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*REVIEW PAPER*

# Computers in Defence An Assessment

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**ABSTRACT**

Computer technology has revolutionised weapons systems and warfare during the last decade. The 'miracle chip' has had impact in all areas of battlefield. The recent Gulf War has amply demonstrated the important role of computer technology in warfare. The best of the high technology was used during the 45 days of air battle followed by 100 hours of ground offensive. Computers and communication formed the heart of every weapon system from Tomahawk, SLAM, Scud, Patriot missiles to night vision of tanks and Stealth fighters. This paper discusses the salient features of computer technology used by the US for this truly hi-tech war. The hi-tech weapon systems using computers for achieving surgical precision have been highlighted. The Indian scenario and the important lessons learnt by the use of high technology, primarily based on computers for future wars, have been presented for their applicability in the Indian context.

## INTRODUCTION

Computer technology has been playing a major role in defence applications, right from early days. Initially, the high computation capability of computers was utilised in major weapon systems and electronic warfare. With the advent of microprocessors, every area of defence equipment and operations has been affected. The need for accurate and timely information is vital for any operation. Computers with their high speed and unlimited storage capacity are revolutionising the concept of warfare. Just as computers are becoming a fact of life in offices, schools, laboratories and factories all over the world, they have become equally vital to Defence Services. In conventional combat, computers act as a force multiplier. They increase the accuracy of individual weapon system; which reduces the number of weapons needed to destroy a particular target. They also allow the commanders to apply their forces more effectively through better intelligence and more effective communications. Combat applications are only the tip of the iceberg. Computers are now involved in every aspect of defence from war planning and weapon design to administration and logistics. The recent Gulf War between the Allied forces and Iraq was totally a new type of hi-tech war. The best of the high technology was used by the Allied troops against the conventional well-established Iraqi forces. This high technology was primarily based on computers and communication systems.

## 2. CURRENT DEFENCE APPLICATIONS

*Tactical Computers:* Microprocessors are replacing most of the instrumentation forming part of artillery guns. The tactical boards are being replaced by video display boards, displaying realtime battle situation. One of the leading applications of tactical computers is in fire control systems, where they can be used simply to relay target information and firing orders or to actually aim and fire the weapon. Almost all tactical aircraft being used by the air forces of different countries make extensive use of computer for various onboard applications. The Advance Tactical Fighter (ATF) being designed for US Air Force is even more dependent on embedded computers than was its ancestor, the F-16. India's Light Combat Aircraft (LCA) will also have similar embedded computers. The variety of tasks performed by the computers will continue to expand as new systems are introduced. These embedded

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computers are at the heart of the so-called 'Smart' munition, which can guide themselves to their target after launch[1].

*Command, Control, Communication, Computer and Intelligence ($C^4I$):* $C^4I$ provides an accurate information system to the commanders at various levels to exercise effective command and control using reliable communications. The degree of integration of command and control systems in weapons with the communication techniques, is gradually increasing with the use of computers. The basic elements of $C^4I$ are surveillance, communication, computation, decision-making and action. Because of the speed at which events unfold in modern warfare, a $C^4I$ system that cannot respond almost instantaneously is of little use. The United States strategic warning network derives its inputs from surveillance satellites, which are controlled by computers from a ground station. Other strategic intelligence is derived from computers that specialise in decoding and analysing reports and correlating data. This intelligence information, together with orders, reports and a flood of other $C^4I$ data, is passed around the globe by a computer-controlled system through network of satellites. At each stage, the information is encoded, decoded, addressed, rerouted or otherwise processed by the computers. A number of $C^4I$ systems are operational in the world at present and were extensively used during the Gulf War[2].

