Machine and System Safety – not without Ergonomics!

An Example of the planning and the construction process of a new tram‘s driver‘s cabin

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Ergonomics and HMIs

When used as intended, harassment, strain, fatigue and mental strain on the operator must be reduced to the minimum possible, taking ergonomic principles into account.

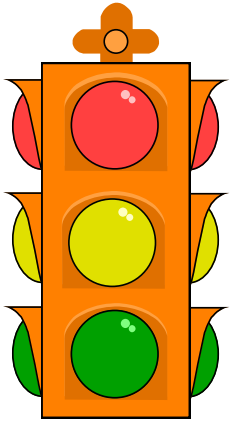
Adaptation of the man-machine interface (HMI, MMI) to the predictable characteristics of the operating procedure is requested.

EU Machinery Directive 2006/42/ec

Basic Ergonomic Standard (Typ A) that has to be applied

- EN 614-1: 1995 – Safety of machinery, Ergonomic design princilples, Part 1: Terms and general principles

- Annex A:
  3-Zone Rating system

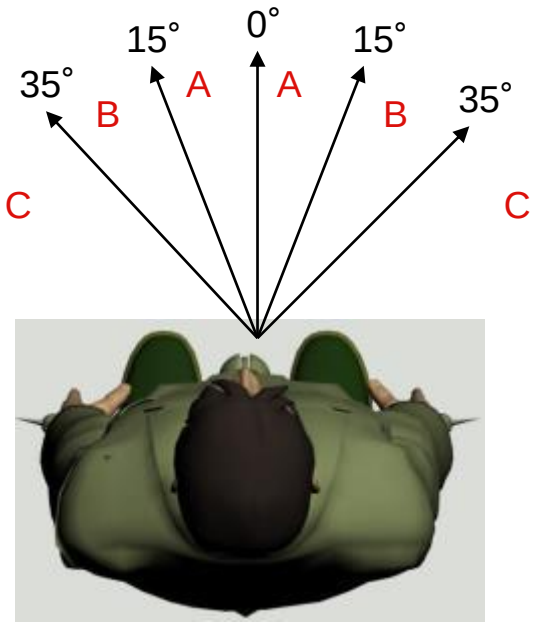


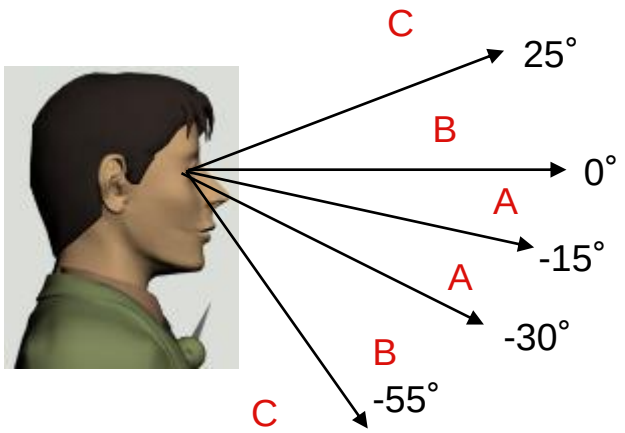
Design of optical displays

Requirements for recognizability

- Positioning: areas A, B, C (ranking) according to **EN 894-2**: 1997
- Importance: Most important display in the optimal field of view (area A)

