THE JOURNAL OF NAVIGATION (2005), **58**, 149–163. 
Printed in the United Kingdom

# Forum

DOI: 10.1017/S0373463304213169

## Concerning Cross Track Distance at Mid-Longitude (1)

John Ponsonby
(Email: johnpon@supanet.com)

KEY WORDS
1. Cross Track distance.

I was amused by the Cross Track Distance at Mid-Longitude problem posed by Paul Hickley in *The Journal of Navigation* **57**, 320. Thinking about it, I came up with a solution. My method gives an astonishingly accurate, though approximate, answer which is found without any appeal to any formula of spherical trigonometry.

Assuming a spherical Earth of radius unity, the radius of the small circle of the Earth at latitude 60° is 1/2. (i.e. cos60°). Exaggerating the difference in longitude for clarity, it can be seen in Figure 1 that the spatial midpoint between the two way-points is at E. (which is not Paul Hickley's point E), and it's distance from the Earth's Axis is:

$$OE = \frac{1}{2}cos(5^\circ)$$

A cross-section of the Earth through the mid-longitude meridian is drawn in Figure 2. Here ε is the "excess" angle of the midpoint latitude over 60°.
We now have:

$$OE = \frac{1}{2}cos(5^\circ) \text{ and } OW = \frac{1}{2} \text{so that } EW = \frac{1}{2}[1 - cos(5^\circ)]$$

$$\angle\text{OWC} = \angle\text{EWC} = 60^\circ$$

$$CE = \sqrt{\left(\frac{\sqrt{3}}{2}\right)^2 + \left(\frac{1}{2}cos(5^\circ)\right)^2}$$

By the sine formula applied to triangle ECW we also have:

$$\frac{\sin(\varepsilon)}{EW} = \frac{sin(60^\circ)}{CE}$$

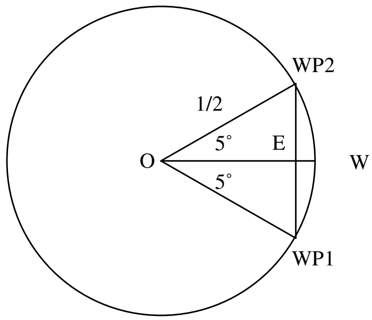


Figure 1. Cross section of Earth at 60°N.

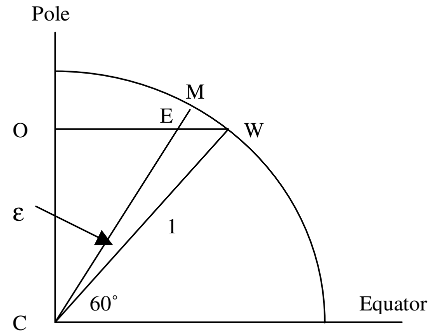


Figure 2. Cross section of Earth at mid-longitude meridian.

So:

$$sin(\varepsilon)=\frac{\frac{1}{2}[1-cos(5^\circ)]\frac{\sqrt{3}}{2}}{\sqrt{\left(\frac{\sqrt{3}}{2}\right)^{2}+\left(\frac{1}{2}cos(5^\circ)\right)^{2}}} \quad \text{or:} \quad \varepsilon=sin^{-1}\left[\frac{\frac{\sqrt{3}}{4}[1-cos(5^\circ)]}{\sqrt{\frac{3}{4}+\frac{1}{4}cos^{2}(5^\circ)}}\right]$$

This exact expression evaluates to give $\varepsilon = 5.6699156$ min of arc. This is not quite in agreement with Paul Hickley's "definitive" result of 5.6624' although precisely the same expression may be derived using spherical trigonometry.

Since CE, which appears as the denominator, is so nearly equal to unity, and since $\varepsilon$ is such a small angle that $\varepsilon \approx sin(\varepsilon)$, an adequate approximation is that

$$\varepsilon \approx \frac{180\times 60\times\sqrt{3}}{4\pi}[1-cos(5^\circ)]=5.6645 \text{ min of arc.}$$

How a student navigator could be expected to obtain this result in two minutes and twelve seconds under examination conditions remains a mystery.

DOI: 10.1017/S0373463304223165

# Concerning Cross Track Distance at Mid-Longitude (2)

Peter Hoare

(Email: p-et-e@hoare34.fsnet.co.uk)

KEY WORDS

1. Polar Gnomic.

I wish to respond to Paul Hickley's invitation in his article on "Great Circle Versus Rhumb Line Cross-Track Distance at Mid-Longitude" in the May 2004 *Journal of Navigation*. It seemed an ideal teaser for an erstwhile Maps and Charts lecturer, albeit

