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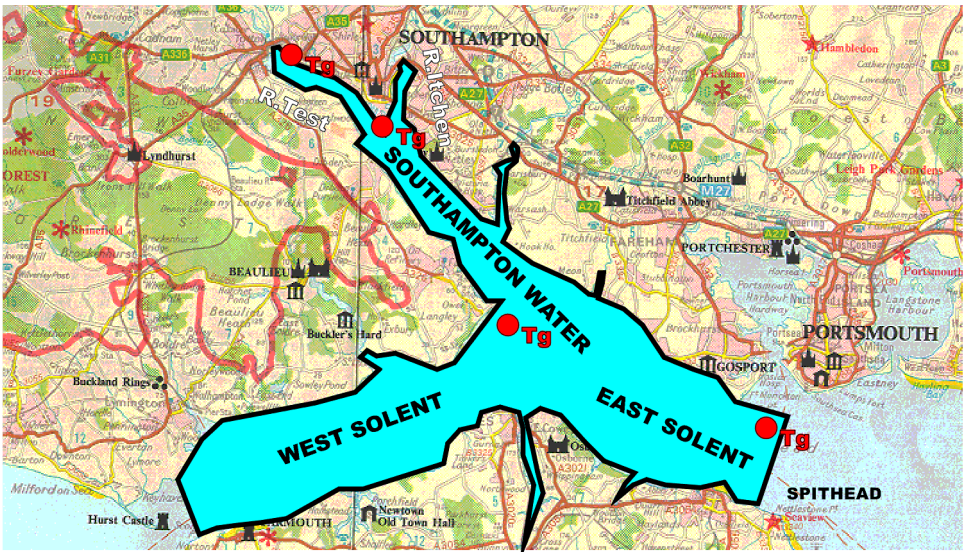
PORT OF SOUTHAMPTON TIDE GAUGE SYSTEM

TABLE OF CONTENTS

CONTRACT DESCRIPTION

The Port of Southampton, owned and administered by Associated British Ports plc, is responsible for the overall vessel traffic in the areas of the River Test, River Itchen, Southampton water and the deep water approaches in the Solent and Spithead.



Area covered by Port of Southampton Tide Gauges

The commercial traffic handled by the port includes large crude oil tankers discharging at the Fawley refinery, bulk carriers, car and container transports. The port administration has three permanent tide gauges installed to provide tidal elevation information to the following users …

- The Port control and Pilot services.
- The Port Hydrographer.
- The general public and marine leisure users.
- Port records and administration.
- The UK Hydrographic office.

The tide gauge data is sent by telemetry to a central data collection and presentation system within the port VTS (Vessel Traffic Service) centre, the focus of port activity. The data is presented and stored on a single PC using a bespoke system written by the previous Hydrographer to the port.

The object of the contract was to replace the existing bespoke tide gauge data collection system with one using new computer hardware and software technology. As the system is in use 24 hours a day by the port control officers it was also deemed that the system would be installed in parallel with the existing system to ensure overlap and a smooth transition.

HERITAGE SYSTEM

The existing system hardware consisted of a standard IBM PC running under MSDOS with a proprietary 4 input serial port card installed. The card was not suitable for use with the Windows operating system. The existing software running on the system consisted of a single task bespoke program that provided the following functions …

- Serial data input from the three connected tide gauges.
- Lookup of predicted values from a single datafile.
- Character screen showing current values, predictions etc.
- Graphic screen showing 24 hour history of the data collected.
- Data storage to an ASCII text format datafile.

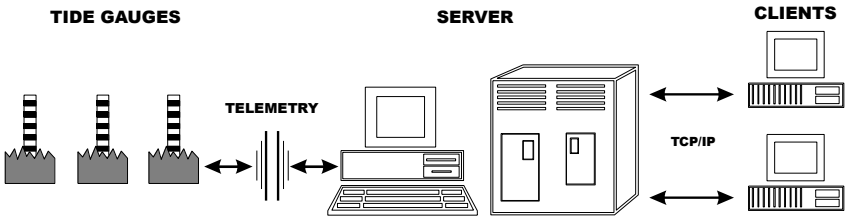
Limitations

The following limitations were the main criteria that were used to decide that the old system should be replaced …

- Single task program with no possibility of expansion.
- Not possible to upgrade the program to Windows compliance.
- 'Hardwired' code for connections and data format.
- Stored data not available in an industry standard format.
- Predictions limited to a single location
- No facilities for Multi-user access to the data
- Non YEAR 2000 compliant

