RADAR SIMULATOR
FOR DEMONSTRATION AND TEST

2012-11-25, Version 20&21&23 radar interface

LINUX SOFTWARE VERSION

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NEW FEATURES OF 2012-11 VERSION
1) High rate serial output messages for heading stabilisation are now allowed on the AIS serial port (Tx interval = 0).
2) All NMEA and AIS input serial messages are accepted at any AIS or NMEA port.
These 2 changes allow all NMEA and AIS functions to work with a single serial port.
3) Some small adjustments are made to the "x,y to range and bearinng" calculations to reduce roundoff errors. These changes may have a significant effect on the target tracking performance of a connected radar.
4) If D page "Display picture buildup" is switched on, then the radar targets on the graphics radar window are not erased from scan to scan. The main object is to allow checking of the smoothness of target tracks in relation to (3).
5) The time lag in calculating SOG and COG for NMEA sentences is user controllable on the NE page.
6) The VLW NMEA sentence works properly.
7) A memory overwriting problem that can lead to "Segmentation fault" when a "No file" message with a maximum length file name (12 char) is displayed on the text pages is fixed.
8) A problem that could lead to a sudden jump in position of a ship target echo (by the length of the ship) is fixed. This problem is seen with exercise SCEN4H at time 2.07.
9) There is a new feature on the L page, section Other:

Enable save / restore window sizes Y/N

If this is switched on, then when the L page is saved, the dimensions of the graphics windows are saved, and will be restored when rdtsim runs again.
10) Linux rdtsim now includes support for the analogue + digital I/O card, which allows connection of meters and control levers for ship control. .

For further information about update history, see file RDTSIM.TXT.

NEW FEATURES OF 2009-6-9 VERSION
IEC 62388 related
1) The number of T page target ships is increased to 100.
2) The tracked target data (!__TTD) sentence is handled as an alternative to $__TTM for receiving data from an attached radar.
3) AIS message 24 for class B targets can be output as an alternative to messsage 19.
4) When using AT page “Dump Own Ship Data”, both true and false own ship speed and heading, and ground relative speed are written to the log file.

Other
5) The AT page log errors are applied to log pulses. Previously they were only applied to serial messages.
6) The ability to rescale radar target video amplitude on the L page is removed. It is hardly needed when a similar effect can be got by changing RA page power.

MAIN DIFFERENCES BETWEEN DOS AND LINUX VERSIONS OF RDTSIM
1) File names.
When copying files from DOS, or directly accessing DOS directories, Linux normally converts the file name to lower case. However, if files are copied by some indirect method (such as compressing the files in DOS then expanding them in Linux) the file names may remain in upper case.
The behaviour with Linux rdtsim is:

A) File names that appear on the rdtsim text pages remain in upper case.
B) When a file has to be read or written, the file name is converted to lower case. However, when reading, if a file with a lower case name is not found, a file with an upper case name will be accepted.
C) The DOS restrictions on file names remain (maximum length of 8 characters with a 3 character extension, no embedded spaces).

2) L page
A) There are 2 methods of driving a serial port:

Direct The port is driven direct by the rdtsim kernel module (simmod). This mode is the only one available for the radar card serial ports. It is recommended to use this type of port for serial messages used for heading stabilisation because the data content and timing are more accurate.

Standard driver
The port is driven by the standard Linux serial port driver. This mode is normally used for ports not on the radar card.

B) Item “freq” that affects the rate of outputting high rate HDT (or THS) serial messages for heading stabilisation works in a different way. For DOS and Linux Standard driver, the output rate is 18/freq Hz. For a Linux Direct port, behaviour is:

freq	Output rate Hz
0	20
1	50
other	100/freq

C) When entering a serial port baud rate, use the actual value. If a *8 clock is in use it is taken into account automatically.
3) D and Q pages.
Most of the features on these pages are not available as Linux does not allow this type of operation.

4) Second radar.
On simulators with 2 radars connected, the 2nd radar works independently.

5) Navigation aids.
The radio navigation aids (GPS, Loran, DF) are removed from the Instruments page. They have quite limited usefulness for rdtsim and the coding has not been converted from DOS. The control of Loran and GPS errors on the NE page is retained as it affects NMEA0183 messages.

PART 1 - OPERATING INSTRUCTIONS

1 GETTING STARTED

This is a brief description of how to operate the simulator for the first time.

1.1 Running the Simulator Program

The simulator program is a normal linux executable, rdtsim which can be run in various ways:

- directly by command ./rdtsim (working from directory rdt). This only works correctly if you are working from a suitable sized text window.
- using command ./runsimk.bat (working from directory rdt). This sets up an 80x25 text window and runs rdtsim in it.
- by picking on the rdtsim icon. If the icon is not set up, this can be done as follows (when using KDE Window Manager)
  Right click on blank space on the desktop.
  Follow path Create New->Link to Application.
  Under General, Enter "rdtsim" as the application name.
  Under Application, enter Command as "$HOME/rdt/runsimk.bat".
  Enter Work path as "rdt/".

rdtsim puts up 4 windows on the screen:

text window	This is used for data entry and numerical readouts.
Graphics Overview	Overview of the exercise situation.
Instruments	Readout of various instruments. Also used for steering the Own Ship.
Radar	Simplified version of the radar picture being output.

1.2 Selection of a Page on the Instructor's Text Window

The instructor has a number of pages which he can call up to monitor and control an exercise. Pages are selected by typing in the page letter at the top left corner of the screen. The H page gives an index of the pages available. To select the H page, proceed as follows.

Key to type	**Effect**
"ESC"	Return cursor to top left if not already there
H	
"RETURN"	Causes H command to take effect

The H page will now be displayed, and you can see which other pages are available. Try selecting some of the other pages.

1.3 Loading an Exercise

Most of the time, an instructor will use exercises which he has prepared and saved on disk. The commands to load an exercise are input on the C page, so return to that page. A demonstration exercise is available called "RADDEMO". To load this, type the following.

Keys to type	Effect
ESC	Return cursor to top left
TAB	Move cursor to "Exercise name"
"RADDEMO"	
RETURN	"RADDEMO" will be entered as the Exercise Name
TAB	Move Cursor to "Load Y/N"
"Y"	
RETURN	Causes exercise "RADDEMO" to be loaded

If you examine some of the pages again you will see the information that has been loaded from the disk. When an exercise is first set up, this information has to be entered through the keyboard. It can then be saved to disk by giving it an "Exercise Name" and requesting "Save" on the C page.

1.4 Exercise Run and Freeze

When an exercise is loaded, it will be in an "Exercise Frozen" condition. Time does not advance or the ships move, but other parts of the simulation work as normal. To start the exercise running, type R at the top left screen position. (Key sequence: "ESC" R "RETURN"). The ships will then move, and the ship controls become active. Command Z causes the exercise to freeze. (Key sequence: "ESC" Z "RETURN").

1.5 The Radar and Graphics Windows

While the exercise is frozen, you can try out some of the following.

Radar. The radar picture should show a coastline and several buoy and ship targets. Switch to 12 mile range and adjust the gain and tuning controls until these are displayed. Try out other radar controls. The target plotting functions will only start to work when exercise is running.

Graphics Overview Window. This gives an overview of the exercise area showing the coastline, own ships, target ships and fixed targets. To change the origin, drag the picture with the mouse. To change scale, use the <---> symbol in the control box at the top left.

Navigation and Instruments Window. This gives a readout of various instruments. You can use it to steer the Own Ship around by picking on the Rudder box, the Ahead-Astern box, and the Autopilot box.

The instructor's radar picture is a simplified version of the radar picture being output to an attached radar.

1.6 Changing the Values Displayed on the Pages

The sequence for changing a value is:

- Select required page. (e.g. "ESC" M "RETURN")
- Move the cursor to the screen position where the information is displayed using

"TAB" or the arrow keys. Screen positions where data can be entered are highlighted with a blue background.

- Type a new value then "ENTER". If the new value is accepted, then "Ok" will appear on the top line of the screen. If it is rejected, then an error message will appear.

Some useful exercises to try out are as follows.

Scanner Height and Shadow Sectors. These are controlled on the M page. Try increasing and decreasing the scanner height and observe the effect on the radar picture. Try entering a shadow sector.

Target Summary. This display on the TS page gives a summary of ship target information. Select the page and compare the target information with the situation shown on the graphics screen.

Graphics Overview Page Options. Some of the details of the display are controlled from the O page. Try changing, for example, the length of the ship vectors.

1.7 Running an Exercise

Exercise RADDEMO is a radar exercise in ORESUND, the channel between Sweden and Denmark. Unfreeze the exercise ("ESC" R "RETURN") and navigate along the channel avoiding going aground or colliding with the buoys and target ships.

2 EXERCISE CONTROL

2.1 GENERAL

Display and input of exercise information is done through the instructor's text pages. Each Page is specified by a letter. In most cases the page letter is followed by a number. The numbered pages allow specification of, for example, several target ships.

2.2 USING THE KEYBOARD TO CONTROL THE SIMULATION

The pages display information showing the current state of the exercise. When the simulator program first runs it automatically reads exercise data from a file default.ex. This file can be changed by the user. It can be re-loaded to return to the initial condition.

Displayed exercise information which can be changed using the keyboard is highlighted with a blue background. To make a change, move the cursor to the screen position where the information is displayed and type in a new value, then *Enter*. If the new value is accepted, *Ok* appears on the top line of the screen; if not, an error message appears (for example, if the new value lies outside of sensible bounds).

With the cursor at the screen top left position, pages can be selected by typing in the page letters (and number if required). To move to other screen positions, the cursor control keys (arrows) are used to move the cursor around the screen. The *Tab* key causes a jump to the next modifiable field, and SHIFT TAB to the previous. The *Esc* or *Home* key causes a return to the top left screen position.

If a printer is attached to the computer then a printout of a text page can be requested at any time by typing PRINT SCREEN.

2.3 SPECIAL INPUT FEATURES

2.3.1 Duplication of Data

In cases where there are several sets of information such as target ships, it may be wished to construct two sets with only minor differences. This can be done easily by typing in a new value for *Copy to Target number* on the T page. The target will then be duplicated at the new target number.

2.3.2 Auto/Keyboard

In several places there is an option where information can be input through the keyboard, or taken from some other source. This is controlled by typing in the "Auto/Keyboard" position "A" for auto or "K" for keyboard control at the appropriate screen position. An examples is the radar pulse length which can be taken from the value selected at the display unit or controlled directly by the instructor.

2.3.3 Position Display

Where a position appears on the screen, there are a number of different methods that can be used for display and input. A function key is used to cycle through the options. The function key to be used is shown on the screen. e.g. "{F2}". The options are:

- Metre from the exercise origin, X and Y.
- Millimetre on a chart, X and Y. (The chart is defined on the C page.)
- Latitude and longitude.
- Range and bearing from the Own Ship in metre.
- Range and bearing from the Own Ship in nautical miles.

The range and bearing options are limited to a range of 32000 m or 35 nm. Greater values give a blank screen.

2.3.4 Position Taken from Graphics Overview Page

The Graphics Overview Page cursor can be used to give a position to be entered on a text page. Use the centre mouse button to leave a marker on the screen. Move the text page cursor to where the position is to be entered, then type Alt P.

2.3.5 Exit to Linux

To exit to Linux, type Ctrl C or Alt X. The program asks for confirmation to avoid an accidental exit. The exercise situation will be lost unless it has been saved on the C page.

2.4 THE R and Z COMMANDS, Exercise Run, Exercise Freeze

These commands can be input when the cursor is at the top left position. When frozen, only the ship manoeuvring and position updates stop working. Other equipment will function as normal. This allows the exercise to be halted at any instant to try out effects such as adjusting the controls of the radar.

2.5 PAGE AI, AD and AT

These pages control separate simulation modules and are documented separately:

AI and AD	in the AIS simulation section
AT	in the ARPA testing section

2.6 PAGE B - Seabed

This page is used for entry of seabed depth information. For rdtsim, this is of secondary importance and it is unlikely that users will want to create their own seabeds, so further details are not given.

2.7 PAGE C - Coordinates, Exercise Load and Save etc.

2.7.1 Exercise Load and Save

Exercises, seabeds, and radar landmasses can be given a name, and then loaded from disk. This is done by typing in "Y" in the "Load Y/N" position. Exercises and seabeds can also be saved by typing "Y" in the "Save Y/N" position. When an exercise is saved, the seabed and landmass names are saved rather than the actual data. When an exercise is loaded, the seabed and landmass files are automatically loaded. Name extensions are automatically added to the names given. They are ".ex", ".sbd" and ".lnd". When a new file is created, one backup is maintained with extension ".ebk" for an exercise file or ".sbk" for a seabed file. Note that .lnd files and .sbd files can contain "include file" commands that request loading of further .lnd or .sbd files, so a "No file" message may give a different file name from the one that appears on the C page. When exercises are saved they are written to the first directory shown on the DI page, normally directory ex.

When saving files, confirmation requests and warnings are used to reduce the risk of overwriting valuable data. Whenever an existing file is to be overwritten, confirmation has to be given. Normally a file being saved will be a new file, or a modified version of an existing one. If an attempt is made to save a file with the same name as an existing one, but without first loading the existing file, an additional warning message is displayed.

2.7.2 Exercise Initialisation

The initial state of the exercise is stored in a special exercise file default.ex which is automatically read in at startup from the default directory. To change the initial state, set up the desired exercise state and save it with exercise name "default". If a redirection file is in use it will also be necessary to copy the new default.ex to the default directory. If file default.ex is not found at startup an error message is displayed and the simulator will not run until an exercise is loaded. There is a second method of selecting a starting exercise. See section "Exercise Redirection File" for further details.

2.7.3 Exercise Record and Replay

Record and replay are controlled by the centre part of the C page. Recording can be switched on manually, or it can be preset between given start and end times. When recording begins, the state of the exercise is saved to disk in the same format as a saved exercise. Further information is then written to the file as time passes. Anything entered through the keyboard is written to the file. At the record interval, the own ship data, and the positions of all moving target ships are also written. Record will normally be terminated either manually, or when the "End Time" is reached. Record will be terminated automatically if an exercise is loaded or the simulation program exited. The name given to the record file is the name of the exercise. The name extension is .rcd. The same .rcd file will be written every time a recording is made with a particular exercise. If it is wished to save a .rcd file for long term future reference, a different "Exercise Name" should be entered before starting to record. (Alternatively, rename the file on completion of recording).

When "Preset" record is switched on, a programmed start and end time for recording can be entered. The software controls "Manual" record by switching it on and off at the specified times. Manual record can still be controlled from the keyboard as normal. Note that when Manual record starts, the software prompts for confirmation if an existing .rcd file is to be overwritten, but when Preset record starts the file is overwritten without a request for confirmation. This allows the Preset recording to be made without operator intervention.

A suitable value for "Record Interval" for a radar exercise is 30s or 60s.

Replay is started by typing "Y" in the Replay Y/N position. The saved state of the exercise is read from disk. Progress of the replay can then be controlled by "R" and "Z" in the same way as an exercise. During "Replay Running", data up to the end of a record interval are read from disk, then held for the length of time given as "Replay Interval". For fastest replay rate, use "Replay Interval 0". It is possible to skip forwards to a particular time of interest by typing the time as "Replay Time". Replay can be ended at any time by typing "N" in the "Replay Y/N" position. The exercise situation will then be the same as when it was recorded, and the exercise can be continued from that position if desired. When the end of the record file is reached, the system is held in a "Replay Frozen" condition until replay is switched off manually. This is done to allow examination or printing of the graphics overview page which gives a different display during Replay.

When Record, Replay, or Print are active, the screen display is made in inverse video to give a clear indication.

2.7.4 Graphics Printout

The C page printout control does not work properly with most modern printers. It is better to use the standard Ksnapshot program of the KDE Window Manager. Its icon is a camera that appears in the panel (lower menu bar). If this icon is not seen, right click on blank space in the panel and follow path Add to Panel-> Application-> Utilities-> Desktop-> Ksnapshot. It may also be necessary to configure the printer by picking on the SuSE menu (green fish) and following path Control Centre-> YAST2 modules-> Hardware-> Printer-> Configure-> (You also need the root password "simuroot").

To make a printout

Pick on the camera icon.
To print the full screen, pick on "Print snapshot".
To print a selected window only, Pick on "New snapshot", select the window with the mouse, then pick on "Print snapshot".
To print a selected window with better resolution, first switch that window to full screen, then make the printout.

2.7.5 Exercise Time

The value for Exercise Time which is displayed on the top line of every page can be initialised on this page. Exercise time will normally lie in the range 0.0 to 23.59. However, some users want to run exercises for several days. To allow this to be done without keeping a proper count of days, hours values up to 99 are allowed. Time 24.0 to 47.59 is day 2 etc.. In NMEA sentences that contain a date (RMC and ZDA), time and date are properly adjusted when Exercise time exceeds 23.59.

2.7.6 Exercise Speed Control

"Acceleration Factor" is the rate of progress of an exercise relative to real time. For normal running of an exercise the value should be 1. Higher values are useful when trying out a new exercise, or to progress rapidly through part of an exercise that is not of much interest.

It is also possible to move rapidly forward to a particular exercise time by entering that time as "Fast forward time".

Accelerated time is most likely to be useful when the own ship is travelling in a straight line, and it may be necessary to use "Disable ship manoeuvring" on the S page to get satisfactory results.

On the graphics overview page, history dots may not be drawn correctly when running with accelerated time, but they are always stored correctly and will appear correct whenever the screen is redrawn.

2.7.7 Coordinate System

The basic (x,y) coordinate system uses Mercator Northing and Easting in units of metre from the exercise origin (Coordinates are internally stored with units of 1/256 m). Wherever a position is displayed, alternative methods can be selected: X,Y in mm on a chart; latitude longitude; range and bearing from the own ship.

The origin of the X,Y coordinate system on the surface of the earth is fixed by "Exercise Origin" latitude and longitude. Any position near the exercise area can be used, but normally the bottom left corner of the main chart is used. The origin position should not be changed for an established exercise area because most positions are stored relative to the origin.

Latitude longitude positions apply to a particular model of the earth. When positions come from different sources, different earth models may have been used, and it is necessary to apply datum shifts if great accuracy is required. The most convenient standard to use is the WGS model of the earth because this is the standard used by GPS navigators. Large scale charts usually have a datum shift needed to convert a WGS position for use with the chart. These values can be entered and used to correct positions. See section "PAGE O - Latitude Longitude Position Datum Shifts" for details of what to enter and how the corrections are applied.

The display of X,Y mm on a chart allows an exercise to be constructed on a chart or a sheet of graph paper. With a chart, use a sheet of transparent graph paper as an overlay. X Y positions read from the graph paper can be directly entered into the computer.

To allow conversion of chart mm units, the chart scale and origin need to be entered on the C page. It is essential that these figures are correctly set before entering positions in "X Y chart mm". The recommended procedure for calculating the scales is as follows.

1. Select the chart origin position, normally the bottom left corner.
2. Use the graph paper to be used for measuring positions (or a ruler or digitiser) to measure the X Y coordinate in mm of a latitude longitude position near the top right corner of the chart.
3. Enter "Exercise Origin Lat Long" as that of the measured position near the chart top right. Enter "Chart Origin Lat Long" as that of the selected chart origin.

4. Adjust "Chart scale X" and Y until the figures for "Origin X" and Y are minus the measured figures.
5. Enter proper "Exercise Origin Lat Long" and "Chart Origin Lat Long".

Separate figures for X and Y scale allow accurate fitting of real charts which very often show paper distortion. A Y scale value of 0 means Y scale equal to X scale.

2.7.8 Seabed

See the B Page for details of how the seabed is defined.

Seabed Origin Lat Long is the bottom left corner of the seabed grid. A value of (0N, 0E) means that the Exercise Origin should be used as the Seabed Origin. This can be useful for a general purpose seabed to be used at any location. Seabed Origin Lat Long and Seabed Chart Scale are used to convert between Exercise X Y (m relative to Exercise Origin) and Seabed X Y (chart mm). If it is wished to use positions displayed as "X Y chart mm" to give seabed coordinates, be sure that the values entered on the C page for "Chart Origin Lat Long" and "Chart scale X Y" are the same as the figures given for the seabed.

2.8 PAGE D - Debug

See the hardware instructions for details.

2.9 PAGE DI - Directory

The page gives a directory of exercise files. All files with extensions .ex, .sbd, .lnd and .rcd are listed. The files are those in the default directory, or those in all accessible directories if a redirection file is in use. If the listing exceeds one page, pages DI2, DI3.. give further information. An exercise (.ex) file can be selected for loading by moving the cursor to the file name and typing *Enter*.

2.10 PAGE H - Help

This displays an index of the pages available, and a description of the use of the control keys.

2.11 PAGE I - Instruments

This page displays the readings of the control levers and is mainly used with simulators with real instrumentation.

2.12 PAGE L - Calibration

This page is used for hardware configuration. See the hardware section for further details.

2.13 PAGE M - Manoeuvring characteristics of Own Ship

This page allows the manoeuvring characteristics of the Own Ship to be specified. There are several M pages defining ship characteristics. The active ship model is selected by the "Ship model number" on the S page.

There are two basic types of ship model available.
Small ship. Most of the detail of the model has been developed to simulate the behaviour of fishing vessels, but it can be used for most types of small ship up to a maximum Ship Mass of 3000 tonnes. A force balance approach is used. It is not recommended to use this model when

defining new ships to be used for radar exercises.

Coefficients. Ship behaviour is specified by coefficients such as maximum speed and turn rate, and acceleration time constants. This makes it very easy to get a desired manoeuvring capability. The mathematical model used is a simple one, but it is quite adequate for many situations. Wind and current still have an effect on ship behaviour, and limited shallow water effects are included.

2.13.1 Small Ship Model

Ship Mass is the ship's displacement and it affects acceleration and deceleration rates, and the drag characteristics of the vessel.

Ship Power is the shaft horse power expressed in kW.

Drag Factor is used to allow for effects of hull shape on ship drag. When mass and power have been set to their required values, adjust the drag factor to give a desired free steaming speed at full power. Typical values are 100 to 300.

Turn rate factor approximates to the maximum turn rate in degrees per minute when free steaming at full power.

2.13.2 Coefficient Ship Model

Ship Mass only affects the deceleration rate when turning and appearance of the ship as a radar target.

Acceleration time constant controls the rate at which ship speed increases when accelerating. In this time interval, the speed change is 62% of the change needed to reach the terminal speed.

Deceleration time constant works in a similar way when decelerating. It applies when the ship is not turning. When turning, response is usually more rapid because of the increased ship drag. The effect is most important for large ships which can be slowed down much more rapidly by turning than using engine power. The effect programmed increases with ship size and the value of "Speed reduction in turn". The effect for a 250000 tonne ship with 70% speed reduction is a time constant 40% of the "not turning" value.

Maximum turn rate is the final steady turn rate reached at maximum speed and maximum rudder. This rate may be exceeded during the early stages of a turn when ship speed will normally exceed the final turning speed.

Wind force factor allows the effect of wind on the ship to be varied. Use a high value for a ship that has a lot of superstructure out of the water such as a ferry. Use a low value for a ship that is mainly submerged such as a loaded tanker. 50% gives behaviour for an average ship.

