MACHINERY CONTROL PROCEDURAL TRAINING IN THE ROYAL NAVY

FUTURE TRENDS

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ABSTRACT
Existing machinery control procedural training methods in the Royal Navy are briefly described. The differing requirements for procedural training in future major surface warships are then assessed. The means by which these requirements can be met using embedded on-board training and advanced technology shore trainers are developed, and the resulting benefits in reduced cost and training time with enhanced operating standards are described.

Introduction

The latest Royal Navy ships now in service incorporate Machinery Control and Surveillance (MCAS) systems. These control the main propulsion system and associated auxiliaries, and also a range of other auxiliary equipments and systems to a more limited extent. A primary and secondary surveillance system is also provided. The Integrated Platform Management System (IPMS), to be introduced in future surface warships, will take this concept a stage further. All platform functions, including Damage Control, but excluding weapons, sensors, navigation and communication systems, will be integrated, controlled and monitored within a single system. The architecture and layout of such a system is still to be defined but is likely to include distributed processing and relatively complex data transmission systems. The Man Machine Interface (MMI) will probably be via a number of programmable VDUs situated in a Ship Control Centre (SCC). The introduction of this new system will have a number of implications for training, both at sea and ashore.

The Royal Navy is committed to increasing on-board training whilst maintaining a level of shore training to give personnel a sufficient standard of expertise before joining ships. Thus the requirements of both shore and on-board trainers need to be assessed. The ultimate objective is to provide both increased training opportunities and more effective training, thus resulting in a significant increase in both watchkeeping and maintenance standards.

Review of Existing Training Methods

Types of Training

The following types of procedural training for frigate/destroyer sized ships are provided at present at sea and ashore:

(*a*) At sea. Procedural training including emergency procedures, reversionary and local control.

(*b*) Ashore. Procedural training including normal operating procedures, emergency, reversionary and local control.

(*c*) Ashore. Familiarization/Introductory training.

These are now described in more detail, highlighting the effect that on-board training has on the ship and the training equipment required.

On-board Procedural Training

In existing ships no special equipment is provided for on-board procedural training. Designated sessions of up to two hours are provided in the ship's operational programme at sea during which other ship activities are severely curtailed. During the training session the ship will be restricted in her ability to manoeuvre and so training can only be conducted in the open sea when there are few other ships in the vicinity. The training sessions will normally be run by up to three senior ratings.

Although, ultimately, training using actual equipment should result in the best training conditions, the restricted training opportunities, the restriction on other ship activities and the close level of supervision required mean that drill opportunities are far fewer than is desirable. A logical step forward would be to provide more accessible on-board training facilities. A slight loss of realism would be acceptable. This would be backed up by infrequent local control drills to enable trainees to use the actual equipment.

Shore Procedural Training

Shore procedural training courses at HMS *Sultan* normally consist of classroom-based familiarization and system training which is then reinforced by a procedural training period on the main ship simulator. During this time, normal operating procedures (e.g. preparing for sea, shutting down, etc.) and emergency procedures will be practised.

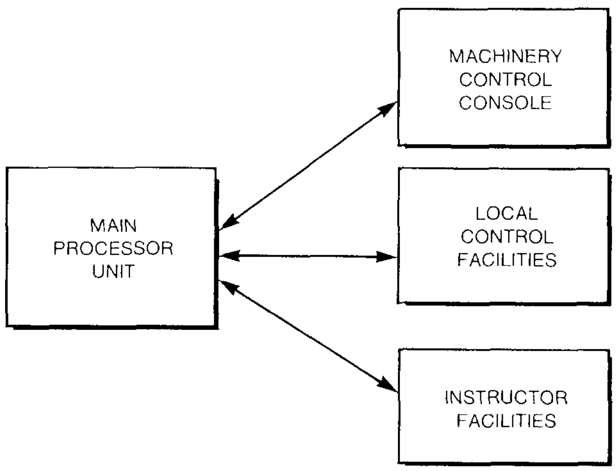

FIG. 1—COMPONENTS OF A TYPICAL SHORE PROCEDURAL TRAINER

Present ship simulators consist of a number of elements (FIG. 1), not all of which are common to all simulators:

(*a*) *SCC Main Machinery Control Console*. A full-size replica (externally) of the ship machinery control console. Interfaces will be provided to the main system simulation computer.