Requested field of vision according to ÖNORM EN 894-2: 1997-04 for control tasks

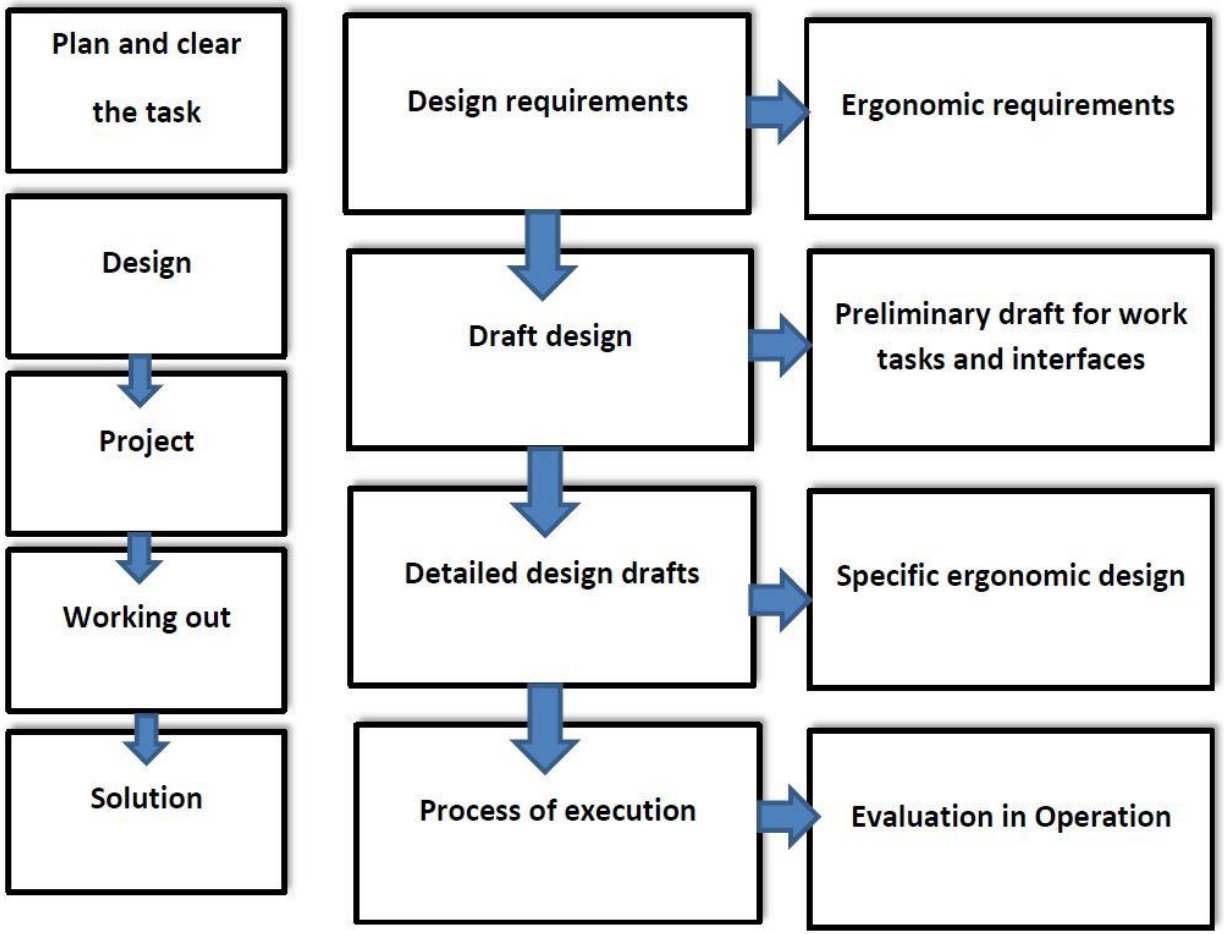




Methodology for the ergonomic design process of the new tram MMI (HMI)

- Setting requirements related to the whole design process that are impacted by ergonomic factors
- Integration and codification of relevant ergonomic standards
- Application of ergonomics of the physical MMI requirements (such as push bottoms, displays and the master controller)
- EN 614-1, safety of machinery, ergonomic design principles
- EN 894 Displays and Controls
- EN ISO 11064-5: Displays and controls

