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Usability of LNCS as an After-Action Review Tool during Exercise Virtual 2016

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Abstract

Defence Research and Development Canada (DRDC) is investigating the use of distributed after-action review (AAR) tools to support the Royal Canadian Air Force Simulation Strategy. AARs provide valuable feedback to the training audience about their individual and collective performance against training objectives, and are used to reinforce learning and maximize training value (McKeown & Huddleston, 2011). Distributed after-action review technologies will allow commanders and instructors to effectively review mission details with warfighters and trainees at different remote locations. At the RCAF's 2016 Exercise Virtual distributed simulation event, DRDC evaluated the effectiveness and operator perceptions of an after-action review tool called Live Virtual Constructive (LVC) Network Control Suite (LNCS), developed by the United States Air Force Research Laboratory. The usability evaluation revealed that LNCS was a valuable interactive AAR tool with high user satisfaction and potential for distributed simulation training, despite its limitations and the technical constraints surrounding the exercise. Operators with more training on LNCS rated the software more positively, suggesting a possible relationship between familiarity and acceptance. These findings suggest that distributed after-action review tools should include user training and be designed with an intuitive interface.



Résumé

Recherche et développement pour la défense Canada (RDDC) étudie l'utilisation d'outils d'analyse après action (AAA) distribués pour appuyer la Stratégie de simulation de l'Aviation royale canadienne. Les AAA procurent des rétroactions utiles au public cible de l'entraînement sur le rendement individuel et collectif à l'égard des objectifs d'entraînement, et servent à renforcer les apprentissages et à maximiser l'utilité de l'entraînement. (McKeown et Huddleston, 2011). Les technologies distribuées d'analyse après action permettront aux commandants et aux instructeurs de revoir les détails de la mission avec les combattants et les stagiaires à des endroits éloignés. Lors de la tenue de l'événement de simulation d'exercice virtuel distribué 2016 de l'ARC, RDDC a évalué l'efficacité et les perceptions des opérateurs de l'outil d'AAA intitulé *Live Virtual Constructive (LVC) Network Control Suite (LNCS)*, élaboré par le Laboratoire de Recherche de la United States Air Force. L'évaluation de la facilité d'utilisation a révélé que le LNCS est un outil d'AAA interactif utile, qui apporte une grande satisfaction aux utilisateurs et qui présente des possibilités pour l'entraînement par simulation distribuée, malgré ses limites et les contraintes techniques entourant l'exercice. Les opérateurs qui avaient reçu une formation plus complète sur le LNCS lui ont donné une meilleure évaluation, ce qui laisse croire à un lien possible entre la familiarisation et l'acceptation. Ces constatations suggèrent que les outils d'analyse après action distribués devraient inclure de la formation pour les utilisateurs et être dotés d'une interface utilisateur intuitive.



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1 Introduction

Exercise Virtual (EV) is an annual distributed simulation event to develop the Royal Canadian Air Force's (RCAF's) training systems, infrastructure and services in an effort to comply with the RCAF Simulation Strategy 2025 (RCAF, 2014). EV is run by the Canadian Forces Aerospace Warfare Centre (CFAWC) with oversight provided by the Director of Air Simulation and Training (DAST). Defence Research and Development Canada's (DRDC's) Virtual Skies 03CE project was started to assist DAST. Research into after-action review best practices indicate that a balance of subjective and objective feedback provides participants with optimal information for performance improvement (McKeown & Huddleston, 2011). In a complex, multi-player environment, fact-based assessment can be difficult because of the overwhelming amount of raw data available. An interactive AAR software can facilitate individual and collective performance evaluation and reinforce learning process in distributed teams. This Reference Document provides details of the use and assessment of after-action review software in support of a Scientific Letter summarizing DRDC's evaluation of EV 2016 (EV16) for DAST.

