FROM HOME ENTERTAINMENT TO FRONTLINE TRAINING

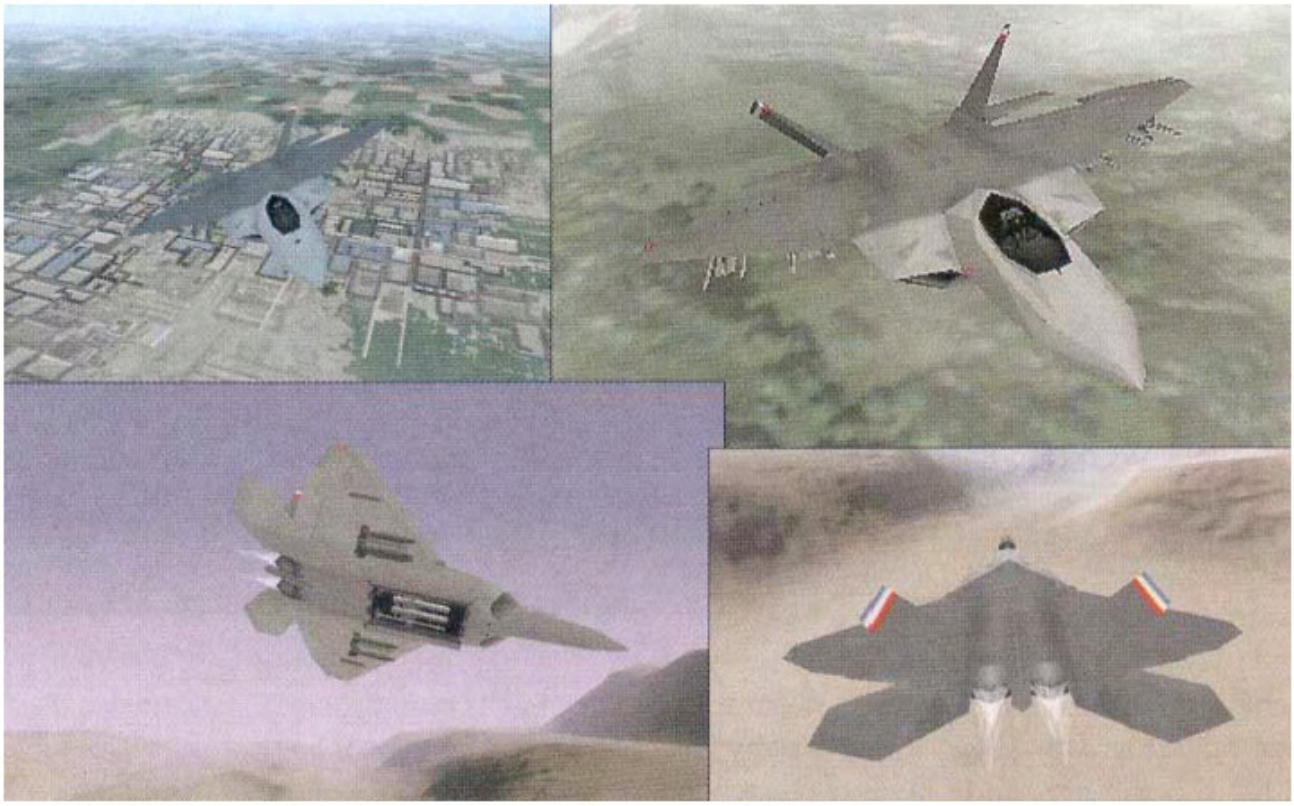
Simulation has probably benefitted most from the continual exponential improvement in computing capacity. Now Digital Image Design, a company which has made its name in entertainment simulations, has expanded its capabilities to produce specialist simulations for specific military systems. Stewart Penney visited DID's headquarters in Warrington in the northwest of England to find out more.

TFX:EF2000 is one of the best received home-entertainment flight simulators. Importantly, it has been well received by real pilots as well as the armchair variety. The game has also been the catalyst for DID's defence business.

