More Than Meets The Eye

Approaches to Maintenance Training

Boeing has worked in close cooperation with DiSTI to deliver its IVEMT trainer for the RAAF's F/A-18E/F fleet. The system becomes RFT at the end of the year.

(Source: Boeing)

For a number of reasons, the use of high-fidelity maintenance training is growing. *Peter Matthews* examines why this is the case and considers what is next for maintenance training.

We live in a world of falling defence budgets and increasingly complex and sophisticated military platforms. To keep these platforms at the height of their combat effectiveness means that maintenance must be of the highest order. The question is, what is the best way to train the technicians that have to support this equipment?

After general maintenance training at a military school or college, maintenance technicians tend to be streamed into specific areas. These areas might encompass generic systems, such as hydraulics, structures or electrics, or they might involve specialising on one platform type. The former approach is generally the norm however some nations adopt the second approach which is often referred to as the 'user-maintainer' system.

Other factors to consider in the training process are the operational requirements of maintenance. It is all very well being trained in a clean, well-lit and benign environment but if equipment needs to be repaired in a Forward Operating Base (FOB) at night and under fire, other factors come into play.

As we have already touched upon, maintenance training is now receiving a much higher emphasis than hitherto. Twenty years ago training technology was aimed at improving the performance of platform operators and the poor maintenance technician came a lowly second. This situation has changed not only due to the increasing cost of military equipment and the associated recognised need to protect that investment but also because modern training technologies are enabling improved and more accessible maintenance training to take place.

These new technologies, predominantly involving Commercial Off The Shelf (COTS) software, have been developed alongside the traditional approach to maintenance training involving real equipment and schematic diagrams. This real equipment could be actual operational equipment or retired equipment that has been modified to become a training rig. The latter might include cutting away certain panels to reveal the inner operation or painting parts in different colours to highlight discrete operations.

This basic training is then often expanded through the application of supervised On the Job Training (OJT) using the real equipment. Although a highly valid approach, using real equipment for basic training or OJT does raise the issue of damage to that equipment as well as the creation of bottlenecks in training if equipment is unavailable.

The initial answer to this conundrum was to manufacture a replication of the real equipment, as Agusta Westland has done

for the UK Royal Navy's Merlin helicopter, or to convert an old airframe for maintenance training. An example of the latter approach has been undertaken by Boeing with a CH-47 airframe for the US Army.

In essence, the two approaches of using real or replicated equipment (live) or a virtual training medium both have pros and cons but they are not mutually exclusive as Canadian company nGRAIN's Director of US Sales, Chris Hawkins explains.

"Let's be clear, virtual maintenance training does not replace hands-on-metal experience – it supplements it. It eliminates the training bottlenecks that occur prior to the hands-on stage, and it accelerates the learning process by providing more effective instructional aids and giving students increased opportunities to practice procedures," says Hawkins.

"Today's forces are under incredible pressure to maximize throughput, ensure maintainers have more knowledge about an increasing number of systems, and increase job-performance. And they must do this with decreased funding.

"Simulation-based training enables our forces to capture the knowledge of subject-matter-experts who may be retiring or are being deployed and ensure that this expertise is retained in the classroom. By using interactive 3D simulation… instructors provide students with a way to familiarise themselves with parts and review common tasks and troubleshooting procedures in a format that can be reviewed prior to entering the classroom, as a training tool, and can also be taken into the field to be referenced on the job."

Boeing's Australia Super Hornet Programme Manager for Maintenance and Aircrew Trainers, Dan Pagel approaches the question from a different angle when he says, "there is still a need for the hardware-based trainers to accomplish training on critical hands-on tasks. Without hardware trainers, the options are somewhat limited: complete this training as On the Job Training when the person is deployed to a squadron, or arrange for an aircraft to be available.

"From Boeing's perspective, the USN and FMS customers prefer a mix of the visual environment maintenance trainers, augmented with hardware devices. The visual environment trainers provide operational and troubleshooting capabilities, while the hardware devices provide the environment for training the critical hands-on skills [such as] rigging a landing gear or removing a leading edge flap servo [for example]."

The majority of CAE's maintenance training systems are based on the company's SimFinity architecture. This example is for the NH90.