REPLACEMENT SYSTEM

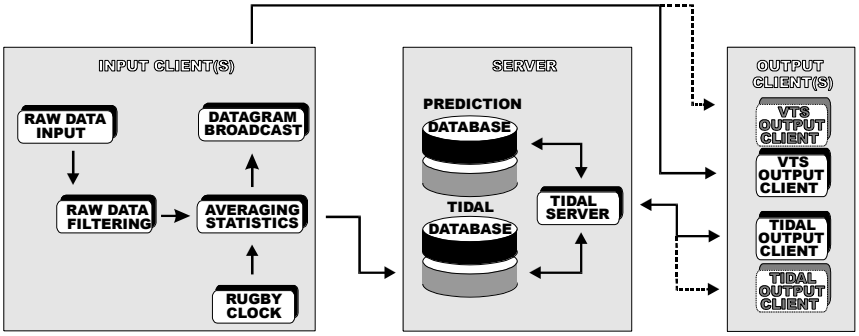
The proposal put forward and accepted in the L.M.Technical Services tender document was to replace the single user data collection system with a design based on modern computer hardware, software and operating system facilities.



PHYSICAL LAYOUT

Client/Server Architecture

The main goals of the new system were the use of programs in a modern multi-user environment using the client/server model for data collection and retrieval.



LOGICAL LAYOUT

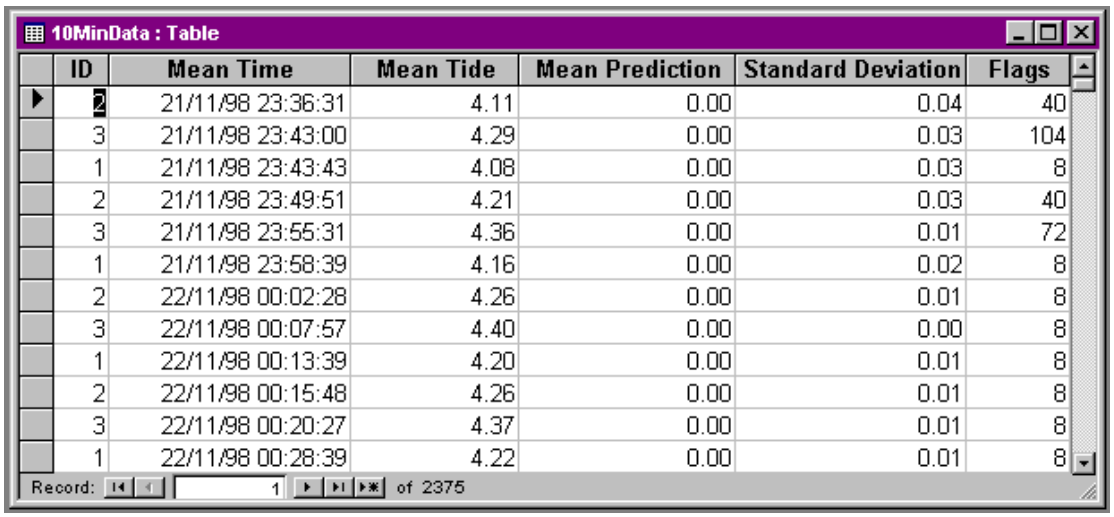
To achieve this architecture the task was broken down into programs that provided the following functions …

- **Input Clients** - Collecting, Filtering and storing the Tide Gauge data.
- **Tidal Server** - 'Middleware' program for retrieving data and calculating predictions.
- **Output Clients** - Programs to enable users to retrieve or view stored data.

The design concept was provide a system design that would be extensible from a single computer to a large network using standard Internet protocols to communicate between the various software elements.

Database Storage

To enable the future expansion of the system and 'open' access to the stored data from other third party software the design made extensive use of modern database technology. In particular the use of the ODBC (Open DataBase Connectivity) drivers as the database interface providing the system with an open data storage design.



