Distributed Synthetic Air-Land Training - Demonstration to Delivery

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ABSTRACT

QinetiQ, supported by Boeing, has led the UK's Mission Training through Distributed Simulation Capability Concept Demonstrator (MTDS CCD) program to demonstrate delivery of collective mission training to front line aircrew and other warfighters. Following the tremendous success of this demonstrator, the UK embarked on a transformation program. This will turn the MTDS CCD "research demonstrator" into a training facility capable of delivering 44 weeks a year of operational pre-deployment and other training activity. The Distributed Synthetic Air-Land Training or DSALT program as it is known is a highly ambitious solution to meet a pressing short term training gap.

This paper will describe the history of the demonstrator program and how it has evolved into a training facility for Air-Land integration. The demonstrator consisted of ten interchangeable fast jet cockpits in immersive visual enclosures, seven simulated consoles from the rear of an E-3 Airborne Warning And Control System (AWACS) aircraft, two Fire Support Team simulators and a Fire Planning Cell training environment. In addition it included a comprehensive suite of computer generated forces, exercise management tools and planning, briefing and debriefing facilities. The paper will then outline the challenges involved in taking a demonstrator and converting it into a reliable, supportable and robust training system at minimal cost. This includes upgrading the system while continuing to deliver training; reverse engineering the documentation needed to provide a certificate of design; and agreeing a set of key performance indicators for a service level agreement, without exposing either the customer or supplier to excessive risk.

DSALT is the UK's premiere facility for the delivery of synthetic air-land integration mission training to teams of front line warfighters. Its success has been achieved through the collaborative development approach adopted between the industry team, the Royal Air Force and the UK Ministry of Defence.

ABOUT THE AUTHORS

Jon Saltmarsh is QinetiQ's Program Director for Mission Training through Distributed Simulation. He ran the business area responsible for undertaking the UK's early research into collective training before moving to a business development role shortly before the follow on demonstrator program was competed. He led and won QinetiQ's bid for the MTDS Capability Concept Demonstrator through the formation of Team ACTIVE and has supported this program through to securing the DSALT contract. Prior to QinetiQ he worked directly for the UK Ministry of Defence and undertook a number of very different roles in research, acquisition, finance and policy. He has a Masters in Business Administration from Cranfield University and a first class degree in Engineering from St John's College, Cambridge University.

David Beattie is a Systems Engineer at QinetiQ who has worked on the Mission Training through Distributed Simulation Capability Concept Demonstrator program since 2006 and was the integration team lead for a number of the events. He is currently leading the technical integration of the new Distributed Synthetic Air Land Training facility. David studied Computer Science at the University of Manchester before taking up employment with QinetiQ in 2003.

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UK MISSION TRAINING THROUGH DISTRIBUTED SIMULATION

In 2005 Team ACTIVE[1], a QinetiQ led team comprising Boeing, cueSim, Evans and Sutherland[2], HVR Consulting and Aviation Training International Limited, was successful in the first phase of the UK Ministry of Defence's (MoD) Mission Training through Distributed Simulation (MTDS) program, by winning the competition for a Capability Concept Demonstrator (CCD). The UK MTDS program aims to address an identified training gap in ensuring Royal Air Force (RAF) aircrew and other warfighters learn to operate successfully as part of a larger team. Such "collective" training has proved difficult to achieve in the live environment except in very large and expensive exercises such as RED FLAG. Research had already demonstrated the potential for advanced simulation to play a major role in preparation for exercises and eventually for actual combat (Smith, McIntyre, Gehr, Schurig, Symons, Schreiber et al. 2007). The 30 month CCD program aimed to de-risk the UK MTDS program by establishing user requirements through a series of demonstration events on a contractor owned facility at RAF Waddington in the UK. These user requirements would be used to underpin the MoD's future competition for delivery of the full UK MTDS program.

THE CAPABILITY CONCEPT DEMONSTRATOR

Team ACTIVE's CCD facility initially comprised a network of fast jet cockpit simulators and an Airborne Warning and Control System (AWACS) simulator networked together through a comprehensive exercise management and control room with an integrated planning, briefing and debriefing suite to support the aircrew learning experience. The system was also provided with a secure networking and encryption room to allow it to be connected to other training systems around the world.

