### BASICS:
Healthy and safe interaction of operators with work equipment can be assured if the design of the human-machine interface takes into account ergonomic principles and safety requirements, possibly considering feedback from the users experience. Human-machine interface design primarily concerns the **task interface**, which defines the functions to be performed by the operator and by the machinery (e.g. allocation of functions, EN 614-2). The design also concerns the **interaction interface**, which tailors the dialogue between operators and machinery (e.g. design of displays and controls, EN 6385, EN 894, EN ISO 9241-110). The task and interaction interfaces are intimately connected, and the interface design serves specified tasks, operational modes and operator qualifications.

### IMPORTANT PRACTICAL ISSUES:
- if the human-machine interface is considered at an early design stage, the task design can be better adapted to the needs of the operator
- an important characteristic of an ergonomically designed operator task is its measured diversity (not only monotonous “left over tasks”)
- qualifications and experience are foreseeable characteristics of the operator; conventions/stereotypes must be considered (e.g. green never stands for danger)
- the design of human-machine interface has to be conform to the expectation of the user
- readable displays serve operator information acquisition and analysis
- replacing memory load with e.g. visual or acoustic information, and presenting information in parallel when it is required in parallel, will help the operator to process the information
- control feedback suitable for the task helps the operator to implement the information

### DETAILED EXPLANATION:
The initial decisions in system design – e.g. on automation involvement – already determine how functions are divided between the human being and the machinery. Operator tasks can only be ergonomically well-designed if the three main **operator task components** (i.e. planning, processing and evaluating) are equally considered at an early stage. High levels of automation, and so called left over tasks for the operator (i.e. the operator is only there for carrying out those tasks of which the machine is not capable) are examples of ergonomically bad design. It is necessary that minimally required operator qualification, experience and skill levels be adequately communicated (EN 614-2, EN 11064-1). The design of the **interaction interface** must be based on dialogue principles for operator-task relationships (EN 894-1, EN 9241-110) and human physical and mental characteristics such as physical strength (EN 1005) and human information processing (EN 894-1). E.g., controls must be adapted to the task and to the operator, the same is true for form, dimension (e.g. grip width) and material/surface texture, force limits, frequency of operation, posture (affects e.g. type of grip) and type and direction of movement of the control (turning, pulling…). The designer has to avoid unclear instructions, too many steps without feedback information, insufficient lightening, too much information at the same time, unfavourable posture, poorly respected reflex behaviour, stimulation of manipulation of safety devices.

For each task and operating mode different solutions concerning the choice and presentation of displays and controls may be suitable. Human perceptual and attentional processes will be supported by information presentation suitable for the task (e.g. in bright environments choose positive polarity displays and controls for clear and unambiguous presentation, EN 894-2; choose digital displays only if exact values are required; provide analogue displays for estimates or relative measures; provide trend displays for level over time, EN 894-2; limit working memory demand by integrative displays, EN 10075-2). Dialogue principles such as self-descriptiveness and controllability determine whether feedback design is readily identifiable for the operator (e.g. feedback about operating mode in understandable technical terms). Conformity with user expectations refers e.g. to compatibility or conventions (for instance, turning purging valve to the left increases flow, but turning dial to the right increases speed; red colour indicates danger). Error tolerance may allow the operator to correct potential errors. Further specifications and examples are given in EN ISO 9241-110 or EN 894-1.
RECOMMENDATIONS:
EN 614-2+A1 : 2008 Safety of machinery - Ergonomic design principles - Part 2: Interactions between the design of machinery and work tasks
EN 894-1+A1 : 2008 Safety of machinery - Ergonomics requirements for the design of displays and control actuators - Part 1: General principles for human interactions with displays and control actuators
EN 894-2+A1 : 2008 Safety of machinery - Ergonomics requirements for the design of displays and control actuators - Part 2: Displays
EN 894-3+A1 : 2008 Safety of machinery - Ergonomics requirements for the design of displays and control actuators - Part 3: Control actuators
EN 1005-5 : 2007 Safety of machinery - Human physical performance - Part 5: Risk assessment for repetitive handling at high frequency
EN ISO 9241-12 : 1998 Ergonomic requirements for office work with visual display terminals (VDTs) - Part 12: Presentation of information (ISO 9241-12:1998)
EN 13861 : 2002 Safety of machinery - Guidance for the application of ergonomics standards in the design of machinery

EXAMPLES:
Source: University of Oldenburg

N° 1: Display with (a) digital (b) analogue and (c) dynamic (trend-supported) tank level feedback.
N° 2: Display with scale violating conventions/stereotypes (left) and respecting stereotypes (right)

Figure 6 — Related elements grouped by proximity

Figure 9 — Effect of framing

N° 3: Allocation of displays and/or controls to different tasks or operating modes (e.g. principle of proximity and framing)

Round form creates the expectation that the operator has to turn the control

Multifunctional control on a wheel loader
Good layout for reaching all buttons, counter-sunk buttons avoid accidental operation, special surface configuration for better haptic perception
Abbildung 3: nicht erwartungskonforme Schalteranordnung (3a) und erwartungskonforme Schalteranordnung (3b)
No 6 Crane steering interface:
not conform to expectation (3a) conform to expectation (3b)