CF-188 ACD Final Configuration for HMD Study

Software Directory Architecture

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Call Up Against Standing Offer W7711-8-7465/01/SRV
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On behalf of
DEPARTMENT OF NATIONAL DEFENCE

Defence R&D Canada - Toronto

Contract Report

DRDC Toronto CR 2002-107

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7 June 2002

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EXECUTIVE SUMMARY

This report is prepared in support of the CF-188 Related Aircraft Crewstation Demonstrator (**ACD**) Upgrade and is the result of the work conducted at location for the Defense Research and Development Canada, Toronto (**DRDC-Toronto**). The specific objectives of the Call-Up against the Standing Offer, as a whole, were to adapt the DRDC-Toronto simulation components and to integrate software in the overall architecture of the ACD. It is understood that this work is intended to support the specific requirements of DRCD-Toronto's experimental design requirements, in order to further support the Department of National Defence's (**DND**) potential selection a Joint Helmet Mounted Cueing System (**JHMCS**) or Next Generation Helmet (**NGH**).

REVISION PAGE

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SECTION ONE – INTRODUCTION

1.1 GENERAL

DRDC-Toronto entered into a contract with CMC Electronics Inc. (**CMC**) to support the integration of the ACD for the current experiment; that is, threat detection and target identification, including weapon release, during a simulated abbreviated Air-To-Surface (**AST**) mission profile. CMC technical personnel performed all work at DRDC-Toronto's Synthetic Environment Research Facility (**SERF**) under the direction of DRDC-Toronto's Scientific Authority (**SA**).

1.2 BACKGROUND

The Human Systems Modelling Group (HSMG) of the Simulation and Modelling for Acquisition, Rehearsal, and Training (**SMART**) Section of DRDC-Toronto is advising DND's Directorate of Aerospace Requirements (**DAR**), Fighters and Trainers (**DAR 5**), on the relative advantages of two competing HMD systems for their procurement as part of the CF-188 Incremental Modernization Program (**IMP**). The two Helmet Mounted Displays (HMD) under consideration are the Joint Helmet Mounted Displays (**HMD**) under consideration are the JHMCS and the NGH. Each system differs in its ability to display Forward Looking InfraRed (**FLIR**) imagery and night vision capability. The NGH is capable of displaying FLIR imagery on the visor and has an integrated night vision capability that uses a low-light level camera mounted in the helmet. In contrast, the JHMCS cannot display FLIR imagery and does not have an integrated night vision capability. DAR 5 believes that these differences will influence the amount of heads-up time (head looking out of the cockpit) pilots have during mission execution and, consequently, will contribute to different levels of Situation Awareness (**SA**), workload and performance.

On 22 February 2002, a Call-Up against the Standing Offer was issued by Public Works and Government Services Canada (**PWGSC**) to CMC, to assist in the integration of completed ACD components and to finalize certain components nearing completion. This work was performed over a period of three calendar months, during a series of three technician visits to DRDC-Toronto's SERF facility, based on the status of Government Furnished Equipment (**GFE**).

1.3 PURPOSE

The purpose of this report, as directed by the SA, is to define the directory architecture of the different software components of the ACD. The following three systems are used an ONYX 3200, an Octane and 5 PCs (4 XP and 1 Windows 2000 operating systems) to host the different software components.

1.4 WORK PERFORMED

In accordance with the Statement of Work, and as further directed by the DRDC-Toronto SA, the following work was performed on the ACD:

1.4.1 Threat generation was implemented on the Out the Window (**OTW**) scene. Five PCs host the VEGA file that includes Cold Lake Air Weapons Range (**CLAWR**) terrain database and the threat object (each represented by a large white sphere);

1.4.2 The FLSIM frequency rate was optimized;

1.4.3 The HMD symbology was integrated and optimized;

1.4.4 The FLIR image and symbology was adjusted for colour, location and brightness;

1.4.5 The Town Generation was tested;

1.4.6 A second threat (180 degree azimuth difference from the first generated threat) was implemented;

1.4.7 The ACD Controls integration was updated;

1.4.8 A software mask was developed to simulate the JHMCS and the NGH views;

1.4.9 The heading, pitch and roll of the aircraft were corrected;

1.4.10 The threat was fixed to the ownship;

1.4.11 A start-up script was written to call up all the executables sequentially using one command;

1.4.12 The HUD symbology was optimized, such as the waterline and pitch;

1.4.13 A control was implemented to be used as an event trigger for threat detection and recording;

1.4.14 A press-to-talk button was implemented for the appearance and disappearance of the FLIR from the NGH condition;

1.4.15 A display was implemented for the FLIR on the DDI display during JHMCS mode;

1.4.16 Data collection was optimized; and

1.4.17 A target designation function was implemented.

ANNEX A
SOFTWARE DIRECTORY ARCHITECTURE

ANNEX A – SOFTWARE DIRECTORY ARCHITECTURE

1. GENERAL

This Annex describes the Software Directory Architecture of the CF-188 ACD upgrade simulator.

