Image Cover Sheet

CLASSIFICATION	SYSTEM NUMBER 509314
UNCLASSIFIED	

TITLE

AIRCRAFT CREWSTATION DEMONSTRATOR INTEGRATION

System Number:

Patron Number:

Requester:

Notes:

DSIS Use only:

Deliver to:

DCIEM No. 97-CR-4

AIRCRAFT CREWSTATION DEMONSTRATOR INTEGRATION

FINAL REPORT

17 November 1997

DSS Contract No. W7711-7-7391/001/SRV

Prepared by

CANADIAN MARCONI COMPANY

HUMAN FACTORS ENGINEERING
AEROSPACE
415 LEGGET DRIVE
KANATA, ONTARIO
K2K 2B2

CMC

AIRCRAFT CREWSTATION DEMONSTRATOR INTEGRATION

FINAL REPORT

17 November 1997

CMC Document Number 1000-1147
DSS Contract No. W7711-7-7391/001/SRV

Prepared by: M. Gamble, Systems Engineer

Reviewed by: G. Youngson, Project Engineer

Authorized by: R.D. Kobierski, Program Manager, Human Factors Engineering

Released by: R.D. Kobierski, Documentation Control

CANADIAN MARCONI COMPANY
415 LEGGET DRIVE
KANATA, ONTARIO, CANADA
K2K 2B2

REVISION PAGE

REVISION LETTER	PAGES AFFECTED	DATE	APPROVAL

TABLE OF CONTENTS

LIST OF ANNEXES

SECTION ONE - INTRODUCTION

1.1 GENERAL

On November 25th, 1996, Canadian Marconi Company (**CMC**) was awarded a contract for the development of an Aircraft Crewstation Demonstrator (**ACD**). As part of this effort, CMC conducted an analysis of existing facilities coupled with a Human Engineering (**HE**) evaluation of the requirements, proposed and designed a fixed-based flight deck and tactical crewstation demonstrator, and implemented the solution as ratified by the Department of National Defence (**DND**). Following the establishment of the preliminary ACD facility for the Directorate of Technical Airworthiness (**DTA**), CMC was awarded a contract to integrate a functionally equivalent ACD at the facilities of the Defence and Civil Institute of Environmental Medicine (**DCIEM**).

1.2 BACKGROUND

To date, a Human Factors Engineering (**HFE**) evaluation of the operator interface has not been possible until the equipment design reached the system prototype stage. It has been observed that at this advanced point in the design cycle, any effort associated with a modification to the systems design is met with significant resistance.

The development of this computer-based test and evaluation tool will facilitate the review of proposed user interfaces within a dynamic setting representative of the operational environment, to ensure the resultant system performs effectively, and can be operated in a safe and efficient manner.

1.3 AIM

This Final Report provides information regarding the architecture of the ACD as well as the configuration issues associated with the maintenance of the ACD. That information, coupled with the "lessons learned" during the integration exercise, provides the basis for any modifications to the preliminary ACD design.

1.4 SCOPE

The effort required to complete this preliminary design effort is described in the accompanying sections of this document, the scope of which is as follows:

a. Section One - Introduction;
b. Section Two - Installation Process;

c. Section Three - Description of Facility; and
d. Section Four - DTA/DCIEM ACD Differences.

1.5 LIST OF APPLICABLE DOCUMENTS

Critical, Technical and Management Proposals for the Development of an Aircraft Crewstation Demonstrator, Canadian Marconi Company, Document Number 1000-P001, Kanata, Ontario, September 27, 1996.

Study of Virtual Prototyping of Aircraft Instrument - Concluding Report, Canadian Marconi Company, Document Number 0687-1090, Kanata, Ontario, August 9, 1993.

International Standards Organization (ISO) Work Instruction - Human Factors Engineering, Canadian Marconi Company, Document Number 9304-1003, Kanata, Ontario, March 4, 1996.

Defence and Civil Institute of Environmental Medicine Aircraft Crewstation Demonstrator, Statement of Work.

1.6 LIST OF ACRONYMS

3-D	Three Dimensional
ACD	Aircraft Crewstation Demonstrator
AERCOL	Aerospace Engineering and Research Consultants Limited
API	Application Programming Interface
ATN	Augmented Transition Network
ATR	Airline Training Resources
CCG	C-Code Generator
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CF	Canadian Forces
CMC	Canadian Marconi Company
COTS	Commercial Off-The-Shelf
CRT	Cathode Ray Tube
DCIEM	Defence and Civil Institute of Environmental Medicine
DE	Development Environment
DID	Data Item Description
DND	Department of National Defence
DTA	Directorate of Technical Airworthiness

DTED	Department of Transport Evaluation Data
DVI	Direct Voice Input
FAA	Federal Aviation Administration
FLSIM	FLight SIMulator
ft	feet
HAT	Height Above Terrain
HE	Human Engineering
HEART	Human Engineering Analysis and Requirements Tools
HELISIM	HELIcopter SIMulator
HFE	Human Factors Engineering
HUD	Heads-Up Display
IP	Internet Protocol
ISO	International Standards Organization
kt	knot
LAN	Local Area Network
NCOT	Naval Combat Operator Trainer
nm	nautical mile
PFC	Precision Flight Control
PMP	Project Management Plan
PRIOR	Prior Data Sciences
SAS	Stability Augmentation System
SDP	Software Development Plan
SGI	Silicon Graphics International
SOLE	Systems Operator Loading Evaluation
SOW	Statement Of Work
TCP	Transmission Control Protocol
TIES	Technical Investigation and Engineering Support
UDP	Unacknowledged Datagram Protocol
UTIAS	University of Toronto Institute for Aerospace Studies
VAPS	Virtual APplications Builder
VPI	Virtual Prototypes Incorporated
WBS	Work Breakdown Structure

