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Aurora Air Traffic Management System

White Paper

August 17, 2006

ADACEL: Aurora White Paper

Printed in Canada.

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AURORA™
Air Traffic Management System

1 The Rationale for Aurora

Most of the world's remote and oceanic airspace is completely beyond radar coverage. Many of the current control systems rely heavily on manual operations and procedural separation standards. The lack of automation combined with the lack of surveillance capabilities severely limits the capacity of the ATC service providers to handle an increasing volume of traffic and be responsive to the increasing demands from the airlines for preferred routes and free-flight type of operations.

Modern ATM systems are expected to offer a complete solution for the problem by incorporating the latest CNS/ATM technologies in surveillance, communications, and ATC automation, as summarized below:

- Incorporate all available surveillance sources, such as radar, ADS-B, ADS-C, CPDLC and voice position reports, providing a seamless ATC environment for complex airspaces which include radar, transition, and non-radar environments;
- Implement reliable communication and data link systems such as CPDLC, and support various implementations of communications protocols and standards;
- Process the route and intent information from flight plans, ADS reports, and downlink requests, and generates internal 4-dimensional flight profiles used for conformance monitoring, conflict probes, and clearances;
- Update the internal flight profiles with position information from the surveillance data and perform conformance monitoring;
- Support automatic and manual exchange of flight data with external ATC units for flight planning, coordination, and transfer of control;
- Support the collaborative decision making process by providing automatic data exchange with external systems such as airlines, traffic management systems, billing systems, meteorological systems, etc.
- Automate the vast majority of controllers' actions, providing the additional bandwidth to handle more traffic and accommodate more pilot requests.

Along these lines, Aurora brings a set of important benefits to both the ATC service providers and the airspace users:

- More aircraft fly preferred, fuel saving tracks over long haul oceanic flights

- Increased surveillance, predictability, and system reliability
- Greater flexibility and responsiveness to in-flight requests through timely, reliable satellite data communications, additional cost savings and benefits
- Streamlines intensely manual processes freeing controllers to respond to pilot requests
- Implementation of common procedures and systems at a regional level
- Market growth --- the result of increased airspace capacity and efficiency through reduced separation standards.

2 Aurora – System Overview

Adacel's AURORA product is an advanced, highly configurable Air Traffic Management system that has proven itself in operation in the New Zealand, Iceland, and Portugal oceanic airspaces, and is in now in operation in US oceanic airspaces. The US Federal Aviation Administration, under the Advanced Technologies and Oceanic Procedures (ATOP) program, has chosen AURORA software for a new ATM system that has been installed by the ATOP prime contractor, Lockheed Martin Transportation and Security Systems (LMTSS) in the FAA's oceanic control centres in Oakland, New York, and Anchorage. When the US installations are complete, AURORA will provide ATM service for more than 80% of the world's controlled oceanic traffic.

The AURORA system's advanced automation tools assist the controller in providing safe and efficient ATM services in procedural airspaces and radar-procedural transition sectors. The system performs the following functions:

1. Flight time calculations: automatic calculation of estimated flight and fix times for all flight operations, both on and off airways.
2. Advanced conflict determination:

- Aircraft-to-aircraft conflict detection: The system alerts the controller if an aircraft's cleared flight profile is not separated from the protected airspace of all other flights within the airspace.
- Aircraft-to-airspace conflict detection: The system alerts the controller if the cleared flight profile is not separated from all reserved airspaces.
- Airspace-to-airspace conflict detection: The system alerts the controller if the reserved airspaces are not properly separated.

The system chooses the applicable separation standards for the airspace and aircraft equipment.

3. Monitoring of conformance of a flight path to its cleared trajectory in terms of current position, time, altitude, and future intentions.
4. Minimum safe altitude warning: The system ensures that the IFR flights in the system are planned at levels/altitudes above the minimum safe altitude and that any clearances entered also provide adequate terrain clearance.
5. Display of flight data and aircraft position data on high-resolution controller displays, including automatic maintenance of flight strip data.
6. Integration of Automatic Dependence Surveillance (ADS) and Controller Pilot Data Link Communications (CPDLC)

7. Full integration with third-party Radar Data Processing Systems (RDPSs).
8. Automatic coordination between adjacent sectors and centres.
9. Recording and playback of all operations, resulting in benefits for training, operational analysis and investigation of incidents.

AURORA also includes a fully integrated training and simulation mode.

