Avoiding Collisions At Sea – Pareto Analysis

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ABSTRACT

It has been almost 40 years since the 1972 International Regulations for Preventing Collisions at Sea known as COLREGs were introduced, and regular amendments have been taking place accordingly ever since. Collision avoidance is believed, in a sense, to prevent groundings, the striking of fixed obstacles, as well as ships colliding with other ships. Over the last half-century despite improvements in navigational aids such as ARPA and attempts to raise the standards of training through the various STCW conventions, collisions still occur. Many studies and accident reports_indicate that the accidents were caused by either human error or are associated with human error as a result of inappropriate human responses. Collisions commonly represent many of these accidents.

This paper discusses key issues regarding the application of Collisions Regulations (COLREGs) at sea and reports on the outcome of a recent EU funded eCOLREGs project known as ACTs. This paper does not attempt to examine the each and every rule included in regulations but the EU Project ACTs' online platform considered each rule and provides some 290 scenarios many developed and videoed in ship simulators for those interested to review and explore more. There also some tests available on the online platform. The paper mainly discusses the basic rules that are usually ignored or disregarded identifying the deficiencies in the maritime education and training (MET) of seafarers which are related to concerns about COLREGs, and makes recommendation by applying Pareto Analysis.

Keywords: *COLREGs, maritime education and training, collision avoidance, Pareto Analysis*

1. INTRODUCTION

COLREGs is one of the internationally agreed conventions of the sea. It is vital to ensure that all seafarers have full understanding to take correct actions to avoid collisions. The International Maritime Organisation (IMO) developed the first standard for Vocational Education and Training (VET) programmes for merchant navy officers (STCW) in 1978, and it has been amended in 1991, 1995, 2003 and 2010 respectively. However, there are currently no mechanism to monitor how these standards are being applied as many VET providers have been found not to follow many requirements. Therefore, there has always been substantial diversity on the knowledge of seafarers affecting the safety of life at Sea. The COLREGs are basically a set of rules required to be followed by all navigation officers. It is one of the most important International Conventions in seafarer's education and training where full understanding and knowledge must be shown/performed prior to taking charge of navigational watch.

The COLREGs provide various guidelines as to passing, crossing overtaking manoeuvres to be made; detailing of which ships have the right of the way depending on the circumstances and the types of ships involved, and what actions these ships should take. It also describes the rules on the signals (lights, shapes and sounds signals)

The recent IMO bulletin "maritime knowledge centre" reports that more than 90% of the collisions are attributed to human factor (IMO, 2010), and this had earlier been reported by Parker (2010). Ziarati (2007), reports that the majority of those accidents and incidents are related to collisions and near misses. There is a clear indication that Collision regulations are either not understood or ignored although they are primary set of rules for taking actions to avoid collisions.

It is interesting to note that the earlier studies show that 85% percent of all accidents are either directly initiated by human error are associated with human error as a result of inappropriate human response (Ziarati, 2006). The human error reported to causing the accidents is now apparently to have increased by 5 percent in recent years. This may be linked to the revolution in automated equipments/systems on board the ships causing the number of accidents to decrease while increasing human element attributed to accidents. The Pareto Analysis methodology of Ziarati (2006) has been applied to identify where maximum benefits could be felt and which Rule if applied correctly that could reduce the number of collisions.

The Maritime Accident Investigation Branch (MAIB) and Mariners' Alerting and Reporting Scheme (MARS) reports conclude that many of the basic principles of collision avoidance are improperly understood / applied at sea (MAIB, MARS).

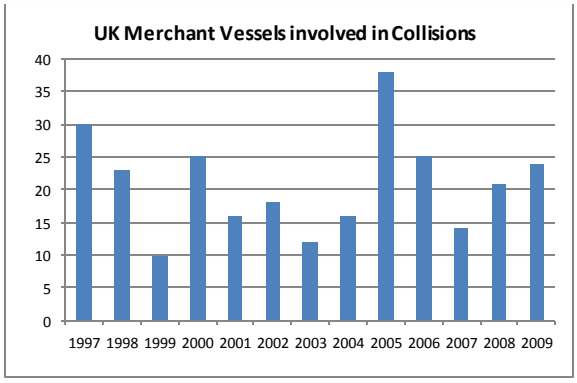

Figure 1: UK merchant Vessels involved in Collisions [Source: maritime Accident Investigation Branch 1997-2009]

The rules serve two main purposes:
a) to provide guidance to mariners on how to prevent collisions at sea
b) to serve as a basis for apportioning blame when collisions occur (Stitt, 2002)

2. COLREG IN MET

Maritime education and training programmes include COLREGs training under a Navigational Watch unit which is usually supported by full mission simulator training. This basically includes a number of hours teaching in class at either a theoretical or practical level. IMO model courses, for instance deck officer programmes, include 100 hours of lecturing that cover most aspects of collision avoidance (IMO, 1999). Similarly, at senior and higher levels, the programmes include 30 hours of teaching that is considered refreshment. Those model courses are designed to provide additional guidance to MET providers as required in Standard Training Certification and Watchkeeping (STCW) II/1 level

Across the world, countries have diverse methods of teaching the COLREGs as well as having diverse methods to identify the knowledge of their deck cadet/navigational officer's competency in COLREGs. Some by multiple choice questions, some with one to one exams to make sure that those deck cadets/navigational officers know / understand the COLREGs.

