Inventory of the engineers’ competences for a new CoC course by using simulators

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Abstract This paper presents achieved results of the first stage of the IAMU Development Project titled “CoC course to revalidate marine engineers’ competences by using simulators”, relevant for Maritime and Education Training and Simulation. This development project is for the completion of the project awarded in the Call for Proposals FY2013 titled: "Simulation-based course to demonstrate seafarers' competences (for deck department)". The main objective of this development project is obtain four complete revalidation courses (deck and marine engineer disciplines) using simulation technology to obtain a well-defined project to reach a common academic programme to demonstrate all competences to license the revalidation certification by using simulation.

In accordance with Part A, Chapter I, Section I/11 Revalidation of certificates, continued professional competence shall be established, among others, successfully completing an approved training course or courses. Every master, officer and radio operator holding a certificate issued or recognized under any chapter of the Convention other than chapter VI, who is serving at sea or intends to return to sea after a period ashore, shall, in order to continue to qualify for seagoing service, be required, at intervals not exceeding five years, to establish continued professional competence.

This paper will describe the first stage of the project, WP1: inventory of marine engineers’ competences by using simulators. The main objective of this paper is to identify which competences can be demonstrated by approved simulator training, according to the STCW 95/2010 in order to design the following step of the development project: a revalidation model course structure using simulation technology to assessment, examination and certification of seafarers’ competence in accordance with the provisions of STCW Code for existing marines who need upgrade their professional maritime certificates in accordance also with the Standards governing the use of simulators, Reg I/12 of 2010 STCW Code.

Keywords: Maritime Education and Training, Simulation, STCW Code, Revalidation of certificates, Marine Engineer

1. Background of the project

International Maritime Organization’s (IMO) international convention on Standards of Training, Certification and Watch-keeping for seafarers (STCW) [1] was ratified by all maritime nations. Today, IMO has advised/encouraged all contracting governments/interested parties to review and, as necessary, to revise their crew academic/vocational competency described in STCW. Furthermore, the European Maritime Safety Agency (EMSA) started a regular assessment process providing quality improvement in the MET institutions throughout EU members, candidate countries and others.

This development project is for the completion of the project awarded in the Call for Proposals FY2013 titled: "Simulation-based course to demonstrate seafarers' competences (for deck department)" [2]. The
main objective of this IAMU Development Project titled “CoC course to revalidate marine engineers’ competences by using simulators” is to obtain four complete revalidation courses (deck and marine engineer disciplines) using simulation technology to obtain a well-defined project and reach a common academic programme to demonstrate all competences to license the revalidation certification by using simulation.

The specific goals are:
- Prepare a publication and integrate all courses as a result of a whole project that can be used by any member that needs to revalidate CoC’s, based on STCW Code.
- Develop teaching materials (simulator scenario’s) that can be used by IAMU and member universities.
- Provide schools and maritime authorities with a modern way to examine the revalidation of the expired CoCs, incorporating into the IAMU’s e-learning platform and it represents a considerable value of practically applicable work which often lacks in most academies.
- Provide maritime industry revalidated and newly educated seafarers.
- Promote the implementation, development, harmonisation and unification of the maritime programme contents.

The development project is divided into following different stages (work-packages, WP):
WP1. Inventory of the competences
WP2. Design courses structure
WP3. Developing and testing simulator exercises for competence assessment
WP4. Incorporating into the IAMU’s e-learning platform
WP5. Integration of projects, review and final discussion

2. Maritime simulation

Within IMO an Inter-sessional Simulator Working Group (ISWG) was established in order to organize and structure simulator related matters for inclusion in the STCW revision. One definition adopted by ISWG [2] reads: Simulation is a realistic imitation, in real time, of any ship handling, radar and navigation, propulsion, cargo/ballast or other ship-system incorporating an interface suitable for interactive use by the trainee or candidate either within or outside of the operating environment, and complying with the performance standards prescribed in the relevant parts of this section of the STCW code.