Training simulators

The original concept for MTDS was for the training audience to make use of the fast jet and AWACS simulators. Team ACTIVE provided eight fast jet cockpits; four two seat Tornado GR4s and four single seat Typhoons built by cueSim. These were of varying fidelity and could be placed in three different types of visual enclosures to help address the question of what fidelity is required for collective and team training. The AWACS facility comprised five type specific E-3C consoles, which had been used previously on the US Distribute Mission Operations (DMO) program, and two consoles consisting of lap-top PC emulations – again to determine the minimum acceptable fidelity for a future MTDS AWACS simulator.

Figure 1. Simulators offering different levels of visual fidelity

Exercise management and control

The exercise management and control room formed the heart of the facility. Boeing's BigTac computer generated force (CGF) system was used to provide a richer operational environment. Several re-configurable role player stations allowed other aggressor or supporting aircraft to be flown manually to increase the trainees' workload. Boeing's InSight system was used to provide the exercise controller's

[1] ACTIVE – Aircrew Collective Training through Immersive Virtual Events
[2] Now part of Rockwell Collins

"God's eye view" and to control the CGF. The exercise management room also contained all the network monitors and technical support consoles needed to ensure the system operated effectively and to capture results necessary to support the evidence backed recommendations which were the output of the demonstration program.

Planning, briefing and debriefing

The concept behind UK MTDS is for aircrew to experience a full planning cycle along similar lines to that they experience at UK Tactical Leadership live fly training events. As such the CCD facility included a planning, briefing and de-briefing suite of rooms. The aircrew planning rooms were equipped with video-teleconference (VTC) facilities; interactive whiteboards and other collaborative working tools; and aircrew mission planning aids, of the types already in-service and familiar to the pilots using the facility.

Figure 2. Interactive After Action Review - the "jewel in the crown" of the DSALT facility

The briefing and de-briefing facility provided seating for 40 participants. The InSight After Action Review tool was used to provide 2-dimensional and 3-dimensional replays of the training exercise on a three screen projection facility. A capability described by the military users as the "jewel in the crown" of the facility. VTC and further collaborative working tools allowed distributed briefing and debriefing to take place when required.

Network connectivity

A key element of the demonstrator program was to achieve connectivity with the US distributed mission operations network (DMON). The challenges to achieving this were as much related to security and export rules, regulations and procedures as to technical issues. Tight coordination between all parties helped to overcome many of the administrative challenges although these were never fully overcome. To mitigate the technical challenges, QinetiQ provided the CCD facility with a wide area network connection room complete with encryptors, translation boxes, filters and firewalls. This reduced the efforts associated with achieving wide area connectivity and made it less difficult to implement relevant security measures requested by the accreditation bodies involved.

Program output

The demonstrator program was a tremendous success. Not only did it capture a huge amount of information related to requirements for UK MTDS, but it also achieved connectivity to the DMON and it resulted in the UK MoD establishing a major new funding line for aircrew collective training. (Saltmarsh and MacKenzie, 2008). However, from a company perspective, the most satisfying achievement was that the RAF and UK Army were so impressed with the demonstrator's capability that they chose to advance their procurement plans. They agreed to establish a training capability, based on the technology used in the CCD facility, to deliver mission specific training to UK Land forces before they embark on operations in Afghanistan.

SUPPORT TO CURRENT OPERATIONS

It was one of the ironies of the demonstrator program that training for Land Forces came about as an unintended consequence of the CCD program. One of the questions to be addressed by the CCD was the level of "training fodder"[3] likely within UK MTDS. The facility was adapted to include a forward air controller (FAC) station and experiments were then run to investigate the level of benefit for the FAC and the increase in benefit for other trainees. The assumption being that the FAC would be a good example of a role player who derived very little training benefit from involvement in the exercise. The result was in dramatic contradiction to this hypothesis. The FAC "trainee", a FAC instructor normally, declaring this was the "best training he had received outside the live environment".