Research conducted by (Syms, 2002) by Nautical Institute highlights the suggestions of seafarers, that the improvement of maritime training and education (MET) systems are necessary which will help them improve the application of COLREGs at sea

The same research (Sym. R.J, 2002) also reports that in northern countries such as United Kingdom, Germany and France, the application and understanding of COLREGs is of a higher standard than when compared to other countries.

Ziarati (2006) extends the problems associated with COLREGs application to MET programmes. Ziarati (2006) emphasises that mistakes are usually made not because of deficient or inadequate regulations, but because the regulations and standards, that do exist, are often ignored.

3. RESEARCH INTO TO COLREGS RULES

COLREGs currently have thirty eight rules and four annexes. It applies to all vessels upon the high seas and in all waters navigable by seagoing vessels. The rules followed as closely as possible in line with the international rules as possible as stated in Rule 1 (Application) of COLREGs (Ford, 2003). For instance, in the United State, additional rules for vessels navigating inland are published alongside the international rules (US, 1989).

From the point of (Belcher, 2002), COLREGs are intended to operate in a environment where the Navigational Officer on each vessel has a complete understanding of the situation, knowing which rules are in effect, how those rules are interpreted and what needs to be done in case the action does not occur. Thus, (Belcher, 2002), perceives that the COLREGs operate in an environment of mutual comprehension, understanding and coordination, with clear logical steps ensuring clarity and predictability.

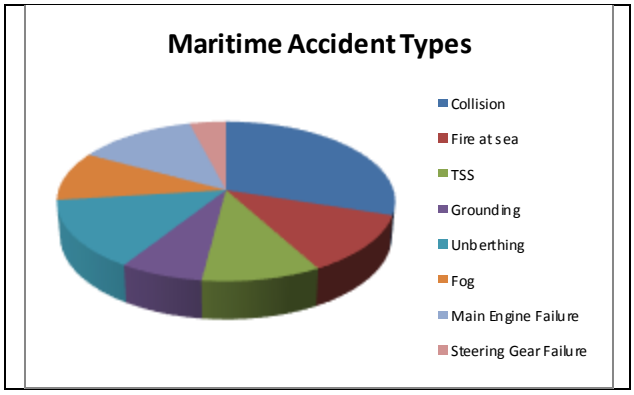

Figure 2 - Variation and Causes of Accidents
[Source: UK Protection and Indemnity Club, 2007]

MAIB (2004) has conducted a safety study that reviewed 66 collisions and near misses in their accident database. As a result of the study, the most common contributory factors in all these collisions were poor lookouts (Rule 5) and poor use of radar (rule 7(b), (c). That means that the standards of lookouts are poor and ineffective and radar is not used properly to identify the risk of collision. In fact, COLREGs clearly state the necessity of maintaining lookout in rule 5 and the use of radar in Rule 7(b), (c):

"Rule 5 - Every vessel shall all the times maintain a proper lookout by sight and by hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make full appraisal of the situation and the risk of collision"

"Rule 7(b) – Proper use shall be made on radar equipment if fitted and operational, including long-range scanning to obtain early warning of risk of collision and radar plotting or equivalent systematic observations of detected objects.

Rule 7(c) – Assumptions shall not be made on the basis of scanty information, especially scanty radar information.

The examples of rule 5 and Rule 7(b), (c) are basic and easy to understand, interpret and comply with compared to other rules of COLREGs. However, it is interesting to see those are the first concerns in the full study report (MAIB, 2004).

The same reports also point out that substantial numbers of accidents took place at night and in restricted visibility.

The example below shows the collision attributed by poor lookout.

Case 1 - Poor lookout
A dredger collided with a fishing vessel in the Dover Traffic Separation Scheme, in daylight, calm conditions and clear visibility. the dredger had been on passage and following the flow of traffic, and the fishing vessel not engaged in fishing, had been crossing the scheme. The vessels approached each other on a collision course for 10 to 12 minutes with the fishing vessel on the dredger's port bow. The watchkeeper on the dredger had seen the other vessel and, having identified it as a fishing vessel not engaged in fishing, was expecting her to alter course at the last minute.

