

The Development of Shared Mental Models during Air Battlespace Collective Training using Dispersed Networked Systems

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ABSTRACT

The UK Ministry of Defence (MOD) has a vision of providing Mission Training through Distributed Simulation, or UK MTDS. The paper will report the human performance results from a three year MTDS Capability Concept Demonstrator (CCD) programme presenting data to qualify the development of shared situational awareness and mental models in a networked training environment. Evidence was collected during five national and multi-national air battlespace exercises, from subjective rating scales, interviews, observational and anecdotal data.

The MTDS CCD facility, based at RAF Waddington, included 8 fast-jet Tornado GR4 and Typhoon simulators, a 7-seat AWACS mission crew training system, and extensive exercise management capability (including virtual role players and Computer Generated Forces (CGF)). Data were gathered during representative daily Planning, Briefing, Execution, and Debriefing (PBED) cycles of air battlespace missions which took place at the collective, joint and multi-national levels.

The MTDS CCD programme assessed the training benefit, and the optimal balance, between co-located teams and dispersed training teams (both in the UK and US). The major source of data across all sites was the application of the Mission Essential Competency (MEC) framework. Each warfighter's expectations were recorded for a series of platform based MECs and compared to warfighter's experiences. These data were used to assess differences between role, platform and site. To allow analysis of the robustness of the networked environment for shared cognitive processes, these were then subdivided into collective experiences, i.e. those that required interactions with other players or entities leading to collective training; and individual MEC experiences.

Analysis of MEC data based on current teamwork theory allowed an assessment to be conducted of how successfully networked and dispersed training audiences were being supported in collective teamwork. The results showed that all warfighters in the UK and US received significant benefit from their participation and developed shared situational awareness enabling them to successfully meet their training objectives.

INTRODUCTION

Training requirement

The UK MTDS programme seeks to use synthetic training environments to deliver operational team and collective training for the air component of the Joint Battlespace.

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The UK Ministry of Defence (MOD) has a vision of providing Mission Training through Distributed Simulation, or UK MTDS. The paper will report the human performance results from a three year MTDS Capability Concept Demonstrator (CCD) programme presenting data to qualify the development of shared situational awareness and mental models in a networked training environment. Evidence was collected during five national and multi-national air battlespace exercises, from subjective rating scales, interviews, observational and anecdotal data. The MTDS CCD facility, based at RAF Waddington, included 8 fast-jet Tornado GR4 and Typhoon simulators, a 7-seat AWACS mission crew training system, and extensive exercise management capability (including virtual role players and Computer Generated Forces (CGF)). Data were gathered during representative daily Planning, Briefing, Execution, and Debriefing (PBED) cycles of air battlespace missions which took place at the collective, joint and multi-national levels. The MTDS CCD programme assessed the training benefit, and the optimal balance, between co-located teams and dispersed training teams (both in the UK and US). The major source of data across all sites was the application of the Mission Essential Competency (MEC) framework. Each warfighters expectations were recorded for a series of platform based MECs and compared to warfighters experiences. These data were used to assess differences between role, platform and site. To allow analysis of the robustness of the networked environment for shared cognitive processes, these were then sub-divided into collective experiences, i.e. those that required interactions with other players or entities leading to collective training; and individual MEC experiences.

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“Collective training involves 2 or more ‘teams’, where each team fulfils different ‘roles’, training to interoperate in an environment defined by a common set of collective training objectives”

NATO Study Group SAS-013

The MTDS CCD was funded to de-risk UK MTDS by defining the user requirements. This demonstrator programme was managed by UK MOD and delivered by the QinetiQ led Team ACTIVE (Aircrew Collective Training through Immersive Virtual Events) which included Boeing, CueSim, ATIL, HVR and Rockwell Collins between 2005 and 2008. The findings of the programme have been summarized in [1, 2, 3]. The output of the programme was a series of reports based on studies and evidence obtained during a programme of nine exercises conducted using Team ACTIVE’s facility located within the Air Battlespace Training Centre (ABTC) at RAF Waddington. The ABTC was linked to US, UK and Canadian distributed Mission Training Centres (MTCs) as the programme progressed as indicated in Figure 1.

