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Simulation of Naval Wargames

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ABSTRACT

Computerised naval wargames are being used worldwide for operational planning, personnel training, operational development, and research and development. These wargames simulate surface, antisubmarine warfare, anti-air, and air warfare. Generally, the three forces participate in these wargames, namely blue (friendly), red (enemy), and neutral. The platforms of these forces, ie, ships, submarines, and aircraft along with their sensors and weapons are simulated under varying environmental conditions. These platforms are manoeuvered by the players with conflicting objectives, and they consequently detect, react, engage, and inflict or suffer damages. Efforts are made to model the performance of weapons and sensors. The outcome of the wargames has been analysed and used for the required purposes.

Keywords: Naval wargaming, wargames simulation training, modelling and simulation, combat models, training, wargames

1. INTRODUCTION

Naval officers, unlike other professionals, cannot practice their profession except during the time of war. Therefore, it becomes necessary to conduct exercises representing the war situation during peacetime. The frequency of the fleet exercises needs to be curtailed due to financial constraints. Consequently, the naval planners have sponsored and supported the development of methods and techniques which permits them to practice their profession during peacetime. One such technique is based on the simulation of war and is known as naval wargaming.

The wargames are classified as manual games, machine games, and computer games. In manual games, the forces are represented by models, pieces, and symbols and the participants move them manually on a board, map, or chart, in the area of operation. Contacts and interactions between the forces are evaluated in accordance with the professional judgement of the umpires. A machine game is conducted on an equipment or system specially designed for wargaming purposes. One such system is the action speed tactical simulator. Such systems are, in essence, simply electromechanical or electronic systems. In computer games, the war scenario is simulated and the player's plans are executed on the computers.

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In manual wargames, consequences of various engagements are based on intuitions and judgement. Computer wargames bring in more realism by minimising judgement factors through quantitative techniques and these games, therefore, enhance manifold the training value. Further, these games keep record of all moves and decisions for post-game analysis. Due to better visual appreciation and graphics, computer games are becoming increasingly popular. In fact, computer wargaming appears to be one of the latest techniques available for visualising and preparing for future battles by incorporating newer techniques of simulation[1] and combat models[2,4].

2. WARGAME FEATURES

In simulating a wargame, the -efforts are made to achieve the followings:

- The simulation should be simple and easy to understand and implement
- It should be realistic
- It should have a provision for players interaction
- It should be flexible.

3. SYSTEM CONFIGURATION

A typical wargaming facility can be divided into game controller (GC) or umpire room, blue room, and red room. Each room be provided with hardware similar to the one shown in Fig. 1. The workstations may be used for graphic display and PCs for display of information and giving commands during game play.

4. MODULAR APPROACH TO NAVAL WARGAMES

The naval wargames generally are based on the logic as described in the Fig. 2. A typical computerised naval wargame[5] consists of the following:

- Game scenario
- Game planning and approval
- Game play

4.1 Game Scenario

The game controller defines the game scenario for the two opposing forces represented by blue