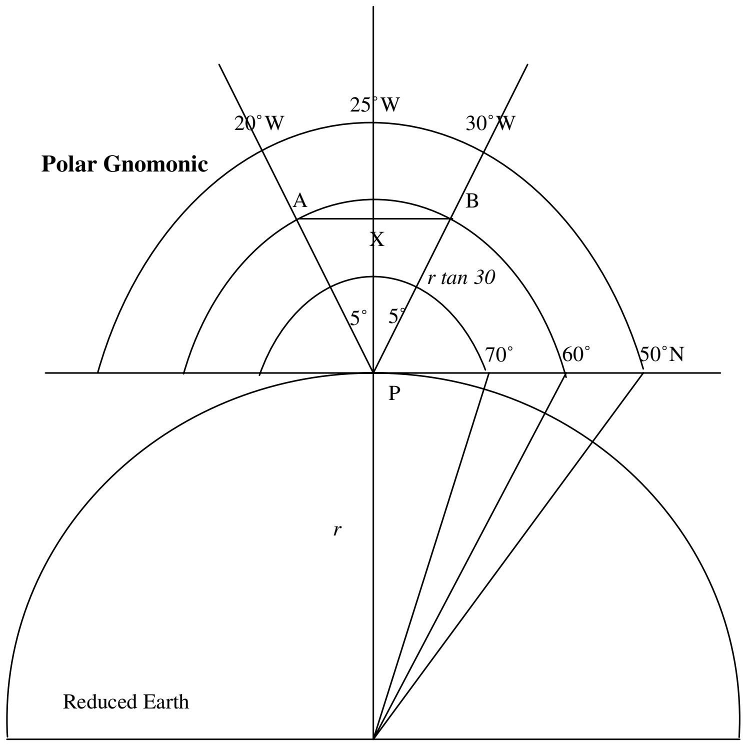


Figure 1. Polar Gnomonic Projection.

45 years ago, to play with on his 81st birthday last week! Since it was a question for pilots, did not require knowledge of spherical trig, and was answerable in 2 minutes and 12 seconds I thought, as did Paul, that there must be a fairly simple solution. Mine follows.

I turned to the Polar Gnomonic, the simplest of all projections to construct and understand. On this projection great circles are straight lines and at the point of tangency, the pole, angles are correct. In our problem both the great circle between the two waypoints and the meridians that pass through them are straight lines. The angle at the pole between each of these meridians (20 W and 30 W) and the mid-longitude (25 W) is 5 degrees. This central meridian bisects the great circle track at 90 degrees. The small circle of latitude is of course a rhumb line. The accompanying Figure 1 illustrates the problem. The angles at the pole are not to scale.

The chart radius of a parallel of latitude is *r*, the radius of the reduced earth, times the tangent of the co-latitude. Both positions at 60°N are therefore on a parallel of latitude, centre the pole and radius *r.tan30*. In the right angled triangle PXA, the chart distance from the pole to the point where the great circle track crosses the 25°W meridian is *r.tan30.cos5*. The tangent of the co-latitude of the crossing point, X, is thus *tan30.cos5* giving a co-latitude of 29° 54′ 20″ and a latitude of 60° 05′ 40″. This compares well with the answers given in the article and is, to the nearest second (40.1964″ to 39.744″) the same as the definitive spherical trig answer – and a lot easier to calculate. I should mention that my solution assumes that the earth is a perfect sphere. I am not sure whether this solution is elegant or neater or neither. It does not use spherical trigonometry but requires an understanding of gnomonic projections. Perhaps that is what the examiners were seeking to establish.

DOI: 10.1017/S0373463304233161

# Concerning Cross Track Distance at Mid-Longitude (3)

Paul Hickley

(Email: phickley@oxfordaviation.net)

KEY WORDS

1. Great Circle. 2. Rhumb Line.

I am grateful to both Dr Ponsonby and Sqn Ldr Hoare for their responses to my original article and would like to thank them for replying. It is interesting that they have come up with such different approaches, one based on solid geometry (but not spherical trigonometry) and the other based on a map projection, which both give exact or near-exact answers.

John Ponsonby chides me for a lack of accuracy in my 'definitive' answer. I used spherical trigonometry to evaluate it, but it is true that I took a slight short cut. In Figure 1, I took angle A as my starting point and used the conversion angle formula (ca = 1/2 change in longitude x sine mean latitude). Knowing angle ACB to be 90°, I could then use sin a/sin A = sin c/sin C to find the co-latitude BC, i.e. side a. However, the conversion angle formula is a slight approximation, though it is generally acceptably accurate when dealing with small changes of longitude.

If I had stuck strictly to spherical trigonometry, I should have first have found the Great Circle distance AC, i.e. side b, then used Napier's rules. Using the sine rule:

$$\frac{\sin b}{\sin B} = \frac{\sin c}{\sin C} = \frac{\sin 30^\circ}{\sin 90^\circ}$$

where angle B (i.e. angle ABC) is 5° (the change of longitude), I can evaluate B, which comes to 2·497619045°. I then use Napier's rule:

$$\sin a = \tan b \tan(90 - B) = \tan 2{\cdot}497619 \times \tan 85^\circ$$

This gives side a, the co-latitude BC. From this we get a value of the latitude at 025W of N 60° 05·6699156′, the same answer as Dr Ponsonby's method. My short cut using conversion angle gave N 60° 05·6624′. As the difference equates to a distance of approximately 13·9 metres on the surface of the Earth, I felt that this was acceptably accurate, if not quite 'definitive'!