10MinData : Table

ID	Mean Time	Mean Tide	Mean Prediction	Standard Deviation	Flags
2	21/11/98 23:36:31	4.11	0.00	0.04	40
3	21/11/98 23:43:00	4.29	0.00	0.03	104
1	21/11/98 23:43:43	4.08	0.00	0.03	8
2	21/11/98 23:49:51	4.21	0.00	0.03	40
3	21/11/98 23:55:31	4.36	0.00	0.01	72
1	21/11/98 23:58:39	4.16	0.00	0.02	8
2	22/11/98 00:02:28	4.26	0.00	0.01	8
3	22/11/98 00:07:57	4.40	0.00	0.00	8
1	22/11/98 00:13:39	4.20	0.00	0.01	8
2	22/11/98 00:15:48	4.26	0.00	0.01	8
3	22/11/98 00:20:27	4.37	0.00	0.01	8
1	22/11/98 00:28:39	4.22	0.00	0.01	8

Record: 1 of 2375

Example of Ten Minute Data table

In this instance the underlying database used was the popular Access product supplied within the Microsoft Office suit of programs. Using this product ensured ease of use for database maintenance, reasonable data security and a simple route to sophisticated end-user data retrieval and presentation facilities if required. The internal use of SQL (Structured Query Language) also enables an easy upgrade path for the database to more powerful corporate databases if required at a later date.

The system hardware was specified as standard modern PC equipment running a Windows 32Bit operating systems such as Windows NT, Win95 and Win98. The only piece of special equipment to be provided was a four port serial input card together with a Windows driver to interface it as standard windows serial ports. The system is interconnected to other computers using standard LAN technology that supports the Internet Protocol (TCP/IP).

The following bespoke programs were authored in C++ for use with the system …

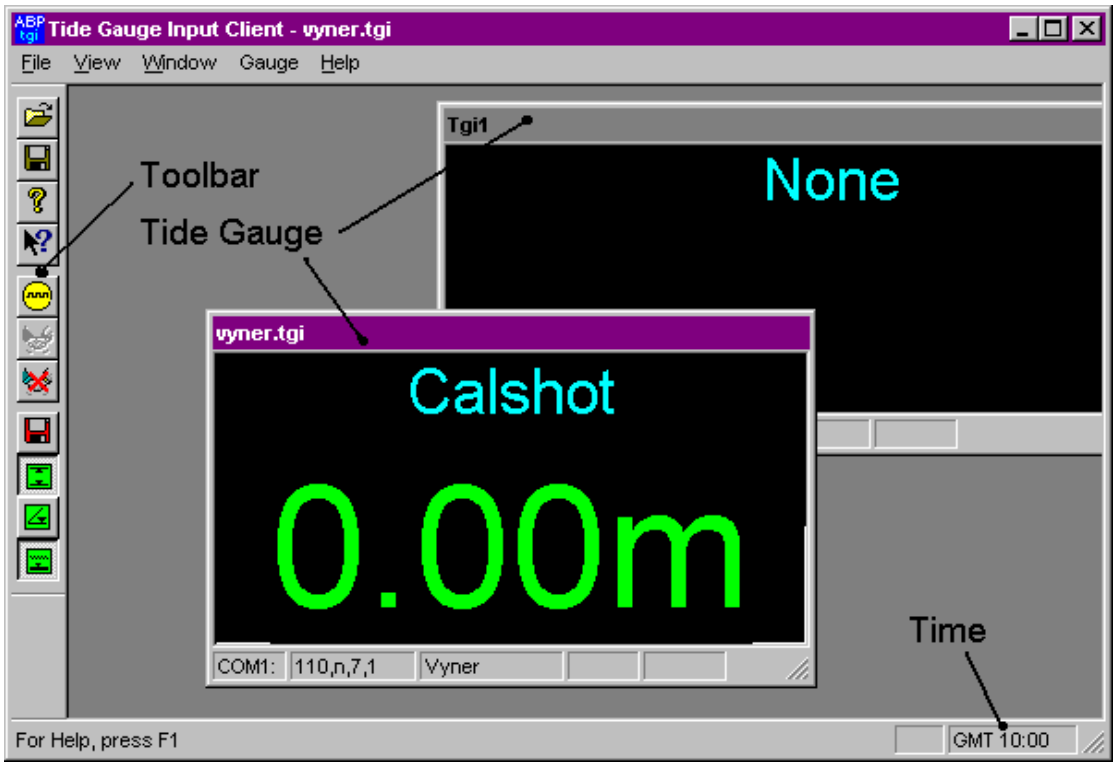
- **TGI** - General input client to collect and filter data and store the results in a central database.
- **TPS** - Server program to calculate tidal predictions and access stored data for output clients.
- **TGO** - Output client to view predicted and stored data accessed via the TPS server program.
- **VTS** - Output client to display current tide gauge data and surge information.
- **IMP** - A small utility program to import prediction data to the database.
- **PPS** - A utility program to automate Passage Planning procedures performed by Pilots.

