Advancing Fighter Employment Tactics in the Swedish and US Air Forces Using Simulation Environments

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ABSTRACT

In today's fast paced operational environment it is almost impossible to evaluate new approaches and capabilities on operational aircraft in active duty squadrons. Further, obtaining range facilities and other aircraft to provide a tactically rich environment for test and evaluation of new concepts and capabilities is both time consuming and very expensive. Finally, many new weapon system capabilities cannot be evaluated in live fly environments as the actual systems do not exist in hardware form yet. Experimentation by expert fighter pilots using simulation facilities in the US and Sweden has resulted in improved tactical employment and training. We will present results from several controlled comparative studies we have undertaken with operational pilots and controllers examining new weapons characteristics and instrumentation for operational aircraft; live, virtual, and constructive data linking and tactics training; precision engagement tactics and system requirements; and embedding human performance assessment in simulation environments and on live aircraft. We will also highlight research currently underway with the Swedish Air Force which is examining and validating simulation technology and methods for integrating Swedish Air Force into North Atlantic Treaty Organization (NATO/OTAN) peacekeeping support operations.

1 HIGH-FIDELITY SIMULATION ENVIRONMENTS

High-fidelity simulation environments have been developed to augment live-fly training on the range for pilots and Air Battle Managers. While pilots experience the full range of forces and visual cues in the cockpit, there are many constraints on range training. Airspace is restricted, the size of friendly and adversary force packages are limited by budgets, and safety and security considerations prevent pilots from practicing wartime tactics. Multi-participant, high-fidelity simulation environments can provide unlimited airspace, large force packages, and the opportunity to employ wartime-only systems and tactics in a secure environment. These simulation environments known as Distributed Mission Operations (DMO) in the US and Mission Training via Distributed Simulation (MTDS) in NATO incorporate multiple, warfighter-in-the-loop (virtual) simulators for pilots and Air Battle Managers together with programmable, computer-generated (constructive) simulations of other entities. These entities include adversary forces, air refuelling tankers, airborne command and control platforms, and supporting friendly forces. Using programmable constructive forces supports training focused on specified learning objectives. Instructors can select pre-programmed scenarios which

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require employment of specific skills and tactics [1]. All entities, virtual and constructive, interoperate using communications protocols which are recorded for later replay and debriefing.

1.1 Using Training Environments for Experimentation

Capabilities that have been developed for DMO/MTDS systems to support training are also well suited for experimentation. Programmable constructive forces support training by ensuring that adversary forces employ specific tactics keyed to training objectives. These tactics are repeatable and multiple enemy actions can be programmed for any basic scenario such as four-ship point defence. Exercise control capabilities permit all entities, virtual and constructive, to be initialized at any set of locations in the gaming area. In training exercises for beyond-visual-range (BVR) air combat, aircraft can be initialized just beyond radar range, fight to a logical conclusion, and reset to the same initial conditions for another engagement. Data recording capabilities are vital for training to support mission replay and debriefing. During replay, teams can assess what went well during their missions, what did not, and extract lessons learned. In addition, data recording supports limited automated performance assessment such as listing the results of all missile shots and incursions into enemy missile range.

These DMO capabilities also support experimentation. Programmable forces allow researchers to generate multiple tactical scenarios with wide variations of enemy weapons systems and actions. These repeatable scenarios can be used to develop and validate tactics, assess the effectiveness of emerging technologies, and to evaluate the effectiveness of training strategies. Exercise control, observation, and data recording capabilities further support experimentation by allowing repeatable and predictable control of scenarios, real-time subjective evaluation of performance, and offline replay with automated assessment.

1.2 DMO Laboratories in the and US Sweden

DMO laboratories have been established at the US Air Force Research Laboratory, Warfighter Training Research Division (AFRL/HEA) in Mesa, Arizona, and the Swedish Defence Research Agency's Air Combat Simulation Centre (*Flygvapnets Luftstrids Simulerings Center* [FLSC]) near Stockholm. Research at these facilities looks at the technologies, training strategies, procedures, and measures of effectiveness required to implement DMO training programs.

