BRIDGING THE GAP

The Role of Low-Cost PC Simulators

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INTRODUCTION

The advantages of using simulators in navigation training are well established and documented. In this paper, the particular benefits offered by PC-based simulators (which integrate a number of elements of watchkeeping training) are discussed.

PC-based simulators have traditionally been limited to a radar view only. But today the graphics capabilities and power of PCs are such that many of the elements previously only found in expensive bridge simulators are now feasible.

Evaluations of PC-based radar simulators with visuals have demonstrated clear benefits. The Institut Maritime du Quebec found that they were able to:

> *"accomplish traditional tasks more efficiently .. the learning process is quicker and easier .. and it is relatively easier to make sure that the students attain the desired objectives .. the time saving is more substantial at the lowest levels of training, ie with cadets and watchkeeping mates. At a higher level (chief officer and master) the advantage of the system is mostly at the level of improving comprehension .."*.

Examples included the teaching of specific rules (for example Rule 17) where it was possible to improve trainees' learning and comprehension, and the teaching of facts such as visual recognition of navaids, where time does not often permit special attention. Furthermore:

> *"we (were) led to new ways of using a simulator .. we used "briefing-exercise-briefing" .. where the student does not have to perform .. he is asked to observe, note the facts, and understand .. following the demonstration the student carries out an exercise in which the principle or principles which have been demonstrated are applied .. we have found this approach so effective that it is now used in each field of learning each time it may be useful"* [1]

The potential advantages of PC-based Simulators lie in innovation and in bridging gaps in training.

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For the trainee there are gaps between:

- theory and application of knowledge. Within this gap the trainee must practise his skills to build confidence for the real world.
- classroom learning and instructor controlled simulator time (which is limited). Within this gap the trainee must reinforce his theoretical knowledge and prepare to make best use of his time on the bridge simulator.
- successive training courses where the trainee can use his own or shipboard resources to improve his knowledge and skills (distance learning).
- initial training and fading knowledge where the trainee needs to revise his knowledge and skills.

For the instructor there are gaps between:

- classroom teaching and full scale bridge simulators. Within the gap the instructor needs teaching aids which can provide practical learning experiences for his students.
- the high instructor / trainee ratio on bridge simulators and consequently limited simulator time available for each trainee. Within this gap the instructor needs a multi-user facility which will enable him to manage a large trainee population effectively.
- supervised learning and private study where the instructor needs to provide motivation, direction, feedback and assistance so that the trainee can develop his skills on his own.

In 1989 PC Maritime won an award from the British Government to help fund a feasibility study into designing a collision avoidance simulator specifically to run on PCs, which were becoming widely available.

Before designing **Officer of the Watch** we analysed the types of simulation for which PCs could be used. The main types can be summarised as follows: [2]

- **Procedural and Knowledge-testing Simulation**
  In this case a set of rules is often taught and the simulator teaches the skills and actions needed for operation or understanding.
- **Process Simulation**
  In a process simulation the trainee neither manipulates nor participates in the simulation. Instead, parameter values are set at the beginning and the process watched without intervention.

- **Situational Simulation**
  Here, the trainee performs a role within a simulated situation so that he can see the effect of his actions. The instructor can test the trainee's performance.
- **Intelligent Simulation**
  These are programs that, ideally, contain all known information on a particular subject. "Intelligent" simulations can be organised around expert systems.

We also considered a number of key design goals including:

- **Ease of use.** The design of the system should be intuitive so that users with limited computer experience are not distracted or delayed in attending to the true application of the system. The user-interface should be icon-based so that language is not a barrier.
  We agreed that "the instructor must not be one of the 'necessary materials' for successful use of the simulator" [3]. Ships (other than Own Ship) should be controlled by an expert system so that instructors can create lessons and scenarios which are effective without their presence.
- **Motivation.** The system should motivate by providing an environment which is interesting and where trainees can "discover" principles and concepts for themselves and learn from their mistakes. The trainee's attention should be directed and controlled where appropriate to avoid lessons degenerating into "play".

- **Flexibility**
  - **Type of use** - the system should be suitable for the trainee's private study or to provide an environment for demonstration, debriefing and group activities.
  - **Place of use** - the system should be suitable for wherever the trainee has access to a PC: at college, at home or at sea.
  - **Scope of training** - the system should be capable of conveying or reinforcing information and developing analysis and decision making skills.
- **Feedback** - the system should contain comprehensive debriefing, playback and review facilities.
- **Cost-effectiveness** - the system should bridge the gap between expensive bridge simulators, where instructor / trainee ratios are high and simulator time limited, and traditional learning methods.
- **Good performance on standard IBM compatible PCs** - so that users require no special hardware configuration.

