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Examining the effects of UAV enhanced maritime surveillance on situation awareness, workload, and trust in automation

Frederick M.J. Lichacz

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Abstract

The Canadian Forces Experimentation Centre (CFEC) conducted an experiment to examine whether the inclusion of a UAV into the current suite of surveillance technologies would improve the detection and integration of vessels along a prescribed area of Canada's Pacific coastline. A sub-goal of this experiment, the results of which are presented in the present technical memorandum, was to examine and compare the situation awareness, perceived workload and ratings of trust in automation amongst surveillance personnel using extant surveillance technology and UAV enhanced surveillance technology. Although the data yielded inconclusive results with regard to the impact of UAV technology on situation awareness, in general, the data revealed that perceived workload and trust in automation are improved when UAV technology is integrated into the extant surveillance system.

Résumé

Le Centre d'expérimentation des Forces canadiennes (CFEC) a mené une expérience en vue d'examiner si l'inclusion d'un engin télépiloté (UAV) à l'ensemble actuel de technologies de surveillance améliorerait la détection et l'identification des navires le long d'une zone prescrite sur la côte canadienne du Pacifique. Un sous-objectif de cette expérience, dont les résultats sont présentés dans le présent mémoire technique, consistait à examiner et à comparer la connaissance de la situation, la perception de la charge de travail et la confiance en l'automatisation au sein du personnel de surveillance utilisant la technologie de surveillance existante et une technologie de surveillance améliorée par UAV. Bien que les données n'aient procuré que des résultats peu concluants quant à l'impact de la technologie des UAV sur la connaissance de la situation, elles ont révélé qu'en général la perception de la charge de travail et la confiance en l'automatisation s'améliorent lorsque la technologie des UAV est intégrée au système de surveillance existant.

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Executive summary

The Canadian Forces Experimentation Centre (CFEC) conducted an experiment to examine whether the inclusion of an Uninhabited Aerial Vehicle (UAV) into the current suite of surveillance technologies would improve the detection and identification of vessels along a prescribed area of Canada's Pacific coastline. In addition to the primary task of studying vessel detection and identification, this experiment provided researchers with the opportunity to examine whether extant surveillance systems and UAV augmented surveillance systems differentially affected operator situation awareness, perceived workload and ratings of trust in automation.

Four littoral scenarios were designed to 1) categorize and identify all contacted targets in the Littoral environment, 2) find and assist a ship in distress, 3) detect an intruder ship in the surveillance area that was smuggling illegal immigrants in a northerly direction along the littoral environment, and 4) identify an intruder ship carrying a 'dirty' bomb in a southerly direction along the littoral environment. Because of the nature of this experiment (i.e., field study), weather conditions limited the data analysis to scenarios1, 3, and 4.

During each mission, the participants received questionnaires pertaining to situation awareness, workload, and trust in automation one hour after the trial began and every hour thereafter until the end of the mission. For the SA questionnaires, except for those questions pertaining to predictions about future events, each response was to be based on the previous hour's work.

Although the data yielded inconclusive results with regard to the impact of UAV technology on situation awareness, in general, the data revealed that perceived workload and trust in automation were improved when UAV technology was integrated into the extant surveillance system.

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Le Centre d'expérimentation des Forces canadiennes (CFEC) a mené une expérience en vue d'examiner si l'inclusion d'un engin télépiloté (UAV) à l'ensemble actuel de technologies de surveillance améliorerait la détection et l'identification des navires le long d'une zone prescrite sur la côte canadienne du Pacifique. Outre la tâche principale d'examen de la détection et de l'identification des navires, cette expérience a permis aux chercheurs d'étudier si les systèmes de surveillance existants et les systèmes de surveillance améliorés par engin télépiloté (UAV) influaient différemment sur la connaissance de la situation, la perception de la charge de travail et la confiance en l'automatisation manifestées par l'opérateur.

