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Determining Competences in MET of Ship Officers

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ABSTRACT: Organizational structure of a ship changes under the influence of technological development. Processes on board a ship change as well. Major change refers to the role of the crew and consequently leads to the change of a method of determining competences. Equipment and working processes are becoming more complicated. They have a strong impact on the crew, i.e. on their competences. Competences prescribed in STCW Convention are not in accordance with the changed role of the crew in the processes on board. In STCW Convention, competences have been grouped according to the ship's functions at different levels of responsibility. Competences have not been prescribed on the basis of the working processes within a system. Such a situation has led to the absence of the proper upgrade of needed competences. Based on the analysis of the functional organizational structure of a ship, the paper suggests more elaborated approach to defining competences. Such an approach links competences with equipment and working processes on board a ship.

1 INTRODUCTION

A proper implementation of new technology includes implicitly social and technical factors affecting system functionality and usage. The implementation of new technology based on social and technical elements considers not only human, social and organizational factors, but technical factors of the organizational systems' design as well. Such an approach to implementation of technology leads to systems that are more acceptable to end users [4].

Automation can improve productivity, efficiency and production quality of almost every industry [1]. In most of the cases, automation has improved on board processes. It contributes to the efficiency enhancement, reduction of maintenance costs and crew expenses, extension of the ship's operating life and it brings other advantages as well [2]. Automation on board reduces the number of the crew. Reduction of the crew members leads to the automation application on higher levels [3].

As a result of new technology implementation, modification of existing knowledge, skills and ways of executing a task has become an important factor in the process of developing and using technologiy on board. Therefore, an efficient inclusion and implementation of new technology has become a huge challenge in almost every industry or an organisation [10]. One of the major obstacles of the successful implementation of automation systems is the crew's lack of their understanding. An increasing number of rapidly developing systems, parameter changes within a system and their interrelation with other parts of the system as well as with other elements of the process, makes the understanding of how the system works more difficult [5]. User's system understanding has a crucial role in the successful application of new technology [6]. Therefore, when developing technologies on board, it is of utmost importance to include the end users in the process, i.e. the crew, since it is the only way of ensuring its successful application.

New technology has brought many advantages; however, it is important to mention its negative side as well, i.e. a drastic change of the man's role in performing operation (activity, action). In past times, a man executed an operation/ activity on his own. However, with automation development his role changes. Instead of executing an operation, a man has started supervising automated systems [5]. When a man only supervises the system, his detection of system flaws could be very slow, which, consequently, can affect an in time reaction expected of him. Such a change turns a man into a passive observer who is not conscious of the complexity of the performed operation (activity) [12].

Technological development and automation on board should enable the crew to upgrade their existing competences, which should enable them to manage automated processes. However, if a system complexity increases, the operation complexity can increase as well. Automation changes the structure of a task and creates new ones. This situation can lead to the development of new types of errors, e.g. when working with paper charts, officer of the watch will cross check his colleague's work, they will share problems and train each other [9]. In this particular case, automation can make a detection of the mistake more difficult and it can affect the officer's in time reaction [9].

Generally speaking, only routine processes are automated. Nowadays however, more complex and critical processes have been automated as well as the processes that need coordination [14].

The introduction of new technology and automation imply a development of new competences for the crew and/ or the upgrade of the already existing ones. Automation reduces the number of simple, physical tasks and affects development of more complex tasks [11] that need more knowledge and understanding to be carried out. Therefore, the need for the already existing skills can diminish. Automation can change task nature and structure in a way that it can make carrying out of simple tasks easier and of complex tasks harder [13].

Experienced crew members can more easily and promptly detect system flaws than the non-experienced ones, i.e. because of their experience they know the system better. Furthermore, the prolonged monitoring of the automatic control can reduce the ability of the crew to react to system malfunctions properly and in time [9].

Therefore, technological development and automation on board can be analysed through their impact on processes on board as well as on competences the crew needs to participate in processes. In other words, in order to analyse the impact of technological development on processes on board, it would be advisable to analyse the processes on board, organizational units and devices first [7].