EV16 included participants simultaneously operating simulators in a number of locations throughout Canada including Trenton, Petawawa, Edmonton, Gagetown, Valcartier, Toronto, and Halifax. After each mission, all the participants joined a video teleconference to review technical issues with performing the distributed simulation, as well as individual and team performance. This Reference Document reports the results of a study using a software tool to support such after-action review tasks after distributed simulations. The software tool investigated in this study, called the Live Virtual Constructive (LVC) Network Control Suite (LNCS) was provided to DRDC by the United States Air Force Research Laboratory (AFRL) through The Technical Collaboration Program (TTCP). LNCS was supplied to DRDC for evaluating its effectiveness to support after-action review of training missions with distributed participants.

LNCS has been designed to support the recording, annotation, and playback of simulations and exercises. It consists mainly of a map display that allows users to monitor the behaviours of participants and computer generated forces during and after a simulation or exercise. **Figure 1** shows a typical LNCS display being used during after-action review. Some functions of LNCS support its use during distributed exercises, specifically sharing the same map view and overlays between two or more LNCS clients operating on different computers on the same simulation network. Such use would support multi-site distributed training events to provide meaningful objective data for the accomplishment of broader simulation-based training goals.

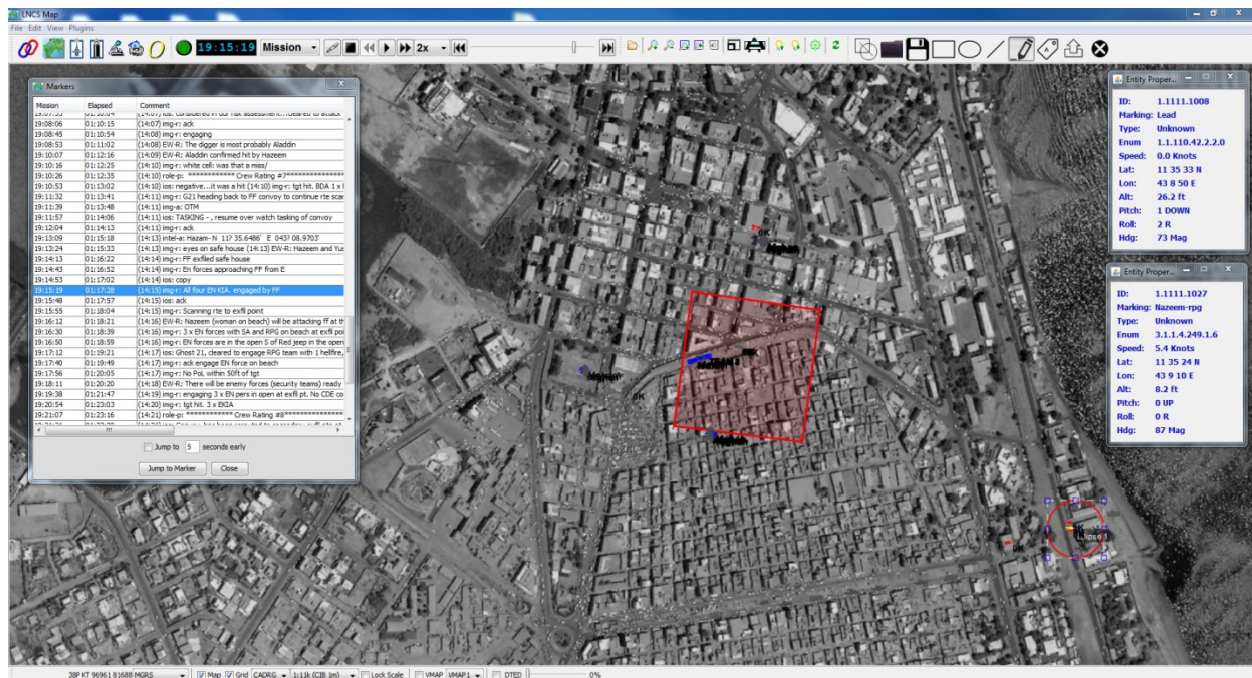


Figure 1: LNCS map display during mission playback.