Digital Image Design (DID) has made quite a name for itself over the last 10 years producing flight simulators for the home market. Such games have in themselves created a whole support industry with companies such as Thrustmaster producing Hotas-type (hands on throttle and stick) joystick and throttle sets and rudder pedals. The best known product, TFX:EF2000 (plus a Windows 95 upgrade, Super EF2000) is well known for its "accuracy" and playability and it has sold more than 500 000 copies worldwide. The next product, TFX3:F22 is due for release in late autumn and promises to be as successful as its predecessors. Other new products will include a ground warfare simulation which is being developed in conjunction with a new graphics engine that will later find application in the flight simulations and various non- entertainment simulators.

For those unfamiliar with TFX:EF2000, it is not a computer game in the traditional sense of the term. It is more akin to traditional flight simulators with realistic graphics and aircraft with the functionality of the real thing. Flight models are six degree-of-freedom and although as the company's David Ewing admits, no quantitative validation has been done, plenty of qualitative testing has been performed including some by pilots who have flown EF2000.

Mr Ewing, who is writing up a PhD on flight dynamics carried out at the University of Glasgow, works on the aircraft including the flight models, plus operational and tactical aspects. Another team works on avionics - as with any modem aircraft this is a major undertaking - with another on instruments etc. Writing such software involves many individuals, and, just as building a real aircraft, a complex design and production process is required. Production planning uses many of the same principles as would be familiar to production staff at any manufacturing site. As well as the project based teams, DID also has an art department and a research department. All software is written in C and Assembler. Staff are split 50:50 coders to artists.



Views from TFX3 shows that the level of graphical detail which can be achieved on a normal home computer is remarkable. As with the real Raptor, TFX's aircraft also has a ground attack capability (lower left).

Testing is an important aspect of software development of any kind and here it starts at the very beginning of the design process, notes David Ewing. The end product is bought by a section of the general public which tends to have strong views on what should be provided and who get very frustrated if the programme's robustness is poor. As well as early testing, DID has access to a number of consultant pilots who provide a qualitative evaluation of the product. There is also Beta testing where selected members of the public receive an initial version to test and comment on. After this comes release: if the public find problems, patches are written. These are then distributed via the DID's internet site (http://www.did.com) or on computer magazine cover disks. To aid customer support the company has a dedicated E-Mail address which has been known to receive 24,000-plus messages in a single fortnight.

TFX3:F22 - which was started in November 1996 - is not simply a version of the EF2000 simulator with a new aircraft, but a completely new approach and concept, explains David Ewing. For instance, the 'player' can assume the role of the F-22 pilot, Awacs controller or the base commander. The last of these runs the war, tasking flights and arranging logistics etc. Additionally, the war is no longer set over Norway but in the Middle East and it is no longer a 'them vs us' scenario, reveals Mr Ewing, but an 'us vs anybody'. The theatre area is 1200 x 1200 miles while there are 40 000 permutations of war from border skirmishes to all out conflict with allies switching allegiance and even the possibility of F-22 versus F-22.

Awacs

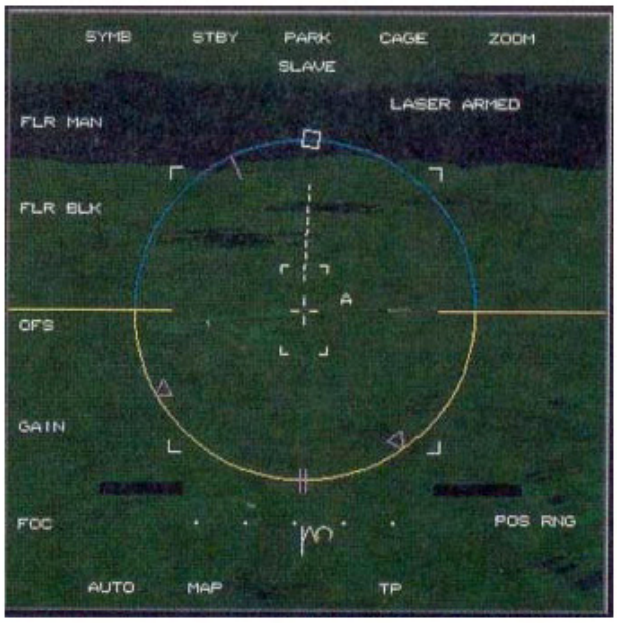
The Awacs role is also new and allows the player to direct the battle. According to its designer, Mick Hocking, USAF crews have seen the game's displays and are impressed. The Awacs controller manages the in-theatre battle and monitors the air traffic while commanding/arranging tankers, combat air patrols and the like.