AURORA is based on a distributed architecture concept. The system can be fully redundant in order to provide the very high level of availability required for an operational system.

AURORA consists of the following main components:

1. The *operational system*, which includes the core flight data processing and conflict prediction functions, the user interface at the controller workstations, and the radar gateway functions that interface AURORA to an RDPS. The operational system also includes communication interfaces that link the system to:

    - External air traffic facilities, airlines, and other destinations through the Aeronautical Fixed Telecommunication Network (AFTN)
    - Meteorological data sources
    - Data link service providers for ADS/CPDLC communication.

    The operational system also includes system monitoring and control, and operational data recording.

2. The *adaptation data management system*, including adaptation data entry, and generation of the operational adaptation database.
3. The *training system*, which provides high fidelity training by re-using the operational software with built-in simulation capabilities.

3 System Configuration

As shown in the hardware architecture diagram in Figure 1, AURORA is a distributed system consisting of IBM RISC/6000 workstations communicating over a dual local area network (LAN). All of the IBM processors run IBM's AIX operating system.

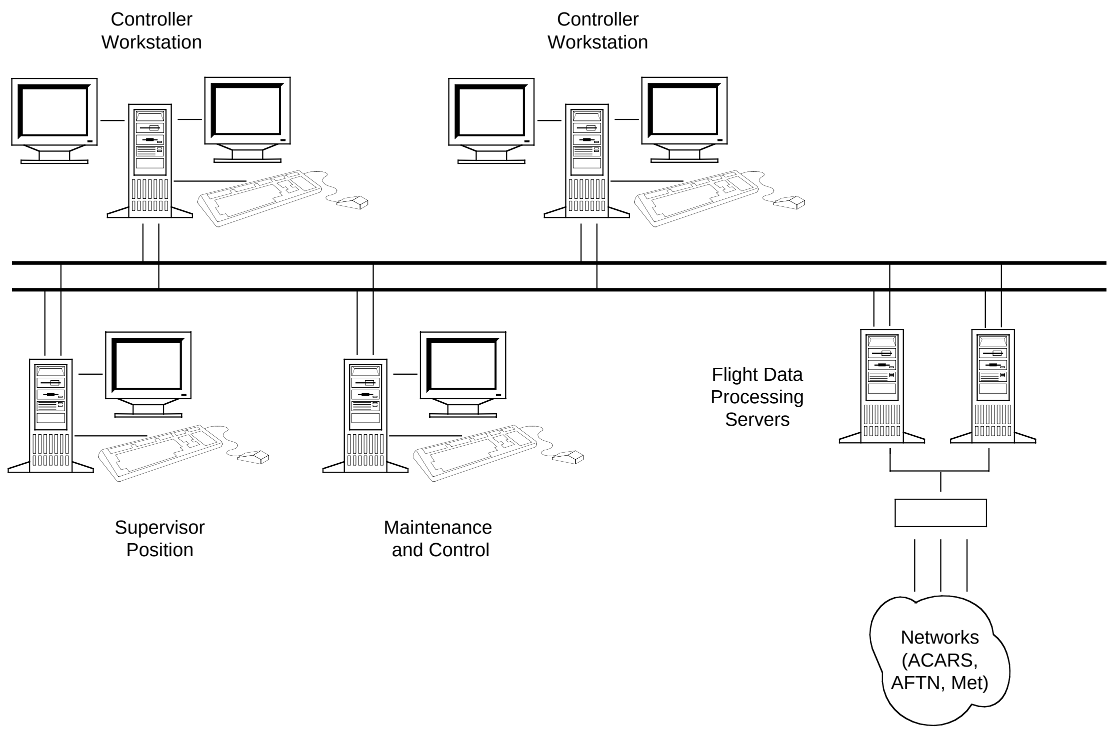

Figure 1 Operational System Hardware Configuration

The processors are identified as either servers or processors: servers provide a centralized set of functions used by other components of the system. Servers are always deployed in a redundant pair with automatic switchover mechanisms so that when an active server fails, the corresponding backup takes over.

Processors support the user interface at a working position. These processors are not paired for redundancy; to recover from a processor failure at a controller workstation, the affected sectors can be moved to a spare position, or consolidated with sectors on another workstation using the system's sectorization functions.

The controller workstations have dual graphics cards to drive high-resolution displays for the ASD and flight data display.