(*b*) *Main processor*. The characteristics of the ship and its systems are modelled by software running on a main processor unit (normally a small mini-computer). Not all systems will be modelled fully and an accuracy sufficient to enable realistic training to be conducted is required.

(*c*) *Instructor Facilities.* An instructor console is provided to enable the instructor to inject and monitor malfunctions, the state of the simulator and the actions of the trainees. This facility interfaces directly to the main simulation computer. The latest simulators are controlled via touch screen colour VDUs, thus reducing the instructor loading whilst enabling him to monitor exercises more effectively.

(*d*) *Local Control Facilities.* These are either provided by actual ship's equipments interfaced to the main simulation or emulations of the equipment and systems displayed on VDUs. Once again the operators' actions will interact fully with the simulation, allowing accurate responses.

On-board Training for the Future

The on-board training requirement is in addition to and complementary to the training given ashore. The intention is that on-board training should consolidate operator and procedural skills and, in time, improve these skills. A basic level of knowledge can therefore be assumed for personnel utilizing the on-board training facilities. Both individual and team training should be catered for where possible.

Two types of skill need to be developed:

(*a*) Normal operating procedures. These procedures include recovering from the deep maintenance state, preparations for sea, start/stop routines for individual equipments, normal operation at sea and shutting down routines. Normal operation will include machinery operation in the cruising state and action state.

(*b*) Emergency Procedures. The procedures required to safeguard men and machinery after malfunction, breakdown or action damage. After carrying out initial safety actions, recovery and/or reversionary/ emergency control procedures have also to be practised.

The activities required to carry out these procedures can be split into three areas:

(*a*) SCC activities. Under normal circumstances all procedures and activities are controlled from the SCC.

(*b*) Machinery Space activities. During normal operation, machinery space activities are minimal. However, during the preparation/shutting down phases and in an emergency it is likely that machinery space activities will increase to a high level.

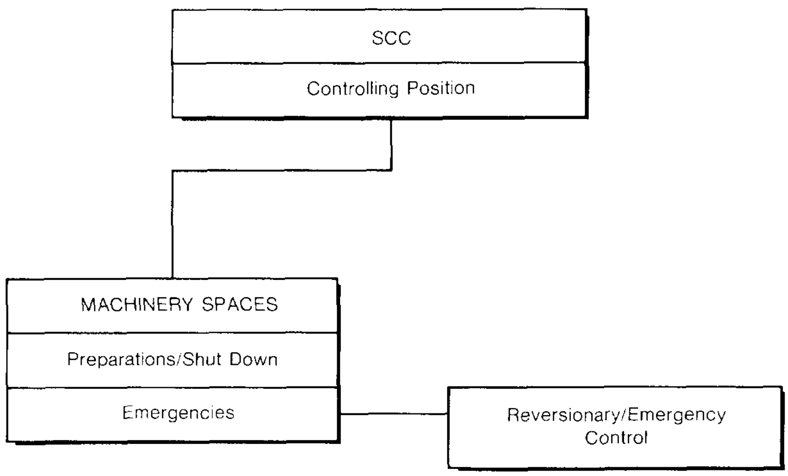

FIG. 2—PROCEDURAL TRAINING ACTIVITIES

(*c*) Reversionary/Emergency Control activities. As a result of a breakdown or damage, main machinery may have to be operated for extended periods in local control. Suitable skills will need to be developed.

The relationships between these activities are shown in FIG. 2.

On-board consolidation and improvement of the above skills, whilst at the same time minimizing the impact on departmental and whole ship activities, will obviously have an effect on the type of training equipment and facilities to be provided on-board. Such equipment will either be stand-alone units or fully integrated within the IPMS concept. The facilities that could be provided by such equipment will now be described.

Stand-Alone Units

Stand-alone units are likely to be IBM PC-compatible or similar machines. Wherever possible, the machines should be fully compatible with any training software developed for the shore stand-alone training facilities. Facilities available on this unit are likely to include courseware covering the following items:

(*a*) Familiarization and foundation knowledge.
(*b*) Systems and equipment training.
(*c*) Maintenance training.
(*d*) Limited procedural training.

The subjects covered in (*a*) and (*b*) need to be implemented in a standard courseware language in order to aid portability and updating/amendment. A limited procedural training capability could also be implemented on such a machine. This would provide an introduction to the basic skills required before progressing to the fully integrated training facilities available in IPMS.

Fully Embedded IPMS On-board Training Facility

The full requirements of an embedded training facility cannot be defined until the functions and characteristics of IPMS are agreed. However, as embedded training is likely to have a large influence on the design of IPMS, its requirements must be considered at an early stage.