1.2.1 The DMO research testbed at AFRL

Four F-16C Block 30 Multi-Task Trainers. These cockpits were developed by AFRL as high-fidelity simulators in both physical configuration of controls and displays and functional simulation of F-16 handling characteristics and weapons systems. The Multi-Task Trainers are equipped with AFRL's Mobile Modular Display for Advanced Research and Training (M2DART), which is a full-field of view, rear-projection, dome display system. The M2DARTs provide a 360° field-of-regard, out-the-window visual imagery combined with the aircraft's head-up display (Figure 1).

Four Deployable Tactics Trainers. These simulators consist of F-16 cockpits with the same software as the Multi-Task Trainers but reduced functionality focusing on combat skills. The deployable trainers are equipped with three screen out-the-window visual displays.

Observation and control console. The console is used to operate the system, select scenarios, control data recording, and support automated data collection.

Constructive forces. Friendly and adversary constructive entities are generated using the AFRL developed Automated Threat Engagement System or the Next Generation Threat System.

Distributed brief/debrief system. Brief/debrief systems support playback of recorded missions displaying a plan-view map display, radio communications, and cockpit displays for each simulator. The plan-view displays at other sites can be controlled from any one site together with voice, video, and interactive whiteboard across the network.

1.2.2 The FLSC simulator system

Eight manned Pilot Stations. The Pilot Stations are not intended to simulate a specific aircraft but rather represent a typical fourth- generation fighter aircraft. The models of aircraft dynamics, sensors, and weapons are all generic parameter-driven models that can be easily adapted to emulate any existing or nonexistent realization of the function. However, the cabin itself and the Man Machine Interface including Hands-On Throttle and Stick (HOTAS) are similar to the JAS 39 Gripen aircraft. Four of the Pilot Stations are equipped with domes with a horizontal field of view of approximately 200°. The remaining Pilot Stations have one to three projector solutions with a horizontal field of view varying from 40° to 120°. The domes, developed at FLSC, will increase the realism in Within Visual Range (WVR) combat, attack and reconnaissance missions, formation flying, air-to-air refuelling, etc. (Figure 2).

Four Fighter Controller positions. These stations simulate the latest version of the Swedish STRIC (Air Defence Centre) system, and use a simulated version of the Swedish tactical datalink.

After Action Review facilities including God's eye view. The After Action Review facilities includes functions for record and replay of missions, displaying the head down displays, the God's Eye View and adding information such as shooting range, sensor coverage, missile tracks, etc.

Constructive forces. Friendly and adversary constructive entities are generated using a combination of commercial of the shelf and in-house developed computer generated forces tools.

Infrastructure and External interfaces. The internal data communication between Pilot Stations, Fighter Controller Positions and other simulator components is managed through a Gigabit network. Connection to external functions and simulators can be done through DIS, HLA and SOAP.

Figure 1: DMO facilities at AFRL

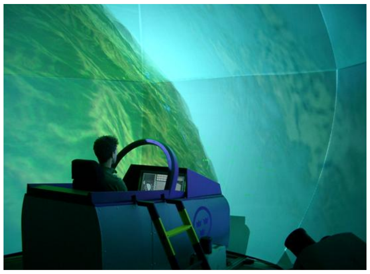

Figure 2: DMO facilities at FLSC

2 F-16 TACTICS DEVELOPMENT

AFRL's DMO research testbed played a vital role in the development of new tactical employment doctrines for employing the AIM-120 Advanced Medium Range Air to Air Missile (AMRAAM). Further, training effectiveness experiments using the testbed demonstrated that with proper instruction, less experienced pilots could learn the new tactics and effectively employ AMRAAMs within a two or four-ship flight [5].

2.1 AMRAAM tactics development

The F-16 is a multi-role fighter with air-to-ground and air-to-air capabilities. Up until the mid-1990's, USAF F-16s were armed with short-range, infrared guided missiles for air combat which required pilots to close within visual range of target aircraft. At the same time, the F-15C, the USAF's primary air-to-air fighter, was equipped with the AIM-120 AMRAAM which has many tactical advantages including,

> "… active radar with an inertial reference unit and micro-computer system, which makes the missile less dependent upon the fire-control system of the aircraft. Once the missile closes on a target, its active radar guides it to intercept. This enables the pilot to aim and fire several missiles simultaneously at multiple targets. The pilot may then perform evasive maneuvers while the missiles guide themselves to their targets," [8].