4 Software Configuration

AURORA's software configuration consists of a number of Computer Software Configuration Items (CSCIs).

AURORA Computer Software Configuration Items (CSCIs) can be divided into three major groups: the Infrastructure CSCIs, the Application CSCIs, and the Training/Simulation CSCIs. The Infrastructure CSCIs support distributed systems in general, but mostly are not specific to air traffic control systems. The applications CSCIs are completely specific to air traffic management. The training/simulation CSCIs are included in this list because of their close relationships with the other operational CSCIs.

5 Concept of operation

The operational system provides automation functions for several operational roles, including the air traffic controller, the supervisor, and support roles.

Air Traffic Controller: Provides separation services to aircraft under his/her jurisdiction and is in direct or indirect communication with aircraft pilots. The controller's interface to the AURORA system consists of two display screens, a keyboard and a mouse. The screens display situation data to the controller in the form of electronic flight strips and, on an Aircraft Situation Display (ASD), a geographical view of aircraft position symbols with associated data blocks showing flight data for the aircraft. The screens also display a variety of dialogue windows that may be invoked by the controller in order to interact with the system's functions.

Supervisor: At the workstation configured as the supervisor position, a user who is logged on with supervisor privileges has access to system functions that handle airspace reservations, setting of certain Variable System Parameters (VSPs), sector consolidation and de-consolidation, re-assignment of control sectors to balance workload or after a workstation failure.

Flight Data Repair: This role can be assumed by an air traffic controller or a supervisor, or it can be an exclusive role on a dedicated workstation. It is responsible for processing incoming system messages, such as flight plans, that contain errors that prevent the system from successfully handling the message. Corrects the errors and resubmits the message to the system.

System Operator and Administrator: The system operator manages the configuration and makes all decisions concerning system availability. Monitors the system, isolates failures, initiates repair actions. The system operator performs system start-up and shutdown, manages distribution of system releases, and performs user management function.

6 External Interfaces

AURORA uses the Aeronautical Fixed Telecommunication Network (AFTN) as the principal interface with neighbouring FIRs, aircraft operating agencies and weather offices. AFTN protocol conforms to ICAO Annex 10 Volume 2 as applicable to an automated centre. AFTN message formats are International Alphabet 5 (IA-5).

AURORA uses the ACARS network (e.g. SITA), to provide an ACARS character-oriented interface to the aircraft to implement the FANS protocol, including CPDLC, ADS and ATC facility notification (AFN).

AURORA receives GRIB data from the meteorological centre using a dedicated X.25 based permanent virtual circuit link (PVC).

Messages received from external links are validated, printed, logged, and routed to the appropriate system function. Incorrect messages are placed in a correction queue. Messages generated by the system are logged before being sent on the appropriate link.

AURORA interfaces with external Surveillance Data Processing Systems, in order to receive and display radar and ADS-B tracks

AURORA is upgradeable to ATN interface.

6.1.1 Message Sets Supported

The following message sets are supported:

a) Standard ATS message set as defined in ICAO PANS/RAC Document 4444 or as amended in agreement with the customer.

b) NAS and ETMS message sets.

c) ARINC radio operator and Air radio operator AFTN messages as reviewed with the customer.

d) ADS and CPDLC messages, as defined in the ARINC 745-2 and RTCA DO-219 respectively. Adacel’s implementation of uplink message number 80 (Route Clearance) currently includes the following fields: Departure, Destination, Departure Runway, Departure Procedure, Arrival Runway, Approach Procedure, Arrival Procedure, Airway Intercept, and Route. Other CPDLC messages are implemented in their entirety.

e) AIDC or On-Line Data Interchange character oriented (OLDI) message set, using the AFTN or dedicated links as agreed with the customer.

f) NOTAM and weather messages, received on the AFTN, as agreed with the customer.

g) Special messages and data links, as agreed with the customer, e.g. interface to a billing system, processing ACARS position reports, co-ordination, hand-off between adjacent ACCs.

h) GRIB format meteorological data in World Meteorological Office (WMO) format FM 92-1X.

7 Controller interface

Most functions of the operational system directly or indirectly support the situation display and flight-data display of the controller interface, including the many dialogue windows that provide access to operational functions.

The Controller Workstation is equipped with a Controller Workstation Processor (CWP), a main display monitor primarily used for an Aircraft Situation Display (ASD), a second display monitor, and a keyboard and mouse plus an optional second keyboard and mouse.

