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AIS and Long Range Identification and Tracking

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KEY WORDS

1. AIS. 2. Radio Horizon. 3. Line-of-sight.

There is a significant error in the equation referring to the rule of thumb for 'line-of-sight' analogue transmissions given in the paper by William Cairns, in the May 2005 issue (Cairns, 2005). This incorrect formula has previously been quoted in other sources, and possibly the author obtained it from one of these. In addition, the term 'line-of-sight' implies geometrical optics, whereas use of the term 'radio horizon' would be more appropriate since this takes account of the extension of radio wave transmission distance over the earth's surface caused by the normal water vapour content of the lower atmosphere over sea.

The article states that the 'line-of-sight' distance, d in miles, with the antenna height h in feet is:

$$d = \sqrt{\left(2\left(h_{antenna} + h_{ship}\right)\right)} \tag{1}$$

The physical interpretation of this statement is that d is given as the range achieved by superimposing the ship antenna installation on top of the shore based one, which is clearly incorrect. The correct formula for the radio horizon between two elevated terminals is:

$$d = \sqrt{2h_{antenna}} + \sqrt{2h_{ship}} \tag{2}$$

for which the physical interpretation is that d is the linear sum of the two individual radio horizons appropriate to their respective elevations above the earth's surface.

In the example quoted in the text, $d = 26$ miles using the incorrect formula, whilst the correct range should be 32 miles for the same configuration. This probably explains why the author states "*AIS may reach distances significantly longer than this rule predicts*".

Under normal radio propagation conditions, the radio horizon is conventionally assumed to be equivalent to rectilinear propagation over an earth whose effective radius is 4/3 times the true physical radius, i.e. $4/3 \times 3960 = 5280$ statute miles. This assumption represents a fortunate coincidence, as will appear below.

In the figure, the radio horizon is given by:

$$arc\,DB + arc\,BE \tag{3}$$

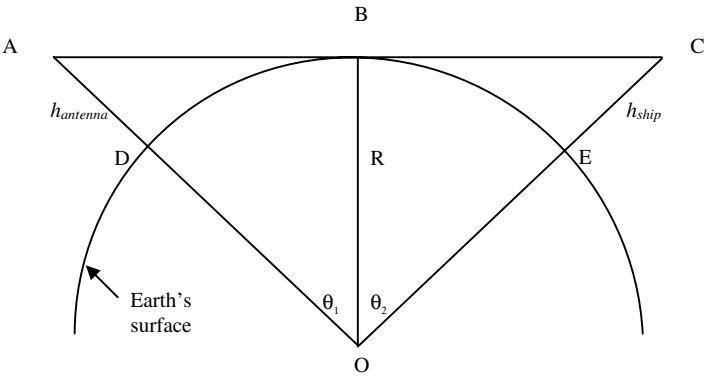

Figure 1.

which can be evaluated as follows:

Since angles θ_1 and θ_2 are very small they can be taken as equal to their respective sines. Then:

$$\theta_1 = sin\,\theta_1 = \frac{AB}{OA} = \frac{\sqrt{\left((R+h)^2 - R^2\right)}}{(R+h)} = \frac{\sqrt{(2Rh+h^2)}}{(R+h)} \tag{4}$$

The individual terms involving h my be neglected since $h \ll R$ so that:

$$\theta_1 = \frac{\sqrt{2Rh_{antenna}}}{R} \tag{5}$$

Hence:

$$arc\,DB = R\theta_1 = \sqrt{2Rh_{antenna}} \tag{6}$$

The effective earth radius R is in miles and h is in feet so;

$$arc\,DB = \sqrt{\left(2 \times 5280 \times \frac{h_{antenna}}{5280}\right)} = \sqrt{2h_{antenna}} \tag{7}$$

therefore the total radio horizon is:

$$arc\ DB + arc\ BE\ = \sqrt{2h_{antenna}} + \sqrt{2h_{ship}} \tag{8}$$

This is the formula for the generally accepted radio horizon between two terminals elevated above the earth, in a normal well mixed atmosphere. The formula gives the radio horizon range in statute miles. If we take a nautical mile as 6080 feet, the formula can be reduced to the simply remembered:

$$1{\cdot}23\left(\sqrt{h_{antenna}} + \sqrt{h_{ship}}\right) \text{nautical miles.} \tag{9}$$

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Assessing Risk of Collision

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KEY WORDS

1. AIS. 2. ARPA. 3. Collision Risk.

1. INTRODUCTION. Edmund Hadnett writing in his article *AIS at the Front Line* in the May 2005 issue of the Journal, attributes to me the argument that '*the automatic radar plotting aid* (*ARPA*) *should remain the principal means of assessing a risk of collision*'. ARPA has never been the principal means of assessing a risk of collision and I have never argued that it has been and should remain so. My argument concerns the merits respectively of ARPA and AIS as navaids or a fusion of data from both.

