

UNITED STATES – CANADA JOINT TRAINING RESEARCH

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ABSTRACT

The United States Air Force Research Laboratory, Warfighter Training Division (AFRL/HEA) developed the Multi-Task Trainer (MTT) technology for advanced training research. Defence R&D Canada has recently joined in a partnership with the United States Air Force, under an international Project Arrangement, to develop a CF-18 MTT at AFRL/HEA, Mesa, AZ. An associated research program is being conducted in both countries. Upon completion of the CF-18 MTT, it will be used for joint training and mission rehearsal research and development (R&D) efforts involving the two countries' sponsoring R&D agencies. This paper presents a review of the joint U.S.-Canada program and a proposed plan for joint training research. The current R&D objectives of the program are described, along with how they support the Canadian and United States Air Forces. The challenges encountered putting together a joint international training research program are reviewed, and some lessons learned are presented. The potential to expand the relationship to include other countries is also addressed. Joint training R&D programs such as this one significantly enhance R&D efforts for the participating nations, and will help lay the groundwork for joint international training using advanced simulation facilities.

ABOUT THE AUTHORS

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INTRODUCTION

The purpose of this paper is to describe a joint United States-Canada Distributed Mission Training (DMT) research and development (R&D) program from the perspective of the two countries' associated defense R&D communities. We begin by providing some background information on national programs and the two R&D organizations supporting those programs. Next we summarize the development of a Project Arrangement between Canada and the United States for development and evaluation of DMT technologies. In the third section, we describe the state of Distributed Mission Training technology today and the two organizations' goals to advance the state of that technology. We then look at the potential for conducting joint training research between the two countries and the possibility of expanding these efforts to our coalition partners. Finally, we describe some of the lessons we have learned, the current challenges we are facing, and the potential benefits of joint international training research.

BACKGROUND

The United States Air Force (USAF) and the Air Element of the Canadian Forces, hereinafter referred to as the Canadian Air Force (CAF), have long had a close working relationship. This relationship includes North American Aerospace Defense and North Atlantic Treaty Organization (NATO) links as well as exchange postings and regular participation in air exercises such as Red Flag and Maple Flag. USAF and CAF aircrews recently participated in joint air operations in the former Yugoslavia and also flew together in the 1991 Gulf War. While it is essential that our two nations continue to fly together in joint training exercises, live training opportunities have steadily diminished over the past decade.

Canada recently began an Incremental Modernization Program (IMP) to upgrade its CF-18 combat aircraft.

However, the CAF budget is not expanding accordingly and upgrades are coming at the expense of fewer operational aircraft and reduced training budgets. As a result, the CAF requirements staff is seeking a new training mix, which places more emphasis on simulation to maintain the high levels of skill and readiness traditional to the CAF. Based on this increased simulation requirement, the CF-18 IMP will replace the two operational CF-18 flight training devices (FTDs) as well as the development system with six new networked flight simulators.

While Canada is beginning its program to develop and install a new generation of networked simulators, the USAF has already established both an R&D testbed for DMT at the Air Force Research Laboratory (AFRL) in Mesa AZ and operational mission training centers (MTCs) at several Air Combat Command wings. The DMT R&D testbed provides the capability to conduct exploratory research and advanced development projects involving the design of training devices as well as the design and delivery of training within a distributed training environment. The operational MTCs provide individual and team training for F-15 and F-16 pilots as well as air weapons controllers. The USAF's goal is to develop similar MTCs for other weapons systems and to link those geographically distributed MTCs to enable inter-team training and mission rehearsal.

To fulfill the DMT goals of both the CAF and USAF, significant advances are required in simulation technology, training design, training delivery, and training evaluation. The customers for these advances are the military users, industrial suppliers, and acquisition agencies of both Canada and the United States. In cooperation with these customers, both nations currently have ongoing R&D programs to develop better methods of identifying training needs, formulating guidelines and principles for training design, and determining the functional characteristics of the simulator and its associated training environment.