With regard to the provision of a lookout, STCW 95 states that the officer in charge of the navigational watch may be the sole lookout "in daylight" provided it can satisfy the provisions in STCW for lookout requirements (STCW, 95). Despite this international requirement to maintain lookout at night, the MAIB research shows that at least three of fifteen vessels had failed to keep a proper lookout at night.

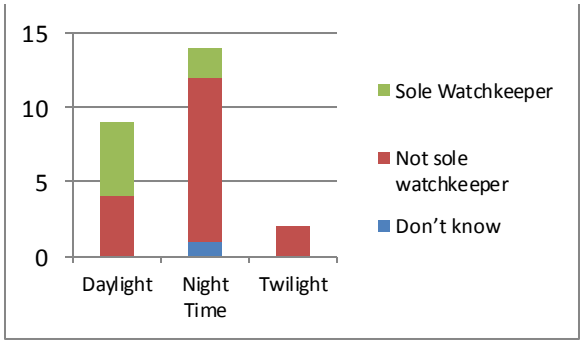

Figure 2 – Vessel failing to keep a proper lookout [Source: Maritime Accident Investigation Branch, 2004]

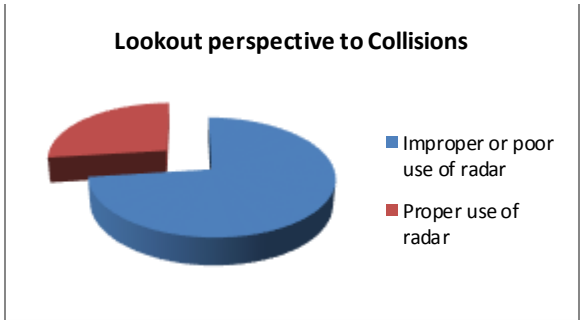

Figure 4 – Lookout perspective to Collisions [Source: Maritime Accident Investigation Branch, 2004]

In the same report, the reason for not maintaining lookout was attributed as "lack of competency". However, MAIB believes that poor visual lookout is linked to poor employment of ratings on the bridge (MAIB, 2004).

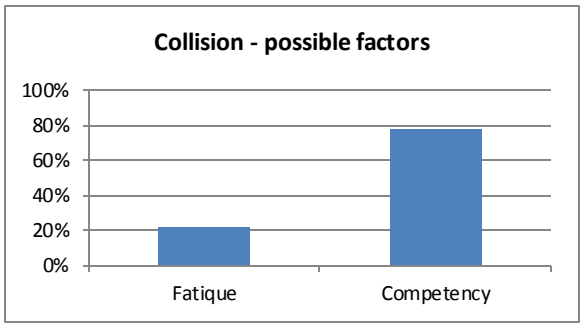

Figure 5 – Possible factors of Collisions [Source: Maritime Accident Investigation Branch,2004]

Bridge watchkeeping practices have inevitably changed in recent years under the influence of automated systems which are being implemented in order to enhance efficiency and safety as well as overcoming the shortage of seafarers (Hwang,. C.N, 2001). As the advanced automation systems are developed and deployed on board, it influences the international rules and regulations which are under consideration for being updated in parallel to revolved systems on board the vessels.

An earlier survey conducted among seafarers highlighted the concerns regarding the application of COLREGs rules at sea. The questions directed to seafarers and the results were noted that 50% of the response was showing that seafarers either ignored or disregard the COLREGs rules (Syms, R.J, 2002). In the same survey 90% of the responders identified the reason as "ignorance", "Poor knowledge of COLREGs" and "lack of training".

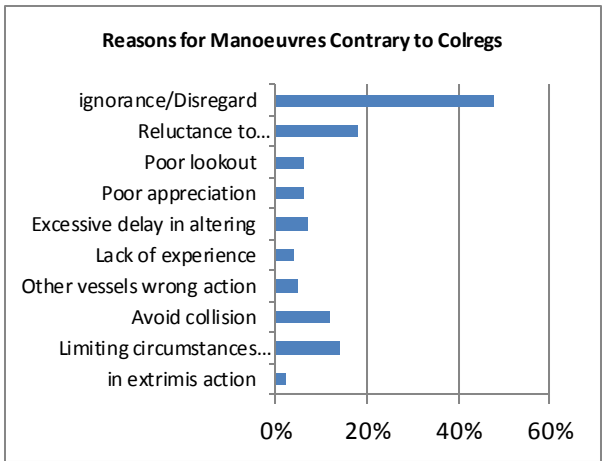

Figure 6 - Reasons for manoeuvres contrary to COLREGs (Syms, R.J, 2002).