The purpose of the programme was to address a number of Key Investigative Areas (KIAs) and wider questions. In order to answer these KIAs, UK, US and Canadian forces, fast jet, rotary wing, Airborne Warning and Control System (AWACS), maritime and land military personnel, participated in MTDS CCD exercises during which their requirements for a MTDS capability were captured.



Figure 1. MTDS CCD dispersed links

When considering the design of a training environment, a number of constituent parts must be considered which together deliver an overall training experience. These parts included the delivery of an exercise management model, the provision of planning, and brief/debrief tools and Synthetic Training Equipment (STE) fidelity requirements.

While much of the work conducted before the MTDS CCD focused on the collective training domain, the MTDS CCD facility provided an environment to examine wider operational contexts, including joint collective air land scenarios. As the programme evolved, attention widened to include how the fast jet crews might benefit from wider training with Forward Air Controllers (FACs), AWACS, rotary-wing aircraft and expanded coalition participation.

An assessment of the impact of dispersion on training benefit, and the optimum balance between co-located and dispersed training allows us to test assumptions here about the development of teamwork and shared mental models.

MISSION TRAINING THROUGH DISTRIBUTED SIMULATION

Training Audience

The current operational tempo and the predominance of coalition operations have increased the need for dispersed training and training across national borders with combined partners. Nine events were conducted in the MTDS CCD facility, five of which involved front line warfighters. These five exercises were: BATTLE BUZZARD, CONDOR CAPTURE, NORTHERN GOSHAWK, ARCTIC OWL and AVENGING EAGLE. Each exercise typically lasted a week with a familiarisation day and then a build up in operational complexity over the next 3 or 4 days. Typically, the fast jet warfighters were exposed to a range of mission types with their workload increasing over the exercise week, including Close Air Support (CAS) and Air Land Integration (ALI). The specific participants are listed in Table 1 highlighting the widening range of potential trainees [4].

Roles and location (ABTC or dispersed)	
UK Tornado GR4	UK Attack Helicopter (dispersed)
UK Typhoon	UK Type 42 Fighter Controllers (FCs) (dispersed)
UK AWACS (co-located and dispersed)	UK Intelligence Officers
UK Air Support Operations Centre (ASOC)	UK Joint Force Air Component (JFAC) mini combat ops
US F15c Langley (dispersed)	UK Forward Air Controller (FAC)
US AFRL F16 (dispersed)	US Distributed Missions Operation Center (DMOC) F15e (dispersed)
US A10 Spangdahlem (dispersed)	US DMOC Control and Reporting Centre (CRC) (dispersed)
US A10 Mesa (dispersed)	US DMOC AWACS (dispersed)
US AWACS Tinker (dispersed)	US DMOC Virtual Surveillance Target Attack Radar Simulation (VSTARS) (dispersed)
US Joint Terminal Attack Controller (JTAC) (dispersed)	Canadian FAC (dispersed)

Table 1. MTDS CCD training participants.

A day in the life of the MTDS CCD facility followed the cycle of PBED. The day began with mass briefings setting the context and overall intent for the day's mission. Led by a Mission Commander, the warfighters would then begin their formation planning, and coordinating between formations (including across national boundaries), as required. Following the completion of the mission execution phase, warfighters would lead a series of debriefings, beginning with a formation level debriefing. The final activity was a mass debriefing in which all participants ran through a facilitated After Action Review (AAR) including time stamped mission replay, to capture the critical lessons identified.

TRAINING ENVIRONMENT

The MTDS CCD facility, illustrated in Figure 2, consisted of fast jet simulators (four Typhoons and four Tornado GR4 aircraft), a seven-seat E-3 AWACS capability, and a comprehensive exercise management and control suite.