The fact that a simulation system represents a powerful teaching tool, which can lead to more effective training outcomes as well as a more efficient use of available teaching time, adds to the increased popularity of simulation equipment. Additionally, the assessment of competence of seafaring skills can be performed in a lifelike simulation centre, which resembles as closely as possible the real system called “ship”. As IMO is seeing the necessity to assess competence rather than knowledge in order to improve shipping safety and simulators are offering possibilities for such, it seems without doubt that much more emphasis will placed on marine simulation in the years to come.

It is quite surprising to see which other types of activities and equipment have become models for a maritime training simulator system and up to date have been developed and installed:
- navigation equipment trainer
- communication procedures/GMDSS equipment trainer
- radar simulator
- radar and navigation simulator
- ship handling simulator with/without motion platform/image generation
- fisheries simulator
- inland waterways simulator
- dynamic positioning simulator
- crane handling simulator
- vessel traffic management simulator
- engine room simulator (ERS)
- search and rescue management trainer
- oil spill management trainer
- propulsion plant trainer
- team generation plant trainer
- electrical power plant trainer
- refrigeration plant trainer
- cargo handling trainer
- ballast control trainer
- dredging ship trainer
- offshore process simulator
- drilling technology simulator

Note: name in brackets and bold is assigned to refer the type of simulator later on.

This list is not intended to be all-inclusive. As technology advances, new systems, both from the shipping industry as well as within the simulation techniques, are being created with certain regularity. From the list it will be clear that all elements of a ship are becoming available for simulation application.

3. Inventory of the engineers’ competences

This section will make the inventory of which competences can be demonstrated by approved simulator training, according to the STCW 95/2010 code Part A Competence tables.

In the CoC Revalidation Model Course structure [3], these are the competences that will no longer require theoretical, written or oral examinations, but can be practically demonstrated by means of simulation, identification of which is one of the objectives of this development project.

The competences that will be taken into consideration will be the ones related to the Engine Department as described in STCW Code Part A Chapter III.

The STCW function Groups in Chapter III are as follows:
- Marine engineering.
- Electrical, electronic and control engineering.
- Maintenance and repair.
- Controlling the operation of the ship and care for persons on board.

3.1 Listed competences considering Chapter III assessable by simulator

In this section a list of competences of chapter III assessable through Engine Room Simulator are described for the model course scenario development and testing.

The legal basis for evaluating only with simulator is found in column 3 of the tables provided, where it says for all these cases (see figure 1):

Column 3, Methods for demonstrating competence; Assessment of evidence obtained from one or more of the following:

(…)

In all cases, one of the modalities is: approved simulator training, where appropriate
Table A III/2

Specification of minimum standard of competence for chief engineer officers and second engineer officers on ships powered by main propulsion machinery of 3,000 kW propulsion power or more

Function: Marine engineering at the management level

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competence</td>
<td>Knowledge, understanding and proficiency</td>
<td>Methods for demonstrating competence</td>
<td>Criteria for evaluating competence</td>
</tr>
<tr>
<td>Manage the operation of propulsion plant machinery</td>
<td><strong>Design features, and operative mechanism of the following machinery and associated auxiliaries:</strong>&lt;br&gt;1. Marine diesel engine&lt;br&gt;2. Marine steam turbine&lt;br&gt;3. Marine gas turbine&lt;br&gt;4. Marine steam boiler</td>
<td>Examination and assessment of evidence obtained from one or more of the following:&lt;br&gt;1. approved in-service experience&lt;br&gt;2. approved training&lt;br&gt;3. approved simulator training, where appropriate&lt;br&gt;4. approved laboratory component training</td>
<td>Explanation and understanding of design features and operating mechanisms use appropriate</td>
</tr>
</tbody>
</table>

Figure 1 Table A-III/2 of the STCW Code


We found that 16 competences out of all the ones (31) described in column 1 of tables AIII/1 and AIII/2 of the STCW 95/2010 (corresponding to the operational and management levels respectively) may be evaluated by using a simulator.