During EV16 two LNCS software clients were installed to investigate its ability to function during a RCAF distributed simulation exercise and to collect user feedback. Each site wishing to use LNCS must install the client locally to playback the AAR. The client can be controlled locally, or by another instance of LNCS on the network. One LNCS client was setup at DRDC – Toronto Research Centre on the Testbed for Integrated Ground Control Station (GCS) Experimentation and Rehearsal (TIGER) Uninhabited Aircraft System (UAS) GCS simulator (McColl, Banbury, & Hou, 2016), while another LNCS client was setup at CFAWC in Trenton in the EV16 exercise control room.

2 Usability requirements

The technical evaluation of LNCS during EV16 consisted of identifying occurrences where the LNCS software exceeded, met, or failed to support usability requirements for prescribed AAR tasks. The “exceed” rating was given when LNCS performed a function or enabled task completion beyond that previously identified as possible with the EV16 simulation system. The “meet” rating was applied when LNCS successfully completed developer-prescribed functions or task enablement. A “fail” rating was given when LNCS did not complete developer-described functions or task enablement. Any failure to meet requirements could be attributable to limitations of the LNCS software itself, or other technical constraints during the exercise, such as difficulty integrating LNCS into the EV16 distributed simulation environment.

There were two instances where LNCS exceeded usability requirements. During the distributed simulation, the exercise control personnel obtained real-time information from LNCS that was not readily available on their other software tools. LNCS allowed the exercise control personnel to identify the locations and trajectories of friendly aircraft and munitions in real-time. Additionally, LNCS was used as a troubleshooting tool for other simulation systems, specifically showing targeting and lasing location errors on TIGER.

LNCS met most of the usability requirements for non-distributed simulation activities. LNCS correctly displayed maps, recorded simulation information, displayed icons representing simulation entities, allowed users to record annotations on the simulation data, allowed users to change the map display, displayed entity information, allowed for playback of recorded simulation data, displayed recorded annotations, and displayed the correct mission time.

LNCS failed to meet six usability requirements in non-distributed and distributed simulation configurations. They are listed in **Table 1**. The significant technical issues included LNCS crashing, distributed simulation data recording issues, radio communication recording issues, technical manual quality, the inability of LNCS to be easily integrated in the video-teleconferencing system, and the inability of the two distributed LNCS clients to communicate over the simulation network. These include both LNCS limitations and technical issues with integrating LNCS into the EV16 simulation system. The last two technical issues unfortunately prohibited the use of LNCS for distributed after-action review during EV16.

Two usability recommendations for LNCS functionality were also identified. During the exercise while LNCS is recording simulation data, it would be beneficial to allow for changes in the time and content of user annotations. LNCS would also benefit from a larger library of icons representing different types of simulation entities. For example, a pick-up truck is currently displayed on the LNCS map as a tank.

Table 1: LNCS usability requirements.

Usability requirement	Identified Technical Issue Resulting in Failure to meet requirement
LNCS software functions consistently.	LNCS crashed on TIGER.
LNCS could be used during video-teleconference mission debriefs.	LNCS could not be integrated into any of the workstations that were used for the VTC debriefings at CFAWC. The machines used for VTC were in a separate room and not connected to the same network as the simulation.
LNCS user manual would include thorough instructions.	The manual does not have instructions for using LNCS for distributed after-action review.
Any LNCS clients operating on machines that are sharing simulation information over a network would be able to perform distributed after-action review functions.	The two LNCS clients were operating on sub-networks with different classification levels. A network firewall between the classifications was blocking data and prohibiting the LNCS clients from successfully connecting to each other.
LNCS would record network radio communications.	For EV16, the radio communications and physical simulations were run with different network configurations. LNCS recording and/or playback of the radio communications malfunctioned in this configuration. Playback of radio communications did not occur.
Connected distributed LNCS clients would coordinate simulation recordings.	When running two LNCS clients on the local TIGER network, if one LNCS client is recording a mission, and the other LNCS client requests to start another recording the first LNCS recording was corrupted and lost.