Side slip factor controls the amount of side slip when the ship is turning. The effect of the factor is easily seen by comparing the value of *Course* (=course made good) and *Heading* on the S page when the ship is making a turn. A value of 0 gives no side slip. A value of 50% gives behaviour for an average ship, and typically causes Course to lag 20° behind Heading when the ship is turning at full rudder.

2.13.3 Factors Affecting Both Types of Ship Model

Delay at start of turn is the time delay before a change in rudder position affects ship manoeuvring. A suitable value is quite small for a small ship, but maybe up to 20s for a large ship. Note that there is an additional delay in response of the rudder to rudder demand. The rudder moves at a fixed rate of 3 deg/s with a slight slowdown the last 5 degrees.

Astern swing to starboard

When going astern the effect of transverse thrust usually causes the ship's head to swing to starboard. This effect is optional as ships with twin propellors, or a nozzle around the propellor do not show the effect.

Maximum Revolutions only affects the reading obtained on the engine or propellor revolutions meter.

Side thruster power

The side thrusters can be used to cause sideways movement of the ship and also for turning. The power of the thrusters can be controlled in the range 0 to 200 % where 100 is the standard figure. For situations where use of side thrusters is not appropriate, they can be disabled by entering power of 0.

Keel Depth affects the range of sonics return echoes, and the point at which a ship will go aground.

Radar Scanner

The height and the positions of 2 shadow sectors can be given. There is an alternative definition on the RA page.

2.13.4 Shallow Water Effects

2.13.4.1 Effects Observed in Reality

Shallow water effects come into play when water depth is less than twice the ship's normal keel depth. The main effects observed are:

A. **Squat**. This is the name given to an increase in keel depth. The cause of it is suction that develops when a liquid is forced through a narrow channel. A simplified expression for calculation is **Squat = $C_B * V^2$ / 100**

C_B	Block coefficient (0.6 to 0.9)
V	Ship speed in knot
Squat	Increase in keel depth in metre

B. Close to the bank of a channel, or close to another ship, the ship may be pulled sideways towards the bank or 2nd ship because of the effect of lateral suction. The amount of squat may also be increased.

C. An increase in water resistance giving a decrease in ship speed.

D. A reduction in effectiveness of the rudder, and possibly in the time taken for a change in rudder angle to give an effect.

E. A directional instability. The ship tends to veer off to one side.

2.13.4.2 Effects Simulated

A. Squat is calculated from the given equation. **Block coefficient** is an operator input. If the ship goes aground because of squat, the squat value is held fixed so that it remains aground until the instructor intervenes.

B. The effects mentioned above are not programmed because they are rather complex and not of much importance for a radar simulator that is mainly used in an open water situation.

C. **Speed reduction** gives the desired decrease in speed.

D. **Turn rate reduction** gives the desired decrease in rudder effectiveness.

E. **Turning instability factor** controls the effect programmed. The formulation is based on the idea that the effect is caused by water piling up on one side of the bow when the ship starts to side slip during a turn, and this causes the turn rate to increase. The effect observed for moderate values is that the ship will tend to veer off to one side. If it is under control of the autopilot, it will overswing. The effect observed for large values is that the ship will go round in circles, and the only way to bring it out of that behaviour is to reduce speed. The severity of the effect depends considerably on initial ship speed and "Speed reduction in turn". For a value of 60%, starting from full speed, a "Turning instability factor" of 50% to 70% will give the "moderate" response, and greater than 80% will give the "large" response.

The shallow water effects are only programmed for the Coefficient model.
Display squat on the O page can be used to show the effect of squat.

2.13.5 Predefined and User Definable Ship Models

The first 6 ship models on pages M1 to M6 are fully user definable in the normal way. There are a further 9 ship models on pages M7 to M15 that are predefined and are not saved as part of a saved exercise. The object is to make a range of fixed ship models available. If it is wished to use one of the fixed ship models, but change some of the characteristics, this can be done by copying the page to one of the pages M1 to M6 by entering a value for "Copy to Ship Model Number". The characteristics can then be changed and saved in the normal way. The predefined models are as follows:

Page	Name	Type of ship
M7	NEW GENERATION	A small cargo ship
M8	SALLY STAR	A medium sized cargo ship
M9	NORSEA	A large passenger and car ferry
M10	BERNICIA	A large oil tanker
M11	SCH123Z	A large tug
M12	ORSINO	A large trawler
M13	ZAIMA	A small trawler
M14	PURSER	A purse seine fishing boat
M15	EGMONDGRACHT	A Dutch medium sized cargo ship. A lot of details about the ship including manoeuvring behaviour and stability calculations are given in book "SCHEEPSGEGEVENS" by K. van Dokum (ISBN 90-70348-54-3) in a mixture of Dutch and English. A related book in the series is "OPGAVEN BELADINGSTECHNOLOGIE" (ISBN 90-70348-52-7) in Dutch only.

2.14 PAGE NE - Navaids Errors

2.14.1 GPS

Fixed errors are in minutes and are applied directly to the latitude longitude. Variable errors are given as '%', and the figure can vary from 0 to 200. Values up to 100 give the errors normally expected for the navigation method. Values above 100 give greater errors such as may be expected in adverse conditions, or when the signals are malfunctioning.

There are 2 sets of error figures. "GPS" controls the first NMEA0183 GLL message switched on by "GLL" on the L page. "GPS2" controls the GLL message switched on by "GL2" on the L page. The errors are only applied to NMEA0183 messages if "NMEA Lat Long Talker" (see below) is set to G (=GPS).

2.14.2 Disable Navigation Aids

The navigation aids can be individually disabled. The effect is that NMEA0183 messages that use that navigation aid as their talker ID are no longer transmitted.

2.14.3 NMEA0183 Messages

NMEA Lat Long Talker controls the NMEA talker ID (characters 2&3) in the NMEA0183 latitude longitude messages. The first value controls the message switched on by "GLL" on the L page, and **Secondary talker** controls the message switched on by "GL2". The option "Decca" is only retained to support older installations. Modern installations will probably want to switch both fields to GPS.

NMEA DTM Local datum and Reference datum

The DTM sentence gives datum offsets to be applied to NMEA positions. The following 3 character datum codes are listed, with the possibility of additional IHO codes for local datum.

W84	WGS84
W72	WGS72
S85	SGS85
P90	PE90
999	User defined (only valid as local datum)

The codes input on the NE page are not checked for validity except that if the field is blank W84 is used.

When DTM sentences are being transmitted, the offsets are those entered on the C page at "Offsets from WGS datum", and this is true whether or not the datum shifts are being applied. To test behaviour of a connected device when handling DTM sentences in a consistent manner, the following procedure is recommended:
Set NE page “NMEA Lat Long talker” to G, and the local and reference datum codes as desired.
Enter some datum shifts on the C page.
Set O page "Lat Long Posn Datum” to E.
Now, simulator positions shown on the Graphics Overview page and the text pages are on the “Local datum”. Positions in NMEA sentences are on the “Reference datum”. Note that for the present purposes, “WGS datum” on the C and O pages should be taken to mean “Reference datum”.

NMEA position errors

Errors are applied to NMEA0183 positions. They depend on the selected talker ID. In the case of the VTG sentence, the values of Speed and Course over the ground (SOG and COG)

include errors controlled by the *Variable error factor*, and there is a time lag after a change of course or speed. This time lag simulates behaviour of a device such as a GPS receiver that calculates SOG and COG from position measurements. The algorithm used is:
1) Convert the correct values of SOG and COG to x and y velocity components.
2) Add some errors to the velocity components based on the NE page Variable error factor to give "Adjusted velocity".
3) Update the present estimates of the x and y velocity components using formula:
New velocity = Old velocity + (Adjusted velocity - Old velocity) / time constant
This calculation is made once a s for x and y velocity components.
4) Convert the velocity components to the new estimate for SOG and COG.

Some users want the time lag to be controllable. This is arranged by entering a value for the time constant on the NE page. In Auto mode, a value dependent on navigation method and variable errors is calculated. In Kbd mode, the user can enter a value. Note that a time constant value of 1.0s or less causes an immediate move to "Adjusted velocity".

A display of NMEA0183 messages being output is made. The NMEA messages to be output are selected on the L page. See the hardware section for further details. If several serial ports are transmitting NMEA data, the display is for the highest port. Sentences which are being output at a high rate (faster than 1 Hz) are not displayed.

2.15 PAGE O - Options

This page allows some optional features of the simulation to be selected by the instructor.

2.15.1 Instruments and Navigation Page Options

Display squat causes the echo sounder history display to show by a yellow line what would have been the depth profile in the absence of the shallow water effects.

Max turn rate 120/240
This refers to the calibration on the Turn Rate meter (degree/minute). Normally use 2=240. 1=120 is available for slowly turning ships that need a very precise turn rate reading.

2.15.2 Graphics Overview Page Options
Various options control the information displayed on the Graphics Overview Page. The most commonly used options are also available directly on the Graphics Overview Page to allow picking with the mouse.

It is possible to enable or disable the numbering of items displayed. This allows selection between display of full information, or a less cluttered screen.

The length of ship vectors can be controlled, and true or relative vectors selected.

Target way points can be displayed on the screen. This is intended to allow checking of correct positioning during exercise preparation.

Auxiliary lines can be displayed. These are details such as traffic separation schemes which have been digitised as part of the radar land file.

If "Display seabed grid" is switched on, the grid squares are shown (including subdivided squares) if their size exceeds 40 pixel. Depth and roughness values are shown for each square displayed. Where the values are missing, the display should be expanded to see further detail. This display is most useful during seabed preparation.

"Contour density" gives an alternative method of viewing seabed detail. Contours can be drawn at 4 density levels, the depths contoured being:
Level 1: 0S, 10S, 50S, 100S, 200, 500S.
Level 2: 0S, 5, 10S, 20, 50S, 100S, 200S, 300S, 400, 500S, 600, 700,
800, 900.
Level 3: 0S, 2, 5, 10S, 20, 30, 40 50S, 60, 80, 100S, 150, 200S, 250,
300S, 400, 500S, 600, 700, 800, 900.
Level 4: 0S, 2, 5, 10S, 20, 30, 40, 50S, 60, 70, 80, 90, 100S,
120, 140, 160, 180, 200S, 220, 240, 260, 280, 300S, 350,
400S, 450, 500S, 600, 700, 800, 900.
S=solid line. Other lines are dotted.
Contour line 0 is drawn in green, 1 to 10 in light blue, and lines deeper than 10 in cyan.
The meaning of the value entered for "Contour density" is as follows.
1 to 4. The density level above is directly requested.
5 to 99. A density level is calculated depending on "Contour density" and scale of the screen. High values of contour density give a lot of detail, but the screen may be cluttered and screen redraw will be slow. If "Display seabed grid" is switched off, a selection of point depths taken from the seabed grid are displayed in cyan colour as well as the contours.

If a multi-seabed is in use, the outline of each seabed is drawn in brown. The contours extend over the whole of the seabed coverage. There will often be a discontinuity at seabed boundaries.

2.15.3 Seabed Outside Area
The depth and roughness of the seabed to be used outside the seabed grid can be given. If an exercise does not require a seabed that varies with position, the ship can be positioned outside of the seabed grid. It is then very easy to change the depth or roughness.

2.15.4 Latitude Longitude Position Datum Shifts
For accurate agreement between positions taken from charts and from other sources, it may be necessary to allow for the datum in use. This is especially the case with satellite derived positions from GPS navigators. GPS uses WGS datum. Some charts, especially older ones, use other datums. Large scale charts usually give a correction to be applied to GPS positions, for example: "Satellite derived positions should be moved 0.02 minutes SOUTHWARD and 0.10 minutes EASTWARD to agree with this chart". Typical values for the correction are up to 300m. For radar landmasses, the corrections can be included in the .lnd file by entering a 'G' line after the scale and origin values at the start of the file. The above example would give a G line: "G -0.02 0.10". See the program DIGIT documentation for further details. For other exercise data, the correction is given on the C page as an adjustment to be made to the Exercise Origin: "Offset from WGS datum". Again, the values to enter for the above example would be -0.02 0.10.

There are three ways that the datum shifts can be allowed for.
N = none. No datum shifts are made.

E = exercise. The "Exercise datum" as defined by "Offset from WGS datum" is used as the basis for simulator latitude longitude positions. If a different datum is used for the radar landmass, it is datum shifted. "Satellite derived" own ship positions transmitted by the simulator as "$GP" NMEA0183 sentences are first shifted to WGS datum. Other NMEA positions are not datum shifted.
W = WGS. Simulator positions are shifted to the WGS datum. This is done by making an internal adjustment to "Exercise Origin Lat Long" displayed on the C page. The result is that all latitude longitude positions are shifted to WGS datum with the exception of the Origin Lat Longs displayed on the C page. Positions displayed as "X Y m" and "X Y chart mm" are not affected.

If positions measured from a chart are input as Lat Long, be sure that position datum N or E is selected.

If the digitised coastline is in several files, a 'G' line is needed after each 'O' line in the .lnd files if datum shifting to a particular datum is required. If no 'G' line is present, it is assumed that the datum for the file is the same as "Exercise datum".

For datum shifts applied to received GLL positions, see section "External Control - Position datum".

2.15.5 Mercator Scale Factor

Positions displayed as "X Y m" are strictly speaking units of Mercator Northing and Easting. For exercise areas that extend a long way north or south of the exercise origin a significant error can result in calculated distances if the units are assumed to be metre. This option should normally be switched on, causing the errors to be corrected, but care should be taken with established exercises. For example, target ships positioned a long way north of the exercise origin will progress more rapidly through their way points if the option is switched on. (This option is forced on from 5/2005).

2.15.6 Auto clear Aground

The effect of this option is to force *Aground* to *off* if you go full astern, so you can escape from an aground situation without instructor intervention.

2.16 PAGE RA - Radar control

2.16.1 Radar Type - Radar Beam Characteristics

Various types of radar can be simulated by adjustments to the variables in the section *RADAR BEAM CHARACTERISTICS.* It is recommended to stick to the standard types which are requested by entering a value at *Load standard characteristics.* The standard types are:

R	A small radar using a radome
L	A low power radar using a normal antenna
M	A medium power radar. This radar gives behaviour similar to earlier software versions that did not allow full control of radar type.
H	A high power radar
S	An S band radar (All the above are X band)

When a type is selected, the variables below (Power, X or S band, and beam widths) are set to appropriate values. These values can also be individually controlled, but there is a danger of defining a radar that does not correspond with any existing real radar.

The variables on the next line are not directly controllable; they are calculated from the beam width figures and displayed for user information.
Antenna length shows the length that would normally be needed for the given horizontal beam width, allowance also being made for X or S band.
Gain. This figure is the ratio of (maximum radiated power density / power density that would result if the power applied to the antenna were spread evenly over the sphere) expressed in decibels. It is a measure of the directivity of the beam and the radiation efficiency of the antenna. It is calculated from the given beam widths, and adjusted to give values that give good agreement with radar manufacturer's figures. The main effect you will see is that the gain increases as the beam widths decrease because the power is packed into a smaller solid angle.
The gain figure has a direct effect on the strength of echoes seen on the radar.

2.16.2 Sea Clutter
In Auto mode the sea clutter level is automatically calculated from the Sea State Beaufort number on the S page. Values in the range 0 to 8 give the available range of clutter. In keyboard mode the clutter level is directly controlled by the instructor.

The direction of the sea is assumed to be that given as the wind direction, and the clutter shows directional variation with the most clutter in the wind direction. The magnitude of the effect is controlled by "Directivity". Clutter intensity also shows random variation.

The sea clutter decays away from its initial level at a fixed rate. For radar interface card versions up to 7, this rate is set by hardware and gives a maximum range of about 6 miles. For radar interface card versions 8 and above, the decay rate is programmable by giving the "Maximum sea clutter range".

2.16.3 Background Noise
Background noise can be controlled from either the RA page or the L page. The software uses the greater of the 2 values entered. If you want to use a fixed value, enter it on the L page, and use a value of 0 on the RA page. If you want it to vary from one exercise to another, enter values on the RA page for the different exercises, and use a value of 0 on the L page.

2.16.4 Interference
Mutual radar interference appears as spiral patterns crossing the screen. Values in 0 to 99 control the number of patterns generated. The radar "interference reject" control can be used to eliminate the effect. In reality interference signals would last for one radar pulse only. In the simulation, because of hardware limitations, they may last for several pulses depending on the PRF of the radar. As a result, the simulated interference is not so easily rejected as real interference.

2.16.5 Radar Characteristics
Scanner rotation period is variable between 0.9 and 3 s. The figure is used to calculate the frequency of the scanner azimuth waveform sent to the radar display unit.

Pulse length. In Auto mode the figure is as selected at the radar display unit and read from the radar interface. Keyboard control allows other values to be used. The calculated length of an echo from a small target will be greater than the pulse length because of effects of target length and pulse spreading.

Maximum radar range. This should normally be set to the maximum range of the radar in use. Smaller values may be used in appropriate exercise situations. They will allow the radar calculations to complete more rapidly giving better systems performance.

Calculation time per rev. This is the time taken by the computer to calculate the radar picture. It is used to assess systems performance. Figures up to 1.0s are normal. Larger values suggest low powered hardware or some type of calculation problem.

2.16.6 Target Characteristics

Land beam width factor

This factor allows the beam width effects applied to land echoes to be varied. These effects were introduced in 10/2004. The calculations require a lot of processing power, and may not work too well with a low powered processor, and / or with very complex land. The importance of beam width effects is that a wide beam radar gives a much less precise picture of the coastline, and, for example, it may only be possible to pick out a harbour entrance when quite close to it. The beam width factor is the percentage of the full horizontal beam width of the radar used in calculating these effects. The recommended value to use is:

100 Use this in normal circumstances.

0 Use this if the calculations appear to be adversely affecting performance (Calculation time per rev > 2s) or the land echoes look unrealistic. The beam width effects are not applied.

150 Use this to simulate a radar that radiates quite a lot of energy outside the main lobe. For example, S band radars are known to give poor performance in complex coastal situations. You can use a high value to show this effect.

Land fade factor controls fading of the land echoes in a similar way to the T page fade factor for a radar target. All land echoes fade to the same extent. See PAGE T for further details.

Minimum target fade factor is the minimum value of the fade factor to be used for targets other than land. It overrides lower values of the fade factor on the T, S and X pages. The object is to avoid the need to individually set the fade factor for every ship target and fixed target.

Side lobe factor

Side lobe echoes are false echoes seen in reality when there is a strong target at close range. There are 2 factors, one for normal echoes, and one for SART and Racon flashes. See sections RADAR SIMULATION - Side lobes, SARTS, Racons for details. Use a figure of 50% to get an effect typically seen in reality, or 0 to avoid any false echoes.

2.16.7 Scanner

The scanner height, position offset from ship centre, and the angular position of 2 shadow sectors can be given. Earlier software took this information from the M page. If the RA page scanner height is given as 0, then the M page figures are still used.

2.16.8 Failures

These allow three types of radar failure to be simulated.

A.	Video	All echoes are lost. Noise remains as normal.
B.	Heading Marker Trigger	Picture alignment may become incorrect.
C.	Scanner Rotation	Scanner rotation no longer seen.

A radar display unit will normally give some warning of the failure for (B) and (C). The exact effect depends on the type of radar.

2.16.9 Gyro bearing

For radars with stepper motor type gyro interface, it will normally be necessary to initialise the Gyro every time the simulation program is started. At other times (e.g. when loading a new exercise) the gyro should correct itself.

2.16.10 Control of Second Radar

On simulators that have two radars at the same ship station, the 2 radars work independently. Page RA2, and the 2nd set of values on the L page control the 2nd radar. You need to have kernel module radmod2 installed to drive the 2nd radar.

2.17 PAGE S - Own Ship

2.17.1 Ship Position, Speed, Course

Two displays are made of Own Ship position. Each can be switched to any of the five position methods available. "Speed" and "Course" give the ship velocity relative to the ground. "Speed relative water" and "Heading" are the values displayed on ship's instruments and the values that should be entered by the instructor to control the ship. Ship's transverse velocity and current velocity are taken into account when calculating the ground velocity from these figures. "Disable ship manoeuvring" allows the instructor to directly control the ship by entering speed and heading information.

2.17.2 Ship model number

This selects which of the 15 available ship models defined on pages M1..15 is to be used for the own ship.

2.17.3 Ambient Conditions

The information includes:

Seabed Depth and Roughness.	The values are computed by interpolation in the grid of seabed squares, or taken from the O page if outside the seabed grid.
Squat	The effect of squat on keel depth when shallow water effects are being applied.
Tidal Current	Speed (knot) and direction of the current vector.
Overall current	The total current calculated, including the W page effects.
Wind	Speed (knot) and direction (of origin) of the wind.
Sea state	The Beaufort number.
Tide height	Height above the depth datum. "Total" includes W page effects.

2.18 PAGE T - Target information

2.18.1 Target Definition, Manoeuvring and Control

Each page defines one target ship.
Displacement gives the size of the target. It decides the radar detection range, and the size and intensity of echo displayed. Targets with displacement 0 are considered to be inactive.

AI Page gives the AI page number on which data related to this target are found, first the

Position Report information, then the Ship Description information. If this is 0 it means none is defined and if you want to enter values, you need to find an AI page with an unused Ship Description.

Small target factor is used to calculate the reduction in echo strength for an S band radar and works the same as the X page value. A typical figure to use is 80% for a yacht or other small ship not made of steel that owes most of its echo strength to a radar reflector, and 0 in other cases.

Ship/Rain cloud/Turning Ship gives normal behaviour. Rain cloud converts the ship into a rain cloud. Turning gives a 2nd method of defining the ship track which is documented in the ARPA testing section.

Fade factor controls fading of the target. A value of 0 gives a steady echo intensity. A value of 99 causes it to fade completely, but it still moves along its track. A value of 98 is used when ARPA testing. Values from 1 to 97 cause the target's intensity to periodically decrease so that its detection may be intermittent. A value of 30 gives a degree of fading that might be typically seen in reality. Higher values model behaviour in adverse conditions. There is an override of the fade factor on the RA page that can be used if it is not wished to set a value for each individual target.

Target manoeuvring ability is defined by giving a turning radius and acceleration and deceleration rates. When a target reaches a way point it will alter at these rates until it is on course for the next way point and has reached the given speed. If the next way point lies inside the turning circle, or "Turning radius" is zero, the change of direction will be instantaneous.

Targets may be automatic, or under keyboard control. Direct instructor control of a target is selected by entering "Auto/Kbd K". The values of position, course and speed displayed on the next line can then be changed. They control the target, and way point information is ignored. If values are entered for "Speed" and "Course", changes are made instantly. If values are entered for "Aim speed, course" changes are made gradually at the rates specified for target manoeuvring.

When under keyboard control, maximum target speed is 600 knot instead of the normal 100 knot. This allows targets to work as helicopters and aircraft. Note that the CPA and TCPA readouts do not work for speeds over 100 knot and the display is supressed.

2.18.2 Automatic Targets

Automatic targets progress between way points. Each way point is defined by its start position, and the speed with which the target is to travel to the next way point. Each target has 9 way points. Way point position can be given as any of the normal positioning methods, and also by range and bearing from the previous way point. Each target has a start time. The target is inactive until this time is reached, and its present way point is displayed as 0. When its start time is reached, the target becomes active at the position of its first way point, and travels at the given speed towards the second way point position. It progresses from one way point to another until way point 9 is reached, and it then becomes inactive. Present way point can be changed at any time, for example if it is wished to miss out one of the way points.