These capabilities support BVR engagements in which pilots working with Air Battle Managers use radar to locate and track enemy aircraft, target, shoot, and leave before coming into enemy missile range. As dedicated air-to-air specialists, the F-15 community conducted extensive analyses of tactical employment concepts to best use these new capabilities. The resulting doctrine was for the flight leaders to use their air-to-air radar to maximize situation awareness while directing the wingmen who are typically less experienced pilots, where to target their missiles and to become the primary shooters. This contrasts with doctrine for air-combat with short-range missiles in which the flight leader is the primary shooter and the wingman provides cover and backup. When F-16s were equipped with AMRAAMs, many flight leaders continued the tradition of being the primary shooters and employment practices became divergent between the F-15 and F-16 communities. To resolve these discrepancies and to ensure that F-16 pilots could employ AMRAAMS most effectively, the USAF Weapons School undertook an extensive analysis of beyond-visual-range tactics. Experimentation using AFRL's DMO testbed supported this analysis [5].

The Weapons School analysis incorporated detailed review of current F-16 and F-15 air-to-air tactics, live-fly evaluation scenarios, and DMO validation scenarios. During live-fly sorties on the training range, Weapons School pilots were opposed by pilots skilled in flying scripted tactics. In contrast, DMO scenarios were limited by the quality of constructive forces available. Operator intervention guided by a subject matter expert from the Weapons School was required to gain the level of control required. DMO studies focused on leadership, systems operation, targeting, and communication. As part of these experiments, Weapons School pilots spent considerable time devising arguments against using the new tactics and assessing the validity of these arguments using DMO. With DMO capabilities, tactical experience that would require months on the training range was acquired in one week. Using constructive adversaries programmed to employ specific tactics with operator intervention when required, Weapons School instructors could evaluate the new plans against a much wider range of contingencies that could be evaluated on the range. These contingencies included a wide range of enemy aircraft, weapons, formations, maneuvers, and tactics. The result of these live-fly and virtual experiments was a comprehensive and unified set of F-16 employment tactics which paralleled F-15 tactics. This single coherent system, however, was not welcomed by all members of the F-16 community.

2.2 AMRAAM tactics training

The principal objection to the Weapons School's proposed AMRAAM employment standards focused on the wingman's role in a multi-ship engagement. A new F-16 pilot graduating from the Formal Training Unit has approximately 80 hours in the aircraft divided among basic operations, air-to-ground, and air-to-air. Within a squadron, pilots serving as wingmen typically have 100 – 300 hours of experience with only a fraction of that time dedicated to BVR air combat. Upon learning about the proposed employment standards, experienced F-16 pilots expressed strong concerns that few wingmen would have learned the required radar mechanization, communication, and tactical skills well enough to perform their role. Under the proposed standards, the flight leader keeps his radar on maximum coverage for optimal situation awareness, identifies the air picture, calls for a specific gameplan, and directivly targets the wingmen to fire at the enemy aircraft identified by the flight leader. The wingman must understand the gameplan and remember his role from the mission briefing, aim his radar as directed, locate the group of enemy aircraft and his target within the group, all while using correct and timely communication and following the Rules of Engagement (ROE). If the wingman fails to execute properly or is too slow, the F-16s may close too near to the enemy and come within weapons range. Squadron F-16 pilots complained that Weapons School instructors could effectively use the new standards only because they had Weapons School instructors as wingmen. Typical wingmen, they asserted, would have much more difficulty executing their assigned roles.