Further work continued, with the RAF working closely with Headquarters Land Forces to define a training process that could support pre-deployment training for

[3] Training Fodder: The involvement of additional personnel, who receive no training benefit, but simply serve to enrich the training experience for other trainees

both Fire Support Teams[4] and the Fire Planning Cell[5]. Team ACTIVE then modified the demonstrator to enable the training to be provided in a spiral development program over the latter part of 2007. This resulted in a ready for training demonstration in early 2008 with the first actual training event, Exercise MOUNTAIN DRAGON 08-1, taking place in April 2008.

Figure 3. Soldiers undertaking pre-deployment training within the DSALT facility

The MOUNTAIN DRAGON series of exercises were designed to run over a period of a few weeks providing at least 3 days training for each fire support team or fire planning cell participant. The training was not designed to teach trainees how to operate their equipment; this was taken as a pre-requisite. Instead it taught how to use the full range of equipment in a realistic operational environment to maximize the individual's effectiveness as part of a team and the wider military operation.

Exercise MOUNTAIN DRAGON 08-1 was a huge success, but it also represented the end of the CCD demonstration contract and consequently the end of any program funding. Nevertheless, based on an identified training gap for air-land integration pre-deployment training and user feedback from this exercise, the MoD decided to place a follow-on contract with Team ACTIVE to provide further MOUNTAIN DRAGON training until March 2013.

The original user requirement for the follow-on program identified 44 weeks per year of training and research activity, for a period of four years at a defined level of availability. This contrasted with the design requirement of the CCD facility to deliver 8 weeks of activity over a 30 month period with no requirement for reliability. This perhaps gives some pointers to the challenges ahead.

TRANSFORMING A DEMONSTRATOR

Working around an existing training program

DSALT was established to meet an operational capability gap in the training of forces deploying to Afghanistan. The MTDS demonstrator had already been pressed into use to meet this shortfall and every three months it was being used to provide important training to UK forces about to deploy on operations. This meant the MoD was unwilling to shut down the facility for a long period of time to allow a significant technology refresh to take place. Instead, Team ACTIVE was required to schedule the upgrades into periods between already scheduled exercises.

The required upgrades were far from all minor software enhancements. The DSALT requirement called for a new 80 seat briefing room, 5 large new planning rooms, space to accommodate a ten console E-3D simulator and a complete reorganization of the exercise management suite and server room. This meant moving walls within the existing building, rewiring most of the facility and building a second storey to provide the additional space.

"Maturation" as we referred to it, covered both making the system more robust and reliable ("ruggedisation") and enhancements to its capability ("upgrades"). It was split into four phases and included the following activities. Phase 1 concerned installation of the steelwork to support a mezzanine floor within the hangar and this completed in late 2008. Phase 2, completed in early May 2009 provided the new planning and briefing rooms on the mezzanine steelwork. Phase 3 replaced all the cabling and computer hardware during the summer of 2009 with Phase 4, software upgrades to each system beginning in the fall of 2009. Each phase was punctuated with another MOUNTAIN DRAGON exercise which required the networks and systems to be re-established, tested and handed over to the training delivery team.

[4] The Fire Support Team is a package of personnel including a Commander, Forward Air Controller, Artillery Observer and Radio Operator responsible for directing artillery and aircraft within an engagement.
[5] The Fire Planning Cell provides a headquarters function coordinating and allocating resources (aircraft, UAVs and artillery) to specific fire support teams