(Source: CAE)

Although Hawkins and Pagel comments about virtual training supplementing live hands-on training using the real equipment is a valid one, this discussion really comes down to what the ratio between live and virtual maintenance training should be? Here, other factors come into play such as the cost of training.

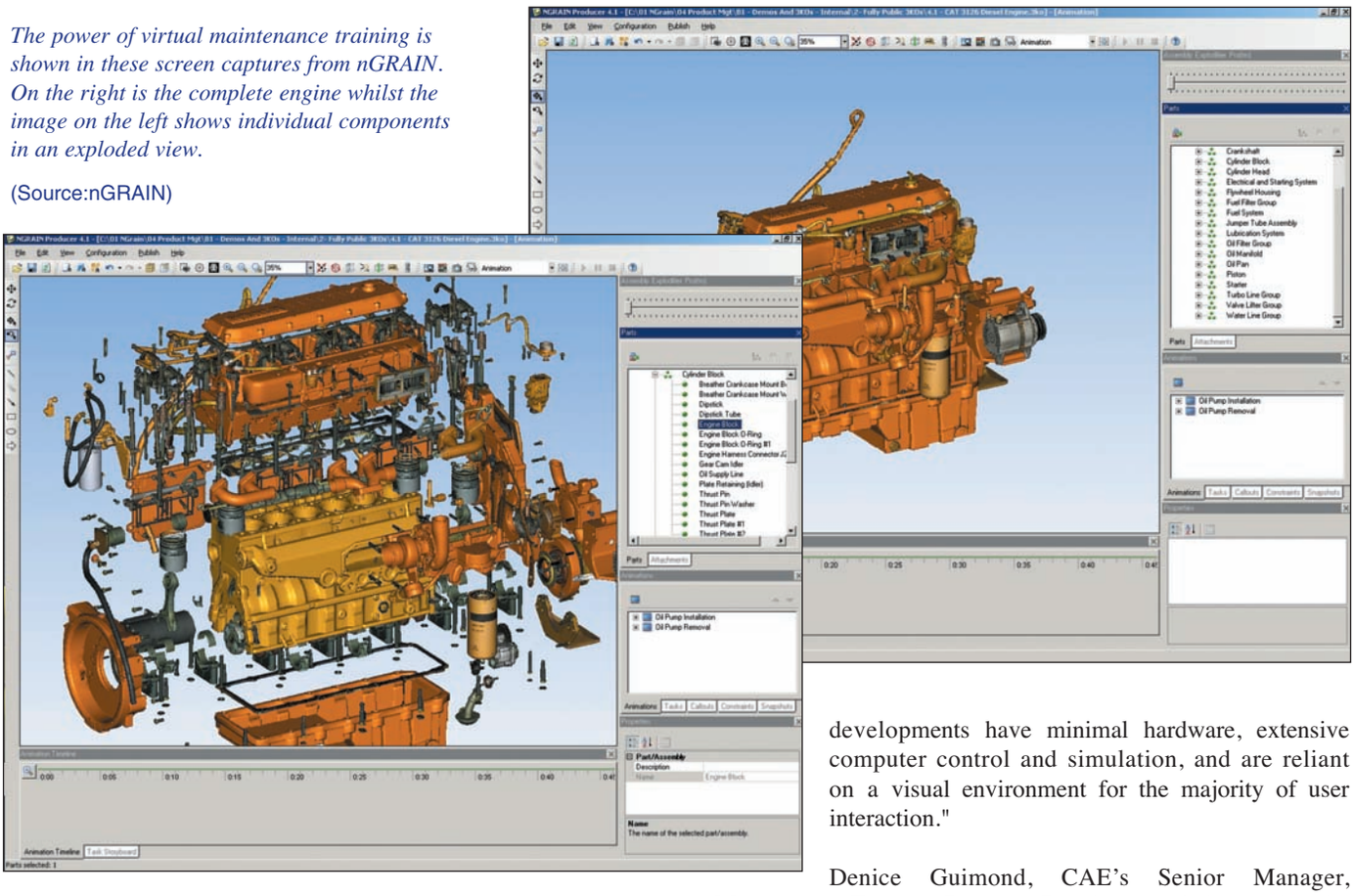
In their paper at ITEC 2009 in Brussels Brandt Dargue and Lawrence Nakamura from Boeing and Christopher Giordano from DiSTI Corporation highlighted the 2008 study by Duke, Bahlis and Morrissey which compared live training on the US Navy's Phalanx replicated trainer with a desk-top Virtual Maintenance Trainer (VMT) for the same device.

