
**DYNAMIC POSITIONING CONFERENCE**
**October 10-11, 2017**

**TRAINING/COMPETENCY SESSION**

# Training Competency Assurance

By Ralph Benham

*Maersk Training, Inc.*

## Abstract

Incident investigations performed by the aviation industry showed that human factors played a key role in causing accidents. Studies of incidents in the maritime industry have shown that similar factors are at play in causing maritime accidents. The aviation industry has successfully addressed these factors, but the maritime industry still lags behind in their training methodology. Maritime companies understand that employees need to be competent to do the job they are hired for. However, having a vessel full of competent personnel by itself does not guarantee success, because individual competency does not equate to group competency. The next evolution in training is the Team Based Integrated Simulation Environment. This training brings in all key personnel involved with the vessel together to learn the skills needed to assure their competency as a team, such as effective communications, leadership, and decision-making.

## Abbreviation / Definition

ACRM – Advanced Crew Resource Management
BRM – Bridge Resource Management
CRM – Crew Resource Management
DP – Dynamically Positioned
DPO – Dynamic Positioning Operator
ECDIS – Electronic Chart Display and Information System
FAA – Federal Aviation Administration
IMO – International Maritime Organization
MEM – Major Emergency Management
NASA – National Aeronautic and Space Administration
NTSB – National Transportation Safety Board
OIM – Offshore Installation Manager
OJT – On-the-Job Training
PIC – Person In Charge
SMS – Safety Management System
SOP – Standard Operating Procedure
STCW – Standards of Training, Certification, and Watchkeeping for Seafarers
USCG – United States Coast Guard

## Introduction

The solutions to lessons learned first by the aviation industry can be better implemented in the maritime industry than they are at the present time. Researchers in the aviation industry observed that individual competency does not necessarily equate to group competency. The solution was to train employees together in full mission flight simulators using their company's specific policies, procedures, and checklists. The maritime industry is still focused on the individual's competency, and not the competency of the crew as a whole. Advances in simulator technology make it possible to train entire vessel crews together using their company's policies and procedures to form more competent teams.

## Background

Crew Resource Management and Human Factors training has been utilized in the airline industry for decades. It started in 1979 when the National Aeronautic and Space Administration (NASA) presented "Resource Management on the Flight Deck." This study of incidents within the aviation industry highlighted three main failures that caused the accidents: interpersonal communications, decision-making, and leadership. In an effort to address these failures, "Cockpit Resource Management" was created.

The cockpit crew was fully competent in their technical skills to fly the plane, so there was no need to require additional aircraft flight training. Therefore, Cockpit Resource Management focused on the need for good communications and teamwork within the cockpit. The training consisted of classroom time and group exercises, which were intended to improve the performance of the leader of the team and a few immediate team members: Pilot, Copilot, and Navigator.

Cockpit Resource Management has been continuously upgraded and improved since its conception. A key improvement came with the development of full-flight simulators, which allowed for more realistic mission-based training that involved the entire flight deck crew in "Line-Oriented Flight Training." During the simulation the aircrew is subjected to normal, abnormal, and emergency situations, and afterward they are assessed on their decision-making capabilities. Based upon the results from those classes, and further investigations into accidents, it was determined that there were elements still missing from the training program. Team performance was added to address the missing elements. This training focused on team building, group dynamics, and decision-making. In order to make it more relevant to the aviation industry, situational awareness, stress management, and crew briefing strategies were added to the syllabus.

Additional changes occurred after the Federal Aviation Administration (FAA) published the first draft of the National Plan for Aviation Human Factors in 1990. That study identified human error as a causal factor in 66% of air carrier incidents, 79% of commuter fatal accidents, and 88% of general aviation fatal accidents. These findings resulted in human factors training being added to the program. Training was also updated to address new technologies and organizational impacts on safety. During this time period, Cockpit Resource Management truly evolved to Crew Resource Management (CRM) and became clearly defined as "The effective use of all resources to include human and other aviation system resources." Flight attendants, dispatchers, and maintainers were added to the training roster, as these personnel can have an impact on the safe operation of the aircraft. In addition, metrics were created to determine if the training was effective. Exercises and evaluations focused on certain CRM behaviors, and the crew's performance rating was based on their use of that particular behavior during the simulation.