Figure 2. MTDS CCD components

A 40-seat briefing and de-briefing room and a selection of smaller formation planning rooms were provided. These incorporated standard in-service planning aids and video conferencing, telephone and interactive whiteboard technology so that warfighters could undertake a condensed cycle of PBED. A classified networking hub connected securely with training facilities in the UK, US and elsewhere in the world was also provided.

SHARED MENTAL MODELS AND TEAMWORK

“Teams do more than simply interact with tools; they require the ability to coordinate and cooperatively interact with each other to facilitate task objectives through a shared understanding of the team’s resources (e.g., members’ knowledge, skills, and experiences), the team’s goals and objectives, and the constraints under which the team works. Essentially, teams also require teamwork.”

Salas, Sims and Burke, 2005 [5]

A recent review of teamwork research resulted in the identification of the “Big Five” components of teamwork. These components quoted from [p5, p 560] are:

1. **Team Leadership:** Ability to direct and coordinate the activities of other team members, assess team performance, assign tasks, develop team knowledge, skills, and abilities, motivate team members, plan and organize, and establish a positive atmosphere.
2. **Mutual performance monitoring:** The ability to develop common understandings of the team environment and apply appropriate task strategies to accurately monitor teammate performance

3. Backup behaviour: Ability to anticipate other team members' needs through accurate knowledge about their responsibilities. This includes the ability to shift workload among members to achieve balance during high periods of workload or pressure.

4. Adaptability: Ability to adjust strategies based on information gathered from the environment through the use of backup behaviour and reallocation of intra-team resources. Altering a course of action or team repertoire in response to changing conditions (internal or external).

5. Team orientation: Propensity to take other's behaviour into account during group interaction and the belief in the importance of team goal's over individual members' goals.

In support of these are three mediating functions:

- Shared mental models: An organizing knowledge structure of the relationships among the tasks the team is engaged in and how the team members will interact.
- Mutual trust: The shared belief that team members will perform their roles and protect the interests of their teammates.
- Closed-loop communication: The exchange of information between a sender and a receiver irrespective of the medium.

Salas et al comment, "there was little empirical or theoretical research available to guide our understanding of how the "Big Five" and the coordinating mechanisms may differ as teams mature." [5]. They report that team leadership and orientation will be significant in the early forming of the team. For the newly formed distributed and co-located teams, clear allocation of command roles will be important and as this is a military team, leadership will be conventionally defined rather than developed ad hoc.

Team orientation is more challenging for the dispersed team members who are facing more formal team forming mechanisms. During the MTDS CCD timeframe, two technology enablers were introduced to minimise the challenge: shared whiteboard technologies and Video Tele Conference (VTC) links. When planning, team leaders at all locations, had as much access to these tools as possible, to foster team communication and development [6]. Communication during this team development time has often been found to be essential for good team performance and orientation.

The theoretical propositions and elements described above will be used in this paper, to test out the validity of the assumption that training in the MTDS environment enabled effective collective teamwork.

ASSESSMENT APPROACH

Data were collected by UK and US research teams at each event using a range of objective and subjective data collection tools. At each training exercise Team ACTIVE human factors experts observed groups of the UK training audience and the exercise management team, i.e. the white force and role players. Interviews and surveys with participants in the UK were conducted. These were supplemented by the Air Force Research Laboratory (AFRL) Coalition Mission Training Research (CMTR) toolset [7, 8] including both UK and US collected data collected by the US CMTR research team at all sites.

Tools

To understand the level of training benefit, a number of surveys and human factor methods were administered to co-located and dispersed participants. The first of these was the CMTR Top Three Bottom Three (T3B3) survey, distributed to the training audience, role players and white force every day. The aim

was to obtain the top and bottom three outcomes of the day. Comments were also used to support the quantitative outputs from other data analysis.

Core to data collection were MECs. These are “Higher-order individual, team, and inter-team competencies that a fully prepared pilot, crew or flight requires for successful mission completion under adverse conditions and in a non-permissive environment” [9, 10].