2 IMPACT OF TECHNOLOGICAL DEVELOPMENT ON PROCESSES ON BOARD

In order to monitor changes resulting from technological development and automation, the ship has been defined as a system consisting of the following elements: organizational units, devices in an organizational unit and processes carried out within organizational units. In the text that follows, interrelations between the afore-mentioned elements and their correlations have been shown. A special attention has been given to the description of processes on board and their basic characteristics. For the purpose of this paper, a ship has been presented as a system whose goal is transport. Set of elements of that system (S) can be presented like this:

$$S = \{OU_1, OU_2, ..., OU_n, D_1, D_2, ..., D_m, P_1, P_2, ..., P_k\}$$

where:
OU – Organizational unit
D – Device
P – Process.

Many organizational units and different devices participate in processes on board, which means that various combinations of organizational units, devices and processes are possible [8].

Process analysis (Figure 1) refers to identification of sub-processes (if they exist within a process) within organizational units that participate in a process, to an operation within a process, to decision-making within a process, and to their executors. The number of sub-processes, organizational units, operations, decisions and their executors within one process determine its complexity [7, 8].

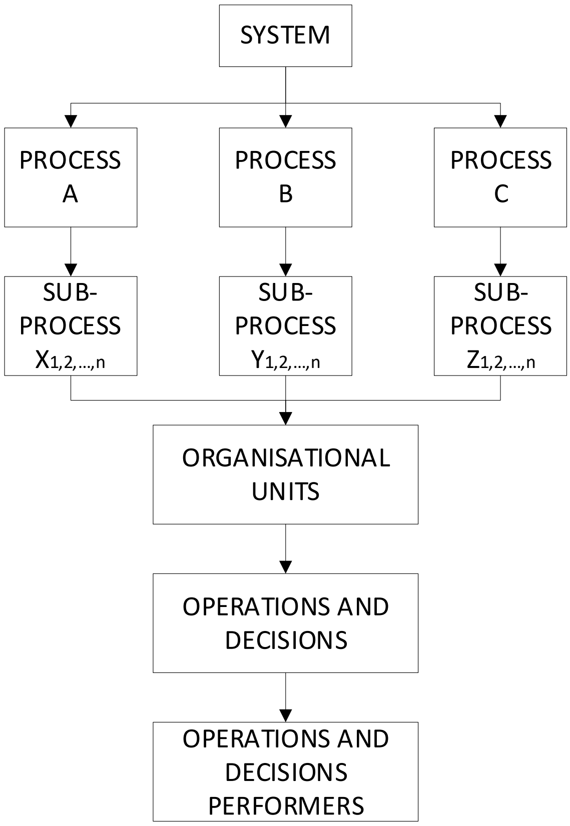

Figure 1. Process analysis

Every process consists of operations and decisions carried out in order to achieve the result. One operation can be divided into more tasks which cannot be further divided. In every process, operations should be arranged according to the order of execution (Figure 2 and 3).

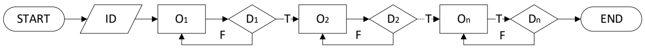

Figure 2. Example of on board process
where:
ID – Input data
O – Operation
D – Decision

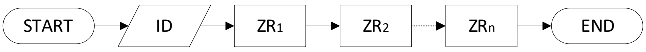

Figure 3. Example of tasks in an operation
where:
ID- Input data
ZR1 – Task within an operation 1

Most of the on-board processes are carried out simultaneously. Some of them have their logical units that can be referred to as lower rank processes (sub-processes). Basic processes on board were determined on the basis of the ship departments' classification by STCW Convention:
1. Navigation process,
2. Cargo maintenance process, and
3. Ship maintenance process [7].

Technological development has almost entirely changed the way processes are carried out on board. The impact of the introduction of new technologies on a process can be analysed through their impact on:
1. Operation executors (crew members or devices),
2. Operations within a process, and
3. Decision-making style [8].