To assess the validity of this concern and to develop training procedures for new wingmen, the Weapons School conducted an experiment using AFRL's DMO testbed [5]. Several recent graduates of the F-16 basic course were selected to receive training in the new employment standards using AFRL's DMO testbed. These new F-16 pilots were trained by Weapons School instructors over one week using strategies developed at AFRL for use with DMO. For this strategy, instructors first identified the competencies required to fulfil the wingman's role using the new tactics [5]. The instructors then identified the experiences necessary to master these competencies and selected DMO scenarios that would provide these experiences. Instructors then trained the new wingmen using a building-block approach starting with relatively simple scenarios emphasizing basic competencies through complex scenarios requiring high-level competencies [1]. For each training mission, instructors first briefed the wingmen on tactical gameplans, radar lookout responsibilities, communications standards, ROE, and other mission-critical skills. The team then flew the simulators as a flight of four aircraft with two flight leads and two wingmen together with an Air Battle Manager onboard a virtual AWACS. During the simulator session, each scenario was initialized in the air with the friendly and adversary forces positioned beyond radar range. Typically, the flight lead would get an air picture from the Air Battle Manager and select an initial gameplan. If required by enemy actions, the flight lead would modify the gameplan and the team would then execute the new tactic. Each setup was flown to a logical conclusion in which all enemy or friendly aircraft had been killed or all learning objectives had been met. Teams would typically fly six to eight Offensive Counter Air scenarios or three to four Defensive Counter Air scenarios in an hour of simulator time. Teams would then replay and debrief each scenario reviewing what elements of the scenario were accomplished in accordance with the briefed plan, what did not go according to plan, why not, and what remediation was required. Teams would brief, fly, and debrief twice each day resulting in skill level enhancements that would normally take two or three years to develop.

By the end of one week of training, the inexperienced pilots had mastered the new employment doctrine. They were able to fulfil their responsibilities within the flight for basic and advanced scenarios. Using the results of this experiment, the Weapons School demonstrated to the F-16 community that the new employment standards were effective and could be used by inexperienced wingmen provided they received proper training. Using DMO, the USAF Weapons School was able to adapt the F-15C AMRAAM employment doctrine for BVR air combat to the F-16, evaluate its effectiveness with both experienced and inexperienced wingmen, and develop a training program for new pilots.

3 COMPETENCY-BASED TRAINING

Continuation training for USAF pilots is based on accumulating experiences [6]. Under the Ready Aircrew Program (RAP), pilots are required to complete a specific number of training sorties encompassing various mission types and activities. For example, every few months an F-16C pilot will need to participate in a defined number of Defensive Counter Air sorties which include several mission elements such as chaff and flare employment. Having accumulated these experiences within the allotted timeframe, the pilot is certified as Combat Mission Ready (CMR). While the RAP has been an effective system for managing flying hours, methods and metrics resulting from research conducted at AFRL, can now enhance RAP in a way that permits field units to routinely assess attained proficiency on critical skills and specify what training activities need to be provided to move to higher levels of proficiency. These methods further enable the Air Force to develop quantitative metrics to determine appropriate intervals for refresher training. Research using the DMO testbed at AFRL and results from field tests in operational exercises has developed a powerful set of tools to define the competencies, skills, and experiences required for successful mission completion. This research has the potential to refine how we define pilot qualifications and how we structure training based on demonstrated competencies rather than on recurring training sorties/events.

RAP has been an effective system for training today's USAF warfighters. It provides the justification for flying hour requirements and associated training resources. Shortfalls inherent to the RAP system can be addressed using new technologies and training strategies.

In an event/sortie-based training system, proficiency, ranging from that of the individual through the team or team-of-teams, is left to subjective assessment. There is no requirement for the inexperienced F-15C pilot to "survive" all Defensive Counter Air missions. Accomplishing the required number of sorties fills the training square and maintains CMR status. Continued CMR status is not dependent on sustained proficiency and individuals may retain combat mission ready status even though they have a higher than average mortality rate in the course of those Defensive Counter Air training missions. Astute squadron leadership should notice that the individual "died" on an inordinate number of the missions and take corrective action but there is no current method to consistently analyze and correct deficiencies nor is there a standard that measures survivability against mission complexity.

RAP training specifications mandate a one-size-fits-all continuation training program. Sortie and event requirements are minimums but all inexperienced F-15C pilots require at least 18 Defensive Counter Air missions during the year. Due to competition for scarce training resources there are times when necessary training over and above the minimum must give way to higher priorities. Then the minimum number of sorties becomes the maximum [3].

Competency-based training, while based on a core number of live and simulated training sessions, will retain the best of the Ready Aircrew Program while providing adaptive training based on the needs of the training audience. The operational community has the opportunity to leverage on-going research and development to begin a phased implementation of competency-based training.