In Canada these efforts are being lead by Defence R&D Canada (DRDC) Defence and Civil Institute of Environmental Medicine (DCIEM) while in the US the Air Force Research Laboratory, Human Effectiveness Directorate, Warfighter Training Research Division (AFRL/HEA) conducts similar R&D programs.

Based on the similarities of the CAF and USAF simulation goals and their common R&D interests in DMT simulation technologies and training methods, a bilateral Project Arrangement (PA) was established between the nations in 1999. This PA provides a mechanism for developing and sharing scientific and technical information regarding DMT, personnel exchange postings, and formalizes the long-standing relationship between the DCIEM and AFRL.

Development of Current Project Arrangement

The current PA between the United States and Canada resulted from five years of discussions, an exchange posting, and a detailed feasibility study conducted by AFRL in support of Foreign Military Sales. In the mid-1990's, the Canadian Air Force was examining options for the replacement of its existing CF-18 simulators. At the time, an AFRL/HEA scientist was on exchange at DCIEM, Toronto. As part of the ongoing technology exchange with Canadian scientists and engineers, he provided a description of the Multi-Task Trainer (MTT) technology that AFRL/HEA had developed to support the F-16 Block 30 for the Air Force Reserves. This exchange resulted in a CAF staff visit to AFRL/HEA and a series of detailed briefings on the MTT technology. Based on these briefings, Canada funded a study of the feasibility of producing up to five FTDs based on AFRL's MTT technology, with the support of Canadian industry.

The feasibility study was conducted in 1997 and the same year the two countries drafted a PA under which the FTDs could be produced. The USAF fast-tracked the PA and was in position to undertake the work by the end of 1997. However, early in 1998 the CF-18 upgrade program was reorganized and along with it, the CAF's plans for new CF-18 FTDs. As a result the U.S.-Canada PA was put on hold for a year. Early in 1999, the PA was revised. This revision reduced the production of CF-18 FTDs to one R&D device, and focused the PA on collaborative R&D. The revised PA, signed in the fall of 1999, provides a vehicle for collaborative R&D between AFRL and DRDC and is strongly supported by the CAF

Under this PA, Canada is funding the construction of a CF-18 MTT at AFRL/HEA to reduce the risks associated with the development of CF-18 FTDs and provide an experimental vehicle for conducting joint Canada-United States DMT research. The CF-18 MTT combines the F-16 Block 30 MTT architecture developed by AFRL/HEA with the software from current CF-18 FTDs. Along with the creation of this CF-18 MTT, the two countries have developed a collaborative R&D program to advance the technology and use of distributed mission training. As part of this R&D program, the CF-18 MTT will be network compatible with AFRL/HEA's DMT testbed and thereby capable of participating in joint training effectiveness research activities involving both national and multi-national team training.

STATE OF THE ART - RESEARCH GOALS

This section briefly describes the state of the art in distributed mission training technology and presents a brief overview of ongoing R&D to advance that technology. In this context, the term technology refers to both the hardware and software used to construct a distributed training system and the design and delivery of training using that system. In general, USAF and CAF research communities agree on the goals for advancing DMT technology.

The state of the art in DMT technology is described below in terms of the key words, *distributed*, *mission*, and *training*. Table 1 shows a summary of the current state of the art for the United States and Canadian Air Forces.

State-of-the-Art: Distributed Category

In this paper, *distributed* training refers to the linking of two or more human-in-the-loop (HITL) training devices over either a local or wide area network. Existing networking and encryption technology supports current requirements for such distributed training systems operating at the same security level. In the United States and Canada, it is routine today to connect HITL training devices for R&D purposes. The United States also routinely conducts distributed training using multiple high-fidelity devices. This training may be conducted using multiple training devices within a single MTC operating on a local area network or it may involve multiple training devices at two or more MTCs such as the F-15C MTCs at Langley and Eglin Air Force Bases.