Turning now to John Ponsonby's approximate solution, it is undoubtedly ingenious and creative. It is also clearly very accurate – a mere 10 metres in error from our

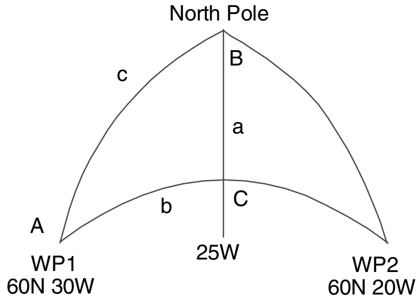


Figure 1.

revised agreed 'definitive' answer of N 60° 05·6699156′. The very minor inaccuracy is caused by the assumptions of small angle theory and the methods of approximation used, but it would be churlish to quibble. However the ingenuity and creativity used would be well beyond the capability of the average ATPL candidate and I am sure that this is not the method that the examiners had in mind.

Peter Hoare's solution gives superb accuracy. It is certainly neat and elegant and I like it very much. The reason that I didn't think of it myself is that we don't teach the Polar Gnomonic on the ATPL syllabus and I am not familiar with the projection. I don't think that it was covered on my Staff Navigation Course in 1974 either, but it may be that I am wrong and have just forgotten. However, I dug out my trusty elderly copy of AP 3456 and looked up its properties and every aspect of Peter Hoare's proof is absolutely correct. As far as I know, the only application of the Polar Gnomonic is for the Meade's Great Circle Diagram, in order to break up a long Great Circle Track into several shorter legs, and then to fly a series of Rhumb Line tracks which approximate to the overall Great Circle path. Interestingly, this is the problem that appeared in the article immediately previous to mine in the *Journal*. I don't know whether the Meade's diagram is still used because many ships these days have navigation systems which provide continuous automatic computing of Great Circle tracks.

Regrettably, I don't think that this was the solution that the examiners were looking for either. As Sqn Ldr Hoare points out, it requires an understanding of gnomonic projections and he suggests that perhaps that this is what the examiners were seeking to establish. I doubt it because the only charts we teach are the Mercator, Lambert, Polar Stereographic, and Transverse and Oblique Mercators. As far as I know, only the last 4 are used in aviation charts these days and all 4 have only a small degree of scale distortion and on all 4, Great Circles approximate quite closely to straight lines. The only reason that we teach the Mercator, I suspect, is because it is a necessary foundation to understanding the Transverse and Oblique Mercator projections. Aerad and the AIDU use mainly Oblique Mercators, with some Lambert projections and Jeppesen use mainly Lambert or Polar Stereographic projections. I don't know anyone who still produces Direct/Normal Mercator projections for aviation. With INS, IRS, FMS and GPS now widely available, the days of holding a single compass heading to fly a Rhumb Line track are becoming a thing of the past.

Perhaps I should send this correspondence to the JAA and ask them what solution *they* had in mind!

DOI: 10.1017/S0373463304243168

# Definition of a Fast and Manoeuvrable Craft and Amendments to the Collision Regulations

Rolf Johannes Undrum

(University of Science and Technology, Trondheim)
(Email: rolfundrum@hotmail.com)

This paper is presented as a think piece and poses the introduction of a new type of high-speed craft to represent the growing number of fast manoeuvrable craft that could safely maintain their speed in heavy traffic areas. A method of defining such craft is introduced and a proposal made for a corresponding amendment to the COLREGS.

KEY WORDS

1. Collision Regulations. 2. Collision Avoidance. 3. HSC. 4. FMC.

1. INTRODUCTION. The need of special rules for fast craft has been debated for some time in various maritime forums. The issue has two aspects; what is a high-speed craft and what rules should apply? This article has a new approach to the problem in the way that a new group of ships called fast and manoeuvrable craft or FMC, are separated from high-speed craft (HSC). FMC have the manoeuvrability required when travelling fast in areas with heavy traffic and should therefore be allowed high speeds in such situations. Ships that are fast, but do not demonstrate the same turning ability, must be prohibited from high speed in vicinity of other ships. There are however numerous new problems introduced with this solution; most important are the problems of recognition and safe operation. FMC must be easily recognised as such by conventional vessels to prevent unnecessary manoeuvres and my proposal is that the Automatic Identification System (AIS) equipment is modified to perform this task. There may be a need for special training of FMC officers that extends that associated with HSC in order to maintain a satisfactory level of safety on board a FMC. This article contains a short deduction of the FMC definition, a proposed amendment to the Collision Regulations and a summary of the expected spin-off effects associated by the FMC concept.