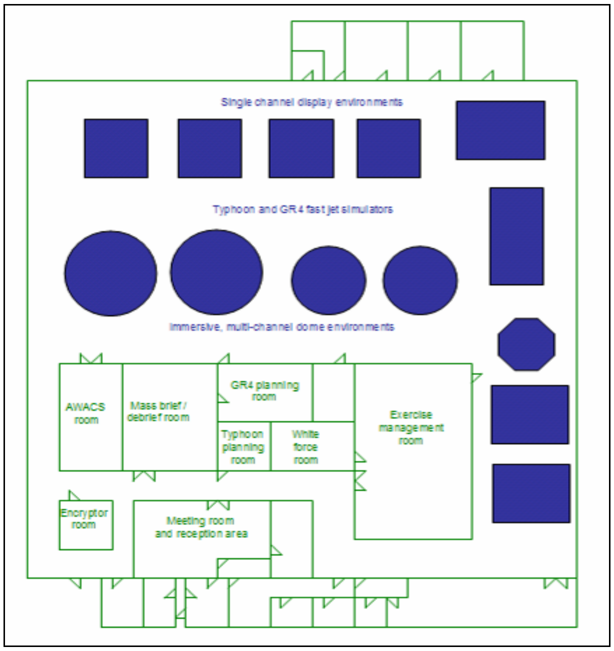

Figure 4. MTDS CCD left little space for increased accommodation requirements

The overall duration of the upgrade program was scheduled to take around 12 months and included around 3 months of MOUNTAIN DRAGON training activity. Had the facility been handed over to Team ACTIVE for its sole use over the period of upgrades it could have been completed in around 6 months so a reasonable estimate of the additional time penalty to deliver training during this period was around 50%. The impact on cost was less pronounced as we were able to establish a smaller team working over a longer period of time to deliver the program. Nevertheless, the cost of additional project management over the longer duration along with re-establishment of the training facility accounted for approximately an extra 15 to 20% manpower effort.

Customer expectations

Throughout the demonstrator program a tension had existed between elements of the customer community over how much emphasis should be placed on delivering training compared with demonstrating the ability to deliver training.

While the demonstration events were, by their nature, expected to deliver some training, their aim was always to gather evidence to support establishing MTDS user requirements. This resulted in a long list of "observations" being identified which were important shortfalls from a training perspective but made little difference to the results of the demonstration program. Nevertheless, these observations still caused long hours of debate over whether each particular one impacted on the ability of Team ACTIVE to address effectively the questions to be answered as part of the demonstration.

Figure 5. A trainee or a participant in an experiment?

Following the decision to create a training system, this ambiguity was removed and all stakeholders were then driven by the single goal of delivering training. This brought its own challenges, which are described in the rest of this paper. The observation list however, ultimately formed a key element of the customer's requirement document. The original aim for DSALT was to maintain the capability of the demonstrator, but enhance it in a few areas defined by the observation list.

Vision

The original vision for turning the demonstrator into a training facility seemed well defined and tightly bounded. Distributed Synthetic Air-Land Training (DSALT) was to be delivered using the existing demonstrator facility with a minimal number of changes: i. Ruggedise the system to improve reliability; ii. Correct a number of identified shortfalls; and iii. Recruit and train a full time team of simulator technicians to support and operate the systems over the following four years.

As with any vision, the devil was in the detail. In the case of DSALT there were five main challenges: firstly to baseline the original demonstrator; secondly, to clarify what was an acceptable and affordable level of ruggedisation; thirdly, to define the necessary action needed to correct any identified shortfall; fourthly, to balance the ruggedisation of the facility against training, skill set and size of the team recruited to run it. And finally, to deliver DSALT in the shortest time possible.

It is helpful to consider these challenges in the context of the first principles of project management (Bing, 1994). Three principles in particular; a clear definition of success, an equitable commitment of resources in line with expected output and balancing the trade between performance, quality, time and cost were missing at the start of the project. The result was a project where although the initial vision looked straightforward, in reality it was anything but.

Defining the requirement

The output from DSALT was defined as four years of available facility time. In a standard procurement, the MoD's acquisition process requires a user requirement document (URD) to be created that then drives development of a systems requirement document (SRD). DSALT went through this process, however there is a significant difference between writing documents based on an existing system and creating ones from scratch. In a number of areas both documents took arguably too little notice of the constraints of the existing demonstrator system. They defined requirements that would be easy to engineer into a new system but would have been tremendously difficult and expensive to implement within an existing system.

For example the requirement for correlation between visual databases is easy to deliver in a new system, where a single image generator standard can be used throughout the system. The demonstrator was constructed from a number of pre-existing equipments with minimal modification, resulting in a need for *eight* different visual databases within the complete system. Changing to a common standard would have been prohibitive in terms of cost.

The result of defining a URD and SRD without detailed reference to the existing system was that Team ACTIVE's response contained a large number of non-compliances. While the requirements were easily accommodated within a new design, the constraints of an existing system rendered many changes as unaffordable or impractical.

