likely.
- Assist rather than hinder informal judgment calls.
- Fatigue could be included more explicitly in the issuing of manning certificates, which set the minimum safe manning levels for a ship.
- Fatigue could be more in focus during medical checks that the doctor has to carry out on officers and crew every one or two years. (Body-mass index is checked in current exams, but mainly in relation to evacuation requirements.)
- Address the abundance of 6/6 watch systems in Norwegian domestic shipping, especially for those on longer tours of duty. Arrange for different watch arrangements to be tried.
- Encourage an open reporting culture on board, make it ok to ask for a break (one expert claimed that a flattening of the hierarchy would help achieve this)
- Introduce three watch systems (possible given framework conditions?).
- Increase seafarer, company, authority and investigator awareness of and competence on fatigue, include as part of normal training.
- Better address fatigue during medical checks.
- Introduce fitness for duty tests.
- Alcohol testing on board.
- Promote informal strategies among crew members.
- Do not use minimal manning levels to justify manning levels.
- Make it harder for companies to fix the timesheets, e.g. digital cards for each seafarer (cf. road transport).
- Organise transport to and from ship.
- People in different phases of life can be more or less prone to work-related fatigue – accept and address.

7.7 Summary of findings on watchkeeper fatigue

Background

As in other countries, the maritime sector in Norway is in many respects far removed from other transport sectors. It has its own national authority (NMA) and up until

recently, has fallen under a different government department (Ministry of Trade Industry and Fisheries) than land-based transport forms (Ministry of Transport and Communications). It is also governed to a greater extent by international rulings, many of which are can be seen as less stringent than those to which land-based transport forms in Norway are subject to. In attempting to understand fatigue at sea in Norway, it is important to understand not only the global nature of shipping, but the need for Norway to compete with "low-cost" countries, and the framework conditions this has created. It is also important to understand the nature of maritime navigation, which tends more to be a team activity than operating on roads or railways is. Domestic shipping in Norway, with which this report is more concerned, is more subject to Norwegian regulations than international shipping, even though many of these regulations consolidate the international ones. Norwegian shipping is dominated in terms of distance travelled by supply vessels, smaller coastal freighters, fishing vessels, and ferries.

Prevalence

International studies indicate that considerable shares of different types of seafarers are often affected by sleepiness and general fatigue. A Norwegian multi-method study of seafarer fatigue in coastal freight transporters finds contrasting results between the share of Norwegian (four per cent) versus other nationalities (60 per cent) agreeing that safety-critical fatigue is a problem. However, variations in tour phase and length, weather and port call frequency, and culture may help explain this difference. According to another Norwegian study, around half of crew on Norwegian supply vessels agree that they are exhausted after four weeks at sea. Findings from expert interviews support that fatigue is generally fairly common, although it could not be quantified by any expert in our interviews. There would appear to be a lot of variation in fatigue depending on the vessel and branch in which it operates (e.g. less in oil supply than in coastal freight transport). Even so, most if not all officers are likely to have experienced high levels of fatigue, and may accept that it is part of life at sea.

Causes

International research has linked the watch system, time of day of watch and being an officer to poor sleep. Working hours, tour length, manning levels, safety culture on board, vessel type, port call frequency, physical load, perceived job demands, job support, seafarer position (e.g. first or second officer) and physical environment have each been found to predict fatigue in watchkeepers. Branch conditions are often influential since they determine several of these factors. Coastal freight transport has been found to produce crew fatigue in several countries. Certain individual differences have also been found to influence fatigue levels.

A Norwegian study of coastal freight transport suggests that fatigue increases with tour length, and that port frequencies and manning levels are also influential. Work activities during rest periods can also be considerable, and also contribute to fatigue. Some of these work activities may be informal, but are nevertheless perceived as essential part of safe working by officers. The level of off-watch work activities fluctuates widely with operational phase and deviations from the norm, but it is not uncommon there are extended periods where hours of work are violated. Nevertheless, 93 per cent of Norwegian crew and officers reported getting enough sleep aboard, even though only 63 per cent of foreign crew and officers said the same. The higher prevalence of fatigue among foreign crew may be because they

work more, and have longer tours of duty. A separate Norwegian study finds that 6/6 watch system is associated with poorer sleep than a 8/8/4/4 system, but no significant difference in resulting fatigue could be found.

Our experts identified many possible causes of fatigue in Norwegian shipping, largely supporting international findings that watch system, time of day, manning levels, branch conditions and several other factors influence fatigue. 6/6 was seen by most as undesirable in terms of the length and quality of sleep it affords, but it was recognized that many seafarers and companies might prefer 6/6, depending on vessel type. Bridge watches carried out between 0400 and 0600 h were seen as most challenging. Particular challenges were identified for particular branches, with ferries subject to time pressure and routine, and coastal freighters subject to narrow operational margins with frequent disturbances from port calls, physical work and a need to multitask. Fishing vessels vary in size, but may be associated with periods of intense physical work. On quiet vessels sailing longer distances, sleepiness from boredom and monotony may be more of a problem. For some branches, narrow economic margins may cause problems in terms of manning, safety attitudes and culture, attention to safety procedures, hours of work and maintenance activities.

Manning levels are important for fatigue in that they can influence how much there is to be done; how much time there is for sleep; and whether there is cover to alleviate a fatigued seafarer. Monontony-related fatigue may be more of a problem in modern shipping due to increasing bridge technology (autopilot). In addition to helping determine operational margins, manning levels, training, culture and so on, organisations may play an implicit role in fatigue in terms of how open they are to hearing about fatigue, and whether they are willing to do anything about it. Finally, commuting to and from the ship may be overlooked both as a cause of fatigue and a situation in which fatigue from work onboard ship will be hazardous, and foreign crews may find local shipping conditions challenging.

Consequences

International studies show that fatigue is responsible for a high proportion of groundings, especially those occurring between midnight and 0600 h. Data from NMA suggests that ten per cent of groundings in Norwegian waters are due to sleeping on watch, but sleep is related to almost no other accident type. However, since the reporting system used does not capture other forms of fatigue other than actual sleeping, and since there are reasons to believe that officers might be dissuaded from reporting fatigue, we assume that fatigue is underestimated as an influential factor in these data. We would also point out, however, that a search of AIBN's web page for fatigue-related accidents also suggested that the share of accidents due to fatigue was low.

Anecdotal evidence from experts supports that fatigue is more of a problem than available accident data suggest, as a cause not only of groundings, but also collisions and accidents due to technical failure. Experts pointed out that there may be a higher level of acceptance for fatigue at sea than in other transport sectors, because the immediate consequences of errors are not as great. There was very little discussion of the longer term consequences of officer fatigue, and very few comments about its effects on health.

Regulation and management

From international studies we identified the following assertions regarding the future regulation and management of fatigue at sea:

1. The current regulation, based on hours of work, manning levels and lookout requirements are insufficient to control fatigue.
2. Fatigue cannot be tackled without employing a standard measure for its prevalence.
3. Avoiding fatigue is unrealistic since vessels will always be undermanned to some extent, and working hours will always fluctuate beyond standard hours of work and rest (due to normal operational fluctuations). This suggests that a focus on systems that can safely accommodate any fatigue arising would be beneficial.

Support for the third assertion is available in the case of Norwegian coastal freight transport, where discrepancies have been found between officially recorded and actual hours worked on board. Support also comes from expert comments that regulations are seen at times as unhelpful and rigid, with the result that they are often down-prioritised by officers. Working hours and timesheets can differ, and manning levels on many vessels are such that captains may deem it safer to violate regulations, especially those concerning the need for a lookout on the bridge. However, one comment that a major oil company inspects deck diaries in order to get a realistic idea of actual time worked, implies that companies with resources can do more to be aware of actual working time, such that they can control it.

