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Simulation in Military Training: Recent Developments

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ABSTRACT

Training is considered to be one of the key factors in achieving military goal. Growing concern over the increasing training costs, time, risk of life and paucity of training ranges has forced people to adopt newer technologies like computer simulation models, simulators and computer wargames in military training. With the advancement of computer and communication technologies along with the advent of other newer technologies, these tools have emerged effective and also have significantly less operational cost. It is also becoming possible to integrate simulators, simulation and live exercise through networking, resulting into an effective training tool. This paper highlights the advancement of simulation technology in military training and also highlights its applications in India.

NOMENCLATURE

AAR	After the Action Review
A2ATD	Armour/Anti-armour Advanced Technology Demonstration
ADS	Advanced Distributed Simulation
ALSP	Aggregated Level Simulation Protocol
APC	Armoured Personnel Carrier
ARPA	Advanced Research Project Agency
AWES	Area Weapon Effect Simulator
BATUS	British Army Training Unit Suffield
BDE-D	Battlefield Distributed Simulation-Development
BFTT	Battle Force Tactical Trainer
CAA	Concept Analysis Agency
CATT	Combined Arms Tactical Trainer
CENTCOM	Central Command
CGF	Computer-Generated Forces
DFWES	Direct Fire Weapon Effect Simulator
DFIRST	Deployable Force-on-Force Instrumented Range System
DIS	Distributed Interactive Simulation
DOAE	Defence Operational Analysis Establishment
DSS	Dismounted Soldier Simulation
FIBUA	Fighting in Built Up Areas
GPS	Global Positioning System
HMD	Head-Mounted Display
INFCOTT	Infantry Commanders Tactical Trainer
JSIMS	Joint Simulation System
MILES	Multi-Integrated Laser Engagement System
MFWG	Mechanised Forces War Game
NTC	National Training Centre
OOTW	Operation Other Than War

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PIP	Participants Instrumentation Package
SAFOR	Semi-Automated Force
SIMNET	Simulation Network
STOW	Synthetic Theatre of War
TES	Tactical Engagement Simulation
TWGSS/PGS	Tank Weapon Gunnery Simulation System/ Precision Gunnery System
JTCTS	Joint Tactical Combat Training System

1. INTRODUCTION

Training is considered to be an important factor in achieving military goal. It helps to overcome battlefield confusion known as 'fog of war' to a greater extent and is recognised as the ultimate force multiplier. It has often been cited as the deciding factor in battle between forces of equal strength. Military training can be broadly classified into two categories, viz., individual training and collective training. Individual training provides job-specific skills and knowledge to individual soldiers. Collective training is directed towards accomplishment of assigned tasks performed by a group in an integrated and synchronised manner with appropriate command and support elements in combat situation. The goal of collective training is to train forces to mobilise, deploy, fight and prevail in battle[1]. Collective training may further be divided into two levels—unit level and formation level (Table 1).

The conventional training methods provide individual and collective training involving huge cost, time and risk of life. Paucity of training sites and ranges sometimes restrict field exercises also. Environmentalists across the world are expressing deep concern regarding adverse impact of force manoeuvres and firing of weapons on the environment. Simulation technology has been receiving great attention worldwide as an effective training tool, and is being used extensively in the technologically advanced countries for both individual and collective training using simulators, computer simulation models and computer wargames. It involves significantly less operational cost and time than the actual field exercises and therefore, it can be conducted frequently to cover trainees in large numbers. There has been a tremendous improvement in these tools with the advancement of newer technologies which are significantly less costly but very effective.

The paper discusses different areas of simulation applications in military training for both indoor and outdoor training, e.g., simulators, simulation and wargaming, networking of simulators and also recent developments in the field of live simulation. A new technological area known as advanced distributed simulation (ADS), which is a combination of live, virtual and constructive simulations as military training tools is being highlighted. It also discusses simulation activities in India.

2. TYPE OF SIMULATION

Simulation in military training may be categorised into three types[2,3]: (i) constructive, (ii) live, and (iii) virtual.