4. SOME RESULTS FROM PROJECT ACTs

The figures below show the there are serious concerns at the % of correct answer to a survey carried out by partner of EU funded project ACTs was around 70 but more alarming was that those with no experience of COLREGs did almost performed as well as the more experience seafarers

and MET lecturers! This clearly is a case for concern. When considering a more challenging rule (10) again those with no experience scored better than those with experience and almost as well as the MET lecturers.

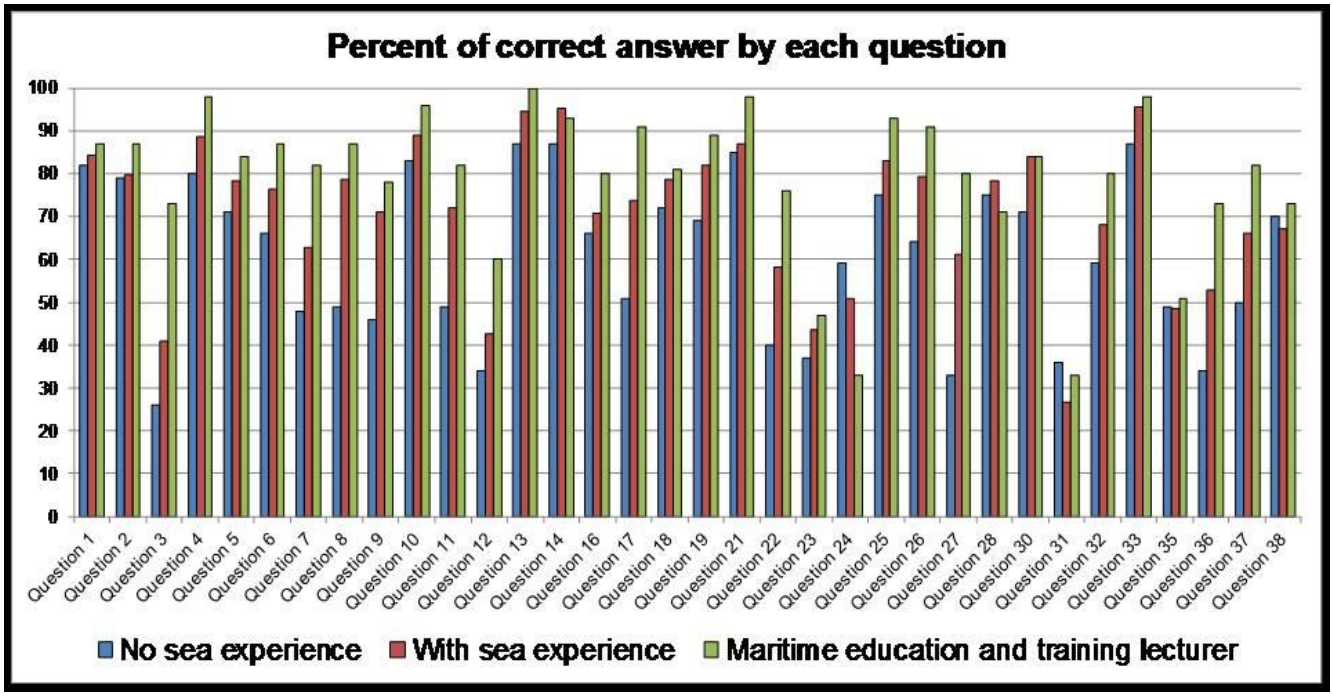

Figure 7. Percent of Correct Answers by Respondents – All existing COLREG rules

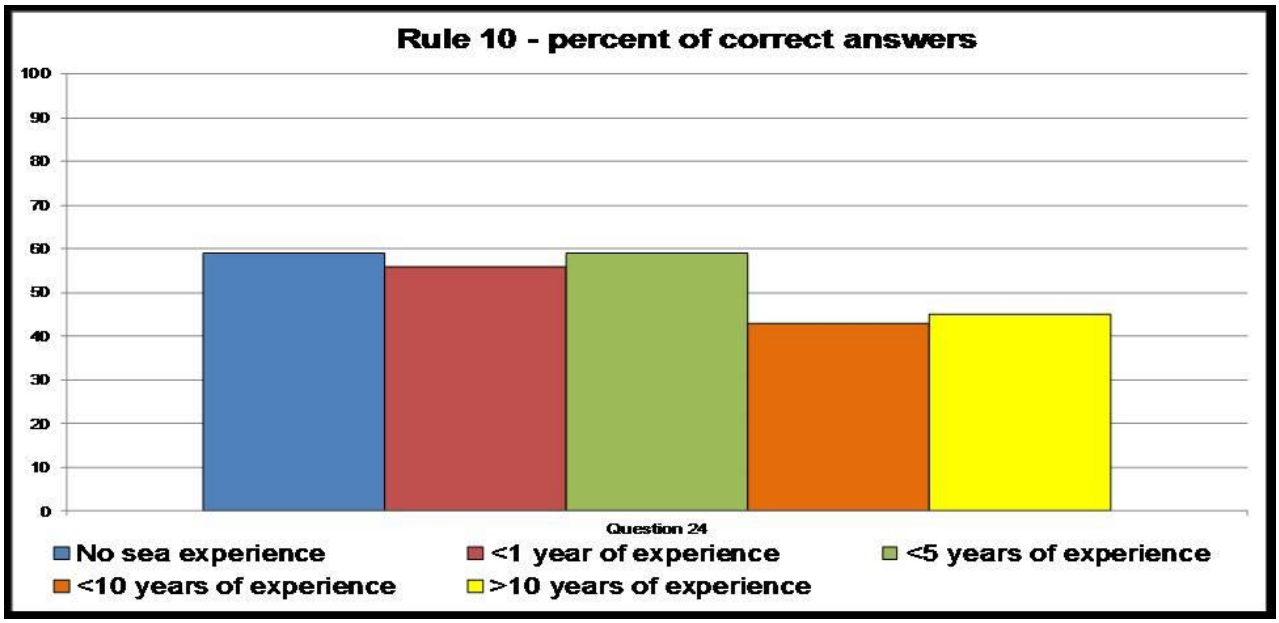

Figure 8. Percent of correct answers to the question on Rule 10

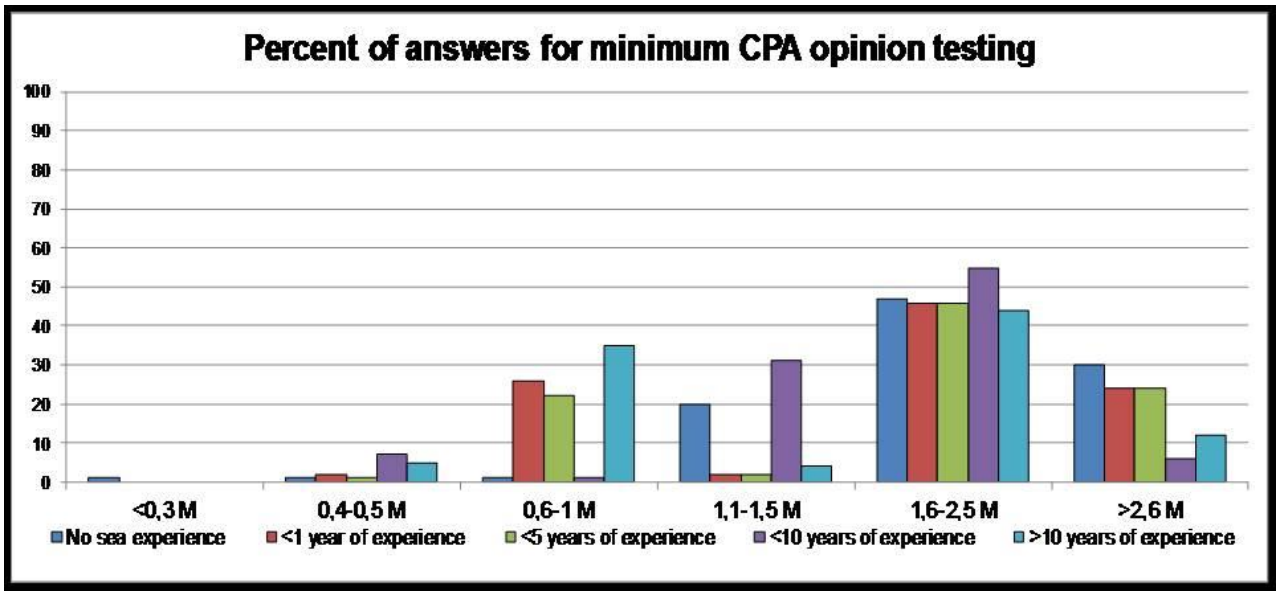

Figure 9. Percent of correct answers to minimum CPA testing

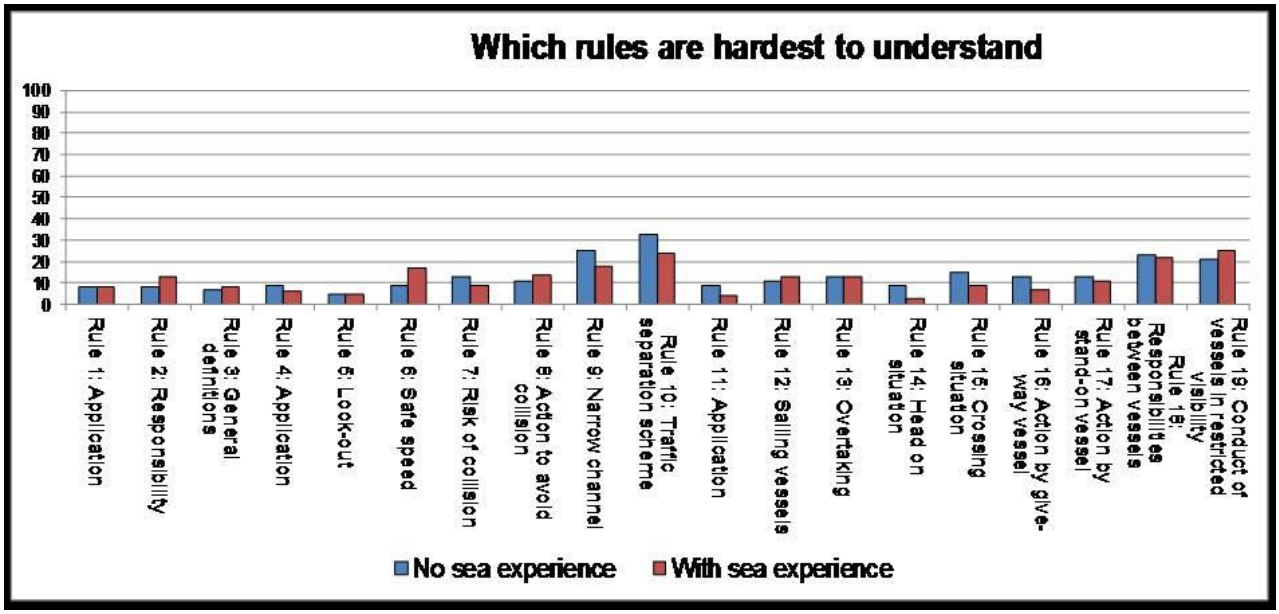

Figure 10. Prelude to Pareto Analysis – seeking opinion on which rules are hardest to understand