Figure 6. Eight different visual systems created a major correlation challenge

Based on our experience with DSALT we would recommend adopting a very different approach to defining the requirements for a future program of this nature. Rather than building up the system requirements from first principles, instead define modifications and enhancements from the existing system baseline. Effort put into developing a comprehensive user requirement or system requirement document would be better spent identifying requirement changes from the existing baseline. Such an approach could flow though the entire development process with acceptance testing, for example, being limited to regression testing to demonstrate the system performs as it did in the original baseline configuration followed by specific tests addressing each area of enhancement.

Contracting for availability

Probably the greatest commercial challenge in converting a demonstrator into a reliable and supportable training facility was agreeing an acceptable commercial position. Both Team ACTIVE and the MoD had very clearly defined positions on this point.

Team ACTIVE argued that, as the research demonstrator had been but together without any attempt to engineer in reliability, it was not possible to impose contractual availability requirements, without an unaffordable increase in contract cost. The MoD argued that they were procuring time on a facility and as such the contract would have to specify the length of time the facility would be available.

Although this deadlock was identified at the very start of the contractual discussions it remained the last point to be agreed. With hindsight it could have been addressed with more vigor much earlier in the negotiations – no additional information became available to alter either parties' position and, with more time, a more elegant solution might have been developed.

The reasons why the MoD wanted an agreed level of availability in the contract are clear; however, it would be worth expanding slightly on Team ACTIVE's concerns. Firstly, the RAF and MoD were used to availability figures for traditional single aircraft simulators. These figures were read across to the complete DSALT system, generating unrealistic expectations of the overall reliability. A 97% or better reliability for a single aircraft simulator is easily achievable in most modern simulators and was a starting point for DSALT. However DSALT is a network of at least ten different simulators. Simple math shows that ten simulators with a reliability of 97% deliver a system reliability of less than 75%.

$$(0.97)^{10} = 0.737$$

Secondly, the MTDS Demonstrator had never been designed with reliability in mind and, more importantly, its reliability had never been measured. Even if it had been, the figures would not have been meaningful. Over the 30 month demonstrator program, the facility had been used in total for less than ten weeks. Moreover, each time it had been operated, it was configured in a completely different arrangement. As such there was no relevant reliability data available on which to base a contractual level of availability.

Finally, defining the impact of a failure was also difficult. For example, did a fault on a single cockpit, affecting only one trainee, merit the same level of penalty as a complete failure of the local area network affecting everyone? How do you define the severity of a fault in terms of training impact? And how do you minimize the impact of any failure when those best placed to provide the mitigation – the instructors – are not under control of the facility supplier?

Figure 7. Not an air conditioned office environment

In order to provide some estimate of expected reliability and determine likely spares holding, Team ACTIVE undertook a detailed component level reliability analysis of all the DSALT systems. Figures were based on manufacturer's data where available or engineering judgments where necessary. It remains questionable whether manufacture's data based on operating in an air conditioned office environment could be read across to an unheated, 1940s vintage aircraft hangar. However, results of this analysis suggested spares usage would be significantly above that actually experienced during the CCD program. While this analysis provided a set of reliability predictions that could be justified, neither Team ACTIVE, nor the MoD felt the figures were robust enough to contract against.

The eventual solution arrived at was to undertake a process of "measure and declare" with an expectation on both sides of continuous improvement from the initially measured baseline. For DSALT a period of six months from completion of the ruggedisation program was agreed as a suitable duration to measure the performance of the system. Based on the availability achieved over this period an "acceptable" level of lost training time would be set. Any losses above this level would need to be made good by the company. Performance would continue to be measured and reviewed on a six-monthly basis and the level of acceptable lost time would be gradually reduced. It remains to be seen how this process works in practice, but it did produce a compromise that both parties felt able to commit to.

Contracting for performance

Commercially the MoD and Team ACTIVE were in a difficult position. DSALT was to be a service provision style contract but the expected level of reliability was not understood. With the exception of MOUNTAIN DRAGON training, the actual duration of other training activities would not become clear until the training syllabi were developed. And, with continued enhancements to the system likely to occur over the succeeding years, any hard performance targets were likely to be undermined by fundamental changes to the system. Moreover, the MoD had a very tight budget – any performance regime involving retention or reduction in payments would likely result in an additional price that breached the budgetary ceiling.