Targets may have up to 3 start times. This allows a target to be re-used within an exercise if its path is simple, and only requires a few way points to define it, or if it needs to travel repeatedly along the same track. When the second or third start time is reached, a target will jump to the position of the way point given as "start way point", and will then progress through the way points as normal. If "start way point" is 0, the repeated start time is ignored. Each sequence of way points is called a "Batch".

It is possible for a target to repeat a track indefinitely. The track is defined by the 1st or 2nd batch of way points, and it finishes with a way point with speed 0.0. The next way point batch should be given with start time 0.00 and start way point 9. This causes the current batch to be repeated when it reaches the way point with speed of 0.0. If it is wished to avoid a sudden jump by the target, the last way point should have the same position as the first.

2.18.3 Rain Clouds
Targets can function as rain clouds which appear on the radar picture. This allows the path of a rain cloud to be controlled in the same way as a target ship. The size and intensity define the appearance of the rain cloud. The cloud may not give a satisfactory appearance through the full range of size and intensity values. Suitable values to start with are Size 3.0 nm, Intensity 30%. Rain clouds still need the displacement to be non-zero before they become active.

2.19 PAGE TF - Target Functions
This page allows some special target functions to be controlled.

2.19.1 Moving Target to Control Fixed Target Position
A fixed target can be caused to move, following the position of a moving target. The purpose of this is to allow a moving target to have characteristics normally reserved for a fixed target, such as ability to work as a SART or racon. It may be necessary to suppress the moving target echo by entering a fade factor of 99 so that the moving target echo does not interfere with the fixed target echo.

2.19.2 Moving Target to Control Own Ship Position
If this value is non-zero, the own ship's position, course and speed are copied from the given target ship. This allows the own ship to move along a programmed track in the same way as a target ship.

Target course and speed are ground relative, and they are copied to own ship ground course and speed. Own ship water speed and heading are calculated allowing for any current that may be acting. On the Graphics Overview page, own ship and target ship vectors are drawn on top of one another and appear green in colour. At exercise load time, the target ship’s fade factor is automatically set to 99 to cause its echo to disappear from the radar.

2.20 PAGE TS - Target summary

This page displays the target number, and its position, course and speed and the values of CPA, TCPA, BCR, BCT relative to the own ship. 15 targets are shown on a page allowing the instructor a good overview of the exercise situation. Course, speed and position may be changed by keyboard input if in keyboard control. Targets with non-zero displacements are marked with a "*" after the target number.
Targets are only displayed if they are active (displacement non-zero and either keyboard control, or current way point in range 1 to 8).

The figures for CPA (Closest Point of Approach), TCPA (Time to Closest Point of Approach), BCR (Bow Crossing Range) and BCT (Time to Bow Crossing) are based on speeds relative to the ground except that the "Bow" direction is the ship's head direction.

2.21 PAGE TX - Text

This page allows a text file related to the exercise to be displayed and edited. Typically, this can be used to give a description of the purpose of the exercise, and points for the instructor to note. Also, notes can be made as the exercise progresses about important events, and points to be made during de-briefing.

The text area occupies all the screen except the top 3 lines. To get into the text area type ***Tab*** and to get back to the screen top left, type *Esc*. The editing commands used in the text area are those used with the DOS EDIT program, except that only the "Cursor Movement" and "Editing Commands" are supported.

The text file has the same name as the exercise, and an extension .TX. It is automatically updated whenever new information is entered. When not running the simulator program, the file can be edited using any normal text editor.

2.22 PAGE V - Events

A record of the most important events of an exercise is maintained on this page. These may be: collision; near miss; ship aground; etc.. "Near miss" means that the separation between centres of own ship and target was less than twice that necessary to cause a collision. For each event, the time and ship position when it occurred are displayed. The information allows the instructor to quickly assess developments, and it gives the student a summary of his performance. If the number of events exceeds the space available then only the most recent events are displayed.

2.23 PAGE W - Water & Tide

2.23.1 Tide Effects

Effects of tidal currents and tide height that apply to all own ships are defined on this page. They are used together with the effects defined on the S page that apply to one own ship only. The current acting on an own ship is the sum of:

A. A current defined on the W page that varies sinusoidally over the tide period (assumed to be 12.5 hours). The state of tide is calculated from "Exercise Time" on the C page, and "Time of high water" on the W page. The given direction applies when the tide is rising.
B. A current defined on the W page that remains fixed.
C. A current defined on the S page that applies to one own ship only. It can be fixed or sinusoidal. If sinusoidal, it is calculated as (A).

The overall current (sum of above 3) is displayed on the S page.

It is possible to define an area where a different current acts. The purpose is to model situations where this is important in reality such as ships entering a harbour or a river mouth. The area is called the "**Current override box**". Its boundary is 4 straight lines, and it is defined by giving the positions of the 4 corners in clockwise order. The current acting within the box is defined as in (A) and (B) in the previous paragraph. To avoid a sudden transition at the box boundary, an "Interpolation width" can be defined. For positions inside the box and within this distance of the box boundary, the current velocity will be interpolated between the values inside and outside the box. A different wind also acts within the current override box. The current override box outline is shown as a dotted yellow line on the Graphics Overview page if "Display auxiliary lines" is switched on on the O page.

The tide height affecting an own ship is the sum of:

A. A tide height defined on the W page that varies sinusoidally over the tide period in the range "Tide Height Minimum" to "Tide Height Maximum".

B. A fixed height defined on the S page that applies to one own ship only.

The total tide height (sum of above 2) is displayed on the S page.

2.24 PAGE X - Fixed Targets

2.24.1 Fixed Target Definition

Fixed targets are used to represent buoys, racons and SARTs and small rocks. **Target height** and **Detection range** determine whether the target will be detected, and the echo intensity. Detection range is for the standard Medium power radar (RA page), and actual detection range will be different under other conditions. The **Fade factor** works the same for a fixed target as for a moving target. See PAGE T for details.

2.24.2 Racon and SART

Morse Ltr is the morse letter to be used for a racon. If a letter is given, the target will behave as a racon (except for racon letter '*', see below). If the letter is valid, the racon will flash the morse code of its letter approximately once a minute. Valid letters are all alphabetic characters and '9'. Other letters will give a single long flash. For a racon, "detection range" is the range for the buoy itself to give an echo. The range at which the racon flashes will be triggered is set to 10 miles for the standard medium power radar and is adjusted to allow for power and gain (as displayed on RA page) in other cases. The height given for a racon should be the height of the transponder above sea level.

If racon letter is given as '*', the fixed target behaves as a SART (Search and Rescue Transponder). When triggered by a radar pulse this type of transponder transmits a radar signal that cycles through the marine radar frequency band in a period of approximately 8 microseconds, repeated 12 times. The effect on the radar picture is a sequence of 12 pulses covering a range of about 7 miles. Gaps between pulses are about 3 times as long as the pulses. The first pulse starts a short distance behind the SART, the exact distance depending on the frequency of the receiving radar. The simulation of a SART differs from that of a racon in several respects beside the dot-dash pattern.

A. A SART gives a reponse to every radar pulse, so it appears continuously on the screen.

B. The detection range given for a SART (modified by radar type) is the range for the SART to be triggered. No flashes will be seen if the SART is beyond that range. A typical figure in reality is 8 nautical miles.

C. The SART itself is not programmed to give an echo. It will normally be attached to a life raft which will itself be a poor radar target. If an echo from the SART location is required, a second fixed target should be positioned there.

For further details see section RADAR SIMULATION - SARTs.

2.24.3 S band effects

Racon - S band capable racons are usually marked on a chart as "3 & 10cm". To enter this in the simulation, enter "S" in the column after *Racon Ltr*. Racons not so marked are probably not S band capable, and should be entered as a space in the column.
SART - S band capability is controlled as for a Racon. Sarts are not normally S band capable.
Small Target Factor - Small targets which owe most of their radar echo strength to a radar reflector give reduced radar echo strength at S band frequencies. Targets in this category are normally yachts and buoys. The Small Target Factor is the proportion of the X band echo strength considered to come from a radar reflector. For an S band radar, this part of the echo strength is reduced to 10% of its X band value.

2.24.4 Alternative Buoy Database

In normal operation, the X page buoy database is part of an exercise file. A disadvantage of this approach is that if the database for an area needs to be updated, it is necessary to make the updates to all exercises in that area, which may be a considerable number. An alternative method is therefore made available. The database is contained in a file with the same name as the land file (*Landmass Name* on the C page) with name extension .buy. At exercise load time, if the .buy file exists, any existing X page entries are deleted, and new values are read in from the .buy file. The .buy file is a text file, and contains comments explaining its structure. Program xtobuy is used to create a .buy file from an exercise file with X page entries. To update the database, there are 2 possible methods:
A) Load an exercise in the area of interest. Update the buoy details on the X page. Save the exercise. Run program xtobuy on the new exercise file.
B) Edit the .buy file. There are comments at the end of the file explaining its structure.
Once the .buy file is created, all exercises in that area will pick up the details from it. For further details see the xtobuy documentation in the Utility Progams section.

2.25 GRAPHICS OVERVIEW PAGE

The display shows the radar coastline and own and target ships with vectors and history dots. The colours used are:

own ships	yellow
target ships	light red, target position shown as '+'.
fixed targets	light red, target position shown as 'x'.
auxiliary lines	magenta
coastline	white
contours	green for depth 0, light blue for 1 to 10, cyan for more than 10
point depths	cyan for any depth
seabed grid	brown
latitude longitude grid	green

A display of text information and selectable options is made in the Control Box at the screen top left. Example:

52N37.53 Cursor latitude
2E12.43 Cursor longitude
2.74 035 Cursor position as range (nautical miles) and bearing from the own ship
<----|-----> Used to change scale of the screen
TRU (or REL) Type of vectors.
Contour 3 Contour density in 0 to 4.

Frz Int 2 — **Frz** (or Run) Freeze or Run. **Int 2** Replay interval (C page).

10:03:40 — Exercise time.

The last 2 lines are only displayed during a replay. The object is to make a replay fully controllable using the mouse during exercise debriefing.

Where selectable items are displayed, pick the text to change state, or change a value. To change a value, use the right mouse button to increase, and the left mouse button to decrease.

To move the display origin, drag the picture with the mouse.

Various details of the display can be controlled from the O page. During normal running of an exercise, the number and time interval for the history dots is controlled from the O page. During Replay, history dots are loaded at each recorded position up to a limit of 250 dots. In most cases this is sufficient to cover the whole exercise. Every 10th history dot is displayed with the own ship or target number and altered colour to assist in assessing previous exercise situations.

2.26 INSTRUCTOR'S RADAR DISPLAY

This display gives an approximation to the radar picture being output from the radar interface. Use the pick boxes to control the display. To offset the centre, use the cursor to mark a position within the radar circle, then pick the "Offset" box. Other functions should be obvious.

2.27 INSTRUMENTS AND NAVIGATION DISPLAY

2.27.1 Instruments

A selection of instruments are displayed as follows.

- Ship's head indicated numerically and by a pointer that rotates in a circle.
- Ship speed
- Turn rate calibrated in degree/min.
- Rudder demand and rudder angle (the centre bar is demand and the 2 outer bars actual value)
- Simple Autopilot
- Propellor revs calibrated as % of maximum value, demand and actual value.
- Under Keel Clearance, with echo sounder depth profile for the previous 15 minutes and depth alarm. Pick the + and - boxes to control the alarm depth. The alarm sounds if Under Keel Clearance becomes less than the alarm depth. When the ship is in shallow water and squat is being calculated, the instructor can switch on a display (as a yellow line) of the depth profile that would have been observed in the absence of squat.

The rudder, propellor revs, and autopilot boxes are used to control the own ship. See the next section.

3 CONTROL OF OWN SHIP

There are 4 possible methods of controlling the own ship. They are described in order of priority, lowest priority first.

3.1 Using the Instruments and Navigation Display

The rudder and engine can be directly controlled by picking the Rudder and Engine boxes using the mouse. The AUTOPILOT box allows a constant heading to be followed. Pick + or - to adjust the demanded heading, and the ON/OFF box to switch the autopilot on or off.

3.2 Using Control Levers for Engine and Rudder demand

Control levers connected as analogue inputs to the Analogue Digital I/O card are needed for this method to work. It replaces the screen picking method if the AD I/O interface card is detected, and *Enable Analogue Controls* is switched on on the L page, AD I/O section.

3.3 Following a Programmed Track

This is done by programming a target ship to follow the desired track, then connecting the own ship to the target ship on the TF page. For full details see PAGE T, and PAGE TF - Moving Target to Control Own Ship Position.

3.4 External Control

The own ship can be externally controlled. The necessary information is sent as NMEA0183 messages. This is usually required when the simulator is connected to an Integrated Navigation System.

3.4.1 Input NMEA Messages for Ship Control

The ship is controlled by NMEA messages received at the same COM ports as are used for NMEA output. The ports need to be enabled to receive data on the L page. The sentences accepted are GLL, VTG, VHW, HDT (or THS), ROT and ZDA. If a GLL sentence is received the program switches to External Control mode, and the exercise starts running (but see E below). If no GLL sentence is received for a period of 8s, the program switches out of External Control mode.

The following points should be noted about the message decoding:

A. GLL sentence. The latitude longitude should not be too far distant (less than 30 degree) from "Exercise Origin" given on the C page.

B. VHW and VTG sentences. Magnetic bearings are not supported. The program attempts to decode a speed in knot. If this fails it attempts to decode a speed in km/hr.

C. Values from a VTG sentence are loaded as the ground relative velocity displayed as "Speed", "Course" on the S page. Values from a VHW sentence are loaded as "Speed relative water" and "Heading". If VHW sentences are received without VTG, the ground relative velocities are calculated allowing for any current that may be acting, and assuming ship's water relative transverse velocity is zero. If VTG sentences are received, no attempt is made to calculate "Speed rel water" or "Heading". It is assumed these values are being sent as another NMEA sentence. If heading is sent by a HDT sentence, but no water relative speed is sent, the only error will be in the speed output as log pulses, NMEA VHW sentence, or speed meter reading.

D. In order to get smooth behaviour of ship heading, and especially if an ARPA radar is connected which gets its heading information from the source of the NMEA messages rather than direct from the simulator, then turn rate information is needed. If ROT sentences are received, they give the turn rate. If they are not, a turn rate estimate is made from HDT sentences. This is only likely to be accurate if the HDT heading has a reasonably high precision. If an accurate turn rate is not available, the heading will lag the source of the NMEA messages, and turning behaviour is likely to be erratic, but ship heading output by the simulator will still be consistent with radar echoes, and an ARPA radar should track correctly. Note that if HDT sentences are being received, the heading in a VHW sentence is ignored, but if they are not, the heading in the VHW sentence performs the same function as HDT. (In all cases, THS can be used as alternative to HDT).

E. ZDA sentences are optional. If they are received, then if ZDA time differs from rdtsim time by more than 30s, rdtsim time is set equal to ZDA time. If the time difference is less than 30s, then the run/freeze state is controlled according to whether rdtsim time is running behind ZDA time. The practical effect is that rdtsim time follows host time, with a time lag of 1 or 2s when exercise is running. If no ZDA sentences are received, the exercise runs continuously while in External Control mode. The main usefulness of controlling run/freeze is that if rdtsim target ships are being made use of, they will behave as intended when exercise is frozen at the host. However, if programmed targets have a delayed start time, they will only work correctly if host time starts off the same as rdtsim time, so it may be preferred not to send the ZDA sentence.

3.4.2 External Exercise Load

A special purpose NMEA sentence can be used to request loading of an exercise. The object is to allow a better level of automation when working in external control mode. Example:
$PEXLD,DOVER95

PEXLD	Proprietary exercise load request.
DOVER95	Name of the exercise to be loaded.

3.4.3 Input Raytheon Course Bus Messages for Ship Control

If a Raytheon Course Bus signal is available, it can be used for giving the heading information in external control mode. The Course Bus signal takes priority over NMEA, and heading and turn rate information in VHW, HDT and ROT sentences is ignored when a Course Bus signal is being received. Normally, NMEA sentences should be sent at the same time to give the position and velocity information. The simulation switches to External Control mode when a Course Bus signal is received, and switches back to normal when no signal is received for 2s. The COM port used for the Course Bus needs to have ***Rx Enable*** switched on on the L page.

3.4.4 Position Datum

It may be that the received GLL messages are also controlling other devices such as an ECDIS, and datum shifts are needed to get exercise data to line up exactly with the ECDIS. This can be done by entering the offsets on the C page as as "Offset from WGS datum", and enabling the shifting on the O page by entering "Lat Long Posn Datum W". If a different offset for the coastline is needed it must be entered in the .lnd file as a G line as explained in the O page documentation. No account is taken of the NMEA talker in deciding whether to apply the datum shifts.

The simulator works by shifting its coordinate system, so ship position latitude longitude will be the same as sent in the GLL message, but all other exercise data will be offset.

Although the documentation refers to "WGS datum", this can mean any datum for which offsets are given.

4 RADAR ECHO CONSTRUCTION

4.1 Radar Video Characteristics

There are 2 types of video. "Target video" is a D.C. signal. "Clutter video" comes from a noise generator. Simulation software uses clutter video for sea clutter and background noise, and target video for echoes from ship targets, fixed targets and coastline. Rain clutter echoes can be of either type depending on the version of the software in use. The software controls the amplitude of clutter and target video using 6 bit D to A converters that give 64 levels. (8 bit using 256 levels for the PCI bus interface).

4.2 Tuning

If the radar is out of tune, then all types of echo except noise, and SART and Racon flashes are shown with reduced intensity. SART and Racon flashes are not affected by tuning because they span the whole marine radar frequency band.

4.3 Bandwidth

The bandwidth of a radar receiver is automatically varied with pulse length so as to reduce noise without seriously affecting echo signals. In the simulation, the radar bandwidth is calculated from formula:

bandwidth = 5.6 /(pulse length + 0.20) pulse length in μs, bandwidth in MHz

This formula gives results which are typical for real radars, for example:

- pulse length = Short = 0.08μs, bandwidth = 20MHz
- pulse length = Long = 1.2μs, bandwidth= 4 MHz

The whole marine radar X band spans 180MHz (9320 to 9500MHz).
The effects of bandwidth that are simulated relate to SARTs and Racons and are explained in the following sections.

4.4 Ship Targets

The target is considered to be a rectangle of

length = 6 * cube root(T page displacement) [m]

length to breadth ratio = 3 + length/30 (max 10).

anginc is the angle of incidence of the radar beam with the longer side of the rectangle.
The echo constructed consists of a hexagon defined by:
A) 2 lines distant (1/2 beam width) * cos(anginc) from the sides of the rectangle.
B) 2 lines of constant range extending 1/2 beam width either side of the nearest and furthest point of the rectangle.
C) 2 lines parallel to the ends of the rectangle and distant (1/2 beam width) * sin(anginc) from them In addition, the pulse length is added to all echoes.

If the pulse length effect is neglected, the centre point of the echo is the same as the position of the target as it appears on simulator screen readouts. If the pulse length effect is allowed for, the centre point of the echo is displaced half a pulse length away from own ship.

The target drawing algorithm was changed in early 2005. The main changes seen with the new algorithm are:

- The old algorithm drew distant targets as rectangular blocks, with a changeover to an aspected shape at closer range. This changeover is no longer seen.
- The old algorithm made a leading edge echo. The new one draws an echo that covers the whole of the target. The difference is most evident when a large ship is in an “end on” situation.

4.5 Fixed Targets

Fixed targets are used to represent small objects such as buoys. The range across the echo is constant, and their size is considered small compared to radar beam width. At ranges greater than 2 miles, echo width is equal to radar beam width. At ranges less than 2 miles echo width is increased to simulate side lobe effects. The effect increases up to a maximum width of twice radar beam width for targets closer than 0.5 mile.

4.6 Side lobe echoes

For normal echoes, these are controlled by RA page *Side lobe factor: Normal*. In reality, the strongest side lobe echoes appear as two echoes either side of the normal main lobe echo offset at the angle of the strongest side lobe. This angle may typically be 60 to 90 degrees. For particularly strong targets, a weaker side lobe echo may extend in a circular arc linking these two echoes and the main lobe echo.

In the simulation the strongest side lobe echoes are at 80 degrees either side of the main lobe. Moving targets ships, own ships, fixed targets and parts of the landmass defined as points may give side lobe echoes. In the case of a target ship that is drawn with an aspected shape, the position of the main lobe echo is taken to be the position of the nearest part of the target ship, and no attempt is made to reproduce the aspected shape in the side lobe echoes. Side lobe factor of 50% gives side lobe strength of a level typically seen in reality, but many modern radars, especially those with long antennas, have quite weak side lobes.

4.7 SARTs

See ANNEX 1 for information published by IMO about behaviour of a SART. The simulation is largely based on this. Note that it is unclear what is the basis for the statement in this annex that “the total displayed length of a SART extends 9.5 miles beyond the SART position” as the figure calculated from other details given is about 7.5 miles.

SART flashes

Slow sweep flash	Flash period is 7.9μs, 0.64 nm. Flash length is calculated from the total width of the marine radar band of 180MHz, and allowing for an effective bandwidth a little more than calculated from the formula given above in *Bandwidth* (dependent on pulse length).
Fast sweep flash	This is detected if the SART is within 1 mile and pulse length is S or M1. For pulse length M1, the flash is quite weak because it is a lot shorter than 1/bandwidth.

Side lobe effects

These are controlled by the RA page *Side lobe factor: SART/Racon.* The effects are an extension of the side lobe effects for normal targets described above.

For a typical SART side lobe factor of 50% the effects are:

- At ranges< about 1 mile, 2 side lobe echoes 80 degree either side of the main echo start to appear. This simulates a radar having the strongest side lobes in these directions.

- At ranges < about 0.5 mile, a circular arc links the side lobes to the main lobe.
- At ranges a little less, an arc completing the circle appears.

4.8 Racons

When triggered by a radar pulse, a racon responds with a morse code radar transmission. The frequency is slowly varied so that the whole of the marine radar frequency band is covered in a period of about 1 minute. A receiving radar only detects the signal for a period of a few seconds when the racon frequency is close to the radar receiving frequency.

In the simulation, a racon flashes the dot dash pattern of its morse code every 64s. Dot length is 0.15 mile, dash length 0.60 mile, and gap length 0.20 mile. Undefined morse letters give a single long flash of length 1.50 mile. The time a flash persists is dependent on bandwidth. Under normal circumstances the result is:

Pulse length	Scanner revs. a flash persists for
L	1
M2	1 or 2
M1	2
S	4

Side lobe effects work similar to a SART.