Quatre scénarios littoraux ont été établis pour 1) catégoriser et identifier toutes les cibles contactées dans l'environnement littoral, 2) trouver un navire en détresse et lui apporter assistance, 3) détecter dans la zone de surveillance un navire intrus se livrant au passage d'immigrants clandestins en direction nord, le long du littoral, et 4) identifier un navire intrus transportant une bombe « sale » en direction sud, le long du littoral. En raison de la nature de cette expérience (étude sur le terrain), les conditions météorologiques ont limité l'analyse des données aux scénarios 1, 3 et 4.
Durant chaque mission, les participants ont reçu des questionnaires sur la connaissance de la situation, la perception de la charge de travail et la confiance en l'automatisation, une heure après le début de l'essai et toutes les heures par la suite, jusqu'à la fin de la mission. Dans le cas des questions sur la connaissance de la situation, sauf celles portant sur la prévision d'événements futurs, les réponses devaient porter sur les travaux de l'heure précédente.
Bien que les données n'aient donné que des résultats peu concluants quant à l'impact de la technologie des UAV sur la connaissance de la situation, elles ont révélé qu'en général la perception de la charge de travail et la confiance en l'automatisation s'amélioraient lorsque la technologie des UAV était intégrée au système de surveillance existant.

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Introduction

The surveillance and protection of Canada's littoral boundaries is a daunting task when one recognizes that the Pacific, Atlantic, and Arctic coastlines are approximately 29,489, 52,000, and 165,000 kilometres in length, respectively. Not only does the length and breadth of these boundaries present specific challenges to the personnel charged with the task of monitoring these areas, but the ability to organize in a coherent manner the quantity of information extracted from these regions is also a daunting challenge. In order to achieve efficient surveillance of the littoral environment, both military and civilian agencies use a variety of sub-surface, surface, air-born, and space-based surveillance technologies to detect and identify all traffic along the coastline. However, despite advances in the capabilities of these technologies to collect, organize, and present this information in a coherent format to surveillance personnel, these personnel must still sift through an enormous amount of information in a timely manner to classify vessels as friendly, hostile, or unknown. Ultimately, the classification of a vessel as friendly, unknown or hostile impacts on what further action against that vessel will occur, which involves costs in terms of money, materials, and labour. For this reason, relationships between situation awareness (SA), workload (WL), and trust in automation (TA), and information processing are an important concern for researchers interested in the study of human performance in complex and dynamic environments. In order to address these concerns, the Canadian Forces (CF) have embarked on an experimentation program designed in part to determine whether the employment and integration of UAVs into the current suite of surveillance technology can improve SA and TA while at the same time decreasing perceptions of WL experienced by surveillance personnel.

Since World War I, researchers and practitioners have come to view SA as critical for accurate decision-making and performance in a variety of work domains such as air traffic control (Endsley & Rogers, 1994), nuclear power plant management (Hogg, Felleso, Strand-Volden, & Torralba, 1995), aviation (Adams, Tenney, & Pew, 1995; Endsley, 1993), and driving (Lee, 1999). Broadly, SA is a cognitive construct that refers to our awareness, knowledge, and understanding of external events in our immediate and future surroundings. It is believed that SA arises from the interaction between information from the external world and the cognitive system (Adams et al., 1995). In addition to examining the validity of Endsley's (2000) framework of SA, the present study sought to examine the relationship between SA and confidence. In general, confidence judgements in our beliefs and knowledge systems play an important role in the decision-making processes that guide our everyday activities (Lichtenstein, Fischoff, & Phillips, 1982; Vickers, 1979). According to Endsley (1995), the level of confidence a person has in their level of SA is an important moderating factor in the relationship between SA and decision-making. For example, air-to-air combat fighters stated that their level of confidence in their SA was an important aspect of engagement, as rules of engagement require a particular level of confidence be achieved before any action (i.e., firing weapons) may be taken (Endsley, 1993).

Researchers have hypothesized that WL, such as the number of aircraft handled by air traffic controllers (Costa, 1993; Kuk, Arnold, & Ritter, 1999; Zeier, 1994), affects cognitive performance by imposing demands on an operator's limited information-processing resources (Gopher & Donchin, 1986; Manzey, Lorenz, & Poljakov, 1998; O'Donnell & Eggemeier, 1986; Rouse, Edwards, & Hammer, 1993; Rueb, Vidulich, & Hassoun, 1992; Wickens & Hollands, 2000). Excessive WL can tax cognitive resources to the point where not enough are available to process all of the information. Accordingly, to cope with reduced cognitive resources, operators may allow performance to degrade within an acceptable limit, or ignore portions of the task altogether (Gopher & Donchin, 1986; O'Donnell & Eggemeier, 1986; Rouse et al., 1993; Wickens & Hollands, 2000). Subsequently, operators may be unable to complete their assigned task or complete the task in a sub-optimal manner, which could place the safety of the operator and others at risk.