Expert comments also suggested that:

- Current insurance arrangements could do more to encourage shipping companies to tackle fatigue.
- International rules on fatigue insufficiently allow for local sailing conditions.
- Fines imposed for lack of punctuality in the ferry branch leads to time pressure and increases the risk of fatigue-related handling errors.
- An open reporting culture does not apply when it comes to fatigue, especially for fatigue that arises during a watch (but informal systems for indicating fatigue may exist among bridge personnel).
- Fatigue is not often taken up as an issue between staff representatives and shipping companies.
- Resources required for in-depth investigations of fatigue-related accidents may prevent learning and applying lessons from such accidents.

Thus most experts agreed that fatigue is not sufficiently controlled in modern Norwegian shipping. Finally, we conclude with a comment by one expert, that progress may require better recognition and cooperation on the issue between the responsible Ministry, unions, shipping companies, the NMA and other authorities[25].

[25] Expert comments supported this. Firstly, we found little recognition that fatigue was a problem from two experts representing a national trade organisation for shipping companies, despite that all other experts thought it was a problem. Secondly, there were markedly differing perceptions, e.g. a union representative perceived that the NMA was to blame for letting manning levels fall, whereas the NMA would probably see that its hands were tied by IMO regulations and Norwegian shipping policy. Thirdly, one expert commented on a certain level of suspicion between NMA and the shipping companies on reporting issues.

8 Comparison of fatigue in different transport sectors

8.1 How prevalent is operator fatigue in the different sectors in Norway?

The use of one-off single item measures in Norwegian studies makes it difficult to conclude much about prevalence for different types of operator in the road sector. This problem is also seen in international studies (Phillips, 2014b). Nevertheless, a summary of findings on the prevalence of fatigue in different transport sectors in Norway can be given in Table 11. The most convincing evidence that fatigue is a problem in the road sector is probably that 13 per cent of professional drivers report experiencing at least one episode of sleep behind the wheel in the preceding year. Other available measures also suggest that substantial shares of bus and truck drivers experience other types of fatigue at problematic levels.

Due to a lack of research on train driver fatigue in Norway, we must rely on Nordic studies, which show that considerable shares of train drivers report experiencing sleepiness and acute and chronic fatigue (see Section 6.2). Important differences among the rail sectors of Nordic countries underline the need for Norwegian research into the prevalence of train driver fatigue.

A Norwegian multi-method study of seafarer fatigue in coastal freighters finds vastly contrasting results between Norwegian and foreign crew reporting safety-critical fatigue, but we cannot be sure about the reasons for the differences (Table 11). Again, knowledge is limited by a lack of Norwegian studies and almost no use of standard measures.

Thus we do not have prevalence rates for sleepiness while operating for either train drivers or seafarers, and are currently unable to compare sleepiness levels for different types of transport operator, either in terms of incidence of falling asleep while operating or in terms of acute or generalized subjective sleepiness. We also know little about aspects of fatigue other than sleepiness, such as mental fatigue, chronic exhaustion or physical fatigue, either within or across different transport sectors. These knowledge gaps limit the extent to which we can identify areas in which fatigue must be addressed within Norwegian transport, and the extent to which we can place Norwegian operators in an international context. The situation could be improved by promotion of a standard measurement battery to quantify various aspects of fatigue, as described in our previous report (Phillips, 2014b). Such a battery could include the Fatigue Questionnaire, the Fatigue Severity Scale or the Epworth Sleepiness Scale, for which population norms are available in Norway (see Section 2.3).

Table 11. Summary of the evidence for the prevalence of fatigue in different Norwegian transport sectors

Sector	Empirical evidence	Expert comments
Road	Compared to leaders and service workers, professional drivers are (Ursin et al., 2009): • 1.8-times more likely to suffer from excessive daytime sleepiness. • 2-times more likely to fall asleep at work. Shares reporting having slept behind the wheel in the preceding 12 months are as follows (Nordbakke, 2004; Phillips, 2012): • 16 % truck drivers (vs 11 % private car drivers). • 12 % bus drivers (vs 11 % private car drivers). • 10 % company car drivers (versus 5 % private car drivers). 14 % of local truck drivers are bothered by fatigue every day (Enehaug & Gamperiene, 2010) 20 % of bus drivers are so tired and exhausted they have considered quitting (Moe, 2006)	Stress, physical demands and/or lack of sleep can lead to fatigue in most types of local/long-distance and goods/passenger drivers. As a frequent problem, sleepiness is confined to certain populations e.g. those carrying out monotonous driving through night. Less is known about the prevalence of mental fatigue, even though it may also affect health and safety. Local truck drivers have more stress/physical demands and may be more at risk for a workplace accident; long-distance truck, more sleep-related fatigue, but there are also physical demands and associated risks. Fatigue maybe worse for taxi and truck drivers. Experts cannot quantify fatigue prevalence.
Rail	-	Little knowledge about prevalence of either sleepiness or mental fatigue in train drivers in Norway. Thought to be less prevalent than in other sectors, but this does not mean that fatigue is not common among train drivers. Main concern among drivers related to lack of sleep and sleepiness.
Maritime	4 % of Norwegian and 60 % of foreign crew and officers on coastal freighters agreed that "I am sometimes so tired in my work time that safety is at stake" (Størkersen et al., 2011). Half of a sample of crew and officers on supply vessels agreed that "After 4 weeks on duty I feel completely worn out" (Kongsvik et al., 2011).	Most experts think fatigue and sleepiness is common at sea. Particularly prevalent on busy vessels with many port calls operated round the clock. Prevalence varies a lot with voyage and vessel characteristics.

Expert comments support the need to measure different forms of fatigue in different populations of operators, within and across branches (Table 11). In the road sector, for instance, mental fatigue or exhaustion has been overlooked in relation to sleepiness, but has important effects on many aspects of driving (Phillips, 2014a). Mental fatigue will also be important for train drivers, not least since it challenges train drivers' ability to continuously think ahead and plan (Phillips & Sagberg, 2014). Finally, at sea expert comments also indicate that fatigue is a problem that justifies a greater weight of empirical evidence than is currently available.

8.2 What conditions cause fatigue?

Due to the problems of measuring fatigue prevalence, together with a lack of longitudinal studies, it is also difficult to draw robust conclusions about the causes of fatigue from Norwegian studies. Nevertheless it is possible to do what many other studies do, i.e. induce possible causes for further investigation.

Perhaps the most important determinant of fatigue for the transport operator is working time. By delimiting the time of day and duration of non-work time, working time is a major influence on an operator's ability to recover from (a) work period(s). This is consolidated by international research, and the reinforced by the findings in this study.

Findings on the causes of fatigue in the road transport sector are given in Table 12.

Table 12. Summary of findings on causes of fatigue in Norwegian road transport sector.