A pre and post MEC survey allowed evaluation of the difference between what training participants expected to receive (CMTR expectations Survey 2a) and, after the exercise, what they actually experienced (CMTR experiences survey 2b). These CMTR MEC surveys were different in the UK and US to accommodate for differences in the type of aircraft and terminology used. In order for comparisons to be made common MECS by role were identified [11].

To determine if warfighters reported that the training had value, a CMTR Reactions survey was used to establish how the aircrew felt about the MTDS concept as compared to their current training.

RESULTS

In order to assess the training benefit gained by co-located and dispersed training audiences, a comparison was made between participants’ ratings of common MECs for similar roles, such as air to air. In this way, participants’ ratings for their expectations of their training and their subsequent experiences could be compared. The first task was to identify MECs that were common between the ABTC trainees and remote sites, once a MEC list was created then the second task was to compare these ratings statistically. Differences between sites could then be analysed to see if training benefit was affected by dispersion.

To enable a comparison between the UK and US, the CMTR MECs were ‘cross-walked’. This means that the MECs that are similar or equivalent in the UK and US surveys have been combined to create a ‘cross-walked’ MEC.

For the purposes of analysis of the collective performance, these MECs were then divided into collective MECs, i.e. those that required interactions with other players or entities leading to collective training; and individual MECs.

The collective MECs were compared statistically to identify significant differences between co-located and dispersed STEs in the UK and US. From these differences, inferences can be drawn about the impact of dispersion on the team and collective training experienced at each site.

These collective MEC crosswalks were carried out on the air-to-air, AWACS and air to ground data collected at each site. For the purposes of this paper, the detailed analysis of the latter will be illustrated in relation to teamwork models. Nonetheless, analysis of the other two major roles found similar effects.

Key results

Over the course of the MTDS CCD, a significant data set for the air to ground role was collected at each participating site. From the data gathered, this analysis will concentrate on data relevant to our validation of the teamwork theory. This will involve the reactions that aircrew provided to the exercises, their daily comments and a comparison of collective MECS.

A validation of previous research [12] was that the planning, briefing and debriefing (PBD) activities were as important in development of teamwork as the execution phase. Both members of the training audience and non-training audience commented on the value of PBD in all exercises. Top three comments from Tornado GR4 aircrew in EXERCISE AVENGING EAGLE include “being involved in the brainstorm,

planning and debriefing” demonstrating the utility gained from this process. Comments made during all the exercises show that both Tornado GR4 aircrew and AWACS found the planning, briefing and debriefing facilities useful. Typhoon participants also commented on the advantage in seeing the whole planning cycle and that the experience supported planning for preparation for war:

- “The opportunity to plan an unusual scenario” - EXERCISE NORTHERN GOSHAWK
- “The planning co-ordination with US forces and multiple platforms was good and it increased my knowledge of how they operate and terms they use” – EXERCISE AVENGING EAGLE Typhoon
- “the mission planning was enjoyable, challenging and useful” – EXERCISE CONDOR CAPTURE Tornado GR4

Other positive T3B3 comments on the debriefing reinforced the need for focus to be on training outcomes:

- “Bringing in aspects of the mission that worked well into the debrief provides good training” – EXERCISE ARCTIC OWL AWACS
- “Player interaction during the debrief” - EXERCISE FALCON FLIGHT Tornado GR4
- “A frank and honest debrief including how we can improve performance - EXERCISE AVENGING EAGLE AWACS
- “during debrief lots of talk of training and lessons learned and little of tech issues” - EXERCISE NORTHERN GOSHAWK Tornado GR4
- “Mass debrief was very information with many tactical lessons being identified” – EXERCISE CONDOR CAPTURE Tornado GR4

During the mission execution phase, major findings from the co-located Tornado GR4 crews were firstly, the need for more targeted fidelity and currency of their aircraft simulation, especially the range of sensor and weapon types. Secondly, for greater immersion and scene detail, the warfighters requested greater horizontal field of view to beyond the peripheral vision of the backseat warfighter [13].