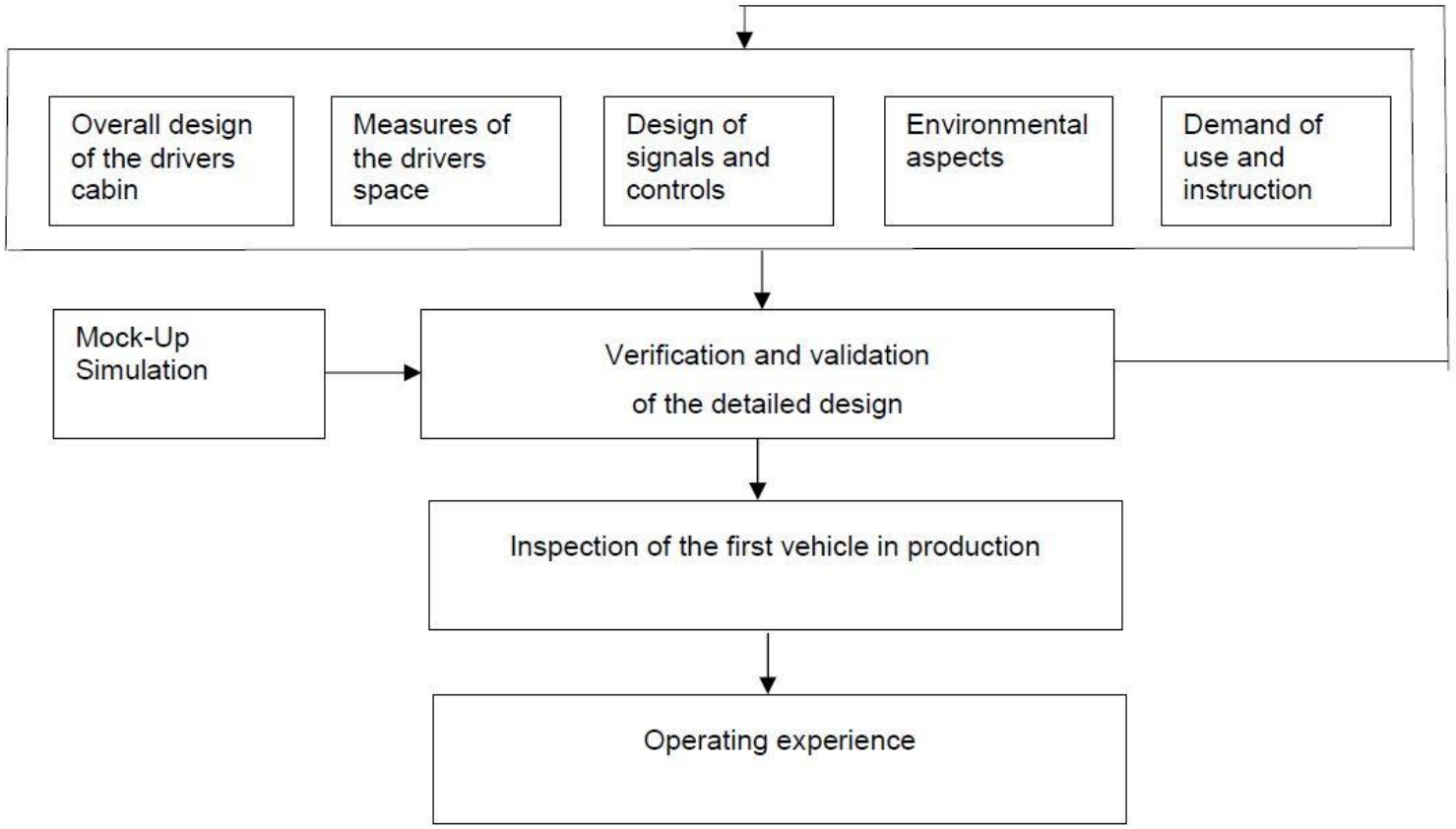
General design requirements according to EN 614 – Part 1 and 2



Process of planing
According to EN 614-1:2009-09

under rquest to
ergonomic principles

Iterative design process according to EN 614 – Part 1,2 and EN ISO 11064 – 5: Displays and Controls