Table 1: Summary of Current DMT Technology

Category	Sub-Category	Current State CAF	Current State USAF
Distributed	Local	Occasional R&D	Routine
	Long-Haul	Occasional R&D	In Development
Mission	Cockpit	High-Fidelity Controls and Displays; Environment in Development	High-Fidelity Controls and Displays; Environment in Development
	Out-The-Window	Low-Med Fidelity	“20/50” Visual
Training	Tactical	Mixed-Fidelity	High-Fidelity Threats
	Validation	Ongoing	Ongoing
	Advanced	Requirements Def.	Ongoing

Although the USAF has awarded contracts for five MTCs, two each for the F-15 and the F-16 and one for the Airborne Warning and Control System, the vision is to develop a DMT capability that will link a variety of systems. The resulting network will link tactical aircraft, intelligence, surveillance and reconnaissance assets, and command and control elements to enable integrated mission training. These additional capabilities will be added to DMT based on prioritized training needs and available funding. To help define the functional requirements needed for these larger scale distributed training events, AFRL/HEA, in cooperation with the Air Combat Command, is participating in a number of recurring developmental training activities such as Desert Pivot run by the Theater Aerospace Command and Control Simulation Facility at Kirtland Air Force Base. The results of these developmental training activities will help to define requirements and concepts for large-scale training events that will become more common as new simulations are added to DMT over the next decade. However, it is important to remember that the USAF training concept views large-scale distributed training exercises as accounting for only a small part of actual DMT use—DMT assets are primarily intended to meet the operational training requirements of the wings.

State-of-the-Art: Mission Category

Mission refers to simulating reality to a sufficient degree to allow humans to train in realistic conditions and experience realistic outcomes of air operations.

This scope is very broad and the current state of the art will be described in terms of the cockpit environment, the “out-the-window” environment, and the tactical environment.

Figure 1 shows a typical high-fidelity FTD cockpit. Today, full replication of cockpit controls and displays is routine in FTDs, although industry continues to devote effort to lowering the cost of component production. Force-cueing systems are increasingly common and their inclusion or exclusion from a flight training device is most often a question of cost rather than availability. Full simulator motion technology is unable to support the rapid onset and sustained forces associated with fast jet aircraft and therefore is typically not used by either the CAF or USAF on their fighter aircraft FTDs. Full replication of cockpit temperature, vibration, and noise requires additional development. We believe that operators will request added cockpit fidelity as they increase their use of simulators for mission training.

The out-the-window component of mission fidelity includes everything you see, including weather, terrain, cultural features, sensor system displays, and other simulated entities. While today’s visual systems and the software models behind them provide a high degree of realism in all of these areas, additional research and development is required in visual system resolution, physical models of the environment, and the real-time processing of sensor systems to develop an immersive environment that contains the extensive visual and sensor information typical of the actual mission environment.