2. THE SEAMAN'S VIEW. For reasons obvious to seamen ColReg Rule 7(d) states:

> In determining if risk of collision exists the following considerations shall be among those taken into account:
>
> (i) such risk shall be deemed to exist if the compass bearing of an approaching vessel does not appreciably change.
> (ii) such risk may sometimes exist even when an appreciable bearing change is evident, particularly when approaching a vessel at close range.

Seamen also understand the necessity (codified in Rule 5) to:

'… at all times maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.'

The manifest need to utilise all available and appropriate means of lookout to assess risk of collision is reiterated in Rule 7:

(a) '… all available means appropriate to the prevailing circumstances and conditions …'
(b) 'Proper use shall be made of radar equipment if fitted and operational … and radar plotting or equivalent systematic observation of detected objects.'
(c) 'Assumptions shall not be made on the basis of scanty information, especially scanty radar information.'

3. RADAR OR AIS—OR A FUSION OF BOTH? The advent of AIS as a navaid offers it, with radar, as an 'available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists.' Owing to

factors inherent in their respective electronics the data derived from the same target acquired by both radar/ARPA and AIS may differ. In principle, then, the seaman may have three options: he may accept the radar/ARPA data and reject that from the AIS; he may accept the AIS data and reject that from the radar/ARPA; or he may elect to utilise a fusion of radar/ARPA data with AIS data.

4. RESPONSIBLE CHOICE. Of crucial importance to seamen in deciding which electronic data to rely upon in the prevailing circumstances and conditions is the fact that whereas in his own vessel he is fully cognisant of the installation of, and responsible for the maintenance and operation of, the radar/ARPA, that is not so in the case of AIS. The validity of AIS data in respect of 'an approaching vessel' is totally beyond any direct means of appraisal. This being so, where data from radar/ARPA and AIS conflicts, radar/ARPA must, in the evaluation of electronic data, take precedence over AIS. In consequence reliance upon data obtained by fusing radar/ARPA data with AIS data cannot be appropriate in any 'circumstances and conditions.'

5. MCA RESEARCH PROJECT 456. My copy of the 'Report on Association of AIS and Radar Data' issued by the MCA on 20 December 2002 does not contain the Executive Summary quoted by Edmund Hadnett stating:

'automatic methods of reliably associating received AIS information with the relevant displayed radar target could prove highly beneficial.'

But the Report does contain the following conclusion (quoted by Hadnett):

'The concept of data fusion for collision avoidance is not valid. The radar target should always remain the basis of collision avoidance assessment when vessels are not in sight of one another',

and the recommendation (not quoted by Hadnett):

'Radar should remain the basis of collision avoidance when vessels are not in sight of one another. The AIS data and information will assist in providing more information but must not be allowed to confuse the mariner or clutter the display.'

6. VESSEL IDENTITY. Lord Donaldson and his colleagues in their celebrated Report Safer Ships, Cleaner Seas (1994), under 'Identification of vessels' said:

> 15.18 We recommend that the UK Government should work through IMO for early implementation of prominently painted unique recognition signs for all vessels.
> 15.19 While we want this visual identification system brought in at once, it should be retained after a transponder regime is introduced as a permanent and alternative simpler means of identification.

The 'unique recognition sign' first suggested by Donaldson (15.14) was the vessel's radio call sign. But, realising that a vessel's call sign may change the Report said (15.17) 'It may be that the IMO Ship Identification Numbers, which do not change when a vessel is sold or moved on to another register, would be more appropriate …' The international discussion which took place thereafter introduced as the primary

identifier of a vessel to be automatically transmitted by a vessel's AIS its Maritime Mobile Service Identity (MMSI) 'a series of nine digits which are transmitted over the radio path in order to identify uniquely ship stations, ship earth stations, coast stations, coast earth stations and group calls'; the vessel's IMO number, call sign and name are included as 'static information' provided by the AIS and updated only 'Every six min and on request'.