CRM underwent further modifications after the National Transportation Safety Board (NTSB) released the safety study "A Review of Flightcrew-involved, Major Accidents of U.S. Air Carriers 1978-1990" in 1994. The initial findings showed that there were three major commonalities amongst the accidents:

- In 81% the pilot was flying and the first officer was not flying
- 73% occurred on the first day the crew was flying together
- 44% occurred on the first leg of the crew's first flight together.

This showed that the CRM training alone was not adequate when confronted with a newly formed cockpit team. Cockpit teams change on a regular basis, so new teams are not an uncommon occurrence. To strengthen the presence of CRM in the cockpit the FAA created Advanced Crew Resource Management (ACRM). ACRM is "a comprehensive implementation package including CRM procedures, training of the instructor/evaluators, training of the crews, a standardized assessment of crew performance, and an ongoing implementation process providing an integrated form of CRM by incorporating CRM practices with normal and emergency SOP." The intent of ACRM is to remove the problem of individuals receiving separate ideology regarding crew resource management. All key personnel within the company are trained with the same syllabus and to the same standards. That way when a new cockpit team is formed, it will be easier for them to function as a team right away.

Further analysis of the data collected by the NTSB showed that 84% of the incidents occurred due to "inadequate monitoring to catch errors made by another crew member or failure to challenge the crew

member who was perceived to make the error." Several companies addressed this issue by changing the "Pilot Not Flying" designation to "Monitoring Pilot" to emphasize that the second pilot in the cockpit is obligated to speak up if the "Pilot Flying" does something wrong. This is similar to when an Officer on the bridge does not question or speak up about something the Captain is doing or has ordered.

The incident rate in the airline industry has been declining since the advent of CRM, while during the same time the total number of flights has been almost doubling every 15 years. Some of this reduction can be attributed to technology; however, without CRM training the improved technology would not be as effective.

## The Maritime Connection

Incident reports within the maritime industry also showed human factors as a leading cause of accidents. A study done by the Dutch in 1987 (Wagenaar & Groeneweg, 1987) showed that in 96 out of the 100 cases reviewed, human error was a contributing factor. In 93 of those cases multiple human errors were made and multiple people made about two errors each. Detailed analysis of each case showed that each individual error was required in order for the accident to have occurred. If any one of those errors was averted the incident would not have taken place. The human errors were categorized into three main types: "an incorrect decision, an improperly performed action, or an improper lack of action (inaction)." (Human Error and Marine Safety, USCGRDC ROTHBLUM 2000). These factors are remarkably similar to those found in the aviation industry.

The maritime industry began to take notice of what the aviation industry was doing to address the human element problem, and realized the cockpit of a plane functions in a similar manner to the bridge of a ship. Statistics from incidents in the maritime industry showed that human factors were the causal factor at approximately the same percentage as within the airline industry. Some instances in the aviation industry were very similar to a situation in which the officers on the bridge all knew the rules of the road, and yet the vessels still managed to collide with each other. Accordingly, several countries got together in order to turn Cockpit Resource Management into Bridge Resource Management (BRM). The first BRM class occurred in 1993. At this time, however, it was not an International Maritime Organization (IMO) requirement.

The United States Coast Guard (USCG) did a study in 1995 that identified the three largest problems as being "fatigue, inadequate communication and coordination between pilot and bridge crew, and inadequate technical knowledge (especially of RADAR)."

The IMO addressed the risk of fatigue during the "Seafarers' Hours of Work and the Manning of Ships Convention, 1996 (No. 180)." The convention outlined the maximum hours of work and minimum hours of rest for seafarers. Mariners are now required to maintain a record of hours of work and rest. The "Standards of Training, Certification, and Watchkeeping for Seafarers" (STCW) convention also requires bridge officers to have RADAR training to ensure watch officers could correctly utilize the RADAR. The "International Management Code for the Safe Operation of Ships and for Pollution Prevention" (the ISM Code) was adopted in 1993 and became mandatory in 1998. The ISM code helped address company-wide problems with safety, roles, responsibilities, policies, and procedures. The Safety Management System (SMS) Manuals provide the employee with policies and procedures and create uniformity within the company. However, incidents and accidents still happen that are directly attributable to human factors.

