10. THE COMPASS AND SEXTANT. A compass card graduated in ks_A would resemble that illustrated in Fig. 1. North would take the place of the IDL while east, south and west would be indicated at 21.6; 43.2 and 64.8 ks_A respectively. The arc of the sextant would be graduated to 30 ks_A.

11. AN ALTERNATIVE. The system which has been outlined could alternatively be based on a natural decimal division of the day and the circle into 1000 millidays (md) instead of 86400 seconds. Developments, in the application of piezo-electricity, make it possible to give consideration to such a radical departure from traditional ways of measuring time.

12. CONCLUSION. If, like other scientific disciplines, celestial navigation adopted the second as the unit of time, a system such as that described is, in the writer's view, the only conceivable one which is both decimal and coherent.

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Alton B Moody comments

The decimal system suggested by K. K. White is the latest of a number of systems suggested over the years. While any decimal system, with its simple relationships, has an obvious appeal, there seems to be little to recommend a system based upon the second of time, with its unnatural relationship to the circle.

Even simple suggestions such as measuring longitude, like Greenwich hour angle, in one direction through 360 degrees, and latitude and declination from pole to pole, through 180 degrees, have met with little favour among navigators. A suggestion that the number of degrees in a circle be changed to 400 to provide a decimal system of sorts and that a corresponding change be made in the number of hours in the day, while providing a relatively simple system with obvious advantages, has fallen on deaf ears. There is not much appeal to a circle graduated to 86400 units.

Not only is mental inertia involved, but natural relationships such as that between a minute of arc and a nautical mile and that between 15 degrees of longitude and an hour of time have, in my view, too much practical merit to be discarded in favour of any nebulous advantages that might be associated with the suggested method.

Speed Control: A Useful Tool of VTS

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1. INTRODUCTION. This paper discusses some of the implications of speed control in the vessel traffic picture, emphasizing how speed relates to other safety factors so that control can be utilized with understanding and sensitivity. Speed control can seldom if ever be examined in isolation. The structuring of vessel traffic schemes implies a need for some form of speed control as an integral part of almost all those schemes. One technique reinforces the other. Speed limits become extremely critical at the lower end of the speed scale, the higher the traffic density, the more critical the limits. Again, the requirement for enforcement becomes clear. No over-emphasis of these operational

limitations should be allowed to cloud the indisputable fact that – for the individual ship as well as for traffic management – speed control can be a most useful tool. At least three papers [1,2,3] have been published in recent years pointing out that speed reduction by ships for safety purposes, either by individual ships themselves or through general imposition by a shore-based vessel traffic system (VTS), needs in all cases to be used with great care, reluctance even.[3] Their warnings can easily be turned into a negative approach to such control. A number of points would therefore seem to demand looking at again.

It is worth setting the record straight now. The maritime community is in the throes of shifting much of its attention from collision avoidance to traffic management, a much wider and somewhat different discipline. It does not focus on collision avoidance so much as accident prevention and traffic facilitation, on preventing the kind of situation arising in which collision avoidance action need be taken. The question of speed control therefore finds itself high on the list of traffic management issues we should quickly look at.

2. SPEED CONTROL. It will be argued that whilst *any* VTS measures should be applied with great care, speed control is potentially an extremely useful, even indispensable, tool for vessel traffic management as well as for collision avoidance. This is especially so when speed control measures are integrated with other traffic management techniques. It could indeed be suggested that one of the reasons existing schemes do not do as well as they should is that they lack this last essential stone for the arch.

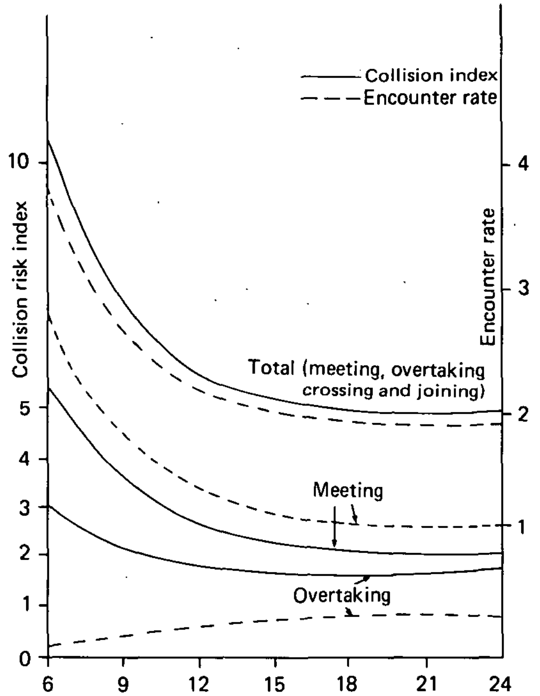

Fig. 1. Effect of speed restrictions on encounter rate and collision rate

We shall begin with positing a chart (Fig. 1)–borrowed from Goodwin, Kemp and Lamb, based on ship domain theory, summarizing their position. We shall then place the chart and some of its immediate conclusions within a wider VTS picture for further discussion and where deemed necessary, recommended modification.