They are the following for operational level:

**Marine Engineering.**
- Maintain a safe engineering watch. (1)
- Use internal communication systems on board. (2)
- Operate main and auxiliary machinery and associated control systems. (3)
- Operate fuel, lubrication, ballast and other pumping systems and associated control systems. (4)

**Electrical, electronic and control engineering.**
- Operate electrical, electronic and control systems. (5)

**Maintenance and repair.**

**Controlling the operation of the ship and care for persons on board.**
- Maintain seaworthiness of the ship. (6)

In table A-III/1, there are a total of 17 competences for the operational level, and 6 of them may be evaluated by simulator; that is the 35.3%.

More specifically the Marine engineering section (operational level) consists of 5 competences, 4 of them may be evaluated by simulator representing the 80%; the Electric, electronic and controls engineering section (operational level) consists of 4 competences, 1 of them may be evaluated by simulator which means the 25%, and the Controlling the operation of the ship and care for persons on board section (operational level) has 8 competences but only 1 may be assessed by simulator, that is the
12.5%. There are no competences that may be evaluated by simulator in the Maintenance and repair section.

The competences that may be evaluated at management level are the following:

**Marine Engineering.**
- Manage the operation of propulsion plant machinery. (7)
- Plan and schedule operations. (8)
- Operation, surveillance, performance assessment and maintaining safety of propulsion plant and auxiliary machinery. (9)
- Manage fuel, lubrication and ballast operations. (10)

**Electrical, electronic and control engineering.**
- Manage operation of electrical and electronic control equipment. (11)
- Manage trouble-shooting, restoration of electrical and electronic control equipment to operating condition. (12)

**Maintenance and repair:**
- Detect and identify the cause of machinery malfunctions and correct faults. (13)

**Controlling of operation of the ship and care for persons on board.**
- Control trim, stability and stress. (14)
- Monitor and control compliance with legislative requirements and measures to ensure safety of life at sea, security and protection of the marine environment. (15)
- Use leadership and managerial skills. (16)

In table AIII/2 there are a total of 14 competences for the management level and 10 of them may be assessed by simulator; that is the 71.4%.

More specifically, the Marine engineering section has 4 competences and all of them may be evaluated by simulators, which means 100% of the competences; the Electric, electronic and controls engineering section (management level) consists of 5 competences, 2 of them may be evaluated by simulator which means the 40%; the Maintenance and repair section consists of 3 competences, 1 of them may be evaluated by simulator which means the 33.3% and the Controlling the operation of the ship and care for persons on board section (management level) has 5 competences and 3 of them may be assessed by simulator, that is the 60%.

Considering the two levels being analysed (management and operational) there are a total of 31 competences and 16 may be evaluated by using simulators; that is the 51.6%.

**Table 1. Summary table of competences (in percentage) evaluable by simulator considering STCW function Groups**

<table>
<thead>
<tr>
<th>STCW function Groups</th>
<th>Evaluable by simulator (operational level)</th>
<th>Evaluable by simulator (management level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine engineering</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Electric, electronic and controls engineering</td>
<td>25%</td>
<td>40%</td>
</tr>
<tr>
<td>Maintenance and repair section</td>
<td>0%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Controlling the operation of the ship and care for persons on board</td>
<td>12.5%</td>
<td>60%</td>
</tr>
</tbody>
</table>

Finally some competences, although they may be evaluated by simulator, also require some supporting material (SM):
- For competence (3), (4), (7), (8), (10), (11) the supporting material may be mechanical publications, dismantling schemes, flow charts and safety procedures review.
- For competence (6) and (14) the use of stability, trim and stress tables, diagrams and stress calculating equipment is required.
- For competence (15) there should be a review of international maritime law, international agreements and conventions during briefing due to the fact that this point is not completely assessable with simulator but must be included in the training program.

3.2 Knowledge, understanding and proficiency of the column 2 of Table A-III/1-2

In column 1 of tables A-III/1 and A-III/2, the competences to remember (or update) and to assess are mentioned, but in column 2, the knowledge to acquire is specified. Therefore, of the sixteen competences evaluable with simulator, not of knowledge of each of these competences is assessable by simulator. On the other hand, there are certain skills that are not strictly evaluated by simulation, but may require the use of additional material. Therefore, this knowledge may also be updated and evaluated through additional material. In other words, although these points cannot be developed or evaluated with the training tool (simulator), they must be included in the training program.