Empirical evidence	Expert comments
Poor sleep. Compared to other professions, more drivers have less than 6 h sleep on work night (24 %) and wake up earlier (Ursin et al., 2009). Age. Older bus drivers suffer more from exhaustion, but have better coping strategies (Moe, 2006), which may explain why truck drivers are less likely to fall asleep at the wheel (Nordbakke, 2004). Branch conditions. More truck (42%) than bus (31%) drivers report to have fallen asleep at wheel (at any time) (Nordbakke, 2004). Branch-related pressures also linked to driving hours violations (Nordbakke, 2004). Qualitative research suggests high psychosocial and physical demands in some bus and truck branches (Askildsen, 2011; Enehaug & Gamperiene, 2010; Schjøtt, 2002; Longva & Osland, 2008), but not directly linked to fatigue. Job characteristics. Above studies suggest low job control and support, and lack of information may cause fatigue for most professional drivers.	It is not just driver attitude, the system is the problem. Working time, shifts, driving and resting time regulations. Particular problems are driving between 0300 and 0600 after a long trip; double shifts; backward-rotating shifts encouraged by driving time rules for long-distance drivers; split shifts for bus drivers; driving hours regulations that do not necessarily allow drivers to rest when tired. Task-related causes. Two problematic tasks characterised as monotonous drives involving high level of automisation (e.g. cruise control), and high demand tasks associated with exhaustion and negative stress loops. Organisational conditions. Goods, coach and taxi branches contain many small independent outfits where drivers "do what it takes" to keep the business afloat. Such companies often lack resources for training and driver support. Driver-leader relationship is key. Safety culture will be key and influence driving hours transgressions. Branch conditions. Differences for goods and passenger transport outlined (see 5.6). Fish and bulk goods transport may be problematic, hazardous goods less problematic. Bus not as sleepy as goods, but has its own particular fatigue causes. Little known about taxi, but fatigue probably a problem due to long days, driving at night. Level of loading tasks influential in goods transport. Transport buyers and shipping agents can set unreasonable driving conditions in goods branch, and a low level of union organisation among drivers means there is lack of opposition. Overtime and pay systems that encourage fatigue are still in use. Individual. Anecdotal evidence that older truck drivers struggle with exhaustion. Poor diet, lack of exercise, ongoing health complaints, improper medicinal use each add to fatigue. Life outside work and commuting cited as problematic. Norwegian causes. Lack of resting places, darkness, poor road conditions, increased physical demands can make Norwegian winters fatiguing.

In the road transport sector, National and EU regulations on working, resting and operating hours are designed to help provide periods and rest patterns that allow for *minimum* sufficient recuperation. However, Norwegian evidence based on empirical evidence and expert interviews suggests that many drivers in the heavy goods, coach and taxi branches may struggle to get the job done within the confines of working or driving hours regulations, which in some cases may be used as operational norms rather than absolute limits. In some cases drivers experience framework conditions that means that they must stretch regulatory boundaries to the full. Such conditions

are nurtured by a relative lack of driver representation in these branches, and are promoted in goods transport by the power of the transport buyer in setting delivery terms and conditions. Furthermore, while working and driving time regulations provide important boundaries and do a lot to limit fatigue, they do not account for all causes of fatigue (e.g. fail to distinguish between night and day driving).

In order to survive, transport outfits may perceive that they need to exploit their driver resources to the full. The tension between framework conditions and the regulations on working and resting time, together with the inability of regulations to account for the wider aspects of fatigue or hold transport buyers accountable, may mean that some drivers in these branches often do not obtain sufficient sleep or rest.

By determining the extent of exertion from which operators need to recover, the type of work is an important fatigue determinant, in addition to working time. Empirical evidence suggests that professional drivers in all branches may face poor physical and psychosocial working conditions relative to many other occupations, with fluctuating periods of overload and underload, in which they have little control and lack social support. Experts suggest that the effects of such conditions on fatigue may be moderated, depending on the transport branch, organisational conditions and various individual differences and habits. In Norway, winter driving and a relative lack of resting places may also contribute to increase fatigue.

Findings on the causes of fatigue in the rail transport sector are given in Table 13.

Table 13. Summary of findings on causes of fatigue in Norwegian rail transport sector.

Empirical evidence	Expert comments
No empirical evidence found directly linking fatigue to causal factors.	Shifts / time of day. Split shifts, shifts against the clock, early starts, and night shifts that progress through sunrise hours may be problematic. Long shifts in the day can also cause fatigue towards the end, if they progress into late evening. Extensive shift-swapping may increase fatigue. Drivers willing to work longer stretches in exchange for longer free periods.
Few work shifts at Flytoget found to be at risk for causing high levels of acute sleepiness, but short rest times (<12 h) between shifts and mismatch between scheduled and actual hours worked may cause increased fatigue.	Individual. Large inter-individual variation in prioritisation of being fit for duty. "Older drivers appear to suffer more", perhaps feeling more sleepy in afternoons. Life phase important, e.g. drivers with young families are often able to choose early shifts – good for work-life balance but perhaps not for fatigue? Time pressure. Limited evidence that time can be perceived as too regulated. Branch conditions. Smaller cargo companies may experience framework conditions that create more pressure for drivers. Cargo and Flytoget involves more night driving, and may be more sleepiness. Tram drivers face busy urban environments and competing demands. Norwegian causes. No serious problems. Norwegian track environment may be less monotonous but presents more cognitive demands. Dark winters not a particular issue. Use of younger inexperienced drivers in summer months may mean fatigue more prevalent then.

The scant evidence from the rail sector on the causes of fatigue suggests that shift schedules are not a major contributor, although increased rest times between shifts may help limit fatigue still further. Expert comments generally support that the way shift schedules are designed plays an important role in limiting fatigue, although problems can inevitably arise at certain times of the day. The interests of drivers in the rail sectors are represented during schedule design, and drivers get to choose

schedules to a certain extent, in marked contrast to many working in road transport. Interestingly, the large degree of control drivers have may itself contribute to fatigue, in the sense that schedules that are optimal for limiting fatigue might not be worked due to the practicalities of home life. This would imply that schedule designers would do well to work with operators, to help them strike a balance between meeting work-life needs on the one hand and recuperation needs on the other. Nevertheless, it is unlikely that rail drivers will continue driving through periods of severe sleepiness. All indications are that most drivers will report this, and then receive support from colleagues and the organisation. This may not, however, prevent the build-up of chronic fatigue over time, and there is some uncertainty about whether different forms of fatigue are equally likely to be reported. There are also indications that some drivers may be reluctant to report fatigue in situations where they perceive that they will let down their colleagues. Drivers could be assisted in reporting fatigue by explicit discussion and further legitimization of the different types of fatigue that are valid. Individual variations were discussed largely in relation to being fit for duty in the rail sector, and again certain branches seem to have their own fatigue-related challenges, although to a much more limited extent than in the road sector.

In the maritime sector, empirical evidence is again limited (Table 14), and focuses largely on coastal freight shipping. Nevertheless, the findings are consolidated by international evidence and expert comments. It suggests that watch system and timings, manning levels, weather, and the operational characteristics and length of the voyage combine to influence fatigue. In many cases there will be curtailed opportunity for sleep, such that sleep timing, sleeping conditions and length of the voyage will be paramount in determining the level of fatigue that builds over time. The 6/6 watch system, commonly worked in Norwegian waters, has been shown by international studies to produce curtailed and poor sleep, relative to other systems, but crew may not always wish to work schedules that are best at limiting fatigue.

Again, fatigue-related challenges faced by an operator can depend on the branch in which they work. As in the road sector, operational margins and supply chain actors can influence working conditions. Again, experts note that there is large variation in individual fatigue proneness and ability to cope at individual level.

Table 14. Summary of findings on causes of fatigue in Norwegian maritime transport sector.