The fruits of this analysis have resulted in **Officer of the Watch**, a PC-based "Rule of the Road" simulator designed to provide a multi-level training facility embracing the following educational objectives:

- To increase motivation, interest and participation.
- To secure information already given in another format (teaching).
- To develop skills.
- To allow self evaluation and evaluation by others. [4]

To meet all the design parameters, we felt that **Officer of the Watch** should be capable of providing the four types of simulation described above: procedural, process, situational and intelligent.

Description

Officer Of The Watch consists of two programs:

1) the **OOW Simulator** where the lessons are carried out in real time with realistic 3-D animation in clear or restricted visibility (fog or rain) and by day or night including dawn and dusk. *Figure 1* shows a typical view through the forward bridge window in full daylight and unrestricted visibility.

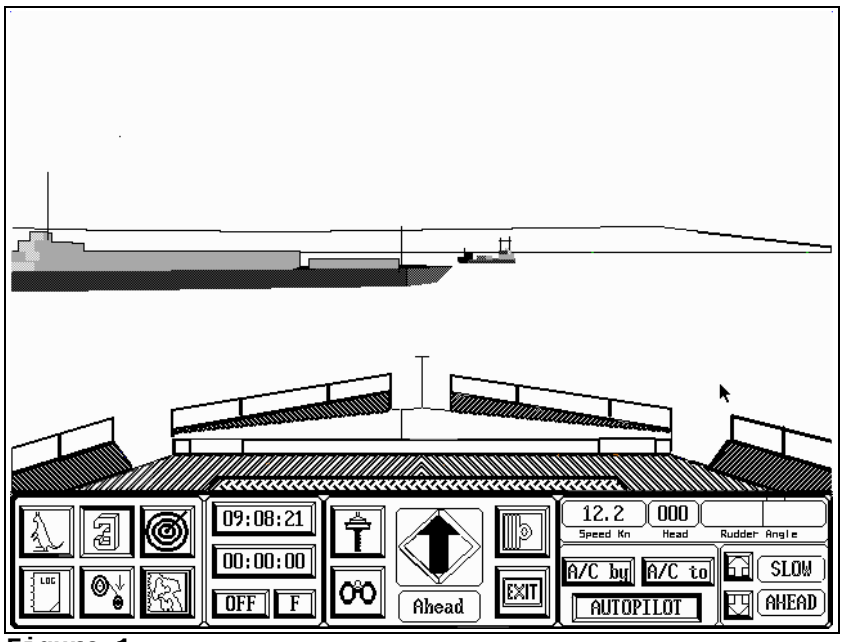

Figure 1

The **OOW Simulator** is founded on an Expert System with a knowledge base of the International Regulations for Preventing Collisions at Sea. The Expert System has two main roles. It controls the actions of all simulated ships (except Own Ship and rogue vessels) and it advises the student who can call the Expert System to get guidance and interpretation of the Collision Regulations if the instructor has allowed it.

Up to nine target vessels can appear in an exercise. The instructor defines the initial course and speed or a set of waypoints for each vessel to follow. Any target vessel controlled by the Expert System which alters course to avoid collision will resume course and speed as soon as it is passed and clear.

The instructor can also specify 'rogue' vessel behaviour, where the vessel will follow its given route regardless of the Collision Regulations.

Each target vessel will show the proper lights and shapes for its class and exhibit typical handling characteristics. The instructor can specify constraints for any vessel which will exhibit the appropriate lights and shapes. For example fishing vessels can be trawling, drift netting or

not fishing; VLCCs can be constrained by their draft; any vessel can be directed to anchor, to become not under command or to go aground at any time during a lesson.

The trainee can save his own version of a lesson at any time for later review or resumption, or while he makes a trial manoeuvre. An additional benefit of the system is that it is eminently suitable for distance learning courses since the trainee can return his material to an instructor for assessment and comment.

2) the **OOW Course Designer** for instructors to create lessons for trainee watchkeepers. This program provides instructors with great flexibility for choosing the elements of the simulator which should be available to the trainee during the lesson; for designing the interaction of target ships; and for defining the events (questions, messages, changes in weather & visibility, equipment breakdowns, new target vessels and so on) which will take place during the lesson.