SECTION TWO - INSTALLATION PROCESS

2.1 MODIFICATIONS TO BASELINE AIRCRAFT CREWSTATION DEMONSTRATOR

Prior to integration of the ACD hardware and software at the DCIEM facility, a number of work items had to be addressed. This process resulted in a series of changes to the DTA ACD design being made to ensure ease of migration from the CMC site to DCIEM, as well as provide a software installation approach that would allow for better revision control between the two sites. The directory structure was redesigned to better identify and isolate individual software components, and software directory dependencies were removed wherever possible. In addition to this effort, some preliminary work had to be done at the CMC site to verify the feasibility of integration of the BG Flybox, as well as the identification of hardware modifications that would required to the DCIEM collective and rudder pedal control systems.

2.2 SITE/EQUIPMENT VERIFICATION

Before the final integration effort was undertaken, CMC made a preliminary trip to the DCIEM facility to confirm integrity of the Local Area Network (**LAN**) and establish that the hardware environment was suitable to support the current ACD design. This site visit also afforded CMC the opportunity to set up the Virtual APplications Builder (**VAPS**) environment and integrate the VAPS library of instrument panels on two DCIEM Solid Impact machines. Work items completed during this visit included:

a. ensuring that the Dual Head cards and displays were properly configured;

b. integrating the Silicon Graphics International (**SGI**) machines onto a LAN and testing for connectivity; and

c. integrating the VAPS library of instrument panels on the two Solid Impact workstations.

2.3 INSTALLATION ACTIVITY

Once the suitability of the DCIEM environment had been verified, the DTA ACD environment was captured on a series of DAT tapes. A second trip to the DCIEM facility followed at which time the DTA ACD environment was installed. Any exceptions or differences between the two environments has been detailed in Section Four.

Establishment of the DCIEM ACD involved the following work items:

a. integrating the VAPS software with the FLight SIMulator (**FLSIM**) and HELIcopter SIMulator (**HELISIM**) software;

b. integrating the Ottawa Uplands Department of Transport Elevation Data (**DTED**) data, the Monterey data and the Paradigm database external scenes with the FLSIM and HELISIM aircraft models on the Maximum Impact machine;

c. integrating the display of the experimenter's workstation software on the Indigo XZ-24;

d. testing that the software packages were communicating across the LAN;

e. integrating the collective and rudder pedals with the BG Flybox and connecting them to the ACD;

f. ensuring that the appropriate software and hardware hooks are available for the integration of an audio system including Direct Voice Input (**DVI**) and three Dimensional (**3-D**) audio, flat panel displays of flight instruments and video distribution of displays; and

g. demonstrating the integrated ACD to DCIEM.

2.4 STATUS

At the time of the integration effort, DCIEM had not yet received some of the hardware components, (CerealBoxes and SCSI Terminal Server) necessary to establish the auxiliary control systems within their ACD facility (ie. centre stick and throttle quadrant). As originally anticipated, the collective and rudder pedals were routed through the FlyBox control box, and connected to the ACD, completing the integration effort.

Although it is not a work item associated with this effort, it was determined that CMC would provide telephone support to the further integration effort of the auxiliary hardware items and control systems.

SECTION THREE - DESCRIPTION OF FACILITY

3.1 GENERAL

This section describes the equipment upon which the integration was performed. Any modifications to the DTA ACD hardware/software that were required to fulfill the contractual obligations of the DCIEM ACD facility integration will be detailed in Section Four.

A full list of all items, Commercial Off-The-Shelf (**COTS**) and otherwise will be provided in Paragraph 3.3.

3.2 DESIGN RATIONALE

Using the preliminary ACD design established in the DTA ACD proposal and further modified as a result of the DTA ACD Analysis exercise, CMC compiled an ACD Design in the format defined within Contract Data Requirements List (**CDRL**) Item 007, for review by the Scientific and Technical Authorities. The ACD takes full advantage of COTS hardware and software, and this trend/philosophy will continue during the final design and implementation exercise.

The design is fully compatible with the VAPS Library of Canadian Forces (**CF**) Instruments, and the FLSIM/HELISIM applications govern the transfer of data in a manner consistent with the input/output requirements of VAPS.

The selected control inputs are of a generic nature to allow ease of transition between the different crewstation environments yet are of adequate fidelity to ensure a realistic interaction with the operator.

To support the evolution of an integrated computer-based facility, any software developments or modifications were fully documented in a Software Development Plan (**SDP**). This Plan, developed in accordance with CDRL Item 016, provides CMC and DND with insight as to the development of the ACD software. This report has been provided as Annex C of this report to facilitate their review of the implementation.