Excluding fatigue, the direct link between incidents and human factors was mostly overlooked, even though communication problems between pilot and bridge crew (a human factor issue) were identified by

the 1995 USCG study. The aviation industry had found that a new team in the cockpit was a leading factor in their incidents. It turns out that a new team on the bridge of a ship has the same effect, especially when another team member such as a pilot is added.

"The 2nd International Workshop on Human Factors in Offshore Operations (HFW2002) – Human Factors in Incident Investigation and Analysis" identified the following human factors issues in the maritime industry: Fatigue; Inadequate communications; inadequate general technical knowledge; inadequate knowledge of own ship systems; poor design of automation; decisions based on inadequate information; poor judgment; faulty standards, policies or practices; poor maintenance; and hazardous natural environment. The idea was that by knowing the human factors involved, one can redesign everything from the ship itself down to the procedures and checklists, in order to make everything more compatible with the user. There was no mention of training the employees to identify when these human factors could be impacting the situation on their vessel. This is similar to when the airline industry starting building safer airplanes by making the cockpits more ergonomic, creating standardization requirements for equipment, and requiring better policies and procedures.

After several high profile maritime disasters that identified human factors as a leading cause, the IMO recognized that the maritime industry required more focus on human factors and soft skills. This was addressed through creating additional training requirements for officers in the 2010 STCW Manila Amendments:

- Reg. A-II/1 for Bridge Resource Management
- Reg. A-III/1 for Engine-room Resource Management
- Reg. A-II/2 and A-III/2 for Use Leadership and Managerial Skills
- Reg. A-II/1, A-III/1 and A-III/6 for Application of Leadership and Teamworking Skills

These classes, however, do not require the use of simulators to demonstrate the officer's ability to utilize the skills. The IMO gives a broad overview of what material is to be covered and how it is to be covered, but there is no standardization of methodology. BRM can be taught in various ways using different ideologies. That means that an employee attending one of these classes may be introduced to one method of BRM, while another employee on the same vessel went elsewhere and was taught a different method. When each returns to their vessel, they will be the only employee who knows that particular method of BRM. Additionally, in both cases an employee attending the STCW classes will likely be taught things that differ from their company's SMS manuals.

Legislation and regulations have addressed a large portion of the human factor issues that were identified from the studies. The ISM Code and STCW regulations have improved safety offshore. However, there are still areas for improvement when it comes to assuring team competency. The maritime industry has not yet adequately addressed the problems associated with competent people working in a team environment.

## Maritime Training Today

Ideally, employees are hired already possessing the skills and knowledge required to do the necessary tasks for their position. It is, however, more likely that the employee does not have all of the necessary skills or knowledge to perform the job exactly the way any particular company wants it done. Thus, the new employee will most likely require some form of training.

That could come in the form of On-the-Job Training (OJT), which helps the employee learn the particulars of their company's policies and procedures. OJT, however, depends heavily upon the knowledge of other employees and those employees' ability and willingness to teach. There is also potentially no way to verify that the employee has received all the necessary information.

Technical classes can help fill in knowledge gaps that OJT missed. These classes can either be equipment- or knowledge-based. Knowledge-based classes are generally certified by an industry recognized body. An example of a knowledge-based class is the STCW Electronic Chart Display and Information System. (ECDIS) class. After successful completion of that class the employee will have a basic understanding of what an ECDIS can do and the rules and regulations regarding the use of the ECDIS. The knowledge-based classes do not necessarily teach the employee how to use the exact equipment that is in their workplace. Manufactures generally offer training for specific pieces of equipment, and these classes generally focus on proper setup and use of that equipment, independent of any other factors. The IMO's STCW Code has addressed this need by requiring mariners to attend a manufacturer approved, equipment-specific ECDIS Training class for the ECDIS on their vessel.

The IMO Leadership and Management classes are also knowledge-based. After attending a class the employee will have been presented with all the necessary knowledge on how to lead and manage their subordinates. There is, however, no requirement for them to demonstrate their ability to perform in a crisis situation.

Simulator classes combine knowledge and technical skills together in one class. One such class is the STCW advanced fire fighting class. The employee is exposed to an emergency response plan based on industry best practices, not the specific plan for their company. They are then put in situations where they have to demonstrate the knowledge they were taught, by extinguishing real fires. The Nautical Institute DP Simulator class is another such class. The Dynamic Positioning Operator (DPO) is required to demonstrate their ability to operate a Dynamically Positioned (DP) vessel in a simulator in order to successfully complete their training. It only addresses the industry guidelines for DP operations, nothing vessel specific or company specific.