4.9 Sea Clutter

The initial value of sea clutter close to Own Ship is calculated from:

- The value displayed on the RA page, with allowance for directivity. (See PAGE RA).
- Power and Gain as displayed on the RA page. High values give increased clutter, but, other things being equal, do not change the target detection capability because target and clutter intensity change by the same amount.
- The horizontal beam width. A narrow beam gives reduced clutter. This interacts with Gain, so the effect may not be evident, but a narrow beam does give better detection capability for a target masked by clutter.
- The pulse length. A short pulse gives reduced clutter and better target detection.
- X or S band. An S band radar is programmed to give reduced initial clutter, and a faster decay rate compared to an X band radar. (The formula used is -7 - 2*range in km (dB)). An S band radar gives considerably better detection capability for a target masked by sea clutter except in the case of a target with a large Small Target factor (echo strength mainly due to a radar reflector). In that case, detection capability is slightly improved.

Echoes are loaded to the interface card, starting at the initial level and decreasing in steps of 1/32 of the total amplitude range until the background noise level is reached. The echo range increase for each step is 1/32 of the RA page value of "Maximum sea clutter range". A non-linear ramp could easily be programmed as an alternative to this linear ramp.

4.10 Rain Clouds

Considering a single radar transmission, the echo of a rain cloud consists of 3 parts, rising part, flat part, and falling part.

```
                 ______________________________ max intensity
                /                              \
intensity      /                                \
              /                                  \
             /                                    \
            /                                      \
______/ start intensity                             \__________
                                                          range
   rising           flat                      falling
   part             part                      part
```

Max intensity is calculated from rain cloud intensity with range decay. Start intensity is a fixed number of units below max intensity. If the echo is too short for the full rising and falling parts to be made, the normal start intensity is used and max intensity will be reduced.

During the rising and falling parts, echo intensity changes at a rate of 1 step every 18m (total of 63 steps available). Some versions of the software apply an intensity decrease during "flat part" to simulate masking effects of the clutter. The rate of decrease is dependent on clutter intensity. Some versions of the software use clutter video for rain clouds, and some use target video. The advantage of using clutter video is that appearance is better when the rain clutter control is not used. The advantage of using target video is that the effect of the rain clutter control is more realistic. (The rain clutter control has little effect on clutter video). The version of software in use at January 2006 uses a mixture of target and clutter video for rain clouds, and does not apply an intensity decrease to the flat part of the clutter.

The shape of a rain cloud in the horizontal plane is predefined by a random number sequence. It depends on the target number allocated as a rain cloud, and it varies slowly with time. For an S band radar, the rain cloud intensity is reduced to 10% of its X band value. (Rain clouds have much reduced target strength at S band frequencies).

4.11 Shadowing Effects

4.11.1 Over Horizon Effects

The range of the sea horizon is calculated using an earth diameter of 17000km (4/3 its true value) to allow for refraction of the radar beam. The echo intensity is reduced for targets which are partially lost over the horizon. In calculating the reduction, ships and point targets are assumed to be of triangular shape, base down. Land lines are assumed to be rectangular.

4.11.2 Above and Below Beam

For a low target close to Own Ship (normally a buoy), a test is made to see if it lies below the beam taking into account scanner height (M page), height of target and beam bottom angle (RA page). For moving targets, a similar test is made for a target above the beam taking into account its altitude (T page).

4.11.3 Ship Targets

The height figure used when testing for detectability of a ship target is the height of masts and superstructure that will give a radar echo. When calculating the shadowing effect on more distant echoes, a "shadowing height" figure reduced to 44% of "detectable height" is used because much of the superstructure does not obstruct the radar beam.

4.11.4 Racons and SARTs

An echo is calculated for the source of a racon or SART. Even if it is not detectable, it is processed as far as the shadowing calculations. In the shadowing calculations, shadowing of this echo decides whether the racon or SART flashes will be displayed.

4.11.5 Rain Clouds

A rain cloud causes more distant echoes to show a reduction in intensity. They will disappear if the intensity reduction is sufficient. The reduction in intensity depends on the rain cloud intensity, and the distance the radar beam travels through it on its path to the target. For an S band radar, the shadowing effect is reduced by the same amount as the echo intensity.

4.12 Model of the Radar Antenna and Radar Wave for Received Echo Strength

The calculation of received echo strength is based on the radar equation:

$$P_r = \text{Constant} * P_t\, G_t\, \sigma\, A_e / R^4$$

P_t — Transmit power — This is the figure entered on the RA page

G_t — Gain — The effect of directivity (beam widths) and radiation efficiency as displayed on the RA page.

σ — Target cross section. This is calculated from ship size for a target ship, detection range for a fixed target, and intensity given in the land file for part of the land. If target size is greater than the horizontal beam width, σ increases with the beam width so that the spreading losses ($1/R^4$) effectively become ($1/R^3$).

A_e — Effective antenna aperture area. When the same antenna is used for receiving and transmitting, this is related to G_t by the formula $G_t = \text{constant} * A_e / \lambda^2$ where λ=wavelength of radar wave. The reason for this is that the beam width figures that decide the value of G_t depend on the antenna dimensions in numbers of wavelengths. The dependence on λ becomes significant when comparing X and S band radars. The S band radar gives a P_r value approximately 10 times bigger than an X band radar having the same beam widths. This corresponds with the greater size of an S band antenna.

R — Target range

P_r — Received power.

4.13 Model of Electronic Processing in the Scanner

In the scanner, the received signal is reduced in frequency to the intermediate frequency, amplified and processed electronically, then converted to the DC video signal for transmission to the display unit. The object of the simulation is to generate the DC video signal. The problem in doing it is to model behaviour of the intermediate frequency amplifier. All radar manufacturers describe this amplifier as having a logarithmic characteristic, but the exact gain function is unknown, and reports suggest it varies considerably from one manufacturer to another. The calculations for received power are made in logarithmic units (dB). At 6/2/2004 the result of the calculations is scaled so that the voltage range of the video output from the radar interface card represents 48 dB of received power.

5 ARPA TESTING

5.1 SUMMARY OF FEATURES

There are special features which assist in assessing the target tracking performance of a connected ARPA radar. These features are divided into 4 categories:

A. The accuracy of target ship echo positions is improved compared to normal training simulators.

B. There is an additional method of programming the own ship track to allow precise turning behaviour to be simulated.

C. Errors can be introduced, simulating those which occur in reality.

D. It is possible to record relevant target data. If the ARPA is capable of transmitting $__TTM or !__TTD sentences, these can be received and recorded along with the "correct" results calculated by the simulator.

Where screen and keyboard control is needed, the AT page is used.

5.2 ACCURACY IMPROVEMENTS

5.2.1 Bearing Resolution

The radar echoes output in response to a transmit trigger are generated by interface card hardware. The hardware works by clocking through echoes contained in a RAM. The RAM is periodically filled up with new echoes by writing to it from the computer bus. The period used decides the bearing resolution. The "echo reload rate" used for rdtsim is 2048 per rev. (1024 is used for normal simulators) giving a bearing resolution of 0.176 degree. At long radar ranges and/or fast scanner rotation rates, it is likely that the Pulse Repetition Frequency of the radar will be less than the echo reload rate, so the bearing resolution will not be fully effective.

5.2.2 Target Echo Position Correction

A possible source of target position errors is the time difference between "position calculation" time and "echo output" time. At high ship speed, the errors could be substantial. These errors are corrected by projecting forward Target Ships and Own Ship along their tracks to allow for the time difference.

5.3 SHIP TRACK

Some of the tests required for the ARPA tracking scenarios require the own ship to turn while stationary, or to turn through a given angle at a precise high turn rate. These scenarios cannot be accurately produced using the normal method of defining the track by way points positions, so a second method of defining way points is provided.

The own ship is connected to a target ship in the normal way on the TF page by “Moving target to control own ship position”. On the T page, at “Ship/Rain cloud/Turning”, Turning should be selected. This enables an alternative method of defining the way points. Each way point is defined by time, speed rate, turn rate, course and speed. When the time of the way point is reached, the ship alters to the given course and speed. It turns at the rate given as the way point “Turn rate”, and speed change is done at the rate given as “Spd rate”. The normal method of defining start times and manoeuvring behaviour by “Turning radius”, Acceleration rate”, “Start time” etc. have no effect. Remember also that when a target ship controls the own ship, “Displacement” should be non-zero to activate the target, and “Fade factor” should be 99 to disable the target ship radar echo.

When the own ship is connected to a target using this method of giving the way points, the own ship continues with constant speed and heading until the time of the first way point is reached. Own ship position, course and speed are then copied to the target, and the target (and own ship) is controlled by the way points. The target does not progress past a way point that involves a backward time step.

Note the following points about turning behaviour:

- To turn to port, enter a negative turn rate.
- The L page item “Max gyro turn rate” still limits Own Ship turn rate, so a value larger than any turn rate to be tested should be used.

If it is wished to define a target ship track in this manner without connecting the own ship to it, then the desired starting position, course and speed should be input by switching to keyboard mode, entering the values, then switching back to auto mode.

5.4 ERRORS

The simulation of errors is intended to allow the error sources described in IEC 872 appendix B to be simulated. The errors are controlled by the lower part of the AT page.

5.4.1 Miss Pattern

This allows intermittent detection of a target to be simulated in a predictable manner. It is handled as a special case of the Fade Factor.

If the T or X page Fade Factor is given as 98, fading is controlled by the "Miss Pattern" on the AT page. This is a 15 character text string, and it controls the echo strength over a sequence of consecutive paints. Scanning starts at the beginning of the string, and each character controls the echo strength for one paint with the following significance:

0 Miss
9 Normal strength paint
1..8 Reduced strength paint
R Return to start of sequence
Any other character, same as R

5.4.2 Radar Errors

The following error sources are allowed for. (Ref. IEC 872 appendix B and IEC62388 Annex E).

A) Target glint

The position of the target is moved forwards or backwards along its track a distance normally distributed with this standard deviation. A typical figure for a 200m long ship is given as 30m. This error is not applied to fixed targets. This error should probably vary with ship size, and a suitable formula is awaited.

B) Roll-pitch bearing error
This error is calculated from the following formula derived from the geometry of the situation, and assuming the roll angle is much greater than the pitch angle:
Measured bearing = arctan (tan (actual bearing) * cos(roll angle))
(bearings relative to ship's head)
This formula is used to calculate the error at maximum roll angle, and the error is then varied periodically in the range 0..maximum as a Sine wave of period half the given roll angle period. The error is maximum at relative bearings 45, 135, 225, 315 and zero at relative bearings 0, 90, 180, 270. The error always moves the target nearer to the fore-aft line. Some randomisation is made to rate of progress along the sine wave. The factor "cos(roll angle) modified by sine wave" is calculated once for every scanner revolution, and the same value applied to all targets.

C) Any other range error with normal distribution
IEC 872 gives pulse shape as one source with standard deviation 20m.

D) Any other range error with rectangular distribution

E) Any other bearing error with normal distribution
IEC 872 gives beam shape as a source with standard deviation 0.05 degree.

F) Any other bearing error with rectangular distribution
IEC 872 gives antenna backlash as a source with + or - 0.05 degree amplitude.

Range errors from sources A,C,D and bearing errors from A,B,E,F are added arithmetically to give combined errors. It is allowed to limit the combined errors to maximum values. A maximum value given as 0 means do not apply any limit.

When the range and bearing errors are applied to calculated values, range error is rounded to units of the range resolution (6m) before adding it to the calculated range. Bearing error is added to the calculated bearing before rounding to the bearing resolution.

5.4.3 Radar Error Checking
A display of the errors calculated for target ship 1 (T1) is made. The object is to allow checking that the error calculations appear correct.

5.4.4 The Heading Alignment Problem
Keeping radar echo bearings correct relative to ship's head to a high degree of accuracy is quite a difficult problem, especially when Own Ship is turning.

There are 2 timing processes involved in simulating the scanner. Both of them are controlled by timers on the interface card that divide down a frequency of 4MHz by a 16 bit number (the time constant) and generate an interrupt when the zero count is reached. (The divided frequency is actually 2MHz for a timer with square wave output such as the azimuth waveform timer).
A) The azimuth waveform. This is a square wave output that the radar display unit uses to determine the scanner direction. It is also used internally in the simulator calculations to control the heading marker signal and the shadow sectors.
B) The echo reload timer. This is set to generate an interrupt when the next bearing element

is due to be loaded to the interface hardware.
The azimuth pulses are output at a fixed rate dependent on the "Scanner rotation period" set on the RA page. If the own ship is not turning the echo reload timer also runs at a fixed rate. If the ship is turning, it is necessary to recalculate the time constant to compensate for the turn rate, and quite complex calculations are needed. Errors inevitably develop in the calculations because of roundoff calculating the time constants.

When the azimuth waveform shows that the ship's head direction has been reached, the "gyro heading" (ship's head direction relative North calculated in gyro steps of 1/6 degree) is compared with the echo count of the echo reload timer (in units of the bearing resolution of 0.176 degree). The difference is the "heading error". The echo reload timer time constant is recalculated once a second after making the ship manoeuvring calculations. If there is any heading error, the calculations are adjusted to correct the error in the following second.

A display is made on the AT page of the **Heading error**. Experience shows that errors up to + or 0.1 degree are normal (or rather more for fast scanner rotation). Values much higher than this indicate some malfunction of simulator software and simulator performance should not be considered reliable.

If the ship is working in External Control mode, it is likely that *Heading error* will be increased because heading updates are not synchronised with other calculations, and an accurate turn rate may not be available.

Another possible source of errors in keeping radar direction properly aligned is interrupt latency problems. If an interrupt request from a timer is not serviced before the next interrupt condition arises, a “Timer overrun” occurs, and performance will be degraded. A display is made of the count of **Timer overruns.** Normal behaviour is for a few timer overruns at program startup, or when loading an exercise. If the count is seen to increase during normal operation, there is some systems problem. One possible cause is a problem with PS/2 mice used with certain motherboards. See kernel module testllat documented at the end of this documentation. The actual timer interrupt rate is 2048 per rev. for the echo reload timer and *Azimuth pulses per rev* (L page) for the 1st radar for the azimuth waveform generator.

5.4.5 Log and Gyro Errors

These figures are entered at the bottom of the AT page.

Log Error The given figures are added to ship's actual speed every second when the log pulse rate is recalculated. For the random part, a new random number is calculated every time a log pulse is output. The errors also affect water relative ship speed in NMEA sentences.

Gyro Error For the variable part, a normally distributed random number is calculated, and gyro rate is adjusted to reach this error after a time interval given by *Interval*. The process then repeats. The error affects serial message headings as well as gyro steps. IEC 872 recommends a value of 0.12 degree standard deviation for gyro variable error. It is unclear whether the turn rate in serial data turn rate messages should best include the effect of the gyro rate adjustment, but the present software does not include the effect. Note that *Heading error* displayed on the AT page has an effect similar to gyro variable error. The overall effect on radar echo alignment is the sum of the two.

5.5 DATA RECORDING

Data recording is controlled by the **LOG RADAR DATA** section at the top of the AT page.

5.5.1 Log File

The data are recorded in a "Log File". The Log File name can be entered. Name extension is .log. The file can be opened in Open or Append mode. In Open mode, a new file is created. If the file already exists, one backup is maintained with name extension .lbk. In Append mode, data is written to the end of an existing file, or a new file is created if none exists. No backup is maintained. The .log files are written to the first directory on the redirection list. Exercise time is written to the file along with any other data.

5.5.2 Received TTM Sentences

NMEA sentences are received at ports assigned as NMEA ports on the L page (Function N or F), and which are enabled for receiving data (Enable Rx = Y). $__TTM and !__TTD sentences are marked "P1", "P2", "P3" or "P4" to show which port they were received at. This allows details from different connected radars to be distinguished. Received $__TTM sentences can be written to the file. An attempt is made to match each sentence to a target for which radar echoes are being generated. If a match is found, a 2nd TTM sentence is written giving the details for the matched target. The NMEA talker for this sentence is "BF" (=Best Fit).

The last 4 received TTM sentences are displayed at the bottom of the TS page to allow comparison with target data information.

5.5.3 TTD Sentences - Structure

The TTD sentence (!__TTD) contains tracked target information in a compressed form. Each sentence can contain data for a maximum of 4 targets. The structure of the sentence is:

!--TTD,hh,hh,x,s---s,x*hh<CR><LF>

1st hh	Total hex number of sentences needed to transfer the message	1..FF (not null)
2nd hh	Hex sentence number 1..FF (not null)	
1st x	Sequential message identifier 0..9 counting up + repeating, same for all sentences in a batch. Null if only 1 sentence.	A batch would normally mean all tracked targets.
s--s	encapsulated data. 1..4 structures of 15 char each	
2nd x	Number of fill bits 0..5 (must be 0 for this structure)	

s--s	Number of bits	Range + Resolution	Description
Protocol version	2	0..3	always 0 for this version
Target number	10	0..1023	0 = reserved for no tracking target
True bearing	12	0..359.9 deg	North up, 409.5 = Invalid or N/A data
Speed	12	0..409.4 knot	409.5 = Invalid or N/A data (See speed mode and stabilisation mode)
Course	12	0..359.9 deg	409.5 = Invalid or N/A data (See speed mode and stabilisation mode)
Heading (AIS)	12	0..359.9 deg	North up, Reported heading from AIS, 409.4 = Invalid or N/A data 409.5 = Radar targ
Tracked/AIS target status	3	Value	Radar / AIS
		000	Non-tracking / No target to report

		001	Acquiring targ	Sleeping targ
		010	Lost target	Lost target
		011	Reserved	Reserved
		100	Established tracking	Activated target (no alarm)
		101	Reserved	
		110	Established tracking, CPA/TCPA alarm	
		111	Established tracking, CPA/TCPA alarm acknowledged	
Operation mode	1	0=autonomous (normal) 1= test target		
Distance	14	0..163.82 nm	Distance to target 163.83 = Invalid or N/A data	
Speed mode	1	0= true speed & course, 1=relative		
Stabilisation mode	1	0= over ground, 1=through water		
Reserved	2	RSFU, set to 0		
Correlation/ Association number	8	0..255	0=reserved for no correlation/association correlated/associated targets are assigned a common number	

5.5.4 Received TTD Sentences - Implementation

The sentences are decoded and each target is handled in a similar manner to a TTM sentence. If data are being recorded, the following are written to the log file.

- The !__TTD sentence.
- For each target contained in the sentence, the important target data written in a format similar to an NMEA sentence. Example:
  $__TTD,7,2374,117,3208,4,0,813,0,1,0

7	Target reference number
2374	Target true bearing is 237.4 degree
117	Target speed is 11.7 knot
3208	Target course is 320.8 degree
4	Target status (see above)
0	Operation mode (0 = normal, 1 = test target)
813	Target range is 8.13 nautical mile
0	Speed mode (0=true, 1 = relative)
1	Stabilisation mode (0=over ground, 1=through water)
0	Correlation / Association number

- If the target is matched, a $BFTTM sentence, as for Received TTM Sentences.

The constructed $__TTD sentences are also displayed at the bottom of the TS page.

5.5.5 Record calculated errors

Some users want to record the errors in target positions to help in assessing the tracking performance of a connected ARPA. If this option is switched on, the calculated errors are written to the log file in sentences such as:

$PTERR,4,11,28.3,-29,0.13,9

PTERR	=Proprietary target error
4	Reference number for this target coming from the radar in the TTM sentence
11	Target number in the simulation. 1..100 are moving targets defined on pages T1..100. 101..600 are fixed targets numbers 1..500
28.3	[seconds] when the target paint was made. This figure may not be exactly

	correct, but should be accurate within + or - 0.2
-29	Range error applied to the target paint [m]. Note that this gets rounded towards 0 by the range resolution (6m) before output through the hardware.
0.13	Bearing error applied to the target paint [degree]. Note that the "heading error" is not taken into account.
9	Echo strength. 9 = full strength. Other values occur only when a Miss pattern is being applied via Fade factor 98. They are the Miss pattern values on the AT page.

Targets are selected for error logging if it appears they are being tracked by a connected ARPA radar. The ARPA has to be sending $__TTM sentences (or !__TTD sentences) which are being matched to a target.

5.5.6 Ship Data

Own ship and Target ship data can be written to the .log file, either as a single event (by entering Dump Y/N Y), or repeatedly at a given time interval (by entering the "Auto time interval"). The Own ship data written is:

- True Heading and Speed (the S page values "Speed relative water" and Heading)
- False Heading and speed (the same with the AT page "Calc Error" Log and Gyro added)
- Course over ground and Speed over ground (as displayed at "Speed Course" on the S page.)

The Target ship data is Range, Bearing, Course, Speed, CPA, TCPA and it is written as a TTM sentence, with an NMEA talker "TD" (=Target Data). A sentence is written for each moving target and fixed target for which radar echoes are being generated. (The tests do not take into account shadowing of a target by another target or by a shadow sector.) Parts of the land are not identified as "targets" and should not be used for Arpa acquisition.

5.5.7 Text

"Text:" is a line of text up to 70 characters long to be entered into the log file. After entering the text by typing "return", the text is written to the file, then cleared from the screen. Typically, this can be used to keep a record of the start point of a test, or the point where some change was made in the testing conditions.

5.6 The High Speed Craft Scenarios

These reproduce the tests specified by Annex D of IEC 872. They are normally supplied in directory HSC.

The pulse repetition frequency of 750 Hz needs to be set on the L page as the value that takes effect at 12 mile range. This only works for radars that use a trigger external to the display unit. The other radar parameters (3° beam width, 1μs pulse length and 40 rpm antenna rotation rate) are set as part of the exercise.

The scenarios are named as follows:

HSC1A	Scenario 1, turning to starboard
HSC1B`	Scenario 1, turning to port
HSC2A	Scenario 2, turning to starboard

HSC2B   Scenario 2, turning to port
HSC3   Scenario 3
HSC4   Scenario 4

For the first 4 scenarios, the own ship turning manoeuvre is programmed to start 3 minutes after the start time so as to allow time to acquire the targets and track them for "at least 2 minutes before own ship executes a turn".

Each exercise (scenario) includes descriptive information on the TX page.

5.7 The IEC62388 Scenarios

These reproduce the tests specified by IEC62388. They are normally supplied in directory SCEN.

SCEN??? The target tracking scenarios defined in section 10.3.14.
ASSOC? The association scenarios (association of radar tracked targets with AIS targets) defined in section 10.8.2. These scenarios need rdtsim.exe 2007-6-27 or later to work properly because they need the automatic calculation of reporting interval for AIS position messages. For further details, see the TX page for each scenario.

SCEN1   Scenario 1
SCEN2A   Scenario 2, Standard vessel, turning to starboard
SCEN2B   Scenario 2, Standard vessel, turning to port
SCEN2AH   Scenario 2, High Speed Craft, turning to starboard
SCEN2BH   Scenario 2, High Speed Craft, turning to port
SCEN3A   Scenario 3, Standard vessel, turning to starboard
SCEN3B   Scenario 3, Standard vessel, turning to port
SCEN3AH   Scenario 3, High Speed Craft, turning to starboard
SCEN3BH   Scenario 3, High Speed Craft, turning to port
SCEN4   Scenario 4, Standard vessel
SCEN4H   Scenario 4, High Speed Craft
SCEN5   Scenario 5, Standard vessel
SCEN5H   Scenario 5, High Speed Craft
SCEN6   the scenario described in 10.3.15.1 for checking range and bearing of tracked targets.
ASSOC1 Association scenario 1
ASSOC2 Association scenario 2
ASSOC3 Association scenario 3
ASSOC4 Association scenario 4

5.7.1 The "10dB" scenario

There is another scenario described in Paragraph 10.3.14.9. The situation is the same as scenario 5, but target echoes to be 10 dB above peak noise level. There are some problems in implementing this scenario, and a standard scenario cannot be defined because it depends on the setting up of the radar interface card. To carry out this scenario as nearly as possible, the following procedure is recommended:
A) Load scenario SCEN5.
B) Decrease the RA page radar power by a factor of 10 (10kW to 1kW, = -10dB).