More and more, many systems are becoming automated with the result that the human operator's role in these systems is becoming more of a supervisory or passive monitoring role (Muir, 1994). Decisions made by these operators are thus moderated by the quality of the information that is presented to them via these automated systems. Accordingly, it is imperative to understand the relationship between operator and machine to optimize the decision process of persons in these automated work environments (Lewandowsky, Mundy, & Tan, 2000; Muir, 1994; Muir & Moray, 1996). One such element that has been identified as important to this relationship is the trust that the operator has in the technology he is using. The level of trust that an operator has in the technology/automation available to him can affect the degree to which the operator overrides the automation, which can in turn effect the speed and accuracy with which decisions are made.

Recently, the Canadian Forces Experimentation Centre (CFEC) conducted an experiment to examine whether the inclusion of a UAV into the extant suite of surveillance technologies would enhance the detection and integration of vessels along a prescribed area of Canada's Pacific coastline. The purpose of this Technical Memorandum is to present the analyses of the questionnaires that were given to the operators and commanders from the extant and UAV enhanced littoral surveillance groups, respectively, to assess the effect of integrating UAV technology with extant surveillance technology on SA, WL, and TA.

Methods

Participants

A total of 10 individuals participated in this study. Of these personnel, there were seven current and one retired member of the Canadian Navy and two were current members of the Canadian Air Force. The military ranks of the participants ranged from Leading Seaman to Lieutenant Commander. All of the participants were male with an average age of 37.3 years with an average of 16.3 years of military service, and an average of 7.6 years at their current rank. Moreover, all of the participants were experienced with surveillance technologies and procedures with an average of 7.3 years of experience in surveillance operations. The 10 participants comprised control and experimental groups. Each group was sub-divided into analysis and command groups comprised of two and three participants, respectively.

Apparatus and Stimuli

A medium altitude long endurance (MALE) UAV equipped with multiple sensors, which consisted of maritime patrol radar and an Electro-Optical/Infrared (EO/IR) camera, was used in this experiment. The intelligence, surveillance, and reconnaissance (ISR) assets used to build the ordinary recognized maritime picture (ORMP) are classified.

Design and Procedure

The Pacific Littoral Experiment (PLIX) was a live experiment in which a MALE UAV patrolled a littoral environment of approximately 80 square nautical miles near Tofino, British Columbia. The information obtained from the UAV was fused with the ORMP, which is available on a continuous basis from the Operations Support Centre Pacific (OSCP). This fusion of data and information yielded the experimental RMP (XRMP).

At Canadian Forces Base (CFB) Esquimalt, where the control and experimental groups were located, the analysis groups were responsible for processing incoming surveillance data and passing that data onto their respective command groups, who were charged with determining how to prosecute the targets. The control groups accomplished their tasks with the use of the ORMP. The experimental groups carried out their tasks with the XRMP.

Four littoral missions were conducted within PLIX. The aim of mission 1 (four hour duration) was to categorize and identify all contacted targets in the littoral environment. Indeed, this is the basis of all of the scenarios in this study. Subsequent missions simply inserted additional objectives into this task. In mission 2 (one hour duration), the analysts and command personnel were required to find and assist a ship in distress. During mission 3 (four hour duration), the players were required to detect an intruder ship in the surveillance area that was smuggling illegal immigrants in a northerly direction along the littoral environment. In mission 4 (three hour duration), the participants were required to identify an intruder ship carrying a ‘dirty’ bomb in a southerly direction along the littoral environment. In addition, a member of the research team acted as a ‘mole’ and provided members of the intruder ship with information regarding the position of the UAV and deficiencies in the extant ISR system. Because of the nature of the current study (i.e., field study), weather conditions and airspace restrictions dictated the duration of each scenario. Indeed, because of weather conditions and confounds only the data from missions 1, 3, and 4 were analysed and presented in this report.

During each mission, all of the operators received questionnaires pertaining to SA, WL (NASA-TLX, Hart & Staveland, 1988), and TA (see Tables 1, 2, and 3 in the Annex, respectively) one hour after the trial began and every hour thereafter until the end of the mission. For the SA questionnaires, except for those questions pertaining to predictions about future events, each response was to be based on the previous hour’s work. Because the command groups were not required to monitor the incoming surveillance data, the command groups only received the WL and TA questionnaires.