Empirical evidence	Expert comments
For crew on coastal freighters (Størkersen et al., 2011) there is a mismatch between scheduled and actual watches worked, such that time for rest and sleep is too limited. Mismatch increased by unusual situations, port calls, need to perform several functions due to low manning or lack of crew competence, and the need to conduct informal activities seen as important. As a result, sleepiness accumulates with voyage length. Foreign crews worked longer hours. Ships registered in foreign countries generally had more fatiguing work conditions. May be some pressure from supply chain actors in some cases. Watch system: on supply vessels 8/8/4/4 associated with better sleep than 6/6 (Kongsvik et al., 2011).	Watch systems. Officers and crew want to work longer stretches in exchange for more time off, so may prefer more fatiguing systems. Traditional preference for 6/6, despite recognition that it limits sleep. May be operational reasons for choosing 6/6 or other "more fatiguing" systems. Time of day. Watches between 0400 and 0600 produce most acute sleepiness. Can be stressful getting enough sleep at unusual times of day. Branch conditions. While severe routine, time pressure, commuting may be issues for ferry crew, port call frequency, operational margins and organisational culture may be key for coastal freighters. May be severe physical demands and greater acceptance of fatigue in fishing, while conditions in oil supply relatively good. Physical work. Officers in smaller crew may need to help out before watch. Loading operations can be extensive and involve night work e.g. shuttle tankers. Manning and equipment. Key for several, since determines watch system and demands on board and in port. Autopilot facilities may increase sleepiness in good sailing conditions, and there will probably be less crew around for support. Organisational support. Is the organisaiton receptive to hearing about and tackling fatigue-related problems? Sleeping conditions. Noise, motion. Individual differences. Position on board associated with certain duties. Large variation in proneness to sleepiness. Older seafarers may cope better with fatigue, but younger crew seem to appreciate links between nutrition, exercise and fatigue. Use of medicine on board, and alcohol on shore can influence fatigue on board. Off-duty time aboard and ashore. Long commutes a challenge. Work-life balance may be more fatiguing for ferry crews, who often go home during free periods. Norwegian causes. Lower manning for Norwegian crew? Bad weather taxing, especially in the northern seas in the winter. Coastline can be demanding, may especially tax foreign sailors.

8.2.1 Recurring themes

We wish to present some recurring themes discussed in relation to causes of different forms of fatigue in different Norwegian transport sectors. We stress that these are *themes* for further exploration rather than empirically determined causes of fatigue.

- **Working and resting time.** Insufficient or poor quality sleep can be caused by having to work time and time again at varying and unusual times of the day in order to fulfill contractual terms, or as determined by shift or watch systems. Can cause both acute and chronic sleepiness or fatigue. Mismatch between planned and actual schedules is also a recurring theme related to working time. Time of day of work (0400-0600 h especially problematic) is also an important cause of sleepiness, and is determined by working time.
- **Branch or framework conditions.** Competition conditions, extent of driver organisation, power of supply chain actors to set demands, aspects of transport infrastructure (especially resting places in road transport sector), individual's freedom to choose schedule worked are examples of factors shared by a branch in which the operators works, that can influence fatigue levels in that branch. Fatigue is also influenced by the operational demands of the branch, need for physical work, other tasks, branch tradition and culture, occupational pride, or the reporting culture in relation to fatigue.
- **Organisational culture** – especially regarding safety and fatigue.

- **Psychosocial work conditions** – job demands, control and support, and other aspects of job design.
- **Sleeping conditions**. Many operators in each of the main road sectors need to sleep at home.
- **Commuting**. Risks for operators while commuting are important for organisations to consider.
- **Non-work life and life phase** – can influence fatigue at work.
- **Individual differences** – proneness, health, coping and use of medicine, drugs or alcohol.

Causes of fatigue that are particular to **Norway** are not included in the above list, since experts cited them only as problems in the road and maritime transport sectors. Long periods of darkness, a challenging geography (e.g. coastline difficult to navigate, poor or icy roads), and inadequacies of infrastructure are nevertheless important to consider as causes of fatigue in Norwegian transport.

Thus, each sector and branch is itself a complex system with unique framework conditions which will themselves influence the level of exertion required over time by the individual operator, and the opportunity to recover from that exertion, through sleep and rest.

Finally, we note that the above factors will often interact in dynamic ways to influence fatigue.

8.3 What are the consequences of fatigue in the sectors?

Norwegian research and accident reports confirm that sleepiness causes substantial shares of serious accidents triggered by truck and bus drivers. Among the findings are that:

- Fatigue contributed to one in three accidents in which trucks drive off the road.
- Fatigue contributed to seven out of 44 fatal accidents triggered by professional drivers in Norway between 2005 and 2008.
- Bus drivers ascribe fatigue as the main cause of one in every 20 accidents in which they are involved.
- Fatigue and stress are the most commonly cited "abnormal conditions" for professional drivers involved in fatal accidents from 2005-2011.

Many near miss incidents that are due to fatigue may also go unreported, and can be inferred from the finding that 36 per cent of professional drivers who have fallen asleep at the wheel report that they carry on driving.

Experts estimate that fatigue contributes to between 15 and 20 per cent of serious traffic accidents caused by professional road drivers. They point out that fatigue is underestimated as a cause of accidents, due to the problems of assigning fatigue as cause, and underreporting by drivers. Based on expert comments, the health effects of fatigue on drivers may have been overlooked.

Norwegian data suggest that 13 per cent of signal pass incidents occurring in the rail transport sector are due to fatigue. Data from other Nordic countries shows that critical incidents are more likely to occur up to the third hour of the shift, before decreasing again, and that fatigue-related accidents are more likely to occur in the darker months of the year (Kecklund et al., 1999). In addition, up to 37 per cent of

Finnish drivers working nights report that fatigue impairs performance (Härmä et al., 2002).

Anecdotal evidence from Norwegian rail experts is supportive. However, they also recognize that underreporting may be a problem, despite a relatively open reporting culture. One expert estimated that fatigue may actually play a role in between 20 and 25 per cent of signal pass incidents, although other experts thought fatigue played a more minor role. Fatigue was also recognized as an important risk during shunting operations and for drivers needing to attend to signals preceding level crossings.

Data from the Norwegian Maritime Authority (NMA) suggests that sleeping on watch is responsible for ten per cent of groundings in Norwegian waters. This figure is lower than that found by international studies analyzing in-depth reports, again suggesting that the contribution of fatigue may be underestimated - again due to underreporting. Sleeping is rarely reported as a cause of any type of accident other than groundings, despite the fact that experts thought that fatigue was also a cause of collisions, both between ships and with quays. According to the NMA's database, fatigue is not mentioned in connection with any accident, unless it is a cause of falling asleep on watch. These observations make us doubt whether fatigue is reported adequately.

Finally, we note that much remains unknown about the effects of fatigue on health, wellbeing or productivity in Norwegian transport operators in any sector.

8.4 How is fatigue managed?

The main way fatigue is controlled in the road transport sector is by working and driving hours legislation. Violations of these rules appear to be common, at least among goods and taxi drivers. Truck drivers who often violate the rules are more likely to report they have fallen asleep at the wheel. Drivers report time pressure as a main cause of violations.

Apart from violations, a problem with driving hours regulations are that they can themselves contribute to stress and time pressure. For instance, one in five local truck drivers report that they have little control over their breaks and cannot carry out their work within formal work hours (Enehaug & Gamperiene, 2010).

Comments from our experts supported the need for working and driving time legislation in road transport, but they too listed a number of problems. These included:

- Inflexibility can prevent the ability of drivers to manage their fatigue effectively (by enforcing breaks during alert periods, or bouts of sleep during the daytime).
- Incoherence between regulation, supportive infrastructure (e.g. nowhere to stop when it's time to stop) and framework conditions (e.g. schedules that allow insufficient time for breaks in reality, especially when the driver is delayed).
- Drivers are often unsupported, and remain largely responsible for compliance, even though the drivers have little control over their work schedule.
- Drivers perceive that the risk of detection of transgressions is low, and it actually is low.
- Ways of evading detection are common knowledge (although prevalence of evasion is not known).

