**Background and objectives**

Piloting and transport work is irregular shift work that involves a certain degree of mental and physical strain. The work is carried out during all hours of the day and night and throughout all seasons of the year. The objective of the Night on the Fairway project was to clarify the workload and work recovery capacity of Finnpilot Pilotage Ltd’s pilots and pilot cutter operators. Of particular interest was the impact of the work shift system on their ability to cope, on their health and on their work ability.

**Methods**

Workplace visits provided a chance to make observations about the pilots’ and pilot cutter operators’ work conditions and the content of the work practices. The employees and supervisors were also interviewed during the visits.

Working hour ergonomics, in other words, the timing and duration of the work during different hours of the day, were analysed using the working hour logs of the company. The report included eight stations, a total of ten pilots and eight pilot cutter operators, for a period of two working weeks each.

A modified Standard Shiftwork Index (SSI, Barton et al. 1995) survey was used to identify the good and poor practices related to the scheduling system and its effect on the individuals' physical, mental and social well-being. The results were reviewed separately by profession, pilotage area, age group and pilotage work experience.

Field measurements were based on workload, stress and recovery tests as well as the impacts of shift work on one’s sleep-wake state and level of alertness at work.

Stress and recovery from work were determined by measuring the functioning of two key stress response systems. The state of the autonomic nervous system, particularly in terms of the body’s recovery during sleep, was analysed on the basis of heart rate variability (Chandola et al. 2010). Salivary cortisol and amylase tests were done to determine the hormonal and metabolic stress response of the sympahto-adrenal system and the hypothalamic–pituitary–adrenal axis (Chandola et al. 2010). The heart rate variability was also analysed to determine the energy consumption required by physically demanding work tasks (Smolander et al. 2011). The physiological measurements were taken during both the work week and the week off, and involved three days and nights of heart rate variability testing and two days of salivary hormone testing.

Actimetry sensors registered the amount of active movement, thereby providing data on the amount and quality of sleep during the work week and the week off. All periods of sleep, by half hour
increments, as well as the experienced quality of sleep were recorded daily in a sleep diary. The data concerning the work included the recording of the starting and ending time of work shifts, an assessment of the level of alertness at the start and end of the work shifts, and the conventionality/abnormality of the work day. The time off work was assessed both quantitatively and qualitatively. The level of fatigue was acquired by measuring the accrual of periods of sleep and wakefulness (Dawson & McCulloch 2005), the ratio of sleep to wake states was expressed as an objective fatigue level.

**Material**

In spring 2014, the work of the pilots and pilot cutter operators was observed at six stations (Harmaja, Emäsalo, Kemi, Oulu, Turku-Utö and Saimaa) as well as the activities of the Pilot Order Centre at Katajanokka.

The SSI-survey was conducted during May-June 2014. The online survey was sent to all 298 pilots and pilot cutter operators. The survey was answered by 194 persons (65%), of whom 123 were pilots (incl. chief pilots and regional chief pilots) and 71 pilot cutter operators. Of the respondents, 99% were men of an average age of 50 years (fluctuating between 23–64 yrs.).

Field measurements were conducted at a total of 19 stations starting in August 2014 and ending in January 2015.

Sufficient physiological measurements were gathered from 73 subjects, of whom 42 were pilots and 31 pilot cutter operators. The measurement data comprised altogether 220 heart rate variability measurement days and 145 saliva sampling days.

The sleep-wake state data was collected from 45 pilots and 32 pilot cutter operators. The measurement days totalled 1,221, of which 744 were workdays comprised of 755 work shifts. Altogether 433 days were days off. The measurements were spread evenly among the different days of the week. A total of 1,216 sleep periods were examined, of which more than half took place at a station and one third at an individual's home.

**Results**

Traffic and geographic factors determine how the performance monitoring, in terms of salaries and workload, has been arranged. The unpredictability of traffic was a common factor overall, but in some places, the predictability was better. There were many types of adverse factors, such as ice conditions and border formalities, and the guards on duty at a particular station might also be very different at different times.
The level of autonomy involved in the work arrangements varied, as did the role of the Pilot Order Centre. The interviewees viewed the possibility to organise their own tasks as a positive aspect, but on the other hand, it creates more work for the pilots and pilot cutter operators, depending on the area in question.