The current design minimizes the requirement for the development of software. As such, the requirements for the SDP have been dramatically reduced, when compared to solutions involving the integration of non-COTS application software.

3.3 LIST OF HARDWARE AND SOFTWARE

Table 3-1 contains a list of the hardware components with the DCIEM ACD facility, including COTS equipment.

Table 3-1 ACD Hardware Components

ACD Element	Equipment
Flight Controls	Aircraft Controls - BG Flybox, rudder pedals, collective
Data Communications	SCSI Terminal Server (not yet delivered)
	Analog to Digital Communications Box (CerealBox) (2 - not yet delivered)
	Cable Adapters
Computer Hardware	SGI Indigo2 Solid Impact Workstations (2)
	SGI Indigo2 Maximum Impact
	SGI Indigo2 XZ-24
	Dual-head cards (2)
Instrument Panel	20" SGI monitors with MicroTouch screens (3 - not yet delivered)
Tactical Compartment/ Researcher and Experimenter Position	20" monitors with touch screens (2)
	Tactical Compartment Controls - trackball, keyboard, mouse
External Scene	DP 9100 Graphics Projector

Table 3-2 contains a list of the software components with the ACD facility, including COTS equipment.

Table 3-2 ACD Software Components

ACD Element	Equipment
Data Communications	TCP/IP Communications Protocol
Instrument Panel	VAPS Images
	X-Touch touch screen drivers (not yet delivered)
External Scene	SGI Performer
	Paradigm Vega SP
	MultiGen II Modeller
	MultiGen Terrain Option
Integration Software	FLSIM/HELISIM Flight Simulation Applications
	Integration Utility
	C/C++ Compiler
	C-Code Generator
Threat Environment	Threat Generator
Data Collection	Data Collection Module
Researcher/ Experimenter Position	VAPS Interface
	Researcher/Experimenter Module

SECTION FOUR - DTA/DCIEM ACD DIFFERENCES

4.1 GENERAL

The differences between the DTA and DCIEM ACDs result in facilities that are identical in function, but only similar in form. These differences are detailed in Table 4-1.

Table 4-1 DTA/DCIEM ACD Differences

Item	DTA ACD	DCIEM ACD
Experimenter's Workstation	Indigo2 Maximum Impact with Dual Head capabilities. External scene generated on Maximum Impact card. Experimenter's panel generated on Solid Impact card.	Indigo2 Maximum Impact (no Dual Head). External scene generated on Maximum Impact card. Experimenter's panel generated on Indigo2 Solid Impact and remotely displayed on Indigo2 XZ-24.
Flight Controls	Precision Flight Control (**PFC**) Stick/Cyclic (2) PFC Throttle Control (2) PFC Rudder Pedals (2) PFC Collective (2)	BG Flybox PFC Rudder Pedals PFC Collective
Flight Control Interface	SCSI Terminal Server (2) BG CerealBox (4)	SCSI Terminal Server BG CerealBox (2)
Cockpit Structure	Semi-permanent frame modeled after CH146 cockpit	No frame
Instrument Displays	29" Mitsubishi Monitor (2) with MicroTouch surfaces 20" SGI Monitor (4), 3 with MicroTouch surfaces	20" SGI Monitor (6)
External Scene	14'x10' Rear Projection Screen Duocom DP9100 Graphics Projector	No projection screen at time of implementation Duocom DP9100 Graphics Projector

ANNEX A

SET-UP INSTRUCTIONS

ANNEX A - SET-UP INSTRUCTIONS

1.1 GENERAL

This annex provides high level instructions for setting up the DCIEM ACD. The instructions assume basic knowledge of SGI hardware as well as experience setting up a small scale LAN. Instructions provide for the basic set-up of the ACD. Refer to the FLSIM/HELISIM manual set for information regarding additional configuration options.

1.2 UNPACKING THE ACD

Unpack Chico (Solid Impact), Harpo (Solid Impact), Quitz (XZ-24) and Groucho (Maximum Impact). Localize the machines to suit the required configuration keeping in mind the availability of power and ethernet cable lengths. Chico is configured to display the pilot position (fixed wing) instrument panel on DISPLAY 0.0 and the engine instruments on DISPLAY 0.1. Harpo is configured to display the copilot position (fixed wing) on DISPLAY 0.0 and the experimenters panel remotely on Quitz. Unpack the ethernet hub and any additional equipment required for establishing the LAN. Refer to Figure B-1 in Annex B for a description of the default configuration.

Connect all monitor, keyboard, mouse and power cables. Groucho requires the addition of a SCSI terminal serial server. Connect the SCSI terminal server to Groucho via the micro-SCSI cable and ensure that the connection is terminated. Chico, Harpo and Quitz require no additional peripherals. Each machine should be connected to the ethernet hub via 10Base-T ethernet cable.

Once all cables have been connected and the ethernet network has been established, the machines should be powered ON.

1.3 VERIFYING THE COMPONENTS

Once all machines have completed the boot cycle, the user will be presented with the workstation login screen. All machines should be logged into using the "acddemo" account - no password is required. Choose a machine from which to verify network availability (Groucho, for example). From the selected machine open a winterm and ping all machines required for the ACD (i.e. execute the command `/usr/etc/ping chico`). A response should be received for all pings. If any one machine does not reply to the ping, re-check ethernet cable connections and the status of the hub.