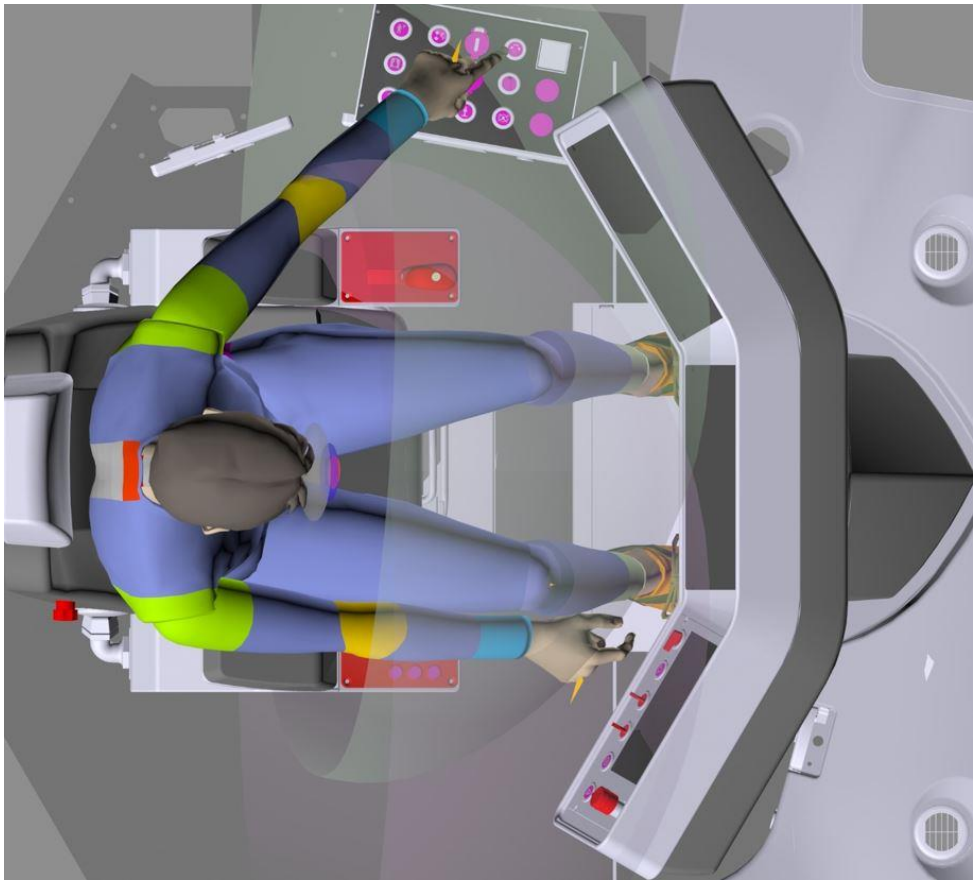


Phase 1: CAD Construction and Mock-Up Simulation

Phase 2: Inspection oft he first vehicle

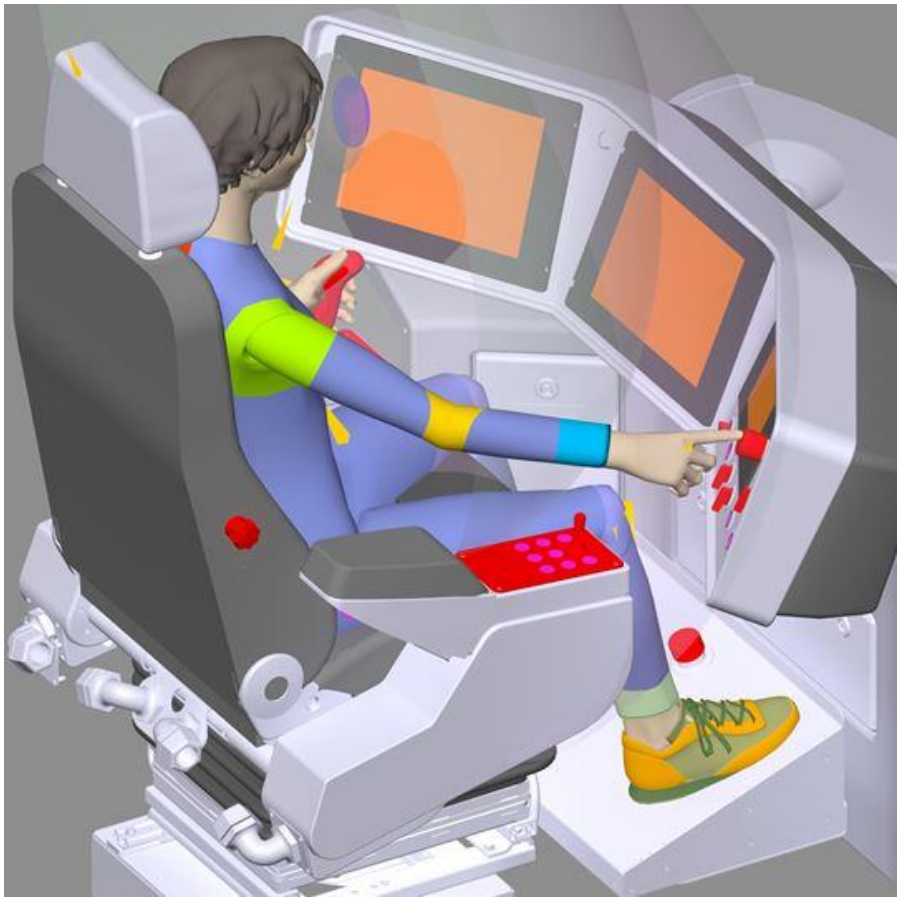
CAD aided check of functionalty and reachability of the controls and visibility of signals