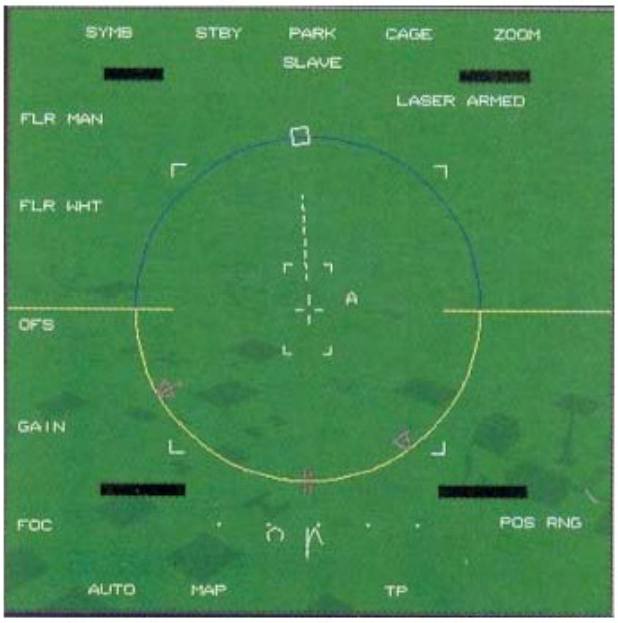
The Awacs module was not originally part of the simulation. It was started by the company's artificial intelligence section and has since developed to the stage where it can be used in the game. This is a good example of the way in which DID uses its creative people by allowing them to run with their ideas: the only constraint is to ensure that the product reaches the marketplace on schedule, says David Ewing.

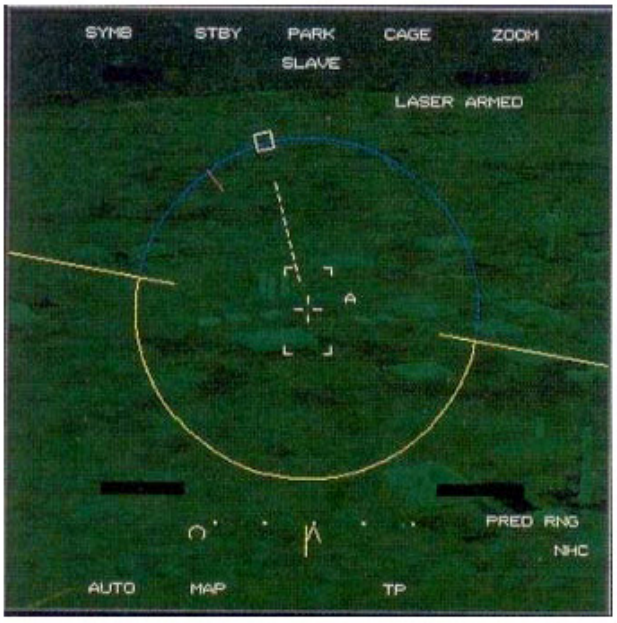
Artificial intelligence is becoming increasingly important in flight simulators for the entertainment market. In many previous entertainment simulations, enemy aircraft have been overly eager to engage, in TFX3:F22, however, the computer pilots, like their human counterparts, will make intellegent decisions based on their mission profiles and particular circumstances before choosing whether or not to engage and how best to do so.