2.1 Constructive Simulation

Constructive simulation is a computer-based simulation. In this, people do not participate in operating weapons/equipment but use logical and mathematical models to represent dynamics of combat. Effects of human influence are being represented

Table 1. Types and levels of conventional military training

Type of training	Level	Content	Training methods
Individual	—	Physical proficiency, weapon/equipment handling, map reading, etc.	Field training with actual systems
Collective	Unit	Training imparted to individuals in combined exercises up to battalion/ regiment level	Field exercises
	Formation	Brigade/division/corp level exercises	Sand model, tele-battle and manual wargame, etc.

through logical statements known as combat rules. These rules based on different combat scenarios are set with the help of experts. The simulation represents the dynamic behaviour of events occurring in the battle scenarios, e.g., movement of forces, attrition calculation, book-keeping of logistics, etc. It provides powerful tools to examine existing and proposed systems and to predict system performance under varying conditions without incurring much cost or risk of actual application, and therefore, it can be repeated a number of times, if necessary. It can be more accurately called aggregated simulation since it includes average effect of individual participants rather than effects of individuals separately. Most conventional simulation tools fall into this category (e.g., *Janus*, Vector-2, *Shatranj*, mechanised forces war game (MFWG), etc.). Its models range from detailed weapon on weapon level to extremely large scale theatre level warfare models, and the resolution of simulation depends on the level of the combat.

2.2 Live Simulation

In live simulation, people operate actual systems in actual operational conditions, e.g., field exercises like those carried out at the National Training Centre (NTC), USA, British Army Training Unit Suffield (BATUS) in Canada, etc.

2.3 Virtual Simulation

Virtual simulation simulates an environment and people feel that they are operating real equipment in real environment, but actually operate real equipment in virtual environment. A virtual environment is a computer-generated simulated environment in which the user is immersed in a 3-D environment through the use of a head-mounted display (HMD). Users interact with the virtual world by means of data input devices, such as treadmills, hand-operated sensors and instrumental gloves. The examples of virtual simulation are flight/tank simulators. The most important current virtual simulation are SIMNET (SIMulator Networking) and distributed interactive simulation (DIS).

3. SIMULATION IN MILITARY TRAINING

3.1 Individual Training

Training to individuals in the operation of weapons/equipment, etc., can be conducted effectively with the help of simulators. A simulator attempts to mimic the operation of a machine realistically by the use of high fidelity mock-ups of the crew stations, sometimes with sound and vibrations. A computer-driven simulator uses computer-generated image to drive the display screens and responds to input controlled by the operator. A computer can integrate real-world images with computer-generated images and can be programmed to generate a variety of scenarioes. The other advantage of a simulator is that, data generated during training can be analysed further to teach the trainer for better application of the training system.

HMD technology in simulator brings realism in the training process, since a trainee can see the world through HMD as he expects to see the world actually. Virtual reality devices add further realism by creating virtual environment. At present, the cost of virtual reality devices is high and thus these have selective applications, but in future it will find all-round applications in military training. Virtual reality technology combined with other emerging technologies like wearable computers, virtual retinal display, augmented reality devices, mind-activated equipment, etc., will make a training process more realistic and meaningful in the coming ages.[4]

Simulators may be grouped into three categories based on applications, viz., (i) driving simulators, e.g., armoured vehicles, flight simulators, etc., (ii) gunnery simulators, e.g., tank or small arms or air defence simulators, and (iii) sensor simulators, e.g., those used in electronic warfare simulation[5].

Reduction in defence expenditure has substantially restricted the procurement of military hardware in many countries and has also made it difficult for replacement of costly components at frequent intervals. Hence, the present day situation demands the need to prolong service life of many existing military hardware components. On the other hand, if costly systems like aircraft are to be retained in service for much longer time, the number of flying hours should be reduced to conserve airframe fatigue life. But it could be only possible at the cost of operational proficiency of the crew. To avoid it, flight simulators can be used to train the crew which can compensate actual flying proficiency with virtual flying in the simulator. The operational cost of a simulator is also very less when compared with the cost of conducting live manoeuvre training. For example, the

cost of operating a Chinook helicopter for one hour has been estimated at US$ 7500, whereas a similar experience could be provided in a simulator[6] at a cost less than US$ 200. With the rapid increase in operational cost of many systems, simulators have turned up to be the most viable option for maintaining combat efficiency. In addition, simulator also helps in the training of those combat actions which are otherwise not possible in field training, e.g., proficiency with infantry weapons against moving targets, low-level flying of aircraft, particularly at night, which is otherwise risky for fighter pilots.