In addition two blank databases were designed for the project one for recorded data and the other for predicted data.

INPUT CLIENT PROGRAM (TGI)

DATA INPUT

Input to the program is in the form of serial ASCII data sent by radio telemetry from individual tide gauges and received on the PC serial ports.



Typical screen shot of TGI program

The user can set up any number of individual tide gauge inputs by providing the following set-up information …

- Serial port information such as Port number, baud rate and parity.
- Data format parameters such as string length, data field position, leading characters and delimiters.
- Database entry with Name and individual ID number of the gauge.
- Database entry with gauge data such as location and filter values.

Current values, last time of data receipt and any error flags are displayed on the individual tide gauge windows and their associated status bars. Values with error flags set are shown in red to highlight them in the display.

RAW DATA FILTERING

The TGI program provides the following raw data filtering facilities …

- String errors such as length and bad characters caused by transmission faults.
- Maximum and minimum acceptable data values.
- Range checking with a predicted value for the same location and time.
- Envelope checking for rate of change between current and previous values.

Detected errors are stored as binary flags within each data record.

DATA AVERAGING

The program accumulates the following database table records for each gauge connection …

- **OneMinuteMeans** - Average of filtered data accumulated over a one minute period.
- **TenMinuteMeans** - Average and SD of filtered data accumulated over a ten minute period.

Each record is saved together with its average time and any accumulated error flags over its selected period.

VTS DATAGRAMS

The OneMinuteMean record is also transmitted as a Datagram over the network. This is captured and displayed by the VTS output client program as the current and predicted data for each particular gauge. The surge value (difference between current and predicted value) is also display as this is of operational use to the port control officers. Datagrams are used for this information as it is ‘connectionless’ and does not tie up network resources as with a connection to the Tidal Server.

SERVER FUNCTIONS

PREDICTION IMPORT

A utility program IMP.EXE was authored to import predicted data from two sources …

- The UK Hydrographic Office hourly data files.
- Output from the popular TIDES.COM program for windows.

A major problem encountered with importing data is the poor quality control associated with the data files. The files produced by TIDES.COM proved the better in that they provided complete date, time and source information for the prediction but lacked co-ordinates for the predicted data set. The UKHO data files were the worst in that they totally lacked date, time, source and location information for their data sets, in fact time and date can only be inferred from the position of values within the set. This situation has been referred to the UKHO and after providing a thin excuse that it conformed to IMO standards they agreed that the situation should be rectified.

TIDAL PREDICTION SERVER

A limitation with most tidal prediction systems is that they only predict tidal data at a fixed location. In the case of Southampton with its ‘double tide’ effect the values predicted at the docks have little resemblance to the values seen in the Solent or Spithead approaches. The TPS (Tidal Prediction Server) provided as part of the system provides a facility where each tidal prediction location can be real (an actual time series) or virtual (a time series with phase and amplitude offsets).

In addition to multiple locations the server also provides the prediction at a given location by co-tidal interpolation between the nearest real or virtual prediction locations. The server replies to the following prediction requests from client programs …

- Provide a one minute prediction set for a day at a fixed location (TGO client time series)
- Provide a single prediction at given location and time (Passage planning and VTS client)

Using a server to provide predictions ensures a high level of Quality Control within the port in that all users that require prediction values are actually using the same data set. The data set can also be subjected to quality checks by the Hydrographer before it is used ‘live’ by client programs.

DATABASE SERVER

The TPS program also provides access to the stored tide gauge data, as recorded by the TGI program, by responding to the following requests from client programs …

- Provide information on available Tide Gauge locations (TGO client)
- Provide a one minute recorded data set for a day at a selected tide gauge location (TGO client)
- Provide a ten minute recorded data set for a day at a selected tide gauge location (TGO client)
- Provide the latest recorded value for a given (TGO client)

Using the TPS server program to access the database as a 'Middleware' program has the advantage of faster and more orderly access to the data by a 'queue' of client programs. The data is retrieved in reply to a specific request and transmitted in a very compact packet over the LAN to the requesting client program.