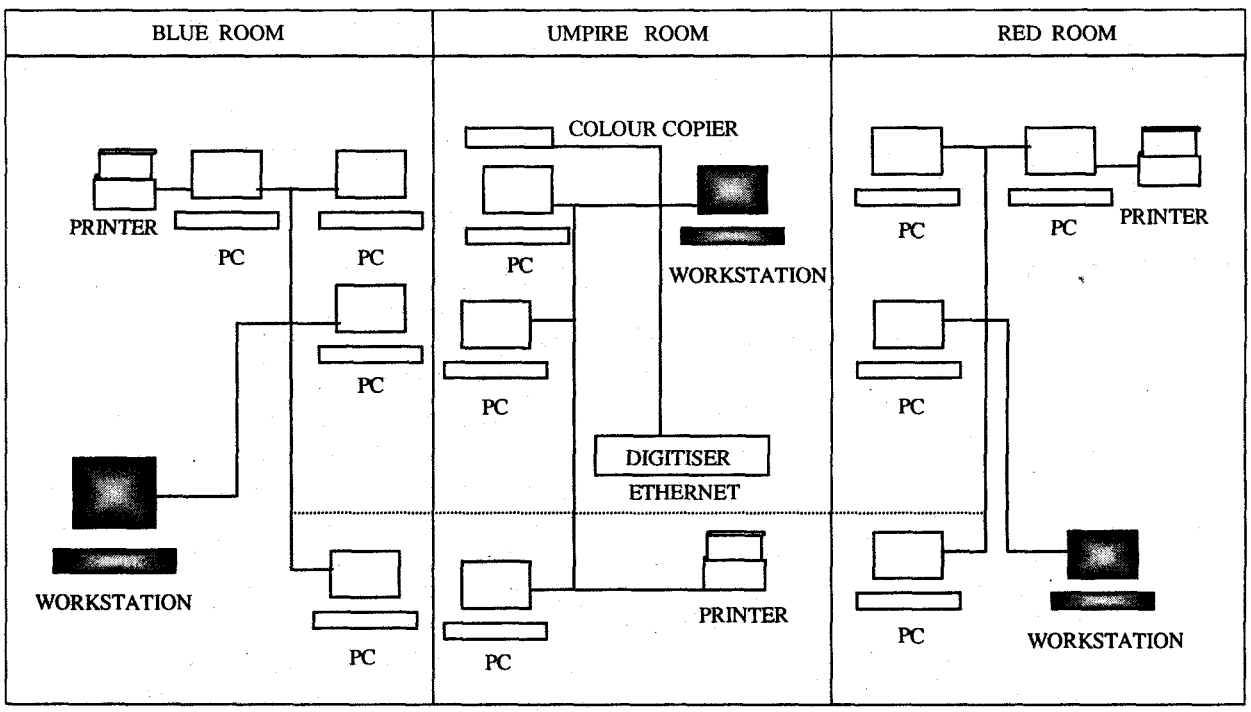

Figure 1. System configuration

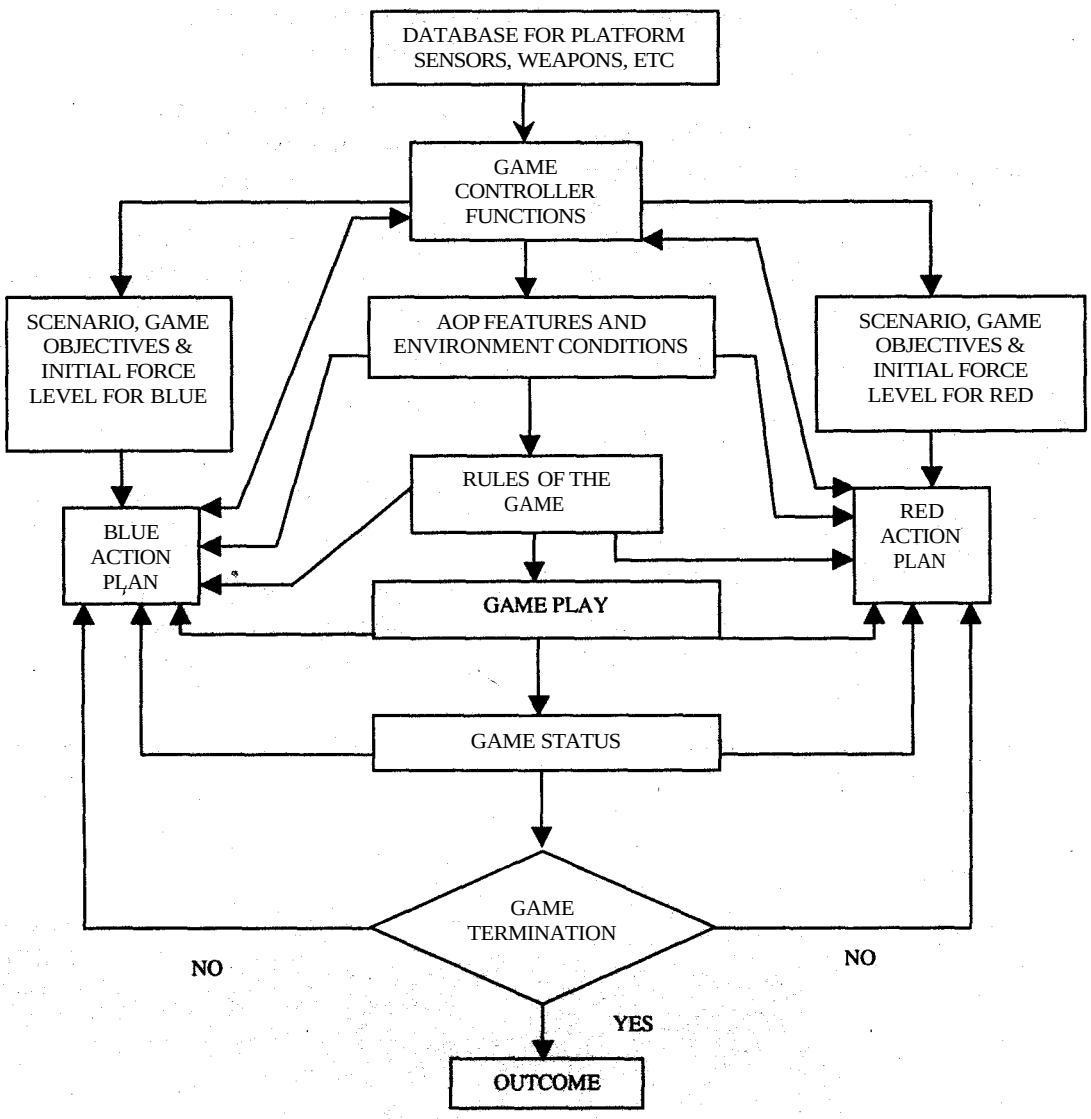

Figure 2. Modular approach to naval wargame

and red, sets the objective and provides intelligence reports to each side about the enemy. The following modules may be required by the game controller for defining the game scenario:

(a) Area of operaton may be defined with the help of mouse in the form of a rectangle.

(b) Reference points are identified as specific locations at sea, which can be identified during game planning and game play. The game controller and both the players can create, delete, or display these reference points. Reference points created by the game controller are available to both the players.

(c) New bases/harbours are defined or existing ones are selected from the database as per the requirement of the game controller.

(d) Resource allocation, such as ships, submarines. Maritime reconnaissance aircraft (MRA) and mines are allocated to blue and red forces through this facility.

(e) Selected platform positioning of both the blue and the red forces can be made using this facility.

(0 Platform attributes help to initialise the platform attributes, viz., number of weapons, sensors, etc.

(g) Date and time is used by the game controller to set the date and time at the start of the game.

(h) Environment-This facility is used by the game controller to define the environmental conditions for various areas within the area of operation. Each area is identified by an area code. The environmental conditions include meterological, navigational, wind, and tidal data.

In addition, a number of modules/facilities may be provided to the players and the game controller for map display during the conduct of a wargame. These are:

- *Zooming:* To zoom a portion of the digitised map selected with the help,of a mouse.
- *Regions:* The game play can be restricted within specified regions. Therefore, the naval chart may be divided region-wise, ie, Western, Eastern, Southern, South-east, South-west and Central.
- *Distance:* A facility may be required for calculating the distance between two points selected with the help of a mouse.
- *Platform legends:* Standard legends may be used to represent various platforms, such as ships, submarines, MRA, etc.
- *Display of lat/long:* Facility for a continuous display of latitude and longitude corresponding to the current cursor position.
- *Map attributes:* A menu-based facility is required for displaying the following attributes:
  - *Text:* The names of harbours, bases, islands and any other information which the players desire to display on the monitor.