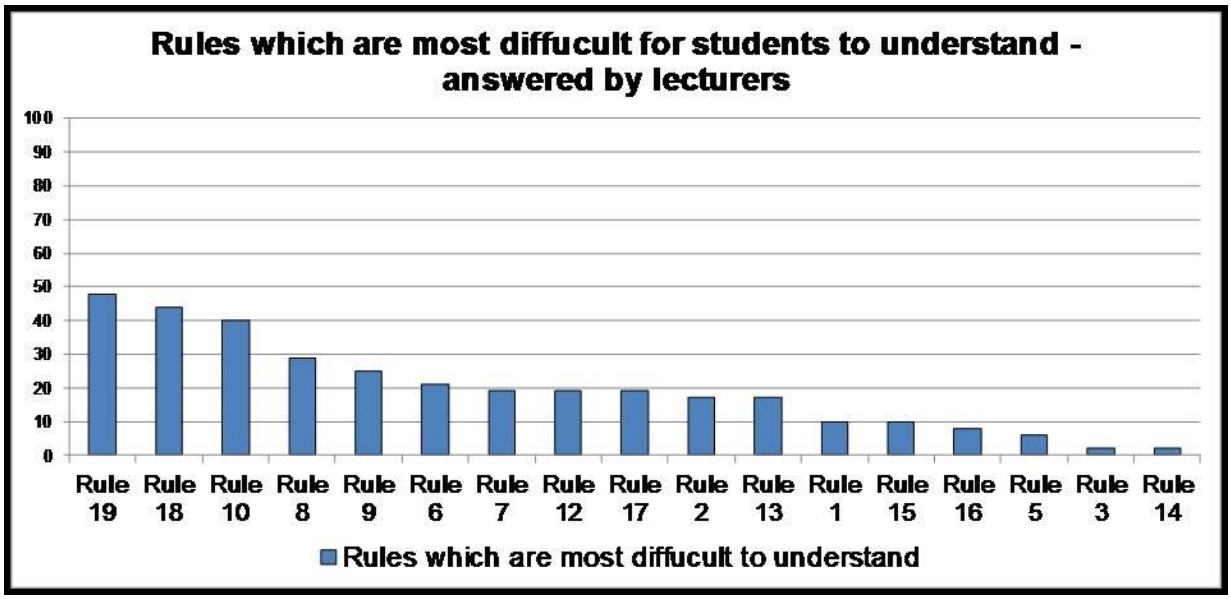

Figure 11. Pareto Analysis – Identifying the most difficult rules to understand in ranking order

5. THE USE OF VHF AT SEA

Collisions should theoretically be avoided if all navigational officers comply with the International Rules for the prevention of collisions at Sea 1972. It is however are shocking that these regulations were contravened to varying degrees in different locations across the world, which results with many accidents investigated and reported (MAIB; MARS).