2. DEFINING A FAST AND MANOEUVRABLE CRAFT. The definition of a FMC is based on the geometrical figure of a collision scenario shown in Figure 1. In the figure, a fast vessel A is heading north directly towards vessel B and turns right to avoid collision. The worst possible heading by vessel B is, in this case, south-easterly and it is assumed that vessel B is too heavy and sluggish to take evasive action. The terms in the figure are as follows: $d$ and $D$ are distances travelled by vessels A and B respectively during the time between $t0$ and $t1$. $SZ$ is

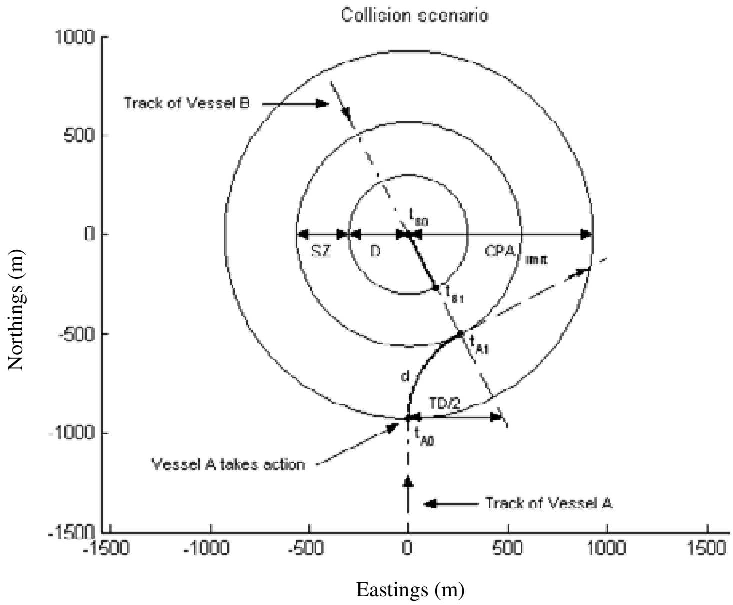


Figure 1. Geometric construction of a collision scenario.

the s*afety zone* which accounts for the errors introduced by the assumption that the vessels are point masses with no dimensions and also that a turning circle is never perfectly circular. A rough but conservative estimate based on extreme dimensions; length of vessel B (500 metres) and breadth of vessel A (30 metres), gives a safety zone of 265 metres. (The tracks of the ships are assumed to coincide at all times with the geometrical centre of each ship, thus the safety zone is the sum of half of vessel B's length and half of vessel A's breadth). *TD* stands for tactical diameter and shows the size of a vessels turning circle. *TD* is collected from trial runs at service speed and will be regarded as constant during the deductions below. $CPA_{limit}$ is the smallest acceptable passing distance to a vessel.

2.1. *FMC Definition.* The situation in the model describes two ships that suddenly find themselves breaking their $CPA_{limit}$. Some form of restriction to the fairway or other special circumstances must be present in order to put the vessels in this situation. The idea is that vessel B is slow and vessel A is fast, even though the mathematics behind the deductions allows any speed. The figure shows vessel A heading straight towards vessel B. Vessel B has during time $t$ ($t = t1 - t0$) reached any point on the boundaries of the distance $D$; the track indicated in the figure is only illustrating the worst possible heading given the starboard turn by vessel A. The idea is that vessel A takes a starboard turn to avoid collision and this turn is circular for convenience. At time $t1$, vessel A is thought to be at the point where its track touches the circle formed by the distance $D$ and $SZ$. Both vessels travel at any arbitrary speed and vessel A experiences a speed loss during the turn. $V_A$ and $V_B$ are the speed of vessels A and B respectively and since vessel A will experience speed loss during turn, $k$ is the linear speed loss coefficient accounting for this behaviour.

https://doi.org/10.1017/S0373463304243168 Published online by Cambridge University Press

The distance ratio can be established from the given information and rewritten as the following expression:

$$\frac{d}{D}=\frac{kV_A t_{10}}{V_B t_{10}} \Rightarrow \frac{V_A}{V_B}=\frac{TD\arctan\left(\frac{2CPA_{\lim it}}{TD}\right)}{k\left[-2B-TD+\sqrt{TD^2+4CPA_{\lim it}^2}\right]} \tag{1}$$

Equation 1 is partly based on the fact that the distance is the product of average speed and time and partly a geometrical interpretation of Figure 1 where the Pythagorean Law and the definition of an angle in radians are used to establish expressions for $D$ and $d$ respectively. Algebraic manipulation of the speed ratio between the vessels provides the definition of a FMC:

$$V_A \geq \frac{V_B TD\arctan\left(\frac{2CPA_{\lim it}}{TD}\right)}{k\left[\sqrt{TD^2+4CPA_{\lim it}^2}-2B-TD\right]} \tag{2}$$

The "larger or equal to" sign comes from the fact that the speed surplus compared to other vessel, as well as a small tactical diameter, is an advantage in terms of collision avoidance.