*Wargaming and Simulation:* Wargaming is simulation of battlefield situation, provided to different levels of commanders to train and test their professional skills and decision-making capabilities. A computer system provides flexibility of use of the visual displays for different operations of war. Highly complex situations can be simulated with the help of computer. The modern computer-based simulations can replace anything from infantry engagement to global nuclear war. The fighter aircraft pilot training simulators are already providing better control and feel and more realistic visual displays on ground, thereby reducing tremendous risk and cost of training. Both air force and navy operate in ranges on which aircraft equipped with electronic pods conduct simulated ground attacks and air-to-air engagements. The flight paths are recorded, combined by the computer and later displayed on the ground, so that the aircrew, who flew the training mission, can review the entire battle. Apart from computerised tank simulators for training the crew, a number of dynamic simulation probabilistic models for tank vs tank battle are being utilized to determine the effectiveness of battle tactics. Multi-media techniques are providing the much-needed realism in wargaming and simulation[3].

*Research & Development:* In advanced countries, the entire effort on research and development in defence is based on powerful supercomputers like CRAY. They are used for simulation and modelling of everything from high speed, high altitude aerodynamics to the effect of ocean currents on submarine detection system. The computer has emerged as a powerful primary tool in design, development and manufacture due to its incredible speed of computation and versatility. To illustrate the capability of the modern computer technology, it is estimated that CRAY could complete the computation of yield of the first atomic device in 1s, which had taken a team of scientists five years in 1940's, using the then available tools. One of the greatest benefits of this kind of computational speed is that it makes possible simulated experiments that in real world would be physically impossible or prohibitively expensive. Computer-aided design and manufacture (CAD/CAM) workstations have cut down the design cycle time and provide more reliable and affordable weapon systems. With capability of storing 3-D geometric models on computer, the CAD/CAM technology is having impact in research, design and development of all major subsystems for weapons.

*Logistics:* Though a majority of computers in defence are being used in logistics and office administration activities, their role is less remarkable but essential. The benefits of computerisation in these areas in defence are much more pronounced than in their civilian counterparts. Some of the major areas are: inventory management, personnel management, pay & allowances, weapon/equipment status, production planning and control, and maintenance diagnostic system. The current defence applications of computers mentioned above are implemented using full range of computer systems from PCs to supercomputers. With fast changing computer technology, there is a regular upgradation of both hardware and software to provide better and more efficient use.

## 3. COMPUTER TECHNOLOGY USED IN GULF WAR

Defence forces have always adopted new technologies, after ensuring that these offer a quantum

improvement in battle effectiveness of their weapons. However, every new technology cannot find its use in weapons systems till it is well proven and tested to meet stringent military specifications. The crucial role of electronic systems and subsystems in the Gulf War in all types of weapons made it a real high-technology war. History may call this war as the 'War of the Chip'. The chip ruled the waves of the Gulf for decision-making in Saddam's command post, Schwarzkopf's headquarters, the Pentagon or the White House or in the combat zone on land, at sea or in the air. The chips worked for surveillance, acquisition, targeting or damage assessment, for planning operations, coordination among Allied or exercising command and control over forces, both strategic and tactical[4].

*Surveillance and Reconnaissance:* To ensure that accurate information is available at all levels for taking correct decisions, an efficient surveillance and reconnaissance technology was established in the Gulf before the start of the war. The main elements, including ground based $C^4I$ used by the Allied Forces for providing accurate intelligence, are shown in Fig. 1.

*Spy Satellites:* There were at least seven different types of birds passing over the Gulf, ranging from sharp-eyed Key Hole photo-reconnaissance satellites (KH 11, resolution 15 cm), to the eavesdropping Magnum, which monitored Iraqi radio communication. LACROSSE, the radar reconnaissance satellite, provided vital information about the enemy's