(Software Charat Ergonomics, Data tall man)

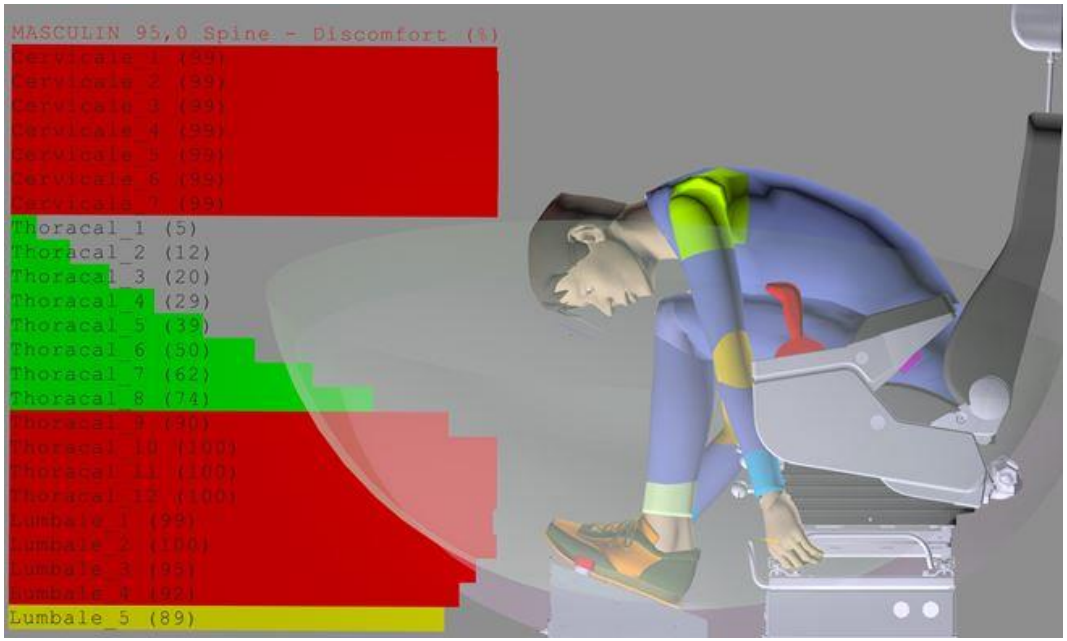


CAD aided check of functionalty and reachability of the controls

(Software Charat Ergonomics, Data small woman)