Other set of tabular display windows provide the controller with additional data, planning tools and functionality. Most of these windows are available on request, and they can be moved around the screen and overlaid temporarily on other windows or the situation display.

Wherever possible, the system will automatically pre-fill window fields based on the aircraft of interest. This minimizes keyboard entries by the controller.

Some examples of important windows are presented below.

7.1.1 Sector Window

The Sector window, shown in Figure 2, displays flight strips for flights of interest to the sector controller. The strips are sorted by flight level and displayed under posting headers for selected flight-levels. Airspace reservation strips affecting the sector are displayed in the bottom of the flight-strip bay. The strips are automatically updated by the system to reflect clearances, revised estimates, coordination events, position reports, etc.

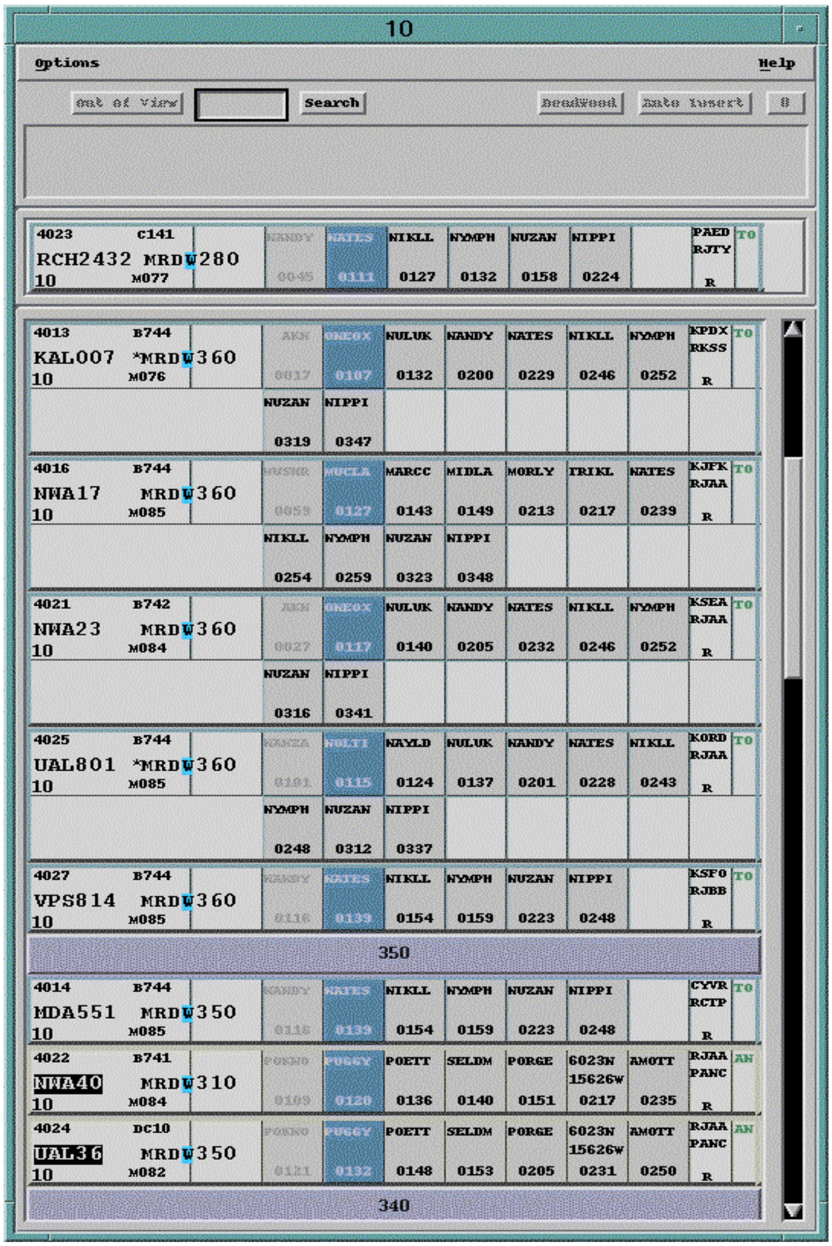

Figure 2 Sector Window

7.1.2 Conflict Windows

- Conflict Summary Window: lists all aircraft-aircraft and aircraft-airspace conflicts which affect a particular sector.