The $CPA_{limit}$ is not an exact quantity; it can be 1 nautical mile in open sea and as small as a couple of cables in restricted waterways. This depends somewhat on the size of the ship, the traffic in the area and whatever the officer on watch finds most comfortable. In relatively wide straits such as the English Channel, where it is expected the FMC concept would be of best use, a medium sized $CPA_{limit}$ may be appropriate.

The speed loss coefficient is the ratio between the $V_{end}$ and $V_{start}$ of a specific vessel when turning. $V_{end}$ is not the steady state speed when the ships speed is constant, but the speed of the ship when it has reached the nearest distance to vessel B. Anecdotal evidence that suggests that speed loss can reach 40 per cent, but in this case we settle for a modest speed loss. The speed of vessel B is in accordance with earlier proposals (see Pike (1995), (1997), and (2001)) on what could be considered as high speed. The idea of fixing the speed of vessel B is to illustrate the worst case condition given the other conditions. Clements (1998) pointed out that this arrangement is somewhat awkward when comparing a 29 knot vessel with a 31 knot vessel. The argument occurred when speed was proposed as a criterion to separate slow vessels from fast. It is however very difficult to imagine any other term that is better suited.

The following values are based on the arguments above: $B=265$ metres, $CPA_{limit}=926$ metres, $k=0{\cdot}95$ and $V_B=30$ knots. These terms should be regarded as constants throughout the rest of the deduction. Now we have the necessary information to make a graphical presentation of the definition.

The vertical line in the figure illustrates the 30 knot cut-off speed. During trial runs at service speed the ships tactical diameter is tested when carrying out the ships sharpest turn. The figure gives the necessary relationship between ship speed in knots and tactical diameter in metres that ensures that no collision takes place *regardless* of the actions by the slower vessel, provided that the turn takes place and that vessel B does not increase speed.

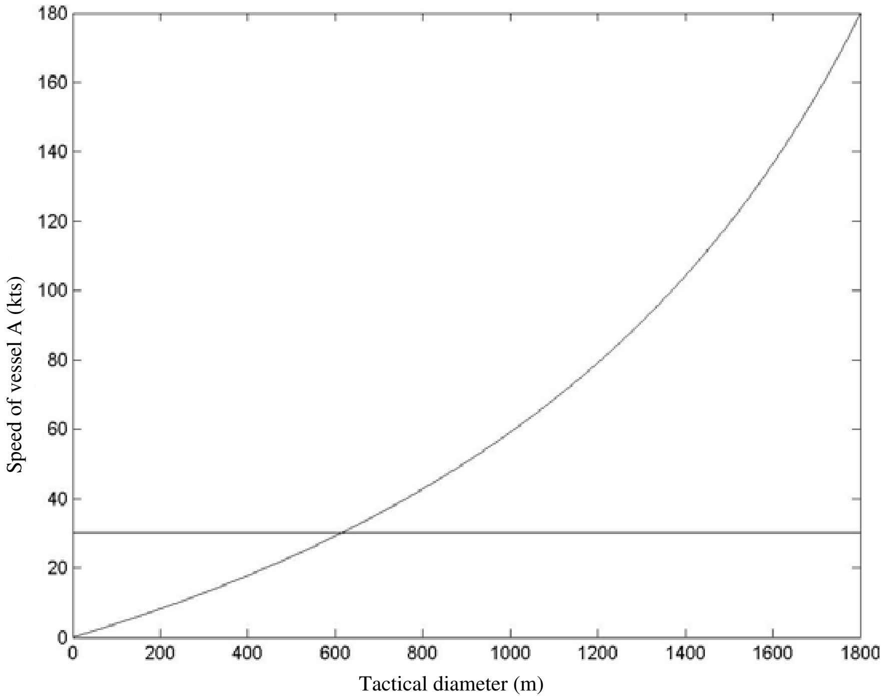


Figure 2. Graphical presentation of the FMC definition.

3. PROPOSED AMENDMENT TO THE COLLISION REGULATIONS. Ships that satisfy the definition are proven to be able to avoid collision regardless of the slower vessels actions, provided that the latter does not increase speed and given the other circumstances in the model. These vessels are so agile that the idea of safe speed is somewhat widened and it is proposed that these vessels should be allowed higher speed than conventional vessels. A suitable proposal for a new rule in the Collision Regulations would be:

*Rule 17 e) Ships that satisfy the following formula:*

$$V_A \geq \frac{V_B TD \arctan\left(\frac{2CPA_{\lim it}}{TD}\right)}{k\left[\sqrt{TD^2 + 4CPA_{\lim it}^2} - 2B - TD\right]}$$

*shall keep clear of all other vessel, but they shall manoeuvre as if they are motor driven vessels whenever they encounter ships of the same kind.*

The FMC concept, if adopted, would not only require amendments to the Collision Regulations. Due to the challenges both the ship and its officers will face amendments will also be needed to the 2000 HSC code and the STCW 95 convention.