Results

Situation Awareness and Confidence

Unfortunately, the SA and confidence data could not be analyzed for two primary reasons. First, because the experiment was distributed, so too was the data collection. Moreover, the data were collected both manually (i.e., paper and pencil ratings) and automatically (i.e., computer). Accordingly, the data collection and extraction process has been a slow and complex process, and incomplete at the time of the preparation of this paper. Second, a large subset of participants misinterpreted the instructions for the SA questionnaires. For example, rather than report on the number of vessels detected within the hour leading up to the questionnaire, some participants maintained a running tally of how many vessels were detected and identified since the start of the surveillance session. Accordingly, the data could not be analyzed in a meaningful manner that would elucidate the participants' level of SA across experimental conditions. Moreover, because the confidence ratings were based on "incomplete" and incorrect responses, it was inappropriate to analyze and report the confidence data as well. For these reasons, it was not possible to evaluate the responses to the SA questions and accompanying confidence ratings.

Workload

The WL data for each of the scenarios is presented in Table 4 in the Annex. Because of the small number and transient nature of the participants, which at times led to there being only one person in an experimental condition, only a general overview of the mean rating data will be presented in this section. As such, the XRMP group showed lower levels of perceived WL than the ORMP group (21.2% vs. 38.2%). This held true for approximately 77% of the testing contexts. Moreover, in accord with the overall ratings of workload, the XRMP group rated their perceived success as being higher than the ORMP group (66.3% vs. 56.3%).

These findings remained consistent with regard to comparisons of operators from the respective XRMP and ORMP groups. The XRMP group had lower levels of perceived WL than the ORMP group (13.8% vs. 45.1%). This was true for approximately 64% of the testing contexts. Interestingly, overall, the ORMP group rated their perception of success as slightly higher than the XRMP group (65.3% vs. 61.5%). This was true for two of the three missions.

The comparison between the XRMP and ORMP command groups were also consistent with the overall WL analyses even if less compelling. The overall perceived WL of the XRMP group was slightly less than the ORMP group (27.6% vs. 31.2%). These ratings occurred on approximately 54% of the testing contexts. However, the XRMP group provided a higher overall rating of perceived success than the ORMP group (72.1% vs. 47.2%). The XRMP group maintained a higher perception of success across each of the three missions.

Trust in Automation

The TA data for each of the missions is presented in Table 5 (the data for this questionnaire do not represent percentages). For the same reasons offered with the WL data, only a general overview of the TA data will be presented in this section. Overall, the XRMP group provided higher TA ratings than the ORMP group (7.0 vs. 5.8). Moreover, the XRMP group provided higher ratings of TA than the ORMP group on 75% of the testing sessions.

Comparisons between the respective XRMP and ORMP operators were consistent with the findings from the overall TA data insofar as the XRMP group provided higher overall ratings of TA than the ORMP group (6.9 vs. 5.6). This was true for approximately 67% of the testing contexts across the three missions.

The comparisons between the XRMP and ORMP commanders were also consistent with the overall TA data analysis. The XRMP commanders provided a higher mean rating of TA than the ORMP commanders (7.1 vs. 5.9). The XRMP group provided higher ratings of TA on approximately 95% of the testing contexts across the three missions.

Discussion

To reiterate, the purpose of this technical note is to report on and compare the findings from questionnaires pertaining to SA, WL, and TA within extant and UAV enhanced littoral surveillance missions.

The analysis of the WL data revealed that overall the XRMP operators and commanders had lower levels of perceived WL than their counterparts in the ORMP groups. Moreover, the XRMP groups rated their level of success as higher than the ORMP groups. In addition, the XRMP groups provided higher ratings of TA than their counterparts in the ORMP groups. Accordingly, these data indicate that augmenting extant surveillance technology and practice with UAV technology had the positive result of reducing perceived WL and increasing TA, issues which have been shown to be important factors in improving human decision-making.

Interpretation of these findings, however, must be made cautiously because of a number of factors inherent in this experiment. First, although the data from this experiment show that augmenting current surveillance capabilities with UAV technology improves perceived WL and TA, the ground truth data (i.e., the number of vessels detected and identified and the speed with which this was carried) needed to qualify the questionnaire data is missing. Therefore, it is not possible to determine whether these improvements in subjective ratings of perceived WL and TA translate into significant improvements in performance. However, when the ground truth data become available, the WL and TA will be evaluated accordingly.