1.4 CONNECTING FLIGHT CONTROLS

Set up the Flybox in the desired location. Connect the power cable and the DB-9 serial connector to the serial output on the back of the Flybox. Connect the other end of the serial cable to serial port #2 on the back of Groucho (or to the SCSI terminal server depending upon availability). To test the Flybox, run the calibration software included with FLSIM. This is done by opening a winterm on Groucho and typing:

```
/usr/vpi/flsim/bin/flsim.cal_bg_flybox <port#>
```

where <port#> represents the serial port to which the Flybox is connected (i.e. /dev/ttyd2 for serial port #2).

The result should appear as follows:

```
        ***  FLSIM CALIBRATION PROGRAM  ***
         **  MSI G3453 Serial Converter **

Words  0    1    2    3    4    5    6    7    8    9    10   11
      0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
```

where the "0000"s are replaced by values representative of the position of the Flybox controls. As the joystick is moved, words 1 and 2 should change appropriately. Press "ctrl-c" to quit the program. If this is not the case or if the calibration program does not start:

a. check the serial cable connection;

b. ensure that power is supplied to the Flybox; and

c. ensure that the port number (i.e. the value used as <port#>) corresponds to the physical port on Groucho to which the cable is connected and that the specified port is not configured as a terminal.

The Flybox is now set up.

1.5 STARTING THE ACD

All operations required to start the ACD should be done from Groucho.

1.5.1 Starting the VAPS Panels

From the toolchest on the Groucho desktop, select *ACD->Left Seat Panels*. This window displays scripts required to start the panels on Chico. Double click on the icon for the aircraft panel desired (i.e. C130). From the toolchest on the Groucho desktop, select *ACD-*

1.4 CONNECTING FLIGHT CONTROLS

Set up the Flybox in the desired location. Connect the power cable and the DB-9 serial connector to the serial output on the back of the Flybox. Connect the other end of the serial cable to serial port #2 on the back of Groucho (or to the SCSI terminal server depending upon availability). To test the Flybox, run the calibration software included with FLSIM. This is done by opening a winterm on Groucho and typing:

```
/usr/vpi/flsim/bin/flsim.cal_bg_flybox <port#>
```

where <port#> represents the serial port to which the Flybox is connected (i.e. /dev/ttyd2 for serial port #2).

The result should appear as follows:

```
***   FLSIM CALIBRATION PROGRAM   ***
 **   MSI G3453 Serial Converter **

Words  0    1    2    3    4    5    6    7    8    9    10   11
      0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
```

where the "0000"s are replaced by values representative of the position of the Flybox controls. As the joystick is moved, words 1 and 2 should change appropriately. Press "ctrl-c" to quit the program. If this is not the case or if the calibration program does not start:

a. check the serial cable connection;

b. ensure that power is supplied to the Flybox; and

c. ensure that the port number (i.e. the value used as <port#>) corresponds to the physical port on Groucho to which the cable is connected and that the specified port is not configured as a terminal.

The Flybox is now set up.

1.5 STARTING THE ACD

All operations required to start the ACD should be done from Groucho.

1.5.1 Starting the VAPS Panels

From the toolchest on the Groucho desktop, select *ACD->Left Seat Panels*. This window displays scripts required to start the panels on Chico. Double click on the icon for the aircraft panel desired (i.e. C130). From the toolchest on the Groucho desktop, select *ACD-*

1.5.3 Setting Up the External Scene

The ACD is currently set up to make use of three terrain databases as the external scene for the FLSIM/HELISIM applications. Defining the external scene that will be displayed is a two step process, including:

a. the scene to be used must be selected within the FLSIM/HELISIM DE. This information is used to set up the initial conditions of the simulation; and

b. a configuration file must be specified to provide similar information to the external scene process.

To specify the initial conditions for the external scene, select the *Configure* menu and then *Initial Conditions* within the FLSIM/HELISIM DE. Press the *Load* button on the displayed dialogue and select the desired scenario from the choices displayed. From the *Configure* menu select *Initial Conditions*. Press the *Load* button on the displayed dialogue and select the desired scenario from the choices displayed. The choices currently available are "ACD_Ottawa", "ACD_Monterey", "ACD_CI_Island", and "ACD_CI_Field". Press *OK* to close the dialogue.

The configuration file for the external scene must be modified at the command line. To change the configuration file, open a winterm and change to the "/usr/vpi/flsim/bin" directory. The current configuration file is named "ACDscene_info.txt". The external scene process will expect a file with this exact name. A number of similarly named files also exist within the same directory, each one of these files contains scene information relevant to a specific terrain database (i.e. "ACDscene_info.ott" for the Ottawa scene). In order to change the scene, simply copy the appropriate configuration to "ACDscene_info.txt". For example, to make Monterey the current terrain database, copy "ACDscene_info.mont" to "ACDscene_info.txt". The "ACDscene_info.ci" configuration file should be used for both "ACD_CI_Island" and "ACD_CI_Field" selections.

1.5.4 Setting Up the Threat

The ACD threat module uses a data file composed of ASCII text entries to define a path along which the threat will travel. The first line of the data file is a header that identifies the category and identity of the threat, followed by the start time and position (x, y, z). The ensuing lines define waypoints consisting of a position (x, y, z) and speed.