4. CONSEQUENCES OF THE FMC CONCEPT. I will try to provide a complete summary of every single feature that the FMC concept brings about. First of all the problem of recognition must be solved. Any conventional vessel,

https://doi.org/10.1017/S0373463304243168 Published online by Cambridge University Press

conventional meaning a ship with limited manoeuvrability and speed potential, having a FMC closing in on the starboard side must at an early stage identify the latter as such. According to my proposal the conventional ship can stand on in this situation and will certainly be very interested in the whereabouts of FMC. It will also be very convenient for FMC that the surrounding ships behave as predictably as possible and do not engage in manoeuvres they are not required to. These problems can be tackled if all ships are equipped with Automatic Identification System (AIS) equipment with a buzzer or blinking light attention getter that warns whenever FMC are present. Such an arrangement would ensure that conventional ships do not yield right-of-way when they are not supposed to, and it creates a predictable environment for FMC. It would also prevent the possible situation where both parties make evasive manoeuvres. Most important however is that conventional vessels such as VLCC will never be forced to step aside for a FMC, which simply is something they can not do due to their limited manoeuvrability.

A vessel that demonstrates good turning ability even at high speeds will satisfy the FMC definition above. To prevent confusion this vessel must be regarded as an FMC even when travelling below the cut-off speed. This arrangement is not favourable for FMC in port areas because traffic density and waterway obstructions are likely to complicate the task of making way for all other vessels. It is however better than making the AIS equipment on board an FMC speed sensitive, an arrangement which would make vital ship characteristics change in an instant. Without this permanent designation of a FMC a conventional ship with a decelerating FMC closing in on its starboard side could suddenly discover that it does not have the luxury of standing on, but must take action to prevent collision with a conventional vessel.

FMC compatible AIS equipment does not entirely solve the identification problem. Unique and possibly brighter navigation lights to help recognition by other vessels should be considered for fitting on FMC. There could also be a need for special navigational aids such as infrared equipment and suchlike as an aid to detecting, in particular, the small craft that sail without AIS equipment and that will continue to be difficult to detect by all ships including FMC.

The high speed expected from future vessels will certainly be a challenge for the officers in terms of safety. If my proposal for FMC were adopted, the master of the FMC must be the originator of every collision avoidance manoeuvre because they could not expect cooperation from right-of-way vessels. These two factors form a need for substantial measures towards safe operation and personnel selection; key words are safety management, operational procedures and crew resource management.

On the other hand an HSC does not display adequate manoeuvrability in situations like this and must therefore reduce speed whenever it comes within some distance of another vessel; 2 nautical miles and 30 knots have been proposed earlier in Pike (1995). This is to make sure that there is enough time to assess the collision risk and then to give time for the slower vessels formulate a proper manoeuvre. This is in accordance with the existing Collision Regulations provisions on safe speed.

It is likely that the full benefits from the FMC concept will not be obvious until smaller passenger catamarans and similar vessels achieve much higher speeds than the 30–40 knot range of today. It is also necessary that these vessels will be common in all parts of the world; the considerable changes in technology associated with the FMC concept indicate that this will come.

The main drawback with the proposals in this paper is the complexity. It is likely that the average sailor will regard the existing regulations with their vagueness as more manageable than the provisions indicated here. The expected future development of fast travel at sea however might show that these proposals are not altogether in vain.

## REFERENCES


Clements, Dick. (1998). High Speed Craft and the COLREGS – A proposal. *Journal of Navigation*, **51**, 430.

IMO. (1995). *The International Convention on Standards for Training, Certification and Watchkeeping for Seafarers. (*STCW 78, Amended 1995*).*

IMO. (2000). *The International Code for High-speed Craft. (2000 HSC code). MSC 97(73).*

Kemp, John. (2002). Collision Regulation – Discussion. *The Journal of Navigation*, **55**, 145.

Mills, Andrew. (1997). Collision Risk with High Speed Vessels. *The Journal of Navigation*, **50**, 140.

Millns, A. T. C. (1998). Fast Craft and the COLREGS. *The Journal of Navigation*, **51**, 437.

Pedersen, Egil. Inoue, Kinzo. Tsugane, Masanori. (2003). Simulator Studies on a Collision Avoidance Display that Facilitates Efficient and Precise Assessment of Evasive Manoeuvres in Congested Waterways. *The Journal of Navigation*, **56**, 411.

Pike, Dag. (1995). Collision Risk with Fast Ferries. *The Journal of Navigation*, **48**, 436.

