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**Expanding Frontiers -  
Challenges and Opportunities in Maritime Education and Training**

**Situation awareness is a new provision  
of STCW 78 , as amended**

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**Abstract:** The paper is devoted to new provisions of STCW 78 (as amended) and namely “obtaining and maintaining the situational awareness “ (SA). This new provision is mandatory by Manila amendments to STCW 78 Code as per *Tables A-II/1,2; A-III/1,2,6* . The wording of this provision is rather flexible but in any case it can imply the development of new approaches to maritime education and training (MET) to influence positively on both educational and training processes. Obtaining and maintaining SA means that a lot of other relevant SA-based skills, including decision making (DM) and performance of actions (PA), are also to be taught, learned and trained. Such Officer Of the Watch (OOW) skills as detecting the loss of SA and recovery of SA are also to be included in training programs of seafarers.

The paper reviews some aspects and trends supporting the possible design and guidance of courses on SA at Sea and encourages educators, instructors and students involved in MET to research and develop this very important Human Element (HE) topic.

**Keywords:** STCW Code, Human Element, education, training, safety, situation awareness, risk assessment, decision making.

## **1. Introduction**

The new provision of STCW 78 (as amended) namely “obtaining and maintaining situation awareness “, is included in Column 2 (Knowledge, understanding and Proficiency) of the STCW Code by Manila amendments (*Tables A-II/1,2; A-III/1,2,6* ) can imply the development of new approaches to MET to positively influence both educational and training processes. The STCW Code in itself is a competence oriented instrument and every competence contains an SA portion. Column 4 of the qualification tables delivers the criteria for evaluating different types of competences included in the Code. We suppose that it may be a quite ambitious theme to review the Code, checking if the SA classical [1] approach agrees with its general concept and if SA methodology can be included in the MET system.

## 2. What is Situation Awareness?

### 2.1 The Basics

In order to realize how to incorporate SA into the systems of the shipping industry and MET, it would be helpful to have a deeper understanding of SA. In its most basic form, SA is knowing *what is going on around you* [1]. It seems obvious but let's explicitly add the requirement that a decision maker on the vessel's navigating bridge must also have a grasp on what is important to know, for example, while proceeding in the English Channel to the south. It is 'so called' local knowledge in navigation but in SA terminology they call it *prior knowledge* about the tasks to be completed or goals to be accomplished during the passage. We understand the term *prior knowledge* in a broad sense not limited by the local professional knowledge of the navigation area. It is, in principle, determined by the experience and educational level of an individual. From here, it is not a giant leap to make the claim that SA varies with, and is completely dependent on, the goals for any given job[2].

More serious attributions involving SA occur when "Bridge (or Engine room) or Shore based Personnel" error due to loss of SA is listed as a cause of accidents. The results from a maritime operations literature survey revealed that 71% of human errors were Situation Awareness related problems[3]. Failure to mitigate accidents due to poor SA also is pointed out in frames of e-navigation concept [4,5].

A general definition of SA that has been found to be more close to marine navigation describes SA as the safety driven *perception of the elements in the environment within a volume of time and space* (navigational area), *the comprehension of their meanings* (dangers, marks, ships, lighthouses...) *and the projection of their status in the near future* (developing of navigational situation) [1]. In other words SA involves the real-time processing of event-based information coming from an evolving situation in an attempt to understand what is happening [6].

### 2.2 Levels of SA

One differentiates three levels of SA.

#### **Level 1 SA – Perception of information**

To speak about navigation, as per Endsley, the first level is perception of navigational information. It is fundamental and crucial. Without a basic perception of navigational information, the cases of forming an incorrect picture of the navigational situation increase rapidly, especially in dynamically changing environments. Without the simple recognition of important information in navigation areas it is unlikely that a Master/OOW will develop anything near an accurate evaluation of a situation and risk. Mariners should be carefully trained and their skill and knowledge duly assessed in the proper perception of navigational information. This level also includes the detection, recognition, and identification of significant things within a given (navigational) situation and area [2].