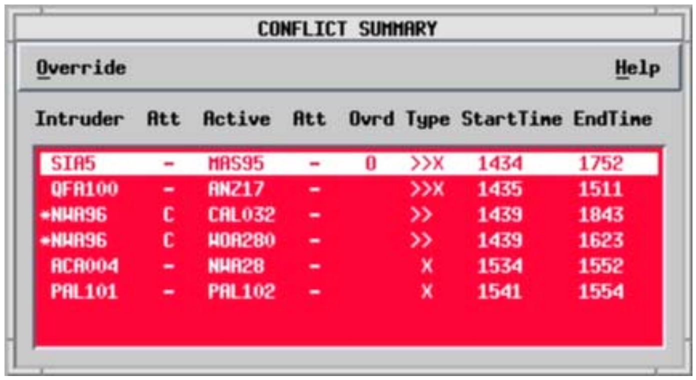

Figure 3 Conflict summary Window

- Conflict Report window: provides the detail of a conflict selected in the Conflict Summary Window.

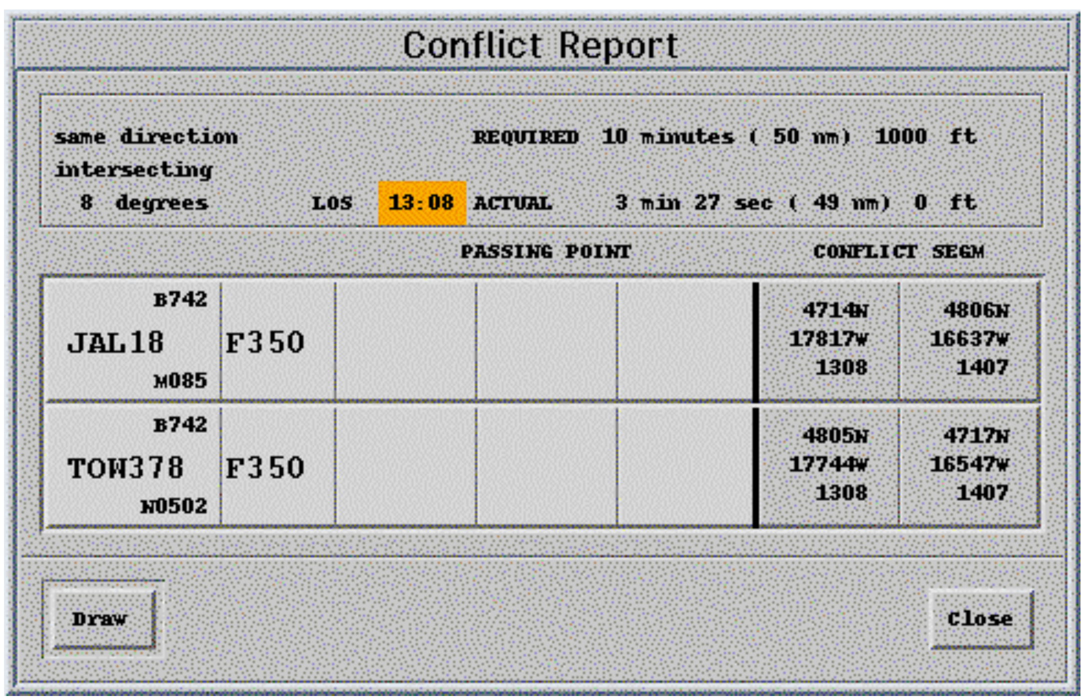

Figure 4 Conflict Report Window

7.1.3 Aircraft Situation Display

The ASD displays aircraft positions and flight data with a background display of selectable maps and lists of aircraft information. Multiple sources of surveillance data are being used, as described earlier.

Many other windows and functions are accessible through the APS and data block, as well as through the menu bar and list entries.