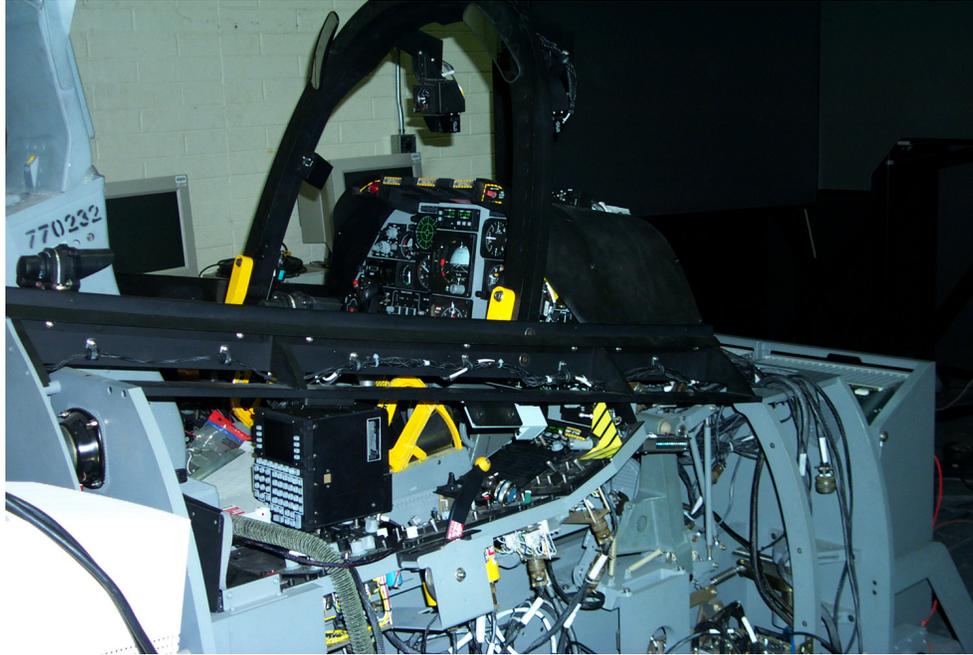


Figure 1: AFRL A-10 MTT Cockpit

The tactical component of the mission has progressed significantly in recent years. In particular, much better models of system performance have become available and integrated with FTDs. The maximum number of real-time entities continues to increase with advances in computer technology. Artificial intelligence has increased the behavioral fidelity of both friendly and threat entities. This has greatly increased the complexity of the training environment without having to add additional HITL devices. Additional R&D is required in all aspects of the mission category.

State of the Art: Training Category

The last element of the state of the art of DMT is *training*, and in this paper we focus on how networked HITL FTDs are used to provide the knowledge, skills, and experiences that are essential for mission success. In the Canadian Air Force, such training occurs almost exclusively in the aircraft, although some training of air weapons controllers uses a distributed software system. In the United States, operational and development systems are routinely used for both initial and advanced flight training. For example, MTC simulator time is an integral part of the F-15 training program and distributed mission training is an integral part of Air Force Special Operations Command annual refresher training. Instructor tools have also improved to allow

more sophisticated real-time interventions and improved performance monitoring.

The increased fidelity of mission simulation has not been matched by the R&D community's ability to perform validation studies. The value of a training device is maximized when all of the training requirements are met for the minimum cost. Since additional fidelity typically means additional cost, justification of increased fidelity should be supported by the results from appropriate R&D studies. Validation studies lag simulator capability for two reasons: complexity and an unwillingness to "lower the bar" from full virtual reality in simulated flight training. Simulator validation studies typically require much planning and support, along with a significant demand on scarce training resources.

The USAF has had some success in conducting large-scale synthetic validation exercises, but few such studies have occurred in Canada. Compounding the complexity issue is the overwhelming view among operators that simulators must replicate the real world as closely as possible. Admittedly, there is a significant motivational aspect of this philosophy that should not be discounted. However, securing funds for defensible validation studies is significantly more difficult when the sponsors do not support reduced fidelity.

Research Goals

The United States Air Force and Canadian Air Force both have R&D programs in place to further develop the technology of Distributed Mission Training. Tables 2, 3, and 4 present a summary of the two countries' current research goals for DMT.

Distributed Simulation Technology Goals

In the distributed category, the Canadian Air Force has a major project underway to build its first two Mission Training Centers for the CF-18 fighter aircraft, a four-ship site in Cold Lake, Alberta and a two-ship site at Bagotville, Québec. These two sites will be linked under the Advanced Distributed Combat Training System (ADCTS) project. The CAF trains air weapons controllers at the Canadian

Forces School of Aerospace Control Operations, and links to this school are being investigated to provide a real-time air weapons control capability to the two CF-18 sites.

The Canadian defense R&D community, under the Advanced Distributed Mission Training, Technology Demonstration project, is constructing the CF-18 MTT referred to above. Upon completion, this device will be returned to DCIEM and can be linked to an existing low-fidelity F-18 simulator known as the CF-18 Aircraft Crewstation Demonstrator. This will provide the basic two-ship formation for conducting training research and development. The two devices will be resident at the DCIEM Synthetic Environment Research Facility (SERF), currently under construction (see Figure 2).

