Forum

A Commitment to Electronics

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1. INTRODUCTION. Electronic systems have been in use for navigation at sea since 1926 when radio direction finding was first introduced. Since that time, systems of increasing complexity have been developed, leading to the sophisticated Navstar GPS which has been heralded as a revolution in navigation. For the first time, the navigator at sea will have continuous position fixing independent of weather and other outside influences and with an accuracy and reliability which is adequate for most practical purposes.

Over the years, electronic systems have rightly been called 'aids to navigation'; systems which help the navigator to determine his position but which, on their own, do not provide the complete answer. Maybourn[1] describes how, traditionally, navigators have relied on a range of aids to navigation each of which complements the other. The attitude towards electronics which was established in those early days of development has persisted to this day, even though both the systems and the onboard equipment have changed dramatically in terms of capability and reliability. The navigator is trained to use electronically-derived information with caution – an attitude which was commendable in the development days but which, today, does not do justice to modern equipment and systems.

This paper suggests that the time has come to change the attitude to electronics and to make them the primary method of navigation. It is proposed that only by changing this basic attitude will the systems be engineered and installed to achieve the desired levels of reliability. It is suggested that many of the problems currently experienced in the use of electronics are the result of the traditional, somewhat negative attitude towards their use.

There is a need to make a commitment to electronics, to embrace them as a viable and acceptable means of navigation. This commitment will enable electronics to be used to maximum advantage and, at the same time, will allow acceptable levels of reliability to be developed.

2. ADVANTAGES OF ELECTRONICS. There are many advantages to using electronics for navigation. The instant availability of precise positions can be the basis of integrated navigation systems which can reduce the manpower required for navigation. Electronic systems are central to the one-man bridge concept being developed for shipping, and will obviously be vital if and when fully automated shipping comes into being.

Using electronic systems on general shipping can lead to cost savings through more precise navigation techniques. Safety margins can be reduced if reliable and precise positions are available and reliable schedules can be set and adhered to (subject, of course, to weather conditions). In traffic separation schemes, electronics are already a virtual necessity in order to conform with the requirements. Boer[2] describes many of the benefits of using electronics for navigation in a more detailed way.

There is a growing fleet of high-speed craft, ferries, motor yachts and military craft where conventional navigation techniques cannot adequately cope with the speed of advance. Without electronics, positions rapidly become history and a full commitment to electronics here could improve safety and scheduling.

There is a rapidly expanding number of electronic navigation users in the leisure market. It is here perhaps that the greatest concern is felt. On the one hand, there is a reluctance to rely on electronics because of a traditional nervousness about the reliability of the equipment and the information it produces. The small boat environment is not conducive to electronic reliability but this is changing and, by using electronics, navigation could be carried out with greater margins of confidence and safety. In racing under either power or sail, electronic navigation can give a vital advantage.

By being able to give precise positions at all times, electronic navigation systems can raise the confidence levels of navigation, and this provides the main advantage. These high confidence levels can be translated into improved safety or efficiency as appropriate, provided, of course, that there is an underlying confidence in the reliability of both the equipment and the systems.

3. CURRENT EXPERIENCE. Most marine navigators today use a mixture of traditional and electronic navigation. Traditional methods are used to check the electronics (which is a step forward from the reverse situation). By using both methods of navigation, the workload for the navigator can be increased rather than reduced. Although precise positions can be obtained from the electronic systems, there is a reluctance to accept these at face value at times, partly because navigation training teaches that the prudent navigator should not rely on information from just one source, and partly because there is often no means of checking the validity of the information produced by the electronic system.

There is considerable frustration in having what appears to be precise positional information yet not being able to use it to full advantage because it cannot be verified. A further problem arises if the navigator wants to use the electronically-derived positions for precise navigation but is worried about the possibility of equipment failure at a critical time, leaving him vulnerable. The only back-up system available could be traditional methods which might not be precise enough for the task.

4. A COMMITMENT TO ELECTRONICS. The dilemma faced by current navigators could be resolved if there was a total commitment to electronics. Instead of adopting the philosophy that electronics may go wrong so they must not be relied upon, a new philosophy should be adopted which says that because total reliance is being made on the electronic systems, they should be engineered to appropriate standards.

