Workload experiment with tug captains

Exploring the mysteries of the human factor to work towards a safer maritime environment

MARIN's overriding aim is to help increase the safety and effectiveness of maritime operations. The outcome of any operation at sea is the result of vessel characteristics, hydrodynamic forces, human decisions and the interaction between man, vessel and the environment.

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To understand and intervene in such a 'socio-technical' system requires an understanding of the total system. This is why we have extended our hydrodynamic and nautical expertise with the addition of the human factor. For hydrodynamic specialists like us, it is a big step to explore the less predictable and complex discipline of social science.

Of course, we have considerable experience of working with seafarers on our simulators. This provides a perfect platform to observe and measure human behaviour, but quantifying and measuring fatigue, mental workload or situational awareness is still work in progress.

Our goal is to express human behaviour in a more structured and objective way. But before we can do this, we have to understand why human behaviour is so complex.

Decision-making process Human performance is the result of a cognitive process. This process starts with the collection of information. This is followed by an information processing step in which situational awareness plays an important role. During the decision-making process problems have to be identified, solutions are generated and evaluated before the final decision is taken. Finally, the execution of this decision results in the operator taking action (e.g. changing a rudder angle), which has an impact on the system performance (e.g. the vessel turns). This decision-making process is influenced by many factors: task demands, complexity, level of automation, teamwork, communication, culture and procedures etc. But also by personal motivation, experience, strategies, memory and fatigue.

The cognitive process is influenced by many different factors

Measuring human behaviour To understand and optimise the decision-making process we add measurable and objective indicators to identify the impact of workload and fatigue on the operator's performance. Eye trackers clarify what people focus on and what information is collected. Physiological measures like heart rate or eye blink rate provide objective feedback, while simulators provide data on the task execution and system performance.

However, there are several challenges when measuring human factors such as the selection of relevant measures and devices and the synchronisation of all data streams during the experiment. In the analysis process the integration of behavioural and technical data is challenging as well.

Maritime eXperience Lab To face these challenges MARIN is developing a Maritime eXperience Lab. This MX Lab will be used for observation and measurement techniques and for human factor experiments, or to test the usability of new information support systems. Tools, methods and experiences developed in the lab will be integrated in the anticipated future Seven Ocean Simulation Centre.

In 2015, we already made the first steps towards a fully integrated human factor test facility/bridge simulator. A workload experiment with tug captains was conducted which involved synchronising EEG, heart rate and skin conductance response data with simulator time traces and video recordings. The experiment showed that EEG and heart rate results were particularly reliable physiological measures to identify workload. Rudder changes were found to be reliable behavioural measures discriminating between low and high workload in predefined conditions. Decision-making variation became visible in the differences in steering actions while sailing under the same circumstances.

Additionally, analysing the total time traces of combined physiological, behavioural and simulator data demonstrated other demanding moments typical for tug captains. Turning the tug in close proximity of the vessel to be towed and stationkeeping in front of the vessel at a distance of only 10 -15 metres in order to receive the tow line is a very demanding situation. An unstable flow pattern in front of the bulbous bow and the risk of being oversailed also increase workload stress.

Being able to objectify levels of cognitively demanding moments creates additional value in infrastructure, vessel and operational design studies. In marginal conditions when the operator performance is crucial, human limits become more visible. In training sessions the combination of measures help to assess training progress and effectiveness. There are still many steps to be taken, but our first experiences are very positive and we will increase our efforts to tackle the many challenges that surround the human factor.