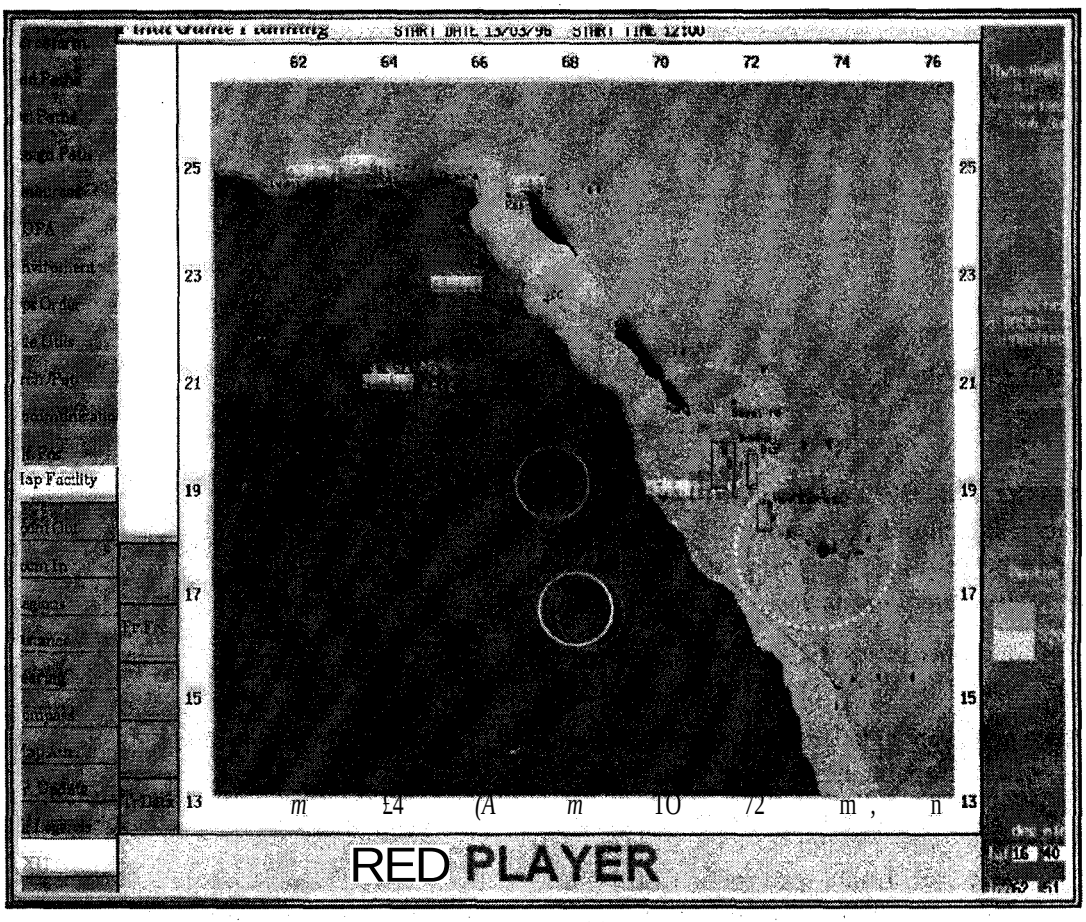

Figure 3. Typical game planning (computer output)

- *Mesh:* A mesh of 2° x 2° be made available for display along with the digitised map.
- *Depths:* The various sea depths in the ocean can be displayed in different shades of blue colour.
- *Command lines:* These are displayed showing the operational control of the Naval Command.

4.2 Game Planning & Approval

4.2.1 *Game Planning*

The players after receiving the scenario details from the game controller, intelligence reports about enemy, and other details, plan their actions. The players plan their moves and input the information using the facilities provided in the software. A typical game planning computer output is given in the Fig. 3. The players require some more facilities in addition to the facilities referred to in Para 4.1.

(a) *Threat zones*

This helps the players to mark the threat zones using different line styles to differentiate the threat from the surface, subsurface, and air.

(b) *Resources display*

The resources allotted to a player are displayed using icon on his computer screen. This facility is needed to visulalise the allotted resources in a tabular form along with their characteristics, such as penant number, maximum speed, endurance, etc.