There study was predicated on the previous study by Nelms (2008) which said that when looking at the life-cycle of a hardware based trainer, 30% goes on procurement and 70% on life-cycle maintenance. Duke, Bahlis and Morrissey's study showed the cost of training one student for one hour on the live trainer cost $92.00 whilst the VMT cost $0.12.

"Interestingly enough, when Boeing was undertaking its initial studies into live maintenance versus VMT around seven years ago, they found that knowledge retention was slightly higher using replicated maintenance trainers however, as the fidelity of the VMT has improved over recent years, knowledge retention has swung the other way," explains DiSTI's Chris Giordano.

The power of virtual maintenance training is shown in these screen captures from nGRAIN. On the right is the complete engine whilst the image on the left shows individual components in an exploded view.

(Source:nGRAIN)



As an example, he cites the Integrated Virtual Environment Maintenance Trainer (IVEMT) developed in partnership with Boeing for the Royal Australian Air Force's (RAAF) F/A-18E/F fleet. This device is about to enter service.

"We are providing two IVEMTs to support the Australian Super Hornet (ASH) programme," explains Dan Pagel. "Both of these devices will be installed at RAAF Base Amberley. IVEMT 1 was completed and declared Ready For Training (RFT) on 18 October 2010 whilst IVEMT 2 RFT is 10 December 2010."

"IVEMPT has been built using a number of our tools including the latest version of GLStudio," explains Giordano. "The device tracks a recent trend of using the platform manufacturer's actual CAD data for the most realistic virtual environments. We also use render-to-texture techniques, known as ambient occlusion, to provide seamless transitions of texture as the student opens panels and gets close to internal components."

IVEMT builds on a long term involvement in F-18 trainig by Boeing as Dan Pagel explains. "McDonnell Douglas/Boeing has been involved with F-18 Maintenance Trainers since the early 1980s, both for the US Navy and Foreign Military Sales customers.

"The maintenance trainer devices have evolved over the years, starting as strictly hardware trainers with no computer control or simulation; the user interaction is directly with the hardware components. Whereas the most recent trainer developments have minimal hardware, extensive computer control and simulation, and are reliant on a visual environment for the majority of user interaction."

Denice Guimond, CAE's Senior Manager, Maintenance Training Business Development believes that the virtual approach to maintenance training has some major advantages which stand out above hardware-based devices.

"The virtual learning environment is significantly more effective than hands-on, whether using hardware trainers or the actual vehicle," says Guimond. "One major advantage of simulation is that the student can be exposed to an infinite set of maintenance scenarios, compared to the limitations of the actual equipment. Considering the maintenance training emphasis on effective troubleshooting and diagnostics skills, the virtual maintenance trainer can simulate software, electrical, sub-components, or hardware faults with increasing level of difficulties."

Here of course, the importance of diagnostic skills, perhaps the most important weapon in a maintainer's armoury, comes to the fore, as Guimond points out.

Although virtual maintenance training systems are growing, hardware based trainers still have their place. This example is for the Merlin helicopter and is located at the Merlin training facility at RNAS Culdrose, UK.