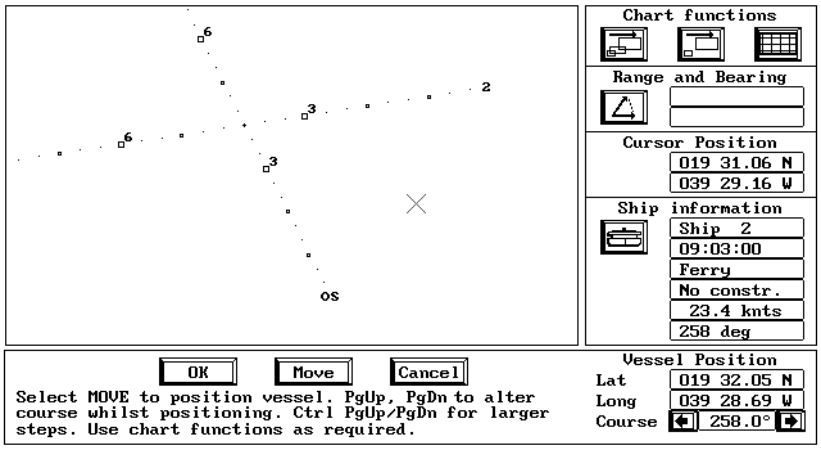

Figure 2 shows a screen from the **OOW Course Designer** where the predicted tracks of ships can be aligned to ensure that appropriate encounters occur. The built-in control provided by the Expert System allows instructors to create realistic and truly interactive lessons which react to the trainee's decisions and actions and will not therefore perform in the same way each time the lesson is run.

Increasing motivation and participation

Many factors have been brought together to ensure the trainee's motivation and participation:

- The **OOW Simulator** is interactive to ensure a high degree of participation.
- Messages can be interjected into lessons to state objectives, give directions or provide summaries.
- The system provides for practice and repetition where needed.
- Lessons are progressive in complexity so that interest level is constantly raised.
- The simulator is dynamic with three dimensional ship and land graphics, realistic radar modelling, representative ship modelling and a full set of bridge instruments to ensure a good transfer of learning experiences from training to full scale bridge simulation or the real world.
- Feedback is provided by
  - allowing the trainee access to the Expert System which will give verification of any other ship's type, constraints, aspect, course, speed, CPA, TCPA and an interpretation of the rules which apply to the situation.
  - interjecting questions into lessons; the trainee will get feedback on the correctness of his answers.
  - a record of the trainee's actions in an activity log.
  - a playback facility to replay the tracks of vessels in the lesson. Each vessel can be "interrogated" for her course, speed or constraints at any time along her track. This enables the trainee's knowledge and skills to be reinforced by review of his actions by himself, colleagues or his instructor.

- A model answer and key parameters which should be adhered to (for example, not to pass within 1nm of any other vessel) can introduce "pressure to perform".

Depending on the objective of the lesson, the instructor can deny access to any of the elements or tools of the simulator including the 3-dimensional view, the radar, the playback, the activity log, the telegraph and the autopilot. This denial of access can apply for the whole duration of the lesson or just a part of it. For example, if the purpose of a lesson is to develop radar plotting skills, then access could be denied to the 3-D view; or if the success of a lesson depends on the trainee assessing the situation during the first 6 minutes of the lesson without altering his course or speed, then the autopilot and telegraph can be disabled for this period. This facility, which applies to almost every element of the simulator, focuses the trainee's attention and avoids the lesson degenerating into "play".

Securing information already given in another format (teaching)

a) Facts

Significant savings of time are possible by presenting and testing facts through Computer Based Training. **Officer Of The Watch** provides a facility for designing questions which can be the sole content of a lesson or introduced at a specific time to test the trainee's response. All answers are recorded in the activity log. The questions are not dependent on the content of the simulator and can include:

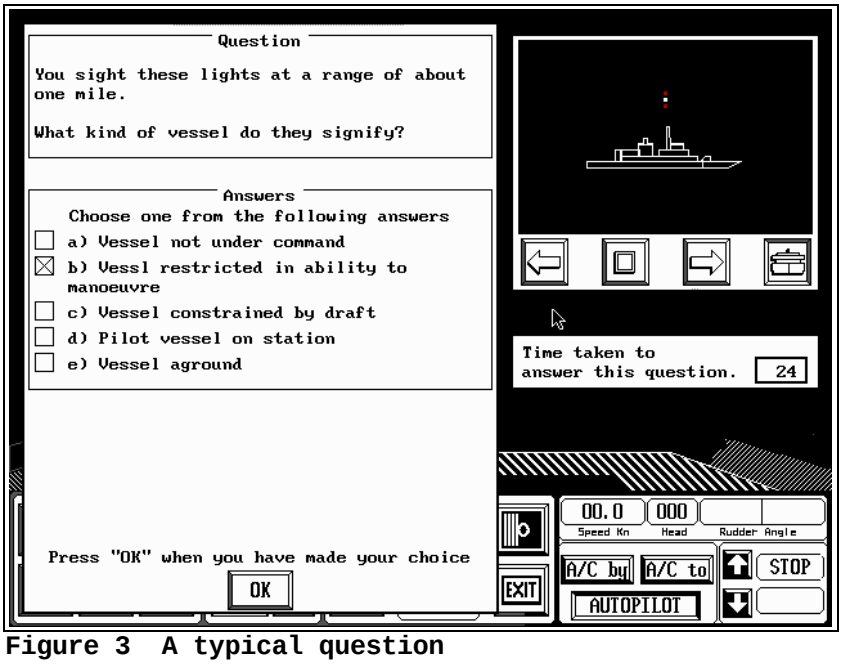

Figure 3 A typical question

- Rule of the Road
- Identification of navigation aids
- Principles of IALA A & B
- Identification of lights and shapes
- Identification of aspect
- Sound signals

Where appropriate the instructor can include a graphic as part of the question on:

- a navigation mark. By day this is shown in colour with its topmark. By night characteristic light flashes are displayed.
- a vessel with shapes or lights if applicable. The image can be rotated to show changes in aspect and an outline of the vessel can be overlaid to help identification at night.

A typical illustrated question is shown in *Figure 3*.

b) Systematic understanding

At this level the power of the simulator and expert system begins to show benefits. Lessons to develop systematic understanding combine simulation with questions and dialogues and increase in complexity until the trainee has mastered the subject. Topics include:

- Watchkeeping procedures
- Relationship of radar view to visual aspect
- Principles of radar (range and bearing measurement, anti clutter settings, shadow sectors, detection and recognition of land or stationary targets etc).
- Real time radar plotting (manual plotting techniques from basic to complex to establish an understanding of the interrelated motion between Own Ship and other ship's including the effects of manoeuvring to avoid collision).

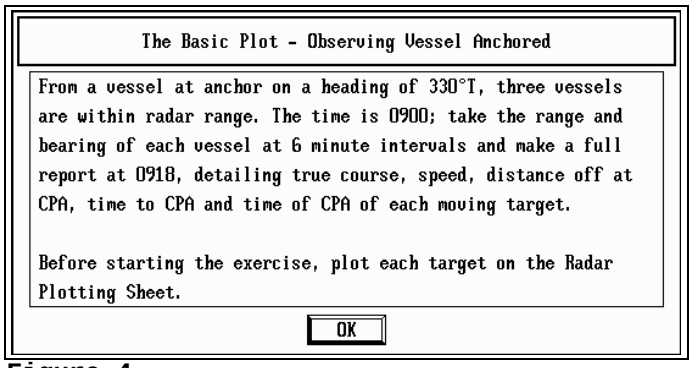

Figure 4

A key feature of effective teaching is that the student knows what the lesson is about - the old maxim "Tell them what you're going to teach them, then teach them, then tell them what you taught them" is very valid. Hence the instructor can write and insert as many messages as he likes during the course of the lesson to give objectives, provide guidance and summarise on completion.

Figure 4 shows a typical message. The trainee has been given instructions; he runs the lesson, updating his radar plotting sheet at 6 minute intervals. When he has completed the run, he is asked questions relating to the true course, speed, CPA and time to CPA of the targets. The answers to his questions are recorded in the activity log. The radar view at 0918 is shown in *Figure 5*.