Major Emergency Management (MEM) and Person In Charge (PIC) classes are simulator-based classes where employees demonstrate their ability to perform in a crisis situation. These classes are not industry mandated, and rarely use the specific emergency response plan from the company whose crew is being trained. For example, a person wanting an USCG Offshore Installation Manager (OIM) certificate only requires USCG approved training in stability, survival suit and survival craft, and firefighting.

The employee should be competent to do their job after attending the various training classes and programs. Yet company-specific aspects of the employees' jobs are not addressed in any of these classes. Many companies add computer based training to cover the company's ISM Code requirements. However, completion of this training generally only means that the employee has been exposed to the SMS manuals and has retained enough information for testing and auditing purposes. Employees are rarely tested on their ability to actually use the SMS.

None of these classes has put the employee into situations with their own crew, utilizing their own company's policies and procedures. Individual competency does not equate to group competency. The ACRM concept of training the entire company as a team, to the same standard, has no clearly defined parallel in the maritime industry.

## Maritime Training - Team Based Competency

The challenge is to take employees who are deemed individually competent, and turn them into a competent team. The aviation industry met this challenge by creating ACRM, which standardized human factors training for the company and incorporated them into the Standard Operating Procedures (SOPs). The maritime industry could benefit from adapting the ACRM philosophy of incorporating human factors into the entire operation. One of the best ways to accomplish this is to develop maritime team based competency training.

Team based competency teaches a standardized human factors platform to all the employees, while at the same time testing their ability to use their company's SMS policies and procedures in various situations. This type of training serves several purposes. The first is to test the effectiveness of the policies and procedures. If policies and procedures are found to be cumbersome, contain gaps, or be ineffective, they can be rewritten to make them more suitable. The second is to ensure the employees know the policies and procedures and are comfortable with using them. Even an employee who is deemed technically competent in their job may not be proficient in the use of the company's SMS manuals. The third one is to integrate the various groups within the company to create a team mentality while verifying team performance. This helps highlight to the crew the need to recognize human factors conditions, and how those conditions can influence individuals as well as the entire team.

## Class Composition

DP vessels tend to be specialized vessels designed to perform a specific job. That means DP vessels often have more than just a marine and engine crew on board. Construction vessels have the construction crew on board, dive boats have the dive team, drill ships have the drill crew, and so on. Each of these groups consists of employees who have been deemed individually competent to do their particular job.

A DP drill ship, for example, has several key operational groups. Some of the groups onboard could be subcontractors who work for the charterer. These subcontractors have their own company's policies and procedures that they follow. The drill ship has a shore side support network. The oil company may have remote drilling and well monitoring locations. The drilling company generally has marine, technical, subsea, and drilling experts in the office that the vessel can call upon for help. Any one person in this large network of employees could have the ability to impact the overall performance of the operation.

While it would be ideal for every employee involved to attend team based competency training, it is just not practical. The company must identify the key personnel in the operation, while keeping in mind that all personnel are important for the operation to succeed. Once the key offshore and shore side personnel are identified, the class can be developed around them.

A possible class roster for a drilling vessel could consist of the rig manager, Captain, OIM, Chief Mate, DPOs, Chief Engineer, Assistant Engineers, deck foremen, crane operators, HSE personnel, company representatives, well site leader, all drilling personnel from drilling supervisor to derrickman, mud loggers, and shore side remote monitoring personnel. However, class size should not become larger than 60 employees, in order to retain manageability.

For an Offshore Supply Vessel the class might only consist of the Bridge team and the Engine room team in addition to the shore side support personnel: the Designated Person Ashore, Company Security Officer, marine superintendent and technical support staff. If the vessel is assigned to a particular installation, the crane crew from that installation could attend the training as well.

Ideally, all the available key personnel from all departments would attend this training at the same time to ensure uniformity on board the vessel. It can be easy for one group to forget about the other group, yet operations in one department can impact all departments. Communications between the various departments are crucial for safe operations, and team based competency training will reinforce that.