3.2 Collective Training

Once a trainee has perfected in operating an equipment/weapon through a simulator, the need arises to train the crew to react under different combat situations that include enemy actions and also coordination among friendly forces. For example, a crew after perfecting the art of handling a tank must learn to operate the tank as part of a force in different formations against another force, i.e., force-on-force engagement.

Technology-aided training can be imparted in two ways: (i) outdoor or field training, and (ii) indoor training. Live simulation falls in the category of outdoor training, whereas virtual and constructive simulations are indoor activities. Training may be conducted through any one of the three categories of simulations as necessary or it may include their combinations, e.g., a training system with live and constructive simulations combined, or a system with the combination of virtual and constructive simulations.

3.2.1 Constructive Simulation: Computer Wargaming

Computer wargaming[7-10] is a popular and effective tool for indoor training and is amongst the oldest simulations in force-on-force training. A computer wargame is a computer simulation model. The distinguishing feature of it is that it has man-machine interactions; players take part in the decision making process, while the computer simulates the combat activities. Wargames are played at different levels of commands from battalion to division and theatre. At each level, games are designed differently according to the objectives of training (Fig. 1). Some games are designed for joint use of multi-services, some for single military service and others for the use of individual field commanders.

Wargaming usually involves a red player, a blue player and a game controller. The players (commanders) communicate their action plans from their respective simulated command posts to the respective subordinate commanders, who in turn communicate with the computer system by giving necessary instructions. The main computer model simulates the activities of the combat, which start with movement of the forces. Target detection and acquisition based on weather conditions, and terrain

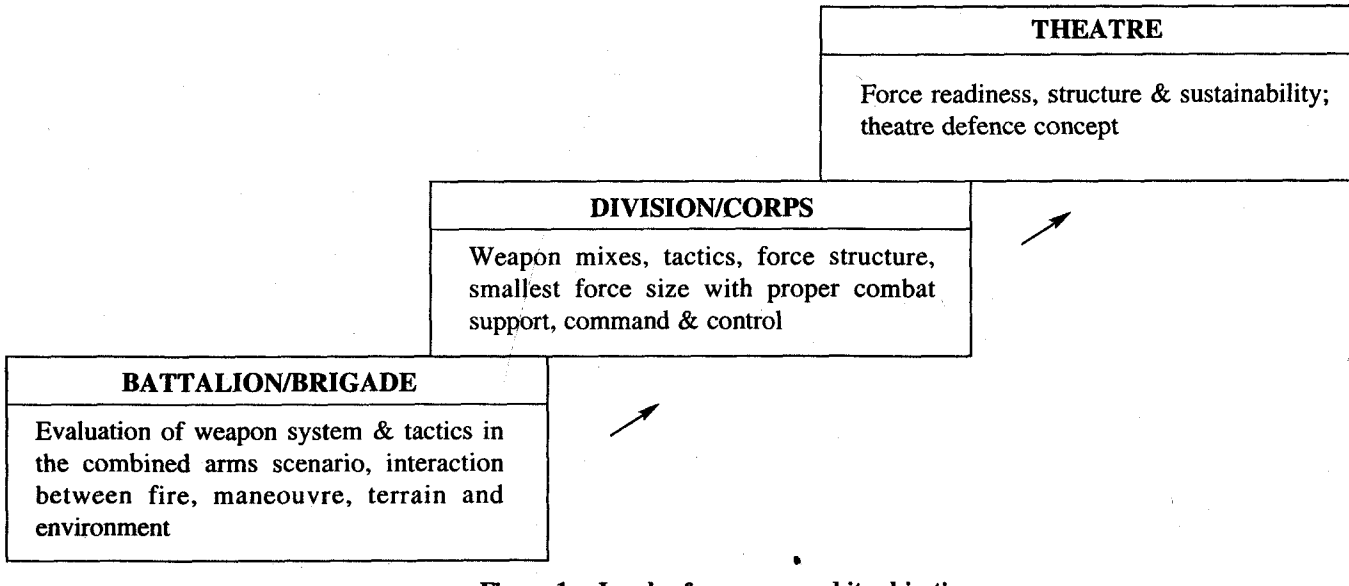

Figure 1. Levels of wargame and its objectives

features are carried out to initiate engagement process. Results of the engagements are evaluated with the help of either look-up tables or mathematical models. The players are free to react on the actions of the opponents during the game. The entire process continues until the game is terminated.