3 User Satisfaction

Feedback was solicited on the use of LNCS from the operators of TIGER at DRDC – Toronto Research Centre and the EV16 exercise director in Trenton. This information was gathered in accordance with the DRDC Human Research Ethics Committee guidelines, and falls within the exception for personnel who are evaluating experimental equipment. Both the Air Vehicle Operator (AVO) and Payload Operator (PO) crew members of TIGER used LNCS to perform after-action reviews for the TIGER missions. Afterwards they completed a System Usability Scale (SUS) (Brooke, 1996) questionnaire assessing their opinions on the usability of LNCS, followed by a 15 minute interview where they elaborated on their experiences with the system. The SUS provides a 100 point score based on the presence of positive attributes and absence of negative ones, and has been found to be a simple, robust and versatile tool (Bangor, Kortum, & Miller, 2008). A score of 68 is considered ‘average’ with scores less and greater than 68 being below and above average respectively (MeasuringU, n.d.). The interview was guided by a number of questions focusing on the tasks completed, completion time, efficiency, errors, satisfaction and usability problems (Kirakowski, n.d.; MeasuringU, n.d.; U.S Department of Health & Human Services, n.d.). The SUS questionnaire and interview questions are included in Appendix A. The EV16 director also completed the SUS after a brief tutorial and approximately 10 minutes of operating LNCS. The exercise director was not asked to participate in an interview because his limited experience with the software would not allow him to effectively answer the interview questions.

The TIGER crew members rated LNCS highly on the SUS, above average (ratings were 77.5 and 80 for the AVO and PO respectively). Specifically, the AVO and PO found the system easy to use, the functions well integrated, they would use the system frequently, and were confident that most people would learn the system quickly. The exercise director rated LNCS below average at 15. He found the system difficult to use, would not use the system frequently, and was not confident that most people would learn the system quickly.

During the interview, the TIGER AVO and PO identified that they used LNCS for debriefs, and the playback feature made it quite easy to convey information about specific incidents (i.e. understanding the situation, what went right or wrong). The pausing feature allowed them to discuss issues when they occurred rather than at the end of the playback. An observation was made that having the mission recorded rather than trying to recall information from memory was particularly useful. They both saw the usability of LNCS for reviewing risks and uncertainties encountered during the mission, having an overview of how the operation unfolded as well as reactions to events from units and entities involved, and overall situational awareness (SA) for distributed AAR.

There were several usability and interface issues noted during the interviews. The issues with LNCS identified by the AVO and PO are listed in **Table 2**. **Table 3** lists LNCS usability and interface enhancement recommendations made by the AVO and PO.

Overall from the AVO and PO, LNCS received positive feedback. The AVO and PO found LNCS intuitive and easy to use, and they agreed that it is a tool that would add value to distributed AAR. It is important to note that the exercise director had more responsibility than the AVO and PO, less time to learn the software, and considerable pressure to perform as the default AAR facilitator. These various stressors as well as less experience with the LNCS may have resulted in the disparity in the evaluations; however the number of evaluators is too small and the number of confounding factors is too high to draw clear conclusions.

Table 2: AVO and PO identified LNCS issues.

Usability and Interface Issues
The resolution and interactivity of the LNCS map was at times difficult, e.g. the map would freeze or altogether disappear for a few seconds when zooming in.
LNCS did not show all entities at all zoom levels.
The sensor footprint on the map in LNCS did not represent the actual one from the simulation, making it difficult to relate what they were seeing in the simulation to what LNCS was displaying in playback.
It was unclear if LNCS was capable of performing all functions required by the AVO and PO because the manual is unclear and incomplete.
The meaning of symbology was in some cases confusing (e.g. crossbones represented a command to kill an entity).
Navigating through menus is somewhat cumbersome and could be made more user-friendly.
During playback, mission time reflects the start record time which is different across units, and in distributed AAR, using a common time scale is essential.

Table 3: AVO and PO identified LNCS improvements.