Adopting this new philosophy means a three-pronged approach to the systems and installation. The types of failure which are possible are; a failure in the power supplies for the equipment; a failure in the equipment itself; and a failure in the external system which provides the basic information. A fourth potential failure could be human error in using the system.

(a) *Power supplies*. For systems which require a reliable power supply, surprisingly little attention has been paid to power supplies in seagoing craft. Power supply failure probably represents the main reason for electronic equipment not working, particularly in small craft.

Reliability can be achieved by firstly engineering the supply to the highest standards and then having an alternative supply available through a changeover switch close to the equipment. External batteries could be available as a back-up but an alternative, and one, perhaps, less prone to failure, would be a battery system built into the equipment itself which is automatically recharged when the equipment is in use. With modern, low consumption equipment, the internal batteries could be adequate for several hours' use, which would give the navigator time to evaluate and modify his navigation procedures if the main supply could not be restored.

(*b*) *Redundancy*. The current philosophy as far as redundancy is concerned is that if the electronic systems fail, then traditional navigation methods can take over. As electronics get more accurate traditional navigation is no longer precise enough for this back-up role and, of course, may not be readily available. Redundancy should be provided by means of alternative electronic systems rather than by utilizing traditional methods which themselves have a considerable element of doubt as far as accuracy and reliability are concerned.

It is a simple matter to build redundancy into electronic navigation equipment. This can be done by adding extra equipment, but there has to be a philosophy. Fitting two receivers is not sufficient because, if they show different readings, which one is to be believed? A minimum of three is necessary so that the bias can be towards the majority and the rogue can be identified. This arrangement only holds good whilst there are three receivers operational, so it could be necessary to go to four receivers to provide a reasonable hedge against failure. Another aspect of the philosophy could be to use receivers from different manufacturers in case there is an inherent fault which could affect them all.

The important thing is to be able to recognize failure when it occurs. A blank display is an obvious failure but false readings are harder to identify except by comparison. Here, the electronic chart or plotter can help by graphically showing an apparent deviation in the track followed when the vessel has been steering a straight course. It could, of course, be a compass or autopilot error but, either way, the navigator is alerted to a problem.

The same warning could be given electronically by any sudden change in the cross track error or the distance to go. Alarms set to operate outside the normal variations of the navigation system in use could alert the navigator to potential errors occurring in this way.

(*c*) *System failure*. This is probably the most difficult area in which to maintain the required level of reliability, because it is outside the user's control. Logically, the navigator should have two systems available so that one can be checked against the other. This is likely to be the case as GPS is introduced with Loran, Decca and Transit Satnav being maintained in operational condition at least until the end of this century. Beyond that, there may be alternative satellite systems, with the Russian GLONASS offering one possibility.

However, comparing two systems does not provide the complete answer because there is still the dilemma as to which one is to be believed if they show different readings. Any divergence in positions, however, is more likely to be a receiver fault than a system fault, the system fault being apparent by a lack of position rather than a false position. In this case, having two systems available would be an adequate safeguard and reliability could be assured through having two receivers operating on the primary system and one on the secondary system.

If a navigator is going to rely on electronic systems then the main requirement is to provide a warning when problems may be occurring. This can be done electronically by comparing readings, by comparing results from different systems and by telling the electronic systems what are the normal operating parameters so that any deviation outside these parameters sounds a warning. In terms of warnings, it is best to err on the side of caution so that any apparent problem is brought to the navigator's attention and he is then in a position to make the final judgement.

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There are already precedents for a total reliance on electronic navigation systems. Aircraft navigate using inertial navigation systems with no back-up, three systems being installed to give a good measure of redundancy. Unlike a marine craft, an aircraft cannot stop and work things out if the navigator is not happy with the situation. Here, the marine navigator has a considerable advantage, which should be exploited in the development of systems. In the event of total failure there is always the possibility of help being obtained from the shore through radio links, which is a method adopted by aircraft.

Space navigation is another area where electronics play a vital role with a total commitment to the system. Space navigation has grown up with electronics so that the navigation philosophies have developed hand-in-hand with the vehicle development.