Second, the small number of participants and the unequal number of participants across experimental groups also limits the interpretation of this data. As shown in Tables 4 and 5, the error data associated with the rating data is substantial. Moreover, in some instances there is only one person for a particular experimental group making it impossible to generate an error score which in turn makes it impossible to perform more in depth analyses of the data. Theoretically, a greater number of observations from a greater number of participants would stabilize the error data. In view of this, even if there were a minimal number of participants in each group, the small "n" associated with this experiment would arguably preclude the appropriateness of performing inferential statistical analyses on this data.

Third, throughout this experiment, environmental factors played an important role in determining when the UAV flights could occur and the duration of these flights. Accordingly, it was impossible to coordinate the timing of these flights with the beginning of the operator shift schedules at CFB Esquimalt. As a result, there were instances where the UAV flight began during the shift of one operator and ended during the shift of a second operator. Consequently, in some instances, it was impossible to collect data for a UAV flight that was derived from an individual who developed a RMP from the start to finish of the flight. Thus, it was impossible in these instances to obtain a true picture of the RMP.

Although these limitations should be considered when interpreting the findings of this experiment, they should in no way overshadow the overall positive aspects of PLIX. Indeed, PLIX was an important venue for studying UAV technology within a littoral environment. Viewed from this perspective, PLIX adds to the successes obtained from Robust Ram and Operation Grizzly (Van Bavel, 2003). Furthermore, the data presented in this Technical Memorandum show an overall trend toward improved TA and decreases in perceived WL when UAV technology is fused with extent surveillance technology. Thus, within this limited context of cognitive human factors experimentation, the data do support the hypothesis that the surveillance of a littoral environment is improved when UAV technology is included in the suite of surveillance tools.

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Annex

Table 1. Situation Awareness and Confidence Questionnaire.

How many targets have been detected? __________
Confidence:

0	10	20	30	40	50	60	70	80	90	100
Certainty of error					Guess			Certainty of correctness		

How many targets have been identified? __________
Confidence:

0	10	20	30	40	50	60	70	80	90	100
Certainty of error					Guess			Certainty of correctness		

How many will be targets will be detected in the next hour?__________
Confidence:

0	10	20	30	40	50	60	70	80	90	100
Certainty of error					Guess			Certainty of correctness		

How many will be targets will be identified in the next hour? _________
Confidence:

0	10	20	30	40	50	60	70	80	90	100
Certainty of error					Guess			Certainty of correctness		

Table 2. Workload Questionnaire.

How much mental and perceptual activity was required?

0	10	20	30	40	50	60	70	80	90	100
Low										High

How much physical activity was required?

0	10	20	30	40	50	60	70	80	90	100
Low										High

How much time pressure did you experience?

0	10	20	30	40	50	60	70	80	90	100
Low										High

How hard did you have to work (mentally & physically) to accomplish your level of performance?

0	10	20	30	40	50	60	70	80	90	100
Low										High

How successful do you think you were in accomplishing the goals of the task?

0	10	20	30	40	50	60	70	80	90	100
Poor										Good

How insecure, discouraged, irritated, stressed and annoyed vs. secure, gratified, content, relaxed and complacent did you feel during the task?

0	10	20	30	40	50	60	70	80	90	100
Low										High

Table 3. Trust in Automation Ratings.

To what extent does the RMP perform its function properly?

0	1	2	3	4	5	6	7	8	9	10
Not at all									Extremely high	

To what extent can the RMP's behaviour be predicted from moment to moment?

0	1	2	3	4	5	6	7	8	9	10
Not at all									Extremely high	

To what extent does the RMP perform the task it was designed to do?

0	1	2	3	4	5	6	7	8	9	10
Not at all									Extremely high	

What is your degree of faith that the RMP will be able to interface with other surveillance systems in the future?

0	1	2	3	4	5	6	7	8	9	10
None at all									Extremely high	

To what extent does the RMP respond to similarly to similar circumstances at different points in time?

0	1	2	3	4	5	6	7	8	9	10
None at all									Extremely high	

To what extent does the UAV respond similarly to similar circumstances at different points in time?

0	1	2	3	4	5	6	7	8	9	10
None at all									Extremely high	

What is your degree of trust in the RMP to respond accurately?

0	1	2	3	4	5	6	7	8	9	10
None at all									Extremely high	

What is your degree of trust in the RMP's display?

0	1	2	3	4	5	6	7	8	9	10
None at all									Extremely high	

What is your overall degree of trust in the RMP?