(Source: T. Nash)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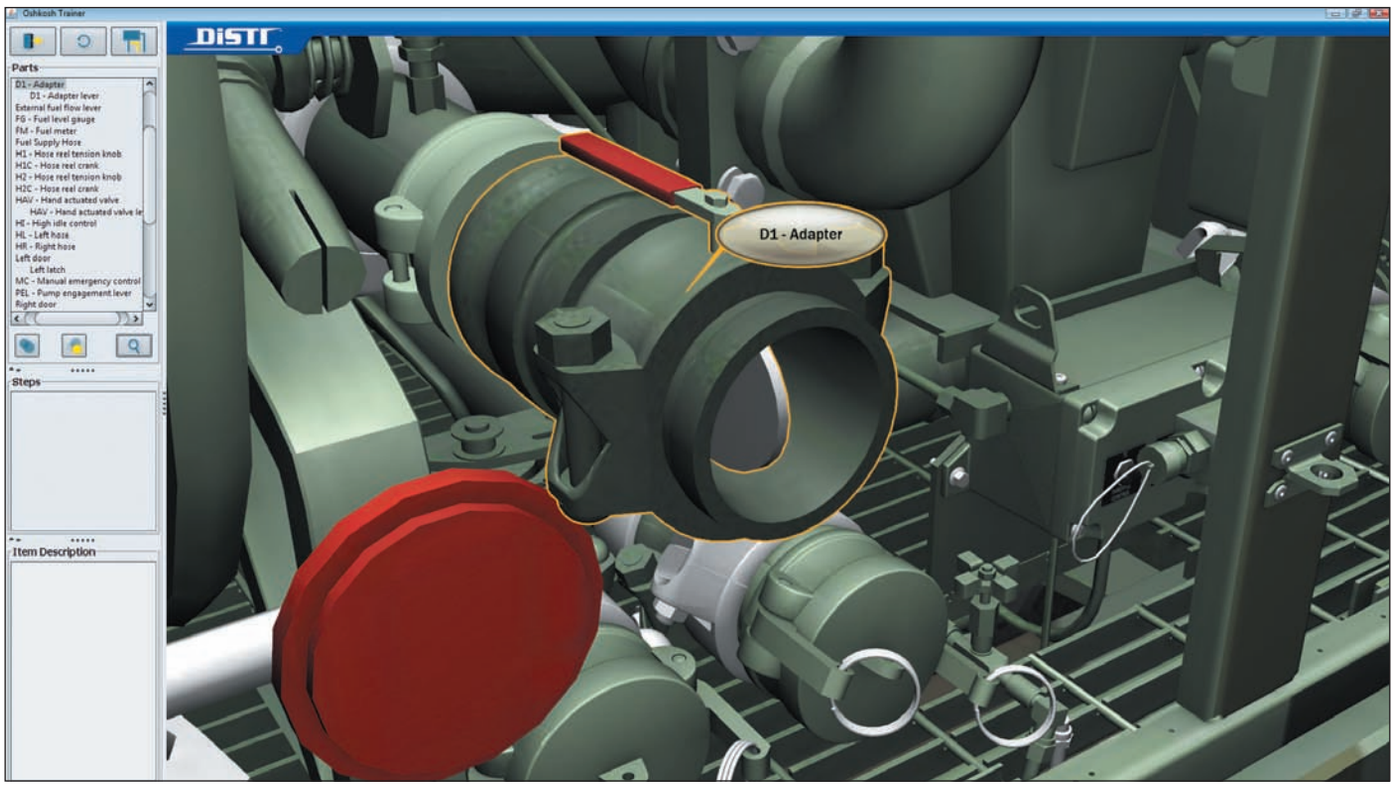

DiSTI's virtual maintenance training systems have been produced for a number of different platforms. As well as ground systems, the company is also on the F/A-18 and F-35 programmes.

(Source: DiSTI)

"The student's diagnostic sequence, operation of test and support equipment, and corrective actions are all tracked in the Learning Management System (LMS). This ensures a consistent high standard of training delivery and record of the personnel qualifications," he says.

"There are additional advantages of virtual maintenance training of course and these include:

Deployability – training can be delivered offsite, with or without instructor mentoring, thus reaching students in the most timely manner. With the increased deployment and operational tempo of military units, continuation training that takes place away from the traditional schoolhouse is essential.

Accessible through the worldwide web (or military WAN), the virtual trainer can concurrently support as many students as required, unlike the hands-on hardware device that can support limited number of students at any one time.

Changes to the aircraft configuration can be implemented in the virtual trainer much faster (and at less cost) than on hardware-based maintenance trainers.

At the operational maintenance squadron, continued access to the virtual maintenance trainer provides troubleshooting assistance, task rehearsal, and refresher training for the actual 'hands-on' maintenance task."

Take-Up

It is clear that maintenance training is going through a renaissance at the present time but is that interest and demand being translated into real business. The answer is yes as far as the people *MT&SN* have spoken to.