The category may be one of *A* for air, *L* for land, *S* for surface or *U* for underwater. The identity may be *F* for friendly, *H* for hostile or *N* for non-military. The starting time is a floating point number that defines the number of seconds after the initialization of the simulation that the threat will remain hidden. The position is given as three floating point numbers: an "x" coordinate (nautical miles east/west of map centre), a "y" coordinate (nautical miles north/south of map centre) and a "z" coordinate (feet above/below map centre). Speed is a floating point value measured in knots. There is no limit to the number of waypoints that may be defined.

1.5.3 Setting Up the External Scene

The ACD is currently set up to make use of three terrain databases as the external scene for the FLSIM/HELISIM applications. Defining the external scene that will be displayed is a two step process, including:

a. the scene to be used must be selected within the FLSIM/HELISIM DE. This information is used to set up the initial conditions of the simulation; and

b. a configuration file must be specified to provide similar information to the external scene process.

To specify the initial conditions for the external scene, select the *Configure* menu and then *Initial Conditions* within the FLSIM/HELISIM DE. Press the *Load* button on the displayed dialogue and select the desired scenario from the choices displayed. From the *Configure* menu select *Initial Conditions*. Press the *Load* button on the displayed dialogue and select the desired scenario from the choices displayed. The choices currently available are "ACD_Ottawa", "ACD_Monterey", "ACD_CI_Island", and "ACD_CI_Field". Press *OK* to close the dialogue.

The configuration file for the external scene must be modified at the command line. To change the configuration file, open a winterm and change to the "/usr/vpi/flsim/bin" directory. The current configuration file is named "ACDscene_info.txt". The external scene process will expect a file with this exact name. A number of similarly named files also exist within the same directory, each one of these files contains scene information relevant to a specific terrain database (i.e. "ACDscene_info.ott" for the Ottawa scene). In order to change the scene, simply copy the appropriate configuration to "ACDscene_info.txt". For example, to make Monterey the current terrain database, copy "ACDscene_info.mont" to "ACDscene_info.txt". The "ACDscene_info.ci" configuration file should be used for both "ACD_CI_Island" and "ACD_CI_Field" selections.

1.5.4 Setting Up the Threat

The ACD threat module uses a data file composed of ASCII text entries to define a path along which the threat will travel. The first line of the data file is a header that identifies the category and identity of the threat, followed by the start time and position (x, y, z). The ensuing lines define waypoints consisting of a position (x, y, z) and speed.

The category may be one of *A* for air, *L* for land, *S* for surface or *U* for underwater. The identity may be *F* for friendly, *H* for hostile or *N* for non-military. The starting time is a floating point number that defines the number of seconds after the initialization of the simulation that the threat will remain hidden. The position is given as three floating point numbers: an "x" coordinate (nautical miles east/west of map centre), a "y" coordinate (nautical miles north/south of map centre) and a "z" coordinate (feet above/below map centre). Speed is a floating point value measured in knots. There is no limit to the number of waypoints that may be defined.

Table A-1 Keystrokes

Keystroke	Effect
Esc	Terminate the simulation
f	Enable/Disable fog
d/D	Increase/Decrease time of day
t	Enable/Disable texture
w	Enable/Disable wireframe rendering
s	Enable/Disable Stability Augmentation System (**SAS**) (HELISIM only)
b	Apply/Remove aircraft brakes
g	Extend/Retract aircraft undercarriage
h	Show/Hide Heads-Up Display (**HUD**)
v	Toggle external viewpoint (pilot/aircraft chase/pilot-look-at-threat/tower/threat chase)
keypad "6"	Pan head right
keypad "4"	Pan head left
keypad "5"	Centre head pan
Up arrow/Dwn arrow	Pitch trim forward/back
Left arrow/Right arrow	Roll trim port/stbd
-	Retract flaps by 10%
+	Extend flaps by 10%

Table A-1 Keystrokes

Keystroke	Effect
Esc	Terminate the simulation
f	Enable/Disable fog
d/D	Increase/Decrease time of day
t	Enable/Disable texture
w	Enable/Disable wireframe rendering
s	Enable/Disable Stability Augmentation System (**SAS**) (HELISIM only)
b	Apply/Remove aircraft brakes
g	Extend/Retract aircraft undercarriage
h	Show/Hide Heads-Up Display (**HUD**)
v	Toggle external viewpoint (pilot/aircraft chase/pilot-look-at-threat/tower/threat chase)
keypad "6"	Pan head right
keypad "4"	Pan head left
keypad "5"	Centre head pan
Up arrow/Dwn arrow	Pitch trim forward/back
Left arrow/Right arrow	Roll trim port/stbd
-	Retract flaps by 10%
+	Extend flaps by 10%

ANNEX B

SOFTWARE CONFIGURATION

ANNEX B - SOFTWARE CONFIGURATION

1.1 INTRODUCTION

The ACD solution combines COTS simulation software with custom developed software to support system integration. The integration software provides the linkages to connect the simulation processes (FLSIM and HELISIM), out-the-window display (Vega) and the crew control devices into the system. The software also contains a module capable of introducing a threat into the runtime scenario. The DCIEM ACD architecture differs physically from that of the DTA ACD, but accommodations have been made in the software to ensure portability between the two facilities.