Experts seemed to think that road transport organisations overall could do more to manage and regulate fatigue among their drivers (e.g. sensible shifts, open reporting culture, well-planned operations, health services who understand driver challenges). Some established companies in certain branches do take steps to tackle the problem (e.g. hazardous goods transporters, ISO-39001-certified companies), but in many goods or passenger transport branches the organisations are often too small, and may perceive that there is too little resource to tackle fatigue.

As in the road sector, there is evidence that watchkeepers on vessels in some branches of the Norwegian maritime sector struggle to keep their working time within the limits described by watch systems and regulations. This is the case even though the regulations on working time are the less stringent than in land transport, allowing seafarers to work up to 14 hours a day and 77 hours a week (see Section 7.1.4). Even these regulations can be perceived as too rigid by seafarers, who may simply want to help their colleagues meet the widely varying demands of a vessel's operation. Captains too may perceive some regulations as failing to address the practical realities of modern shipping, with its low manning and increased demands. As a result there can be large discrepancies between recorded and actual hours worked on board, such that transgressions in the maritime sector may be more systematic and serious than in the road sector.[26] However, empirical studies are needed to test this assertion. We found little evidence of the systematic management of fatigue by shipping companies, or even recognition that fatigue was a safety problem. There was evidence of a lack of an open reporting culture related to fatigue, at least during a watch. Apart from working and resting hours, informal systems on board may be one of the most important ways in which fatigue is regulated in modern shipping.

Working time in the rail sector would seem to be more favorable than in either the road or maritime sectors. In Flytoget, for example, a normal working week is limited to 33.6 h, yet it is possible for professional drivers in the road sector to *drive* up to 56 h a week and seafarers to work up to 77 h a week (Sections 5.1.3, 6.1.4, 7.1.4). Furthermore, compliance of working and resting hours appears to be better in the rail sector in Norway than in the road or maritime sectors. The following conditions are amenable to management and regulation of fatigue:

- Open reporting culture concerning fatigue (drivers have a traditional obligation to report if they are not fit to drive, and surrounding conditions attempt to nurture open reporting).
- Highly organized working relations (nearly all drivers are union members, and employee unions work together to achieve common goals) that fit well with the "Norwegian model" (see Section 2.2).
- Drivers participate in development of shift schedules, and working time is flexible such that it can be adjusted to suit the driver's developing needs.
- Monitoring by employer of schedules worked for any fatigue-related problems.
- Drivers are taken care of systematically following serious incidents.
- The need for driver restitution is largely respected all stakeholders in the transport operation.

[26] E.g. while main daily rest transgressions were found to have been committed by 31 per cent of drivers in the road sector, 24 per cent are minor, and 7 per cent serious and reportable (Nygaard, 2014).

- There are regular health checks and follow-ups by the company health service, and recent regulations require companies to conduct psychological checks following incidents.

While we could find no comprehensive programs devoted to the assessment and management of fatigue, we found several ways in which organisations detect and manage fatigue-related issues, at least in passenger branches. These included:

- Education of new drivers about the risks of shift working and how to manage them.
- Encouragement and regulatory obligation to report fatigue (or not being fit for duty) before or during driving. The company is obliged to find other non-safety-sensitive duties where possible.
- Drivers are encouraged to raise fatigue-related issues with their leaders, who can also monitor for signs of excessive overtime or risky shifts. This appears to be done largely informally, however.
- Commissioning by companies of independent assessments of shift schedules.
- Rest facilities offered at base to maximise sleep opportunity for drivers during shorter off-duty periods.

In the rail sector, a driver's non-work life may be important in regulating his or her fatigue, and the organisation may be unwilling to interfere in this domain. Non-work life may often determine whether drivers exploit their freedom to choose or swap shifts that may increase their fatigue. Drivers may also choose to work well-compensated shifts that are more fatiguing, even though there are limitations placed on the number of such shifts they can work. This implies that there is a balance to be struck when deciding actual schedules worked, in terms of the flexibility and freedom drivers have to choose their own working time, on the one hand, and the benefits in terms of fatigue, on the other.

8.5 Comparing sectors on a fatigue-risk trajectory

In our previous report (Phillips, 2014b), we presented a modified fatigue-risk trajectory, developed from a model by Dawson and Fletcher (2001). The trajectory describes different levels at which fatigue can be monitored and tackled, and the idea is that a comprehensive fatigue management system should account for each of these levels.

Table 15 summarises the different levels of the trajectory and assesses the extent to which the different Norwegian transport sectors account for them, based on our findings in this report. According to this table, there are several fatigue-risk areas that each of the three transport sectors could better address. In particular, little is done to account for life outside work as a cause of fatigue at work, and little is done to assess either actual sleep obtained or the extent to which an operator has recovered from previous work or monitor fitness for duty. There is little evidence of systematic analaysis of schedule for fatigue risks in the road or maritime sectors. In none of the sectors do companies monitor on-the-job fatigue, or use formal systems to monitor aspects of behaviour or performance that indicate developing fatigue. In the road and maritime sectors, there is uncertainty as to whether companies legitimize and support the open reporting of severe fatigue. Investigations of accidents and incidents could also be improved, such that each branch could learn from them.

Table 15. How well do different sectors account for different levels of the modified fatigue-risk trajectory?. For explanation see Phillips (2014b).

Risk level	Description	Road transport	Rail transport	Maritime transport
1	Working time, work quality, non-work life quality.	Some problems with how regulations limit the build-up of fatigue, and how regulations are enforced. Managers do not assess schedules for associated fatigue risks. Little known about extent to which psychosocial and physical work conditions cause fatigue. The role of non-work life in fatigue at work is largely unaccounted for.	Working time most favourable of the three sectors; but time off between shifts could be extended. More could be done to account for the routine nature of work in the build-up of fatigue. The role of non-work life in fatigue at work is largely unaccounted for.	Working time least favourable in terms of fatigue. Managers do not assess schedules for associated fatigue risks. Sleepiness due to standing watch at unusual times of day a known problem. Many other aspects of work are also fatiguing, and there can be large fluctuations in demands that are not accounted for. The role of non-work life in fatigue at work is largely unaccounted for.
2	Actual recovery from work.	Nothing done to assess actual sleep or recovery from previous work.	Nothing done to assess actual sleep or recovery from previous work.	Nothing done to assess actual sleep or recovery from previous work.
3	Reports of fatigue and behavioural symptoms.	On-the-job fatigue and its behavioural symptoms are not assessed. Branch to branch variation as to whether drivers feel they can report severe fatigue.	On-the-job fatigue and its behavioural symptoms are not assessed, but drivers encouraged to report safety-relevant levels of fatigue, and supported when they do so.	On-the-job fatigue and its behavioural symptoms are not assessed. While crew may develop informal ways of identifying and tackling fatigue, formal reporting threshold may be high.
4	Fatigue-related errors.	Few, if any, branches monitor aspects of performance that indicate fatigue.	Little done to monitor aspects of performance that indicate fatigue.	Some fatigue-related errors may be captured, but only in informal ways.
5	Fatigue-related incidents and accidents.	Investigations of serious accidents account only for sleep behind the wheel, or clear violations of driving and resting hours regulations.	Uncertainty as to how fatigue is reported for signal pass incidents. Fatigue accounted for in serious investigations.	Fatigue only appears to be reported where sleep on watch has led to grounding.

8.6 What do experts say can be done to tackle fatigue?

Recommendations about what organisations and authorities can do to better address fatigue, derived directly or indirectly from the experts' comments, are presented in Table 16.