"We're getting a lot more interest in maintenance training than we have ever had before," says DiSTI's Christopher Giordano. "My view is that budgets are static or declining and military users are looking for more cost-effective ways to train. The virtual maintenance trainer is the optimum way to achieve better training for lower cost."

DiSTI's optimism is reflected north of the border in Canada as nGRAIN's Chris Hawkins explains.

"What was once thought only to apply to flight simulators is now being applied across a number of applications – from medical to maintenance training – it is a huge area of growth," he opines. "Our implementations initially started within the schoolhouses; helping our forces in training our troops to acquire the knowledge they need to be successful in the field and this area continues to grow. We are also seeing OEMs identify the value in simulation-based training as a way to reduce the cost of sustaining the aircraft and vehicles they manufacture. The Lockheed Martin C-130J program is a great example of this – CAE has contracted nGRAIN to provide maintenance training solutions that will be used by the Canadian Forces in sustainment of that aircraft. Recently we also announced a partnership with EADS that will incorporate our technology with high-end Virtual Maintenance Training simulators that replicate fully operational aircraft."

As far as CAE is concerned, Denice Guimond is under no doubt that, "there is an increasing demand for virtual maintenance training systems due to demographic issues, such as workforce attrition and turnover and the loss of experienced personnel; aircraft systems complexity, evolution of standards, and the application of virtual environments used in training into actual maintenance operations. In virtual maintenance training, there are many synergies with common aircrew training elements, potentially with significant savings to the customer if the overall aircrew and maintenance training solution is combined."

Guimond has touched on a very interesting point which echoes the thoughts on the use of CAD data mentioned earlier by DiSTI's Giordano. We live in a digital world and so often, digital data from the design process is used for design and then filed. By sharing this data across the development, design, training and sustainment phases of a platform's life, countless millions of dollars could be saved, training fidelity would be greater and concurrency between platform and trainer would be assured.

Although the VMT provides a bucket load of benefits, at some stage, the embryonic maintenance technician must get his or her hands on the real equipment. This process is vital only if to experience the tactility, form, fit and function of real equipment.

One example concerns maintenance onboard ships. It is little use, and perhaps highly dangerous, if the first time that a maintenance technician removes a heavy Line Replaceable Unit (LRU) from the avionics bay of a F/A-18 is on the deck of a pitching aircraft carrier at night in a force nine storm. This task could be undertaken during OJT following training on the VMT. Either way, just like flight training, maintenance training must recognise the 'live-virtual balance'.

Canadian Air Force Uses NGRAIN Equipment Maintenance Training Solutions for AFILE

Canadian company nGRAIN has recently announced that its interactive 3D simulation solution has passed the necessary testing for the Canadian Air Force Integrated Information Learning Environment (AFILE). The company's Virtual Task Trainer (VTT) solutions will be made available to maintenance technicians across the Air Force community on the standardized AFILE platform.

AFIILE, a project launched in 2008 by the Department of National Defence, is designed to standardize the accessibility and management of training programmes. Using industry standard Learning Management and Learning Content Management Systems, and conformant with the internationally-accepted Shareable Content Object Reference Model (SCORM), the AFIILE links students, instructors, training resources and course management capabilities into a single virtual classroom. The platform ensures students have access to the same training content, and that learning can be tracked and monitored from any Air Force school.

A Canadian CP-140 Aurora

"The AFIILE programme marks a new training approach for the Canadian Air Force," said Arnold van den Hoeven, Director of Canadian Defence at nGRAIN. "With this programme, airmen across the country will have universal access to the nGRAIN solutions made available on AFIILE. Instructors will be able to track student performance and have confidence that their students have access to the information they need..."

Two nGRAIN VTT solutions passed the testing for SCORM (Sharable Content Object Reference Model) compliance on the AFIILE system . The nGRAIN solutions leverage interactive 3D simulations of the CP-140 Aurora maritime patrol aircraft to deliver results-driven training for aircraft maintainers and technicians. The MK-46 Lightweight Torpedo VTT and the CP-140 Corrosion Control VTT each enable students to feely explore the systems, identify parts, review key assembly/disassembly and maintenance

Future Technologies

As we have seen, despite a place for live maintenance training, the VMT continues to gain traction and popularity. The question is, how much better can it get and what technologies are waiting in the sidelines to improve it still further?