This annex provides an overview of the ACD system architecture, as well as a breakdown of the source directory structure and a specification of the parameters monitored by the data collection module.

2.1 ACD SYSTEM ARCHITECTURE

The DCIEM ACD platform consists of two SGI Indigo2 Solid Impacts (Chico and Harpo), one SGI Indigo2 Maximum Impact (Groucho) and one Indigo2 XZ-24 workstation (Quitz) interconnected across a LAN. Intercommunication between processes is accomplished using shared memory as well as via TCP/IP and UDP/IP communication protocols. Groucho provides the primary control interface to the experimenter and is the platform on which the majority of process execution takes place. Chico and Harpo host the VAPS executables, while Quitz is used as a remote display to Harpo for displaying runtime information to the experimenter. A pictorial representation of the ACD system architecture is presented as Figure B-1.

In order to accommodate the Precision Flight Controls hardware and provide the threat generation facility, modifications had to be made to the FLSIM/HELISIM runtime user tables. These modification allowed the integration of user code into the simulation runtime processing loop. As such, the default "sim" and "external scene" processes have been replaced by ACD specific components. Intercommunication between the different simulation modules is accomplished via a combination of UDP/IP messages and command line parameters. Figure B-2 provides a visualization of the dataflow between the simulation processes.

For details regarding the implementation of specific processes, please reference the comments included in the source code, as well as the online documentation provided in the "/usr/acd/doc" directory on Groucho.