Organisations can tackle fatigue by introducing tailor-made fatigue management programs, or by including fatigue as part of existing safety risk management systems (Phillips & Sagberg, 2010a). Many road and transport companies and ship owners could probably improve fatigue levels by implementing only a few of the measures presented in Table 15. A main challenge for the road and maritime sectors is that leaders or transport owners in many cases might perceive that operational margins are such that they do not have resources to tackle fatigue, even though they may be ethically motivated to do so. In some cases there may be a view that drivers are a resource that need to be fully utilized if the business is to survive. Therefore, measures that make it financially desirable for companies to tackle fatigue may assist the likelihood that measures in Table 15 will be considered. The right people need to be convinced about the potential business benefits of a healthy and safe work force, in terms of reduced turnover, lower sickness absence, increased productivity and so on (Wallington et al., 2014; Bidasca & Townsend, 2014). Transport buyers could also be encouraged to hire companies with safety certification encompassing effective fatigue management, or insurance companies could offer reduced premiums to such

companies. Where companies do take action to tackle fatigue, perhaps by implementing some of the measures in Table 16, it will of course need to be anchored in company policy and procedures and consolidated by visible management commitment and engagement.

The particular challenges to be met by road and maritime authorities are given in Table 16. There would appear to be less that the regulators can do in the rail sector, and this reflects the better alignment of rules and demands in the rail sector, and the low level of working hours violations that results. In the rail sector, much of the focus has been on controlling fatigue through shift schedule design and hours of work. This is understandable given the established effects that shift work has on sleep and fatigue. However, schedules and actual hours worked can differ substantially, and drivers' ability to choose and swap schedules may reduce the extent to which the originally designed schedules limits fatigue. Thus there is a need to measure and monitor how tired drivers are, such that any problems can be captured. Such monitoring would also allow fatigue caused by seasonal variations or serious life events to be identified and tackled.

There is an additional need to learn more about the role of different forms of fatigue in rail incidents. Simple reporting tools for measuring fatigue are available (Kecklund & Ingre, 2006). Education of drivers and leaders on how to use these tools to report fatigue arising during normal work or in the run up to incidents, would provide a good starting point for the further control of driver fatigue in the rail sector.

Table 16. Expert suggestions to reduce fatigue prevalence in different transport sectors.

Road	**Regulators, authorities:** • Find ways to encourage the sector to act collectively on fatigue in branches with highly individualised work. • Implement minimum rest period following loading and unloading. • Find ways to actively engage transport buyers, shipping agents and truck owners in driver health and safety. • Increase extent to which actors other than drivers are punished for violations of driving and resting hours. • Consider ways to change driving/working hours legislation to give drivers more control, and allow them to follow their biological clock to a greater extent. • Increase perceived risk of detection for violating driving and working hours. • Ensure appropriate rest facilities are available when driving hours rules say they are needed. **Organisations:** • Educate the drivers they employ about fatigue and its risks. • Work to change the culture from perceived need to hide fatigue to one of openness about fatigue. • Include drivers in the design of transport schedules that account for systematic evidence of fatigue risks. • Measure and monitor different forms of staff fatigue. • Educate to standardise reporting of severe fatigue, and the role of fatigue in company incidents / accidents. • Give drivers feedback about (i) the fatigue-related risks of their operation, (ii) personal feedback about when they tend to get more tired. • Help drivers identify when they are operating in "high-risk mode", and tell them what they should do about it – to include reporting to line manager. • Use speed-limiters with a lower maximum speed than 90 km/t. • Provide facilities and information to help drivers exercise and eat healthily. • Promote a home life that allows for optimal recovery from work.
Rail	**Regulators, authorities:** • Consider imposing normal minimum 12 h rest between shifts. **Organisations:** • Measure and monitor different forms of driver fatigue. • Educate to standardise reporting of severe fatigue, and the role of fatigue in incidents. • Help drivers identify fatigue risk modes. • Have rules that make clear what is expected of drivers in risky situations, i.e. which tasks must be prioritized. • Consider giving drivers feedback on driving style (braking, speeding, alarm cancelling) related to fatigue levels. • Increase focus on and concern about mental exhaustion (i.e. in addition to sleepiness). • Better account for driver fatigue in the early planning of transport operations. • Provide better facilities for sleeping, healthier food, and promote physical activity. • Educate and encourage leaders to detect different forms of fatigue in their drivers, and to help drivers deal with it. • Introduce fitness-for-duty tests. • Balance shift schedules that are optimal in terms of reducing fatigue and those that are desirable for drivers. • Monitor and limit excessive shift-swapping or overtime that may increase fatigue. • Reduce mismatch between scheduled and actual hours worked.
Maritime	**Regulators, authorities:** • Address mismatch between regulations and the widely fluctuating demands of sailing a vessel. • Reduce room for interpretation about what levels of manning are defensible in terms of safety. • Include fatigue more explicitly in manning certification. • Educate to increase authority and investigator competence concerning fatigue. • Introduce alcohol testing on board. • Make it harder for companies to complete timesheets inaccurately. **Organisations:** • Measure and monitor different forms of watchkeeper fatigue. • Encourage an open reporting culture about fatigue on- or off-duty on board and off-duty while ashore. • Educate to standardise reporting of severe fatigue, and the role of fatigue in incidents. • Increase manning. • Increase system resilience, such that disturbances and deviations do not cause fatigue. • Plan to better accommodate watchkeeper fatigue at times and during phases of operation when it is most likely. • Survey and legitimise informal ways in which fatigue is managed among watchkeepers. • Emphasise fatigue and fitness during formal medical checks. • Arrange for watch systems that are less fatiguing than 6/6 to be trialed. • Educate to increase seafarer and company awareness of and competence on fatigue. • Introduce fitness-for-duty tests. • Organise transport to and from ship. • Help employees address non-work life issues influencing fatigue at work.

8.6.1 Common recommendations

Interestingly, there are several measures arising that are common to all transport sectors. In addition, measures suggested for one transport sector may be usefully applied in others. Thus it is possible to produce some common recommendations for all land and sea transport branches. Furthermore, it is useful to structure common recommendations according to the expanded fatigue-risk trajectory presented in Section 8.5. The common recommendations are given in Table 17.

Table 17. Common recommendations on how to improve transport operator fatigue, structured using the expanded fatigue-risk trajectory (see Section 8.5 for explanation).

Risk level	Description	Recommendation
-	Set preconditions for risk management	• Establish business case for tackling fatigue.
1	Working time, work quality, non-work life quality.	• Address any mismatch between hours of work and rest regulations and demands of working. • Systematically assess planned and actual work schedules for fatigue risks.
2	Recovery from work.	• Provide facilities and information to help drivers rest, exercise and eat healthily. • Consider assessing need for recovery, recovery + fitness-for-duty tests. • Empower leaders to help subordinates tackle fatigue. • Include fatigue monitoring and reduction as part of company health program. • Promote a home life that allows for optimal recovery from work. • Address commuting risks.
3	Reports of fatigue and behavioural symptoms.	• Use standard battery to measure and monitor different forms of operator fatigue at work. • Monitor links between working time and operator fatigue in order to improve schedules. • Legitimise and encourage open reporting of and discussion about fatigue. • Give explicit information about what to do in the event of severe fatigue, including how work tasks should be prioritised in the event of fatigue. • Legitimise informal ways in which operators cope with fatigue that are likely to be effective. • Give operators feedback on personal fatigue tendencies.
4	Fatigue-related errors.	• Improve operator and leader knowledge about how to identify fatigue and associated risks in self and colleagues. • Give operators feedback on fatigue-related operational risks.
5	Fatigue-related incidents/accidents.	• Standardise reporting on fatigue as part of incident and accident reporting, whether or not investigators believe it is contributory.