0	1	2	3	4	5	6	7	8	9	10
None at all									Extremely high	

Table 4

NASA-TLX RATINGS

Perceived Mental Effort

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Participants	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	20	-	1	30	-	1	40	-	1	20	-	1	80	-	1	80	-	1	90	-	1	90	-	1	40	-	1	10	-	1	20	-
XRMP	2	45	15	2	45	5	2	40	20	2	25	5	2	5	5	1	20	-	1	10	-	1	10	-	1	10	-	1	40	-	1	30	-
OCOM	2	20	0	2	25	5	2	30	10	1	20	-	3	53	15	1	20	-	1	10	-	1	20	-	2	50	30	2	50	30	2	45	25
XCOM	2	50	10	2	45	15	2	55	15	2	50	20	3	63	12	3	46	13	2	55	5	2	40	10	3	53	12	3	46	8	3	43	6

Perceived Time Pressure

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Participants	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	30	-	1	20	-	1	40	-	1	50	-	1	70	-	1	80	-	1	90	-	1	80	-	1	10	-	1	10	-	1	20	-
XRMP	2	5	5	2	5	5	2	10	10	2	10	10	2	0	0	1	0	-	1	0	-	1	20	-	1	0	-	1	0	-	1	10	-
OCOM	2	20	0	2	20	0	2	20	0	1	20	-	3	36	12	1	10	-	1	10	-	1	10	-	2	30	20	2	30	20	2	25	15
XCOM	2	10	0	2	15	5	2	15	5	2	20	10	3	43	8	3	23	8	2	15	5	2	10	0	3	10	0	3	20	0	3	23	3

Perceived Physical Effort

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Participants	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	0	-	1	0	-	1	0	-	1	0	-	1	90	-	1	80	-	1	100	-	1	90	-	1	30	-	1	10	-	1	20	-
XRMP	2	10	0	2	25	15	2	15	5	2	15	5	2	0	0	1	10	-	1	0	-	1	0	-	1	0	-	1	10	-	1	0	-
OCOM	2	15	5	2	15	5	2	25	15	1	10	-	3	30	20	1	10	-	1	10	-	1	10	-	2	45	35	2	40	30	2	20	10
XCOM	2	10	0	2	10	0	2	30	20	2	35	25	3	30	15	3	16	3	2	15	5	2	10	0	3	13	3	3	26	12	3	23	13

Perceived Mental and Physical Effort

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Participants	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	10	-	1	30	-	1	20	-	1	40	-	1	90	-	1	90	-	1	100	-	1	90	-	1	40	-	1	40	-	1	30	-
XRMP	2	35	15	2	35	15	2	30	10	2	20	0	2	5	5	1	20	-	1	0	-	1	20	-	1	30	-	1	10	-	1	30	-
OCOM	2	15	5	2	20	0	2	20	10	1	20	-	3	40	15	1	20	-	1	20	-	1	30	-	2	55	35	2	45	35	2	35	15
XCOM	2	35	5	2	30	20	2	40	0	2	50	20	3	56	8	3	40	4	2	45	5	2	35	5	3	36	8	3	43	6	3	43	12

Perceived Frustration

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Participants	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	10	-	1	60	-	1	70	-	1	70	-	1	80	-	1	90	-	1	90	-	1	90	-	1	10	-	1	10	-	1	20	-

XRMP	2	0	0	2	0	0	2	5	5	2	10	10	2	0	0	1	0	-	1	0	-	1	40	-	1	0	-	1	0	-	1	20	-
OCOM	2	35	35	2	40	30	2	45	35	1	70	-	3	20	12	1	70	-	1	70	-	1	70	-	2	55	15	2	50	20	2	40	30
XCOM	2	5	5	2	15	5	2	15	5	2	25	5	3	16	3	3	10	0	2	10	0	2	40	30	3	20	10	3	26	6	3	26	8

Perceived Success

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Participants	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	70	-	1	30	-	1	30	-	1	40	-	1	90	-	1	90	-	1	80	-	1	60	-	1	100	-	1	100	-	1	20	-
XRMP	2	80	0	2	75	5	2	75	5	2	70	0	2	75	25	1	50	-	1	50	-	1	50	-	1	50	-	1	60	-	1	50	-
OCOM	2	35	25	2	45	15	2	50	30	1	20	-	3	80	5	1	30	-	1	40	-	1	40	-	2	55	25	2	60	20	2	55	25
XCOM	2	90	10	2	70	10	2	65	5	2	65	15	3	73	3	3	76	6	2	75	5	2	65	5	3	80	0	3	73	3	3	53	16

N = Number of participants
M = Mean rating
E = Standard error

Table 5

TRUST IN AUTOMATION RATINGS

To what extent does the surveillance systems perform is function properly?