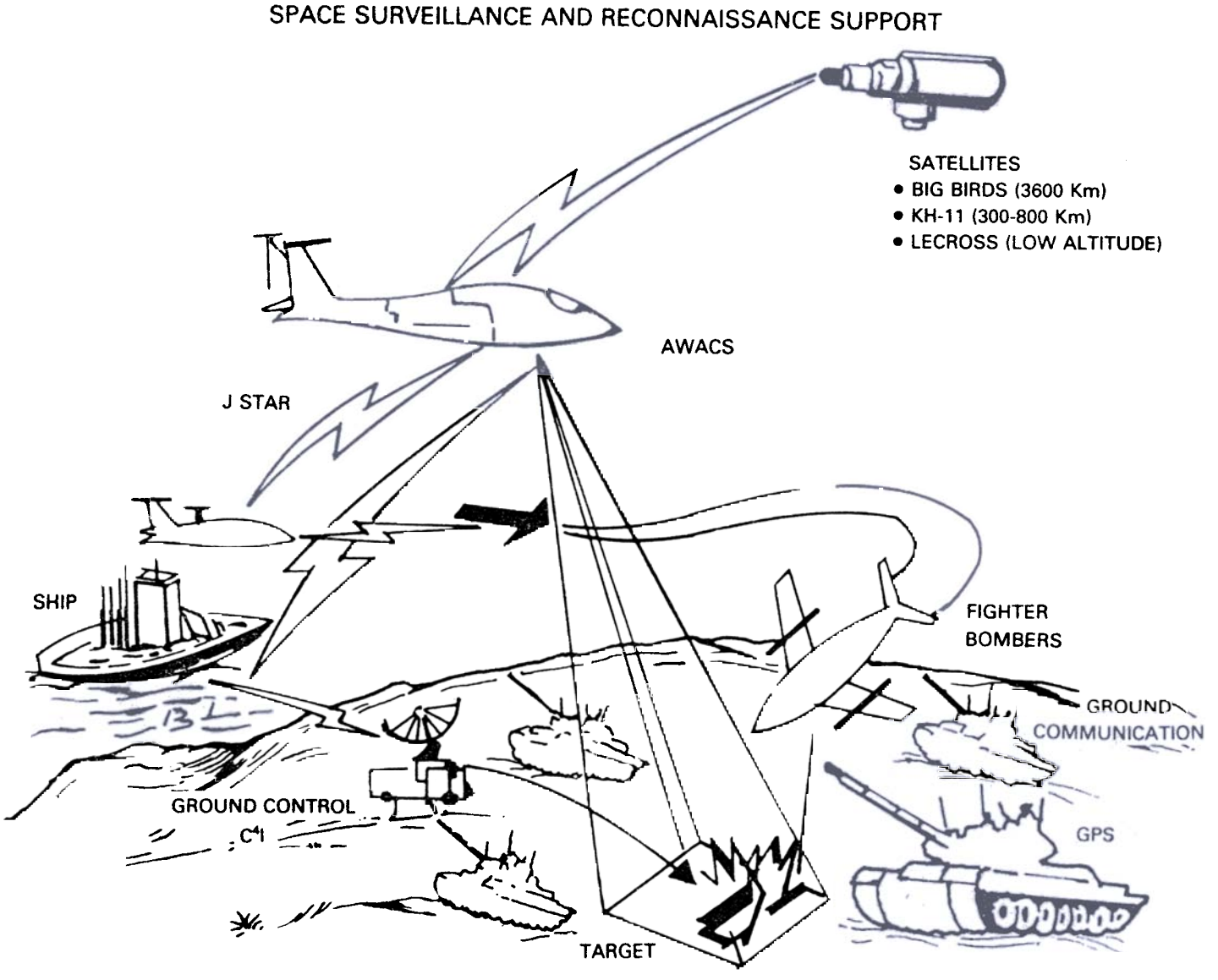


**Figure 1. Hi-tech battle scenario during the Gulf War**

installation at night and through the clouds (resolution 0.6–3 m).

*AWACS:* At any time, one of the three airborne warning and control system Boeing aircraft was engaged in mapping the advances of airborne attackers within 700 km and guided friendly fighters to the targets. The ground support complex consisted of three Raytheon MVCF860 computers to remove clutter and display map of the area. Capable of processing 9 million instructions per second, it could also interpret radar signals, relay map display, assess target status as friend or foe.