Organisations, authorities, unions and other transport stakeholders can consider the recommendations. Most recommendations assume that the transport company in question is motivated to reduce fatigue. Note that recommendations at one level can lead to improvements and less need to tackle fatigue at other levels. For instance, improved recovery from work will lead to less fatigue symptoms or errors. Monitoring links between working time and operator fatigue could also lead to improvements in working time arrangements, and improved reporting of fatigue could lead to better management of fatigue-related errors.

9 Conclusion

Empirical data on operator fatigue in Norway is limited. That which there is supports international data suggesting that there is a problem to be tackled, especially in the road and maritime sectors. While the framework conditions of the rail sector may allow for the better control of operator fatigue, surprisingly little has been done to assess how tired train drivers are, and there is little explicit knowledge about the role of different forms of fatigue in serious rail incidents. Increased knowledge about the prevalence of different forms of fatigue in operators working in different branches of the road, rail and maritime sectors is required to identify operator populations who are most exposed to fatigue, such that countermeasures may be implemented. Knowledge could be generated using available standard self-report batteries including fatigue measures for which there are Norwegian population norms.

Existing evidence suggests that operators in certain Norwegian transport branches may have elevated risks of fatigue, relative to other branches in their sector, and may therefore particularly merit further investigation. These are, in the road sector, coach, truck and taxi branches; in the rail sector: smaller cargo companies; and in the maritime sector: smaller coastal freight transporters and fishing vessels.

While limited by lack of explicit links to actual fatigue levels, empirical and anecdotal evidence supports international findings, suggesting that there are multiple causes of transport operator fatigue in Norway, many of which may interact dynamically. Contributors to fatigue that span the main sectors each contribute to fatigue by influencing sleep or exertion. They can be categorized as framework conditions, branch conditions, organisational culture and support, psychosocial work conditions, working and resting time, work tasks, conditions surrounding work tasks, sleeping conditions, commuting, recovery during non-work time, life phase and other individual differences.

On the question of whether there are unique "Norwegian causes" of fatigue, poor or demanding roads, ferries, tunnels, lack of resting places, high physical demands and icy roads and darkness were cited as possible causes for professional drivers in road transport, while difficult coastline, dark, icy waters and difficult weather and physical conditions were cited for watchkeepers at sea.

There is good evidence that fatigue plays a major role in serious road incidents and accidents involving truck and bus drivers, though little is known about accidents involving taxis or other vehicles. In the rail sector, we must rely on international evidence, which also suggest that fatigue plays an important role in more serious incidents. In the maritime sector, there is evidence for a major role of fatigue in groundings in Norway. In each of these cases the role of fatigue is probably underestimated, due to underreporting, lack of understanding or systematic consideration of fatigue as a factor, or difficulties in assigning fatigue as a cause. A lack of appreciation of the different ways in which fatigue may influence operators in the lead up to incidents may also play a factor.

Regulation of fatigue by delimiting operating or other working hours is problematic in the road and maritime sectors, partly because operators in some branches may

need to violate the rules routinely in order to get their work done. In the road sector there is lack of coherence between regulations, framework conditions and road infrastructure, and there are signs that regulations can in some cases contribute to fatigue.

We found little evidence of any programs for the management of fatigue by companies in any of the three main sectors. Even though fatigue is addressed in several different ways by the major rail companies, companies do not seem to measure how tired drivers actually are. Organisations in many road and maritime branches, especially, could potentially do a lot more to address operator fatigue, but may lack resources due to narrow operational margins. Creation of financial incentives to tackle fatigue, or at least setting out the business benefits, may encourage the implementation of countermeasures, many of which span the road, rail and maritime sectors. These include the measurement and monitoring different forms of operator fatigue, fitness-for-duty tests, assessment of links between working time and staff fatigue, open and systematic reporting on fatigue, education of leaders to help subordinates tackle fatigue, feedback to operators on fatigue-related operational risks, fatigue monitoring and reduction as part of company health program, and facilities and information to help drivers rest, exercise and eat healthily. Companies could also promote a home life that allows for optimal recovery from work, and consider addressing risks from fatigue while commuting.

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Appendix 1 – Interview schedule (Norwegian)

E-mail invitation to experts (in Norwegian)

Forskningsintervju med ressurspersoner på søvnighet/fatigue innen vei, sjø eller jernbane

Transportøkonomisk institutt (TØI) gjennomfører et omfattende forskningsprosjekt som skal gi økt kunnskap om søvnighet/fatigue hos profesjonelle førere på veg, sjø og jernbane. Prosjektet, som heter *Fatigue in Transport*, begynte høsten 2011 og vil vare frem til 2015.

TØI ønsker forskningsintervjuer med ressurspersoner på emnet, og vi har sendt denne e-posten til deg fordi vi tror du kan bidra. Dersom du vil delta i et anonymt forskningsintervju som varer i omtrent en time, eller kjenner til andre aktuelle ressurspersoner, så gi oss gjerne beskjed. Forskningsintervjuene gjennomføres høsten 2012, der hvor det passer ressurspersonene best (ev. per telefon om ikke annet er mulig).

Hovedmålet med prosjektet er å gi et bedre kunnskapsgrunnlag for regulering og håndtering av trøtthet og redusert årvåkenhet blant profesjonelle på veg, skinner og sjø i Norge. Prosjektet er finansiert av Norges forskningsråd. Mer informasjon om prosjektet kan hentes fra www.toi.no/fit.

I forskningsintervjuene vil vi gjerne få synspunkter på forekomst, årsaker, konsekvenser, og håndtering av trøtthet/fatigue på vei, sjø eller jernbane. Vi vil bruke forskningsintervjuene for å undersøke likheter og forskjeller mellom ulike transportsektorer, undersøke om norske forhold byr på spesielle utfordringer mht. trøtthet, og få kunnskap til å utarbeide en mini-spørreundersøkelse som skal gå til utvalgte grupper av profesjonelle førere på veg, sjø eller jernbane.

Prosjektet vårt trenger din kunnskap, og vi håper du har mulighet til å være med på et anonymt forskningsintervju, eller en kort spørreundersøkelse.

Vi håper at du vil bidra. Dersom du ikke kan bidra, håper vi på at du kjenner til andre ressurspersoner på emnet, som vi kan ta kontakt med. Send ditt svar til ton@toi.no

Beste hilsen: Ross Owen Phillips (Prosjektleder), Tor-Olav Nævestad (Prosjektmedarbeider)

Schedule for interviews with experts (in Norwegian)

Bakgrunn.