Pike, R. D. (1997). Fast Craft and the COLREGS. *The Journal of Navigation*, **50**, 256.

Pike, R. D. (2001). Collision Regulations and Fast Craft. *The Journal of Navigation*, **54**, 477.


DOI: 10.1017/S0373463304253164

# Collision Rules For High-Speed Craft


Dag Pike

(Email: dagpike@compuserve.com)



Re-visiting the requirement to introduce amended collision regulations to meet the developing threat in encounters between high-speed craft and slower, mainly smaller vessels. This paper looks at the requirements of different types of encounter and the ability to identify high-speed craft through AIS. It introduces proposed changes to the Colregs that could help to reduce the perceived threat to small, slow craft.



KEY WORDS

1. High-speed craft. 2. AIS. 3. Colregs.


1. INTRODUCTION. The subject of changing the Colregs to accommodate the perceived threat from close quarters encounters with high-speed craft has been visited on a number of occasions in the past. (See Clements (1998), Millns (1998), Pike (1995, 1997, 2001), Weber (1998)). Whilst there is general acknowledgement that there is an increased level of risk when high-speed craft are involved in an encounter because of the reduced time scale that is available for assessing the situation and taking action, finding a solution has proved more difficult.

One of the problems has been in defining what is a high-speed craft and a second has been for other vessels to be able to identify an approaching craft that qualifies as a high-speed craft. Identification is important if the approaching craft may take action that is peculiar to a particular class of craft. Because of this problem it has been proposed that any action required in an encounter involving a high-speed craft should be taken by the high-speed craft, at least in the initial stages of the encounter. However, this does not solve the problem of the other vessel or vessels involved in the encounter recognising a high-speed craft for what it is and being able to anticipate its action.

With the advent of the Automatic Identification System (AIS) the other vessel can resolve this problem of identification and this has prompted this fresh look at proposals for amendments to the Colregs to accommodate the increasing threat that could be posed by the growth in the numbers of high-speed craft.

## 2. INDENTIFICATION OF HIGH-SPEED CRAFT.

An AIS unit on board a vessel will continuously transmit that vessel's course, speed, position and a number of other parameters. There is scope within the AIS transmission for particular categories of vessel such as deep draft vessels to be identified and there is no reason why high-speed craft cannot be allocated a category of this nature, although the speed read out alone will also do this. Suitably equipped vessels within range of VHF transmissions receive these messages, which could be anything between 10 and 20 miles for most shipping. The information can be displayed on a radar or electronic chart display or on the dedicated alphanumeric display of the AIS unit so that the status of an approaching vessel can be identified.

This would appear to solve the problem of identification but it leaves one category of vessel without this capability. Identification is only possible on vessels that have an AIS receiver and at present only vessels over 300 tons grt are required to fit these units. This leaves a considerable number of vessels, mainly small craft, without an identification capability and fitting AIS to these craft is currently done on a voluntary basis. Small craft, and particularly leisure craft, could be the very type of craft that would be vulnerable to the approach of a high-speed craft. Not only may they be difficult to detect either visually or by radar from the high-speed craft but also many types of leisure craft such as sailboats have limited manoeuvrability and low speed. This makes the taking of avoiding action difficult, or impossible, in the limited time scale of a high-speed encounter. However, this situation already exists in any encounter between a high-speed craft and, say, a sailboat so the position will not deteriorate if the rules are changed to put the onus for action onto the high-speed craft.

## 3. DEFINITION OF A HIGH-SPEED CRAFT.

High-speed craft can be defined by both their speed and their size as far as modifications to the Colregs are concerned. Speed is always going to be a difficult definition because if the craft are defined as any vessel proceeding at, say over 30 knots then a 29 knot craft does not come under this definition. If a specific speed is made part of the definition and the proposed rules suggest that a reduction in speed is required during an encounter, there could be a situation where a 30-knot craft is required to slow to, say

20 knots whilst a 29-knot craft can maintain its speed. This is clearly not what is required, so it is perhaps better to define a speed vessels have to reduce to so that this speed would then be the maximum for all vessels in certain defined situations.

It could be beneficial also to define a size of vessel to which any proposed rule change could apply. Small high speed vessels do not pose a particular threat because of their excellent manoeuvrability and stopping capability and so could be excluded from any rule change to prevent their operation becoming over complicated. A size discrimination already exists in the Colregs in the form of a 20 metre limit where craft are excluded from operating in the inshore traffic zones and this same size limit could be used for excluding small high-speed craft from new requirements.

4. HIGH-SPEED ENCOUNTERS. As any imposition of action on high-speed craft that might be considered in a change of the Colregs would almost certainly involve that craft reducing speed it is worth considering the various types of encounter that might be involved and consider the risks and potential action as far as high-speed craft are concerned.

