A Pilot Study on Modelling of the Human Body Loading as a Function of Ship Motion for Crew Safety in Seakeeping

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Problem and Purpose

For the safety of crew on board a ship, the impact of ship motions (e.g., pitching, rolling, and heaving) on the human body is critical. The motion of a ship in waves (Fig. 1) can cause discomfort, fatigue (Table 1), injury, and even death, particularly under extreme weather conditions or fast ship speeds. Thus, the ship and seat designs need to be optimized based on how the ship motion affects crew members. By modeling the ship, seat and human, designers of these systems will be able to evaluate safety in a scientific way.

This project aims to introduce Human Body Models (HBM) in simulations of ship motions in heavy sea conditions on the human body.

A further aim is to understand how to predict injuries in these simulations to leverage injury prevention.

Figure 1: A fast RIB (rigid inflatable boat) exposed to a severe acceleration environment [https://commons.wikimedia.org/wiki/File:RDN_RHIB.jpg].

Table 1: Prevalence of musculoskeletal pain among the study sample (de Alwis et al., 2020).

Area of the body	Round-1 n (%)*	Round-2 n (%)*
Any area of the body	242 (70.8)	237 (72.9)
Head	45 (13.2)	52 (16.0)
Neck	93 (27.2)	103 (31.7)
Upper back	50 (14.6)	51 (15.7)
Lower back	165 (48.2)	142 (43.7)
Shoulder	76 (22.2)	80 (24.6)
Elbow	23 (6.7)	22 (6.8)
Hand	9 (2.6)	9 (2.8)
Hip	25 (7.3)	18 (5.5)
Knee	66 (19.3)	60 (18.5)
Foot	20 (5.8)	20 (6.2)

* Percentages have been calculated based on the total number of subjects, i.e. 342 in Round-1 and 325 in Round-2

Realization

The project was conducted jointly by the Division of Vehicle Safety and the Division of Marine Technology at the M2 department. The work was carried out in three Work Packages (Fig. 2).

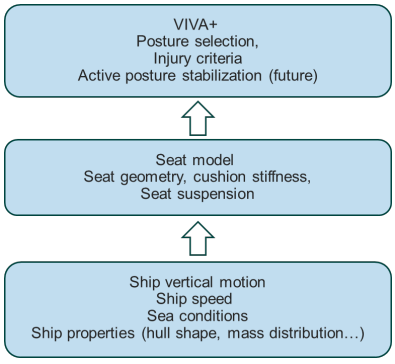

Figure 2: Flowchart of the modelling procedure.

Results

The Open-Source HBM VIVA+ was identified as the best option for further development to enable assessment of spinal loadings. Posture variation can represent various seat configurations and states. We have the capacity to simulate a range of sea conditions, speeds, vessel shapes, dynamic seat properties, and other parameters. A new unique set of HBM validation data has been obtained via collaboration with Ullman Dynamics and is currently processed (Fig. 3).

- We have gathered the essential competences and modelling resources to be able to address injury risk assessment as a function of sea conditions, boat driving and vessel and seat properties.
- The modelling system will ultimately benefit boat crews as well as society by reducing injuries and costs.
- This work has already been taken further in a collaborative initiative between RISE, Chalmers M2 department, and KTH Eng Mechanics department.

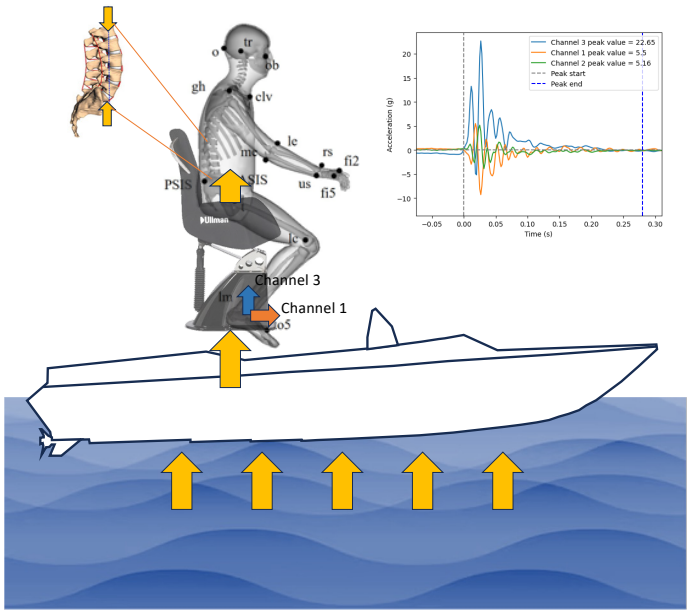

Figure 3: The modeling-system for crew safety in seakeeping, consisting of the wave pattern, the vessel properties, speed and direction of the boat, the crew seat model and the human body model. The lower back and the neck are the most critical body regions for musculoskeletal symptoms.

References

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