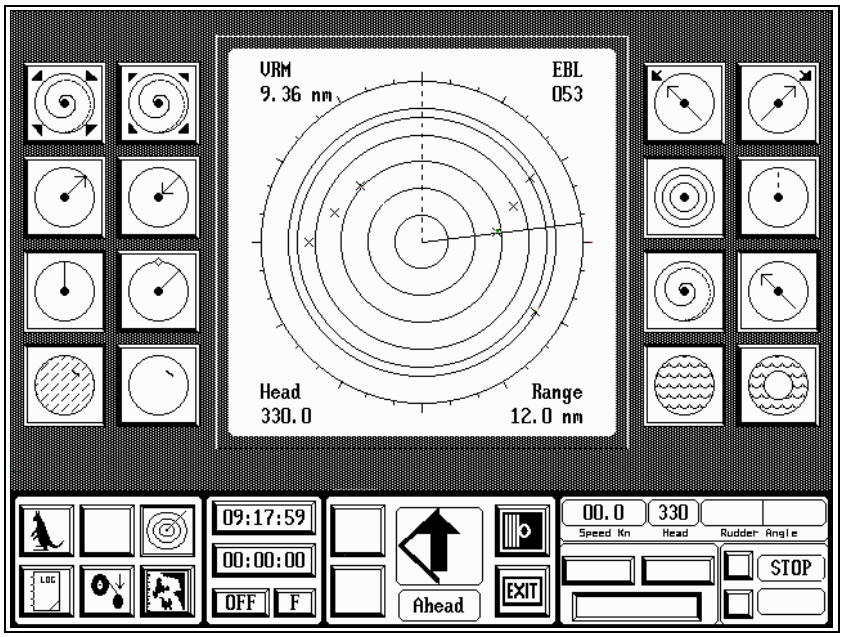

Figure 5

Courses can be developed with, for example, each lesson addressing aspects of specific rules. Once the principle is grasped the trainee needs to practise his knowledge. Lessons for this purpose can introduce one or more target vessels at intervals so that the trainee has to maintain a high state of watchkeeping to identify new vessels and take action.

For example the instructor could introduce a new vessel at 6 minute intervals always crossing from starboard to port. The instructor will not know the position of Own Ship since the trainee may have altered course or speed for previous vessels. To overcome this problem, the instructor can position new targets in a **relative position** to the Own Ship's current position. For example, defining the target ship's position as range 3nm, bearing from Own Ship 60°, relative course 285° you can create a crossing situation without worrying about the actual position or course of the Own Ship. This example is illustrated in *Figure 6*.

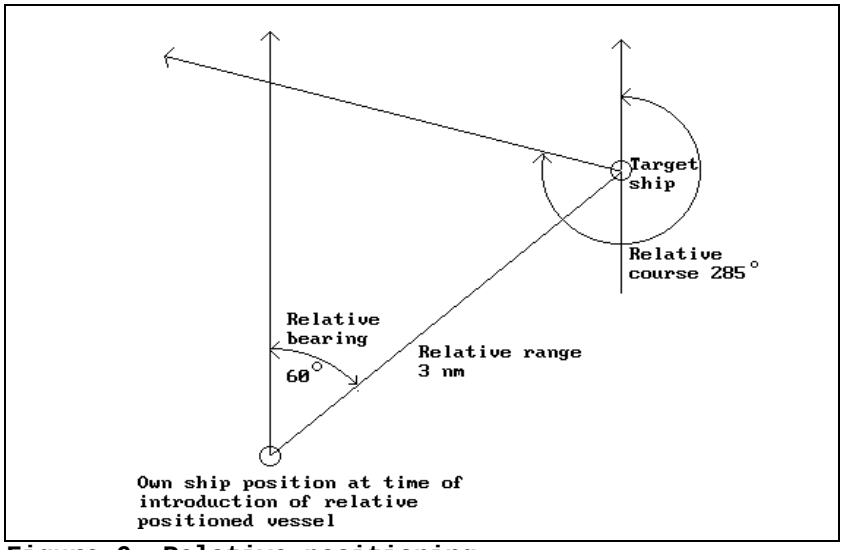

Figure 6 Relative positioning

Figure 7 illustrates some of the effects of relative courses. Other situations are possible such as placing Own Ship behind a target ship on a relative bearing of 360° and relative course of 0° thus putting Own Ship in the overtaking role.