The new product is ambitious - especially when it is to run on standard home computers - including as it does

the aircraft's avionics (there are 65 types of aircraft, 32 types of ship and 33 types of land vechicle in TFX3:F22), and the data flows etc. It is more than just a flight simulator, says David Ewing, it is about the USAF's strategy and its ability to achieve and maintain air supremacy. "It is a complex game of cat and mouse or 3D chess," he adds. Aiding DID in its endeavour has been Colonel John Warden, late of the USAF, and generally regarded as the architect of the Gulf War air campaign.







Screen shots from the Jaguar Tiald trainer, the darker shot (above left and right) is a view using the thermal imager while the brighter shot shows the TV sensor view. The views, tracking and all other aspects of pod are represented in the trainer which is controlled using the same inceptors as in the aircraft's cockpit.

The' gameplay' of any product is important. If it does not hold the player's attention then it will have a short shelf life. Hence some changes are made to missile characteristics, for instance shortening their ranges to make dogfighting more likely. Similarly, bringing consultants such as Col Warden into the team adds the war's progress into the game playing aspect of TFX3. Likewise, notes David Ewing, the company has to make the game natural to the player in much the same way as a systems house makes its products natural to the operator. This gives the company an added flexibility, and advantage, when transferring some of its skills to its military products. A player can, like any other computer game, click a button and start the game. However, mission planning is a significant part of TFX3:F22. At its most basic the player can select an automatic route using a shortest-safest slider, etc, which will modify the computer generated route for the shortest distance or to avoid the enemies defences. At a more complex level, the player can take advantage of a full briefing system which includes reconnaissance images, etc, (as would the real thing) and takes account of fuel usage and covert ingress measures.

Intuitive interface

The user interface has to be intuitive and graphical as although most users are computer literate some aren't: market research shows that the average buyer of TFX:EF2000 tends to be older than the norm and with more disposable income than the average computer games exponent. While the audience is more likely to acquire peripherals to enhance their enjoyment of EF2000, they are also more sophisticated, which in turn makes them

vociferous in their desires.

One feature which has been added to DID's simulations, following user requests, is an air combat manoeuvring instrumentation (ACMI) type playback of the action. This was implemented and has now become a useful debug tool, notes Simon Kershaw the producer of TFX3, as it indicates when an aircraft makes an 'odd' manoeuvre or uses suspect tactics. As with many other aspects of its products, DID has a dogfight consultant working with them in this area.