2. ACD CONFIGURATION

The ACD is driven by a workstation local area network containing one ONYX 3200 computer, one SGI OCTANE computer and five PC computers, utilizing Windows XP and Windows 2000 Operating systems to host the different software components. The ONYX computer hosts the simulation controller software necessary to produce the most aspects of the simulation environment. The ONYX hosts the OTW scene on the HMD, the FLIR imagery and associated symbology, and the Heads Up Display (**HUD**) simulation (includes essential performance and controls instruments and necessary weapon/aiming/navigation symbology). The SGI OCTANE computer hosts the FLSIM (aerodynamic flight model) for the ACD, and the router for data management. The PCs host the software necessary to produce the OTW scene and threats, rearward projected onto their respective approximate four feet by six feet panel screens.

The simulator physical layout includes a CF-188 Part Task Trainer (**PTT**) cockpit shell configured with Active Matrix Liquid Crystal Displays (**AMLCD**) inset into the forward instrument panel, as per the currently CF-18A arrangement, to represent the Digital Display Indicators (**DDI**). The other fully functioning parts of the PTT include the throttle quadrant, the landing gear control panel, the control stick and rudder pedals, and the Hands On Throttle and Stick (**HOTAS**), as modified to accommodate the evaluation equipment suite, sensors, display formats and functionality. The display push tiles, themselves, have no function; nor does the Up Front Controller (**UFC**). All other side panel switches and side consoles are represented exactly as per the current CF-18A configuration, but have no function beyond the ability to move switches. The HUD, normally represented by a combining glass positioned on the top of the forward instrument panel, is not represented. Finally, a Head Tracker is mounted on the back of a Kaiser SimEye XL 100 HMD, to read the head position data.

Each ACD computer employs a start-up script that starts all the software executables sequentially. The main communication protocol between computers hosting the different software is the UDP protocol.

Two modes of HMD are simulated: the NGH and the JHMCS. The JHMCS employs an approximate 40 degree circular Field of View (**FOV**), with the HUD simulation centered in the FOV. The NGH employs a rectangular FOV with the HUD simulation centered and the FLIR simulation displayed in the top right corner of the FOV.

The simulation is configured as follows:

a. five viewable panel screens are positioned to provide a representation of a near-360 FOV outside the cockpit (for target and threat detection);
b. one DDI displays the FLIR simulation imagery and associated symbology when in JHMCS mode;

c. the HMD displays the OTW scene, the FLIR imagery and associated symbology, and the symbology associated with HUD simulation when in NGH mode; and
d. the HMD displays the OTW scene and the symbology associated with HUD simulation when in JHMCS mode.

3. SOFTWARE DIRECTORY STRUCTURE

SIM12 (ONYX)

THE SOURCE FILES AND EXECUTABLES:

The files located in this machine are the scene, controls and Calibration files.

START-UP SCRIPTS:

All the executables are started sequentially with a few seconds between; the following start-up files are in sim12:

/home/acddev/start_all_jhmcs
/home/acddev/start_all_ngh
/home/acddev/start_stick
/home/acddev/start_throttle
/home/acddev/start_calibration
/home/acddev/start_router (use only if header files are set to send data to sim12 IP address)
/home/acddev/src/scene_cgl/cf18_otw ngh.adf
/home/acddev/src/scene_cgl/cf18_otw jhmcs.adf

VISUAL SCENE, HUD AND FLIR:

The simulation of the outside world (OTW scene) is projected on each eye of the SimEye visor, with 100% overlap. The scene is generated using VEGA. Two virtual channels are being sent to the physical channels of the ONYX (channel 0 and channel 1) to the HMD.

The NGH HMD includes a terrain database with the HUD symbology (implemented in VAPS) overlaid in the center and a FLIR symbology (done in Open GL) and finally a FLIR scene (implemented in VEGA) overlaid on the top right corner of the display.

The JHMCS HMD includes a terrain database with the HUD symbology overlaid in the center of the display.