The main purpose of the embedded training facility is to aid procedural training without affecting other ship activities, thus increasing the number of training opportunities whilst maintaining realism and training effectiveness. For embedded training to meet these objectives it should have the following characteristics:

(*a*) Availability of one or more IPMS MMI positions to be designated as 'training mode'. The other MMIs are to remain available for normal ship control.
(*b*) MMI positions configurable in either trainer or normal mode. It is envisaged that in the cruising state only one position needs to remain in the normal mode in order to retain full control of all functions.
(*c*) At higher states of readiness (i.e. defence and actions states) the training facility is not required. All positions will therefore be available for the normal control mode when in this condition.
(*d*) Two different modes of training are to be available:
 (*i*) Self-teach.
 (*ii*) Instructor-supervised.

The self-teach mode will be available at all times in the cruising state to enable an individual to work through a syllabus of different exercises with no external supervision. In the supervised mode more elaborate exercises will be available, with the instructor increasing the complexity depending on student progress. Facilities are also to be available to allow the instructor to monitor the student(s) fully.

(*e*) In the self-teach mode only one position needs to be designated for training (FIG. 3). This position will be 'disconnected' from IPMS to ensure there is no possible interaction and will interface with the training package which will initiate malfunctions and other events and make the correct simulated IPMS responses.