*Aegies:* A computerised ship-based defence system was installed to detect, identify and track a variety of enemy targets–from incoming missiles to surface vessels to submarines. Aegies is a combination of phased array radar, 16 UYK-7 mainframe computers, 12 UNISYS UYK-20 minicomputers, and a whole lot of defensive weapons. The systems command and decision computers processed the readings from the cruiser radar and also signals from similar sensors.

*JSTAR:* Joint Surveillance Target Attack System for Air Force and Army (JSTAR) enabled the two forces to zero in on enemy targets on way to the battle front. The equipment featured a phased array radar, digital communication facilities, a computerised operations and control system, with nearly two million lines of program code.

*Command, Control, Communication, Computers and Intelligence:* One of the major tasks accomplished by the Allied Forces during operation 'Desert Shield' was to integrate command, control, communication, computers and intelligence ($C^4I$) belonging to the different nations forming part of the coalition. The Command Control Centres employed in the Gulf were based on EC-130 E and had 15 workstations for updation of computer-generated maps and colour data displays. The information was then passed along to ground headquarters and naval forces. Four optical disks allowed operators to view a detailed worldwide map and zoom in from a 2000-sq mile presentation to a 4-sq mile presentation in just 2s.

*MILSTAR:* The old World Wide Military Command and Control System (WWMCC) has given way to the satellite-based Military Strategic and Tactical Relay (MILSTAR) for providing a reliable communication system to support US and other multinational forces. It linked Pentagon with headquarters of the Central Command, the commander of the Gulf forces, and its subordinate headquarters.

*NAVSTAR:* The Navigation Satellite Timing and Ranging (NAVSTAR) and Global Positioning System (GPS) provided the much-needed fix in location, velocity and time domain for meeting the need of every unit and platform, whether operating on surface, below or above. It had the capability of determining longitude, latitude and altitude to an accuracy of 16 m SEP (spherical error probability), velocity to 0.10 m/s and time within 100 ns.

*JTIDS:* It is a time division multiple access (TDMA), fully secure, jam resistant, digital information distribution system, with multiple pathways architecture. All JTIDS terminals allowed users to insert information or extract it whenever required.

*Electronic Warfare:* Long before the start of air battles on 17 January 1991, the electronic wargame was active in the Gulf. The countries surrounding Iraq, particularly Saudi Arabia and Israel, were fully utilizing their sophisticated and sensitive receivers and other passive systems for monitoring electronic emissions from Iraq's communication links, radars, aircraft, tanks and other weapon systems. It was probably the first time in warfare that such sophisticated systems, including remotely piloted vehicles (RPV), were used to draw an accurate 'electronic order of battle'. The Iraqi air defence system against which the electronic war (EW) was fought had both strategic and tactical support provided by equipment from both east and west. The entire range of radar frequencies from 70 MHz to 18 GHz was used. The well-equipped high altitude aircraft like F16/F15 used their long range oblique photography (LOROP) and signal/communication intelligence (ELINT/COMINT) missions together with data up to 160 km beyond the border. F-45 Wild Weasels combat aircraft was specially designed to attract ground-based radars. They fired high speed anti-radar missiles (HARM), locking horns with Iraqi radar signals and destroyed the surface-to-air missile sites[5].

*Night Vision:* One of the factors which played a vital role in the Gulf War was the night vision capability of Allied weapons. The air offensive in 'Desert Storm' relied heavily on aircrafts equipped with navigation and attack systems able to penetrate Iraqi air space at night. Even during the ground battle 'Desert Sabre', extensive use of night vision devices was made by all tanks and infantry soldiers. F-15Es were fitted with Low Altitude

Navigation and Targets Infra-Red Night (LANTIRN) System. The system mounted under the belly of the aircraft comprised a navigation pod having a wide field forward-looking infra-red (FLIR) and a terrain following radar. The targeting pod had a laser designator/tractor with narrow field FLIR and automatic target tracker. Each of the pods had its own computer using 2 lakh lines of source code to help the pilot in accurate engagement of targets at night.