*/home/acddev/src/scene_cgl/cf18_otw ngh.adf **
*/home/acddev/src/scene_cgl/cf18_otw jhmcs.adf **

**Note: License for VEGA is on sim10*

MASK CALIBRATION:

The calibration file is used to properly calibrate the virtual terrain database and the cockpit mask according to each test pilot height and head position. The output file is saved and used later during the experiment.

*/home/acddev/src/mask_calibration/cf18_otw calib.adf**

THE CONTROLS:

The stick and throttle both simulate the HOTAS of the CF-18A cockpit configuration. They are connected to the ACD via the cereal box and the data is then relayed to FLSIM to control the motion of the Ownship, which is reflected on the outside scene and the HUD display.

The Controls data are read from the two cereal boxes and sent to the ONYX through the serial port dev/ttyd3.

/home/acddev/src/ctrls/cf18_stick
/home/acddev/src/ctrls/cf18_throttle

ROUTER:

The router is a data manager tool that distributes the data between the systems. Each system registers, then subscribes to, the data structure it requires. The main traffic is from FLSIM to the outside scene, from the controls to FLSIM, and from the PC to FLSIM. It uses UDP communication protocol. The ipc_settings.h is responsible for setting the receiver and transceiver IP addresses.

/home/acddev/src/router/start_router (Alternative solution, not used at this point)

HEADER FILES:

The header files are necessary for setting information such as the machine IP addresses, the port used so the router can send the data to the correct computer.

*/home/acddev/common/ipc_xxx**
*/home/acddev/common/udp_xxx**

Some other header files are necessary for the data structure needed by each simulation code.

*/home/acddev/common/*flsim_export.h
*/home/acddev/common/*cf18_msg_types.h
*/home/acddev/common/*acd_msg.h

*The *ipc* and *udp* header files are too numerous to list and may be easily accessed and identified in the specified */home/acddev/common* directory.

THE DATABASE OF THE TERRAIN AND OBJECTS:

The visual scene is generated using the VEGA tool; each object is a model – such as the target, the buildings and the terrain, and each model is of the format of .flt.

/home/acddev/src/scene_cgl/Shiny_Shpere.flt
/data/db/cold_lake_cd/Models/clawr.flt

HUD CONTROL PANEL:

The control Panel is a user interface to the HUD VAPS code that provides a selection tool to the different configuration of the HUD, Virtual HUD, HMD HUD, MIXE1 and MIXE2 (Not used currently but is functional).

/home/acddev/src/scene_cgl/Control_Panel/ hmd-scenarios

ACD2 (OCTANE):

HEADER FILES:

The header files are necessary for setting information such as the machine IP addresses, the port used so the router can send the data to the correct machine.

*/usr/people/cf18acd/common/ipc_xxx**
*/usr/people/cf18acd /common/udp_xxx**

Some other header files are necessary for the data structure needed by each simulation code.

*/usr/people/cf18acd /common/*flsim_export.h
*/usr/people/cf18acd /common/*cf18_msg_types.h
*/usr/people/cf18acd /common/*acd_msg.h

*The *ipc* and *udp* header files are too numerous to list and may be easily accessed and identified in the specified */usr/people/cf18acd/common* directory.

HEAD TRACKER:

The head tracker is a device, which gives the heading, pitch, roll, x, y, and z, of the head movement. It is composed of a transceiver and a receiver. They are mounted on the HMD. The head tracker data can be extracted either by the following file mentioned below or through VEGA directly. For this experiment the head data is read directly from VEGA and is used by the HMD.

/usr/people/cf18acd/other/from_cmc/head_track/head_tracker head_track.adf

ROUTER:

The router is a data manager tool that distributes the data between the systems. Each system registers, then subscribes to, the data structure it requires. The main traffic is from FLSIM to the outside scene, from the controls to FLSIM, and from the PC to FLSIM. It uses UDP communication protocol. The ipc_settings.h is responsible for setting the receiver and transceiver IP addresses.

/usr/people/cf18acd/src/router/router.py (Currently used)

AIRCRAFT SIMULATION MODEL:

FLSIM is a tool that simulates the aircraft model and the aerodynamic characteristics of the aircraft. FLSIM generates the database co-ordinate system and is able to detect the height above terrain for collision detection.

/usr/vpi/flsim7/bin/

MISSION COMPUTER SIMULATION:

The SIM is a collection of different aircraft displays and some aircraft managing software such as the mission computer, the flight management system. The interfacing between the controls and the simulation is hosted in the mission computer software.

/usr/people/cf18acd/src/sim/

TOWN GENERATION:

The experimenter using the framework tool generates the town around the virtual database. The generated file's suffix is *.scn and is generated in the same directory. The buildings and objects generated appear in the HMD and FLIR scene as the simulation starts.