Table 2: Current Goals in the Distributed Category

<p><u>Canada</u></p> <ul style="list-style-type: none">• Develop CF-18 Mission Training Centers (ADCTS Project).• Include air weapons controllers at Canadian Forces School of Aerospace Control Operations• Link CF-18 MTT with AFRL/HEA <p><u>United States</u></p> <ul style="list-style-type: none">• Enhance Readiness Training and Mission Rehearsal Capabilities.• Integrate Legacy Simulators.• Expand DMT to Other Domains (e.g., Space, Information)
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Figure 2. DCIEM Synthetic Environment Research Facility, under construction

Current AFRL work in the distributed category is concentrating on the issues of multi-level security and implementation of the High-Level Architecture. AFRL is also pursuing the limited involvement of The Technical Cooperation Program (TTCP) and NATO countries in its DMT network. Wide area linking of USAF MTCs and other simulator sites is being pursued by other USAF organizations. Air Combat Command envisions that 80-90% of DMT will be within an MTC and 10-20% will involve networked MTCs. TRW Inc. has been engaged by the USAF to knit together all the diverse DMT and legacy training devices under an Operations and Integration contract. AFRL is also actively pursuing the integration of legacy systems and new areas such as space systems into the DMT environment.

Mission Simulation Technology

In the cockpit portion of the mission category, the Canadian Air Force is interested in new levels of cockpit environmental fidelity and is being supported by Defence R&D Canada in these pursuits. DRDC is investigating the collection of vibration data suitable for driving an aircraft motion seat, and digital recordings of in-cockpit noise. Achieving the highest level of fidelity will require data collection during weapons release and such opportunities are very scarce in today’s world of highly constrained defense budgets. DRDC is also interested in improvements to aerodynamic models of aircraft, and in particular the CF-18.

In the out-the-window area of mission fidelity, Canadian R&D activities involve the creation of 20/20 visual systems, along with R&D methods to relate visual system capability to operator performance. DRDC is also collecting data to support highly accurate modeling of aircraft representations in a simulator. The CAF has detailed

its requirements for the next generation of CF-18 simulators, and these were released as part of an ongoing industry competition.

In the tactical component of the mission category, DRDC is seeking to reuse existing tactical libraries in its R&D facility. In addition, DRDC is developing the means to modify the performance of computer-generated forces based on models of human performance, for example, fatigue or g-effects.

AFRL continues to push for high realism and low-cost construction of flight training device cockpits. AFRL is also investigating the integration of helmet-mounted sighting systems into FTDs. Other interests include improved integration of Night Vision Imaging Systems (NVIS) with FTDs.

AFRL is also involved in development of an eye-limited full field-of-view visual system, including collimated flat-panel displays, the development of laser projection technology, advanced PC-based image generation systems, and new visual/sensor database development tools. Efforts continue to make flight training device visual systems smaller, simpler, and more deployable

AFRL is developing a new threat environment system that will contain high-fidelity models for replication of a tactical environment. In conjunction with this work, new, physics-based models of sensor system interactions are being developed, along with an advanced model of environmental conditions. Advances in the behavior of computer-generated forces are also programmed for study

Training Technology

In the training category, DRDC efforts concentrate on review of existing measures and the identification of common and specific elements. Longer term goals

Table 3: Current Goals in the Mission Category

<p>Canada</p> <ul style="list-style-type: none"> • Produce a 20/20 visual system, including high-resolution laser projection, PC-based image generation, and advanced database development tools. • Develop increased fidelity models of weapons and sensor systems. • Collect and implement noise and vibration data. <p>United States</p> <ul style="list-style-type: none"> • Develop a 20/20 visual system, including high resolution laser projection, PC-based image generation, advanced database development tools, and flat-panel collimated displays. • Develop a proof-of-concept physics-based threat system, including advanced modeling of environmental conditions.