C) Increase RA page “Background noise” until the targets become hardly detectable. Because the targets are at different ranges, this will be a different value for different targets. I suppose you need to consider a single target only for each run. Also ensure L page "Background noise" is less than the RA page value as the simulation uses the greater of the 2 values.
D) Put back RA page Power to its original value (10kW).
E) Carry out the test and check for correct tracking.

You can save the scenario, but it will only be valid for radar interfaces set up the same as the present one.

For further discussion of this scenario, see file SCEN.TXT.

5.7.2 Other IEC62388 Testing Requirements
IEC62388 is a new standard for radar performance. It is likely that modifications to rdtsim will be needed for best usefulness in testing to this standard. At the present time (June 2009) the following changes have been made:
A) The number of target ships is increased to 100.
B) AIS message type 24 is added.
C) Serial messages $__THS (transmission) and !__TTD (reception) are handled.
The following remain unclear:
D) Handling of the CCRP. (Consistent common reference point). The present simulation calculates target Range, Bearing, CPA, TCPA from the ship centre. The radar scanner can be offset from this position by entering values on the RA page. Maybe more flexibility is needed..
E) Further AIS messages need to be handled by the radar. (Types 2,3,4,9,12).
D) The $__TLB sentence needs to be handled by the radar.

There are further comments about this in file RDTSIM.TXT. If you have got any comments, please send them.

5.8 The IEC60872 Scenarios

These reproduce the tests specified by IEC60872. They are normally supplied in directory SC872. The scenarios are SC872-1, SC872-2, SC872-3 and SC872-4. Each scenario has a TX page detailing the test procedure and expected results.

There are some difficult questions in carrying out these scenarios relating to the noise background and the “test reference target” described in IEC60872. See file SC872.TXT for discussions about this.

In order to properly define the target tracks for these scenarios, it is necessary to give the target course to at least one decimal place of precision. This is possible with rdtsim version 2007-11-28, but not with earlier versions. The scenarios will work with the earlier versions, but they cannot be set up to proper accuracy.

6 AIS SIMULATION

6.1 OUTLINE

AIS (Automatic Identification System) is a method of sending ship related information by a VHF Radio link. The sender would normally be a ship, a shore station, or a navigation aid (buoy). At the receiver, the messages are decoded and converted to a serial data stream for transmission to marine electronic equipments which can make use of them such as electronic charts and radars. This extension to the radar simulator generates these messages for objects defined in the simulation (ships and buoys).

6.1.1 Serial Line Characteristics

These are as defined for high speed NMEA - bit rate 38k4 bit/s, 8 data bits, 1 stop bit, no parity, RS422 signal level.

6.1.2 Message structure

The sentence used is the AIVDM:
!AIVDM,x,x,x,x,s--s,x*hh<CR><LF>

1st x	Total number of sentences needed to transfer the message.
2nd x	Message sentence number.
3rd x	Sequential identifier to link multiple sentence messages. 0..9 or null for a single sentence message.
4th x	AIS channel number. (A, B or null field).
s--s	Contents of the radio message as 6 bit fields.
5th x	Number of fill bits needed to complete the last 6 bit character.

The radio message consists of a sequence of bits. It is split into 6 bit parts and each used to form a character in the s--s field. The characters are encoded so as to all be printable characters that do not interfere with normal message structure. Some of the messages are too long to fit in a single sentence while keeping within the normal 82 character limit. They are split over several sentences, and the 1st 3 x fields are adjusted appropriately. “Sequential identifier” is the same number for all sentences in a multi-sentence message.

In the case of messages generated for the own ship, there is an option on the AD page to use the alternative AIVDO message.

6.1.3 Message Types Simulated

Messages of the following types that are normally transmitted from ships and buoys are made available for transmission from the radar simulator. The messages are fully defined in document ITU-R M.1371-3.

Message ID	**Content**	**Comment**
1	Position report	For ships with Class A AIS equipment. Available for Own Ship and moving target ships. Data output: ID, LAT, LONG, SOG, COG, ROT, HDG, Navigation status, Position accuracy=high, Other fields are set to default values It is possible to introduce an offset from true position.
5	Static and Voyage	This gives additional information about a ship that is

	related data	transmitting Message 1. A larger transmission period is normally used (e.g. 6 minutes).
14	Safety Related broadcast Message	Up to 161 characters of safety related information.
18	Standard Class B Equipment Position Report	Similar to message 1 but with reduced information content
19	Extended Class B Equipment Position Report	Similar to message 18 but with additional information.
21	Aids-to-Navigation Report	Fixed targets defined as AIS beacons transmitting position and descriptive information.
24	Static data report	Normally used for Class B. There are 2 variants, Part A (Name) and Part B (Other static data). Part B should be transmitted within 1 minute following Part A. This message appears to be the preferred method for a Class B AIS to send static data rather than 19.

6.2 GENERAL

Two categories of ship are defined, AIS Class A and Class B. Each transmits a Position Report message with a short time interval, and a message giving descriptive information with a longer time interval. A Class A ship transmits Position Report message 1. The descriptive information is contained in an additional message 5. A Class B ship transmits Position Report message 18. The message can be expanded to include descriptive information and it becomes a message 19. The message 19 replaces a message 18. Alternatively, a message 24 can be used to send Class B static data. Part A is transmitted immediately followed by Part B.

All the features are controlled from 2 pages, AI - control AIVDM messages and AD - display AIVDM messages for test purposes. The messages are output to the COM port assigned to AIS messages on the L page. The *time stamp* field required by some messages is set to the Exercise time seconds.

For test purposes, the AIVDM messages can be logged to disk by use of the /MFA switch on the command line. (M=messages, F=file, A=AIVDM). The messages are written to file MESSLOG.TXT Any messages appearing in the Systems Messages box are also written to the file..

The AIS specification says that positions should be on WGS84 datum. If datum shifts are entered on the C page at “Offset from WGS datum” and datum shifting is enabled on the O page at “Lat Long Posn Datum”, then offsets are applied to shift the positions to WGS84 datum. This works the same as normal NMEA0183 messages with a GP talker.

6.3 PAGE AI

This page is used for defining the messages to be transmitted. There are 12 AI pages allowing definition of 60 Position Report messages, 12 type 5 messages, 12 type 14 messages, and 12 type 21 messages. The data rate limit is set to 3700 characters /s, which is just less than full time transmission. This is considerably more than actually required because the VHF radio link on which the messages are transmitted can not take such a high rate.

6.3.1 SHIP POSITION REPORT

The top 5 lines define 5 Position Report messages.

Targ num Target number, 1..59 for target ships, 0 for Own Ship.

Offsets X,Y Offsets from true position [m] used in calculating the reported positions. This is mainly used for testing an AIS capable radar to show what is the effect when an AIS target position doesn't coincide with the target echo

AIS Class A or B. Class A transmits message 1 and 5. Class B transmits message 18 and 19 (or 24). Normally, use Class B for yachts, pleasure boats, and smaller fishing boats and Class A in other cases.

Navigation Status The figure transmitted as part of message 1.

The meaning of the number is:

0	under way using engine	1	at anchor
2	not under command	3	restricted manoeuvrability
4	constrained by draught	5	moored
6	aground	7	engaged in fishing
8	under way sailing	9..14	reserved
15	not defined		

MMSI number The MMSI number (User ID) to use for the target. See "User ID" below.

Tx interval Transmit interval [s] (also known as Reporting interval) in range 0..180. A value of 0 gives no transmissions. The calculation when to send the message is staggered with the target number so that all the messages with the same Tx interval don't transmit at the same time. Besides direct keyboard entry, this variable has an Auto mode. This causes automatic calculation of the proper value to use based on the condition of the ship. The values are:

Class A ship	Proper transmit interval [s]
Anchored or moored and not moving faster than 3 knot	180
Anchored or moored moving faster than 3 knot	10
Speed 0 to 14 knot	10
Speed 0 to 14 knot, changing course	3 1/3
Speed 14 to 23 knot	6
Speed 14 to 23 knot, changing course	2
Speed > 23 knot, changing course or not	2
Class B ship	
Speed < 2 knot	180
Speed 2 to 14 knot	30
Speed 14 to 23 knot	15
Speed > 23 knot	5
Other	
Aids to Navigation	180
Static and Voyage related data (Message 5, 19, 24)	360

For an invalid target, or one that is out of AIS range, the "Auto" Tx interval is set to 0.

For Class A, a ship with a turn rate 5 degree /minute or more is considered to be "changing course". A value of 3 for the Tx interval should strictly be 3 1/3. To allow for this, intervals of 3, 3, 4 in sequence are used. This gives smooth behaviour for a ship which is close to the transition point from "changing course" (3 1/3 s interval) to "not changing course" (10 s interval).

A Class B ship normally transmits Message 18. The program looks for a Ship Description with the same Targ num as the position message. If it finds one, then at the appropriate time interval, it gets the relevant descriptive information from there. It is optional whether to send the static data as message 19 or 24. If 19 is selected, a message 19 is transmitted instead of the message 18. If 24 is selected, it is transmitted as an additional message.

For a target ship, values are needed for “heading” and “rate of turn” in order to construct the type 1 position report message, but only the ground track is properly defined. A value for heading is calculated from the ground velocity and the tidal current velocity defined on the W page. If you want heading to differ from COG, you need to enter a current on the W page. If you don’t want this current to affect own ship, enter an opposing current on the S page, or use the current override box. Rate of turn is zero except when “Turning radius” is non-zero and an alteration is made:

- In Auto mode: at a way point.
- In Keyboard mode: when a new value is entered for “Aim course”.

6.3.2 SHIP DESCRIPTION

This section allows data entry for the fields in message types 5, 19 and 24.

Targ num As for Ship Position Report.

Tx interval As for Position Report except that values up to 600s can be entered. The normal figure used in reality is 6 minutes (360s). A smaller value (e.g. 120s) is recommended for demonstration and training so that a connected device will pick up the ship description more quickly.

Further information gives the details needed to construct a type 5 message. Most of the fields have a default value to use if the information is not available. The default value for text fields is all '@', and '@' is also the recommended character to use for blanks at the end of fields. The most important fields are:

IMO number A number, normally 7 digits long allocated to a ship when it is constructed. (Except ships less than 100 tonne and yachts and fishing boats). Default 0.

Call Sign Up to 7 characters of text allocated to a radio transmitter by the national authority.

Ship name Ship name, up to 20 characters of text.

Ship/cargo type The most important types are:

30	Fishing	31	Towing	32	Towing > 200m
33	Dredging	34	Diving	35	Military
36	Sailing	37	Pleasure	40	High Speed Craft
50	Pilot vessel	51	Search & Rescue	52	Tug
53	Port tender	54	Anti-Pollution	55	Law Enforcement
56, 57	Local vessel	58	Medical transport		
60	Passenger ship	70	Cargo ship	80	Tanker
90	Other ship types	0	default (not available)		

For types with 1st digit other than 3 or 5, a different 2nd digit can be used with meaning

1	Carrying hazardous cargo of IMO category A
2,3,4	Carrying hazardous cargo of category B, C, D

Example, 73 means a cargo ship carrying hazardous cargo category C.

Dim/RefPos Gives the ship dimensions and position of the position sensor. A + B give the ship length and C + D the beam. All 0 = default.

ETA Estimated time of arrival at destination. Month in 1..12, 0 = default. Day in 1..31, 0 = default. Hour in 0..23, 24 = default. Minute in 0..59, 60 = default.

Destination Up to 20 characters of text.

Max Pres Stat Draught Ship draught in units of 1/10 m. Default 0.

Vendor ID Used for message 24.

The Ship Description is used to construct a message 5, 19 or 24. If target *Targ num* is defined as AIS Class A, a type 5 message is constructed. The User ID is constructed from Targ num so it is the same as the Position Report message coming from the same ship. The message is transmitted as an additional message.

If target *Targ num* is defined as AIS Class B, the Ship Description is used to construct a message 19 or 24 decided by AD page "Class B Tx 18+19 or 18+24".

6.3.3 AID-TO-NAV DESCRIPTION

This section allows data entry for the fields in the message 21.

Targ num Target number of fixed target that is to generate the message in range 1..500. It is used to get the position information, to test for valid target, and to construct the default User ID.

Tx interval As for Ship Description. The normal figure used in reality is 3 minutes (180s).

Type of A-N These are defined by IALA as follows. 1..19 are fixed aids (X). 20..31 are floating aids (L).

0	default, not available	10 X	Beacon cardinal E	20 L	Cardinal Mark N
1 X	reference point	11 X	Beacon cardinal S	21 L	Cardinal Mark E
2 X	RACON	12 X	Beacon cardinal W	22 L	Cardinal Mark S
3 X	Offshore structure	13 X	Beacon, port hand	23 L	Cardinal Mark W
4 X	spare	14 X	Beacon, starboard hand	24 L	Port hand Mark
5 X	Light without sectors	15 X	Beacon, preferred channel P	25 L	Stbd hand Mark
6 X	Light with sectors	16 X	Beacon, preferred channel S	26 L	Pref chan P hand
7 X	Leading light front	17 X	Beacon, isolated danger	27 L	Pref chan S hand
8 X	Leading light rear	18 X	Beacon, safe water	28 L	Isolated danger
9 X	Beacon, cardinal N	19 X	Beacon, special mark	29 L	Safe water
		30 L	Special Mark	31 L	Light vessel

Off position indicator 0=on position, 1= off position, only valid for floating Aid.
Other fields have the same meaning as for ships..

6.3.4 SAFETY MESSAGE

This section allows data entry for the fields in the message 14.

Targ num As for Ship Position Report. It is used to test for valid target, and to construct the User ID.

Tx interval As for Ship Description

Up to 161 characters of text information can be entered as 3 separate text strings. Blanks at the end of the text information are not transmitted. The number of sentences needed to transmit the message varies with the length of the text information.

6.3.5 VALID TARGET

Tests are made for *valid target* the same as when calculating radar echoes.

Own ship Always valid.
Target ship Displacement non-zero + either keyboard control or present way point in 1..8.
Fixed target Detection range non-zero.

If the target isn't valid, no message is transmitted. The target is also tested to check it is within the detection range given on the AD page.

If several messages 5, 14, 19, or 21 of the same message ID with the same ***Targ num*** are requested, only the 1st one will be actioned. A message 5 or 14 is not transmitted if the target to which it is linked has Tx interval of 0.

6.3.6 User ID

In AIS terminology “User ID” and “MMSI number” appear to mean the same thing. (MMSI means Maritime Mobile Service Identification). It is a 9 digit number allocated to ships and other possible sources of AIS messages. For normal ships, the 1st digit is in range 2..7. The 1st 3 digits show the country. For example, UK uses 232, 233, 234 and 235. USA uses 366, 367, 368, 369. The remaining digits are allocated by the national authority. It is possible to enter a full MMSI number. Alternatively, ‘0' can be used, and the default MMSI number will be calculated as follows:
Own ship 0
Target ship the target number in 1..59
Fixed target 1000 + target number in 1001..1500
For realistic AIS messages, the full MMSI number should be entered. For many test purpose, it will be simpler to use the default value, which makes it easy to relate an AIS message to its source. Note that some JRC equipment uses an MMSI number of 0 to mean “not initialised” which conflicts with the default MMSI number for Own Ship.

6.4 PAGE AD

The first few lines of the page give control over the AIS messages.

Use VDM or VDO for own ship
For messages generated for the own ship, this option allows switching between the VDM and VDO messages. VDO is normally used for messages generated by this own ship and VDM for other ships. Using VDM allows VDM messages to be generated for a ship that has full manoeuvring flexibility. Using VDO is appropriate, for example, when the AIS messages are related to radar echoes and NMEA positions.

AIS range Set the range limit for detection of AIS targets. A value of 0 means no limit. A typical figure found in reality is 20 nautical miles.

All X targs mess 21
Each X page target that is valid (Detection range non-zero) generates a type 21 AIS message. The field "Name of Aids-to-Navigation" is set to "AID TO NAV nn" where nn is the X page target number. The object is to allow overloading of the AIS output (AIS specification says 500 targets should be handled).

Every second, 4 targets are scanned, so the sequence of scanning the 500 fixed targets takes 2 min 5s. To overload the AIS, you need to set up an exercise with more than 500 valid targets (T page + X page).

Lost heading targ

It is possible to force the heading information in a position message to its default value (Heading 511, Turn rate -128) for one T page target. The object is to simulate a gyro failure to allow checking an AIS display gives a proper indication.

Class B Tx 18+19 or 18+24

There are 2 available methods for a Class B target to send static information, either by sending a message 19 or a message 24. This option allows selection of the method. All Class B targets are affected. The message 24 is actually in 2 parts, Part A giving the ship name and Part B giving other static information. Part A is transmitted immediately followed by part B.

Extra message file

A list of extra messages to transmit out of the AIS port can be made in a text file. Each line in the file gives an AIS sentence beginning with '$' or '!', with special cases:
A line beginning 'W' gives the time to wait in s.
A line beginning ';' is a comment line.
The file must have an extension ".ais" and it must be located in an exercise directory (normally ex). To start processing the file, enter its name, then "Load Y". The "Line number" display shows the present position in the file. 59999 means end of file.
The object is to allow testing of sentences such as "$AIALR" and "$AIACK" which may normally be transmitted along with AIS information and do not have an information content that needs to relate to other simulated information. See example file test.ais.

The lower part of the page is used to display and analyse the messages for checking purposes. All the screen information shown is got from decoding transmit messages in the output buffer.

Freeze Hold the display. Otherwise it is refreshed every time some new messages are transmitted. If the display is blank, it will pick up the 1st display and hold it. To trap a message, re-select the AD page, and the first valid display page will be held.

Analyse The basic messages sent are always displayed. This option causes the messages to be broken down to display individual fields. Latitude and Longitude are converted to degrees and minutes. Other fields are displayed as a decimal number or a text string as appropriate without any conversion being made.

Select Only display messages with certain Message ID and User ID. Message ID of 0 means don't restrict the messages displayed. User ID selection has a separate enable/ disable.

“ ++ “ on the bottom screen line means the display has been truncated because it overflows the screen.

6.5 Combined AIS and NMEA output

It is possible to add the normal range of NMEA sentences to the AIS data stream. See section *PAGE L - Serial ports* for details.

6.6 Received AIS messages for Target Ship Control

The target ships can be controlled by received AIS messages. This is normally useful when the radar simulator is being controlled by an external simulator. To make this work:

- On the L page, section Serports, switch on "Enable Rx" for the AIS channel or a Fast NMEA channel (and save the data, exit and start again).
- On the AD page, switch on "Rx AIS Display Y". This causes the received messages to be displayed below instead of the transmitted messages. You can check what messages are being received. Note that if an error or warning condition is detected in an AIS message, you only get a message if the AD page display is being made.
- On the AD page, switch on "Control targets".

The effect is that an unused T page target is attached to any AIS target (identified by its User ID (MMSI number)) that is sending an AIS position message (type 1, 18, 19). The target size is initially set to 1000T displacement. If an AIS message is received that contains the DimRefPos field, (type 5, 19 or 24 part B), the target size is adjusted to a suitable value.

If a position message for an attached target is not received for a period of one minute, it is detached and set back to Displacement 0.

Only VDM message are processed. It might be convenient to also handle the VDO message for controlling Own Ship, but this has not so far been done because the heading hasn't got sufficient precision (only one degree), the message rate isn't normally more than 1Hz, and there isn't any "ship speed relative water" in the message, which might be needed in some situations. If it is wanted to control Own Ship, it should be done in the normal way by sending NMEA messages down a different channel from the AIS.

6.7 Sample Code

An example program written in C, testais.c, is included. It contains code to encode and decode AIS messages of the types handled by the AIS simulation. See the source file for further details.

7 FURTHER TECHNICAL DETAILS

7.1 COMMAND LINE SWITCHES

These can be used on the command line when rdtsim runs to vary the functions of the program. The following switches can be used:

-m Controls writing of test data to file messlog.txt. The options are:
- -ma Write AIS messages transmitted.
- -mn Write received NMEA messages
- -ms Write messages that appear in the Systems Messages box

-s Controls writing of Sperry radar serial messages to file sbebyte.dat
- -sr Only write received data
- -st Write a text file (otherwise a binary file)

-sw Wait for receive data before starting to write

7.2 DISK FILE USAGE

7.2.1 Disk Files Needed by the Simulator Program

The following files needed in running the simulator must be kept in the same directory and this must be the default directory when the program runs.

rdtsim	simulator program executable
calib.dat	calibration data
default.ex	starting exercise

File calib.dat may have additional letters in its name to show which simulator installation it applies to. e.g. calibhu.dat for Hull simulator.

Additionally, exercise, landmass, seabed, and text files will be required for the exercises to be undertaken. These have names with extensions .ex", ".lnd", ".sbd" and ".tx". These are most conveniently kept in sub-directories and a redirection file used as described in the next section.

7.2.2 Exercise Redirection File

A redirection file is used to specify where exercise data is located and to give a starting condition at program startup. A general purpose file sim.red is normally used. It must be in the default directory.

A special purpose .red file can alternatively be used. Its name must be given on the rdtsim command line. This allows different redirection files to be used for different situations. For example, ./rdtsim jsmith will cause the redirection list to be read from file jsmith.red, which could contain directories used specifically by instructor J. Smith.

7.2.2.1 Exercise Directories

A list of directory paths where exercise data is located is given. Any number of directories can be specified for reading, but data written during "Save" or "Record" is always written to the first directory in the list.

ex
ukex
swedex

Directory paths are searched in the order in which they are listed in the redirection file. Path names are restricted to a maximum length of 30 characters. A comment line can be used in the list by starting the line with ";". For the present directory, use "." and for the parent directory "..".

7.2.2.2 Startup Condition

Two special lines can be used to give the startup condition. They can appear anywhere in the .red file.

Starting exercise

Example: #starting_exercise_name=lisboa
This causes exercise lisboa.ex to be loaded when rdtsim first runs. If this line is present it overrides exercise default.ex.

Start command
This causes commands normally typed at the keyboard to be automatically performed at program startup. Only "page select" and "run" commands are allowed. A comma is used as a command separator. The object is to allow the simulation to start up running an exercise without any operator intervention.
Example: #start_command=TS6,R
This causes text page TS6 and be selected, and the exercise to start running.

7.2.3 File messlog.txt
This file is created every time rdtsim runs. It contains:
- A summary of the rdtsim configuration.
- Error and information messages.
- Certain test data that can be requested on the rdtsim command line. See section "Command Line Switches".