### Level 2 SA – Comprehension of information

Following [2], situation awareness of the Master/OOW as a construct goes beyond mere perception of navigational information. It also encompasses how navigators combine, interpret, store, and retain this information. Thus, it includes more than perceiving and attending to information or formal scanning, but also the professional keeping of sharp look out, the integration of multiple pieces of information and a determination of their relevance to the safety goals. This requires the fusion of diverse bits of information and the establishment of importance to the goals at hand. A seafarer has attained Level 2 SA when he has extracted meaning and significance from Level 1 data. Level 2 SA reveals a comprehension of the current state and an ability to make inferences about how the current situation came to be.

### Level 3 – Projection of situation

The highest level of SA includes the ability to forecast future navigational situation events and their dynamics. It relates to operators who have the highest level of understanding of the situation (this should be the Master, Pilot or VTS operator). This ability to project from current events and dynamics to anticipate future events allows for timely decision making. One can say that *risk assessment* is some sort of formal *projection* of the situation, i.e. level 3 SA in its principle can be based on statistical data and experience.

There is no doubt that education and training as processes are consistently linked and all the above said for navigation is applicable to other competences which are included in the functions and levels of the STCW Code.

The provision “obtaining and maintaining situational awareness” is included directly in the following STCW Code competences:

- Maintain a safe navigational watch, (A-II/1) as per function 1;
- Use of ECDIS to maintain the safety of navigation, (A-II/1) as per function 1;
- Application of leadership and teamwork skills, (A-II/1) as per function 3;
- Maintain a safe engineering watch, (A-III/1) as per function 4;
- Application of leadership and teamwork skills, (A-III/6) as per function 3;
- Use of leadership and managerial skill (A-II/2, A-III/2) as per function 3;

In sections A-VI/5A-VI/6 related to security, we can also find the competence which has a direct wording link with SA; it is “Encourage security awareness”.

To understand that such concepts as Situation Awareness (3 levels), Decision Making and Performance of Actions exist in the STCW Code in intra-text information, we used the Leximancer software for analysis of the Code. To gain an insight into the content of the Code, the software was configured in such a way as to map the document in a manual mode. The following sample seed words were applied [7]:

- Level 1 SA = (perception, detection, recognition, identification);
- Level 2 SA = (comprehension, combine, interpret, store, retain, information);
- Level 3 SA = (project , projection ,dynamics, anticipate, future ,events);
- Decision making (DM) =(decision, making);
- Performance of actions (PA) = (performance, actions).

The Leximancer conceptual map is shown in Fig.1, where 50% of the most important concepts are identified. In principle, we can state that all the five above mentioned concepts have already existed in the STCW Code [7] prior to the Manila amendments, but they were not structured in the Code and they are not structured in the 2010 version. Arrows drawn by author show the consistency of SA1-SA2-SA3-

DM-PA algorithm. Straight lines linking concepts show their statistical correlations. The concept of ECDIS, linked with other concepts, is indicated only as an example of an important concept in the STCW Code text.

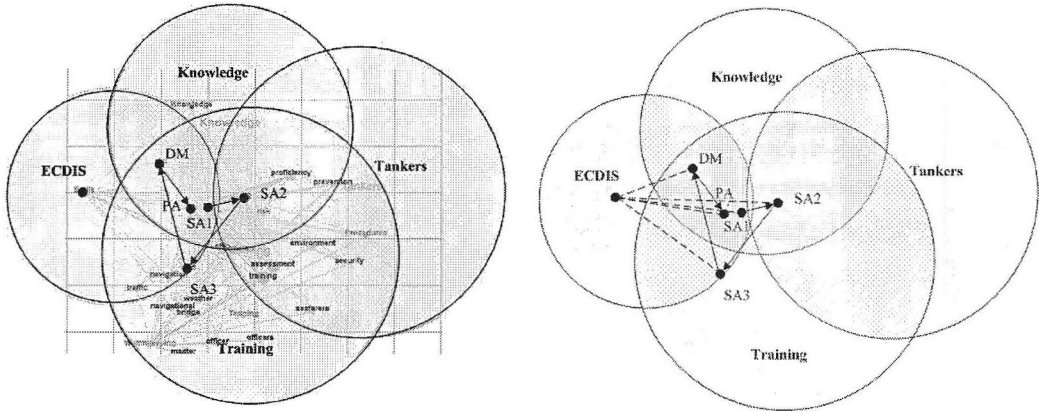


Figure 1 The intra-text information mined by Leximancer software from STCW Code text