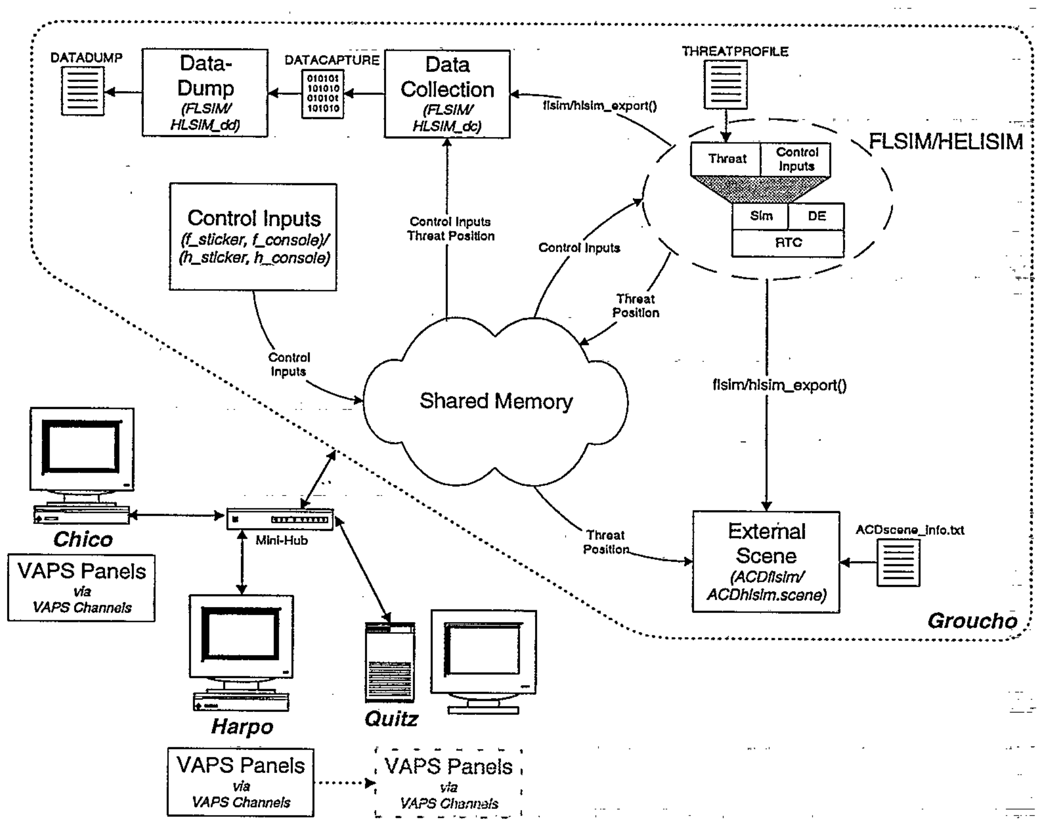


Figure B-1 System Architecture

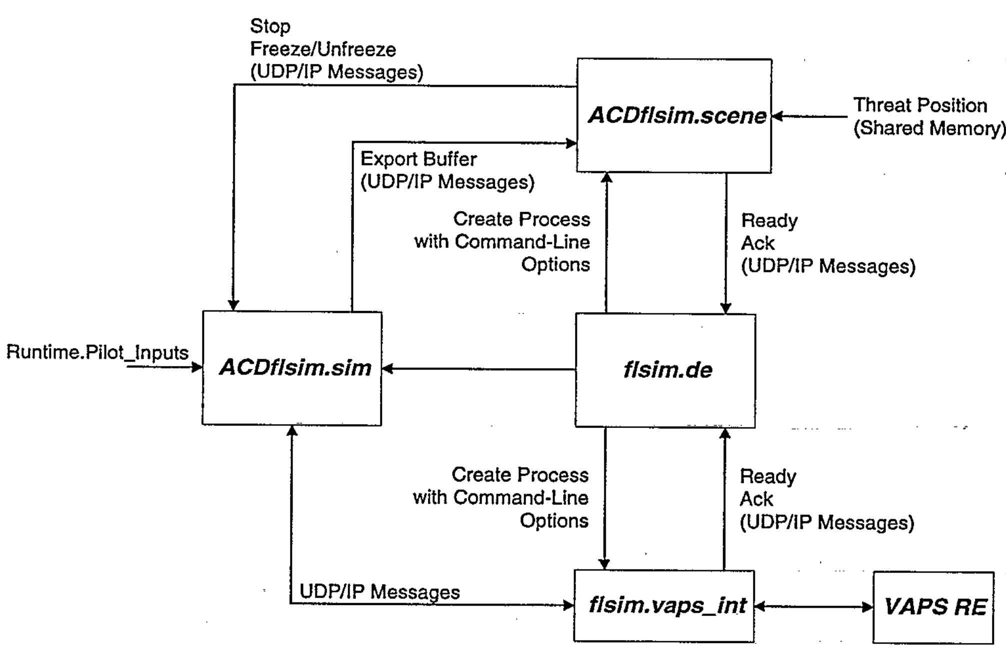


Figure B-2 Dataflow Between Simulation Processes

2.2 ACD COMPONENTS

The ACD runtime implementation consists of multiple interconnected processes. The following subsections define these processes and provide a high level explanation of their function as well as their location.

2.2.1 Control Inputs

Crew inputs are made through various hardware devices (stick, throttle, pedals, etc.) which provide analog and digital outputs. These analog outputs are then converted to RS-232 by BG CerealBoxes and monitored by Groucho through multiple serial ports provided by a Central Data SCSI Terminal Server. Two processes (f/h_sticker and f/h_console) act as the control interface for the crew inputs. F/H_sticker is executed first and reads input from the flight stick/cyclic and pedals, as well as sets up the common shared memory arena which the remainder of system components access. F/H_console reads inputs from the throttle quadrant and writes them to the common shared memory arena. After these two processes have been started, data is then available to all software components that connect to the common shared memory arena. F/H_sticker and f/h_console are located in the "/usr/people/acd/bin" directory.

2.2.2 Simulation

The COTS products FLSIM and HELISIM provide realtime simulation of the various aerodynamic models in the ACD. Although the core simulation is COTS, customized modules had to be compiled into the simulation executable to support integration of the crew control inputs, as well as the threat generator. FLSIM and HELISIM generate runtime simulation based on user-defined aerodynamic coefficients and equations of motion. The data used to define these aerodynamic characteristics is stored in the "/usr/vpi/flsim/data/aircraft" directory.

The control inputs are read from the common shared memory arena on each iteration of the runtime simulation loop and are then used as inputs to the aero-models. The threat generation module reads in an ASCII text file (defined by the THREATPROFILE environment variable) at runtime and uses the waypoint data stored in the file to calculate a threat position and orientation at each iteration of the simulation loop. Threat position and orientation are written to the common shared memory arena as well as to two VAPS channels, "to_re_TOpos.CHA" and "to_re_TOtype.CHA". Refer to theses channels files for details of their contents.

2.2.3 External Scene

The external scene process uses the Vega Application Programming Interface (**API**) to generate realistic scenery for the out-the-window scene representation. The scenery database and other scene specific information are extracted from a configuration file

("ACDscene_info.txt") at runtime and used to initialize elements of the external view. The external scene reads pilot eye position and orientation from the FLSIM/HELISIM data export shared memory arena as well as threat position and orientation from the common shared memory arena. Various runtime keystrokes are provided to the experimenter to enable/disable visual effects (such as fog and time-of-day) as well as hide/show HUD symbology and interrupt execution of the simulation. A complete list of keystrokes is provided in Subsection 1.4.6 of this annex. Crash detection is accomplished via a "Height Above Terrain" (**HAT**) calculation which also serves as input to the radar altimeter calculations executed by the FLSIM/HELISIM simulation process. In order to support HUD symbology, the ability to overlay VAPS frames was also incorporated into the external scene process.

2.2.4 Data Collection

Data collection is accomplished by an independent set of processes that monitor information written to both the common shared memory arena and the FLSIM/HELISIM data export shared memory arena. The data capture application should be invoked following establishment of the FLSIM/HELISIM DE. The data capture application is located in "/usr/people/acd/bin/" as "FLSIM_dc" and "HLSIM_dc". The rate at which the data is collected is defined by the DATARATE environment variable. The data is captured in a binary format and written to the file specified by the DATACATURE environment variable. Following completion of the simulation, the data stored in the DATACAPTURE file may be converted to ASCII text format using the data dump application ("/usr/people/acd/bin/FLSIM_dd" and "/usr/people/acd/bin/HLSIM_dd"). The data dump application sends the converted data to "stdout" so the ASCII output should be redirected to an appropriate file.