3.1 What is Competency-based Training?

"Competency-based Training is the ability to compare individual aircrew performance to a defined proficiency level, maintain acceptable levels of performance and target areas requiring improvement." [7]

As previously discussed, traditional training methods concentrate on the number of times the aircrew is exposed to a training event that replicates, with varying degrees of accuracy, the combat environment. Competency-based training focuses on mission performance rather than mission type. The design of the training system will retain training accountability and the justification for training resources. Most importantly, competency-based training does not remove the responsibility of commanders, supervisors, and instructors to train personnel under their command. Assessment tools oriented to measuring and tracking performance will enable more efficient post mission analysis and review by providing detailed information on "what happened" thereby allowing those responsible for the learning outcome to concentrate on the "why".

Competency-based training provides a seamless stream of consistent performance data regardless of the live or virtual training methods. The ability to measure performance against standards established by the user community not only provides control by the operational community but also defines consistent measurement criteria across a single weapon system at multiple bases. While the initial implementation will be applicable for local training, the concept is expandable for sensor-shooter training and to Air Operations Center and Air & Space Expeditionary Force certification.

3.2 Implementation

The transition to competency-based training requires a phased approach. In the near term, simulator-based training using syllabi based on specification of Mission Essential Competencies [4] will develop proficiency sooner and more efficiently than traditional syllabi. Properly structured virtual training, applied when a unit member first arrives, has shown to accelerate those individuals ahead of their peers [7]. Our goals for the near-term operational implementation of competency-based training involve redefining aircrew experience which is currently expressed as the number of hours in the aircraft. Using a competency-based approach, experience will be expressed in terms of knowledge and skill and identified gaps in training will be addressed with validated, standardized scenarios, syllabi, and tools. We can now use competency-based assessment to quantify and evaluate pilot learning curves at specified points in the training continuum and reassign training methods and media to achieve the biggest bang for the resource investment.

In addition, we can use the competency-specifications to identify common knowledge, skills, and experiences across multiple mission areas and across multinational mission contexts. What we now know is that the competency development process is generalizable to these other contexts and can be used to identify common approaches to training, common objectives, and common outcome metrics that can be applied within and across international, distributed mission training, rehearsal, and exercise events.

4 TRANSFORMATION IN THE SWEDISH AIR FORCE

Swedish Air force has seen two major changes during the last 15 years. First of all the transition from a mixed fleet of aircraft types including the J35 Draken (supersonic interceptor), the AJ 37 attack, the S 37 reconnaissance and the JA 37 fighter versions of the Viggen aircraft, to the multi role JAS39 Gripen. Secondly the change of defence doctrine from a focus on invasion defence to a more diversified use of the armed forces, still to defend Sweden against armed attack and to maintain Swedish territorial integrity, but also to assist the Swedish society in times of severe peacetime difficulty and to contribute to peace and security in the world. This includes a need to train pilots to participate in Partnership for Peace and Peace Support Operations including NATO tactics and terminology.

During both these changes the FSLC simulator facility has been able to prove its worth. During the former by training pilots with different background achieving a common view on tactics and behaviour using the JAS 39 Gripen system. During the latter providing realistic scenarios in NATO led operations using NATO staff providing experience

The common denominator for success in both these paradigm shifts is the ability of the simulator to provide virtually unlimited training which cannot be provided in the real environment, provide instant feedback in showing when and where critical decisions were made and the results of these, and the ability to be able to try different tactics to a certain problem in order to learn the best way to the most efficient solution.

4.1 Beyond Visual Range Combat Training

The increased capacity of the SwAF when it moved from earlier generations of aircraft to the 4th generation JAS39 Gripen necessitated the development of simulation facilities to be able to cope with this advance in capabilities. The SwAF needed a cost effective tool to achieve a uniform tactical view and behaviour from pilots coming from different background flying different kind of systems and performing different kinds of missions.

The decision was taken to procure a many versus many simulator where pilots could fly simulated BVR scenarios in a controlled situation. There they could develop tactics and learn how to behave in different kinds of threat environments using the JAS39 Gripen systems such as tactical data links, fighter links, and advanced displays.

The requirements on design and development of the FLSC was that the system should be based on commercial-off-the-shelf components and accepted standards to reduce the cost and give the flexibility to integrate new hardware and software components. The emphasis should be on training effectiveness rather than making the simulator an exact copy of the real aircraft and its subsystems.