*Surgical Precision:* The use of Smart bombs based on precision guidance was one of the key high technologies used during the Gulf War. The conventional bombs missed their target 70 per cent of the time, whereas the precision guided munition (PGM) was highly accurate. A PGM is an air-to-surface weapon with a guidance system to steer it on to the target. A laser guided bomb (LGB) homes on to a spot of intensive light produced by a laser. The laser illuminating a target can be carried by another fighter/bomber, a smaller control aircraft, or by ground troops. Another version of the Smart weapon is the electro-optically guided bomb (EOGB), which contains a TV camera or an IR sensor for night attack and a transmitter. After the bomb is released, the pilot can take evasive action, while the weapons system operator steers the bomb to the target[6,7].

## 4. FUTURE TRENDS

*Fifth Generation:* Since launching of a programme in 1981 by Japan towards a new generation of computers called Fifth Generation, there has been a race among all major countries to catch up. The machine will have natural language interface using knowledge information processing (KIPS). The hardware using VVLSI is aimed at providing one million logical inferences per second (LIPS) for problem-solving software. USA and the European countries have launched massive research programmes in these frontier areas, in respect of both hardware and software. Strategic Defence Initiative (SDI) programme, commonly known as STARWAR is no more relevant, but it has helped in pushing up computer research for future weapon systems.

*Global Protection Against Limited Strikes (GPALS):* Based on the experience gained in Gulf War, the United States Government has given a new focus to the SDI programme and is concentrating on a new programme called global protection against limited strikes. While the advanced space - and ground-based interceptors will continue with SDI, a new thrust towards providing protection for troops deployed in the field will be attempted under a programme called Tactical Missile Defence Initiative (TMDI)). TMDI will become a focal point for all future theatre missile defence programmes, including the US Patriot missile system.

*Strategic Computing Initiative:* Defence Advance Research Project Agency (DARPA) of USA had a ten-year plan called Strategic Computing Initiative to develop machine intelligence technology. It simultaneously proposed to advance computer technology at several levels—new materials and fabrication processes for creating inherently faster chips, new parallel computer architecture for rapid computation and new software technology for endowing machines with flexible and intelligent behaviour.

*High Performance Computing and Communications (HPCC):* To upgrade the capability in high performance computing and communication, the United States has enhanced funding by 30 per cent and given three major projects to Jet Propulsion Lab, Goddard Space Flight Centre and Ames Research Centre. High performance computing represents the leading edge for the entire computer industry and is bound to play a significant role in fundamental scientific research, enabling design and production processes to improve computing power. The major goals of HPCC are[8]:

(a) Interfacing a new generation of scalable high-performance parallel computer and software technology to achieve one trillion computer calculations per second. This will make the computers 1000 times faster than at present and will be useful in 'grand challenge' applications.

(b) Developing a national research and educational network to connect universities, high schools, research laboratories and industry by networks with data speeds of one billion bits per second.

(c) Educating scientists, engineers and technical personnel to use such powerful capabilities.

*Virtual Reality:* Another field of future research being undertaken for NASA is in the area of virtual reality. This covers the whole range of computer-generated alternative realities which according to experts will be possible before 2000 AD. Virtual reality will have the ability to create an artificial world and have people interact with it, so that real-time situation is created. In fact, it is predicted that by using virtual

reality goggles connected to a 3-D model, a vacationer will be able to tour distant lands complete with sight, sound and smell from his own living room. The future military applications of this high technology research are unimaginable at present.

*Computer Research:* During the last four decades, computer technology has made remarkable progress and the process continues. The following major areas of computer research will have far-reaching implications for defence applications:

(a) Expert system research aims to develop knowledge of engineering tools necessary for battle management systems.

(b) Image processing research effort involves development of algorithms to find range, terrain modelling, classifying object shapes/surfaces using spectral ranges. High speed parallel architecture computers capable of processing one trillion instructions are planned.