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Groups	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	4	-	1	3	-	1	2	-	1	3	-	1	5	-	1	8	-	1	5	-	1	5	-	1	8	-	1	9	-	1	9	-
XRMP	2	7	0	2	8.5	.5	2	6	2	2	8	0	2	7.5	2.1	1	7	-	1	6	-	1	6	-	1	7	-	1	6	-	1	7	-
OCOM	2	5.5	2.5	2	6.5	1.5	2	6.5	1.5	1	5	-	3	7	1	1	5	-	1	5	-	1	5	-	2	6.5	1.5	2	6.5	1.5	2	6	2
XCOM	2	7.5	.5	2	7.5	.5	2	6	0	2	5.5	.5	3	7.6	.57	3	8.3	1.2	2	8	1.4	2	6	1.4	3	8	.58	3	7.6	.67	3	7.3	.88

To what extent can the operating picture be predicted from moment to moment?

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Groups	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	3	-	1	3	-	1	4	-	1	3	-	1	5	-	1	7	-	1	5	-	1	5	-	1	9	-	1	8	-	1	8	-
XRMP	2	6.5	.5	2	8.5	.5	2	8.5	.5	2	8	0	2	8	1.4	1	7	-	1	5	-	1	5	-	1	7	-	1	6	-	1	6	-
OCOM	2	5	2	2	7	1	2	6.5	2.5	1	6	-	3	6.6	1.5	1	5	-	1	5	-	1	5	-	2	7	1	2	6	1	2	6	1
XCOM	2	7.5	.5	2	8	0	2	6	0	2	6	1	3	6.3	2.1	3	7.3	1.5	2	8	1.4	2	5	1.4	3	7.3	.88	3	7	.58	3	7.3	.88

To what extent does the operating picture perform the task it was designed to do?

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Groups	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	4	-	1	4	-	1	3	-	1	4	-	1	6	-	1	8	-	1	6	-	1	5	-	1	8	-	1	7	-	1	7	-
XRMP	2	7	0	2	8	0	2	8	0	2	8.5	.5	2	7	1.4	1	7	-	1	5	-	1	5	-	1	9	-	1	9	-	1	9	-
OCOM	2	6.5	1.5	2	6.5	1.5	2	7	2	1	6	-	3	7	1	1	4	-	1	4	-	1	5	-	2	6	1	2	7	1	2	6	1
XCOM	2	8	1	2	8	0	2	5.5	.5	2	7	1	3	6	2.6	3	7	2	2	8	1.4	2	5.5	2.1	3	7.3	.88	3	7.6	.67	3	7	1.2

What is your degree of faith that the operating picture will be able to interface with other surveillance systems in the future?

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Groups	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	7	-	1	6	-	1	2	-	1	2	-	1	5	-	1	9	-	1	9	-	1	5	-	1	9	-	1	8	-	1	9	-
XRMP	2	8.5	.5	2	9	1	2	9	1	2	8	0	2	5	0	1	7	-	1	8	-	1	5	-	1	8	-	1	8	-	1	7	-
OCOM	2	7.5	.5	2	7	1	2	7.5	1.5	1	6	-	3	7	1	1	6	-	1	6	-	1	6	-	2	6.5	1.5	2	6.5	1.5	2	6.5	1.5
XCOM	2	9	0	2	8.5	1.5	2	7	1	2	7.5	1.5	3	8	1.73	3	7.6	.67	2	8	1	2	6.5	.5	3	7.3	.88	3	8.3	.88	3	8	.58

To what extent does the operating picture respond similarly to similar circumstances at different points in time?

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Groups	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	5	-	1	3	-	1	2	-	1	3	-	1	6	-	1	7	-	1	5	-	1	5	-	1	7	-	1	8	-	1	8	-
XRMP	2	5	0	2	8.5	1.5	2	8	1	2	8	0	2	5.5	.5	1	6	-	1	7	-	1	6	-	1	7	-	1	7	-	1	6	-
OCOM	2	6.5	1.5	2	6.5	1.5	2	7.5	1.5	1	5	-	3	6.6	.88	1	5	-	1	5	-	1	5	-	2	6	2	2	6	1	2	5.5	1.5
XCOM	2	6.5	1.5	2	7.5	2.5	2	5	0	2	6.5	1.5	3	6.3	1.33	3	6.3	1.33	2	7	2	2	5	0	3	6.3	1.3	3	6	1	3	6.3	1.3

What is your degree of trust in the operating picture to respond accurately?