The general results that can be extracted from the conceptual map in Fig.1 show that intra-text information mined from the STCW Code text is as follows:

- The above concepts have the intra-text probabilistic relationships with all other important concepts mined from the text.
- All 5 concepts, including SA levels, are positioned in the common area of intersection of the two very important themes of Knowledge and Training.
- The STCW Code pays great attention to SA though the combination of words Situation (*or Situational*) and Awareness practically occurs only few times in it. This finding is apparent from intra-text mined information.

It is possible to conclude that all the principles of SA are of high importance in the STCW Code; they “soar in air” of the Code and we subconsciously apply them in our professional activity. In other words the competences in STCW Code obviously exist, but Situation Awareness is submitted in a very much implicit format. In our view point it needs to be structured in salient manner, researched, and applied to maritime education and training.

### 3. STCW Code is the competence-oriented standard for MET

#### 3.1 What is a competence?

The core definition can be formed by the following statement. Competence is the acquisition of knowledge, skills and abilities at a level of expertise sufficient to be able to perform in an appropriate work setting[8]. It is quite obvious that STCW competences are included in the STCW concepts positioned above. The definition of competence can be written briefly as follows:

$$Competence = Knowledge + Skill + Ability$$

To gain *competence* in an appropriate field of activity is impossible without gaining SA in this field.

As per the STCW Code: *Standard of competence* means the level of proficiency to be achieved for the proper performance of functions on board ship in accordance with the internationally agreed criteria as set forth herein and incorporating prescribed standards or levels of knowledge, understanding and demonstrated skill [9].

The competencies of seafarers specified in the STCW Code are grouped at the following levels of responsibility: Management Level (ML), Operational Level (OL), Support Level (SL) and under the following seven functions:

1. Navigation
2. Cargo handling and stowage
3. Controlling the operation of the ship and care for persons on board
4. Marine engineering
5. Electrical, electronic and control engineering
6. Maintenance and repair
7. Radiocommunications

A competence-based mind map of the STCW Code (2010) is shown in Fig.2, where appropriate tables of minimum standards, functions and responsibility levels are submitted. Therefore, it can be used as competence- based taxonomy for inclusion of SA into STCW Code ideology and structure.

The STCW Convention and Code is a competence-based standard for MET. Competence-based education (CBE) is an institutional process that moves education from focusing on what academics believe graduates need to know (teacher-focused) to what students need to know and be able to do in varying and complex situations (student and/or workplace focused) [10].

Following the terminology of [10], in the STCW Code large skill sets are broken down into competencies which may have sequential levels of mastery. Competencies reinforce one another from basic to advanced as learning progresses. The impact of increasing competencies is synergistic and the whole is greater than the sum of the parts.

Competencies within different contexts may require different bundles of skills, knowledge and attitudes. The challenge is to determine which competencies can be bundled together to provide the optimal grouping for performing tasks. This is achieved in the STCW Code by including the appropriate competences into functions. If we define CBE as a process, then the SA approach, as a part of CBE, can be considered as a dynamic core of all sets of competences included in STCW Code, especially in watchkeeping.

For example OOWs on ships of 500 gross tonnage or more are to be educated, trained and assessed in the function of Navigation at the operational level by 9 competences; each of them including appropriate SA segments.