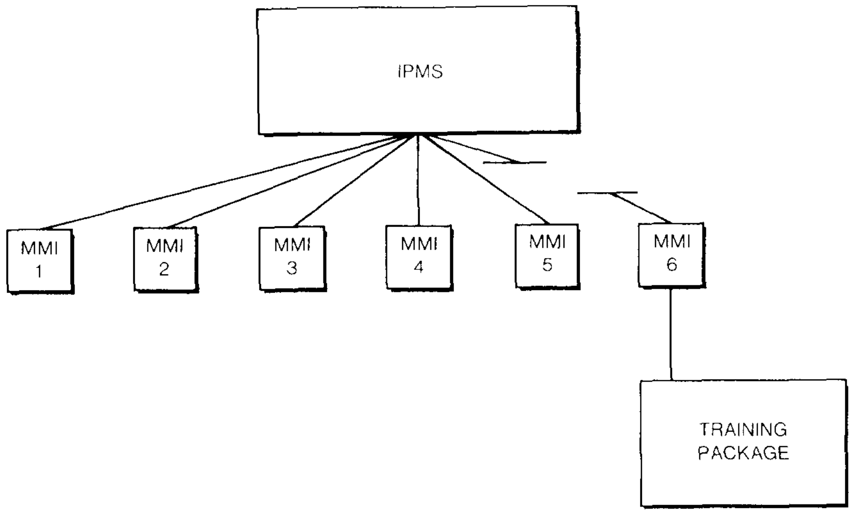

FIG. 3—IPMS—SELF-TEACH TRAINING MODE

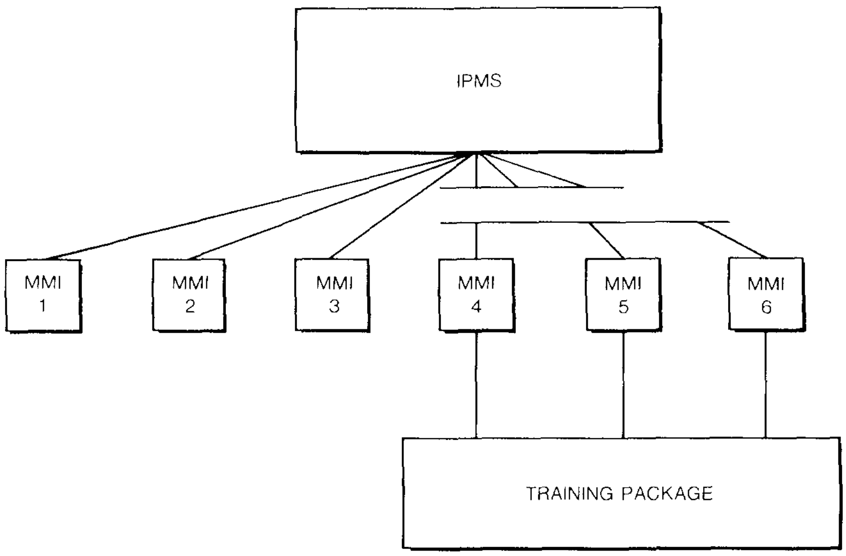

FIG. 4—IPMS—INSTRUCTOR-SUPERVISED TRAINING MODE
4: LOCAL OPERATION MMI
5: INSTRUCTOR MMI
6: TRAINING MMI

(*f*) In the instructor-supervised mode up to three positions, all sited in the SCC, may be required to be designated in the training mode (FIG. 4). The three designated training MMIs will be disconnected from IPMS and interfaced to the training package. The main training MMI will provide the majority of the IPMS functions normally found at the SCC control positions and will interact fully with the training package. The Instructor MMI will have facilities to allow the supervisor to inject malfunctions and to monitor student progress. A further MMI will be available for use by other trainees to simulate operation of machinery and systems locally from machinery spaces when remote control is not available. Local operation will interact fully with the training package simulations and will be reflected by the machinery state seen at the main training MMI. This will enable the three activities (SCC, Machinery Space, and Reversionary/Emergency Control) to be practised from the designated MMIs, all sited in the SCC.

(*g*) The designation of up to three MMIs in the training mode is to have no effect on the full and safe remote control of all machinery and systems from the remaining control position(s). Although physical disconnection of the training MMIs is not required, interaction with IPMS when in the training mode is to be limited to that required to return the MMIs to the normal control mode quickly and safely.

(*h*) The Local Operation MMI is to have interactive representations of systems and machinery local control panels. The trainee will have the ability to operate a limited number of system elements and machinery from this position, typically:

- fuel
- lub oil
- HP and LP air
- hydraulics
- GT Local Control Panels (LCPs)
- DG LCPs
- important electric motors, etc.

(*i*) The instructor's MMI must have sufficient facilities to enable injection and monitoring of a wide range of malfunctions and breakdowns, the extent of which will be dependent upon the final machinery configuration. The instructor may also require access to the Local Operation MMI functions to enable him to role play where necessary.

(*j*) The training package software, which may be incorporated with IPMS, will contain simulations of the ship machinery and systems of sufficient extent and realism to provide the correct responses to inputs from the three training MMIs.

Embedded training within IPMS is desirable in order to increase training opportunities and effectiveness, thus resulting in a rise in watchkeeping standards. In order to implement embedded training a separate package of training software will be required. This could have a degree of commonality with the shore procedural trainer software. Safeguards are needed to prevent training interacting with the normal ship control process. Up to three MMI positions will be required to provide effective instructor-supervised training, although a single MMI position may be used in the self-teach mode. All training can be supplemented by a suitable training package operating on a PC-compatible stand-alone machine.

Shore Procedural Training Requirements

The top-level requirements for shore procedural training for the future frigate are to:

(*a*) Develop familiarity with the following ship characteristics:
  (*i*) Layout of main and auxiliary machinery.
  (*ii*) Main platform systems and equipment.
  (*iii*) Layout and functions of the control and surveillance systems.
  (*iv*) Limits of main propulsion machinery in all configurations.
  (*v*) Modes of operation including reversionary and emergency modes.

(*b*) Develop familiarity with the operation of the Man Machine Interfaces.
(*c*) Enable pre-sea, pre-start, start/stop and shut-down routines to be carried out.
(*d*) Enable normal plant operation from the SCC (including all platform systems operable from the SCC).
(*e*) Carry out all main propulsion and auxiliary machinery breakdown procedures within the SCC and take remedial action both inside and outside the SCC.
(*f*) Enable operation of the plant in reversionary control modes.

In order to meet these requirements the shore procedural trainer is likely to include computer-based training (CBT) facilities for foundation knowledge and system training. A conventional procedural trainer may use representations of or actual ship IPMS equipment, together with the necessary stimulations and simulations. Alternatively an advanced technology trainer may be used. This choice will be examined in more detail later. The degree of fidelity will depend on the training requirements. Consideration would also be given to the integration of all training tasks, including Damage Control, within a single integrated package.

The envisaged layout for a conventional shore procedural trainer is shown in FIG. 5.

