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TITLE

Integration of a Direct Voice Input System into the Aircraft Crewstation Demonstrator

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INTEGRATION OF A DIRECT VOICE INPUT SYSTEM INTO THE AIRCRAFT CREWSTATION DEMONSTRATOR

FINAL REPORT

22 September 1999

Contract Serial No. W7711-7-7397/001/SRV

Prepared by

CANADIAN MARCONI COMPANY

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MARCONI CANADA

INTEGRATION OF A DIRECT VOICE INPUT SYSTEM INTO THE AIRCRAFT CREWSTATION DEMONSTRATOR

FINAL REPORT

22 September 1999

CMC Document Number 1000-1193
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REVISION PAGE

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SECTION ONE - INTRODUCTION

1.1 BACKGROUND

The navigation and communication Control Display Unit (**CDU**) of the Canadian Forces Utility Tactical Transport Helicopter (**UTTH**), the CH146 Griffon, has been identified as a critical system component. The CDU has a computer-like interface with multiple screens, multi-function "soft keys" and a custom-designed keyboard. The pilot uses the CDU interface to enter and modify mission data, including communication and navigation functions.

Following the identification of numerous problems with operation of the CDU, the Systems Modelling group at the Defence and Civil Institute of Environmental Medicine (**DCIEM**) was requested to assist the CH146 Software User Advisory Group to study and correct these problems.

A Direct Voice Input (**DVI**) control experiment aimed at basic CDU communications functions has been previously developed by Canadian Marconi Company (**CMC**) under contract to Chief, Research And Development (**CRAD**). The DVI-controlled CDU was flight trialed in the National Research Council (**NRC**) Flight Research Laboratories (**FRL**) Bell 412 helicopter using Department of National Defence (**DND**) helicopter pilots as test subjects. The informal feedback was positive and indicated strong potential for the use of DVI in DND aircraft. It was recognized that this new technology requires rigorous evaluation to determine the degree to which it might address deficiencies associated with the UTTH CDU.

It was proposed that a capability to control the DCIEM Aircraft Crewstation Demonstrator (**ACD**) CDUs using DVI be developed in order that tests and evaluations of DVI may be performed in a realistic workload environment. The ACD is an ideal facility to carry out this research in a cost-effective manner. The ACD may be configured to represent the CH146 Griffon flight deck complete with virtual CDUs. The ACD also permits establishment of a realistic test environment in which typical in-flight tasks for the Griffon may be duplicated, and the impact of DVI on workload and task completion may be assessed.

On March 9, 1998, CMC was awarded a contract for the integration of a DVI system into the ACD based on the Statement of Work for Direct Voice Input for the Control Display Unit, Annex A to Contract W7711-7-7397/001/SRV, 6 March 1998 [Reference 1].

1.2 AIM

The aim of the project was to integrate a DVI system into the DCIEM ACD and to deliver a similar system to the ACD run by the Directorate of Technical Airworthiness (**DTA**).

1.3 OBJECTIVES

The specific objectives of the contract were to:

a. determine user requirements for the DVI system;

b. design the DVI/ACD configuration;

c. develop communication voice commands sets for use with the CH146 Griffon CDU. One command set will mimic the CDU key selection process, and a second command set will be based on a protocol presently being designed by DCIEM;

d. provide hardware and software specifications of potential DVI systems with vendors and costs;

e. procure the DVI hardware and software items;

f. attend a training course for the selected DVI system with one DCIEM representative;

g. integrate the DVI hardware and software into the ACD;

h. test and evaluate the overall system at the contractor's facility;

i. install, set-to-work, and demonstrate the DVI system at DCIEM; and

j. prepare reports summarizing all activities performed during the contract and all possible activities that may be explored at a future date in connection with these activities.

1.4 SCOPE

The DVI system was required to function effectively in the high and variable noise environment of the CH146 helicopter. It was highly desirable that the system be easy to program and operate. A simple voice training facility was also required.