Though wargames are being used for the last few decades for military training, their importance in military decision-making had been truly felt in 1990s prior to the Operation Desert Shield and Desert Storm. Many defence organisations like Central Command (CENTCOM), Army Concept Analysis Agency (CAA), RAND Corporation of USA, Defence Operational Analysis Establishment (DOAE) of UK used simulation and wargaming models for understanding different possibilities of that war. It was for the first time that a distributed wargame called Internal Look 90, networking different systems located at different geographical locations in USA, was used for studying the war. The studies made at CENTCOM regarding possible war situations influenced US decisions on the war. For example, General Schwartzkopf decided to use the A-10 ground attack aircraft in the war, which was not included in his original attack plan, only after he went through a simulation study report[3]. The report suggested that A-10 would be effective in that war scenario.

3.2.2 *Live Simulation*

The live simulation is the outdoor training for force-on-force engagement and may be conducted through either laser-based tactical engagement simulation (TES) system[5] or live exercises through global positioning system (GPS) enabled battlefield simulation system[11].

3.2.2.1 *Live Simulation through Tactical Engagement Simulation System*

The only difference between live exercise and TES is that, instead of firing live ammunition, laser pulses are transmitted to the targets by the attacker. There are two different types of TES simulators. In one type, e.g., multi-integrated laser engagement system (MILES), the target system includes laser pulse receiver for detecting transmitted pulses. If the receiver detects these transmitted pulses, the system measures beam strength and uses probability of hit and probability of kill tables stored in the computer unit of the target simulator to assess outcome of the hit. The other type of simulator, e.g., Saab BT-46 simulator system of Sweden, which is a more advanced one, uses two-way retro reflective principle[12,13]. The tank weapon gunnery simulation system and precision gunnery system (TWGSS/PGS) of USA, the direct fire weapon effect simulator (DFWES) UK, and the Combat Dueling System of Germany are all based on the Saab BT-46 simulator system. Its firing system includes a transceiver unit and the target system has four retroreflectors fitted in different parts of the target besides other components. If the firer's transceiver receives information that bounce back from a retroreflector, then the coordinate of the retroreflector is used to evaluate the type of kill by the built-in computer. The probability of kill table, corresponding to vulnerability of the area of the target represented by the coordinates along with the random number generated by the computer, is used for assessing kill status of the target. After each exercise, game controllers collect data on every engagement in the exercise area stored in the memory card of the system's computer unit, which is then transferred to the master computer for after the action review (AAR). The position information of each participant is determined using GPS and is stored in the respective memory cards for analysis at AAR. These simulators can be attached to or removed from participants' body rapidly and easily during the training.

The training incorporates all standard gunnery procedures to be practiced against real targets. It can be used for conducting all arms, training of all direct firing weapons, including small arms, provided the simulators corresponding to respective participants are compatible. It is expected that at the end of this century, it would be possible to incorporate area weapon effect simulator (AWES), close-air support weapons, mines, NBC, etc., for all arm combined force-on-force training[14].

3.2.2.2 *Live Exercise through GPS Enabled Battlefield Simulation System*

Deployable force-on-force instrumented range system (DFIRST) is a GPS enabled battlefield simulation system that has been used for armour warfare training exercises in orchard training area, Idaho, USA. DFIRST device consists of a GPS antenna, a combat vehicle kill indicator light, an L-band communication antenna, a participants instrumentation package (PIP) , an on-board computer,

radio communication system, and a in-vehicle display. During the exercise, PIP monitors position transmissions from all DFIRST equipment vehicles. When a target is within firing range, the gunner fires a simulated round by pulling the trigger at the designated target after virtually selecting ammunition based on type of the target. After obtaining information of locations of the firer and the target through GPS, ammunition type, firing accuracy, armour protection, the on-board computer execute hit and damage computations considering probability of kill tables. An external weapon effect simulator emits smoke discharge with sound when a tank gunner fires the main gun which reveals the identity of the firer and brings realism to the process. Once a round hits a target, it is immediately communicated and the target vehicle's kill indicator light flashes to indicate the type of kill. It also indicates 'near miss' in case a round just misses the target.