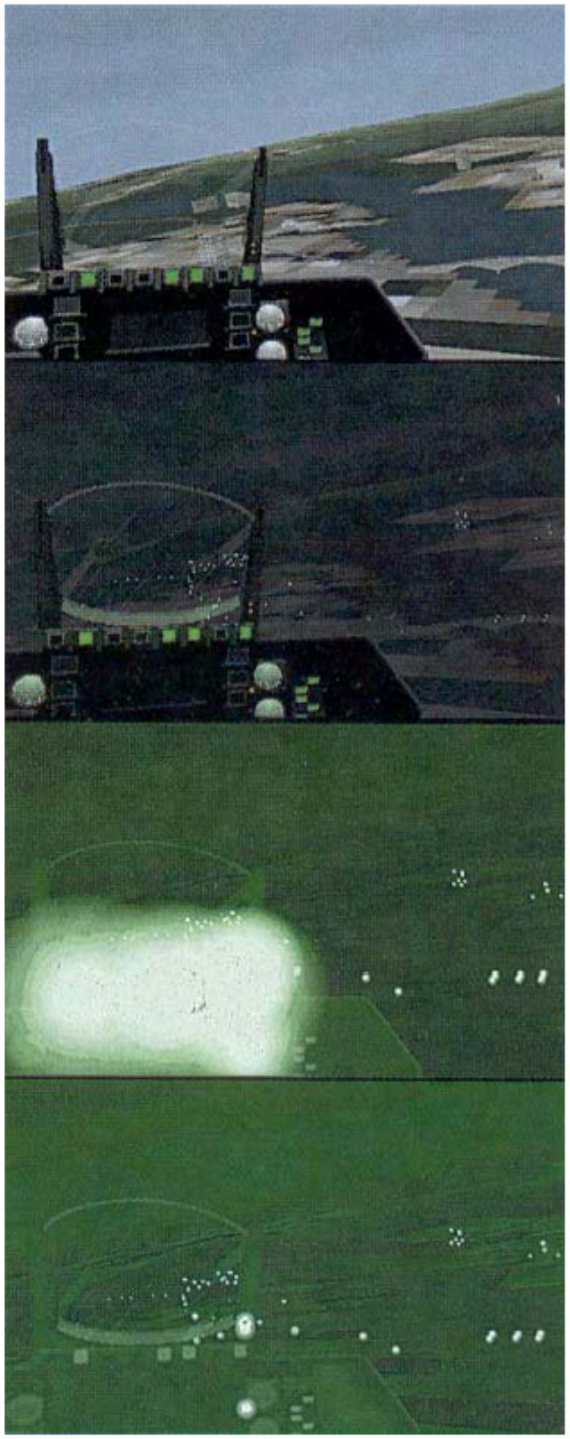
The aircraft not being flown by the player are computer controlled. These use a simpler set of flight rules than the player-controlled vehicles but nevertheless they do follow basic classical theory. The player rues an aircraft with a far greater depth of modelling, says Jeremy O'Brien. Modelling, which covers aerodynamics and the FCS, uses techniques similar to the real aircraft. Although assumptions are made, the end result is valid while being balanced against the need for the computer to be able to calculate the parameters and drive the graphics. Aerodynamic modelling does include an estimation of interference drag, etc, in both the EF2000 and F-22 simulations. Control inputs can be either digital through the keyboard or analogue through a joystick. These inputs can be seen when looking at external views of the player's aircraft as the control surfaces (and high lift devices) move and/or deploy: deflection moments, however, are not calculated.

Weapon models are also simple but they do conform to the laws of physics and aerodynamics. Weapons are one aspect which tend to be modified for games playing purposes. Ranges in particular are reduced - after all, it would be a bit boring simply blatting everything at beyond visual range. One aspect not modelled is CofG shift as weapons are used or fuel is burnt. However, it is unlikely with the limitation of computer systems (and no feedback through the pilot's inceptors) that anybody would notice it anyway.

For the first time, fuel is expended by all TFX3 aircraft in flight, not just the player controlled one. This leads to a big logistical problem as all of the aircraft need to be vectored to tankers and/or returned to base before they run out of fuel.

The flight model can operate at different rates to screen refresh, particularly on lower specification machines, as this allows more variables to be considered without the aircraft becoming unresponsive. However, Jeremy O'Brien admits that they do not know how the control system is scheduled on the real F-22 so they make an educated guess. Additionally, in pitch the player can switch between pitch rate or angle-of-attack demand, whereas in reality there is mixing between the two.

Mr O'Brien and Mr Ewing, essentially the FCS team, are also responsible for the dogfighting engine. This is manoeuvre based, rather than a point and go, system.



The NVG 'sampler' showing views (from top to bottom) of daylight, darkness, NVGs without compatible lighting and NVGs with compatible lighting. The system also has other aircraft, those with standard beacons cause similar flare to the incompatible lighting.

Cross fertilisation of ideas from the games has led DID to establish a military division. Originally a Tiald capability appeared in the TFX simulation, but interest from a number of companies led to DID producing a Tiald demonstrator which has apparently sold well. The TFX:EF2000 Terprom feature will be similarly exploited while a "button trainer" for the E-3 has been shown to the RAF Sentry crews at Waddington. Previously DID produced the graphics and flight model used by Data Sciences in the Jetstream Instrumentation Trainer sold to RAF Cranwell in 1996 (see Low cost-high fidelity simulation, Aerospace, October 1996) and in the same company's 737 simulator for British Airways (see Aerospace Industry, Aerospace, September 1996).