The vocabulary to be used was to be supplied by DCIEM based on the previous DVI trials and the requirements of the future DCIEM trials. Two sets of vocabulary were to be developed; one which exactly emulated CDU keypresses, and one which achieved the same functionality as the first, but which took advantage of DVI capabilities to bypass menu structures and address the required functionality directly.

SECTION TWO - PROJECT ACTIVITIES

2.1 GENERAL

The project involved the following discrete activities:

a. determination of user requirements;
b. DVI/ACD system configuration design;
c. development of "keyset" and "syntax" voice command sets;
d. equipment procurement;
e. training;
f. integration of DVI into ACD;
g. test and evaluation;
h. system installation at DCIEM; and
i. project documentation.

Each activity is briefly described in the following subsections.

2.2 DVI SYSTEM USER REQUIREMENTS

User requirements determined for the purposes of the project consisted of:

a. functionality to be controlled using DVI;
b. vocabulary to be used;
c. suitability for high noise environment;
d. feedback; and
e. headgear.

DVI system user requirements were not formally determined for this project in the sense of conducting a human factors engineering analysis of the mission, functions and tasks in accordance with MIL-HDBK-46855. Instead, the scope of the planned trials was confined to control of communication functions of the CDU. This level of functionality was similar to that used for the previous voice recognition demonstration developed by CMC and the NRC and flown at FRL. User requirements for control were then determined subjectively based on the functionality available for control, guidance from DCIEM about the intended experimental design, and previous experience in the application of DVI in this environment. A future effort should include a thorough examination of the Griffon mission to determine the user requirements most appropriately addressed through use of DVI.

Previous DVI work had highlighted the importance of using a well-structured vocabulary, achieving high recognition rates, and implementing effective audio and visual feedback. An intuitive and well-structured vocabulary protocol was required to achieve high recognition performance while providing flexibility to accommodate user variances. High recognition performance in the noisy environment associated with a helicopter was also a prime consideration for the selection of the DVI system. A versatile output from the DVI system was required to ensure flexibility in the provision of feedback to the operators to ensure that they were continually aware of the success of their commands and the status of the DVI system.

For the experiment in the ACD, the use of a light headset with a boom microphone was considered satisfactory. Although the Griffin crews use helmets and voice-activated microphones, accommodating these features was not considered essential for the conduct of the trial.

2.3 DVI/ACD SYSTEM CONFIGURATION

The DVI/ACD system configuration (Figure 2-1) was developed with the goal of minimizing changes to the ACD CDU hardware and software as a result of the inclusion of the DVI software. The DVI acts as a standalone, modular subsystem to the ACD. The DVI software module is embedded in the ACD runtime software, and may be activated when DVI is required to be connected to the ACD. If the DVI module is not activated, its presence is transparent to the operation of the ACD.