Donaldson duly noted (15.7) that 'An older form of communication, by Morse code using a signal lamp, had the advantage that there was little likelihood of confusion as to the addressee, but is now rarely used.' And he reported that whereas in USA the authorities legislated (15.6) for the mandatory use of VHF bridge-to-bridge radio communication for collision avoidance, the UK Government had issued M Notice M845 advising against the use of radio communication for collision avoidance which 'We believe that until automatic identification is in place is the more prudent course'. The question is 'why did Donaldson and his two assessors fail to see that since, VHF voice radio had all but taken the place of signalling in Morse code by lamp the obvious requirement, to avoid confusion as to the addressee, was to provide a *radar-readable* unique identifier for every registered vessel?' To begin with, Donaldson and his colleagues did not once, in the sixteen months of their Inquiry, go to sea as a group to obtain first hand evidence. Had they done so, surely they would have seen the futility of mandatory painting of call signs on ships' sides and decks, given darkness, reduced visibility and varying aspect? True, it was their conclusion that 'Transponders are vital …' and they had stated (15.20) that: 'Widespread installation and use of transponders will allow vessels to respond automatically to interrogation by coastal authorities or by other vessels'. But the Inquiry went on to say: 'There are some technical problems involved with adapting aviation transponders for maritime use …' adding 'A recently developed alternative is radio transponders which in turn need an electronic position fixing system such as the Global Positioning System (GPS) …'. Unfortunately, the Inquiry was not permitted to hear evidence establishing the feasibility, already demonstrated in field trials under Admiralty supervision, of a marine radar interrogator-transponder (MRIT) system, embodying the latest digital transmission technology. Even so, Donaldson's Inquiry said: (15.27) 'We do not wish to express any concluded views on the respective merits of radar and radio transponders …'. Hence it fell to IMO to make the choice, on behalf of the world's merchant fleet, in the 'Performance Standards for an universal shipborne automatic identification system (AIS)', MSC.74(69) adopted 12 May 1998. As a harbour master at one of Britain's greatest ports remarked recently 'What a disaster that was!'

7. CLASS B AIS. This comment would not be complete without a mention of Class B AIS, a project currently under discussion in IMO, the requirement being to provide an AIS Class A equivalent for carriage by 'non-SOLAS' vessels, given that the lower limit for mandatory carriage of AIS is 300gt. Factors such as patent rights and the prospect of radio frequency overload have led to the notion recently expressed in IMO that for Class B AIS 'a new technology may be needed'. Why not look at universal MRIT?

8. WHAT THE SEAMAN NEEDS. Since VHF voice radio has all but replaced Morse signalling by lamp (except in warships) for bridge-to-bridge communication, the pressing requirement, which AIS does not meet, is to provide

seamen with a means of establishing direct, immediate and unambiguous message exchange by VHF voice radio bridge-to-bridge with an addressee selected on the radar/ARPA display. Once this can be guaranteed reservations about the use of VHF bridge-to-bridge for collision avoidance may be eliminated. The use of bridge-to-bridge VHF voice radio communication then becomes a matter of seamanship reinforced by the IMO 'Guidelines on the use of VHF at sea' (COMSAR 6/WP.6 Annex 3). Best practice at sea keeps the use of bridge-to-bridge VHF voice radio communication firmly under the control of the Master (or Pilot) and limited to facilitating and ensuring compliance with ColRegs by all vessels at all times.

Insistence upon the use of radio call signs and resort to Interco to eliminate misunderstanding would go far to establish the use of VHF voice radio in appropriate circumstances and conditions as an aid to the avoidance of collision. The seaman does not need AIS, however useful it may be to shore authorities for their purposes; nor is AIS of more than marginal value to the seaman as a fall back to, and check upon, GPS (GNSS) or Loran C position fixing. Radar-conspicuous charted objects equipped with MRIT enabling them to be immediately identified when observed on radar/ARPA offer by far the best alternative to GPS or AIS-equipped aids to coastal navigation.