This section aims to determine the knowledge required for each of the 16; that is, more detailed selection will be provided based on the specific knowledge that students need to refresh or update, and for which they must demonstrate their understanding and proficiency.

Table 2 shows a list with the specific knowledge areas for each competence and the use of Engine Room Simulator (ERS). If a knowledge aspect is evaluable by using additional material apart from the ERS, rather than mentioning the type of simulator, this is indicated as Supporting Material (SM). In case of a specific knowledge that today cannot commonly be assessed by simulator or SM, it is indicated by “It depends on the simulator”.

| Competence (1) Maintain a safe engineering watch | With ERS |
| Competence (2) Use internal communication systems | With ERS |
| Competence (3) Operate main and auxiliary machinery and associated control systems | With ERS |
| Competence (4) Operate fuel, lubrication, ballast and other pumping systems and associated control systems | With ERS & a) Operational characteristics of pumps and piping systems, including control systems. With ERS; some SM may be used during briefing (dismantling schemes, power point presentations or video tutorials) |
| Competence (5) Operate electrical, electronic and control systems | With ERS & Control system:  
a. Various automatic control methodologies and characteristics. With SM during briefing.  
b. Proportional-Integral-Derivative (PID) control characteristics and associated systems devices for process control. It depends on the simulator. |
| Competence (6) Maintain seaworthiness of the ship | With ERS & Ship stability. With SM during briefing and debriefing understanding that comprehension must be demonstrated by simulated action. Ship construction. With SM during briefing such as structural ship design programs. |

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And for competences at management level:

<table>
<thead>
<tr>
<th>Competence (7) Manage the operation of propulsion plant machinery</th>
<th>With ERS</th>
</tr>
</thead>
</table>
| Competence (8) Plan and schedule operations | With ERS &
|             | a) Physical and chemical properties of fuels and lubricants. |
|             | b) Technology of materials. Depending on the simulator. |
|             | c) Naval architecture and ship construction, including damage control. With SM during briefing such as structural ship design programs |
| Competence (9) Operation, surveillance, performance assessment and maintaining safety of propulsion plant and auxiliary machinery | With ERS |
| Competence (10) Manage fuel, lubrication and ballast operations | With ERS |
| Competence (11) Manage operation of electrical and electronic control equipment | With ERS |
| Competence (12) Manage trouble-shooting, restoration of electrical and electronic control equipment to operating condition | With ERS |
| Competence (13) Detect and identify the cost of machinery malfunctions and correct faults | With ERS |
| Competence (14) Control trim, stability and stress | With ERS & With the SM during briefing and debriefing, understanding that comprehension must be demonstrated by simulated action |
| Competence (15) Monitor and control compliance with legislative requirements and measures to ensure safety of life at sea, security and protection of the marine environment | This competence consists of a wide knowledge of legislative requirement, which can be explained and evaluated with the SM during the briefing. Nevertheless, some skills may be simulated, like for example, discharging oily water using a virtual flow-meter according to Marpol. |
| Competence (16) Use leadership and managerial | With ERS |

4. Conclusions

In accordance with the spirit of STCW which promotes the use of simulators in MET since 1995 and considering that nowadays the competences of seafarers are usually demonstrated only in oral or written exams, it is necessary make the inventory of the marine engineer competences that can be demonstrated by approved simulator training, according to STCW 95/2010 Code Part A competences table.

This paper presents achieved results of the first stage of the IAMU Development Project titled “CoC course to revalidate marine engineers’ competences by using simulators”. Due to the fact that some of the competences necessary for revalidation are not assessable on simulator, an inventory of marine engineers’ competences by using simulators has been carried out. Considering the two levels being analysed (management and operational) there are a total of 31 competences and 16 of them may be
evaluated by using simulators; that is the 51.6%. Moreover, more detailed analysis is carried out based on the specific knowledge in Column 2 of tables A-III/1 and A-III/2. This selection process of competences will be the point of departure for the following stages of this development project: the design of two CoC model courses to provide training and use of simulation material for marine engineers.

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References