5. TEACHING. The teaching of marine navigation has always been conservative and it tends to reflect the examination syllabus rather than the practical needs of the navigator. In teaching, the teacher can only assume that the trainee will have a single receiver available so he will teach prudence and caution. With information available from only one electronic source, this is the correct approach and traditional navigation methods have to be taught as the primary means of navigation.

The influence of teaching on the practice of navigation is considerable. The standards set in the classroom tend to be perpetuated in the practical application of navigation so, if we are going to see changes in the attitude towards electronic navigation, the lead will have to come from teaching. This then raises the question of whether teaching is to change from being reactive to proactive. Should teaching take the lead in the change rather than reflect what has been general practice?

No doubt the teachers of navigation would say that their teaching simply reflects the requirements of the examination syllabus, in which case should it be the syllabus which should be changed to reflect a new approach to electronics? This question of teaching and examinations is one which perhaps needs re-appraisal in the rapidly changing world of navigation. Whilst it is hardly possible to expect the examination syllabus to be the catalyst for change, there is a vital need for it to reflect current thinking and to take a more open and positive view towards electronic navigation that recognizes the very influential role that it plays in shaping attitudes to navigation techniques. Maybourn[1] forecasts that the need for a highly-trained professional navigator will diminish or disappear as it has in the air, but then the marine navigator has never been a specialist, so it will be the training which will change.

6. SETTING STANDARDS. If a change is to be made to a position where electronic navigation becomes the primary means of navigation at sea, then where is the incentive to come from and who will set the standards? For the yachtsman, the situation is easy; he sets his own standards and forms his own opinions and reaps the benefit or suffers the problems. There are no standards in this virtually unlegislated area and few recriminations if things go wrong. This perhaps explains why there is a greater readiness to accept electronics in this unfettered world. However, yachtsmen are being faced with examinations and, although voluntary, they are starting to have an influence on attitudes.

In other sectors of marine navigation the standards are set partly by normal practice and partly by legislation. There is increasing legislation regarding electronics, but this is generally aimed at specifying the capabilities of equipment and a minimum outfit. In these regulations no attempt is made to build in redundancy in terms of either equipment of systems except in the case of radar where two units are specified under IMO requirements.

National authorities are generally reluctant to set standards except insofar as these standards reflect those decided internationally by IMO. The attitude of IMO when it comes to setting standards is reactive and the time scale involved almost invariably means that IMO standards tend to reflect current practice rather than to establish new standards.

The IMO standards set the baseline and it is up to shipowners and operators to set higher standards. This they will do if they see some commercial advantage. With electronic navigation there are commercial advantages in knowing the vessel's position at all times, but the advantages of providing the redundancy and back-up are less easy to define. From an operator's point of view, the main advantage would be that the vessel does not have to be delayed in harbour for repairs if equipment is not working.

The cost factor in upgrading electronic navigation systems to provide a high level of reliability is comparatively low. An operator should be able to see enough commercial advantage, particularly when GPS is fully operational, to justify the investment. At this time, the operator will set his own standards and eventually IMO will take these standards and make them an international requirement. Now that the pattern of future electronic position fixing is becoming established, it would be helpful if IMO set some guidelines at this stage – even if they do not see a clear enough pattern to set standards. A starting point for setting standards could be in specifying the alarm systems which are necessary for there to be an adequate safeguard.

7. CONCLUSIONS. Safety at sea is based on widely varying standards. The authorities are apparently quite happy to see ships roam the oceans with only a single propulsion system and a single steering system and the attendent risks involved. Yet when it comes to navigation, the approach is much more conservative. Despite these varying standards when it comes to safety, much can be done to increase the reliability of navigation systems. Electronic navigation is entering a new phase where there will be reliable world-wide coverage and where it can provide the primary means of navigation. A careful assessment of the requirements of redundancy both in terms of equipment and systems will enable modern electronic navigation systems to be used with confidence. However, the switch to full reliance on electronic systems from the more traditional methods of navigation will need some basic rethinking in philosophy as far as teaching and the setting of standards are concerned. The change to electronic dependence will take place with or without this rethinking because of the commercial advantages and there is a need to recognize this change and to adapt the infrastructure to match it.

REFERENCES

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KEY WORDS

1. Marine navigation. 2. Radio navigation.