For example, before the "real time communication", the master had to inform the shipping company and charterer about the processes on board whenever it was possible. Nowadays however, the master does not make important decisions on navigation, cargo or the crew without the prior consultation with shipping companies or charterer's services, although his legal responsibility has not changed.

In the text that follows, three examples have been given when:
1. Introduction of Electronic Chart Display and Information System – ECDIS has affected the navigation process,
2. SRV - Shuttle and Regas Vessels and FSRU - Floating Storage and Regasification Unit have affected cargo handling (one more operation has been added to the process), and
3. Communication system development has affected the communication with all stakeholders as well as the crew's welfare.

Ad 1) ECDIS introduction on board has changed the navigation and position control. Traditional navigation control implied work on paper charts, gathering data and information from navigational and other devices, data transfer on charts, i.e. their usage during navigation. Charts were corrected manually on a regular basis. With the ECDIS introduction, the whole process has been entirely automated. It includes gathering digital charts, publications and all the accompanying corrections.

Ad 2) Development of versatile SRV and FSRU ships, has affected operations within the process of loading, unloading and handling liquefied gas, i.e. a new operation has been added. Units for liquefied cargo regasification have been integrated into the SRV and FSRU ships enabling gas unloading from the ship into the gas supply system. In this case, there is no need for tank terminals and regasification units onshore.

Ad 3) In the beginning of its development, ship-to-ship or ship-to shore communication was used in dangerous situations, i.e. when the safety of the ship, crew, passengers or the environment was in danger. Afterwards, a system used for communication with maritime authorities and for navigation was developed. At the same time, communication systems started to be used for commercial purposes, e.g. when dealing with cargo, logistics, communication between the ships and companies and when gathering and sending data from the ship to the company. Finally, communication systems started to be used for improving the crew's welfare, which implies available phone and internet connections.

Today, the way in which operations on board have been carried out is changing, some of the operations are not needed anymore, whereas some new operations have been developed. It can be concluded that the major change refers to the crew's role in processes on board. Modified crew's role in carrying out operations and tasks resulted in need to adjust existing competences of the vessel's crew [7, 8].

3 IMPACT OF TECHNOLOGICAL DEVELOPMENT ON THE CREW'S COMPETENCES

Technological development on board has affected competences in the following way:
1. The already existing competences have been upgraded,
2. New competences have been developing, and
3. Some competences are becoming redundant [8].

Ad 1) Introduction of new systems whose goal is to improve a process implies the upgrade of the crew's existing competences. The impact of technology on the existing competences can be analysed through its effect on the existing knowledge, understanding and skills. When a new technology has been introduced on board in order to improve a process, the following changes usually occur:
1. The upgrade of the existing knowledge,
2. The upgrade of the existing understanding, and
3. Some of the existing skills are becoming redundant.

The upgrade of the existing knowledge implies acquiring new knowledge referring to the system it has been implemented in. The upgrade of the existing understanding refers to understanding the way in which a new, upgraded system executes tasks within an operation. If some of the existing skills are becoming redundant, it means that a man does not use the skills he had needed before the introduction of the new system. These skills are not needed anymore since the system itself is executing tasks.

Ad 1) Navigation on paper charts requires using of navigational instruments for measuring, determining and comparing physical values and measurements of the vessel environment (distance, vertical and horizontal angle, time, speed, depth etc.). It is important to continuously "place" oneself and the ship spatially on the basis of measured and obtained results. ECDIS usage can result in a non-critical reliance on the ship's position shown on monitor. In this case, the skill to use navigational instruments decreases, whereas the skill to use ECDIS develops. This situation can reduce the spatial orientation skills since the only skill that has been developing is the skill to use the computer.

Ad 2) Development of new competences can be the result of technological development that has enabled the crew to carry out operations they were not able to do precisely enough (e.g. dynamic positioning system development), and of the introduction of new technology in the existing process.