## Class Structure

The class would have more simulator time than classroom time. The classroom time would cover the necessary CRM skills and human factors training to become a competent team. The CRM aspects discussed in the classroom will be incorporated into the simulator exercises so that the learning objectives from the classroom will be immediately brought into use. This is accomplished by creating conditions that could lead to a loss of situational awareness. The intent is to create a need to make important decisions in a situation where an incident could result if the wrong decisions are made. Conditions that can result in a loss of situational awareness include, but are not limited to:

- Distractions
- Imprecise communications
- Multi-tasking
- Misplaced priorities
- Workload
- Too many things to keep track of
- Shift change

Other human factors that could impact the team and result in poor decisions being made are:

- Biases – overconfidence Bias or Confirmation Bias
- Using procedures as a crutch
- Groupthink and Social Influence
- Normalization of Deviance
- Performance-Shaping Factors (Stress, fatigue, time-pressure, etc)

After the exercise, feedback will be given to the students. Their use of CRM skills will be critiqued and discussions will be had about what went well and what needs improvement. This immediate feedback helps with knowledge retention, and will allow the students to try to make the necessary improvements during the next exercise.

## Integrated Simulators

Ideally, this training would be vessel- and job-specific, but current technology does not allow that level of integration and individualization for all vessels. Aircraft cockpits tend to be more standardized for any particular aircraft type, which makes plane- and airport-specific simulations practical. Unlike the aviation industry, however, ships have very little standardization between them. Two ships can look identical on the outside and have completely different bridges and engine rooms.

This inability to make the training vessel-specific will not detract from the learning objectives. It is highly likely employees will find themselves at some point on a vessel within their company that has some equipment, or a layout, that they are not completely familiar with. Equipment and layouts that they are not familiar with add a degree of uncertainty and stress to the student, but this can actually help with the learning objectives of the class because the focus of the integrated simulation environment is human factors and soft skills. Technical skills, while important, are not stressed. However, the vessel type and

job being simulated is pertinent. A dive boat crew would receive little benefit if they train on a drill ship simulator.

While making the simulations vessel specific is still difficult, simulator technology continues to improve, making new scenarios possible. One such improvement is the ability to directly integrate the bridge, engine room, and a crane into one simulation. This allows the bridge team, the engine room team, and the crane operator to share the same experiences. For example, a loss of power on the vessel will result in the DP system losing thrusters and the crane losing power. By incorporating other simulators, such as a drilling simulator or a pipelay simulator, other vessel types can receive a similar training experience. While these other simulators may not be directly interfaced together, communications between instructors and synchronization of events can make it appear that they are linked.

Another way to add a layer of realism is to simulate an actual future job. For DP drilling vessels the drill floor could simulate drilling in a section of the hole that is forecasted to be potentially tricky. The issues they encounter in the simulator would then be something they could potentially see at their next location. For a crane vessel, the crane could be lifting an oversized heavy lift with tight tolerances. Potential environmental conditions like high current or large swells can also be replicated in the simulator.

## Retention of Training

Research has been done on how humans process, retain, and retrieve information. By utilizing the results of these studies, the retention level of the employees can be increased. The more relevant and realistic the immersive simulation environment becomes, the better the retention level. To accomplish this the employee needs to see a direct link between the class's objectives and their job performance and requirements. This is accomplished by using their company's specific SMS. The class is more meaningful and relatable, so it is more likely it will have increased retention levels and longer lasting positive impact. Another way to ensure retention is to use cross-sensory presentation. This is accomplished by a combination of classroom and simulator time.

Feedback is also critical to the learning process. After every simulation the personnel will critique their own performance using the feedback tools they learned in the classroom. They will be able to identify what they did well, and what were areas for improvement. This encourages critical thought and analysis of their performance. After their own review, they receive feedback from the instructors. It is important to point out what went well, what were specific areas for improvement, and what can be done to improve them.

## What are the advantages to this training?

Standardization of training within the company will mean that all employees have the same ability to identify human factor issues, and know the importance of speaking out when necessary. This helps reduce the inherent risk that happens when a new crew is put together. Personnel will already know what to expect when they get to their new assignment. The discussions of "on my last ship this is how we did it" and "that is not how we do it on this ship" will be fewer, because all ships within the company operate to the same standard.