RUGBY TIME CLOCK

Modern PC clocks are notoriously inaccurate and can easily wander several minutes in a month. To the typical computer user this is not a great problem and the time can easily be adjusted on a regular basis either manually using utility programs or automatically when the system accesses the Internet. An additional problem is that modern computer operating systems go to great lengths to set clocks to adjust for daylight saving and local time variations, all of which are not required by a data logging system.

For an automatic tidal data logging system in a maritime environment it is critical that the data logging time is accurate and that the time base is Greenwich Mean Time referenced (UTC). To achieve this the TPS server program is connected to a hardware device that reads the correct time, in this case the Atomic Clock Signal transmitted from Rugby and Frankfurt. The program automatically checks the clock hardware for errors (loss of signal, battery state etc.) and sets the data logging PC clock on the transition of each midnight.

OUTPUT CLIENT PROGRAMS

VTS OUTPUT CLIENT

The VTS output client program was designed to be run anywhere on the LAN (local area network) and 'listen' for network datagram transmissions from the TGI Input client program. The purpose of the program is to display the current one minute mean filtered value as a numeric display together with its current surge value (difference between prediction and recorded values). Each of the datagrams contain the following information in a very compact binary data transmission packet …

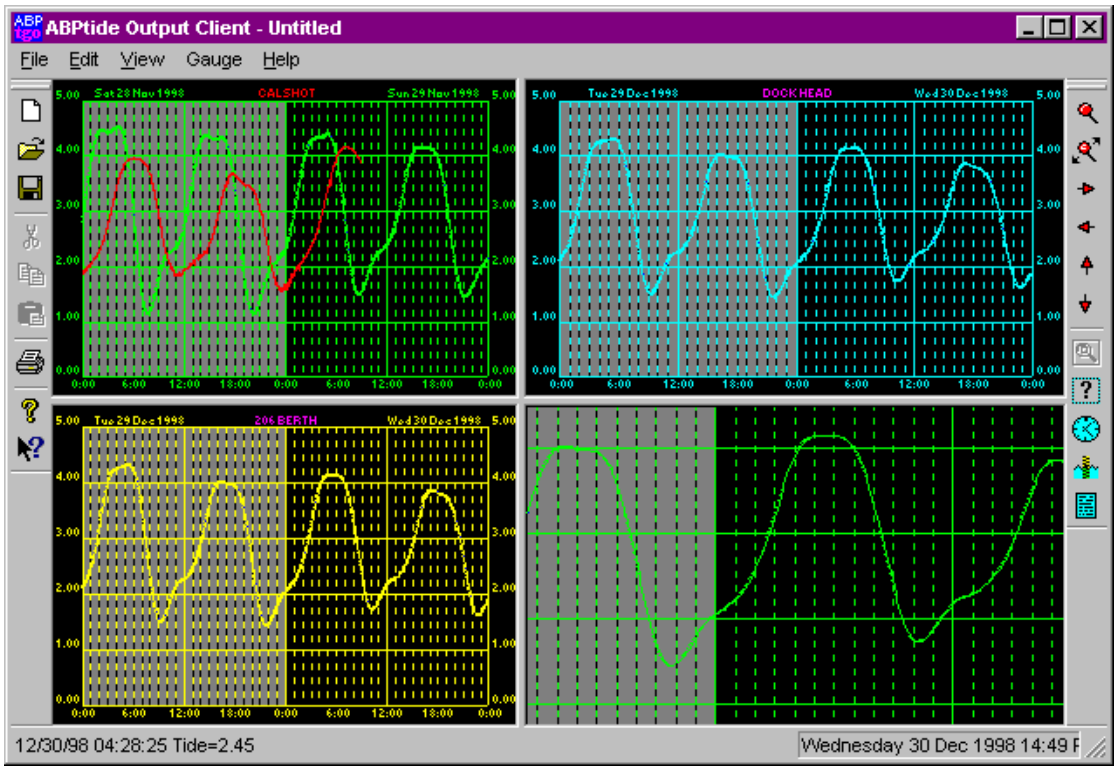
- **Name -** The name identifying the source tide gauge.
- **Time -** The mean time the data was recorded (normally 30 seconds slow)
- **Tide -** The latest one minute mean for the source gauge.
- **Prediction -** The predicted value for the source gauge at the Mean time.