The majority of the survey respondents rated the interaction between colleagues as very or fairly good; there were no significant differences between the different professions and areas. Half of the respondents felt that they received support and assistance from supervisors when necessary, but the experience varied by area.

The respondents stated that piloting work involves more of a mental than a physical strain. The interviewees did not experience the physical strain as particularly problematic, except for the shaking and jolts caused by poor weather conditions. This issue was raised most often by pilot cutter operators. The physical stress is slightly greater during the hydrocopter season than during open water seasons. In some areas, a large percentage of the work involves motoring, often for long distances on poorly maintained roads during the night. On the basis of the physiological data, the physical workload was, on average, quite low, but it included high peaks recurring a couple of times over a 24h period.

According to the survey, the highest stress at work was caused, in both professions, by an insufficient number of personnel, the unpredictability of schedules and the management approaches of supervisors, and for the pilots, by the weather conditions and for pilot cutter operators, by a lack of respect, and the ineffectiveness of co-operation within the workplace. The hormonal stress measurements indicated that the daily average levels of cortisol were higher than is typically the case, and there was a clearly higher frequency of bed-time levels that were classified as elevated, also in comparison to many other types of shift work. Even on the weeks off from work, the physiological results were not completely normal. In other words, there were indications of cumulative stress.

The survey respondents’ own assessment of their current work ability was an average of 8.0 (WAI-scale 0–10, Tuomi et al. 1998). The work ability assessment of the pilot cutter operators was, on average, slightly better than that of the pilots. It’s worth noting that nearly one third of the pilots and one fourth of the pilot cutter operators assessed that their work ability had decreased. The youngest age group had the best work ability, but the work ability assessment clearly weakened as the number of pilotage years increased.

The working hours of the pilots are recorded as the time used for actual piloting tasks. The working week of the pilots varied, based on the information in the work logs, between 15–38 hours, and the work shift was an average of 3 hours with fluctuations between half an hour and six hours. The logged working hours of pilot cutter operators includes all work tasks. The working week of the pilot cutter operators was an average of 41 hours, and the work shift was an average of 3 hours with
fluctuations between half an hour and nine hours. Based on the data recorded during the monitoring phase, the working time was an average of 5 hours with fluctuations between half an hour and nearly 24 hours. According to the survey, the number of working hours (from the start to the end of the work) was generally viewed as being suitable, as was the number of consecutive work days and days off.

According to the work logs, 14–28% of the work shifts began or ended late at night or early in the morning. The working hours recorded during the monitoring phase were classified in accordance with their starting and ending time as either daytime work (6 am-9 pm) or night-time work (9 pm-6 am). Daytime shifts comprised 59% and night shifts 41%, so the result deviated from the logged results.

The majority of the survey respondents were satisfied with the 'week at work – week off' system, felt they could influence the solution of problems related to the work schedules and stated that personal preferences were taken into consideration in the work schedules.

In the survey, the majority viewed daily resting periods during the work week as suitable and one third felt they were too short. During the monitoring phase, the amount of free time during the work week was viewed as sufficient and the quality of the free time as good, on average. The pilot cutter operators viewed the time off work as sufficient and gave a higher quality rating than pilots did.

Nearly half of the pilots and more than half of the pilot cutter operators stated that the work schedules disturbed their well-being to a significant or quite significant extent. The opportunities to influence the daily work schedules were viewed as minimal by both professions.

Of the survey respondents, half assessed their alertness and sleeping rate as abnormal. This phenomenon was present both at work and during time off.

On the basis of the survey, the duration of sleep was estimated to be about 7 hours during working days and 8 hours on days off, with fluctuations between 4 hours and 10 hours. The duration of the measured sleep during the monitoring phase was an average of 6 hours, which was less than the normal amount and the estimated amount. The range in hours of sleep was considerable, with the periods of sleep fluctuating between half an hour and nearly 14 hours. The subjects slept significantly more on days off than on work days, with a difference of up to 2 hours.

The subjects’ own estimate regarding the quality of sleep was, on average, quite good or at least reasonable based on the monitoring of the diaries. The actimetry testing indicated that the sleep efficiency and restlessness during sleep were normal, on average. Based on the heart rate variability data, the quality of sleep during longer periods of sleep appeared to be normal. The variable that depicted the balance in the autonomic nervous system throughout an entire day clearly leaned more toward the sympathetic or stress response side. This indicates that the individuals were not able to achieve enough recovering sleep and the short periods of sleep they slept in addition to the longer periods were insufficient for proper recovery.
According to the survey, sleep problems were quite common during the work week: the process of falling asleep, staying asleep and waking were often or continuously problematic and were even further emphasised in connection with night work. On the other hand, these sleep problems did not fully disappear on days off or during holidays.