This paper will now discuss linking these results to an analysis of teamwork theory. In order to assess how the MTDS programme supported teamwork theory, the main performance indicators, MECs, were rated according to the importance of the big five and three mediating functions. This analysis provides us with early analysis of the importance of training objectives at the team level. Prescriptively, it could provide insight for white force and trainees of the key aspects that must be incorporated in the daily plan and reinforced as learning points in the AAR.

For the collective MECs, Figure 3 provides an approximation of how recent team theory and research could be used to balance and inform training design. In order to validate the percentages provided, it is suggested that an independent rating exercise of each element is carried out by a team of role specific warfighters.

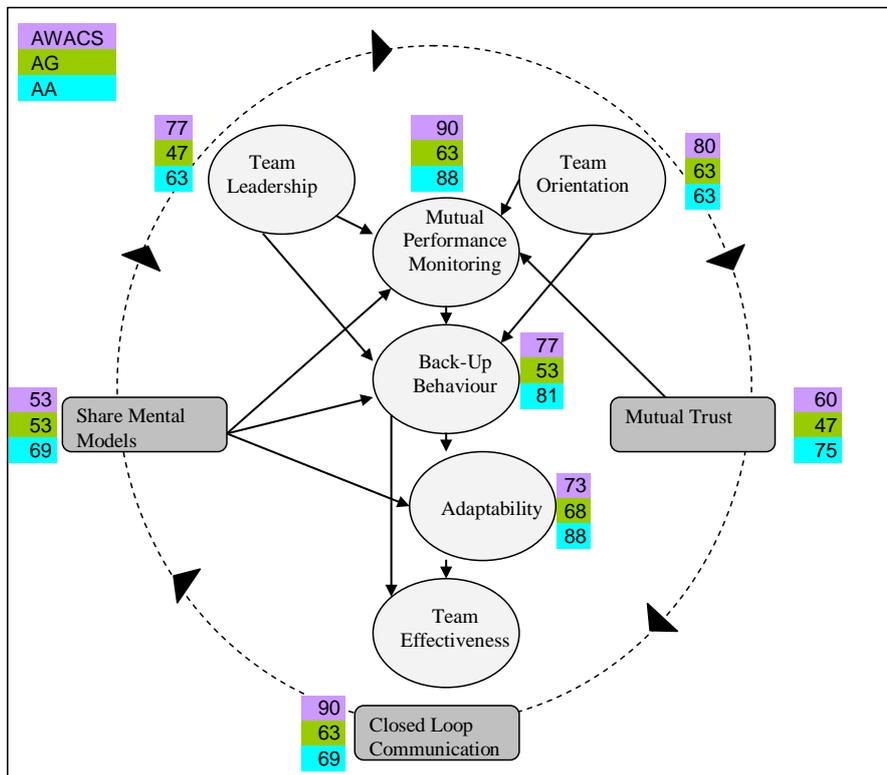


Figure 3: Illustration of how an assessment of teamwork factors could be used to inform training design and delivery based on the model described in Salas et al (2005).

Here percentages indicate how important aspects of theory might be for the roles participating in MTDS. Further postulation on the link between team theory and training performance assessment would suggest that the design of training systems could be validated against such models. For example, where a MEC rates highly on many individual elements and is considered important for a specific training need, the design of the training environment should be customised to meet these requirements. Understanding of the training need in terms of this model could also assist the training instructors in designing and reinforcing key teamwork elements.