7.3 EXERCISE PREPARATION PROCEDURES

A selection of exercise areas are normally supplied with a simulator. An area consists of the land in .lnd files, the seabed in .sbd files, and a "starting exercise" (.ex file) that contains other information such as buoys. An exercise area is normally contained in its own directory, and includes a text file .txt which gives information on data sources, area covered etc.. Most exercise areas are not supplied with ready made exercises giving suitable scenarios for collision avoidance training because instructors usually prefer to make such exercises for themselves. The recommended procedure for making an exercise is as follows:

1. Load a suitable starting exercise to give the land, seabed, buoys and any other useful information that has already been prepared. Change the exercise name on the C page.
2. Plan the tracks of some target ships to make an interesting exercise and enter the way point details on the T page. Normally the exercise needs to be run to be sure the target ships will reach the proper place at the proper time to make an interesting situation, so the details entered are just a first estimate.
3. Enter a suitable value for "Heading" on the S page. To control the own ship speed, there are 2 possible methods.
    A. Use the instruments display as normal.
    B. Enter a suitable value for "Speed relative water" on the S page, and enter "Disable ship manoeuvring Y" on the next line.
4. The "Acceleration factor" on the C page can be used to speed up progress when checking the exercise. A suitable value is 30 or 60.
5. Save the exercise on the C page.
6. Run the exercise. Check if the target ships' tracks result in an interesting situation. Note down any changes to their tracks that are needed.
7. If the own ship is not expected to follow a straight course, it will be necessary to change direction at appropriate points by entering "Heading" on the S page.
8. Load the exercise. Make any changes to the target ship tracks that are needed. Repeat from (5) until everything is OK.

9. Enter "Acceleration factor 1" and "Disable ship manoeuvring N". If desired, you can enter details about the exercise, and explanations of its purpose on the TX page.
10. Save the exercise.
11. The new exercise will appear in directory ex (assuming a normal sim.red file is being used). It is best to copy a proven exercise to another directory (e.g. ukex in the example given above) and delete it from the ex directory.

7.4 INSTALLATION AND BACKUP PROCEDURE

7.4.1 Operating System

The software has been developed and tested using SUSE Linux 10.0 (kernel 2.6.13) and 10.2, and KDE window manager. There are not any features that restrict operation to this environment, and other distributions that use 2.6 kernel and other Window Managers should work, but some adjustments may be needed. Early versions of the software also worked under Linux 2.4 kernel, but this implementation has not been kept up to date.

7.4.2 Making the rdtsim executable

The software is normally supplied in file rdt?????.zip.
Make a directory rdt, copy this file into it and expand it using unzip.

To make the rdtsim executable, do "make" in directory rdt.
For rdtsim to run, you also need the following files:

calib.dat	calibration file
default.ex	starting exercise
sim.red	exercise redirection file. Set this up to suit the location of your exercise directories. If this is a dual DOS/ Linux computer, it is optional whether to copy the exercise files, or to set up sim.red to use the DOS directories.

7.4.3 Kernel Modules

Two kernel modules are used:

simmod.ko.	This drives the serial ports, the log and gyro pulses, the optional ADIO card, and provides some useful functions for other drivers. It has to be loaded first.
radmod.ko	This drives a radar.

Afurther modules is optional.

radmod2.ko	This drives a 2nd radar. It is built from radmod2.c which is a copy of radmod.c with the first line changed to "#define RADNO 1". Normal practice would be to use the same driver for driving 2 similar devices, but this has not been followed because the module uses a lot of static storage, and the normal situation will be only 1 radar.

One further module is

testllat.ko	It is used for testing interrupt latency. High values of latency have caused a problem with some Linux kernel versions used with certain hardware.

7.4.4 Making the kernel modules

The kernel modules have to be built for the Linux version running on the computer. This is done as follows.

7.4.4.1 Build the kernel itself from its source

A) Ensure the C compiler and kernel source are loaded on the computer.
B) Go to the kernel source directory (cd /usr/src/linux).
C) Check the .config file exists (ls -a .config).
If it does, you can make the kernel by changing to root (su + enter root password) then doing "make". If it doesn't, there may be some way of creating it, but this varies with the Linux distribution.

7.4.4.2 Make the modules

Go to the rdt/module directory.
Enter "make". This should make the 4 modules, simmod.ko, radmod.ko, radmod2.ko, testllat.ko..

7.4.4.3 Test installation

To install the modules for test purposes, change to root (su + enter root password) and enter ./setmod.bat
To check the modules installed correctly, "lsmod".
You can then run rdtsim and check that the simulation appears to work OK.
Do this before going on to the next step.

7.4.4.4 Automatic installation

To set up the automatic installation procedure working from directory rdt/module as root:
make install
This command copies the modules to a directory /usr/src/linux/drivers/radar, copies the installation script "radaris" to directory /etc/init.d and runs insserv on it.

Shut down the computer and start up again. If everything works, the modules should be automatically installed.
To remove the automatic installation procedure, working from directory rdt/module as root
make uninstall

7.4.5 Using testllat to test interrupt latency

Kernel module testllat can be used to test interrupt latency. Some versions of Linux kernel used with certain types of hardware have excessive latency. The result is that the radar picture is seen to wobble around, and high values of AT page "Heading error" are seen.

testllat sets up a serial port to work at maximum speed, and measures the time between character output and the Transmit Holding Register Empty interrupt. If nothing is interfering with the interrupt enable, you should get values of 61us. Anything more than that is due to interrupt latency.

To run testllat, install it by "insmod testllat.ko" (need to be root) and use "dmesg" to examine the kernel message buffer. The values displayed are the time (microsec) from sending a byte and when the THRE interrupt handler runs. The important figures are "max" (largest time for 1000 interrupts) and "maxsofar" (largest time since start of run). The interrupt latency is approx 61 less than the values displayed. rdtsim should run correctly if values do not exceed 300.

testllat attaches itself to a serial port on the radar card, or to a port working as COM1 (address

3F8, IRQ4) if the radar card is missing or in use. For further information see the comments at the start of file testllat.c.

7.4.6 The Text Window

For correct operation of rdtsim, the text window needs to run in an 80x25 Xterminal or konsole window. Using SUSE Linux, this can be arranged by running
./runsimk.bat

7.4.7 Program Exit

It is quite easy to exit rdtsim by mistake if you pick on the X exit button in a window title bar. The easiest way to solve this problem is to remove the exit button from the title bar. Using SUSE Linux and KDE, this is done by right clicking on the title bar, then picking "Configure Window Behaviour". Follow the instructions to select what appears in the title bar.

7.5 SYSTEMS MESSAGES

Systems messages are displayed in a small window at the bottom right of the instructor's screen. The window can be cleared by typing Ctrl Z. The main types of message are as follows.

File not found messages. when reading of a file from disk is requested. Usually this is caused by incorrect spelling of a file name. Check on the DI page.

C language run time error messages. These indicate some malfunction of programs written in C. The messages include "Overflow" and "/ by Zero". They can be caused by hardware or software malfunction. The detail of the message can be useful in program fault correction.

Confirmation and Warning Messages. These mainly relate to disk file security.

7.6 EXERCISE UTILITY PROGRAMS

7.6.1 Program xtobuy

This program extracts a buoy database from an exercise file and writes it to a .buy file. Using a .buy file for a buoy database has the advantage that the database for an area is kept in one file rather than multiple copies being kept as part of different exercise files. The .buy file has the same name as the Landmass file used by the exercise.
 Example: ./xtobuy raddemo.ex
This command creates file oresund.buy. oresund is the name of the land file used by raddemo.ex.
The .buy file is a text file. There are comments at the end of the file explaining its structure. It can be edited to update the database. It is recommended to maintain its structure with 1 line for each buoy, and comments at the end of the file. Then a buoy's line number in the file is the same as its number on the X and Graphics Overview pages. See the PAGE X documentation for further details,

ANNEX 1 - IMO Publication about SARTs SN/Circ. 197

OPERATION OF MARINE RADAR FOR SART DETECTION

WARNING: A SART will only respond to an X-Band (3cm) radar. It will not be seen on an S-Band(10cm) radar.

Introduction

1. A Search and Rescue Transponder (SART) may be triggered by any X-Band (3cm) radar within a range of approximately 8n Miles. Each radar pulse received causes it to transmit a response which is swept repetitively across the complete radar frequency band. When interrogated, it first sweeps rapidly (0.4us) through the band before beginning a relatively slow sweep (7.5us) through the band back to the start frequency. This process is repeated for a total of 12 complete cycles. At some point in each sweep, the SART frequency will match that of the interrogating radar and be within the pass band of the radar receiver. If the SART is within range, the frequency match during each of the 12 slow sweeps will produce a response on the radar display, thus a line of 12 dots equally spaced by about 0.64 nautical miles will be shown.

2. When the range of the SART is reduced to about 1 n. mile, the radar display may show also the 12 responses generated during the fast sweep. These additional dot responses, which also are equally spaced by 0.64 nautical miles, will be interspersed with the original line of 12 dots. They will appear slightly weaker and smaller than the original 12 dots.

Radar Range Scale

3. When looking for a SART it is preferable to use either the 6 or 12 nautical mile range scale. This is because the total displayed length of the SART reponse of 12 (or 24) dots may extend approximately 9.5 nautical miles beyond the position of the SART and it is necessary to see a number of response dots to distinguish the SART from other responses.

SART Range Errors

4. When responses from only the 12 slow frequency sweeps are visible (when the SART is at a range greater than 1 n mile), the position at which the first dot is displayed may be as much as 0.64 n mile beyond the true position of the SART. When the range closes so that the fast sweep responses are seen also, the first of these will be no more than 150m beyond the true position.

Radar Bandwidth

5. This is normally matched to the radar pulse length and is usually switched with the range scale and the associated pulse length. Narrow banwidths of 3-5MHz are used with long pulses on long range scales and wide bandwidths of 10-25MHz with short pulses on short ranges.

6. A radar bandwidth of less than 5MHz will attenuate the SART signal slightly, so it is preferable to use a medium bandwidth to ensure optimum detection of the SART. The Radar Operating Manual should be consulted about the particular radar parameters and bandwidth selection.

Radar Side Lobes

7. As the SART is approached, side lobes from the radar antenna may show the SART

responses as a series of arcs or concentric rings. These can be removed by use of the anti-clutter sea control although it may be operationally useful to observe the side lobes as they may be easier to detect in clutter conditions and also they will confirm that the SART is near to own ship.

Detuning the Radar

8. To increase the visibility of the SART in clutter conditions, the radar may be detuned to reduce the clutter without reducing the SART response. Radars with automatic frquency control may not permit manual de-tune of the equipment. Care should be taken in operatinmg the radar in the de-tuned condition as other wanted navigational and anti-collision information may be removed. The tuning should be returned to normal operation as soon as possible.

Gain

9. For maximum range SART detection the normal gain setting for long range detection should be used i.e. with a light background noise speckle visible.

Anti-clutter sea control

10. For optimum range SART detection this control should be set to the minimum. Care should be exercised as wanted targets in sea clutter may be obscured. Note also that in clutter conditions the first few dots of the SART response may not be detectable, irrespective of the setting of the anti-clutter sea control. In this case, the position of the SART may be estimated by measuring 9.5 n miles from the furthest dot back towards own ship.

11. Some sets have automatic/ manual anti-clutter sea control facilities. Because the way in which the automatic sea control functions may vary from one radar manufacturer to another, the operator is advised to use manual control initially until the SART has been detected. The effect of the auto sea control on the SART response can then be compared with manual control.

Anti-clutter rain control

12. This should be used normally (i.e. to break up areas of rain) when trying to detect a SART response which, being a series of dots, is not affected by the action of the anti-clutter rain circuitry. Note that Racon responses, which are often in the form of a long flash, will be affected by the use of this control.

13. Some sets have automatic/manual anti-clutter rain control facilities. Because the way in which the automatic rain control functions may vary from one radar manufacturer to another, the operator is advised to use manual initially until the SART has been detected. The effect of the auto rain control on the SART response can then be compared with manual control.

PART 2 - HARDWARE

8 COMPUTER HARDWARE

8.1 Simulator Variants

Prior to February 2003, numerous versions of the software existed with different optional features. The present software includes all the options, and the only differences between one installation and another is in the hardware. The features which may differ are as follows.

1 or 2 Connected Radars

A 2nd radar can be connected. A 2nd radar interface card is needed. All relevant items on the L page have a 2nd set of values for controlling the radar. Details of the radar are given on page RA2. Kernel module radmod2.ko needs to be installed.

RS422 Serial Capability

Many of the serial data outputs of the simulator are specified as needing a RS422 signal level. The outputs affected are: Fast NMEA; Raytheon Course Bus; AIS; Sperry radar. The PCI bus radar interface has 2 RS422 serial ports on board.

Analogue Digital Interface

This interface card allows the connection of control levers and meters for ship control. Further documentation is supplied with the card.

8.2 Expansion Slots

The radar interface is available as a PCI bus card. The 2 radar option needs a 2nd slot. The analogue interface option needs an ISA bus slot.

8.3 Serial Ports

The software supports 4 serial ports. They are displayed on the L page as SER0..3. There are 2 operating modes:

D Direct drive port. The port is completely controlled by simulation software. The driver part of the software is in the simmod kernel module, and is accessed using device files /dev/sim0, dev/sim1 etc. These ports only work if serial port hardware is located by the simmod driver. If the PCI bus radar card is in use, its serial ports act as /dev/sim0 and /dev/sim1. If a 2nd PCI bus radar card is found, its ports act as /dev/sim2 and /dev/sim3. Some other types of serial port card are recognised, but it is normally better to let the standard serial port driver look after them.

S Standard driver port, accessed via the standard /dev/ttyS device files. These ports will only work if suitable hardware supported by the Linux serial drivers exists in the computer.

The normal situation for an installation with 1 connected radar is to use "S S D D" for the L page values.

When S/D is changed, you need to save the data at "Save to file CALIB.DAT Y", exit and start again before the changes take effect.

The device files connect to SER0..3 as:

	Used if Driver = D	Used if Driver = S
SER0	/dev/sim2	/dev/ttyS0
SER1	/dev/sim3	/dev/ttyS1
SER2	/dev/sim0	/dev/ttyS2
SER3	/dev/sim1	/dev/ttyS3

There are certain advantages in using a direct drive port:

- It is necessary for a Sperry radar serial port.
- For radars that use serial information to stabilise their heading (NMEA HDT or Raytheon course bus), better performance can be expected because the information is calculated in the driver and timed by a kernel timer so it is likely to be very accurate. These messages can be output to a standard serial port, but they are calculated by a user space program and timing is not guaranteed.
- Similar considerations apply to the case of external control of the Own Ship using serial messages including heading information, especially if the radar is heading stabilised from the source of the serial messages rather than rdtsim.
- Transmission frequency of HDT sentences. For a direct drive Fast NMEA port transmitting high rate HDT sentences (Tx interval = 0), the transmission frequency is decided by L page item "freq"

freq	Tx rate Hz
0	20
1	50
any other	100/freq

  Note that IEC62388 mentions testing with frequencies up to 50Hz.

8.3.1 Connection details for PCI bus radar card

End Bracket Connectors

Upper 9 pin D	SER2	(SER0 for 2nd card)
Lower 9 pin D	SER3	(SER1 for 2nd card)

RS422 card 9 pin D

pin	**signal**
1	Tx Data -
2	Tx Data +
6	Rx Data -
7	Rx Data +

Note: Radar interfaces up to version 23 have a tracking mistake on the 2nd serial port (SER3) that causes the Rx Data connections to be reversed. Pin 6 is Rx Data +, pin 7 is Rx data -.

9 EQUIPMENT ATTACHED BY DIRECT COMPUTER CONNECTION

9.1 NMEA0183 Serial Interface

Most computers have one or two serial ports on the motherboard that work at RS232 signal level. If more outputs are needed, a small driver card is available that can drive 8 output channels at RS423 level from 1 RS232 input channel.

Computer connections

9 pin serial port pin	25 pin serial port pin	signal
2	3	RS232 Rx data
3	2	RS232 Tx data
5	7	RS232 signal ground

9.2 Printer

Older installations drove a printer directly using Hewlett Packard Deskjet 500 control codes. A printout is requested on the C page. It is nowadays preferred to use the standard KDE printing system. Any type of printer with Linux support can be used. See Page C.

10 RADAR INTERFACE CARD

10.1 Overview

The card generates the signals needed by a radar display unit. It connects to the cable that would normally lead to the radar scanner and performs the functions of the scanner. It also provides log and gyro signals which are needed to allow the display unit to operate in stabilised and true motion modes. The main signals involved are:

- **Scanner azimuth signal**. This is a square wave generated by the scanner used to synchronise the display unit to the scanner bearing. The frequency is different for different types of radars. Typical figures may be 360, 1080, 2048 pulses per scanner revolution.
- **Heading marker pulse**. A short pulse output by the scanner. The leading edge of the pulse indicates the ship's head direction.
- **Radar video signal**. This signal is output in response to the transmit trigger from the display unit. It consists of the radar echoes after removal of radar and intermediate frequencies. The simulated signal consists of the simulated echo signals from radar targets and clutter.
- **Gain and anti sea clutter controls**. These are signals output by the display unit used to control the video signal. Most radars perform these functions in the display unit so the effects are not required.
- **Tuning control**. This is a signal output by the display unit with a feedback from the scanner showing state of tune. Both signals are normally analogue DC voltages.
- **Gyro repeater signals**. The simulator can generate stepper motor type signals, or an NMEA0183 serial message can be used to give the ship's head direction.
- **Log pulse signal**. Set to 200 pulses/ nautical mile, polarity selectable on the L page.

10.2 Radar Interface Card Versions

Interface cards up to 4/2005 were ISA bus cards, versions 8..12. Later cards were PCI bus cards, version 20&21&22. Version 20 is the PCI bus card without any version information written on it. The PCI bus card contains 2 serial ports. The ports use RS422 signal level and a *8 clock. When connected by ribbon cable to 9 pin D connectors, they give the same pinout as Brainboxes' cards. The PCI bus card in its standard form uses the same pinout on the end plate 25 way D connector as the ISA bus card. However, it has the additional link selectable capability to use an RS422 signal level for some of the signals. The main new features for the PCI bus cards are:

Version 21	There is a regulator on the -12v power line. This is necessary for noise reduction when running under Linux. A tracking mistake in connecting the gyro signals to the connector is corrected. (This mistake caused the gyro to turn in reverse direction for V20. This could be corrected by reversing 2 of the gyro connections).
Version 22	There is a fuse on the +12v reference. A tracking mistake that reversed the connections for the 2nd RS422 serial port Rx data is corrected. Some links and test points are renumbered.

Only the PCI bus cards other than V22 are fully documented here.

10.3 Gyro Compass Interface

Normal gyro signals consist of stepper motor signals S1, S2, S3 and a COM supply which is typically +35 or +70v. S1, S2 and S3 are driven as open drain signals by T5..7, and also pulled up to the COM voltage by resistors R12, 14 & 16. This arrangement caters for a variety of gyro sensing circuitry in the radar. In many cases, a +12v supply is sufficient for the COM voltage. Linking LK1 connects the computer 12v supply for this purpose, and the supply is output at PL1 pin 3 for connection to gyro COM. If a higher voltage is needed, an external supply must be used. It should be connected to gyro COM with it's negative side connected to computer ground or mains ground. If pull up resistors are needed, the COM voltage should be connected to CON1 (PL1) pin 3. LK1 (LK2) must not be linked.

The step rate output is 6 steps (one complete sequence) per degree. The radar may need to be adjusted to this step rate. On modern radars the adjustment is usually a menu item. On older radars it is usually circuit board links or switches. If the gyro is found to move in the wrong direction, 2 of the connections for signals S1, S2, S3 should be swapped.

10.4 Computer accessible signals

The radar video signal is controlled by 16 bit transfers from the computer bus. The tuning A to D and D to A converters are controlled by 8 bit transfers from the computer bus. Other signals are controlled through a Z8536 CIO which is used for timing waveform and digital I/O.

CIO Port A - Bit control mode(Standard address base + 2)

A4	Spare transistor output, open drain or pull up to +12v.
A5..A7	Spare

CIO Port B - Bit control mode(Standard address base + 1)
All signals are inverted at the output connector.

Signal	Direction	Signal description		
B0	output	\	1	Gyro stepper signals
B1	output	|	2	
B2	output	/	3	
B3	output	Log pulse		
B4	output	Scanner azimuth, square wave		
B5	output	Heading marker pulse		
B6	input	Pulse length 3		
B7	output	A transition enables switching of RAM A10.		

CIO Port C - Bit control mode (Standard address base + 0)

C0	output	Tx trigger if LK14 linked to 3
C1	input	State of RAM A10
C2	input	Pulse length 2
C3	input	Pulse length 1

Video RAM outputs - PCI bus cards

D0..D7	Target video intensity data
D8..D15	Clutter video intensity data

10.5 Connection Lists - PCI bus cards

10.5.1 CON1 & PL1 to radar

THE END PLATE MUST BE GROUNDED TO THE COMPUTER CASE to reduce noise and ripple on the signals.

25 way D pin number	**Signal**	**Note**	**Direction**
1	Pulse length 1		input
2	Radar trigger	(A)	input (optional)
3	Gyro reference voltage		input (or output)
4	Gyro phase 3		output
5	Gyro phase 2		output
6	Gyro phase 1		output
7	Anti sea clutter control	(B)	input (optional)
8	Log pulse		output
9	Ships head marker, standard or RS422+	(C)	output
10	Scanner azimuth pulses, standard single phase		output
11	Gain control	(B)	input (optional)
12	0v		
13	Spare digital (transistor) output		
14	Pulse length 2		input
15	Tune control		input
16	Tune indicator		output
17	Pulse length 3		input
18	External azimuth voltage		input (only used if LK2=3)
19	Standby (Tx enable)	(A)	input (optional)
20 to 21	0v		
22	Ship’s head marker, 0v or RS422-	(C)	

24	Tx trigger output, screen or RS422-	(C)	
25	Tx trigger output, standard or RS422+	(AC)	output (optional)

Notes
A) If the card is linked for internal trigger (LK14=3) the transmit trigger is generated on the card. Trigger input at pin 2 is not used. Trigger output is at pin 25. Some radars need to disable the trigger when switched to Standby. This is done by connecting a signal at pin 19. Polarity of the signal is decided by LK9.
B) Gain control, and anti-sea clutter control, are for radars that need these functions to be performed on the interface card because they are normally performed at the scanner. Many radars perform the functions in the display unit so the functions are not needed on the interface card.
C) The standard heading marker and trigger signals are ground relative voltages, but RS422 signal level is available as an option set by links, see below.

PL1 Pin 1 = Video. Pin 2 = Screen.

10.5.2 RS422 Serial Ports
CON5 RS422 serial data port A (COM4). To 9 way 'D' plug.

1	Tx1-	1
2	Rx1-	6
3	Tx1+	2
4	Rx1+	7
5	RTS1-	3
6	CTS1-	8
7	RTS1+	4
8	CTS1+	9
9	Gnd	5
10	NC	

CON6 RS422 port B (COM3) - Connections as for CON5 above.
Note: Radar interfaces up to version 21 have a tracking mistake on the 2nd serial port (SER3) that causes the Rx Data connections to be reversed at the 9 way D plug. Pin 6 is Rx Data +, pin 7 is Rx data -.

10.5.3 2 Phase azimuth
LK12 2 phase azimuth RS422. To 9 way 'D' socket.

1	Azimuth 1+	1
2	Azimuth 1-	2
3	Azimuth 2+	3
4	Azimuth 2-	4
5	Gnd	5

These signals are an alternative to the standard single phase azimuth signal at CON1 pin 10. They have a frequency half that of the single phase signals.