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In general, the theme of all their papers seems to run, speed reduction should neither be recommended nor imposed unless there is a particularly strong reason for doing so. The optimal (safest) speed for any ship is really its service speed. Blanket speed limits have generally little effect on safety over a fair range of speeds. The more severe speed limits give rapidly increasing penalties in terms of traffic congestion, and so on. But speed control cannot really be examined in isolation. It is demanded more and more as shipping routes become more crowded, more structured, and as lateral manoeuvre freedom is reduced. A careless reading of these papers could leave the impression that speed control has but a small role to play in safety at sea. Nothing could be further from the truth. Traffic management and collision avoidance both gain by it.

3. THE SHIP. Let us first examine the problem of the individual ship. It is generally considered that a ship should not be slowed down without an overriding reason for doing so. It has been amply demonstrated that, mathematically, reductions in speed tend to increase both the collision risk index and the encounter rate. Slowing down reduces one's capability for avoiding another ship and makes it more probable that another (poorly navigated one) will run into you. Put another way, one's exposure time is longer, and manoeuvrability less.

Such an approach totally ignores at least one important human factor. Slowing down – assuming traffic density allows – gives one additional time to work out solutions to the traffic picture, time which can be very well spent. With this time for negotiation and better communication, the human element in the accident equation (the factor which causes 70–80 per cent of the casualties) can be run way down. Additional time can make the essential difference between having an accident or not.

All this applies with special emphasis to slowing down in fog and other conditions of poor visibility. Today's almost universal utilization of radar has led to the abandonment of an old and tried rule of navigation – a ship should be able visually to see at least twice its stopping distance ahead. But unless a ship is certain that every threat to safe navigation will appear on its radar, that old rule is still a good one. The faster a ship goes, the longer its stopping distance, and the farther ahead its lookouts must be able to see. Most collisions still occur in fog.

At the same time, it must be recognized that in a totally unstructured traffic situation (i.e. one where traffic is liable to come at you from any and/or all directions, whether there is traffic separation or not) at or approaching saturation density, slowing a vessel down will only increase the threat of congestion, perhaps to the point where everyone will have to stop and wait until the situation is sorted out on the v.h.f. radio. Luckily, such situations are rarely found in the real world. Proper traffic management – including keeping traffic moving at the fastest speed compatible with safety – should have kept them from arising in the first place.

4. TRAFFIC MANAGEMENT. This may be seen as those measures taken by a shore authority to comb out traffic into orderly, recognizable streams, at the same time working so far as possible to maintain a regular, even, safe traffic density. It does *not* ordinarily deal with collision avoidance *per se*, a matter usually best left up to the individual ship (although there may be a reserved right to intervene if the shore thinks it usefully can). Traffic management helps reduce uncertainty, a major cause of trouble in any traffic system.

Figure 1 looks primarily at meeting and overtaking traffic situations, both in management isolation. Under these conditions, in meetings, both the collision index and the encounter (any penetration of one vessel's domain by another) rate go up as the ship's speed is slowed, markedly so at the lower (left) side of the chart. In overtaking situations, the collision index is shown as going up much as in the previous case, but the encounter rate does go down. In any case, both overtaking curves are significantly lower than the corresponding meeting ones. Let us take this chart as a given.

The first comment is that in most scenarios, there need not be *any* meeting situations. Traffic separation schemes – the first, easiest and cheapest control measure for ships there is, internationally recognized as such – take care of that. Those places where separation schemes are not in fact found necessary, the natural configuration of the waterway (or the very low traffic density) does the job by itself. Although seldom sufficient management by itself, traffic separation at least removes any reasonable threat of meeting encounters. Where rogues persist, enforcement measures are called for. So we can effectively scratch meeting encounters.