(c) Research in the area of speech production and recognition entails different levels of noise and stress environment. The present limited vocabulary is required to be expanded needing processing power of twenty million inferences per second.

(d) An improvement of 20-30 per cent per year in computing power is aimed at primarily using different types of parallel architectures.

(e) The present growth of computers has been made possible due to exponential improvement in micro-electronics. Major thrust areas include high performance gallium arsenide-based high density chips.

## 5. IMPACT ON FUTURE WARS

Gulf War has been the testing ground for all sophisticated and conventional weapons systems under adverse environmental conditions in the desert, on sea and in the air. The wars of the future may be on the lines of the Gulf War, rather than like the Vietnam or Afghan War. Some major lessons learnt from the information technology angle are:

(a) The 'chip' has brought in the concept of a composite air wing by streamlinging command, control and information.

(b) Integration of multiple weapons systems from multinations has become a reality.

(c) Precision guidance will be essential for all types of weapons, including tanks and artillery bombs in the future.

(d) Airborne optically guided bombs will be the order of the day and would be able to pinpoint targets within a few metres CEP.

(e) Electronic warfare with stress on ECM and ECCM will be crucial. A force which is able to neutralize the opponent's radar and communication centres in a few minutes of commencement is likely to succeed. Thus, an aggressor will have advantage against the defender.

(f) Technical superiority rather than superiority of numbers in land, air and sea will be the deciding factor.

(g) Reliability and maintainability of all high-technology weapons, as well of the human beings will play a major role in future wars.

(h) The futuristic technology weapons being planned will get a shot in the arm and will become operational in future wars.

(i) Chemical and biological weapons will continue to be developed as a deterrent and antimeasures will be essential.

(j) Unmanned vehicle technology will stabilize, providing a safe mode of gathering intelligence behind enemy lines and under adverse environmental conditions, including chemical, nuclear and biological war conditions.

## 6. INDIAN SCENARIO

*National Scene:* The information revolution brought about by computer technology during the last 40 years has changed the world more than during all the earlier 19 centuries. India has also been affected by the miracle chip, but not to the same extent as the western world. Till recently, the national policy has been one of caution, thereby controlling computerisation in various sectors. The available computer systems have always been years behind the ones available in the advanced countries[7].

It is only in the last few years that the government has allowed transfer of technology, in both public and private sectors. A number of state of art mainframe and super minicomputer systems are now available indigenously. Advent of IBM PC compatible has brought in a very large number of business houses in the fray in what is commonly known as 'screw driver

technology'. Some of the leading computer firms are making all-out R&D efforts to catch up with the rest of the world. The area of software development, which is manpower intensive, offers on ideal opportunity to the country to take a lead in this technology. A number of software business houses are doing yeoman service in developing complex software for various applications. With the establishment of the Centre for Development of Advance Computer Technology (CDACT) and success of PARAM, India is entering the era of parallel computing. The Department of Electronics has also funded certain basic programmes in the area of Fifth Generation computers, with various educational and research institutions in the country[8,9].

*Defence Sector:* Defence Services in India have always been in the forefront in making use of the latest technologies for meeting their tactical and operational needs. All the three Services have well established computer centres for training their officers and staff in various applications using computers. Their major thrust has been in the area of management information systems, wargaming, simulation and training. Till recently, Army, Navy and Air Force have been heavily dependent upon imported weapons systems along with their embedded computer systems.

Defence Research & Development Organisation (DRDO) has now started extensive use of computer technology for its major programmes like Integrated Guided Missile Development Programme (IGMDP), Main Battle Tank (MBT) and Light Combat Aircraft (LCA). Both *AGNI* and *PRITHVI* use strap down inertial navigation in closed loop guidance system, with onboard computers for guiding the missile in its flight and accurately calculating the thrust termination phase. The use of strap down inertial guidance system is claimed as a pioneering effort by DRDO against the conventional platform guidance system using stabilisation by gimbals. In *AGNI* and *PRITHVI* missiles, the gyros and accelerometers are strapped on and they give their output to the computers, which instantly convert it into inertial measurements. With extensive use of computer technology, the missiles have been able to achieve their trajectories very close to the predicted and simulated paths. In the other projects under IGMDP, computer systems are being utilized for design and testing. The third generation fire and forget anti-tank missile uses computer-based image processing for acquiring the target[10].