"Mobile technologies are certainly an area that is generating quite a bit of discussion," says nGRAIN's Chris Hawkins. "New devices and operating systems have entered the consumer market which now has military organisations exploring their application in the field. We have several implementations that are deployed wirelessly – aircraft maintainers of the F-35 for example record damage directly onto a laptop computer whilst our landmine database is used by sappers in the field on a ruggedised PDA."

The use of such systems demands a coherent approach to standards of course. "What we advise our customers is to ensure that they select a device that is flexible and interoperable with their current technology investments," continues Hawkins.

"There is no sense investing in a new operating system if it can't support the tools they already have. For example, not all devices support Flash, which is a commonly used tool used in training solutions. Many learning management systems are Microsoft based. It's important that they really invest in their due diligence to pick a solution that will meet the need of a maintenance technician and support the equipment lifecycle as a whole."

The mobile approach has also been recognised by Christopher Giordano at DiSTI.

"We have deployed our maintenance training solutions onto laptops, iPads and iPhones," he explains, "and this approach is likely to gather pace in the future. One of the major benefits of this approach is that training can be undertaken at home or on deployment thereby making training more flexible."

As far as CAE is concerned, Denice Guimond says that the two main impacts on future maintenance training fall into the M&S and external technologies camps.

"In modelling and simulation, the ability to embed training features (modes) into actual equipment will blur the boundary between training and operational support," he says. "This blended approach is already implemented into hardware trainers where faults and functions are simulated, although the removal and installation of parts, or rigging of controls, are definitely hands-on activities."

"Aircraft design and maintenance technologies, such as system built-in diagnostic features, condition monitoring, and structural repair processes, also have an impact on the maintenance training needs and learning method."

To Conclude

Maintenance training continues to grow and in fact, despite the economic downturn, is seen by many armed forces as a way to save money. This growth is today, mainly focussed on virtual maintenance training although as we have seen, there is still a place for live hardware-based training systems.

According to industry, one of the growth areas in the future will see increased use of virtual maintenance training undertaken on remote devices such as ruggedised laptops, PDAs or iPads. In essence, the military user wants faster, more cost-effective, and more focused maintenance training. The last word on the topic belongs to nGRAIN's Chris Hawkins.

"From a technology perspective, the [armed] forces are looking for simulation solutions that provide a high level of realism in the visual representation of the equipment. They want a simulation that is truly interactive, and un-scripted, so that what is represented on the screen truly mimics how the actual equipment behaves. It must also be easy-to-use and deploy and integrate with existing tools or Learning Management Systems."

procedures, as well as review troubleshooting exercises. nGRAIN VTT solutions are proven to optimize valuable instructor time, provide students with access to training outside of traditional class hours, and increase student performance and training throughput.

"The Canadian Air Force is transforming its training approach to develop more capable airmen and airwomen in a shorter period of time," said Major David O'Brien, Air Force Technician Performance Solutions, 2 Canadian Air Division.

"To meet these demanding goals, the Air Force is redesigning its training with the most advanced training methodology and employing cutting-edge technology - to improve the training experience, to reduce training times, and to increase performance on the job. We are pleased to see the first two nGRAIN products pass AFIILE SCORM testing. The company's products have been sent to the training schools and will be deployed in the AFIILE environment in the weeks to come."

nGRAIN VTT solutions are based on the 3KO (3D Knowledge Object), a unique approach which embeds subject-matter-expertise with detailed 3D models into a self-contained format. The nGRAIN 3KO is optimized to run on a common Windows-based computer without the need for specialized graphics acceleration hardware.

In the 3KO format, information related to the model itself is protected and cannot be reverse engineered, making it ideal for a distributed learning environment such as AFIILE.

Air Force instructors will also have the ability to reuse and repurpose the nGRAIN solutions by updating the 3KO as needed or inserting it into Microsoft Word, PowerPoint or Adobe PDF files or published as part of an HTML page.

"nGRAIN technology is known to improve comprehension and accelerate learning of complex technical information," said Major Denis Forest, AFIILE Project Director at National Defence Headquarters.

"The reusability of the 3KO is tantamount to our success. With nGRAIN onboard AFIILE, the Air Force has the confidence that our national training programmes will have access to essential simulation technology."