The answer to the overtaking problem (if there in fact is one) is simply to prevent them from taking place at all. Maximum speed limits (as well as minimum ones, where called for), combined with a no-passing rule, should totally eliminate this threat. While simply slowing down they may not contribute much to the overall traffic safety picture; here as elsewhere, when speed control is integrated with other VTS measures, it can be of the greatest help.

Traffic management views maritime traffic in the gross, as a rule somewhat crudely, and its activities can be reduced to keeping those 'blips' on its radar screen flowing in order and a proper distance apart. Keeping the speed up tends to keep the blips apart. Slowing it down tends to squeeze them together, although this does not get to be a critical factor until or unless a system approaches maximum capacity. This permits full scope for application of speed control, especially as an additional tool for effective VTS.

5. COMPARISON WITH OTHER SYSTEMS. It is becoming fashionable these days to compare vessel traffic systems with air traffic systems, hoping to draw useful lessons therefrom by analogy. Both at least are international in character. But the idea contains a number of inherent difficulties. Air traffic systems operate in three dimensions, vessel systems in two. Compared with aircraft, ships are grossly underpowered, slow, difficult to manoeuvre or to stop. Speed control plays but a small part in air systems. Comparison does not appear to be particularly helpful here.

It would seem to be much more helpful in general, and especially here, to play the traffic control problems faced at sea against those dealt with in every city and on every highway on land. Both surface systems are by definition two dimensional. Vehicle manoeuvring problems tend to be more alike. There is traffic management. Manoeuvring off the fairway is limited, if it is possible at all. There is speed control. There is traffic separation. There are 'no passing' zones. Collision avoidance rests with the vehicle, ordinarily, although as we all know, the police will intervene on those rare occasions when they do see a problem developing and when they think they can do some good. There is much more to be learned here.

Just think what would happen in your town or village if every driver whipped through at full speed, reserving to himself the right to choose which traffic rules to obey and which to ignore. Just think what would happen if there were no police, requiring *everyone* to obey the law, reducing uncertainty, immediately collaring those rogues who could not or would not comply. Also note that this is still the situation too often in confined waters at sea, and, perhaps more importantly, in our ports and the approaches to them.

6. CAVEATS. Neither the threat of meeting nor of overtaking thus rules out the use of speed control as a VTS tool. On the contrary, such control is most useful in structured schemes. The full ramifications of imposing control nonetheless need to be properly understood. Much of what has been written admittedly is most difficult of application in the approaches to ports and other areas where a number of traffic streams converge to enter/exit or to pass. Traffic in such places tends naturally to be unstructured, even

where separation schemes are involved. Such situations often provide the model for arguments against speed control. But even here much can be done. Crossing schemes can be better designed. Traffic roundabouts can be instituted.

In short, structuring marine traffic routes usually leads directly to a requirement for speed control, recognized or not. It *is* possible, in a given VTS area, using Goodwin, Kemp and Lamb, to define a range of speeds within which limits may be imposed without significant penalties. It is also possible to identify, for that area, a critical speed such that identifiable penalties accrue if the limit is set below that speed. But this data is extreme, truly valid only for crossing and joining cases. Such knowledge should only encourage, even justify, the imposition of speed control.

The more one studies VTS, either theoretically or clinically, the more one comes to realise the importance of adequate enforcement in any scheme. Just think of the effect just one rogue has on Fig. 1. Or the effect she has on traffic in the Strait of Dover. There is no practical need for there to be even one rogue in any system. But for this result to be attained, it is necessary to recognize that we live in an imperfect world. There must be some measure of effective policing of any traffic scheme, with proximate and meaningful sanctions for violators of any kind.

7. CONCLUSION. The several papers which triggered this one have been of the greatest value in better understanding various specific aspects of traffic management. Ship domains markedly facilitate the scientific determination of the minimum spacing of vessels in a stream, and thereby the spacing out of ships in any scheme, for instance. But they do not solve all the management problems we face. The application of speed control is a case in point. There utility depends in large part on consideration of and integration with factors and techniques outside those integrated in domain theory. This we have to remember, too. Theory does flag the lower limits of control, indicating when we may be getting into counterproductive speeds.

Well, there you have it. Any reader who concludes that any of these papers supports the idea that ships should be encouraged to go careering around in complex and crowded traffic situations at full service speed has read it wrong. They all do tell us to be careful, but that speed control can be a good thing; it all depends on how, where and when it is used. We just cannot afford to apply it without a full understanding of what all of the effects will be.

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