(c) *Environment display*

This facility is needed to access the prevailing environmental conditions.

(d) *Range circles*

This facilitates the players to display the range circles of weapons and sensors available on the platforms.

(e) *Mines*

This facility is used by the players to lay the mines in pattern, random, or staggered modes within a specified rectangular area and evaluate the effectiveness of the minefield.

(f) *Platform tracks*

This facility is used by the players to draw the movement plans of the platforms.

(g) *Search/patrol*

This facility is used when the players decide to send a platform for search/patrol missions. For a search mission indicated by the player, a measure of effectiveness, namely percentage of area covered to that of the total area to be searched, is evaluated. If the desired effectiveness is achieved, the player may send the platform for the search/patrol mission, else the player may change the input parameters to arrive at the desired effectiveness value.

(h) Platform/fleet details

This facilitates the users to retrieve the details of the platform when deployed in stand-alone, fleet, or composite mode. In case a platform has helos/fighters onboard, the details of sensors and weapons are also provided.

(i) *Closest point of approach (CPA) & rendezvous problems*

This facility is used to:

- Estimate true track and speed of another ship from its relative movement and the closest point of approach.
- Estimate the time at which two ships, steaming different courses and speeds will be at a certain distance apart.
- Estimate the finish time, if speed is given, or to judge the speed, if finish time is given, for a platform to the rendezvous.

(j) Draw/erase

This is used either to write text and draw arcs, circles and ploylines or to erase these.

4.2.2 *Plan Approval*

After the plans are prepared by the players, these are transferred to the game controller, who studies the feasibility of the plans before their approval. If plans are approved, a message 'plans approved. Await commencement of play' is sent to the players. If plans are rejected, a message 'plans not approved' is sent to the players. In such case, the players are asked to revise their plans. Once the plans are revised, these are again submitted to the game controller for approval.

4.3 Game Play

The game play starts after the plans of both the players have been approved. The game controller indicates the game-turn duration before starting the game play. The game controller is provided with a facility to advance the game based upon the predefined action plans submitted by the players. The forces are moved as per the approved plans. The players are allowed to change the plans at any time during the game play. The players watch the movement of their forces but the game controller has overall picture of the game. When the forces come closer, the detection, the weapon hit, and the damages are evaluated using mathematical models. The game controller has powers to overrule the outcome to the mathematical models before the required information is transferred to the players. Players watch the continuous movement of the forces on the workstation and the additional PCs for giving the input during the game play.

4.3.1 *Facilities to Conduct Game Play*

Various facilities required by the players and the game controller for conducting the game play are:

(a) *Players*

For the game play, the players in addition to the facilities discussed earlier, such as range circles, environment, closest point of approach, threat zones, search and patrol, platform/fleet details, etc., require the following facilities:

- *Manoeuvre:* To manoeuvre the platforms during the game play by entering speed and course.
- *Sensor ON/OFF:* To change the status of the sensors(on/off) located on the platforms.
- *Weapon Firing:* To fire a weapon after a target is detected. Salvo firing is also permissible.
- *Communication:* To communicate with the game controller.
- *Status Tables:* To see the present status of platforms and sensors.

(b) Game controller

In addition to facilities, such as range circles, environment, closest point of approach, communication, status tables, etc., the game controller requires the following additional facilities during the game play:

- *Neutral Force:* To introduce the neutral ships or merchant ships during the game play.
- *Platform/Fleet Details*
- *Game Advance:* To advance the game by a given time and update the positions of the platforms accordingly.
- *Game Turn:* This helps the game controller in altering the game-turn cycle during the game play.
- *Detection:* This is used to obtain the detection of various platforms. The game controller may overrule these detections.
- *Damage:* Once the weapon is fired by a player, a hit or miss is declared using hit probability tables and random numbers. When a hit is declared, the corresponding damages are awarded as per predefined rules using random numbers and tables. The game controller may overrule the damage declared by the system.