Support to the Big five as illustrated by the Air to Ground participants

The data were reviewed to identify evidence for the five teamwork elements and mediating functions defined by [5]. Evidence from subjective ratings by the Tornado GR4 aircrew indicates that training was enhancing their shared understanding and development of team orientation. The crews agreed that:

- I feel I will be better prepared to lead a mission due to this training
- The event has helped me to improve my team coordination skills
- In training I was able to apply lessons learned from previous missions to new ones

In terms of their understanding of collective team training, their experience of ‘Operations with other formation/packages (e.g., multi-package; tanker, AWACS; air to ground, air to air, Composite Air Operations (COMAO)’ was higher than their expectations providing evidence based recommendations for MTDS utility. Further illustration of the benefit they gained from working with other teams can be found in some examples of daily T3B3 comments during EXERCISE ARCTIC OWL:

- “Mission planning good to see more COMAO/multiple aircraft integration”
- “Another good insight into COMAOs - especially air land integration”
- “Good coordination work between ASOC/Unmanned Air Vehicle (UAV)/Combined Air Operations Centre (CAOC)/FAC provides good effects in scenario”

The need for closed loop communications were reported as essential to build the air picture and created immersion. Interviews in EXERCISE BATTLE BUZZARD established that the radio ‘chat’ is “awesome” and “top training” – it is this realistic radio traffic that provides collective training benefit. Communications with other US players, AWACS and FACs were seen as significant contributors to training. “Good comms w/JTAC - critical to hitting correct tgt [target]”

Technical problems with communications were often reported as an immersion breaker, but when working were seen as a critical enabler of collective training. Such an effect was seen with all players.

Further, consideration of the MEC survey data across all sites using crosswalks allowed many aspects of the MTDS CCD to be qualified, for example, the fidelity level requirements at dispersed and co-located sites [13] and the range of training feasible [4].

In this analysis, the collective MEC data using survey 2a and 2b, was analysed in relation to the Big Five [5]. A subjective rating of the collective MECs provided a view of which MECs had required most, if not all, of the elements of Salas et al’s propositions [5]. Overall, analysis of the collective air to ground MECs found that team leadership was the most frequent element in the collective MEC set (Figure 4). Meeting this need in the MTDS would demonstrate a partial fulfilment of predicted team development [5].

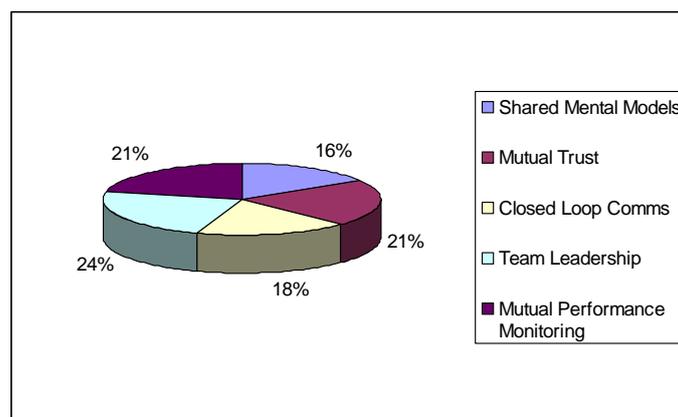


Figure 4: Approximate distribution of teamwork factors in the air to ground MECs

Next, the verification turned to an analysis of the success with which the MTDS CCD met training experiences. Table 2 highlights several collective MECs with significant elements of the Big 5 and mediating functions.



The statistical analysis of these MECs (expectations vs. experiences) allows a qualification of how well the MTDS programme was training effective team and hence taskwork.