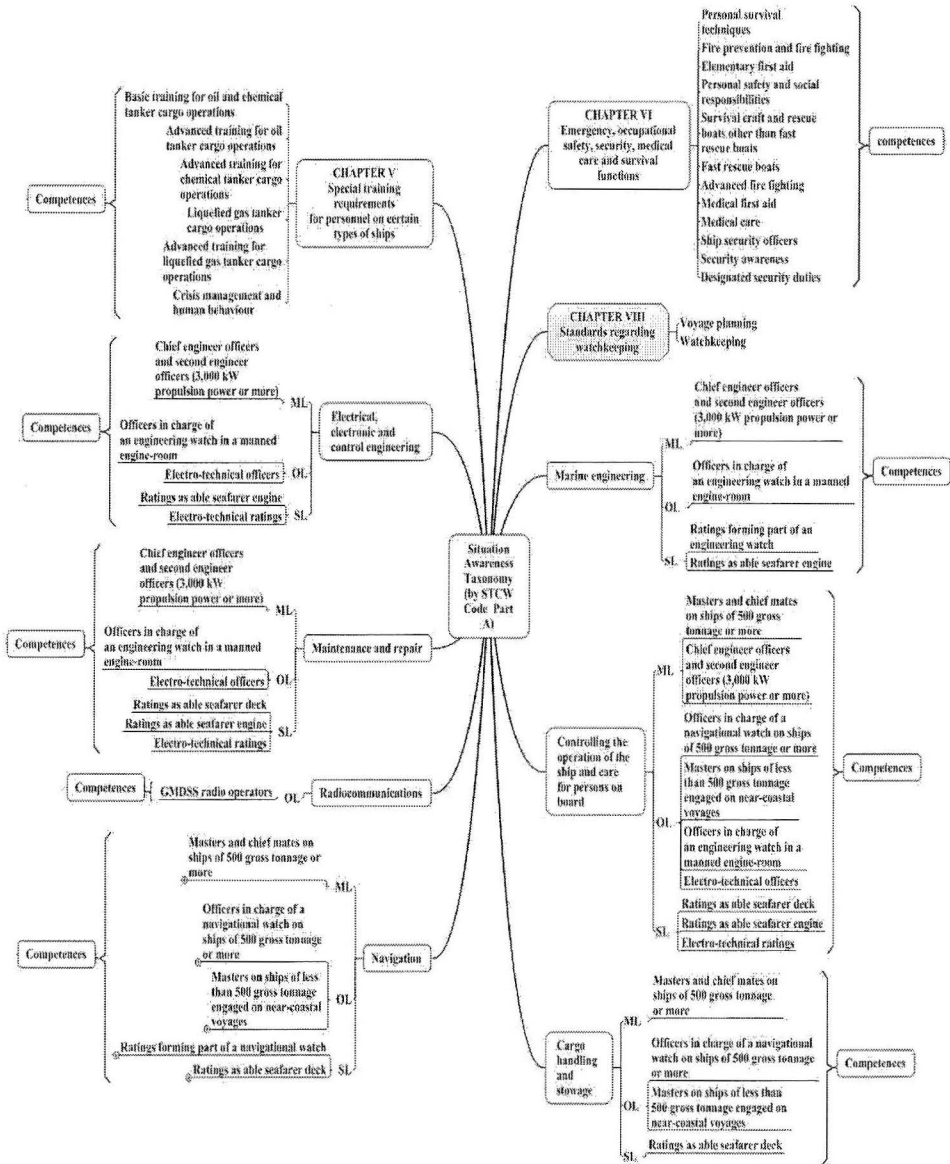


Figure2. STCW Code (2010) -Competence oriented mind map

Both techniques determine the required professional behavior that can be expressed by means of a verb and the appropriate taxonomy is presented as per Bloom [11] and as per Endsley [1] in the comparison table below.

### 3.2 Competence and SA behavior verbs

It is clear from the comparison table that competence contains an SA portion. Comparison of professional behavior verbs from the table below gave us an idea that SA principles, as a part of competence, can be applied both for training and education

including assessment. Both techniques determine the necessary professional behavior which can be used to measure the competency and degree of SA at all three levels. The sets of behavior verbs confirm that a competence-based approach contains the SA process.