There is a base station for monitoring and controlling the exercise, and an AAR cabin where the participants can view, replay and analyse the simulated exercise. Game controllers in the base station can create a simulated minefield by entering coordinates of the minefield boundary into the main computer of the system. When GPS tracking data indicate a target entering a minefield, the system software determines the resulting damage of the target by considering minefield characteristics, target vulnerability data, etc. Similarly, the system can also include virtual artillery units in the exercise. The base station superviser may activate artillery fire on the target if engaging armoured vehicles are within the effective firing range of the virtual artillery battery. Using ammunition characteristics, target type, etc., damage due to artillery fire can be determined using mathematical models within the system software. Game supervisers in the base station can also suspend the operation of a vehicle through communication link or warn any participant verbally through radio link, if necessary.

These training processes bring more realism because of the fact that the participants are free to manoeuvre and actually perform all the necessary activities while engaging targets, e.g., target detection, acquisition, range estimation, selection of ammunition and loading, etc. A firing system can itself be a victim of the opponent, if it fails to take evasive measures.

3.2.3 Virtual Simulation

3.2.3.1 Networking of Simulators

It was felt that if the simulator systems could be networked together in such a manner that they may participate in the same simulation exercise, collective training could take place effectively using these existing simulation systems. The SIMNET[15,16] project sponsored by Advanced Research Projects Agency (ARPA), USA was initiated in the early 1980s in that direction. It focused on exploring the construction of large distributed networks of simulators with associated command and support elements where any authorised participant could enter from anywhere in the network using his simulator as a node and join the battle. The goal was to create low-cost environment where combined-arms combat teams could practice jointly and frequently in virtual battlefield. SIMNET comprises standard combat simulators representing the individual weapon systems of infantry platoons, tank platoon, artillery battery, combat helicopter squadron, patrolling, and so on.

SIMNET architecture includes network of manned simulators with high resolution image generators, semi-automated force (SAFOR) workstations, planned view displays for observing battle area graphically, stealth displays for observing the battle from any place using magic carpet simulator and data collection and analysis systems. Magic carpet provides both a situation (map) display and out-the-window view of the battlefield, and is invisible to other simulators. SAFORs are computer-generated forces (CGF) systems that usually generate multiple battlefield entities, e.g., tanks, aircraft or infantry, using computer algorithms and their behaviour is controlled in real-time by software. The software reacts according to simulated battlefield scenario and produces intelligent and realistic actions dynamically rather than following a pre-set program. SAFOR systems can be used to play the part of both enemy as well as friendly forces in the battle. The software is integrated with networked simulator system or can be used as a SIMNET node. SAFOR encodes human expertise and therefore it reacts according to the combat situations. It produces quantifiable and repeatable training environment, and as such is helpful for training purposes. SAFOR has constrained domain of operations and hence, it is known as semi-automated, since a human being is always at the control when

SAFOR fails to generate a reasonable course of actions. SIMNET is the first successful application of large scale, real-time, man-in-the-loop simulator networking for collective training in a dynamic and free-play environment in which battle outcome depends on the coordinated actions of all the participants operating different simulators.

3.2.3.2 Distributed Interactive Simulation

SIMNET program involved the networking of simulators produced by the same vendor. This concept has been further extended to networking simulators of different fidelity and functions. This extended concept of networked simulators is called DIS. By creating environments which involve various types of simulators communicating to each other, it is found that effective training can be accomplished at different levels, from operational team training to force-on-force combined arms training[17-19]. Because of heterogeneous types of simulators in DIS network, simulations have different scopes and data structures, as such, a common language (protocol) is needed to understand and communicate to each other. DIS uses IEEE-1278 standard protocol to create a distributed interactive environment. The other significant feature in DIS is that it uses curve terrain instead of flat terrain which was used in SIMNET, by considering synthetic terrain and terrain database.