It is reported that use of VHF is becoming a common practice in collision avoidance although it is not the part of the COLREGs (MCA, 2002). The MCA (Maritime and Coastguard Agency) in the UK took this issue serious and issued guidance for their seafarer network to highlight the dangers associated with the use of VHF. The summary of that same report states that

"*Although the use of VHF radio may be justified on occasion in collision avoidance, the provisions of the Collision Regulations should remain uppermost, as misunderstandings can arise even where the language of communication is not a problem"*

Similarly, MARS has been compiling the collision and near miss reports received from the seafarers to emphasize the dangers associated with the use of VHF. (MARS, 2005). MARS does state that:

"*The use of VHF should be kept to minimum and only be used, for instance, an obstruction exists on starboard side for stand on vessel, and however, reduction of speed should be preferred on communicating the intention on VHF"*

It should not normally be the case for navigational officer to use VHF to take action to avoid collisions, however, it does usually happen, and the only reason might be that using VHF is easier than learning and interpreting the 38 rules and annexes in COLREGs.

(MAIB, 2004) study shows that after examination of the use of VHF in the collisions and near misses that it was only used in 14 of the 47 collisions, and was only effective in 3 of those

Case 2 - VHF assisted collision
A cargo vessel was outbound from River Humber in poor visibility. The master of the cargo vessel had the con, a helmsman was steering and the bosun was stationed on the forecastle as a lookout. The master

saw the target of an inbound vessel on his radar, and he called the unknown fishing vessel using VHF with the intention of requesting to pass "green-to-green" in the channel. He received an instant response but, by then, it was too late. He received instant response but, by then it was too late. His ship was committed to the manoeuvre, and the fishing vessel was trying to pass red-to-red. They collided, causing extensive damage to the fishing vessel.

Case 3 – VHF assisted collision
Two container ship were navigating in China Sea. Risk of collision appeared however both did not realised until 3 minutes of the accident. The stand on vessel tried to contact via VHF on 3 minutes to collision instead of complying the COLREGs rules. However, he got respond after several call, and disagreement took place and ships collided.

Case 4 - Rule 19
This case study is devoted to article in Seaways (September 2008) which studies in some depth the problems of interpreting Collision Regulations (COLREGs) 19. The article identifies the Rule 19 to be a continuing problem. The Article is by Captain Roger Syms FNI, a Research Associate from the Australian Maritime College. Here is his story: "I recently received a letter from a seagoing officer concerning a discussion he had with his colleagues, the subject of which was a collision problem in poor visibility. The scenario, is somewhat similar to the Scenario 3 presented in the COLREGs survey a few years ago, is: Own ship and the other two vessels involved, one head on and the other to starboard steaming parallel at a range of 0.7 miles, are all proceeding at much the same speed, approximately 17kts. All are stated to be container vessels, which I assume suggests that all have better than average manoeuvring capabilities.
Apparently the discussion as to the correct manoeuvre within the Rules came up with four possible responses. To quote the letter:

Action possibilities

1. *Turn hard to port (according to rule 2b);*
2. *Reduce speed and turn hard to starboard;*
3. *Turn hard to starboard without reducing speed;*
4. *Do nothing.*

The correspondent preferred action 3; however some of his colleagues suggested that action 1 was, to quote the letter again, "the correct answer". The latter totally floors me, particularly the suggestion that this is somehow permissible under rule 2b.

In order to allow this perplexity to be considered last, let us examine each of these proposed responses, in reverse order.

Option 4: Do nothing
This is simply not an option. A collision situation is developing with the vessel dead ahead, in such circumstances own ship has to do something. Once our vessel has determined that "risk of collision exists" as per Rule 19(d), "she shall take avoiding action in ample time". Further, Rule 19 (d)(i) states we should 'avoid altering to port', which leaves us with only one remaining option, to alter to starboard. The target vessel is end-on s slowing down doesn't feature either.

Option 3: Turn hard to starboard without reducing speed
This is the correct response within the Rules 19 (d) and avoiding altering to port as per 19 (d) (i). The only minor comment I would make is that a drastic hard-over action is probably not necessary. Any reasonably apparent movement to starboard, anything say, beyond 50˚ will be sufficient to indicate to the vessel ahead that we are following the Rules and will result in allowing the vessel to starboard to draw ahead.

Option 2: Reduce speed and turn to starboard

I have no problem with this either. In taking such action own ship is again clearly indicating that she is complying with the relevant sections of Rule 19.