The agreed solution was similar to a service credit regime, but based on hours rather than financial credits. Where Team ACTIVE provided additional hours above that agreed for an exercise because training overran, these could be banked and offset against any hours lost through unreliability. If Team ACTIVE continued to build up significant credits, then either the RAF would be required to cut back on usage or find more money. Conversely, if Team ACTIVE built up a significant deficit of hours, then the MoD could quickly move to termination or other remedial action. Such an approach provided a management lever for the MoD while protecting Team ACTIVE from being locked into several years of loss making performance arrangements that could never be delivered profitably.

Systems Engineering

Probably the biggest difference between a research demonstrator and a training system is in the level of systems engineering that underpins the design. As a research tool, the CCD was not subject to the level of systems engineering processes appropriate for a production system. Instead, Team ACTIVE relied on expert engineers and scientists, well versed in all aspects of the demonstrator, to trouble-shoot problems on the fly when they occurred. DSALT was to be run by less skilled simulator operators and technicians who had never been intimately involved in the system. This required a well documented system that performed in a tightly defined and stable way.

We identified two approaches to achieving this stability. Revisit the design of each sub-system and ensure sufficient engineering documentation is in place to support a formal systems engineering approach. Or, carefully document the system behavior and performance in its current state and lockdown the configuration, to avoid any changes that might inadvertently impact performance. While the systems engineering approach was the more expensive, the enhancements expected to occur to DSALT over its remaining life precluded locking down the configuration. Although there were significant debates within Team ACTIVE over which approach to follow, it was a credit to the MoD that despite their tight budget, we were never pressurized to compromise in this area.

LEARNING FROM EXPERIENCE

Transforming a demonstrator into a training solution is not a decision to take lightly. The MoD conducted a detailed investment appraisal and cost benefit analysis that determined building on the existing CCD capability was the best approach to delivering DSALT. As operations become increasingly complex and rapidly change their nature, gaps in training capability can emerge quickly. Simulation is widely recognized as the way to understand how to respond quickly to a changed environment or threat. It remains the safest and easiest way to visualize new concepts. And it is a small step from developing tactics to training these tactics on the same simulation. We are therefore likely to see the "DSALT approach" being repeated more often in the future.

Other than to refer to the apocryphal saying "if I wanted to get there, I wouldn't start from here", what are the key learning points to come out of this program?

1. Carefully consider all the compromises and costs involved in building on existing capability compared to starting again from scratch.
2. Be very clear about the aim of the program from the outset – what specific improvement is required over the existing system?
3. Carefully baseline the existing system in as much detail as possible before defining the new requirement.
4. Allow enough time to complete the program in a single phase, accept that some training may be missed during this period.
5. Agree the performance regime early in the contractual negotiation.

6. Manage expectations about what can be achieved cost effectively and what enhancements will be prohibitively expensive.
7. Ensure a very close working partnership between the customer and supplier from the earliest stages of the project.

While the DSALT program had rather more challenges than might be expected from a standard procurement, its success cannot be under-estimated. From a position where there was no endorsed user requirement, the full DSALT contract was placed within nine months with the first building work having begun four months earlier than that.

8. Switching roles allowed DSALT pilots and soldiers to understand each other's perspective

DSALT is already delivering hugely beneficial mission specific training to soldiers before they deploy to theatre. The training scenarios are designed to reduce the chances of mistakes resulting in blue-on-blue casualties. While there is no way to measure the number of in-theatre mistakes that this training may have prevented, feedback from theatre has focused on how similar the training has been to real operations. As such, both Team ACTIVE and the MoD agree that the effort involved in bringing DSALT to contract was well worth it.

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REFERENCES

Smith, Ebb; McIntyre, Heather; Gehr, Sara; Schurig, Margaret; Symons, Steve; Schreiber, Brian & Bennett Jr., Winston (2007). Evaluating the Impacts of Mission Training via Distributed Simulation on Live Exercise Performance: Results from the US/UK "Red Skies" Study. Meeting Proceedings RTO-MP-MSG-035, Paper 12.

Saltmarsh, J. and MacKenzie, S (2008). The Future of Collective Training: Mission Training through Distributed Simulation. *RUSI Defence Systems.*

Bing, John, A. (January 1994). Principles of Project Management, PMNETwork, PMI, p40