4. NEW ERA IN MILITARY TRAINING

The defence analysts have known computer simulation since 1950s. Due to limited scope of computers in terms of data storage and processing power needed for simulation, it had very restricted application to handle large battle simulations in those days. In 1960s and 1970s, substantial improvements were made in the field of military simulation with different levels of resolutions. With the development of computer technology, large and complex simulations involving digitised terrain and expanded scenarios were found possible to be executed using computers. But computer simulation got wider applicability in 1980s only with the advent of microprocessor-based computers, high speed data communication links, larger mass storage devices and flexible, high resolution graphical displays at low-cost. It is now possible to integrate live simulation with constructive simulation resulting into a very effective training tool. The continuing evolution of computer capabilities provide far more accurate, real-time simulations with 3-D graphical displays. The emergence of networking of simulators through satellite communication has made it possible to communicate with different simulators positioned at different geographical locations, and therefore, without moving to ranges it is possible to participate in an all-arm integrated battle.

4.1 Advanced Distributed Simulation

A new technological area has thus emerged out of these advanced technologies, and is known as advanced distributed simulation (ADS), which integrates simulation, simulators and live equipment weapon systems and creates a realistic synthetic battlefield environment. ADS, which is the synergistic combination of live, virtual and constructive simulations, provides a time-coherent interactive synthetic environment through geographically distributed and potentially dissimilar simulations[2,20-22]. Since virtual simulation is very prominent in ADS, so the term ADS and DIS are used interchangeably. The only difference cited is that DIS conforms to IEEE-1278 standard protocol, whereas ADS includes aggregated level simulation protocol (ALSP)[23].

4.2 Applications of ADS/DIS

Constructive simulations often do not consider details of individual weapon systems. High resolution 3-D terrain, detailed human decision-making and human interaction with the system are not well-represented, and therefore, cannot be used for individual training realistically as compared to other two simulations. Constructive simulations use aggregated effect of these factors, and therefore, it results in computational efficiencies at the expense of poor inspectability and understandability by the users. Although, constructive simulations are used extensively for collective tranining both at unit and formation levles, yet it is not suitable for traninig in other operational areas like operation other than war (OOTW) and fighting in built up areas (FIBUA). On the other hand, live simulation brings operational realism in training, but at the expense of huge cost, time, space, risk, etc. Specially, conducting and managing training at the formation level is not only very difficult, but sometimes creates border tension with the neighbouring states. Virtual simulation (e.g., SIMNET, DIS) is emerging as an effective training tool, but its application at the formation level has

limitations. Therefore, combining all these three types of simulations and exploiting the unique advantages of each, ADS/DIS is able to provide better support for current operational mission than any one type of simulation could individually.

The concept of ADS/DIS was first successfully demonstrated in 'Armour/Anti-armour Advanced Technology Demonstration (A2ATD)' programme of US Department of Defense for military material acquisition process[24]. It was not only verified and validated successfully but also provided with analytical reasoning of the simulation outcomes. Since then, a good number of DIS compatible systems have been tested.

Dismounted soldier simulation (DSS) is one of the DIS compliant real-time virtual simulation system for individual soldier and small unit simulation in the synthetic battlefield environment. DSS immerses an individual soldier within the virtual environment and interacts with other live, constructive, and virtual DIS entities[25]. The soldier is able to move, shoot and communicate, while at the same time, visualise his surroundings through a wireless HMD and interact with the virtual battlefield elements. DSS interacts with CGF entities on a DIS network and allows the real world soldier to do his normal activities freely, like running, walking, crawling, jumping and also engaging CGF targets with his surrogate weapon within the synthetic battlefield. Visual effects of firing of weapons in the virtual battlefield are visualised by the soldier with 3-D sound effect, as expected in the real-world battlefield.

Some of the other DIS/ADS application areas are: (i) synthetic theatre of war (STOW), (ii) combined arms tactical trainer (CATT), (iii) joint tactical combat training system (JTCTS), (iv) joint simulation system (JSIMS)[2,18,21], (v) kernel blitz 95, (vi) battle force tactical trainer (BFTT), etc. The last two had been demonstrated by the US Navy[26]. The US Air Force is also in the process of acquiring DIS technology for their own applications after carefully studying DIS potentials[19].

TRADOC Analysis Centre, USA, initiated a project known as JLINK[24,27] which connects *Janus*, a constructive simulation with DIS compatible simulations like SAFOR and battlefield distributed simulation–development (BDS–D) simulation facilities using software interface. *Janus* operates at the level of individual tank, armoured personnel carrier (APC), helicopter, etc. and is played at battalion/brigade level. *Janus* contributed to DIS its large validated database of weapons/equipment and attrition/acquisition models, whereas DIS contributed computer-generated forces, player generated scenarios and a 3-D visualisation capability. The combined effect generates a man-in-the-loop capability, and thus, become an important training and analysis tool.