MEC	MTDS findings
Close Air Support (CAS) missions	There were no significant differences between expectations and experiences. Trainees were receiving the level of training experience that they had anticipated demonstrating that the MTDS experience was meeting their expectations whether co-located or dispersed. This infers that the collective teamwork planned and delivered during performance met their needs.
Multinational and joint operations	
Mission planning	
Suppression of Enemy Air Defence (SEAD) training	A significant interaction was found between experience, expectation and platform ($p < 0.05$). The co-located Tornado GR4s rated their experience of this competency significantly lower than expectation, rating it as not at all effective. This is likely to be as a result of simulator fidelity limitations. The dispersed A10s, however, rated their experience higher than expectation, suggesting they received a better training experience than the Tornado GR4s. It is interesting to note that dispersion was not a disruptive influence on the teamwork requirements.
Combat Search And Rescue (CSAR)	<p>A trend ($P=0.06$) was found for an interaction between experience, expectation and platform. As per the previous MEC, the Tornado GR4s rated their training experience lower than expected, and the A10s ratings were higher than expectation. For the co-located team, this was reported as being due to the visual field of view and the need for greater visual detail at low altitude.</p> <p>EXERCISE AVENGING EAGLE provided the most effective training experience, rated at somewhat effective, with the remaining exercises rated at slightly effective. This MEC was being experienced at a sufficient level but should be simulated to a higher degree where training needs require it. Of interest was the rarity of training in this MEC and that it was welcomed by warfighters as an essential and unique experience in synthetic environments. Enhancements to enable such training in UK MTDS in simulation are ongoing because of these results.</p>
Problem with leadership in the air	A significant difference ($p < 0.01$) was found with overall experience rated lower than expectations. There was a significant difference between exercises ($p < 0.05$). EXERCISE AVENGING EAGLE was the most effective at providing training experience of leadership fallout, rated at somewhat effective, probably as a result of the complexity of participants and a strong blue planning process. It is likely that by this final exercise, both the technologies and management of training were more capable of generating realistic experiences [6].

MEC	MTDS findings
COMAO operations and operations with other formations and packages	<p>Overall, the data show that aircrew received significantly ($p < 0.05$) more effective training experience than expected. Experience ratings were highest in EXERCISE ARCTIC OWL, rated at very effective. This exercise provided a novel interaction of air, land and maritime assets in a complex synthetic battlespace.</p> <p>The overall average rating across all exercises was quite effective, which is akin to aircrews' rating of this MEC experience being met to a very good extent. The MTDS CCD was then meeting the collective training need.</p>
Push CAS/package fallout	<p>Overall, experience was rated significantly lower than expectation ($p < 0.001$). However, in EXERCISE CONDOR CAPTURE the training experience was rated significantly higher than expectations, being rated at quite effective. Package fallout can be interlinked with unexpected leadership handover and so more training opportunity is needed to enhance learning.</p>

Table 2: Examples of Air to Ground collective MECS with significant Big 5 elements

The foregoing analysis highlights the interaction between the training design and environment with team outcomes. It is worth noting that in spite of specific equipment fidelity issues, air to ground training was successful at all sites delivering collective team of team training. Future enhancements are already ongoing to target the mission execution capability enabling deeper experience of specific MECs. This will allow consideration of team as well as inter-team training. As the dispersed A-10 results illustrate, collective teamwork can be delivered at each site given a sufficient level of equipment fidelity. More so, manipulation of the aspects of the Big 5, forcing the team to work together through planned injects, resulted in stronger learning. Communications and joint planning were particularly significant as an enabler of collective performance.

DISCUSSION

The MTDS CCD aim was to provide warfighters with an environment in which they could learn to operate at a team of teams' level with national and coalition partners. For this to occur successfully there needed to be sufficiency in the training environment through PBED. Communication between dispersed teams via shared VTCs and open platform communications during planned events supported the development and delivery of concerted actions.

Safeguards between sites, both in terms of technologies, exercise management and shared data, maximised the opportunity to work as a collaborative team [6]. Of significant value was the facilitation of the communications between the warfighters and role players so that they were sufficiently realistic to immerse and hence train participants. For example, in communications with other US players, AWACS and FACs were seen as significant contributors to training, e.g. "Realistic comms with other real assets – just like real life" (AWACS warfighter). Finally, decision making under pressure where warfighters had a limited time to act/react to situations and coordinate with others was experienced successfully. These results will be described in detail, and presented next in the context of current teamwork theory.