Optimization of Design Details
Example: Lever for the seat adjustment



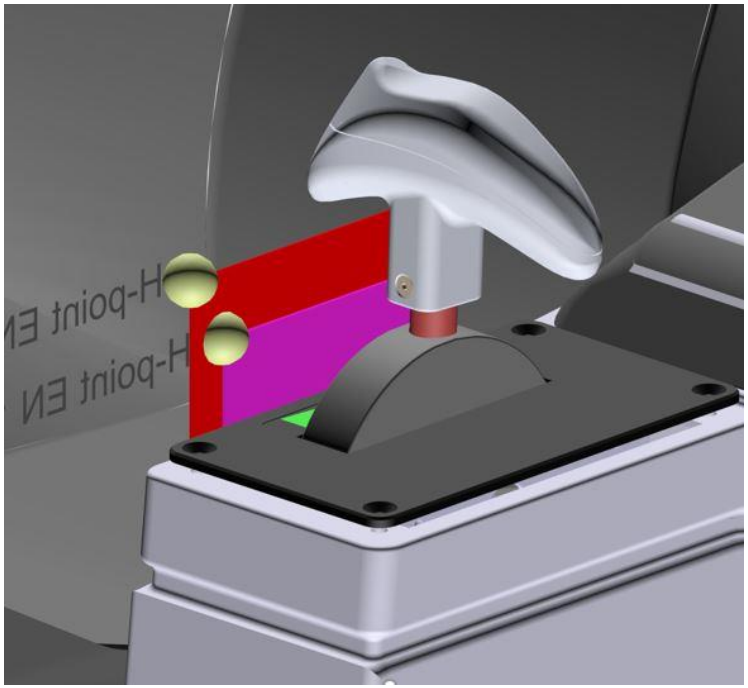
Master Controler – Most important Element in the HMI for Tram Driving

A simple Joystick was rejected by a group of test drivers

6. QUESTIONS ABOUT THE SEATING POSITION IN THE COCKPIT				
6.1 Do you feel comfortable with the posture of the legs and the support on the footrest?	☐	☐	☐	☐
6.2 Do you find your seat height comfortable in relation to the instrument panel ?	☐	☐	☐	☐
6.3 How do you perceive the general sense of comfort in your sitting position?	☐	☐	☐	☐
6.4 How do you feel the accessibility of the control elements on the console frontally with the 3 sections?	☐	☐	☐	☐
6.5 How do you feel the comfort when getting in and out of the driver's seat?	☐	☐	☐	☐
7. QUESTIONS ON VISUAL AND SIGHT CONDITIONS				
7.1 Do you feel that you have a good view through the windscreen from your chosen sitting position (as far as can be seen from the mock-up)? How do you assess the panel's view?	☐	☐	☐	☐
7.2 Left section	☐	☐	☐	☐
7.3 middle section	☐	☐	☐	☐
7.4 right section	☐	☐	☐	☐

Process of Optimization of the Master Controler

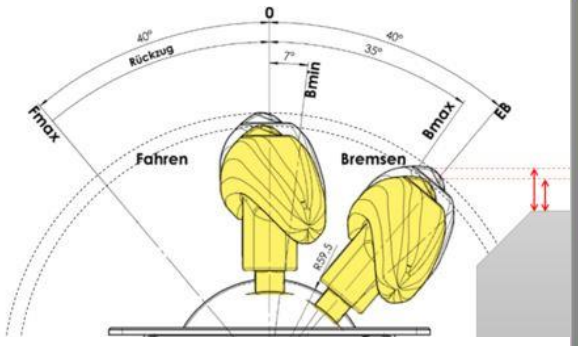
CAD Generated Design with respect to the values of finger and hand – arm comfort