The current data capture facility only monitors a small subset of the information available through the FLSIM/HELISIM data export interface. The parameters currently being collected are:

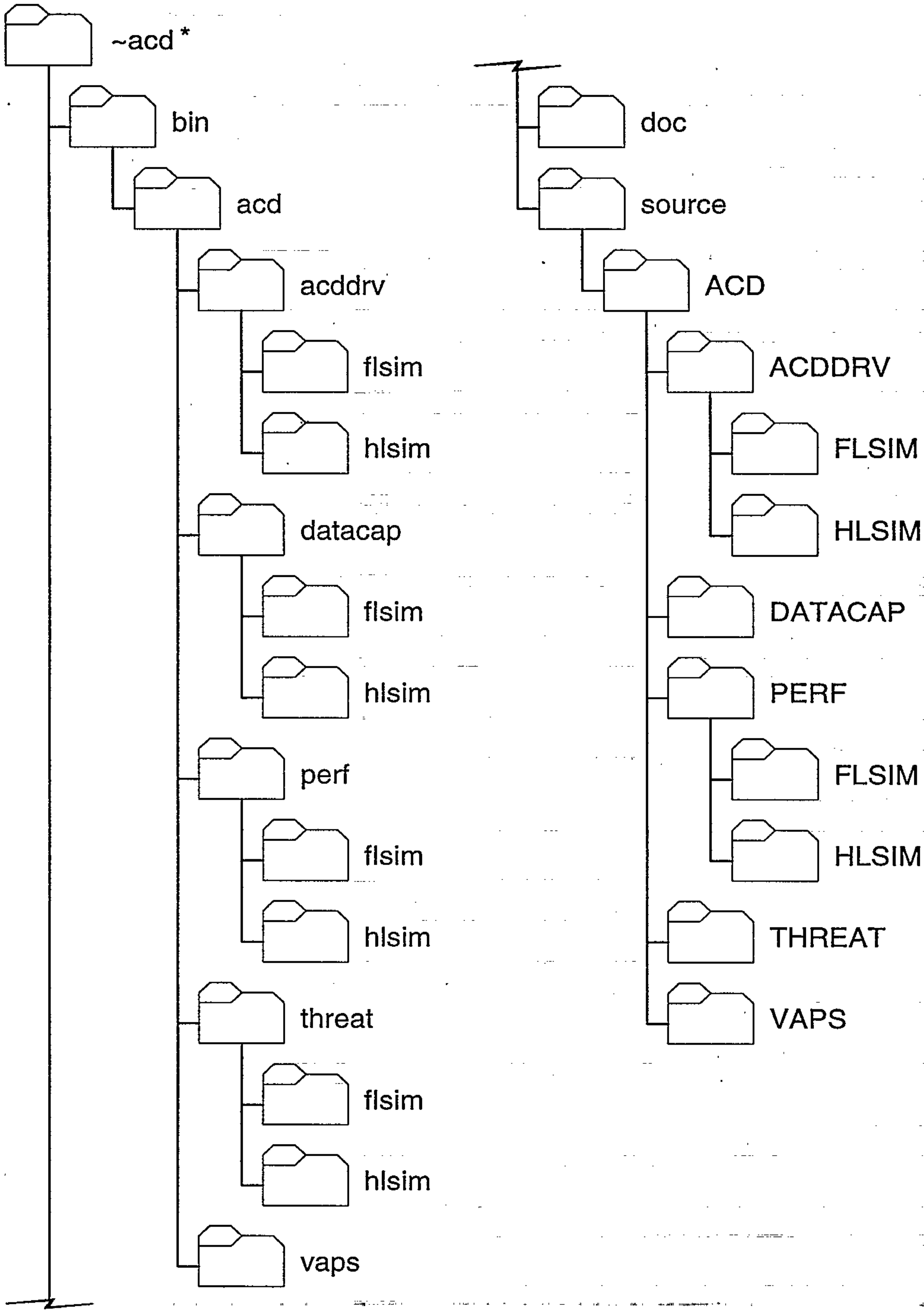
a. Simulation time;
b. Aircraft Lat/Lon Position;
c. Aircraft Altitude;
d. Aircraft Orientation (pitch, roll, heading);
e. Aircraft Orientation Change Rate (pitch rate, roll rate, heading rate);
f. Aircraft Vertical Speed;
g. Aircraft Airspeed;
h. Aircraft Mach Number;
i. Aircraft Angle of Attack;
j. Aircraft Weight;
k. Aircraft Fuel;
l. Aircraft Undercarriage Status;
m. Control Stick Position (fore/aft, port/stbd);
n. Control Throttle/Collective Position;
o. Control Pedal Position;

p. Threat Position (x, y, z); and
q. Threat Orientation (h, p, r).

The FLSIM/HELISIM data structure detailing additional parameters that may be monitored is defined in "flsim_export.h" and "hlsim_export.h" found in the "/usr/vpi/flsim/include" and "/usr/vpi/hlsim/include" directories, respectively.

3.1 SOURCE CODE DIRECTORY STRUCTURE

The source code for the ACD software is stored on Groucho under the "/usr/acd" directory. The subdirectories are defined in Figure B-3.



*Note: "~acd" represented "/usr/acd" at time of DCIEM ACD intsallation.

Figure B-3 Source Code Directory Structure

ANNEX C

DTA ACD SOFTWARE DEVELOPMENT PLAN

#S09314