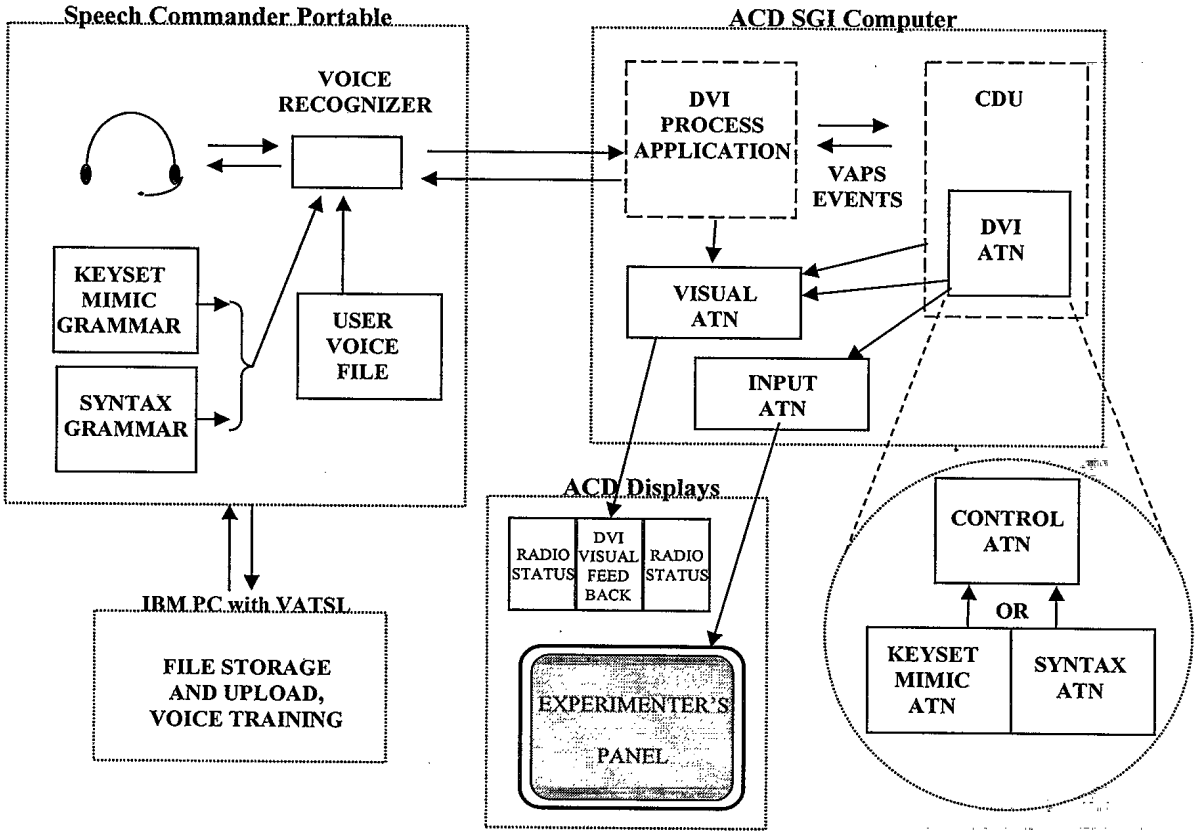

Figure 2-1 DVI System Configuration

The portable DVI unit (Speech Commander Portable) holds the recognition and voice files required for DVI operation and connects directly to the ACD for that purpose. Only one voice file may be loaded on the portable DVI unit at a time. This limitation will need to be overcome for an effective installation in a multi-crew aircraft. The portable unit is disconnected from the ACD and connected to the IBM Personal Computer (**PC**) for library uploads and downloads, development work or voice recognition training.

The IBM PC, with the Verbex Voice Systems, Inc.(**VATSL**) speech recognition card installed, is a standalone DVI system which may be used for development and voice training while the Speech Commander Portable unit is being used with the ACD. It also acts as a depository for all user voice files and grammar files to be uploaded to the portable unit.

When operating the DVI system with the ACD, the grammar file and the user voice file must be loaded on the Speech Commander Portable as recognizer (.rec) and voice (.voi) files. The user utters the command through the headset microphone and the Speech Commander Portable compares the command with the voice file looking for a match. If a match is found the speech commander uses the associated grammar to search the grammar files for a match. Again if a match is found the appropriate output (display, host or voice response) associated with the grammar or word is sent from the Speech Commander Portable to the DVI Process Application in the ACD Silicon Graphics International (**SGI**) computer. The DVI Process Application compares the Speech Commander output to a lookup table and generates the appropriate Virtual APplicationS Builder (**VAPS**) event(s). The VAPS events are in turn sent to the CDU DVI Augmented Transition Network.

Operator feedback is provided by both visual and audio means. Control is provided over the extent of the feedback. Visual feedback is provided to the operator in a display at the top of the instrument panel. The feedback always indicates whether the system is listening for voice commands. Visual feedback of the actual commands and the present configuration of the radios may also be enabled (Visual feedback reflecting the result of the voice command is also available on the CDU with a change in the appropriate status indication).