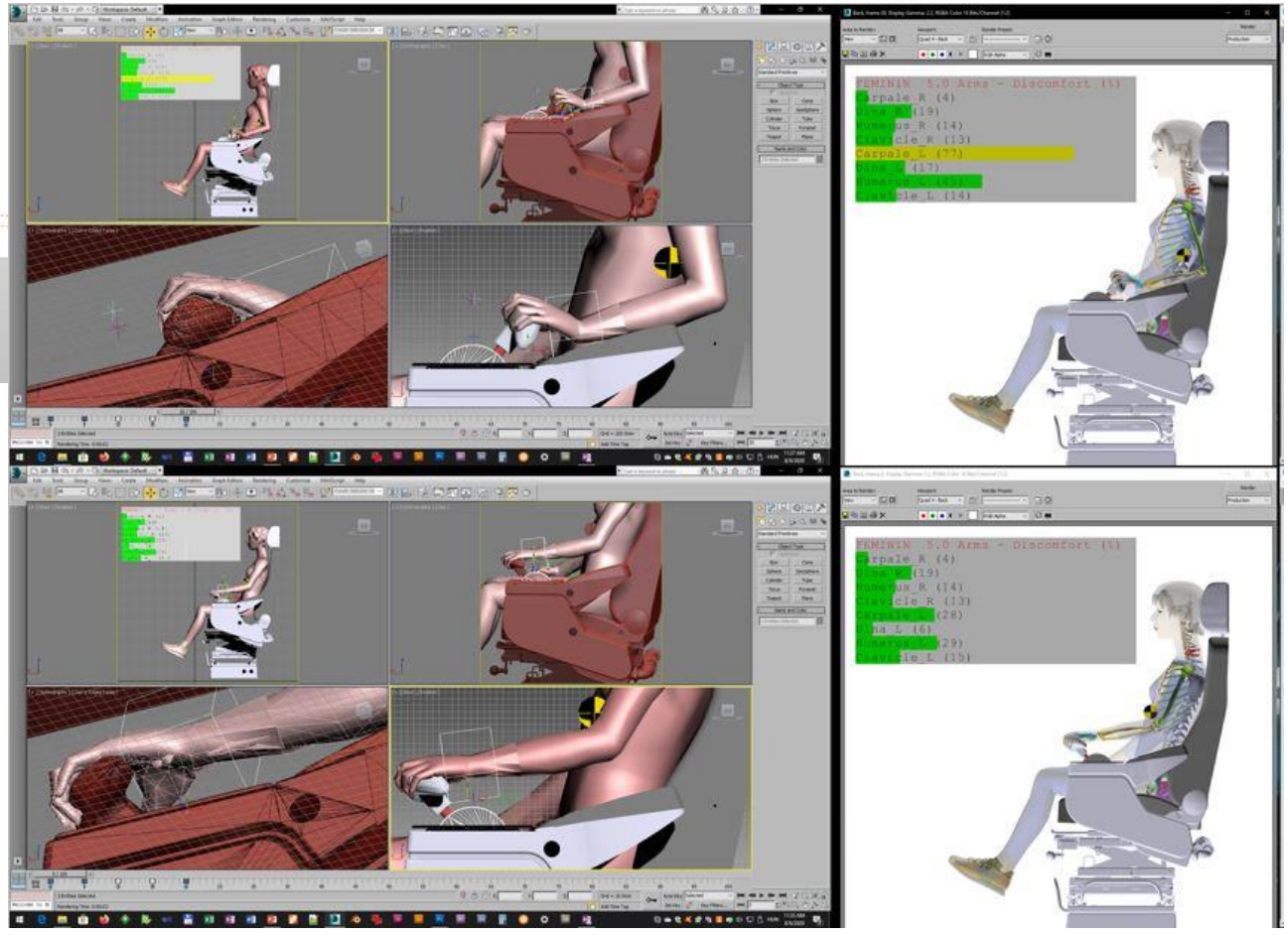


Additional Anaysis with
Motion Capturing
System TEA Ergonomics

Computer Aided Design Check for various functional positions of the Master Controler

Software Charat with NASA Comfort Analysis





Outcome and knowledge

- At an early status of the design process a clear strategy for including ergonomic assessment has to be defined
- A good strategy for such a procedure is:
  Clarification – analysis and definition – conceptual project – detailed project – operational feedback.
- As outlined before a comprehensive ergonomic model for the assessment of main aspects of driving and using the HMI in the tram should be established.
- Application of a digital model for the ergonomic assessment at all steps of the design taking the increased number of digital functions of the HMI into account

Thank you very much for your attention!