5. MATHEMATICAL MODELS

During game planning, the minefields are created according to the desired effectiveness. The platforms are also despatched on search/patrol missions, keeping the coverage factor into consideration. Mathematical models are used to evaluate the effectiveness of search and patrol vessels. The mathematical models are used for obtaining the probability of detection and the probability of hit of weapons. However, the game controller can overrule the outcome of the mathematical models. These mathematical models are discussed below:

5.1 Minefield Effectiveness

A measure for effectiveness in terms of percentage for effective area covered by* the mines in the minefield has been defined. Based upon its value, the player may lay mines up to a desired level of effectiveness. The factor is calculated using[6] the following relations:

(a) *For random minefield*

$$E_{rm} = \{1\text{-}\exp(-,/V7i/?^2M)\}\text{xlOO}$$

(b) *For pattern minefield*

$$E_{pm} = \frac{NnR^2 xlOO}{A} \quad \text{for } NnR^2 < A$$

$$E_{pm} = 100 \quad \text{for } NnR^2 > A$$

where A is the area of minefield in nautical miles(n.m.), N is the number of mines, and R is the range of action of mine in nautical miles.

5.2 Search Effectiveness

While the platforms are despatched on search mission by the players, a measure of effectiveness of the search based on the area searched to that of the total area to be searched (expressed as percentage) is calculated. This information is used by the player for search planning. The following mathematical relations[7] may be used:

(a) *For planned search*

$$E_{ps} = (A_c/A_s)xiOO \quad \text{for} A_c < A$$

$$E_{ps} = 100 \quad \text{for } A_c > A$$

where A is the area covered and $A^{\wedge}$ is the area to be searched.

(b) *For random search*

$$E_{rs} = \{1 - \exp(-A_c / A_s)\} \times 100$$

where A_c is T_s x /?(x S_p , T_s is the time spent for search, S is the speed of search platform, and R_s is the effective range of sensor.

5.3 Patrol Effectiveness

During game planning, the platforms are despatched for a crossover or a linear patrol. The following relations can be used to evaluate the measure of effectiveness for the patrol based on the percentage chance of detecting a target crossing the patrol[8]. A desired level of effectiveness can be obtained by varying the inputs.

(a) *Crossover patrol*

$$E_{cp} = \left\{1 + \frac{r(r-1)^{1/2}}{r+l}\right\} \frac{1}{\lambda+1} \text{ x } 100$$

(b) *Linear patrol*

$$E_{lp} = \left\{1 - \left(\lambda - \frac{(r^2+1)^{1/2} - 1}{2}\right)^2 \Big/ \left(\lambda(\lambda+1)\right)\right\} \text{xlOO}$$

where r is the patrol speed / target speed, and A. is the length of barrier-sweep width/sweep width.

5.4 Probability of Detection

The following relation may be used to evaluate the probability of detection:

$$P_d = 1 - \left[1 - \exp(-k\,x)\right] / \left[1 - \exp(-k\,R_s)\right]$$

where x is the distance of the target from the sensor, /?(is the effective range of sensor, and k is the shape parameter.

5.5 Probability of Hit

The following mathematical relations may be used to estimate the weapon hit probability[9]:

h_p = exp(-A.j x jq) if jq < max range

= 0 if jc, > max range

where X_f is the I/max range of weapon, ct is the shape parameter, and jc, is the distance between the firing unit and the target.

6. AREAS OF APPLICATION

Naval wargames have the following areas of application[10]:

a) Operational planning, which deals with the problems of future levels, deployment, or employment of forces.

b) Personnel and team training is the most common application.

c) Operational development deals with the development of tactics, doctrine, and procedures to maximise effectiveness of weapon systems and/or combat units.

d) Research and system development deal with the design and development activities aimed at improving weapon systems and producing new platforms.

Use of naval wargames has also been extended to evaluate the weapon systems", where a helicopter is evaluated in an antisubmarine warfare scenario to evaluate its capabilities.

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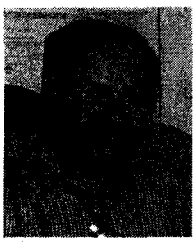

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