4.1. *Head-on Encounters.* When vessels are meeting head-on, the time scale for action is at its shortest but the time required for the action is also the lowest. In this situation only a small alteration of course is required for the two vessels to change to safe courses. This change of course action can be carried out effectively by just one of the vessels involved and so it is proposed that no slowing down action would be required in this situation.

4.2. *Overtaking Encounters.* Here the overtaking vessel will be the high-speed craft unless it is one high-speed craft overtaking another. In any overtaking situation, the overtaking vessel is the one to keep clear under current rules and the safest approach is for the manoeuvre to be carried out as expeditiously as possible in order to reduce the time involved in the manoeuvre. In this situation there would be no requirement for a high-speed vessel to slow down.

4.3. *Crossing Encounters.* The crossing encounters are the ones where there can be most risk when a high-speed craft is involved. The assessment of collision risk in a crossing situation needs more time and the involvement of high-speed craft reduces the available time for assessment and action to decide which is the give way vessel and which is the stand on vessel. In this situation there is a clear requirement for the high-speed craft to slow down in order to create the additional time required for successful collision avoidance manoeuvres.

4.4. *Multi-ship Encounters.* Most multi-ship encounters are likely to include a crossing vessel so these situations would qualify under paragraph 3 above. However, there could also be a case for requiring a reduction in speed in multi-ship head-on encounters because the action of two vessels taking avoiding action under the Colregs could impinge on the sea room available to a third or fourth vessel.

5. PROPOSED AMENDMENTS TO THE COLREGS. Whilst not attempting to present a legally binding definition for a change, it is considered that a new rule could be developed that would require high-speed craft to reduce speed in certain conditions when encountering other vessels. Rather than propose a blanket rule that would require a reduction in all circumstances and could

possibly have a negative effect on many high speed operations, the rule could only require a reduction in speed in crossing and multi-ship encounters. Such a rule would narrow down and possibly halve the need for a reduction in speed by high-speed craft.

Rather than attempt to define a high-speed craft by size and speed, it is proposed instead to require all vessels to proceed at a speed of 20 knots when involved in crossing or multi-ship encounters. Such a requirement would encompass all vessels irrespective of size and operating speed except those under 20 metres in length. 20 knots has been selected as an arbitrary speed limit in these situations but it seems to present a good balance between high-speed operations and safety requirements.

In terms of when this speed reduction is required it is proposed that it should apply when the high-speed vessel is within 2 miles of another vessel. This will give both vessels adequate time to respond although such a change could also impinge on the current rules that require the stand on vessel to maintain course and speed in any encounter. It also has to be recognised that a large fast vessel may take some time to reduce speed and it would probably be a requirement to for such a vessel to have reduced speed by the time it is within the 2-mile range.

6. OTHER FACTORS. Many high-speed craft, particularly those that are based on multihull designs, create a considerable wash at certain speeds. Research has shown that whilst these craft have acceptable wash levels at their normal operating high speed, this wash increases considerably when the craft is slowing down or accelerating. This factor could cause problems when these craft are conforming to the proposed new regulations, with small craft being mainly at risk from the increased wash. In the open sea the increased wash at moderate speeds has not proved to be a significant factor but the size of the wash can increase significantly when it encounters shallow water – and this can occur at some distance from the vessel that created the initial wash.

Many of the current generation of high-speed craft that might be required to slow down to meet the proposed regulations are ferries that have to maintain a tight schedule. By definition, many of these fast ferries will operate on routes that will cross the main shipping channels and so the majority of the potential collision encounters are likely to involve crossing vessels. This could create a situation where their average operating speed is considerably reduced because of the need to slow down. However, the current practice with many of these vessels is to take early avoiding action to reduce the chance of a close quarters situation and this option would still be open under the proposed changes to the regulations.

7. CONCLUSIONS. The proposed changes to the Colregs could go some way to alleviating the concern amongst the operators of slow small craft about encounters with high-speed craft. By limiting the range for action to 2 miles it still leaves the high-speed craft with the option of taking early avoiding action whilst still maintaining speed but it reduces the speed of closer encounters and allows more time for avoiding action on the part of slow or unmanoeuvrable craft. The introduction of AIS allows high-speed craft to be identified at an early stage but small craft not fitted with AIS will still have to rely on traditional means of identifying such craft.

## REFERENCES

Clements R., (1998). High Speed Craft and the Colregs – A Proposal. *The Journal of Navigation* **51**, 430.
Millns A.T.C., (1998). Fast Craft and the Colregs. *The Journal of Navigation* **51**, 437.
Pike R.D., (1995). Collision Risk with High Speed Ferries. *The Journal of Navigation* **48**, 436.
Pike R.D., (1997). Fast Craft and the Colregs. *The Journal of Navigation* **50**, 140.
Pike R.D., (2001). Collision Regulations and Fast Craft. *The Journal of Navigation* **54**, 477.
Weber H., (1998). Fast Craft and the Colregs. *The Journal of Navigation* **51**, 132.