Leadership of the collective team was directed by overall directed by Rules of Engagements (ROE) and translated by the air commander into an overall mission plan, subsequently delivered by a series of sub

teams. Actions by adversary forces pushed these team and leadership skills to their limits to exercise collective performance. It was essential then that teams had sufficient situational awareness and shared mental models trusting each other to deliver the required effect; and to respond flexibly to changes enforced by the adversaries. These included needing to adapt to damage/loss of allies, the ability to replan and deal with new targets/orders in the rapidly changing environment, all while maintaining clear lines of command and communications throughout.

Hence, the MTDS environment can be analysed by the teamwork model described in [5] providing a case study to test out some of the predictions made. Of the fundamentals of teamwork, the Big Five, how well did the MTDS experience support their development?

As the programme and capability is still maturing some aspects of the MTDS CCD findings are relevant only to the facilities of that time and so reassessment at a later stage may be necessary. For example, the co-located air to ground cockpits need more targeted fidelity so that wider and more realistic missions can occur, e.g. in the range of weaponry and sensor suite. The MTDS CCD capability is undergoing upgrades to add detailed targeted fidelity to the facility in response to these findings. Despite these limitations for intra-team operations, when participants were questioned over inter-team operational utility, they were very positive about the collective training benefit.

Other teamwork aspects supported the vision of MTDS as an environment for team and individual skills training. Specifically, being in command in the air of a large COMAO gave package leaders an experience rare in the real world. The ability to lead a team was welcomed both by experienced crew and by those more inexperienced as essential practice. It allowed rehearsal of leadership and decision making due to manipulations by the red force, and general ‘mission friction’. Also, critical to the delivery of the required effect was the ability to monitor each other’s performance. Lessons were learnt in collaborative AAR, where each site linked together in VTCs and a timed replay of critical events occurred. Shared mental models were facilitated by such joint planning and review and further enhanced by active learning during VTC brainstorming, e.g. “The planning co-ordination with US forces and multiple platforms was good and it increased my knowledge of how they operate and terms they use” – RAF Typhoon pilot.

In common with the need to adapt during the planning phase, an expert white force assured that the level and tempo was appropriately managed. They facilitated learning during mission execution by moderating the ability and actions of the red force, changing the ROE, prioritising team training objectives and inserting events and intelligence through role players. Mutual trust developed between co-located and dispersed sites during the event week so that new requirements were met through pre-defined roles and plans.

During PBED, closed loop communications were a critical enabler of backup behaviour, the importance of comms across the teams reinforced learning experienced across roles (e.g. air land integration) and cultures (e.g. learning the process and language differences, especially terminology). These elements further enforced the development of shared mental models. Moreover, where comms performance was missing or unpredictable, participants reported that they felt it gave them a more realistic experience of current ops but others were less favourable, reporting that any loss of comms prevented team learning.

The final aspect required for an effective team, is team orientation “the belief in the importance of team goal’s over individual members’ Goals” [5]. Examples of this were evident in mission execution and during AARs; discussions were led by the white force highlighting how specific missions required an effect to be delivered that was more important than a team goal. For example, when a ground commander called for air support of troops under fire and the air assets were heavily involved in completing their own plan. In this case, the fast jet team’s response to the ground requirement was untimely and the AAR reinforced the bigger picture of the air land battlespace and how supporting own troops at that point was more significant than delivery of individual effects. Such team learning is vital for current operations and

as a result of the MTDS CCD programme, the capability is being used for Distributed Synthetic Air Land Training (DSALT) furthering the understanding between the air and land element such as in current operational theatres.

CONCLUSIONS

The MTDS CCD programme was successful in providing collective training for the co-located and dispersed participants showing an increasing degree of relevant operational utility as the facilities and management of dispersion matured. It coped with a widening training audience by implementing safeguards and analysis of trainee performance pre and post each exercise using the MEC approach.

Analysis of the training team data in relation to the teamwork theory helps us understand how this networked collective environment enabled appropriate teamwork that resulted in acceptable mission outcomes. These findings provide further validation of MTDS within and across teams and national boundaries.

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