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Groups	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	4	-	1	3	-	1	1	-	1	2	-	1	5	-	1	6	-	1	5	-	1	5	-	1	8	-	1	8	-	1	8	-
XRMP	2	8	1	2	6	2	2	7.5	.5	2	8	1	2	6	1	1	7	-	1	6	-	1	6	-	1	7	-	1	6	-	1	6	-
OCOM	2	5.5	2.5	2	7.5	1.5	2	1.5	1.5	1	6	-	3	7	.58	1	5	-	1	5	-	1	5	-	2	6	2	2	6	1	2	6.5	1.5
XCOM	2	7.5	.5	2	8	1	2	6.5	.5	2	7	2	3	7.3	.88	3	7.3	.88	2	8	1	2	5	2	3	7.3	.88	3	7.3	.88	3	7	.58

What is your degree of trust in the operating picture's display?

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Groups	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	4	-	1	3	-	1	2	-	1	2	-	1	5	-	1	6	-	1	5	-	1	5	-	1	8	-	1	8	-	1	9	-
XRMP	2	9	0	2	8	0	2	8	1	2	7.5	.5	2	5.5	1.5	1	6	-	1	6	-	1	6	-	1	7	-	1	6	-	1	5	-
OCOM	2	5.5	2.5	2	6.5	1.5	2	7.5	1.5	1	5	-	3	6.7	.88	1	6	-	1	5	-	1	6	-	2	6.5	1.5	2	6	1	2	6.5	1.5
XCOM	2	8.5	.5	2	7.5	.5	2	6.5	.5	2	7.5	1.5	3	7.3	.88	3	7.3	.88	2	8	1	2	5	2	3	7.3	.88	3	7	.58	3	7.3	.88

What is your overall degree of trust in the operating picture?

	Scenario 1												Scenario 2												Scenario 3								
	Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3			Hour 4			Hour 1			Hour 2			Hour 3		
Groups	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E	N	M	E
ORMP	1	5	-	1	2	-	1	2	-	1	2	-	1	5	-	1	5	-	1	5	-	1	5	-	1	8	-	1	8	-	1	9	-
XRMP	2	7.5	.5	2	7	0	2	7.5	.5	2	7.5	.5	2	5.5	1.5	1	7	-	1	5	-	1	5	-	1	8	-	1	6	-	1	5	-
OCOM	2	5.5	2.5	2	6.5	1.5	2	7	2	1	4	-	3	7	.58	1	5	-	1	5	-	1	5	-	2	6.5	1.5	2	7	1	2	7	1
XCOM	2	8.5	.5	2	8	1	2	7	1	2	7	2	3	7.6	1.2	3	7.3	.88	2	8	1	2	5	2	3	7.3	.88	3	7.3	.88	3	7.3	.88

N = Number of participants
M = Mean rating
E = Standard error

List of symbols/abbreviations/acronyms/initialisms

CF	Canadian Forces
CFB	Canadian Forces Base
EO/IR	Electro-Optical/Infrared
ISR	Intelligence, Surveillance, & Reconnaissance
MALE	Medium Altitude Long Endurance
OCOM	Ordinary Recognized Maritime Picture Commander
ORMP	Ordinary Recognized Maritime Picture
OSCP	Operation Support Centre Pacific
PLIX	Pacific Littoral Experiment
SA	Situation Awareness
TA	Trust in Automation
UAV	Uninhabited Aerial Vehicle
WL	Workload
XCOM	Experimental Recognized Maritime Picture Commander
XRMP	Experimental Recognized Maritime Picture

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(U) The Canadian Forces Experimentation Center (CFEC) conducted an experiment to examine whether the inclusion of a UAV into the current suite of surveillance technologies would improve the detection and integraton of vessels along a prescribed area of Canada's Pacific coastline. A sub−goal of this experiment, the results of which are presented in the present technical note, was to examine and compare the situation awareness, perceived workload, and ratings of trust in automation amongst surveillance technology. Although the data yielded inconclusive results with regard to the impact of UAV technology on situation awareness, in general, the data revealed that perceived workload and trust in automation are improved when UAV technology is integrated into the extant surveillance system.

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