FSRU ship's crew has to possess additional competences referring to regasification unit installed on this type of ship. On the other hand, long-term mooring when the ship serves as a temporary regasification terminal lessens the usage of all competences referring to conventional ships, most of all to navigation and manoeuvring.

Technological development does not have an impact on the operation only, but on the whole process as well, which, consequently can lead to the development of new professions. Electro-Technical Officer – ETO is a new profession and an example of how a new organizational unit can lead to the development of the new profession.

Ad 3) As a result of technological development, a man has been replaced with new systems. Therefore, some of his competences are becoming redundant. It can happen that the crew rarely uses the competences they used every day since they do not need them anymore. Therefore, the need for some professions can diminish (e.g. radio operator).

In order to adjust the crew's competences to processes on board, it is important to analyse the process itself, i.e. sub-processes, operations and decisions within the process, and their executors as well [7, 8]. Such an approach of adjusting competences to processes on board is called the process approach, and is shown in the Figure 4.

In the text that follows, the process approach will be applied to the process called Ship's Arrival to Port and Cargo Loading on LNG ships with membrane tanks. This process can be divided into six sub-processes:

1. Ship Navigation (PPA),
2. Communication with External Stakeholders (PPB),
3. Pilot Boarding (PPC),
4. Manoeuvring with Assistance of Tug Boats (PPD),
5. Ship Berth (PPE), and
6. Cargo Loading (PPF).

Figure 4. Process approach of determining competences
Source: [8]

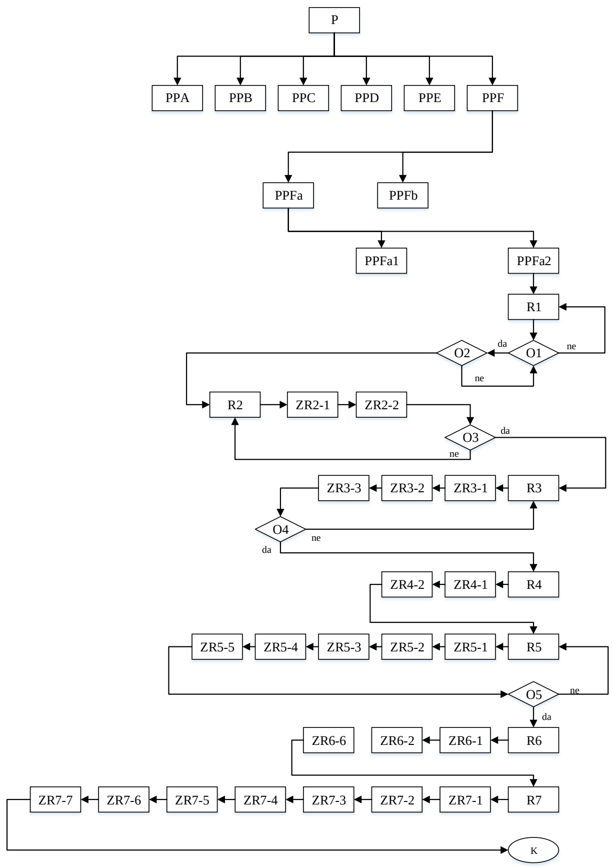

Figure 5. Sub-process "Cooldown of Cargo Tanks" on board LNG ships

Each of these subprocesses can be divided into one or more subprocesses, within which one or more actions and decisions may be performed that have one or more executors. Given the complexity of the whole process, only the sub-process Cooling Down of Cargo Tanks has been described in the following text (Figure 5). The sub-process Cargo Loading consists of the sub-processes Cargo System Preparation (PPFa) and Cargo Loading (PPFb). The Cargo System Preparation sub-process consists of two sub-processes: Cooling Down of Cargo Tanks (PPFa2) and Checking of all Cargo Loading Systems (PPFa1).