*Transportøkonomisk institutt gjennomfører et omfattende forskningsprosjekt som skal gi økt kunnskap om søvnighet/slitenhet hos profesjonelle førere på veg, sjø og jernbane. Prosjektet heter "*Fatigue in Transport"*, og er finansiert av forskningsrådet. Det begynte høsten 2011 og vil vare frem til 2015. Vi har plukket deg ut som en ressursperson på emnet, og vi vil gjerne ha dine synspunkter på forekomst, årsaker, konsekvenser, og håndtering av trøtthet/slitenhet i transportsektoren. Det er selvfølgelig frivillig å delta, og du kan trekke deg fra undersøkelsen når du ønsker. Informasjonen du gir oss behandles anonymt: det du sier skal ikke kunne knyttes til deg (med mindre du vil det selv?). Vi kommer senere til å utarbeide en mini-spørreundersøkelse som skal gå til profesjonelle førere på veg, sjø eller jernbane.*

Spørreskjema

1. **Om deg:** Hva er din bakgrunn/stilling?
2. **Om begreper:** I dette intervjuet skal vi bruke ordene "slitenhet" og "søvnighet" for å vise til trøtthetsrelaterte problemer. For oss er det en viktig å skille mellom disse begrepene. (Vi bruker opprinnelig begrepet "fatigue" og ikke slitenhet.) **"Slitenhet"** (fatigue) = følger av arbeidsoppgaven – for eksempel oppgaver som krever høy konsentrasjon, som er kjedelige, monotone osv, som fører til at man blir mindre årvåken og opplagt. **"Søvnighet"** = mer å gjøre med kroppens behov for å sove, og er regulert av "kroppens klokke" og tid på dagen. Søvnighet avhenger av hvor lenge man sov sist og hvor lenge man har vært våken.
3. Bruker du disse ordene i din arbeidshverdag – er det fokus på disse fenomenene?
4. Hvordan?
5. I ditt arbeid, oppfattes slitenhet og søvnighet som risikofaktorer?
6. **Om sektoren – trøtthet og sikkerhet generelt**
    a. Ut i fra din erfaring: hvilke oppgaver, eller situasjoner er mest ulykkesutsatte? (Hvor og når?)
    b. Ut i fra din erfaring: hvilke risikofaktorer er de viktigste i veg/sjø/jernbane -sektoren?
    c. I disse oppgavene/situasjonene hva er de viktigste måtene å redusere risikoene på?
    d. Hvor viktig er slitenhet og søvnighet som risikofaktorer ift til de andre du har nevnt?
7. **Forekomst av slitenhet og trøtthet**
    a. Ut fra din erfaring, hvor utbredt er slitenhet og søvnighet blant norske profesjonelle førere?
        i. Ut fra din erfaring: hvor er problemene relatert til slitenhet og søvnighet størst?
            1. Kjøretøy/Fartøy
            2. Roller
            3. Oppgaver
            4. Operasjoner.
            5. Hvilken næring?
        ii. Når er problemene størst?
            1.tid på dag,
            2. hvilket skift,
            3. tur

4. ukedag,
5. måned,
6.sesong

b. Hvilken transportsektor tror du er mest utsatt for slitenhet / søvnighet?

8. **Årsaker:** Ut fra din erfaring, hva forårsaker slitenhet og søvnighet? Hva tror du er de viktigste årsakene? (Hvorfor?)
    a) Individ (helse, kjønn, alder, erfaring)
    b) Føreroppgaven (fysiske krav, stress, monotoni, overvåking, teknologi, tid på dagen)
    c) Skiftrelaterte (uregelmessige/uforutsigbare, nattskift, mot klokka, for mange timer)
    d) Organisatoriske forhold (arbeidspress, kultur, for mange oppgaver, lav bemanning, størrelse)
    e) Sektor/næring (tidspress, gods/passasjer, konkurranse, lovverk)
    f) Hjemmeliv (omsorgsoppgaver, sosialt liv)
    g) Geopolitiske (særnorske årsaker?, utenlandske førere i Norge)

9. Konsekvenser (slitenhet og søvnighet)

a. Sikkerhet generelt
    i. Kjenner du til hendelser (sovning, nestenulykker, ulykker) som skyldes slitenhet eller søvnighet
    ii. I hvilken grad rapporteres det? (underrapporteres det?)
    iii. Mener du at ulykkesgranskere og tilsynsmyndighet har et godt nok fokus på dette?
b. Hendelser
    i. Sovning: ut fra din erfaring hvor ofte skjer det blant operatører i de ulike sektorene?
    ii. Nestenulykker: i hvor stor andel av hendelsene er sovning/slitenhet en medvirkende eller utløsende årsak?
    iii. Ulykker: i hvor stor andel av hendelsene er sovning/slitenhet en medvirkende eller utløsende årsak?
c. Andre konsekvenser av slitenhet/søvnighet som indirekte påvirker sikkerhet?

10. Styring / organisasjoners rolle

a. Hvordan er slitenhet og søvnighet håndtert av sektoren / organisasjoner / ansatte? (*id., behandling, forebygging?*)
b. Synes du man gjør det bedre i andre land enn i Norge? (Hvilke? Hvordan?)
c. Hvilke norske sektorer / norske organisasjoner innfor denne sektoren er spesielt gode på dette? (Hvilke? Hvordan? Kontaktinfo?)
d. Hva mener du er forutsetningene for god håndtering av trøtthet/slitenhet på arbeidsplassen?
e. Arbeidstidsbestemmeler
    i. Hvordan synes du arbeidstidsbestemmelser fungerer som et virkemiddel for å håndtere slitenhet og søvnighet? Hva er bra, og hva er dårlig?
    ii. Hva fremmer eller hemmer etterlevelse av arbeidstidsbestemmelsene ift slitenhet og søvnighet?
    iii. Hvilke sektorer, organisasjoner eller arbeidsroller har størst problemer med å etterleve arbeidstidsbestemmelser?

iv. Hvilke sektorer / organisasjoner / arbeidsroller har de mest uhensiktsmessige skiftordningene?
v. Om arbeidstidsbestemmelser ikke fantes, hvordan tror du risikoene fra slitenhet og søvnighet hadde vært?

f. Uformelle systemer og ansvar i praksis
   i. Kjenner du til at det finnes uformelle systemer for å håndtere trøtthet/slitenhet i norske transportorganisasjoner?

g. Andre måter å håndtere på
   i. Hvilke andre tilnærmingsmåter kunne du tenke deg? Hvilke tiltak?
   ii. Kan trøtthet/slitenhet håndteres godt gjennom generelt HMS-arbeid og risikostyring? Eller en separat FMP?
   iii. Kjenner du til erfaringer med andre måter å håndtere trøtthet/slitenhet på?
   iv. Hvor tror du innsatsen må settes inn for å forebygge slitenhet? (den enkelte sjåfør, organisasjonen, myndighetenes tilsyn osv)
   v. I hvilken grad hadde det vært mulig for norske bedrifter å ta hensyn til aktiviteter utenfor arbeid når de driver med risikostrying?

-Er det noe annet du mener vi burde tatt opp?
-Kan vi evt. ta kontakt med deg for å få kvalitetssikret spørreskjemaet vårt når vi kommer så langt?
-Hvilke temaer mener du vi definitivt burde ha med i spørreskjemaet?

Tusen takk for din hjelp!

Appendix 2 – Accidents involving merchant vessels, Norway, 2010–2013

Accident type	2010	2011	2012	2013	Sum
Work accident / accident to person(s)	242	234	267	254	**997**
Fire / explosion	30	26	24	40	**120**
Missing vessel	3	4	1	**8**	
Grounding	99	114	110	101	**424**
Storm damage	1	4	1	1	**7**
Capsizing	4	4	5	2	**15**
Collision	25	13	11	14	**63**
Injury from contact with quay, bridge..	53	51	58	60	**222**
Leakage	6	7	9	15	**37**
Machine damage	2	6	**8**		
Environmental pollution	8	21	17	16	**62**
Stability failure (without capsize)	1	1	**2**		
Other	16	24	26	22	**88**
Sum	**487**	**503**	**531**	**532**	**2053**

Data from NMA

Institute of Transport Economics (TØI)
Norwegian Centre for Transport Research

Established in 1964, the Institute of Transport Economics is an interdisciplinary, applied research centre with approximately 70 professionals. Its mission is to develop and disseminate transportation knowledge that has scientific quality and practical application.

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