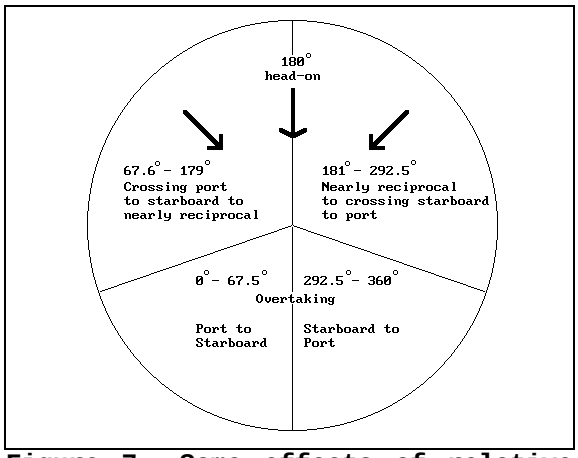

Figure 7 Some effects of relative courses

Development of Skills

Analysis and decision making

In previous lessons the trainee will have learned systematic techniques as part tasks including:

a)Maintaining a proper lookout by radar, eye and ear.

b) Determining if a close quarters situation is developing

c) Application of the International Rules for Preventing Collisions at Sea.

d) Effects of speed and distance on the time available to make decisions

e) The benefits of safe speed [5]

At the stage of skills development, lessons will pull together all the above to test and develop the trainee's powers of analysis and decision making. He must determine the best manoeuvre, ensure its effectiveness and resume course and speed when all targets are past and clear. In this type of lesson it is likely that the instructor will give the trainee access to all the facilities of the OOW Simulator except for the Expert System.

Lessons for this purpose can be set in Open Water, Confined and Congested Waters and in and near Traffic Separation Schemes and contain up to 9 other vessels. Changes in visibility by fog and/or rain, equipment breakdown and emergency situations can all be introduced and trainees can save their version of a lesson at any time to carry out trial manoeuvres if they wish.

Self evaluation and evaluation by others

At least three levels of evaluation and debriefing can take place; by the trainee himself, by the instructor and by a group which may or may not be led by an instructor.

Clearly self-evaluation requires discipline and motivation, nevertheless the committed trainee can be given access to the Expert System, Activity Log and Playback to review his decisions and to gain reinforcement on his interpretation and calculations.

The trainee can call the Expert System whilst in the Visual or Radar mode where he will get advice on any target vessel in four stages:

- TARGET INFORMATION gives the type of vessel, its relative bearing, aspect, and whether a close-quarters situation is expected.
- DETAILED INFORMATION gives exact type (for example, a ferry), constraints (for example, not under command), range, course and speed, CPA and TCPA.
- ENCOUNTER STATUS advises which is the give-way vessel if a close quarters situation is expected.
- EXPERT SYSTEM EXPLANATION justifies the decision made under ENCOUNTER STATUS, quoting from the knowledge base of the International Collision Regulations.

A sequence of advice screens follows.