Table 4: Current Goals in the Training Category

<p>Canada</p> <ul style="list-style-type: none">• Optimize the value of FTDs by addressing the question “How little is enough?”• Validate the use of simulator training hours for specific training tasks.• Identify common and mission specific measures of performance for national and international DMT.• Develop a capability for joint and international DMT.• Develop a mission rehearsal capability. <p>United States</p> <ul style="list-style-type: none">• Identify Mission Essential Competencies for specific training tasks.• Develop advanced measurement and training tools.• Extend DMT to Mission Rehearsal.• Develop an international DMT capability.

involve comparing high vs. low fidelity for specific training tasks, the development of a capability for international DMT, and the ability to support mission rehearsal.

Current AFRL goals include the development of automated measures of performance and developing performance measures that are related to specific training tasks. AFRL is also developing advanced tools for distributed briefing and debriefing and is support the USAF goal of developing a mission rehearsal capability using DMT assets.

The current DMT R&D goals of DRDC and AFRL have a high degree of similarity. Both organizations are interested in improving the three basic categories of Distributed Mission Training. AFRL R&D is broader in scope than DRDC R&D and has significantly more resources allocated.

However, significant room for cooperation exists in all areas. Currently, the R&D goals are most closely aligned in the pursuit of out-the-window fidelity for DMT. However, there is potential for cooperative work in the training and distributed categories, as discussed further below.

FUTURE INTERNATIONAL TRAINING RESEARCH

Bilateral cooperation on development of a CF-18 MTT and common R&D interests involving DMT technology provide the ideal circumstances to network Canadian and U.S. DMT R&D facilities for the purposes of training research. The past decade has repeatedly shown that modern air operations are likely to be conducted in a coalition environment. International DMT will benefit pilots from all allied nations by increasing individual and team skills. In addition, an international DMT capability will also provide member nations with increased opportunities to understand system capabilities, as well as the preferred tactics, techniques, and procedures of their potential partners in coalition operations.

From a research perspective, the hypothesis or goal under consideration is that members of both air forces will be better trained with international DMT experience than without it. There are two significant challenges to Canada-United States DMT research using connected R&D FTDs. The first challenge is creating a detailed requirement that is supported by the respective air forces. The second challenge is addressing security concerns. The latter point is considered beyond the scope of this paper, except to state the shared belief that if the training research requirement is sufficiently justified on both sides of the border, the means will be found to address the security concerns. Table 5 summarizes the questions to be answered in defining the detailed requirement.

Table 5: Defining the Requirement for Research in International DMT

- Is it technically feasible to connect U.S. and Canadian training research sites?
- What level of classification will be required?
- Who is the target trainee audience?
- What are the appropriate sponsoring agencies?
- What are the interoperability issues of interest to the respective air forces?
- What are the missions of mutual interest?
- What current training requirements can be addressed?
- How will instructors from the two countries coordinate results?
- What kinds of performance measures are to be used?
- What kind of validation study will be performed, e.g., a joint, international exercise?
- What resources will be required and dedicated by each country?