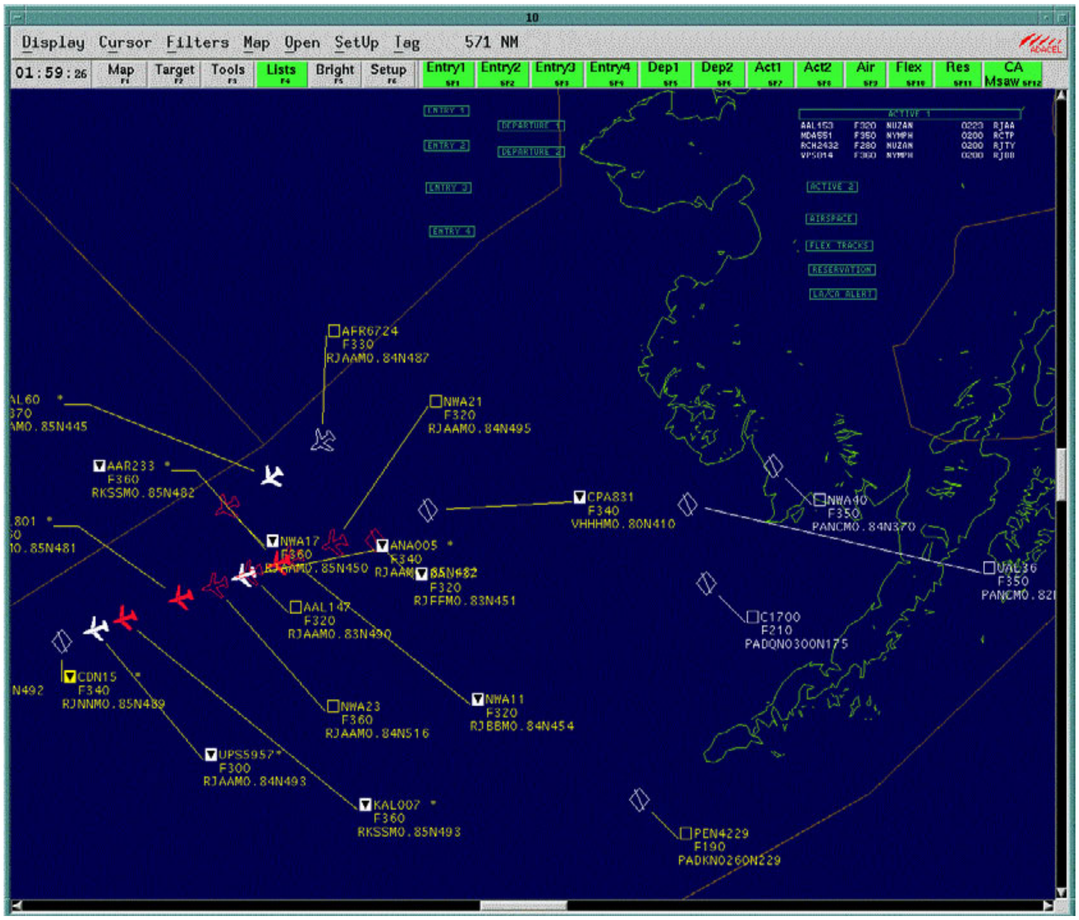

Figure 5 Airspace Situation Display

8 Adaptation Data Management

Adaptation data is used to tailor the operation of the AURORA system to the specific geography, airspace, and procedures of a particular FIR. Adaptation also includes unique site-dependent data required by the operational software at system initialization and provides default settings for state data.

For AURORA, adaptation includes the system configuration, environmental, airspace, geographic, system parametric and other site unique data necessary for operational air traffic control at a particular control centre.

Adaptation data is maintained by the Environmental Data Management (ENVT) component of the system. The ENVT application uses the Sybase RDBMS and text data-entry forms in a GUI interface. It provides the user interface and a number of utilities for preparing the adaptation database and for performing adaptation-related processing.

9 Site Training System

AURORA supports high-fidelity training by using the operational hardware and software in combination with simulation-specific components that provide a simulated external environment for the operational components.

A typical training configuration consists of a Training Server (TRNS), as many CWPs as desired, an MCP, and one or more Pilot Position Processors (PPPs).

The TRNS is the training configuration of the Flight Data Processing Server (FDPS), which also hosts the simulation software component (SIM). SIM is driven by simulation scenario files containing scripted external messages and flight plans, and injects scripted external messages (inter-facility and air-ground data link messages) into the system for distribution to the appropriate operational system component.

The Pilot Position Processor (PPP) hosts software that allows the user to assume the role of a pilot (e.g., to participate in CPDLC dialogues, and to control flight trajectories) or of an adjacent facility (e.g., to participate in online coordination dialogues).

The Exercise Preparation (EXPREP) component of AURORA provides tools for the creation of exercise scenarios.

For more information about the Aurora Air Traffic Management product, please visit www.adacel.com or contact Bill Lang, Adacel's Vice President of Adacel's Air Traffic Management division at bill.lang@adacel.com or at 1-514-636-6365.