## 7. REALISTIC ASSESSMENT

*Application Areas:* Computer systems have major applications in almost all areas of defence. Some of these have already been implemented and others are under consideration. At any level, before applying computers, it is imperative that a proper feasibility be established to assess short- and long-term benefits and implications. The futuristic computer technology is poised for an exponential growth and will have major Defence implications. Some of the important areas of Defence applications are:

(a) Corps and Division level wargaming simulation for effective training and evaluation of field commanders.

(b) A PC-based expert system to assist junior commanders in carrying out more accurate appreciation in different battle situations.

(c) An expert system for diagnosis and maintenance of sophisticated weapons systems like missiles, radars, AFVs, etc.

(d) Logistic management system is an important area where new technology will be able to contribute by making available latest status and various options of meeting the changing requirements of battle.

(e) Image understanding for target identification and classification. Artificial intelligence techniques can be used to automate the extraction of low level map features for imagery.

(f) Development of high performance processors and software linked through a reliable computer-based communication network is essential for achieving a responsive, reliable, survivable and cost-effective battle management system.

*Challenge:* As every silver lining has a cloud, computers are no exception. The challenges to computers in defence applications include rapid obsolescence, vulnerability and the cost of producing and maintaining software. The cost of the machines themselves is not a serious drawback. As a rule, the productivity increase made possible by computers, pays back their initial cost rather quickly. The vulnerability of computers to computer virus and eavesdropping are other dangers in their use in vital defence applications. The most significant problem of computers in defence is the astronomical cost of modifying the software that operates them. Software costs consume more than 80

per cent of the weapons system cost. Still one can never be 100 per cent sure of reliability of the software.

Whatever the technology produces, it is certain that one problem is going to get worse. We can speed up computers almost without limit, but the human mind still plods along at its accustomed pace, and unless we are willing to take the enormous risk of surrendering our authority to machine, critical decisions must still be made by human being. In the last two years, the Gulf War has provided us with many examples of this kind of dilemma–USS Vincenne, which reacted too quickly and the 'Stark', which did not react quickly enough. These two incidents have given reminders that although computers can give us access to enormous amount of information in a very short time, what we do with that information is strictly up to us[1-8].

## 8. CONCLUSION

During the last four decades, computer technology has made phenomenal progress. The modern computer is 10,000 times cheaper, a million times faster and far more reliable than its ancestor. If the automobile technology had made similar progress, a car would be as cheap as this copy of *Defence Science Journal*, more powerful than a train, could go round the world 25000 times on a tank full of petrol and would be so small that one could park six of them on a full stop! The same trend is likely to continue in future. Defence applications are likely to grow futher. In the near future, we are likely to see advances in parallel processing and similar technologies that will increase computer power by another order of magnitude.

Those who learn from others, experiences avoid tragedy striking them. The Gulf War has very significant lessons for a third-world country like India. By no stretch of imagination can we afford hi-tech, the kind of weaponry used by the US against Iraq in the Gulf War. However, certain measures to strengthen an effective $C^4$ I are necessary. India can ill-afford to ignore the role of computers, both hardware and software, in various systems/subsystems. India's strength in software to upgrade the performance of the existing and future weapon systems must be nurtured to fruition. Modern wars are fought by taking correct decisions in real-time, based on up-to-date realistic information. Therefore, information must be available to the users at the right time, at the right place and in the right form. There is an urgent need to tackle the doctrinal, technological and organisational problems at the earliest, so that a solid foundation is laid for building effective defence forces to cope with a hi-tech war, if thrust upon us[11].

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