5. SIMULATION APPLICATIONS IN INDIA

In India, application of simulation in military training is yet to take pace unlike western countries where simulations and wargames are extensively used in every aspect of the battlefield: air (flight procedures and tactics); land (combat, gunnery and fire support units integration) and sea (operations and engine room as well as target identification and acquisition). Realising the effectiveness of simulation as a tool for military training in India, the three Services have started simulation activities in their respective simulation development centres. Recently, Indian Army has inducted a computerised wargaming package known as *Shatranj*, developed by the Defence Research & Development Organization (DRDO), for training the battalion commanders and the staff. *Shatranj* is a two-sided, free-play, real-time and dynamic computer wargame model having six workstations in a network. Mechanised forces war game (MFWG), also developed by DRDO is a PC-based regiment level armour warfare wargame software package. MFWG[9] considers mechanised infantry, artillery, antitank weapons and antitank mines besides fighting tanks. The software includes detailed terrain analysis and after the action reviews for post game analysis. Similarly, Infantry Commander's Tactical Trainer (INFCOTT) is a single PC-based simple and nondynamic users' friendly software, developed for training commanders at the sub-unit level in the deployment of an infantry company. It is used to assess the efficacy of deployment of sections, platoons, all the major infantry weapons, minefields against attack by a battalion or battalion plus a company force supported by armour and artillery fire units.

The Indian Navy has been using analog tactical trainers for quite a long time for ship/submarine manoeuvring. Computer wargames, viz., *MINTAG*,

Manthan and *Sagar* developed by DRDO have also been inducted into the Indian Navy for integrated training. *Manthan*[9]includes ships, submarines and aircraft as platforms with different types of weapons and sensors. It is configured with three workstations and three PCs in a local area network. Indian Air Force has also been using air wargame systems developed by DRDO. *Sabre* developed by the Centre for Development of Advanced Computing (C-DAC), Pune, for armour warfare wargame packages is also being used by the Indian Army for training armoured corps officers.

The Indian Air Force and the Indian Navy have been using flight simulators and gunnery simulators, respectively for the last few decades but sophisticated simulators as well as all range simulation packages for different levels of battle training are yet to be introduced in the training establishments. The Aeronautical Development Establishment of DRDO developed *Kiran* flight simulator which has been used by the Indian Air Force, and has presently undertaken the development of light combat aircraft (LCA) simulator.

6. CONCLUSION

Traditional users of simulation have been using it for training the operation of complex equipment, such as ships, aircraft, AFVs and their weapons. However, increasing complexity in other military systems has led to more equipment being trained by simulation techniques. Environmental pressures and costs are making major military field exercises much more difficult to execute effectively. Therefore, there is an interest in networking synthetic devices not only with each other but also with real equipment and computer wargames, to increase the complexity and level of training. Now, simulation is capable of delivering cost-effective training for most of the equipment and scenarios, from routine to most complex situations, to the combatants both individually and collectively.

In India, the situation had not been very encouraging. Only lately, its potential use has been recognised and some efforts have been recently made for the development and use of simulation models for training purposes in all the three Services. Slower recognition of simulation technology and potential benefits than the expectation, has been partly because of lack of funds and also lack of awareness. Now, time has come to speed up the development and application of simulation processes in military training in India. Therefore, both Armed Forces and DRDO must make concerted efforts. Following are some suggestions in this direction:

- All the defence establishments/institutions associated with the development and/or usage of simulation models should come together and form a forum with an objective to create a common simulation environment for the promotion of simulation activities in India.
- The forum should periodically conduct discussions, seminars, etc. on simulation activities.
- Identification of present and future requirements of simulation and also how to handle them.
- Since advancements of simulation technology are moving along with the advancements of computer and associated technologies, identification of all the associated fields in the development of simulation and simulators and on planning how to communicate with them is essential. Trends in the future development of computer hardware should be constantly monitored for the development of cost-effective and powerful software.
- All the military training establishments should include simulation in their curricula. The trainees should be encouraged to design simulation (wargame) models of different levels of warfare. Such ideas and designs would help in the development of computer models in the later stages.

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