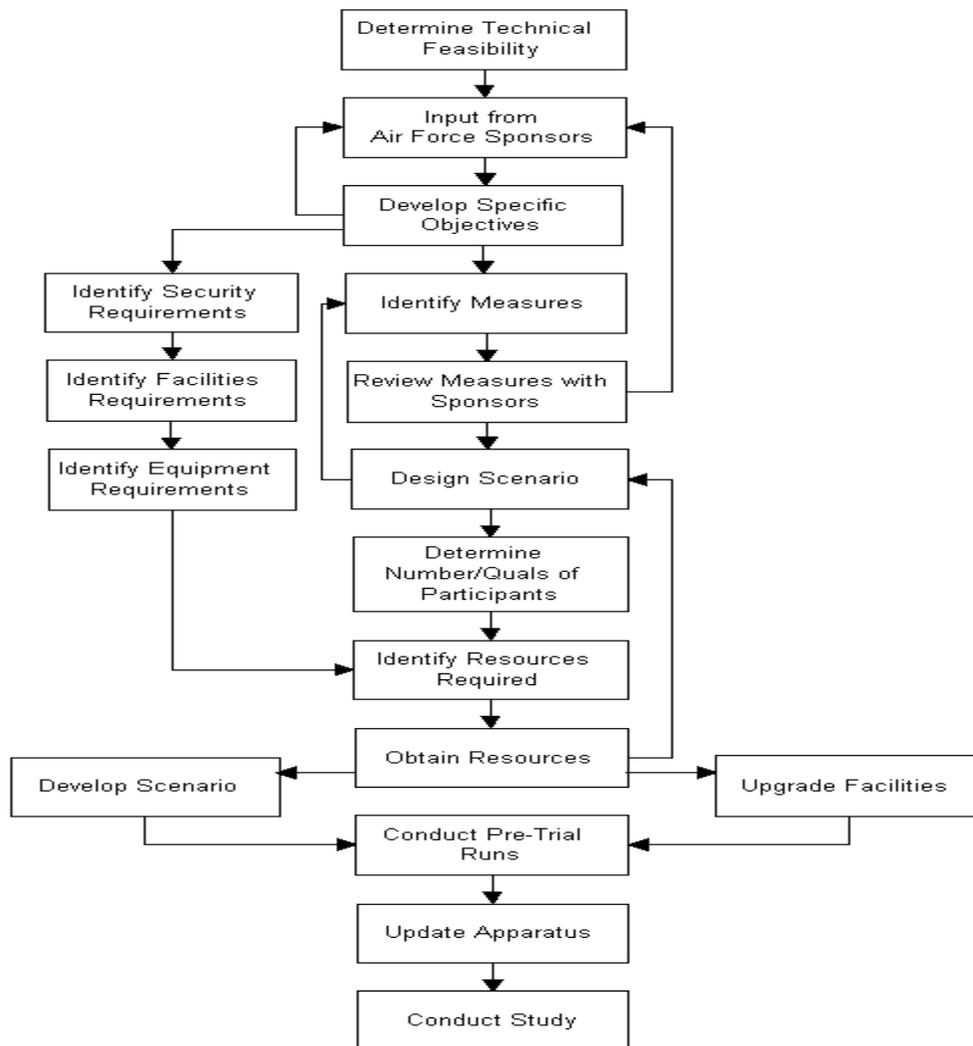


Figure 3. Process Diagram For First Canada-United States International DMT Study

Figure 3 provides an outline of the process to be followed for the first joint United States – Canada DMT R&D study DRDC and AFRL staff will develop the processes illustrated in Figure 3 into a complete R&D plan during the next year. Figure 3 shows several opportunities for iteration and refinement of the study plan. Development of objectives in consultation with air force sponsors is seen as an iterative process as operator goals are translated into testable hypotheses. It is assumed that selected measures will be both generic and specific to the scenario selected, requiring them to be revisited during scenario development. Furthermore, the exact nature of the study will depend on the resources available and limited resources may require a re-design of the work. In addition to Canadian – United States studies, additional opportunities exist for international cooperation within the TTCF and NATO organizations, including a three-way study involving the U.S., the United Kingdom, and Canada.

Moving from international training to mission rehearsal is a logical step. The main technical requirement to move from training to rehearsal is the timely creation of specific tactical environments, i.e., terrain, sensor, and threat databases. While this should not be seen as a solved problem, it is by comparison, much simpler than the policy requirement of shared intelligence information. Typically, intelligence information is closely held until required for operational use. In the opinion of the authors, R&D demonstrations and studies do not provide sufficient justification to change this policy. So research into mission rehearsal should focus on other issues.

As already noted, optimization of the tools and processes involved in rehearsal is a valid DMT development area that can contribute to mission rehearsal capability. However, some measures of performance development may also be required to move from training to rehearsal. Table 6 shows some differences between training and rehearsal.