10.6 Links, Addressing, Test Points, Potentiometers - PCI Bus cards

Links

LK1 Connects +12v to the gyro reference if required. Alternatively, if a different voltage for the pull up resistors is needed it can be brought in from an external source at CON1 pin 3 and LK1 must be open.

LK2 Selects the scan rotation output voltage. 1 = 5V, 2 = 12V, 3 = external supply (CON1 pin 18) Vertical 1,2,3 from left.

LK3 Normally open. Link to short circuit capacitor C1 for DC level video output.

LK4 Pulse length input resistors R18, 23 & 26 pull up or pull down. Link to + (right) for pull up, or - (left) for pull down.

LK5 Video polarity. Link to - (left) for negative going video or + (right) for positive going video.

LK6 Heading marker output at CON1 pin 9. Link to 1 (left) for RS422+ or 3 (right) for standard ground relative signal.

LK7 Heading marker output at CON1 pin 22. Link to 1 (left) for RS422- or 3 (right) for standard 0v.

LK8 Trigger output at CON1 pin 24. Link to 1 (left) for RS422- or 3 (right) for standard 0v.

LK9 Radar On/Off or Standby polarity. Link to + (left) for high input tx enable or - (right) for low input tx enable. Leave open for radars that generate their own trigger, or when testing without a radar connected if the trigger is otherwise disabled.

LK10 Trigger output polarity. Link to - (right) for negative going trigger or + (left) for positive going trigger.

LK11 Link to B (left) for normal STC input. Link to A (right) for reverse polarity STC input and fit resistors R70 to R73 & LK16.

LK12 2 phase RS-422 azimuth output (see connectors above).

LK13 Trigger output signal level. Link to 1 (left) for RS422 or 3 (right) for standard ground relative.

LK14 Trigger input select. Link to 1 for negative going trigger input, or 2 for positive. Link to 3 for trigger pulses generated internally by the radar interface and for testing without a radar connected. Vertical 1,2,3 from left.

LK15 Link to connect anti-sea clutter circuit output if this function is needed on the interface.

LK16 Link only for reverse polarity STC input with LK11 'A'.

LK18 Tuning indicator polarity. Select tune 1 (left) for negative or 3 (right) for positive output voltage.

LK19 Normally linked to 3 (right). Link to 1 (left) for a negative tune control input voltage.

Addressing

The PCI bus radar card (version 20) can be identified from its configuration register values. (Use a program such as testpci to display the registers).

Vendor ID (PCI config register 0, low 16 bit)	10B5
Sub-vendor ID (PCI config register 11, low 16 bit)	A7E3
Sub-vendor unit (PCI config register 11, high 16 bit)	B200

The addresses of the on board devices are as follows:

BAR2 + 0	CIO port C
BAR2 +1	CIO port B
BAR2 +2	CIO port A
BAR2 +3	CIO control
BAR2+0x10	A to D converter (tuning control input)
BAR2+0x20	D to A converter (tuning indicator output)
BAR2+0x30..0x37	UART address for 1st serial port

BAR2+0x38..0x3F	UART address for 2nd serial port
BAR3	Video RAM load

BAR2 is base address register 2, PCI config register 6.
BAR3 is base address register 3, PCI config register 7.

Test points

TP1 Video output from power amp
TP2 Radar trigger
TP3 Anti sea clutter circuit output
TP5 Noise generator output
TP6 Ground

Potentiometers

VR1 Trigger delay
VR2 Trigger o/p pulse width
VR3 STC set zero
VR4 Video DC level (gain)
VR5 Noise appearance
VR6 Tune output max setting
VR7 Tune output zero setting
VR8 Clutter output level
VR9 Tune input voltage range
VR10 Video output level

10.7 Adjustment Procedure - PCI Bus cards

10.7.1 Radar Video

On the radar:

Turn the anti-rain clutter and anti-sea clutter controls fully anti-clockwise (off).
Switch off any auto anti-clutter or averaging controls.
Turn the Gain control fully clockwise (max).
Set the range to 12 miles or 16 miles.
Power up the computer and radar. Leave at least 15 minutes before starting setting up.

It is also possible to do most of the setting up without the radar connected. Move the LK14 link to position 3 (internal trigger).

Run program testrad and select test 2. This makes a short range clutter ramp counting down from maximum, and a target video ramp stepping down from maximum to minimum intensity in 16 steps starting at 6 mile range.

Connect oscilloscope external trigger to TP2 and adjust for a trace. Set the time scale to 20µs/cm.

If the interface card is generating the trigger, (LK14 to position 3) the length of the trigger pulse can be adjusted using VR2.

If the anti-sea clutter (STC) circuit and LK15 are fitted, monitor TP3 and adjust VR3 until the pulse just disappears.

Monitor TP1 and adjust VR4 until clutter and target echo ramps appear on the scope. 16 steps should be visible on the target video ramp.

Adjust VR5 for suitable clutter appearance.

Turn the radar gain to maximum and adjust VR10 for a target video ramp voltage of 4.0v peak to peak (or a suitable voltage for the type of radar being used).

Adjust VR8 to set the maximum clutter level to about 1 volt less than the video voltage. Readjust VR10 if the video ramp voltage is affected.

If the video gain is being controlled on the interface, turn the gain control on the radar fully clockwise (maximum). Run testrad test 3 and monitor TP1. Carefully adjust VR4 for the position where the video amplitude starts to reduce when the radar gain control is just turned from maximum. Turn the gain back to maximum.

10.7.2 Delay

VR2 is used to adjust the delay.
Run program testrad, test 3. This makes an echo at 0.20 to 0.24 miles range, maximum target video.
Set the VRM to 0.20 miles on 1/4 mile range. Adjust VR1 to bring the start of the echo onto the VRM. Also adjust the gain control so the end of the echo comes just before the screen edge. If there is insufficient adjustment, adjust the radar's internal delay.

10.7.3 Heading Alignment

There are 2 methods of measuring the alignment error, and 2 methods of correcting it. Method 1 is recommended in both cases.

Alignment measurement - Method 1

Run testrad, test 3. On the radar, turn off any interference rejection. A short flash marks the start of the heading marker pulse. This flash should lie along the heading marker.

Alignment measurement - Method 2

Run the simulator program. Select a situation where there are land echoes ahead of the ship near the screen edge. On the M page, enter a shadow sector ending at 000. e.g. Centre 355, Width 10. The edge of this shadow sector should line up with the heading marker.

Alignment correction - Method 1

Use the radar's internal heading alignment (usually a potentiometer or menu item) to correct the alignment. Ensure the L page item "Ship's head offset" is set to 0.

Alignment correction - Method 2

Measure the error in degrees, and convert to number of azimuth pulses. Run the simulator program. Enter the correction needed as "Ship's head offset" on the L page, then save the values by entering "Y" at "Save to file CALIB.DAT". For example, if the flash or shadow sector edge appears at 350, and the radar uses 2048 azimuth pulses per rev, the correction required is 10*2048/360 = 57. (Positive numbers move the heading marker pulse clockwise, and negative numbers anticlockwise).

10.7.4 Tuning Indicator Output

Fit link LK18 to 3(+) for a positive voltage output or to 1(-) for a negative output.
Run testrad test 5.
At the prompt type 0 (zero) and enter. Adjust VR7 until the tune indicator on the radar just shows minimum.
Type F8 and adjust VR6 until the tune indicator on the radar just shows maximum.
When the simulator system is loaded enter the values 00 and F8 as the "Tuning Indicator" values, minimum and maximum on the L page. Save the data by "Save to file CALIB.DAT Y".

10.7.5 Tuning Control Input

The maximum tune input voltages are 0 to +20 volts with LK19 to 3(+) or 0 to -20 volts with LK19 to 1(-).
Switch on the radar and start transmitting (not Standby).
Turn the tuning control on the radar fully clockwise.

Run testrad test 2.
Adjust VR9 until the reading is between F0 and F8. This is the value for "Max".
Read the value with the tuning control centred ("Centre") and fully anti-clockwise ("Min").
When the simulator system is loaded enter the measured readings as the "Tuning Control" values on the L page. Save the data by "Save to file CALIB.DAT Y".

10.7.6 Drive Capability Summary

Video output. Will drive a 25 ohm load when fitted with a heat sink.

Trigger output. 0 to +12 volts 300 mA positive or negative, width 0.5 to 4 μS.

Gyro, 3 phase step by step output. Open drain output or pull-up to reference voltage by resistors R12, 14 & 16. 100 volts 500 mA maximum output. Outputs via 500 mA ultra fast blow fuses FS2 to FS4. +12 volt reference voltage via fuse F5 (V22 and later interfaces).

Scanner (Azimuth) pulse train output. 180 to 4096 pulse/rev. 0 to +5, +12 or external voltage up to +25 volts max. Output via 500 mA ultra fast blow fuse FS1.

Heading marker. Open drain output +50 volts 500 mA maximum. Optional pull-up resistor to +5 volts via R25.

Log output. Open drain output +50 volts 500 mA maximum.

10.8 Simulation of Second Radar

Some simulators have two radars driven from one computer. Two radar interface cards are used. The radar is controlled by page RA2 and the 2nd set of values on the L page.

testradt will simultaneously drive the 2 radars, so setting up of the second radar is straightforward. All the L page items have a 2nd set of values for the 2nd radar except for "Ship's head offset". The software requires both radars work with the same offset, so the radars' internal adjustments should be used.

For PCI bus cards, the first card is the one in the slot of lowest unit number (usually the one nearest the power supply).

11 SPECIAL INSTRUCTIONS FOR CERTAIN RADARS

11.1 STN Atlas Radars

11.1.1 Azimuth Pulse Voltage

Atlas radars need an azimuth pulse voltage of 24v.
For PCI bus cards, link LK2 to 3, and connect a 24v supply to 25 way D pin 18.

11.1.2 STC Adjustment Procedure

The Atlas STC signal is a ramp synchronised to the transmission. At maximum STC the ramp starts at -4v at transmission and decreases to 0v at 12 mile range. The interface card will handle this signal connected at the normal STC input (25 way D pin 7).

The adjustment procedure for radar video is modified as follows (PCI bus card):

- Start with LK11 removed. Carry out the normal adjustment procedure for radar video. Ignore the step "If LK11 for STC is fitted monitor TP3...". Suitable voltages for the Atlas radar are about 1.5v for the target video ramp and 1.2v for the clutter video ramp.
- Adjust VR4 until the lowest amplitude (most distant) step on the target video ramp starts to disappear.
- Fit LK11. Turn STC full on.
- Adjust VR10 until the lowest amplitude (most distant) step on the target video ramp starts to disappear.

11.2 Large Raytheon Radars

These radars often take heading information from a Raytheon Course Bus signal, so an RS422 serial capability is needed, and a serial port should be assigned to that function on the L page.

The radars need a 2 phase azimuth signal at RS422 level. For PCI bus cards, this is available at LK12.

The radars expect a *log sense* output which is switched on on the L page at *Output log pulse dirn bit*. See the L page for details.

11.3 Sperry Radars

11.3.1 Special features

With modern Sperry radars, the azimuth pulses consist of bytes of RS422 data. The special features apply to this type of radar, and not to early models that used traditional azimuth pulses. The special features are:

A. The RS422 signal from scanner to display. The radar scanner transmits RS422 data at a rate of 4096 bytes per scanner revolution instead of the more usual azimuth pulses. The data content of the RS422 bytes consists of information on heading marker, pulse length, tuning indicator, and various status and error conditions. The data stream isn't continuous and has to be accurately timed according to the simulated scanner rotation speed.

B. The connections list between scanner and display consist of:
Normal video signal using coax cable.
Twisted pair RS422 cable carrying the signal described in (A) at 76.8kbaud.
Twisted pair RS422 cable carrying commands from the display to the scanner such as pulse length demand, Tx/standby request, tuning control information at 76.8kbaud.
Twisted pair RS422 cable carrying the Transmit trigger signal from the scanner to the display.
In addition, there are the normal connections for log pulse, gyro signals and NMEA0183 data.

11.3.2 Connection details

RS422 9 pin D		**Radar**		
pin	**signal**	**pin**	**signal**	**Connect list**
1	Tx Data -	TSA4	TX DATA-	213
2	Tx Data +	TSA3	TX DATA+	213
6	Rx Data -	TSA2	DU DATA-	213
7	Rx Data +	TSA1	DU DATA+	213

Note: Radar interfaces up to version 21 have a tracking mistake on the 2nd serial port (COM4) that causes the Rx Data connections to be reversed. Pin 6 is Rx Data +, pin 7 is Rx data -.

Radar interface 25 pin D		**Radar**		**Connect list**
	Gyro S1 RTN \	TSC1		
3	Gyro S2 RTN > linked	TSC2		
	Gyro S3 RTN /	TSC3		
4	Gyro S1	TSC6		
5	Gyro S2	TSC5		
6	Gyro S3	TSC4		
8	Log pulse	TSD7	LOG	197
21	0v	TSD8	LOG RETURN	197
24	Tx Trig -	TSA6	TX TRIG-	
25	Radar trigger output	TSA5	TX TRIG+	213

Radar interface PL1, BNC Coax, connect to radar SKV

Serial port
selected for NMEA on L page

If 9 pin	**If 25 pin**		**Radar**		
3	2	Tx data	TSE3	RX DATA 1B	199
			+ TSF3	RX DATA 2B	200
5	7	Signal ground	TSE1	RX DATA 1A	199
			+ TSF1	RX DATA 2A	200

The serial port connections are made in parallel. The TSE connection is for navigation aid data, and the TSF connection for heading information. Both types of message are transmitted on the same serial data stream. The TSF connection is only needed if ship’s heading is to be sent as NMEA data.

Trigger output - PCI bus card
Connect LK8 & LK13 to 1 to get the RS422 signal level for the trigger.

TXDATA-	Connect to 25 way D pin 24
TXDATA+	Connect to 25 way D pin 25

11.3.3 Radar Interface Link settings - PCI bus card

LK1	Gyro ref	link for +12v gyro ref. if the gyro is used for heading information
LK5	+ve or -ve video	- (left)
LK8	trigger return	1 for RS422-
LK10	+ve or -ve trigger	+ (left)
LK13	trigger	1 for RS422+

11.3.4 Effects implemented by RS422 messages

Pulse length effects

Bit	**Position on L page**	**Name**	**Pulse length μs**	**PRF Hz**
0	1st	long	0.75	785
1	2nd	medium	0.25	1800
2	3rd	short	0.05	1800

Tuning

This should work without any adjustment provided the setting up procedure described below is followed.

11.3.5 Radar Setup

General

Menu settings: (Input password 118BH where necessary).

System Configuration: All default values.

I/O options:

Serial port 1:	Nav Sensor (input only)		
Compass:	Standard	S. Stepper	360:1
Log:	Yes	Neg pulses	200 PPNM

Transceiver:

Display marker	HL
TxRx	Aloft

System:

Video:	Normal
Algo 1:	Off
Algo 4:	Off
Algo 4:	High ranges

TXA settings:

Trig delay	Adjust as necessary
Test:	Offset

Heading information.

It is optional whether to use the gyro signals or the NMEA HDT sentence.
Switch to Standby, then select menu INITIALISATION - I/O OPTIONS

To use the HDT sentence, select
- SERIAL PORT 2 - COMPASS - HDT
Connect the NMEA signal to TSF
ON the L page, switch on HDT, Transmit interval 0.

To use the gyro stepper signal, select
- SERIAL PORT 2 - NO INPUT
- COMPASS TYPE - S STEPPER

Connect the gyro stepper signals as described above.
Ensure radar interface card link LK2 is made.

Tuning

Use the radar menu SYSTEM - TX SETTINGS - COARSE TUNE
Adjust the Coarse tune to a centre value.
This should bring the tuning indicator into range when the tuning control is adjusted at the screen bottom left.

11.3.6 L Page Settings

Tuning control & indicator	Not relevant.		
Azimuth pulses per rev	4096		
Background noise	4 (recommended)		
Pulse lengths (1st 3)	0.75	0.25	0.05
PRFs	785	1800	1800
Initial echo length	1	Intensity 30	
NMEA		Switch on GLL, ZDA (to get lat. long. and UTC displays)	
	If required for compass stabilisation, switch on HDT + set Transmit interval=0.		

Sperry radar Switch to Y.

Notes:

C. If this or the next option is changed, save the data, exit and start again.

No Rx bytes The object of the option is to allow normal output of Sperry signals without a display unit connected. Operation of the radar scanner is normally controlled by bytes of RS422 data received from the display unit. The main effects are:

A. At startup, the scanner remains in standby until the received data shows "Transmissions started".

B. The tuning control and pulse length information is contained in received bytes.

C. If no bytes are received for half a scanner revolution, the scanner switches to standby.

If "No Rx bytes" is switched on, effects (A) and (C) are suppressed. (B) will still work if a display unit is connected. This will not normally be the case, so "Disable tuning" should be switched on (L page) and the pulse length should be controlled manually (RA page).

Serial port section

Assign either SER2 or SER3 function as S (Sperry radar), and make serial port connections to the appropriate connector

11.3.7 Serial Communications Test

A test feature is available to assist with debugging Sperry radar serial communications problems. The serial data is written to a file sbebyte.dat. Tx bytes are written with bit 7 clear. Rx bytes are written with bit 7 set. The normal use of bit 7 as heading marker in the Tx data is stripped off. To activate the test, run with the -s switch. Additional letters may follow s:

r Only write received data.

t Write a text file. Otherwise the file is binary. It is best for systems performance to minimise the amount of data written by using a binary file, but of course, you need a binary file viewer.

w Wait for received data before starting to write. This is useful if you want to investigate an interaction between receive and transmit bytes.

Example ./rdtsim -swt will switch on the test with w and t effects..

12 ADIO (ANALOGUE AND DIGITAL I/O) CARD

This card is an optional extra that can be used for connecting control levers and meters so that a control panel can be used to control Own Ship. It becomes effective when the ADIO card is installed, and "Enable Analogue Controls" (Page L, section A/D IO) is switched on.

12.1 Interconnection / Addressing

The card controls 11 analogue inputs, 12 analogue outputs, and 15 bits of digital I/O. It uses a block of 16 addresses in the I/O address space. The base address is set up on SW1 1..6. The standard base address is 100 (switches 1,2,3,4,6 on, switch 5 off). The card plugs into an ISA bus slot and connections are made by way of a 50 way IEEE488 connector. The card has circuitry to optionally rescale some of the analogue voltages and condition the digital I/O, but details vary from one version of the card to another and are not included here.

Digital I/O and the A to D converter are handled by a Z8536 CIO addressed as follows.

100	C port
101	B port
102	A port
103	control port

Analogue outputs are addressed at ports 104..10F.

The digital inputs and counter/timers of the CIO can generate interrupts, link selectable as IRQ 7, 10,11,12 or 15. The standard RDTSIM does not use interrupts, so no IRQ link should be used.

12.2 Analogue Inputs

Analogue inputs are connected to the 11 channel analogue to digital converter IC8. 8 bit converter TLC541 or 10 bit converter TLC1541 can be used. They convert voltages in the range 0 to +5 volts. The maximum input current is 2.5 microamp.

In most cases the analogue inputs are used for reading the positions of control levers and joysticks by potentiometric division. The computer ground and +5v supplies are used as A to D reference voltages and are also made available in the connector for connection to each potentiometer as analogue ground and analogue +5v. The signal coming back from a potentiometer is A to D converted to enable the position of the control lever to be measured. Most of the potentiometers can be adjusted manually and they should be positioned centrally within their active range. They are calibrated by software using the L page. There is no overvoltage protection on the analogue inputs unless the rescaling circuits are used. *IEEE488* refers to the connector on the card’s end bracket. *IDC* refers to an interconnection board that is available as an optional extra.

A to D Channel	**IEEE488 /IDC pin**	**Signal**
0	38	

1	39	
2	40	
3	41	
4	42	
5	43	Side thruster fore or single (optional)
6	44	Side thruster aft (optional)
7	45	2nd (starboard) engine demand (optional)
8	46	Engine demand
9	47	Rudder demand
10	48	

Other pins:

30..33	analogue +5 volt ref. output
34..37	analogue 0 volt ref. output

12.3 Analogue Outputs

12 analogue outputs are driven by three quad 8 bit D to A converters IC5, IC7, IC9. Maximum DAC output current = 5mA The reference voltage is selectable as +5 or +10v, the outputs can be taken direct or via dropping resistors to facilitate driving meters, and a number of the channels can be rescaled, but details vary from one version of the card to another and are not given here.

DtoA Chan	Port Addr	IEEE488 /IDC pin	Signal
0	104	26	rudder angle
1	105	29	turn rate
2	106	28	engine revs. *
3	107	27	ship speed / engine power selectable on the L page
4	108	5	
5	109	7	
6	10A	6	
7	10B	4	
8	10C	10	
9	10D	11	
10	10E	8	
11	10F	9	

* The engine revs meter can be a centre zero or single sided type. This is selected on the L page. Only fixed pitch propellors (M page) show -ve revs. The revs. readout is decided by M page "Maximum Revolutions" assuming the meter calibration goes up to 1000 revs.

12.4 Digital I/O

CIO ports A0..6 and B0..7 give 15 bits of digital I/O which can be configured as input or output by software. Digital outputs can also be configured as 3 state or open drain signals by software. The CIO is addressed at 100..103 with port A at 102 and port B at 101.

Port addr	IEEE488 /IDC pin	Signal
A0	20	
A1	21	
A2	22	

A3	23		
A4	24		
A5	25		
A6	50		
A7	49	reserved for ADC chip select	
B0	12	gyro 1	
B1	13	gyro 2	
B2	14	gyro 3	
B3	15		
B4	16	trip log	
B5	17		
B6	18		
B7	19		
Other PL1 IEEE488 pins		1..3	0v digital ground

12.5 Signal Calibration Using the D and L Pages

Analogue Inputs

Note the channel number for a particular signal given above. On the D page, enter "A to D channels Read Y/N Y". Note the reading for the channel when in the minimum, centre and maximum positions. ("Minimum" means full astern or full port rudder). Enter the values for that channel at "A to D" on the L page.

Analogue Outputs

Note the channel number and port address for a particular signal given above. On the D page, enter the port address as "Port Address". Also enter "Disable Interface Outputs Y". Enter values for "Value to Write to Port" until the output is the minimum value. Repeat for maximum value, and also for centre value if it is important (e.g. for rudder angle indicator). Enter the values for that channel at "D to A" on the L page. Save the data by "Save to file CALIB.DAT Y".

12.6 2nd Engine Control + Side Thrusters

Some users want the ship controls to be extended to include a 2nd engine control and side thruster controls, with feedback about the controller states as NMEA RPM sentences. This works as follows.

To activate the 2nd engine control:

Connect the control lever to analogue input 6. Switch it on on the L page, section AD I/O, at "Dual engine + propellor". This 2nd control is for the starboard propellor, and the original one becomes the port propellor control.

To activate the side thrusters:

Connect the thruster levers to analogue inputs 5 & 6. Switch them on at L page, AD I/O section "Side thrusters Dual". If only 1 side thruster is required, connect it to analogue input 5, and switch it on by “Side thrusters Single” for a side thruster effect or “Bow” for a bow thruster effect.