**Table 1. Comparison of professional behavior verbs**

Competence	Suggested professional behavior verbs (Bloom)	Situation Awareness	Suggested professional behavior verbs (Endsley)
<b>Level 1: Knowledge (K)</b>	Define, describe, find, <b>identify</b> , label, list, match, mention, name, outline, <b>recognize</b> , record, repeat, reproduce and state.	Level 1 SA – Perception (P)	detect, recognize, identify
<b>Level 2: Understanding (U)</b>	Classify, cite, <b>comprehend</b> , convert, discuss, distinguish, estimate, explain, extend, generalize, give examples, <b>interpret</b> , make sense out of, paraphrase, predict, restate (in own words), summarize, trace and translate.	Level 2 SA – Comprehension (C)	comprehend, combine, interpret, store, retain
<b>Level 3: Application (A)</b>	Act, administer, apply, articulate, arrange, assess, calculate, chart, collect, compute, construct, contribute, control, demonstrate, determine, develop, discover, establish, extend, implement, include, inform, instruct, manipulate, operate, participate, <b>predict</b> , prepare, preserve, produce, <b>project</b> , provide, report, review, show, solve, teach, transfer, use and utilize.	Level 3 SA – Projection (Pr)	project, anticipate

<p><b>Level 4: Integration (I)</b></p>	<p>Analyze, appraise, categorize, combine, communicate, compare, compile, compose, conclude, contrast, correlate, create, criticize, decide, defend, design, develop, devise, differentiate, discriminate, express, facilitate, formulate, generate, hypothesize, illustrate, incorporate, integrate, interpret, invent, judge, justify, model, modify, negotiate, organize, outline, plan, point out, prioritize, rearrange, recommend, reconstruct, reinforce, relate, reorganize, revise, select, separate, solve, structure, subdivide, substitute, support and validate.</p>		
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Paraphrasing the definition of SA [1] to make it more flexible for the educational process, the following wording can be used. SA is a perception of elements of an arbitrary space within a volume of time or within a volume of any other of its characteristics, comprehension of their meanings and the projection of their status in the near of origin.

### 3.3 Human Element: Situation Awareness - core guidance proposal

The integration of all generic SA elements extracted from MET processes, watch-keeping procedures and different types of drills and training conducted on board ships as per SOLAS 74 requirements, can form the core content for the SA guidance and also for the appropriate course consisting of the following main items to be developed:

- 3.3.1 Situation awareness basics
  - 3.3.1.1 SA impact on accidents at sea
  - 3.3.1.2 SA as a basis for Decision Making and Performance of Actions
- 3.3.2 SA approach to Maritime Education and Training (at different levels of responsibility, qualification functions and competences as per STCW Code provisions)
- 3.3.3 Team SA
  - 3.3.3.1 Communication and team SA
  - 3.3.3.2 SA in Bridge team management
  - 3.3.3.3 SA in Engine team management



- 3.3.4 SA behavioral markers
- 3.3.5 Assessment of SA
- 3.3.6 Errors in SA
- 3.3.7 Watchkeeping [12]
  - 3.3.7.1 Building and obtaining SA
  - 3.3.7.2 Maintaining SA
  - 3.3.7.3 Detecting the loss of SA
  - 3.3.7.4 Looking for clues of degraded SA
  - 3.3.7.5 Recovering SA
- 3.3.8 Training for SA

## 4. Conclusion

The main conclusions from this research can be formulated as follows:

- SA is the basis for decision making and performance of actions;
- SA is a very important part of any professional competence;
- The concepts and principles of SA are included in the STCW Code, but they need to be structured, researched, and applied for maritime education and training. In other words the competences in the STCW Code obviously exist, but Situation Awareness is submitted in a very much implicit format;
- SA methodology can be applied both for training and education processes of seafarers, including assessment procedures;
- Implementation of ISM and ISPS Codes can be improved by using SA methodology;
- Watchkeeping procedures especially need to be researched from the view point of SA.

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