As there can be several versions of the TGI program running on the network and therefore multiple sources of the datagrams, the VTS program maintains a list of all the gauge names seen. The user can select up to four of these gauges to be displayed simultaneously from the programs multiple pane display.

GAUGE OUTPUT CLIENT

The TGO (Tide Gauge Output) client program has been designed to provide the user with a simple to use 'front-end' to the data collection system, the program provides graphic display of the following information …

- One minute recorded data for a given gauge and two day period
- Ten minute recorded data for a given gauge and two day period
- One minute predicted data for a given gauge and two day period



Typical screen shot of TGO program showing four gauges

The user can select up to four gauge locations for display in any one of the four pane window display. Each display can be zoomed by dragging the mouse around the data required, similarly data can be selected for visual inspection in numeric form with the option to output the selected data to an ASCII data file. The gauge to be displayed is selected from a server provided list of available gauge locations. The date of the required data is selected using a simple graphic calendar dialogue box, the program always shows a two day display of the selected date together with the previous day's predicted and recorded data.

PASSAGE PLANNING

The PPS passage planning program is a separate utility program which simulates the current passage planning calculations performed by hand for each planned passage by the port Pilots. In addition to automating the existing 'Blue Book' calculation the program adds QA features such as saving data in a common database, obtaining tidal predictions from the Prediction Server program and storing the results of each calculation in a common database.

FUTURE EXPANSION

GRAPHIC PASSAGE PLANNING

The Tidal Prediction Server program has been designed to provide predictions for variable time and location, this is exactly what a vessel passage is, a series of different locations (along a selected route) together with a series of times (ETA at the way-points along the route).

A future plan is to present a graphic plan of the port from which the passage planner selects a series of predefined routes together with entry of anticipated speed/ETA. The program will then be able to plot a projected selection along the route showing bathymetry, time elapsed and predicted tide elevations. The program will be able to highlight possible problem time/locations for vessels of a given draft and predict possible passage 'envelopes' given various clearance criteria.

VIRTUAL PREDICTIONS

The existing system will provide historic data for the analysis of phase and amplitude shifts of locations within the port area not covered by physical tide gauge equipment. This will add to the accuracy of predictions across the whole of the port area and help to identify areas where physical tide measurement equipment may be required.

TIDE GAUGE UPDATING

The existing gauges suffer from inherited capabilities which are no longer required such as slow transmission speed, data averaging/smoothing and inefficient data formats. As these gauges eventually fail they will be replaced with equipment based on modern technology. The TGI input client program is designed to be easily connected to these newer gauges as they become available.

A need has been already been identified for an additional gauge at the Nab Tower location in the Solent. The facility to add gauges to the system is only limited by the bandwidth of the LAN installed on the computer equipment at the port. An interesting proposal has been suggested of Tide Gauge data being transmitted to the system using a WAN instead of the current radio/microwave telemetry system, this opens the possibility of directly providing the tide data on vessels under the control of pilots and local service traffic such as public ferries.

INTERNET WEBSITE

A proposal is being considered to provide the tidal data on a web page server which could easily be accessed either internally over an Intranet or external public access via the Internet. The system has been designed to easily expand to accommodate this requirement which is currently only limited by hardware and data semantics.

CONCLUSIONS

With hindsight the system has rapidly evolved as it has been developed. The major change from the original specification has been the departure from using the data access facilities offered within products such as Microsoft Access and SQLserver in favour of the 'Middleware' design of the Tidal Prediction Server.

A major problem encountered in the commissioning of the system was the interfacing of a modern high-speed multitasking computer system with very slow (110 baud) incoming data streams from old technology tide gauges. The trade-off being between providing a modern interactive GUI environment without an inordinate amount of processor time being spent scanning for data input.

Another area of difficulty encountered was the transmission of data across the legacy network system currently installed throughout the port. For historical reasons the existing network includes legs which support older Netware/MSDOS architecture and are not compatible with newer Windows NT operating system environments. As the base protocol used by the system is TCP/IP then these legs will gradually be accessed as their equipment and software is updated. The proposed new VTS system will probably be based on Windows NT architecture and will undoubtedly be the catalyst for bringing the LAN up to date.

In conclusion the system has succeeded in providing the main objectives of its design which are evident in the following features ...

- An expandable system based on modern computer technology.
- Rigorous data quality control and storage to IMO standards.
- Multi-user access to current and historic data.
- Data stored in an industry standard database format.