Usability and Interface Enhancement Recommendations
The option to switch from Lat/Long grid to Military Grid Reference System (MGRS) was deemed essential, as some units/nations have a preference for one over the other.
The confusing symbology could be fixed by having a mouse-over feature explaining the function behind the symbol.
Having the ability to enter additional information, like a bulls-eye, with features such as zooming in for detail, would be desirable.
Adding objects on the display is useful during playback, having options such as labels indicating areas of interest, color, patterns, symbologies, would make it easier to communicate during a debrief.
Changing the scale automatically and smoothly (such as in FalconView ¹ or Google Map) would diminish issues with map resolution and interactivity.
Displaying the actual current time, instead of mission duration, would allow everyone involved with the distributed mission to coordinate their actions.

¹ FalconView is a mapping system that can display maps with different features, resolutions and levels of detail. It enables users to overlay reference points, symbols and other geographical and reference information.

4 Summary

This Reference Document presents the evaluation of after-action review software, LNCS, at EV 16. Despite technical issues that precluded its use for distributed teams, the users observed the potential of this interactive tool for evaluation of their individual and collective performance and for reinforcing learning. In terms of usability requirements, LNCS met or exceeded expectations in most cases, except for six instances where it failed due to limitations of its functionality or other technical constraints during the exercise. This currently limits its value for distributed training. User feedback revealed that software features such as playback and pausing of the recorded video stream facilitated discussions and review of specific mission events, as well as overall mission SA. The overall satisfaction seemed to depend on familiarity with LNCS. These findings suggest that an interactive and distributed AAR tool for the RCAF should have a highly intuitive user interface with AAR specific features and be accompanied with training. DRDC will share these results with AFRL for the continued development and improvement of the LNCS software.

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Appendix A System Usability Scale

© Digital Equipment Corporation, 1986.

	Strongly disagree						Strongly agree
1. I think that I would like to use this system frequently	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
2. I found the system unnecessarily complex	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
3. I thought the system was easy to use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
4. I think that I would need the support of a technical person to be able to use this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
5. I found the various functions in this system were well integrated	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
6. I thought there was too much inconsistency in this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
7. I would imagine that most people would learn to use this system very quickly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
8. I found the system very cumbersome to use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
9. I felt very confident using the system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
10. I needed to learn a lot of things before I could get going with this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		

Appendix B Software usability interview questions

- ❖ *Tasks*: What tasks did you use the software for?
- ❖ *Task completion*: How successful were you in completing the task(s) you were trying to accomplish?
- ❖ *Efficiency*: How efficient/effective were you in completing the task(s), given the software provided?
- ❖ *Task time*: How long did it take you to accomplish the task(s)? Was it within the acceptable timeframe?
- ❖ *Errors*: How often did you make any unintended actions, slips, mistakes, or omissions while trying to complete the task(s)?
- ❖ *Usability problems*: Were there user interface problems you encountered? If so, what were they?
- ❖ *Task satisfaction*: Did software have sufficient functionality to assist you in completing the task? If not, what additional functionality would you require to accomplish the task(s)? Was the user interface design intuitive? How easy/hard was it to learn? Would you remember enough to use it effectively in the future?

<https://www.usability.gov/what-and-why/usability-evaluation.html>
<http://www.measuringu.com/blog/essential-metrics.php>
<http://sumi.uxp.ie/>

List of symbols/abbreviations/acronyms/initialisms

AAR	after-action review
AVO	air vehicle operator
CAFWC	Canadian Forces Aerospace Warfare Centre
DAST	Director Air Simulation and Training
DRDC	Defence Research and Development Canada
EV	Exercise Virtual
GCS	Ground Control Station
LNCS	Live-Virtual-Constructive Network Control Suite
LVC	Live Virtual Constructive
MGRS	Military Grid Reference System
PO	payload operator
RCAF	Royal Canadian Air Force
SA	situational awareness
SUS	system usability scale
TIGER	Testbed for Integrated Ground Control Station Experimentation and Rehearsal
UAS	uninhabited air system

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Evaluation; Review; After-Action Review; RCAF; Performance