To activate the NMEA sentences:

The NMEA RPM sentence is switched on in the normal way on the L page, section Serports. If "Dual engine + propellor" is switched on, 2 RPM sentences are transmitted, with shaft numbers 1 (starboard) and 2 (port). In reality with 2 propellor arrangements, the propellors usually rotate in opposite directions. No account is taken of this because it would make it unclear for a fixed pitch propellor whether it is giving forward or astern thrust. Negative revolutions are only made for a fixed pitch propellor going astern.

The side thruster sentences are switched on at L page "RPM: Send thrusters". This causes 2 further RPM sentences to be transmitted for the side thrusters with shaft numbers 7 (fore) and 8 (aft). The side thruster propellors are assumed to work with fixed pitch, and maximum speed 400 rpm. If only one side thruster is connected, only the shaft 7 sentence is sent. It is also possible to switch on RPM sentences for the Engine demand at “Send EngDmd”. The shaft numbers used are 2 greater than the Engine actual value (3 & 4 for dual engine control).

12.7 Programmed Effects of 2nd Engine Control and Side Thrusters

For propulsion in the fore-aft direction, the calculations work the same as the single propellor case, the engine setting being taken as the average of the 2 controls. A difference in the engine settings causes a turning effect. The effect is considerable at low ship speeds, but decreases to 0 at ship speeds of 10 knot and above.

The effect of the side thrusters is to move the ship sideways, and to cause a turning effect if the 2 thruster settings are not equal, or a single thruster entered as “Bow” is used. The effect is considerable at low ship speeds, but decreases to 0 at 6 knot and above. The extent of the effects is adjustable using M page "side thruster power".

12.8 Engine control is “return to zero” type

Switch this on if the engine control has a spring in it that causes it to return to the zero position.

13 OTHER COMPUTER HARDWARE

13.1 NMEA Line Driver Card

This card is used to drive up to 8 NMEA serial lines at RS423 signal levels from one RS232 line from the computer.

Connection list:

PL1 9 way D socket	Computer serial port D connector if 9 pin D	if 25 pin D	Signal name at computer
2	2	3	RS232 Rx data
3	3	2	RS232 Tx data
5	5	7	RS232 signal ground

PL2 3 way KK

1	0v power
3	+5v power

Terminal block
8 outputs at RS423 level and 1 input which is passed straight on to PL1 pin 2 for connection to the computer RS232 Rx data. Other pins are signal ground.

14 THE D AND L PAGES

14.1 PAGE D

14.1.1 I/O Ports
The I/O ports are on the ADIO card, an optional extra used for connecting control levers and meters for ship control. Access to I/O ports is controlled by entering the port address, then requesting a read or write from the port. A byte written is written once only. If "read" is selected, the value is read and displayed repeatedly once a second. Usually the result of writing to a port is unpredictable because the simulator software will also be writing to the port during normal execution. "Disable Interface Outputs" allows output ports to be controlled through the D page without interference.

14.1.2 Display Picture Buildup
This causes some of the graphics windows to be constructed in visible rather than hidden memory, and can be useful for software development. In the case of the graphics radar window, it causes radar targets not to be erased from scan to scan. This gives an effect similar to "target trails" and is useful for checking the smoothness of target tracks generated by the simulation. This is important when testing the tracking performance of a connected radar.

14.1.3 Test NMEA
This allows an NMEA sentence to be entered for test purposes. It will be transmitted along with any other sentences requested on the L page. The sentence must begin with '$', but there are no other restrictions on its structure.

14.2 PAGE L

14.2.1 General
The main function of this page is to allow calibration and configuration of hardware features.

For calibrating analogue inputs and outputs, a minimum value, centre value and maximum value can be entered. *Centre* allows accurate adjustment of a centre position which is essential in some cases. In other cases, only min. and max. are significant. Centre is ignored if it is given as 0. The values are set by using the D page to control the A to D and D to A converters, and for the radar interface card, by using testrad. The procedure is detailed in the adjustment procedure for the radar interface.

The values entered on the L page are not saved as part of a saved exercise. The are saved in file calib.dat as described below.

14.2.2 AD I/O
This section allows calibration of the analogue inputs and outputs on the optional ADIO card. If the card is installed and "Enable Analogue Controls" is switched on, then a control panel connected to the ADIO card controls Own Ship. Otherwise, Own Ship is controlled by screen picking the instruments window. See the section on the ADIO card above.

14.2.3 Radar
Tuning and heading marker offset
The tuning control and tuning indicator can be calibrated and the ship's heading pulse

correctly aligned. The details are given in the description of the radar interface card.

Disable tuning
This causes echoes to be output as if the radar were perfectly tuned, and is useful when testing, or if there are problems getting the tuning working properly. State of tune is also displayed. This is a number (0 when properly tuned) that gets subtracted from echo intensity in units of D to A levels.

Background noise is generated as a low level of clutter video. It can be controlled from the L or RA page. The software uses the greater of the 2 values entered. If you want to use a fixed value, enter it on the L page, and use a value of 0 on the RA page. If you want it to vary from one exercise to another, enter values on the RA page for the different exercises, and use a value of 0 on the L page. The unit is D to A converter steps, where 63 is the maximum clutter video level that the interface can produce.

Configuration for different types of radar
This is done by entering the following information:-

Azimuth pulses per rev
Azimuth pulses per revolution of the scanner to be output from pin 10 of PL1 on the radar interface card. The proper value for many radars is given by program testrad. The software can handle values from 180 to 8192. It is recommended to use values between 360 and 2048 if possible. The problem with low pulse rates is that shadow sectors can not be accurately positioned because they are calculated in units of azimuth pulses. The problem with high pulse rates is that the rotation rate may not be accurate because of roundoff errors calculating the timer time constants, and the high interrupt rate may affect systems performance.

Pulse lengths
The 8 pulse length values for the different states of the pulse length bits.

Bit	PL1 pin	signal name	Port address
0	1	Pulse length 1	160 bit 2
1	14	Pulse length 2	160 bit 3
2	17	Pulse length 3	161 bit 6

The easiest way to get suitable values is to enter values of 0.1, 0.2 .. 0.8 for the 8 pulse lengths. Switch the radar to the different pulse lengths by changing range and pulse length setting. Note the pulse length values displayed on the RA page. Check the proper pulse lengths in the radar manufacturer's documentation and replace the appropriate values on the L page with the proper values. Most radars have only 1 or 2 pulse length bits. If some of the bits are left unconnected, it is advisable to copy the data so as to allow for unconnected bits reading as 0 or 1.

PRFs
The Pulse Repetition Frequencies for the 8 different states of the pulse length bits. These are only relevant if the interface card is generating the trigger pulse (LB3 set to INT). Check the proper value corresponding to each pulse length in the radar documentation and enter it here.

Initial echo Length and Intensity
Many radar scanners show a strong received echo immediately after transmission caused by breakthrough of the transmission pulse into the receiver circuitry. Some display units give an error message such as "Low video" if this echo is not found. The simulation does not normal-

ly reproduce this echo, but it can be produced by entering length and intensity values here. Note that for "Length" to be accurate, the delay must be correctly adjusted.

Special Effects for Sperry radars

Sperry radar	Switch this on for a Sperry connection; off in other cases.
No Rx bytes	Entering Y causes normal operation of the Sperry signals without the need to have a display unit connected.

If either of these is changed, it is necessary to save the data at "Save to file CALIB.DAT", exit the program and start again for the changes to take effect. See also - SPECIAL INSTRUCTIONS - Sperry radars.

Output log pulse dirn bit

This option switches on a *log pulse direction* signal which shows if the ship is going ahead or astern. The signal is output from the spare transistor output controlled by port A bit 4 on the radar interface card. If this option is switched on, astern speeds give log pulses. If it is switched off, they do not.

Invert pulse

The state of the log and heading marker pulses can be inverted. This may be necessary for certain radars to work properly, though most radars will work with either setting.

Timer overruns and **Heading error**

These 2 displays allow checking that the radar simulation is working properly. (The same displays are also made on the AT page). A *Timer overrun* occurs when a timer interrupt does not get serviced before the timer again counts down to request a further interrupt. Normal behaviour of the timer overrun count is that it may count up by a few initially, or when loading an exercise. If the value counts up during normal running of the simulation, it shows some type of interrupt latency problem. Kernel module testllat can be used to check this.

Once a rev. at the heading marker position, the ship's heading as indicated by gyro steps or serial data messages is compared to the direction of the radar echo output position. The difference is the *Heading error*. An aim of the simulation is to keep this figure as small as possible. Normal values are up to 0.15 degree (possibly larger for small values of RA page Scanner rotation period). Larger values indicate some type of systems problem, and the simulation should not be considered reliable. (Just after loading an exercise, or changing Own ship heading using the keyboard, large values are normal). If timer overruns are occurring, large values of Heading error are likely.

14.2.4 Serial Ports

The serial ports can be configured and assigned to different functions. All the values in this section except *NMEA selection* only take effect at program startup, so you need to save the data at *Save to file CALIB.DAT*, exit the program and start again after making changes.

Function

The available functions can be selected. The options are:

	Standard baud rate	
0		The simulation software makes no use of the port. Be sure to use this setting if a mouse controlled by a mouse driver is connected to the port.
N	4800	Normal NMEA
F	38400	Fast NMEA

A	38400	Automatic Identification System, variant of Fast NMEA
R	9600	Raytheon Course Bus. See below.
S	76800	Sperry radar signal giving the scanner azimuth and other information.

Any number of NMEA outputs (type N or F) can be selected. 2 Sperry radar outputs are needed if 2 Sperry radars are connected. In other cases, only a single output of that type is valid. Outputs of type F, A, R and S normally need a RS422 signal level.

Driver Standard / Direct
See section "Serial Ports" for explanation. The normal way of working is to use D for the ports on the PCI bus radar card, and S for other ports, so the values to enter are S S D D.

NMEA selection (0, 1 or 2)
There are 2 lists of NMEA sentences to be transmitted further down the page. This selects the 1st or 2nd list for use with the port, or 0 disables the output. The value has an effect for NMEA ports and AIS ports. An AIS data stream would normally be separate from NMEA, but since some electronic charts have only a single serial port and rely on a NMEA combiner to combine data from different devices, it is convenient to be able to send NMEA on the AIS output. If you don't want this feature, ensure NMEA selection is set to 0 for the AIS port. NMEA sentences on the AIS port work the same as Fast NMEA.

Enable Rx
This enables the port to receive serial data. It only has an effect for NMEA, Raytheon Course Bus, and AIS ports. Other types of port are controlled automatically according to their function. Received NMEA data is used in External Control mode, and for TTM and TTD message processing when ARPA testing. AIS input is used for external control of target ships. NMEA and AIS data can be received at any NMEA or AIS port. Raytheon Course Bus input its used in External Control mode.

Baud Rate
Normally this value should be left as 0.0, and the proper baud rate for the selected function will be used. Other values can be used for test and experimentation. For a normal serial port valid baud rates are those for which (115200 / baud rate in Hz) gives an integer. The serial ports on the PCI bus radar card work with a *8 clock, so valid baud rates are 8 times more.

Tx cnt, Rx cnt, Rx err
The count figures give the last 3 digits of the count of bytes transmitted and received at the port. Rx err gives the type of receiver error since the last display was made coded 0=none, V=overrun, P=parity, F=framing, C=checksum (NMEA + RCB), M=malformed (NMEA). The object is to allow checking the port is behaving as expected.

14.2.5 Raytheon Course Bus Message
This is a signal transmitted by Raytheon heading sensors. It is transmitted every 50 ms. Each message gives a value for gyro heading; magnetic heading (set to the same as gyro heading for this application) and turn rate. Bytes 13..15 contain additional information that cycles through a sequence that repeats every 9 messages. This part of the message is used to send speed information (set to water relative speed in range -99.9..+99.9 knot) and speed status (set to pulse log type).

14.2.6 NMEA Sentence Control

Sentence selection

2 sets of selections are available, and each serial port can use either. *Tx interval* and *Add checksum* have 2 values, one for Tx1 and one for Tx2.

The messages available are as follows:

Ship position

GLL	Geographic latitude longitude. The talker is selected on the NE page as "NMEA Lat Long Talker". The errors applied will differ with the selected talker.
GL2	As for GLL, but the talker is selected as "Secondary talker". If both GLL and GL2 are switched on, each message is preceded by an STN "Multiple Data ID" message.
GGA	Time, lat long position and satellite data from a GPS. The satellite data fields are filled with dummy information.
RMC	Time, lat long position and speed and course made good over the ground from a GPS.
GNS	The talker is set to GP. UTC and latitude longitude are set to the simulated values. Mode indicator is set to DDD and number of satellites to 5. Other fields are defaulted.
DTM	The fields are set as follows: Talker GP or LC as decided by NE page "NMEA Lat Long Talker". Local datum NE page "NMEA DTM Local Datum" Local datum subdivision code Null field Lat long offsets C page "Offsets from WGS datum" Altitude offset Null field Reference datum NE page "Reference datum" This sentence is transmitted immediately prior to any sentence that contains a latitude longitude position. See PAGE NE for further details.

Ship speed and heading

HDT	Heading. This can be switched to THS, the preferred alternative.
VBW	Speed in direction of ship's head and transverse, both water and ground relative.
VHW	Heading and speed in direction of ship's head relative water.
VLW	Distance run (uses the same values as the AltN page readout).
VTG	Course and speed made good relative ground.

Time

ZDA	Time. The actual date is used for the year-month-day part of the message, and the Exercise time for the hour-minute-second part. Local time is not used. If Exercise time goes beyond 23.59, date and hour are appropriately adjusted.

Instrumentation

DBT	Depth below transducer. This sentence is switchable to the alternative DPT sentence. See below.
MWV	Wind speed and direction. The figure entered on the S page is used to calculate the relative wind velocity in knots.
ROT	Rate of turn.
RPM	Propellor shaft revolutions and propellor pitch. The values depend on M page values:

	Maximum revolutions. Sets the maximum. Propellor pitch Fixed/ Controllable. Fixed pitch gives revolutions variable in +- 100% of maximum. Pitch is set to null field. Controllable pitch gives pitch varying in +-100% and revolutions varying in 40% to 100% of maximum.
RSA	Rudder angle

VTG uses the same talker as GLL. Other messages (except GLL and GL2) are preset to a suitable talker for the type of information.

Tx interval
This is the interval at which NMEA sentences are transmitted, normally in the range 1..4 s. Certain sentences may need a faster rate than 1Hz, and this can be requested by entering a Tx interval of 0. The most important sentence is HDT (or THS) which needs to be transmitted at a fast rate if it is to be used for stabilisation of radar heading.

For a Direct drive port, the effect for slow NMEA (4k8 bit rate), is that HDT sentences are transmitted continuously. For a Standard driver port, they are transmitted at 18Hz rate. If other sentences are switched on, they are transmitted once a second with a HDT sentence between each.

The effect for Fast NMEA (38k4 bit rate) is that HDT sentences are output at a rate decided by "HDT freq". Higher rate output is made for sentences VTG, GGA, ZDA. They are transmitted every 110 ms. If other sentences are switched on, they are transmitted once a second. If high rate sentences are not switched on, Tx interval of 0 works the same as 1.

Decimal Places
The number of decimal places in latitude longitude fields, and in the HDT heading can be controlled.

HDT freq
This is a special feature for some users who want a high rate for HDT sentences, but need the rate to be adjustable. It works for Fast NMEA and AIS ports. For Standard driver ports, the output rate is 18/freq Hz. For Direct drive ports, the output rate is:

freq	Output rate Hz
0	20
1	50
other	100/freq

Add checksum
The checksum is mandatory for a few NMEA sentences, but optional for most. This option causes it to be added to all sentences.

HDT or RCB heading increment
The heading information in a NMEA HDT sentence or Raytheon Course Bus signal changes in increments of this amount. The object is to simulate the behaviour of real heading sensors. This can have a significant effect on the tracking performance of ARPA radars. The options are:

6	1/6 degree	=0.167 degree	Normal gyro steps.

4	1/4096 rev	=0.0879 degree	Used by some heading sensors
M	1/65536 rev	=0.0055 degree	Resolution used in most simulator calculations

Note also that the HDT and RCB heading is derived from the same source as gyro heading and its rate of change is limited by *Max gyro turn rate*. (See below).

Depth Sentence
The standard depth sentence to use is DBT (depth below transducer). Some users prefer to use DPT sentence, so it is made a switchable option. When constructing DBT sentence, the transducer is assumed to be at the same depth as the keel. (Keel depth is given on the M page). The DPT sentence contains depth below transducer, and also transducer position relative to keel which has to be a negative number. For the purpose of constructing this sentence, the transducer is assumed to be at 3/4 of the keel depth.

Heading Sentence
The traditional HDT sentence can be switched to THS, the preferred alternative nowadays.

RPM Sentence
Normally this is a single sentence for the single engine / propellor. It is possible to send additional sentences for a 2nd engine / propellor, for side thrusters and for engine demand. See section “2nd Engine Control and Side Thrusters” in the AD I/O card documentation.

14.2.7 Section Other

Maximum Turn Rate of Gyro Stepper
This value allows gyro turn rates to be limited to those which the hardware can handle. The maximum turn rate of the ship varies with manoeuvring characteristics but is typically 10 deg/s. A "Maximum gyro turn rate" greater than this should normally be used. When a large change in ship's heading is made by the instructor on the S page the gyro will turn at the given maximum rate, and this can be used for experimentation to see what the hardware is capable of. The turn rate limit applies to serial data messages (NMEA and RCB) as well as gyro steps.

Enable save / restore window sizes
If this is switched on, the size of the graphics windows is saved as part of the L page data and restored when rdtsim runs again

14.2.8 Saving of Calibration Data
When new calibration values have been entered and checked, the data are saved by entering "Save to file CALIB.DAT Y". The file calib.dat created is automatically read when the simulator program runs.

It is allowed to use extra letters in the filename calib.dat to show which simulator the data apply to. For example caliblir.dat could be used for Lisbon radar simulator. When the simulator program runs it will read the calibration data from the first file found having a name that matches calib???.dat. Only one such file should be present in the default directory. When new calibration data are written, the existing file name will be retained. The file caliblir.dat would first be created as calib.dat, then renamed by:
mv calib.dat caliblir.dat

15 PROGRAM TESTRAD

15.1 General

Program testrad controls a radar interface card by outputting various test patterns to it for purposes of setting up and checking for correct operation. The results can be observed on a connected radar display unit and on an oscilloscope connected to the test points of the interface card. Further details of use of testrad are given in "Radar Interface Card - Adjustment Procedure".

Some simulators have 2 radar interface cards driven from one computer. testrad performs identical tests on the 2 interface cards.

The most important effects tested relate to radar video. See "RADAR ECHO CONSTRUCTION - Radar Video Characteristics" for details of radar video. When using testrad, state of tune and pulse length have no effect on the radar video.

15.2 Running testrad

15.2.1Command line switches

-s Load echoes in a spiral pattern. This is useful for checking the echoes load to their correct sector.

15.2.2 Other variables

Details for the radar can be read from file calib.dat, or they can be directly entered.
Positive or Negative going heading marker pulse can be selected. Negative is the most usual, but most radars will work with either. Use of positive corresponds with "Invert pulse Head Mk Y" on the L page of rdtsim.

It is necessary to enter a value for "Azimuth pulses per rev". This depends on the type of radar display unit connected, and figures are displayed for a number of radars. A value can also be found by experimentation. Enter a low value and run test 2. The radar picture will probably show a large gap where the trace jumps back to the ship's head when the heading marker pulse is sensed. Exit testrad and run again with an increased number of azimuth pulses, and repeat until the trace progresses smoothly through the ship's head direction without any gap or overshoot.

testrad then prompts for the test to be performed. There are 4 tests. Tests 2 to 4 run continuously. They can be halted by a key press. It is then possible to continue, select another test or exit testrad. All the tests drive the radar picture at a rate of one revolution in 2.5s.

15.3 Test 2

15.3.1 Radar Video - Intensity levels

At range 0, a clutter video echo of maximum intensity is output with intensity counting down to reach 0 at 5.7 mile range. At 6 mile range, a target video echo of maximum intensity is output, and this decreases to 0 in 15 steps, each step 0.4 mile. (16 intensity levels, 15..0, end range of echo 12 mile). When normally adjusted, the maximum clutter video echo should be a little weaker than the maximum target video echo.

15.3.2 Azimuth pulses per rev
These are the figures supplied at initialisation.

15.3.3 Pulse length bits
The state of the 3 pulse length bits is displayed. Their significance varies from one radar to another, but each pulse length selected on the radar display unit should give a different reading. The pulse length selection normally varies with a setting of "Pulse length" and the range in use.

15.3.4 Tuning A to D converter
This reading gives the position of the tuning control on the radar display unit as a 2 digit hexadecimal number. The maximum value depends on the adjustment of VR9 on the interface card, and should agree with the figure entered on the simulator L page.

15.3.5 Transmission indicator
If transmissions are detected, a display is made of 8 'T's moving across the screen. If the radar interface card is linked for internal trigger, the display will not be affected by the radar being switched to Standby or switched off unless the "Standby" connection at interface card PL1 pin 19 is working. The transmission indicator will not work if the IRQ indicator is not working.

15.3.6 IRQ indicator
If radar card IRQs are detected, a display is made of 8 'I's moving across the screen.

15.3.7 Log and Gyro
Log and gyro are driven at a rate of one log pulse transition and one gyro step per scanner revolution for checking purposes. This is equivalent to a speed of 3.6 knot and a turn rate of 1 degree in 15s.

15.4 Test 3

15.4.1 Radar Video - Heading Alignment
A flash showing the start of the heading marker pulse can be used for checking the heading alignment. It is recommended to make this alignment by internal adjustment in the radar. If this is done, then the alignment is correct if the heading marker lies on top of the flash.

15.4.2 Radar Video - Delay Adjustment
A target video echo of maximum intensity at range 0.20 to 0.24 miles can be used for checking the delay. Select 1/4 mile range and check the position of the echo. It may be necessary to reduce the gain, as the echo tends to "spread" at high gain settings. The delay is adjusted by interface card VR1 and/or an internal adjustment in the radar display unit.

Other information displayed for Test 3 is the same as test 2.

15.5 Test 4 - Special purpose test pattern
This test is similar to test 2, but the radar video pattern is defined in a text file. See file testrad.dat for examples and explanation. This test is only used for special purposes when the response of the radar display unit to specific echo patterns needs to be investigated.

15.6 Test 5 - Tuning Indicator

This test is used to check operation of the tuning indicator on the radar display unit. A 2 digit hexadecimal number controls the voltage output to the indicator. The values necessary to get a certain deflection should correspond with those entered on the simulator L page. The voltage output can be adjusted by interface card VR7.

15.7 Running without a radar connected

testrad is often used for setting up an interface card and testing for correct operation without a radar connected. When used like this, LK14 should be set to 3. The useful test is test 2.

15.8 Use with Sperry radars

Additional functions are needed with this radar to handle the RS422 data streams. See “SPECIAL INSTRUCTIONS FOR CERTAIN RADARS - Sperry radars” and “PAGE L - Serial ports - Programmed baud rate” for details of the serial data streams. When testing without a radar connected, it isn’t necessary to use the special Sperry options.