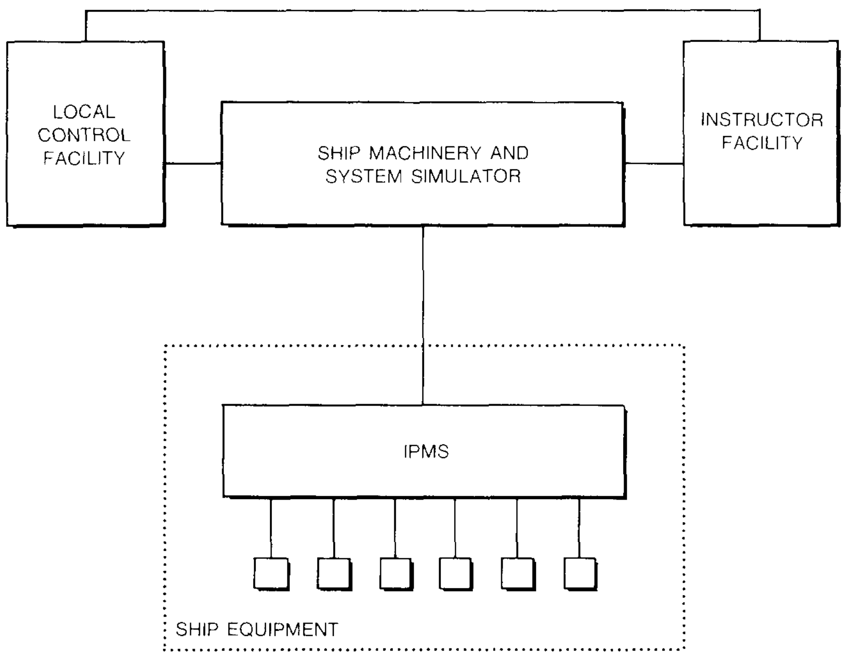

FIG. 5—SHORE PROCEDURAL TRAINER: ENVISAGED LAYOUT

A computer-based training package is also likely to be provided in order to develop the required foundation and systems knowledge.

Advanced Technology Trainer

A conventional shore procedural trainer for a future major surface warship is likely to be dedicated, complex and expensive. However, the potential introduction of embedded training facilities within IPMS on board the ship means that the shore training requirement can now be re-assessed. Provision of full and accurate shore training may not be necessary, as this would be available on board without impinging on the ship's operational programme. A training analysis is therefore likely to indicate that training facilities ashore could be simplified in order to impart a baseline of skills which could then be developed using the on-board embedded trainer. An Advanced Technology Trainer utilizing large touch-screen VDUs could provide the basis for suitable shore facilities.

In such a system, consoles, local control panels and other equipment would be emulated on large, touch-screen VDUs arranged in a spatially correct layout. Interaction with the systems would be via the touch-screens and the facilities provided would be tailored to the training requirements. The amount of simulation software required would therefore be reduced, with corresponding cost benefits. Special interfaces are not required and readily available commercial equipment would be used, thus further reducing costs.

As standard VDUs are used these could easily be rearranged and run with alternative software in order to represent different ship types. Greater flexibility would therefore be obtained from a single set of hardware.

Review of Computer-Based Training Requirements

There is likely to be a requirement for a stand-alone computer-based training system both ashore, for familiarization training, and on board, covering a similar range of subjects. Maintenance training could also be incorporated with the system.

It is also possible to implement a limited procedural training capability on the CBT system. This could provide a self-teach mode to enable trainees to reach a minimum standard before progressing on to the main trainer with instructor supervision.

The CBT system could consist of a number of work stations which could be either independent or networked. It is also possible to incorporate instructor monitoring facilities. The extent of the CBT system would be defined after a full training analysis.

Conclusions

The following Procedural Training systems will be required for a future major surface warship:

(*a*) Shore Procedural Trainer.

(*b*) On-board Embedded Procedural Trainer.

These will be supported by a Computer-Based Training Package, common elements of which can be used both ashore and at sea.

Deficiencies in present on-board training highlights the need for an on-board training system which, for maximum effect, should be embedded within IPMS. The requirements of the embedded trainer will impinge on the design of IPMS and should be considered at an early stage.

A shore procedural trainer will be required. The Damage Control training function could be integrated with this trainer. The shore procedural trainer may use stimulation and simulation of actual ship-fit equipment. Alternatively an Advanced Technology Trainer shows significant through-life cost savings, together with a great increase in flexibility.

All the above systems can be backed up by a computer-based training package, written in a standard authoring language.

By addressing the training requirements at an early stage, an integrated system of Computer-Based Training, Shore Procedural Training and On-board Training can be developed. This would achieve benefits in both training standards and overall costs, whilst reducing the training time ashore and minimizing the effects on the ship's operational programme.