Audio feedback is also available to the user upon selection. Audio feedback is provided in the form of tones and verbal messages. The synthetic tones are provided directly from the DVI system. The verbal messages are digitized recordings of a female voice. The feedback responses are identified by "tags" and associated with a specific utterance for a voice response. The voice and audio tone responses may be initiated within the DVI system or by the host SGI computer.

Complete details of the DVI configuration and operation are provided in the DVI/ACD User Manual Supplement [Reference 2].

2.4 DVI VOCABULARIES

Vocabularies are the spoken words or utterances which the user wants the DVI system to recognize, as well as to generate events to drive or control an external or host system. Utterances should be selected carefully in order to avoid confusing the recognizer by having utterances which are very close to the same. Where possible, key words which cue the DVI system to accept only specific utterances is a desired approach which will yield a much higher recognition performance, as well as reducing utterance recognition time.

Two primary vocabulary protocols were developed, tested and evaluated based singularly on the requirements and in support of the DCIEM experiment. Their names are Keyset and Syntax. Each is described briefly in the following subsections.

2.4.1 CDU Keyset Vocabulary

The mimicking of the keyset selections used to control the communications was the first vocabulary developed. This vocabulary mimicks the keyset labels on each of the pages of the communications control pages of the CDU. The verbal response by DVI is a repeat of the user command as a confirmation that the command (utterance) was recognized correctly by DVI. No shortcuts or syntax utterances were used to ensure faithful mimicking of the user keystrokes. Only those commands required to fulfill the requirements of communication control for the DCIEM scenario were developed. Once developed and tested, this protocol required no further evaluation or development due to the strict nature of the protocol. As requested by DCIEM, the deliverable was restricted to the Communications Summary Page voice controls options. The ability to include or exclude specific voice inputs from supplementary CDU communication control pages (which were created in the initial development effort) was provided in the User Manual Supplement [Reference 2] soft copy deliverable as commented-out lines in the grammar file.

2.4.2 CDU Syntax Vocabulary

The second vocabulary protocol developed was the syntax protocol based on the vocabulary provided by DCIEM. This protocol was developed to be intuitive and reflect the mental model of the user community with regards to communication control. Compromises were required to satisfy the requirements of achieving the optimum application vocabulary for the DVI and achieving the best utterance recognition. A "free talk" protocol was found impractical, as the size of the grammar file to be searched for each word incurred poor recognition as well as a slow response time. A structured approach minimizing the vocabulary, but having variables to permit some flexibility, drastically improved recognition in a noisy environment and reduced response time. As requested by DCIEM, the deliverable was restricted to the Communications Summary Page voice controls options. As stated above, the ability to include or exclude specific voice inputs from supplementary CDU communication control pages were included in Reference 2.

2.5 EQUIPMENT PROCUREMENT

The required equipment consisted of commercially available Verbex Speech Commander Portable control units, IBM PCs installed with a Verbex VATSL voice card and Verbex software, and technical manuals. The equipment was acquired from Sure Control Systems in Toronto, and was tailored to meet the requirements of the DCIEM and DTA ACD operating environments. Each system consisted of one PC with voice card and two Speech Commander Portable units. The equipment was accepted at CMC in Kanata where it was assembled, integrated with the ACD and functionally checked. Following the functional check-out one set of equipment was shipped to DCIEM and integrated with the DCIEM ACD.

2.6 TRAINING

Training courses were provided at Sure Control Systems in Toronto for two CMC and two DND representatives. The training was conducted successfully in accordance with the

requirements of the contract. In addition, both Sure Control Systems and Verbex provided help line support in answering questions and resolving development issues during the course of the project.

2.7 INTEGRATION OF DVI IN THE ACD

The operation and control of the DVI in the ACD is managed through DVI specific controls and displays on the ACD experimenter's panel. The experimenter's panel is available to the controller at all times during the operation of the ACD. The following DVI controls and displays are available on the experimenter's panel:

a. DVI timeout control and display;
b. 1667 Hz tone selection;
c. time-stamped event readout;
d. audio feedback control;
e. visual feedback control;
f. data collection control;
g. syntax vocabulary display; and
h. keyset vocabulary display.