In the survey, pilots reported difficulties of alertness and sleep patterns, on average, slightly more often than pilot cutter operators. Neither the survey nor the measurements indicated any notable differences in the amount of sleep between the professions. The measurements taken from first-hand monitoring indicated that pilot cutter operators have slightly more sleep problems and were slightly more tired at work than pilots.

Half of the respondents often or continuously felt severe sleepiness in connection with working the night shift and one third estimated that sleepiness has an effect on their work performance. Nearly half of the respondents felt sleepy during their days off as well.

The level of objective fatigue at the end of the work shift was "alarming" (sleep deprivation) in one fifth of the cases, "problematic" in one fourth and "manageable" in half the cases. On average, the sleep-wake ratio during work days was positive. Individual differences were significant, indicating that the situation has not always been positive: sleep was, at its shortest, less than 3 hours at the start of the work shift and consecutive hours awake reached nearly 17 hours at the end of the work shift, thereby resulting in a negative sleep-wake ratio. No differences in fatigue levels were linked to either profession or sleep during the day.

The subjective value for the level of alertness at the start of the work shift was alert on average and slightly weaker at the end of the work shift, with fluctuations in both from very alert to very sleepy. The alertness during night work was clearly lower than during day work, both at the start and at the end of the work shift.

Altogether 6% experienced severe sleepiness at the start of their work shift, which means that the alertness is poor in terms of safety (Åkerstedt et al. 2014). At the end of the work shift, the majority had a normal level of alertness, while 15% experienced severe sleepiness. The personal assessment of one’s alertness was clearly more positive than the computational level of fatigue.

On the basis of group comparisons, there was no single clear reason for the weakening of alertness, but the estimates of the levels of alertness fluctuated. The most severe sleepiness was experienced at the end of the night shift and after a work shift of more than 12 hours. There was no difference in the alertness between professions, but pilots were sleepier after their work shifts than pilot cutter operators.
Discussion

Scheduling working hours during the night, in other words, during the normal sleeping hours, is the key factor behind fatigue and working hour load, because night work is preceded by insufficient sleep and long hours of staying awake, and night-time work takes place during the lowest level of alertness. This situation is a clear risk factor for pilotage.

The length of the working hours is another significant cause of working hour load. Even though individual work shifts are short, consecutive work shifts and the resulting number of consecutive working hours and/or repeated short periods off work, as well as tasks that are not reported in the logs but are carried out on top of the actual pilotage may lead to an overload situation.

On the basis of the survey results, one area of concern that arose was the poor amount of sleep and the resulting fatigue on the job, especially at night, and the weakened work ability experienced by the respondents. In terms of coping and safety at work, it’s important to oversee the working environment (sleeping conditions), the employees (lifestyle), the work organisation (the rhythm of work and rest) and the working community (number of personnel).

On the basis of periods of sleep and staying awake, the fatigue levels are nearing the risk threshold on up to one third of the work days. Too little time is set aside for sleeping on work days, and there are situations in which the person has not rested sufficiently prior to the start of the work shift. The subjects’ personal assessments of their alertness appear to be optimistic, when compared to the measured fatigue level. The balance of work and rest needs to be improved, since safety and health are directly linked to work schedules and opportunities for recovery.

On the basis of the physiological data, the work disrupts the body’s ability to manage stress and recovery. The recovery from work could be classified, at best, as reasonable, so there is cause to find the means to improve this situation. The physiological measurements in the data do not, however, indicate which factors in the work cause stress or hinder recovery, or who, in particular, belongs to the risk group.

Sleep problems are directly connected with one’s lifestyle and health behaviours. Weight management, dietary habits and regular exercise have positive impacts on the quality of sleep and the body’s ability to adapt and recover from stress. From a health perspective, a recommended minimal MET level of 8–9 in terms of endurance should be sufficient for coping with the physical demands of the work, but the individual must also maintain sufficient muscle condition, balance and agility.
References