Each pilot in the SwAF spent 3-5 weeks in basic tactical training at FLSC developing skills in BVR [2]. Each week consisted of 40-80 missions, compared 5-10 missions a week in a Wing. At the end of the training the results were verified in live training. This is a very important part of the training package since when the pilot experiences the same sensations in the real aircraft and in the simulator he will be reinforced in his trust in the outcome of the simulator. The training covered the whole mission loop planning, briefing, weapon performance, energy management, criteria for weapon delivery, co-operation with wingmen and Fighter Controller through the data link, BVR combat tactics, and debriefing. In addition to the training, the pilots and instructors also developed tactics based on experience gained in the simulator and verified in real flight to be used in the SwAF. At the end of the training course, the pilot could participate in live training exercises with pilots from other wings in Sweden, joining up on the datalink and perform BVR air combat in a unified manner.

In order to improve the syllabus and the facilities, each training week is evaluated by the pilots, grading the course content, the instructors and the simulator itself, prompting continuous improvement to the facility. The extensive training in the FLSC facility saved a lot of money by performing training in the simulator instead of the aircraft, saved a lot of resources by using computer generated forces instead of real aircraft, were performed in a safe and controlled environment, allowed for instant feedback, and capability to replay and retrain difficult moments and finally, achieve a uniform tactical behaviour.

4.2 Swedish Air Force Interoperability Training

The fact that Sweden is taking a more active part in international cooperation, such as participation in Peace Support Operations (PSO) sets new requirements on the Swedish Air Force operations. The squadron must obviously be prepared to operate in a new geographical environment. It must also be prepared to operate in an unfamiliar organisation (NATO), using unfamiliar methods and terminology. It must be prepared for combined operations, co-operating with other squadrons, controllers etc that uses unfamiliar equipment. On top of that, it must be prepared to fight, using communication in English.

To meet these requirements, a comprehensive training and experience building package was conceived including training to expand the SwAF competences from a Swedish defence perspective to an international combined perspective. This transformation has been divided into a number of areas. Some of these have been carried out in the FLSC facilities, some of these in the aircraft, and some of these consist of flying exercises that has been prepared in the simulator and then been performed in real exercise. Examples of these areas are given below.

4.2.1 NATO organisation and terminology

A theoretical training package was created. The training covers wide areas such as NATO organisation, methods and procedures, order formats, regulations, implementation of ROE, terminology etc. The theoretical package is computer based and highly interactive. Apart from facts and knowledge, it also provides a background for the practical training, for example with fictive radio and TV news about the conflict, adding a realistic flavour to the exercises.

SwAF personnel in general are quite fluent in English. Nevertheless, at the beginning of the training, it was obvious that a frightfully high percentage of the pilot’s available brain power was used for talking. Of course, that left little brain power to think about the fighting. The concentrated training, intense fights and communication in English, made a very big difference. After about one week of training, pilots had become almost as good warfighters while speaking English, as while using their native tongue. After 2-3 months more, they were thinking in English (instead of thinking in Swedish and translating before talking).

4.2.2 NATO missions

The training spanned all the way from environment familiarisation, basic mission training etc, step-by-step increased to coalition training in cooperation with all non-Swedish units (AWACS, SEAD, EW, CAP, fighter escort, tankers, CSAR etc) that can be expected to participate in a real operation.

The high flexibility of the simulators at FLSC (which are generic) was very useful, as the cockpits could rapidly be changed to generate both adversaries and coalition aircraft with realistic performance (aircraft, sensors, weapons, data links etc). Having manned adversaries and coalition aircraft made it possible to provide both threat and allied forces with a realistic tactical behaviour. Thanks to this technical flexibility, it was possible to configure the eight cockpits in any given combination; four versus four, six versus two etc. The mix was changed from sortie to sortie. In addition, constructive forces were used in order to create a complete scenario. Constructive simulations were used to generate aircraft, surface vessels and ground vehicles with their associated sensor and weapon functions. These entities could either have a programmed behaviour, they could be able to react to situations (manoeuvre, fire weapons, use ECM etc) in accordance with given rules, or they could be operator controlled. The four Fighter Controller Positions at FLSC were also reconfigured (radar simulation and voice-/data communication) to represent NATO ground based and airborne fighter control and also adversary fighter control.