Cooling down of cargo tanks is an integral part of the preparation of tanks for loading, which has to be carried out according to the cooling down plan. On older ships, crew members control and supervise the process of cooling down the cargo tanks in manual mode. Nowadays, on ships of newer construction, cooling down of cargo tanks is carried out in automatic mode, and the whole process is supervised by an officer of watch from the bridge or from the cargo control room.

The sub-process Refrigeration of Cargo Tanks consists of seven actions (R), 10 decisions (O) and 22 tasks in actions (ZR):

1. R1 - generating cargo cooldown plan (man),
2. O1 - decision on the commencement of cooldown (man), based on an estimation of time, temperature, ship speed and cooldown schedule,
3. O2 - decisions on the temperature of the cofferdams between tanks (man),
4. R2 – preparation of device for heating the cofferdams between tanks (device),
   a) ZR2-1 - checking of glycol pumps (device),
   b) ZR2-2 - testing of high pressure and glycol temperature alarms (device),
5. O3 - decision on the schedule of operations of the nitrogen generators and operating mode (man),
6. R3 – checking of nitrogen system (device),
   - ZR3-1 - checking both nitrogen generators (device),
   - ZR3-2 - checking pipelines and valves on the cargo tanks (device),
   - ZR3-3 - checking whether the system is connected to both of the nitrogen generators (device),
7. O4 - decision on the schedule of use and on compressors capacity (man),
8. R4 - checking gas detection system (device),
   - ZR4-1 - checking operation of the pump and gas concentration analysis device (device),
   - ZR4-2 - checking and, if necessary, calibration of sensors that activate ESD (device),
9. R5 - checking the equipment and instruments in the compressor and electric motor room (device),
   - ZR5-1 - checking both of the compressors (device),
   - ZR5-2 - setpoint setting on pressure control valve (device),
   - ZR5-3 - nitrogen pressure check (device),
   - ZR5-4 - checking the ventilation system (device),
10. O5 - decision on the selection of the tank for the return of LNG (man),
11. R6 - checking of main liquid cargo line, vapour line and cool-down line (device),
    - ZR6-1 - visual inspection (human),
    - ZR6-2 - opening of the valve on the cool-down line (device),
    - ZR6-3 – checking of the LNG return valve (device),
12. R7 - cooling down of cargo tanks (device),
    - ZR7-1 - starting cool-down pump (device),
    - ZR7-2 - opening cool-down pump discharge valve to a given setpoint (device),
    - ZR7-3 - adjustment of the cool-down line valves on cargo tanks (device),
    - ZR7-4 - monitoring cargo tank pressure (device),
    - ZR7-5 - monitoring pressure difference between cargo tanks and insulation space (device),
    - ZR7-6 - monitoring pressure in the nitrogen system (device), and
    - ZR7-7 - monitoring the trend of decreasing temperature in the cargo tanks (device).

Above is a description of one standard process carried out on board of the LNG carrier. LNG carriers are merchant ships with high level of technology and complex equipment required for maintaining cargo condition and standard vessel operation. Thus, taking a standard process on board LNG carrier, gives good example where technological process is analyzed in detail pointing out actions, tasks and decisions carried out by crew or automation system. This process approach is applicable for analyzing any process on any ship in order to determine required competences for particular action or task.

4 CONCLUSION

Successful application of new technology on board depends on the crew's understanding of it. One of the problems with new technology is that there is no ergonomic standard, i.e. new technologies do not adapt to people, people must adapt to new technologies. Under the impact of new technologies and automation, processes and devices on board become more complicated which, consequently, affects competences.

If competence changes are not in accordance with changes of processes on board, a delayed upgrade of the crew's existing competences needed for on board processes can occur. The approach suggested in this paper, which encompasses a detailed analysis of processes on board, can enable a proper and in time modification of needed competences with changes that occur on processes on board under the impact of new technologies and automation.

When interviewing active professional seafarers, it is obvious that working and operating principle of the equipment on board is not a problem, but technological complexity of hardware and software of this equipment. Thus, including active seafarers in this detailed analysis of processes on board are of the utmost importance.

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