Table 6: Characteristics of Training vs. Rehearsal

Characteristic	Training	Rehearsal
Crew	All crews	Specific Crews
Terrain	Ranges; Generic Operating areas	Specific Area
Planning	Process oriented	Task oriented
Equipment	Large variety of potential threats and friendlies	Specific threats and other friendly participants
Contingencies	Minimized for comparison	Maximized for preparedness
Feedback	Based on instructors' full knowledge	Based on assumptions about the mission

While Table 6 is not exhaustive, it does illustrate that the differences between training and rehearsal are significant enough to possibly warrant different tools for evaluation. Specific goals must be developed in cooperation with experienced operators, as indicated in Figure 3.

DISCUSSION AND CONCLUSIONS

Canada and the United States have found benefit in cooperation in the construction of a Canadian R&D flight training device and advancement of the technology of Distributed Mission Training. Extending this work to international training and rehearsal research in the form of networked R&D FTDs appears to be of potential benefit as well. However, this next step represents an increased commitment on the part of both parties. To date, the effort has involved coordination of R&D goals and sharing of the results of technology development.

Moving into international training and rehearsal research will require the two respective R&D organizations to develop a single research plan with the joint commitment of resources.

The follow-on step to international training and rehearsal research is the extension of the cooperation from the R&D community to the training communities of the respective air forces. This adds to the responsibilities of the two R&D organizations not only to learn to work side by side, but also to create a common vision for two sponsoring organizations. The authors do not assume these goals will be achieved, but as of this writing there appears some cause for optimism. Sponsor buy-in can be achieved early, during the development of a plan for the international R&D activity. Because of the history of exchanges between the two R&D organizations, the capabilities and culture of each organization is familiar to the other. Any U.S.

concerns about a one-way flow of technology out of the country can also be addressed during the joint development of a single R&D plan, created to advance the knowledge of both organizations. The authors believe that given the establishment of clear interoperability benefits, the issues of technology control can be addressed.

A further step in the justification and benefit of joint international R&D is the establishment of links to the acquisition process. As a component of Air Force Materiel Command, the United States Air Force Research Laboratory has a mandate to perform R&D that leads to improved capabilities or reduced costs. Defence R&D Canada, before achieving status as a government agency, was similarly situated under the Canadian Assistant Deputy Minister of Materiel, for the Department of National Defence (DND). While the CEO of DRDC is now the DND Assistant Deputy Minister of Science and Technology, there is still a strong focus in the headquarters of DRDC on delivering systems to the Canadian Forces. In Canada, recent efforts to link DMT R&D activities to the acquisition community have been successful. In particular the current work with AFRL/HEA would not have received approval from its air force sponsors without being able to link the R&D products to the air force acquisition project (i.e., ADCTS).

AFRL/HEA has also achieved significant success in links to the acquisition process through the laboratory's A-10 program, jointly sponsored by Air Combat Command, Air Force Reserve Command, and the Air National Guard. AFRL has also developed F-16 MTTs which were fielded and used by the Air National Guard. Neither R&D organization has yet achieved the status of being included in every flight training device acquisition process conducted in the respective countries. Such a goal, while admittedly lofty in nature, is worth seeking. The two R&D organizations are well positioned to address the service requirements for advanced technology that is compatible and interchangeable between platforms.

In conclusion, the Canadian and United States Air Forces have traditionally enjoyed a high level of international cooperation that has extended into the respective R&D organizations. Current cooperation in the area of DMT R&D is seen as beneficial to both R&D organizations, and there is strong interest in extending this to a single coordinated plan for international DMT training and rehearsal research. The most significant lesson learned in the area of international cooperation is "walk before you run," i.e., take advantage of a scientific exchange or

cooperation through a TTCP/NATO working group, to understand the goals and workings of the other organization before beginning a common program of R&D. Second, international training and rehearsal research must be supported by the appropriate agencies within the respective air forces. Third, both R&D organizations must be willing to commit significant resources, including scientific, engineering, operational, and program management skills. Fourth, the program must have a clearly identifiable product, which justifies the resource commitment.