The crew and shore side employees will have a better understanding of their policies and procedures after they have trained together as a team using their own Company's SMS manual. They will also be able to confidently utilize procedures that they may not often require, such as emergency procedures. The involvement of shore side personnel in the class reinforces the company's commitment to the training,

which in turn will enhance the impact of the class. By training as a group they will gain a better understanding of how their actions can impact other operations on the vessel.

Crew turn over is always a large concern when a company invests in training. One advantage of this particular kind of training is that it is intended to develop the correct mindset towards safe operations within the company. A new employee who has not received the full team training will arrive on a vessel that has a unified approach to how situations are handled, so it will be easier for them to integrate into the team. They will not have to worry about expectations changing based on who is on board at the time.

## Conclusion

The aviation industry has utilized CRM and ACRM training for decades and success has been measured by a steady reduction in incident rates. The maritime industry identified the need for CRM training and 2010 STCW Manila Amendments addressed this need. The additional training set forth by the IMO helped reduce incident rates, but there is still room for improvement. Aviation's "Line Oriented Flight Training" that includes a company's entire flight crew does not have any parallels in the maritime industry. Shore based and vessel based employees do not normally attend simulator training as a group. The maritime industry is also lacking a parallel to the FAA's ACRM package. Maritime companies generally do not require standardized training incorporating both CRM skills and use of their SMS.

Having all the key offshore personnel and key shore side support personnel attend team based competency immersive simulator training, involving human factors and utilizing their SMS, can improve safety on board. This is accomplished by integrating CRM into the company's normal and emergency SOPs. Team based training also takes individually competent employees and makes them into a competent team. A competent team tends to be more efficient and better able to find solutions to problems, resulting in cost reductions. This has been proven in other industries that have sent their employees to team based training. It has also shown successful results in the offshore drilling industry through team based well control classes, as well as large scale immersive simulated environment classes involving an entire DP drilling vessel. These positive results can be expanded to the rest of the maritime industry.

It is time for the maritime industry to start utilizing CRM and team based training to ensure that not just the employee is competent, but also the vessel's crew as a whole.

## Acknowledgements

My sincere thanks to my colleagues at Maersk Training for sharing their knowledge and viewpoints on human factors with me, Evelyn Baldwin for reviewing my draft, and my wife, Alice, who kindly suggested grammatical changes right up until the paper was submitted.

## References

A. Wagenaar, Willem & Groeneweg, Jop. (1987). Accidents at Sea: Multiple Causes and Impossible Consequences. International Journal of Man-Machine Studies. 27. 587-598. 10.1016/S0020-7373(87)80017-2.

Dr. Anita M. Rothblum. (2000). Human Error and Marine Safety. U.S. Coast Guard Research & Development Center.

Thomas L. Seamster, Deborah A. Boehm-Davis, Robert W. Holt, and Kim Schultz. (1998) Developing Advanced Crew Resource Management (ACRM) Training: A Training Manual. Federal Aviation Administration Office of the Chief Scientific and Technical Advisor for Human Factors.

Rebecca R. Gray, Dr. Mark Rogers, Glen Hewitt, et. Al. FAA Human Factors Awareness Web Course. Retrieved September 14, 2017, from http://www.hf.faa.gov/Webtraining/index.htm

United States. U.S. Department of Homeland Security, United States Coast Guard. February 21, 2017. Navigation and Vessel Inspection Circular No. 10-14 Ch1, Washington, DC.

United States. National Transportation Safety Board. 1994. A Review of Flight crew Involved Major Accidents of U.S. Air Carriers, 1978 through 1990. NTSB/SS-94/01. Washington, DC.

United States. NASA, Ames Research Center. 1980. Conference Publication 2120, Resource Management on the Flight Deck, Proceedings of a NASA/Industry Workshop. Moffett Field, California.

2nd International Workshop on Human Factors in Offshore Operations (HFW2002), Human Factors in Incident Investigation and Analysis. April 8 -10, 2002. Houston, Texas.

Airbus S.A.S. A Statistical analysis of Commercial Aviation Accidents 1958-2016. 2017. Reference X00D17008863 Issue 1. June, 2017. Art & Caractere. France.

Boing Commercial Airplanes, Aviation Safety. Statistical Summary of Commercial Jet Airplane Accidents Worldwide Operations, 1959-2016. 2017. Seattle, Washington.