A detailed description of all the controls and displays is provided in the User's Manual.

2.8 TEST AND EVALUATION

Test and evaluation activities were undertaken to establish the robustness of the system, a methodology for file management, and effective strategies for voice training. Procedural recommendations emerging from the test and evaluation activities were reported in detail in the User Manual.

2.9 SYSTEM INSTALLATION AT DCIEM

Following successful establishment of the DVI capability in the ACD run by the Directorate of Technical Airworthiness at CMC Kanata, CMC personnel installed an identical capability in the DCIEM ACD, and provided an introductory technical course to train DCIEM personnel on use of the system. The installation was completed successfully during a two-day deployment to DCIEM.

2.10 PROJECT DOCUMENTATION

The primary project documentation is CMC document number1000-1165, Integration of a Direct Voice Input System into the Aircraft Crewstation Demonstrator, User Manual Supplement, dated 23 June 1998 [Reference 2]. The project documentation is completed with this Final Report.

SECTION THREE - RESULTS AND DISCUSSION

The project objectives were successfully accomplished within the scope of the project guidelines. Provision of the User Manual will enable independent experimentation with the DVI facility by DCIEM personnel in accomplishing the overall objectives of introducing an effective DVI capability into the Griffon helicopter fleet. Since the voice control requirements were restricted to control of communication functions of the CDU, the experimental environment did not represent an optimized interface for an operational application. In the field additional functionality would be required, for example, control of navigation systems should be added. A future effort should include a thorough examination of the Griffon mission to determine the user requirements most appropriately addressed through the use of DVI.

Numerous operator interface issues and deficiencies with the Verbex DVI package were identified. These deficiencies caused errors in the programming and file management of the DVI system, and were a source of frustration particularly to inexperienced staff performing the experiments. Explanatory notes were provided with the User Manual to help alleviate the difficulties caused by these deficiencies. In future implementations, an enhanced Graphical User Interface (**GUI**) could significantly improve the file management, system control and voice training aspects of the system. This will be a significant step in achieving acceptance by the staff conducting experiments on the DVI control concept.

SECTION FOUR - CONCLUSIONS AND RECOMMENDATIONS

It is concluded that the objectives of the project were successfully accomplished. Technical deficiencies complicated the operation of the system leading to errors and operator dissatisfaction. An improved GUI could significantly enhance operation of the system and ultimately user acceptance of the DVI concept.

It is recommended that a future DVI effort be directed towards improvement of the DVI experiment GUI for the system, addressing in particular voice training techniques, system control and file management.

SECTION FIVE – REFERENCES

1. Statement of Work for Direct Voice Input for the Control Display Unit, Annex A to Contract W7711-7-7397/001/SRV, 6 March 1998.

2. Integration of a Direct Voice Input System into the Aircraft Crewstation Demonstrator, User Manual Supplement, CMC Document Number 1000-1165, 23 June 1998.

ANNEX A

GLOSSARY OF TERMS AND ACRONYMS

ANNEX A - GLOSSARY OF TERMS AND ACRONYMS

ACD	Aircraft Crewstation Demonstrator
CDU	Control Display Unit
CF	Canadian Forces
CMC	Canadian Marconi Company
CRAD	Chief, Research And Development
DCIEM	Defence and Civil Institute of Environmental Medicine
DND	Department of National Defence
DTA	Directorate of Technical Airworthiness
DVI	Direct Voice Input
FRL	Flight Research Laboratory
GUI	Graphical User Interface
Hz	Hertz
MIL-HDBK	MILitary HanDBooK
NRC	National Research Council
PC	Personal Computer
SGI	Silicon Graphics International
UTTH	Utility Tactical Transport Helicopter
VAPS	Virtual APplicationS Builder
VATSL	Verbex Voice Systems, Inc.

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