This solution also gave the pilots hands-on experience from the adversary pilots' situation, learning both about their abilities and their Achilles heels. To be able to fly the adversary's aircraft, learn about his abilities and shortcomings, and then use this knowledge in your own tactics is an advantage that should not be underestimated. The training covers the whole mission cycle. Every mission starts with the reception of an ATO. Based on that, the squadron does the mission planning, attends and gives briefings, performs the mission and also goes through debriefing and reporting after the mission.

After the training package, the pilots felt entirely familiar with the environment, with the NATO organisation, with methods and tactics, with language and brevity words, with regulations and order formats etc. This opinion was also shared by participating NATO personnel (pilots and fighter controllers), for example from British Air Warfare Centre, which was essential for the credibility of the training.

4.2.3 Red Flag Missions

In June 2006 SwAF participated for the first time in a USAF Red Flag exercise in Alaska together with wings from US, Canada, and Japan. The Swedish participation consisted of seven JAS39 C/D Gripen and 87 SwAF personnel stationed at Eielson Air Force Base in Alaska. The wings at Eielson have co-operated in an Air Expeditionary Wing using NATO methods and vocabulary. This participation was seen as a first real test on how well the training at FLSC with focus on participation in NATO led missions and the transformation of the SwAF to being able to provide resources for Partnership for Peace operations had succeeded.

To prepare for this exercise the SwAF decided to train the upcoming Red Flag – Alaska missions in the FLSC simulator. The basic configuration of the FLSC simulator used earlier was kept, adding relevant data from the exercise area including 1000 * 1000 km geographical data, airfields, no fly zones etc. Missions were executed including both the flight to the exercise area, learning the layout of the land, landmarks etc, and started at the execution of the mission. The different scenarios comprised air-to-ground attack, laser guided bombs, ground threats, limited SAM sites. The pilots participating in the Red Flag exercise, trained for a week at FLSC. In addition to the prepared scenarios a lot of time was spent on actually learning the local geography.

Early comments from the Red Flag – Alaska exercise are very encouraging. One of the Pilots said "it felt like we have already been there." Further evaluation of the exercise will follow but an additional advantage of the Red Flag exercise is that the scenarios and results achieved in the virtual Red Flag exercise, updated with data from the live Red Flag can now be used for more Swedish pilots as a verified scenario. Since it is not possible to send all SwAF pilots on international training exercises, this will allow more pilots to reach the same level of understanding as the participating pilots.

4.3 Training cost comparisons

In addition to the benefits of training in a simulator with respect to safety, unlimited airspace, unlimited friendly, neutrals and enemies, lack of weather and technical constraints, immediate feedback etc cost is often mentioned but not quantified. Below is given an estimate of costs and resources requirements related to performing a training package for a SwAF Peace Support Operations transformation, including language, tactics and missions, in the simulator compared to do it in real aircraft.

	Simulator : Aircraft
Direct cost Calculated on 4 weeks of simulator training compared to 50 missions.	1 : 4
Indirect cost Including other friendly, neutral and hostile forces	1 : ∞
Time to perform the training Calculated on 4 weeks of simulator training compared to 50 missions.	1 : 3

5 CONCLUSIONS AND EMERGING DEVELOPMENTS

DMO systems combine human-in-the-loop simulators for teams of pilots and other warfighters together with programmable, real-time constructive simulations of other entities. Together, these systems provide capabilities for training and experimentation that cannot be duplicated on the training range or using computer simulation alone. DMO can be a complementary mechanism for conducting large-force, multinational training with substantially less impact on logistics, environment, and warfighting resources. The ability to train on a regular basis, while routinely tracking the development and sustainment of critical warfighting competencies, holds the promise to expand combatant performance on many levels. Employing DMO for large force employment follows proven strategies in smaller venues using simulation and part-task training to accelerate learning and performance levels. In order for DMO to be successful, both nationally and internationally, it must be broadly accepted as a compliment to historically live-fly focused training and exercise. With this acceptance comes a requirement that high fidelity simulation and competency-based training be employed regularly by the operational forces in the field. Time and resource management were critical drivers of the F-16 WIC's validation study as well as training initiative in air combat. Distributed mission operations provided solutions with sufficient credibility and confidence for the limited objectives. As operational objectives expand, DMO must also expand mission emulation credibility to provide quality training and mission evaluation.

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