As a follow on, DID has produced a Tiald part task trainer for the RAF to teach Jaguar pilots the switchology of the system. As Nevil Plura, military division software manager explains, the system has five preset exercises and 100 random targets. Each starts with a briefing featuring reconnaissance style views of the target. This is then replaced with the view that the pilot would see on the cockpit multifunction display (MFD). The system can mimic all of the pod's functions such as slewing, locking on, fields of view and white or black hot images. Having released the bomb the pilot is presented with a debrief and further 'photographs' of the target. The system can also simulate environmental effects such as cloud and other obscuration, thus forcing the pilot to switch between television and thermal imaging sensors.

Unlike traditional PC based computer based training, where the player sits facing a computer and monitor and

uses the keyboard for control (or dedicated third-party joysticks), the Jaguar pilot is faced with a large display representing the MFD, a Jaguar stick and the Tiald controller (a fixed hand-grasp with the necessary buttons which resides on the left hand console behind the throttles). This all sits on a dedicated base plate which will allow easy transportation of the simulator.

DID honestly notes that their Tiald simulator covers only that system - i.e. it is a dedicated part task trainer. But they also note that the RAF has 11 systems installed at Coltishall for the cost of one of the opposition's which intensifies the training effect. Basic simulators which train specific skills have become more popular in recent years as personal computers have become faster and cheaper simultaneously: the intent is not to replace time in the aircraft but it does enhance the training quality of the flying hours.

Another carry-over from DID's entertainment products is seeking the advice of those who do the job. Nevil Plura notes the importance of working with the pilots and the instructors. Having created a system for the Jaguar, DID can foresee a market for the Harrier GR.7 and the Tornado (for which touchscreens would be used to replicate the navigator's cockpit interface) within the RAF, and as projects director Don Whiteford notes, trainers for other targeting pods such as Lantirn, etc, could use the same basic work.

DID's reaction time is well illustrated by the Tiald simulator. The code does have some overlap with that used in TFX:EF2000, says Nevil Plura, but not much. Three months of coding produced the initial product which was driven by a keyboard and a modified Thrustmaster joystick and throttle (Thrustmaster is a well known supplier of Hotas equipped sticks and throttles for the entertainment market). After a break, a further month of coding finished the product.

Martin Kenwright, DID's managing director, founded the company in 1990 having started by producing simulation graphics at home in the 1980s. He continues to own part of the company which has a œ4m turnover. He believes that DID has a particular advantage when producing dedicated part task trainers as the company is geared to producing what the customer wants - a throwback to producing entertainment simulators for a sophisticated consumer base. Working as the supplier and taking components from others (Oxley provided the floor units and Ultra the stick tops for the Tiald simulator) takes the complexity, and inflexibility, out of providing the software to a prime and gives DID an advantage, notes Mr Kenwright.

At first, DID took three months to prove it could do the TIald simulator. The company also needed to become ISO9000 approved which it did in 11 months, mainly says Martin Kenwright, because tight internal procedures were already in place. DID is developing products which fill holes where operators want simulators/trainers at a sensible price, i.e. not custom units or workstations allowing multiplay solutions rather than single units.

Oxley; as well as providing components to DID, produces NVG compatible lighting and wanted a demonstrator to illustrate the difference between its systems and standard aircraft lighting. Having successfully produced a demonstrator, which is entirely software based, DID is now studying the possibility of producing a trainer which would give neophyte NVG users a basic understanding, and an experience, of using the devices before they are used for real. A feature of NVG use is the effect on the user's field of view. To represent this, DID will probably use virtual reality (VR) technology. If such a device is developed into a trainer its prospects are good, as an increasing number of vehicles, and individuals, are being equipped with night vision equipment.