/usr/people/cf18acd/src/framework/framework
/usr/people/cf18acd/src/sg

CONTROL PANEL:

The Control Panel is a user interface to the HUD (VAPS code) that provides a selection tool to the different configuration of the HUD, Virtual HUD, HMD HUD, MIXE1 and MIXE2. The control panel has a drop down menu that the user can select the desired configuration from the four options available.

/usr/people/cf18acd/src/EWS/

The viewer tool enables you to dynamically view the aircraft flight path and its location in relation to the town generated

/usr/people/cf18acd/src/viewer/

DATA COLLECTION:

Data collection is a tool used to record the continuous and discrete data during each experiment run, each data is time stamped. The files are generated automatically and each new experiment is appended to the previous one.

Data collection reads data from the HOTAS, HMD, Head Tracker, FLSIM and SIM.

/usr/people/cf18acd/src/datacol/datacol <name of test subject> <trial>
/usr/people/cf18acd/src/datacol/data/.txt (all the recorded text files)*

THE CONTROLS:

The stick and throttle both simulate the HOTAS of the CF-18A cockpit configuration. They are connected to the prototype via the cereal box and the data is then relayed to FLSIM to control the motion of the Ownship, which is reflected on the outside scene.

/usr/people/cf18acd/src/ctrls/cf18_stick (The currently used version is on Sim12)
/usr/people/cf18acd/src/ctrls/cf18_throttle (The currently used version is on Sim12)

/usr/people/cf18acd/common/ipc_xxx
/usr/people/cf18acd/common/udp_xxx

OTW2 (PC):

THREAT GENERATION:

The threats are generated using the VEGA tool. A threat is an object that is added to the database and changes location dynamically throughout the experiment. The goal is to have two threats appearing within the vicinity of the aircraft with a separation of 180 degrees azimuth from each other. Each PC will represent a separate screen position, to simulate the 360 degree FOV around the pilot during the flight.

The threats are aircraft fixed and appear randomly around the aircraft. The threats appear every 5 seconds with 20 seconds interval.

The first PC (PC1; screen 0) is the master and the remainder of the PCs (PC2 through PC5; screens 1 through 4) are considered the slaves. The master PC generates the threat position and sends it to the router. The slave PCs acquire the threat position from the router and display the result on the screen.

The executables are identical in every PC except that are running from their respective PC hard drive.

PC1:
*C:\CF18\scene\src\ cf18_scene.exe screne0.adf**

PC2:
*C:\CF18\scene\src\ cf18_scene.exe screne1.adf**

PC3:
*C:\CF18\scene\src\ cf18_scene.exe screne2.adf**

PC4:
*C:\CF18\scene\src\ cf18_scene.exe screne3.adf**

PC5:
C:\CF18\scene\src\ cf18_scene.exe screne4.adf*

*Note: License for VEGA is on otw1

ANNEX B
GLOSSARY OF TERMS AND ACRONYMS

ANNEX B - GLOSSARY OF TERMS AND ACRONYMS

ACD	Aircraft Crewstation Demonstrator
AMLCD	Active Matrix Liquid Crystal Display
AST	Air to Surface Tactics
CLAWR	Cold Lake Air Weapons Range
CMC	CMC Electronics Inc.
DAR	Directorate of Air Requirements
DAR 5	DAR – Fighters and Trainers
DDI	Digital Display Indictor
DND	Department of National Defence
DRDC-Toronto	Defence R&D Canada, Toronto
FLIR	Forward-Looking InfraRed
FLSIM	Flight Simulation
FOV	Field-of-View
GFE	Government Furnished Equipment
HMD	Helmet-Mounted Display
HMCS	Helmet Mounted Cueing System
HOTAS	Hands-On-Throttle-And-Stick
HUD	Heads-Up Display
IMP	Incremental Modernization Program
JHMCS	Joint Helmet Mounted Cueing System
NGH	Next Generation Helmet
OTW	Out-the-Window
PTT	Part Task Trainer
PWGSC	Public Works and Government Services Canada
SA	Scientific Advisor
SA	Situational Awareness
SERF	Synthetic Environment Research Facility
SMART	Simulation and Modelling for Acquisition, Rehearsal and Training
HSMG	Human Systems Modelling Group
SOW	Statement of Work
UFC	Up Front Controller

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(U)

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

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(U) Aircraft Crewstation Demonstrator
Air to Ground Scenario
Helmet Mounted Display
Forward Looking Infrared
Situational Awareness