Option 1: Turn hard to port (according to Rule 2b)
That anyone should even contemplate this is a real worry, a sure-fire recipe for death and disaster if ever there was one. However let us slow the heart rate somewhat and try and view it dispassionately.
First, can such action in any way be justified under Rule 2(b)? Answer, a most definite no, Rule 2(b) suggests that actions beyond and contrary to the Rules may be necessary in order to 'avoid immediate danger'. At this point in time the vessel ahead is six miles and a little over 10 minutes away. This can hardly be construed as immediate danger.
Second, even in the unlikely event that it could be construed as immediate, this situation cannot be viewed as in extremis, where no other options for safe compliant manoeuvres are available. In this case, as we can see, there are two perfectly good ones, both of which comply perfectly with the requirements of Rule 19.

Why not starboard?
So the question has to be asked, why would presumably competent seafarers contemplate such a dangerous manoeuvre to port? Or, put more correctly, why are they so reluctant to move to starboard?
No apology should be made for moving into conjecture here, when I say my guess is Rule 19 (d) (ii), which states that what also should be avoided, when vessels are not in sight, is 'an alteration towards a vessel abeam or abaft the beam'. I am more than convinced that this is the problem, because a good 80 percent of the seafarers I have talked to over that last 20 odd years invariably get this wrong. It is one of the most commonly misconstrued rules in the book.

The plain fact is that, in this case, Rule 19 (d) (ii) does not apply. Why? Because the vessel to starboard does not comply with Rule 19 (d): ' A vessel (our own ship) ... shall determine if a close quarters situation is developing and/or risk of collision exists.' This vessel is proceeding parallel with us at 0.7 miles, and will remain so into infinity. She will remain at the same distance, therefore the risk of close quarters and/or collision does not even begin to exist.
If, as I strongly suspect, this is yet another potential fatal misconstruction of 19 (d)(ii), what can be done in mitigation? Other than chucking out the whole sorry 1972 COLREGs mess and starting again may I suggest that at least the current wording of 19 (d) should be reconstructed to remove this all too common confusion?

What is needed is a set of words which make it absolutely clear that 'avoiding an alteration towards' refers to a vessel abeam or abaft beam, only when it is perceived as a close quarters or collision risk, and not, as seems to so many at sea, to apply to any vessel abeam or abaft the abeam in any circumstance.
Yet again we have evidence that, after a 30-year existence, we have a Rule governing conduct in the most difficult circumstances a vessel can find herself in, zero visibility, still misunderstood by the majority of those at sea. It's high time we did something about it.

Individual will be offset by the investment another company has made in a potential recruit. In addition, the reality of the current tightness in the employment market and potential demand will require employees to be recruited from non-maritime backgrounds. CPD supports different levels of entrants from those without previous maritime experience to aspiring mariners and current practitioners who wish to realise their chosen ambition".

5. CONCLUSIONS

This paper only concerns significant problems associated with the COLREGs rules. When reviewing the outcome of the EU funded Project Acts, it is clear that there are real concerns as respondents with no seafaring experience did, more or less, as well as the more experienced seafarers. What is even more alarming is that these respondents were almost as good as navigation lecturers. It is pertinent to note that results of survey were based on a small sample but even so the outcome not encouraging. The new survey is underway which would shed more light on the level of understanding and application of

COLREGs. The introductory part of the paper has identified serious issues with COLREGs and the results of ACTs survey have not been reassuring.

CPA and use of VHF have also been a case for concern. If COLREGs are understood better and interpreted correctly the probable effect will be the more confident navigational duties that officers can perform. It reduces the use and dependency on VHF.

The MET programmes are the parts of the broken segment if the COLREGs today are not as effective as it should be. The MET institutions should revise their programme and make sure that the seafarers know the COLREGs as required. There is no room for being correct 80% or getting a mark of say 75% and pass the subject. The cadets and more experience seafarers should be correct 100% and no less.

A set of standards for officers and higher ranks across Europe may be helpful to justify the understanding of seafarers so that COLREGs can operate in an environment of mutual comprehension, understanding and coordination. The Project ACTs online course with over 290 scenarios many of which were developed in ship simulators and videoed would help all seafarers to interpret COLREGs and apply them correctly when there is possibility of a collision.

The COLREGs may need to be updated to meet the improved technology demands. The more automated systems may well be included where needed.

The national authorities may take the COLREGs more serious and issue similar guidance (MCA, 2002) to their seafarer network to spread the word COLREGs and discourage the use of VHF at sea.

This paper was primarily based on treating all rules equally but as show by the Pareto Analysis some of the Rules particularly for instance Rule 19 is more challenging and hence further work as demonstrated by Case 4 above is recommended. Also it is of paramount importance to consider a more than one rule applies. The latter cases more complex and require a new project. It is hoped that EU will support funding a new ACTs project which more complex rules and where multi-rules apply could receive the same treatment as was the case in Project ACTs.

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