As well as trainers for airborne applications, DID is working on a Ground Warfare Technology Demonstrator simulator. The photo-realistic landscape is built up from information derived from commercially available satellite imagery. The system shows eight vehicles and networks five computers, allowing two drivers and two gunners to train with an instructor in the loop. The non-human controlled vehicles use artificial intelligence which has to be superior to that used in the aircraft-based simulators as mistakes are more noticeable on the ground. According to Paul Hollywood, one of the artists working on the simulator, a lot of detail can be added to the view if the data are available, and likewise, the world in which the simulation is set can be changed in days. This in turn allows the trainer to be portable and upgradable, to a new location, while troops are being deployed.

One of DID's strengths is that the vehicle interacts with its environment. This is particularly important with games (destroyed targets remain destroyed etc), but also it adds to the realism of the military division's products. The tank simulator, for example, leaves scorch marks. It also incorporates accurately modelled ballistics.

Ground warfare simulations are becoming more 'en vogue' as networked computers become cheaper, more powerful and easier to operate. Previously only the richest armed forces have been able to afford large numbers of networked computers for exercise purposes.

Distributed Simulation

A variant on the networked simulators has been produced with Sweden's FFV Aerotech. DIS (Distributed Interactive Simulation) used an off the shelf networking package (VRLink) to link 12 copies of TFX:EF2000. This has been demonstrated to the Flygvapnet among others. As with the other simulations, DID stresses that the intent is not to replace full blown simulators but to provide a specific aspect at good fidelity for a realistic price. DIS thus allows a group of pilots to pre-fly a mission while becoming aware of formation changes and the switching ('piccolo playing') required to perform the task. When fully exploited, DIS allows air, sea and land assets to be interactively linked and even for individuals to get out of their vehicle and move on foot across the terrain.

In a gaming environment, DID has been a successful with a cut down version of TFX:EF2000 which allows users of British Telecom's Wireplay service to partake in head-to-head dogfights over the phone network. Wireplay is a dedicated games network which users pay œ1.50/hr to use. Compatible versions of EF2000 are available on magazine cover disks and at the DID website. Unsurprisingly, the game is the most played on the network.

DIS works by only sending the relevant information across the datalink. For instance, if the position, altitude and time reference is transmitted the receiver can determine an aircraft's exact location. If prediction algorithms are included, network traffic can be reduced by update information only being sent if a 'player' has deviated from the prediction. This along with the advent of modems which work with cable (rather than telephone systems), ADSL (Asymmetric Digital Subscriber Line, a new British Telecom fast internet service) and general improvements in terms of bandwidth and latency to standard data communications, presents a bright future for affordable distributed simulation.

To continually improve the entertainment simulators and the military training systems DID has a major (pooled) R&D effort under the auspices of a dedicated department led by Chris Orton. Part of the department's task is to ensure that new equipment - be it processors (optimising code for new or improved chips), accelerator cards, etc - work with DID's products. DID's position in the market means it can work with the hardware suppliers in advance of a product's launch to ensure that DID's simulations are compatible - if not a fix can be engineered and patch code distributed by suitable means. Another task is to develop new techniques such as the halos used in the NVG system and the new graphics engine being used in the land warfare game.

Graphics acceleration cards are becoming mote powerful for lower cost at a quicker rate than the computer, to the extent that the home buyer can obtain such hardware for less than œ200 ($300). Soon computers will be equipped with graphics accelerators as standard and DID is determined that it will make the best use of the advances so today's market leading graphics are not left behind. Therefore the company has reworked its 256 colour (eight bit) graphics to 16.7 million colours (16 bit) which, as Mr Orton explains, allows effects such as

opacity to be produced in hardware at a significantly faster rate. The technology will also begin to make VR helmets a reality which could be applied to the entertainment products as well as, for example, an NVG trainer.

The increasing volume of military work means that the company is likely to grow from 72 employees to 90 over the next year, with a second office being acquired. New games cost around œ1m to produce and take 12-18 months to reach the market. There is continual pressure to innovate, be it the overall game play, combat capability, the wargaming or graphics. So what will the next game be after the F-22? The Joint Strike Fighter of course.