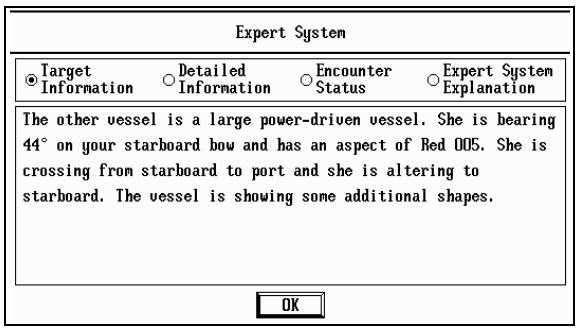

Figure 8 Target Information

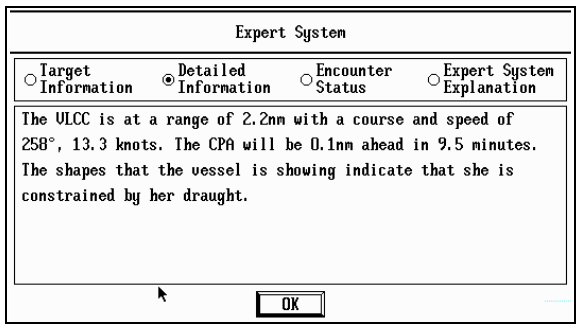

Figure 9 Detailed Information

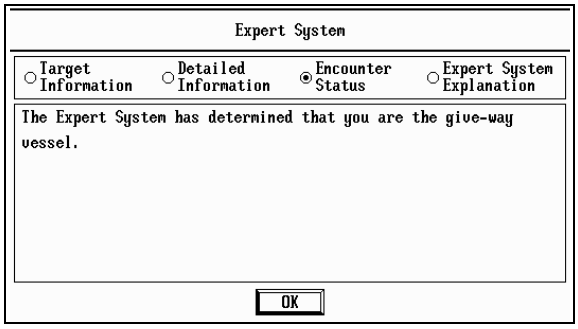

Figure 10 Encounter Status

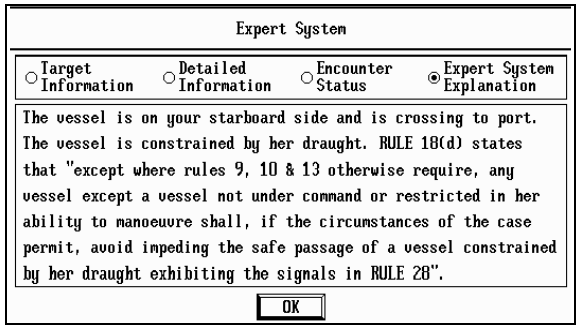

Figure 11 Expert System Explanation

The Activity Log records changes in direction of view from the bridge, the time spent in the various modes (visual, radar and chart); the time spent using the Expert System; the use of bearing repeater and binoculars; and alterations in course or telegraph setting. The trainee's response to questions is also recorded here. This enables the instructor to profile the trainee's performance and use of procedures, or the trainee to review his use of the tools available to him within the lesson (for example regular and frequent use of the radar and changes in view from the bridge would demonstrate his vigilance in watchkeeping). The Activity Log is of significant benefit to the Instructor when assessing the trainee's overall performance in a lesson.

The Playback view shows the charted area with the start positions of all vessels as well as land, depth contours and navigation marks. Buttons allow time-marked tracks of the vessels to be run forwards in slow or fast time and to be paused at any moment. Additional tools allow the user to expand or contract the chart view, measure range and bearing between any two points (for example, between a specific time on the track of two vessels), and to get information about the course, speed and constraints for any vessel at any time along its track. An example is shown in *Figure 12*.

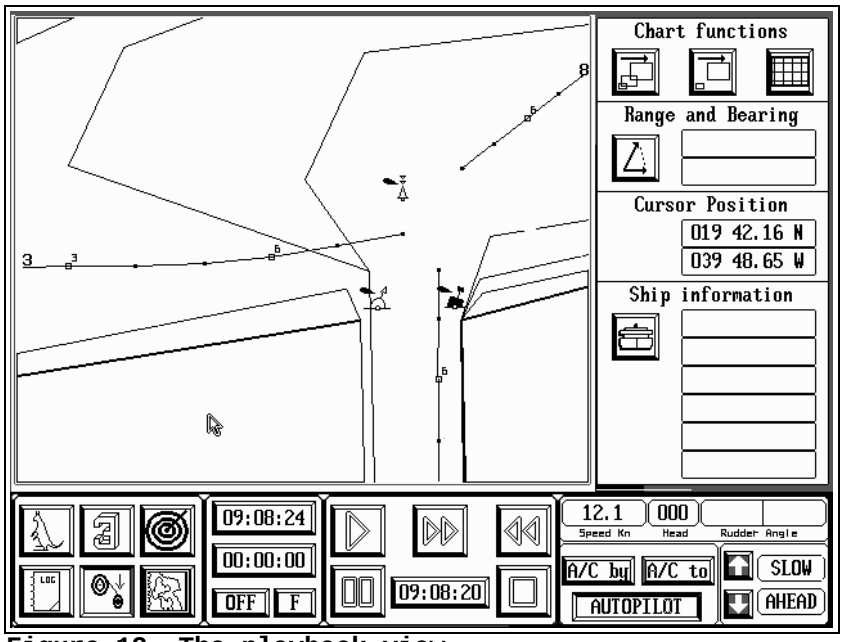

Figure 12 The playback view

The Playback view is ideal as a forum for debate and debriefing, particularly if an LCD projection panel is used with an overhead projector to project the image onto a large screen. The actions of Own Ship and target ships can be analysed in depth and lessons learned. This facility is also useful in a straight teaching mode, where the program can be used to illustrate points, or for the "briefing-exercise-briefing" approach described in the opening section of the paper.

Finally, it is sometimes instructive to look at situations from another perspective. The watchkeeper on a VLCC should appreciate the problems of the fisherman and vice-versa. At any point in a lesson, the Instructor can "jump" to any other vessel and raise new questions!

REFERENCES AND NOTES

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