

CANADIAN AERONAUTICAL MOBILE DATA TRIALS

Allister Pedersen

Communications Research Centre (CRC)
 Department of Communications, Canada
 P.O. Box 11490, Stn. H
 Ottawa, Ontario, Canada K2H 8S2
 Phone: (613) 998-2011 Fax: (613) 990-0316

Andrea Pearson

Telesat Mobile Inc. (TMI)
 1145 Hunt Club Road
 Ottawa, Ontario, Canada K1V 0Y3
 Phone: (613) 736-6728 Fax: (613) 736-4548

ABSTRACT

This paper describes a series of aeronautical mobile data trials conducted on small aircraft (helicopters and fixed wing) utilizing a low-speed store-and-forward mobile data service.

The paper outlines the user requirements for aeronautical mobile satellite communications. "Flight following" and improved wide-area dispatch communications were identified as high priority requirements.

A "proof-of-concept" trial in a Cessna Skymaster aircraft is described. This trial identified certain development work as essential to the introduction of commercial service including antenna development, power supply modifications and doppler software modifications. Other improvements were also proposed.

The initial aeronautical mobile data service available for pre-operational (Beta) trials is outlined. Pre-operational field trials commenced in October 1992 and consisted of installations on a Gralen Communications Inc. Cessna 177 and an Aerospatiale Astar 350 series light single engine helicopter.

The paper concludes with a discussion of desirable near term mobile data service developments, commercial benefits, current safety benefits and potential future applications for improved safety.

INTRODUCTION

Wide-area mobile communications services will improve significantly in North America with the introduction of MSAT services in late 1994 or early 1995.^[1] In advance of the launch of MSAT; Telesat Mobile Inc. (TMI), with support from the Canadian Department of Communications Research Centre (CRC), has been introducing mobile satellite services using leased satellite capacity.

The initial service offering is a low-speed store-and-forward packet-switched mobile data service (MDS) via leased capacity through the INMARSAT II Atlantic Ocean Region West satellite and the Teleglobe Canada ground station located in Weir Quebec.^[2] For more than 2 years the mobile data service has been used for Wide Area Fleet Management (WAFM) by various trucking companies, other land mobile fleets, marine fleets and portable users with

battery-powered briefcases. The MDS also serves SCADA (Supervisory Control and Data Acquisition) applications such as monitoring of remote natural gas compressor stations. The development of an aeronautical mobile data service known as AeroKIT™ was of considerable interest to prospective commercial and government users.

USER REQUIREMENTS

The user requirements for aeronautical mobile satellite communications were first discussed with potential MSAT aeronautical end-users in a series of meetings initiated by CRC in 1983/84. Although there is interest in the full range of MSAT voice, data and fax services; "flight following" and improved wide-area dispatch communications were identified as high priority requirements by Canadian aircraft operators.

While most commercial passenger flights in Canada are served by existing terrestrial VHF radio services, a significant number of aircraft operate in rural, remote and rugged areas well beyond coverage of terrestrial VHF radio dispatch systems and also beyond Transport Canada radar and VHF air traffic control coverage. HF systems are used to the extent possible but congestion, interference and varying propagation conditions may preclude any use of HF in the Canadian North for several weeks at a time.

There is therefore an urgent requirement for reliable, wide-area, cost-effective, truly mobile communications for small general aviation aircraft including helicopters. In the simplest terms the aviation community wants reliable communications for conventional dispatch purposes and "flight following". The Ontario Ministry of Natural Resources requires pilots to maintain a "flight watch" by having aircraft communicate their positions once every 30 minutes to their regional dispatcher.

The potential end-user community for this aeronautical mobile data service includes aircraft involved in search and rescue, forest-fire fighting, wildlife surveys, power line monitoring, air ambulance medevacs, resource development, airborne fishery surveillance and policing.

The Canadian market could include civilian and military aircraft, commercial passenger jets operating on routes in northern Canada, charter aircraft and various other general aviation aircraft.

PROOF OF CONCEPT TRIAL

Under the MSAT Field Trials Program, CRC provided a CAL Corp. land mobile data terminal to avionics specialists Gralen Communications Inc. and TMI for a "proof-of-concept" trial. Working with Telesat Mobile, Gralen Communications installed the 12V land-mobile data terminal and a prototype aeronautical mobile antenna in a Cessna 337 Skymaster.

The aeronautical mobile data trial was relatively straightforward to implement with end-to-end commercial services already in place for land, marine and SCADA applications. Successful 2-way mobile data communications, including GPS position reporting, were demonstrated as illustrated in the system concept (figure 1). The dispatch centre for the proof-of-concept trial was co-located in Ottawa at the TMI hub.

This proof-of-concept trial, while very successful, resulted in certain work being identified as essential to the introduction of commercial service. The proposed work plan included antenna development, power supply modifications, doppler software modifications, appropriate physical packaging for the transceiver and work on the existing land mobile dispatch centre. Other improvements also proposed included a cockpit dash-mounted emergency message switch and a dash-mounted "message waiting lamp".

TMI AEROKIT SERVICE-BETA TRIALS

The proof-of-concept trial and subsequent development effort resulted in a pre-operational AeroKIT™ service appropriate for Beta trial customers. While still under development the service already offers an effective wide-area aeronautical fleet management service that consists of 2-way store-and-forward messaging and flight following with the ability to constantly monitor aircraft position.

CAL Aeronautical Data Radio

As shown in Figure 2, the mobile installation includes a CAL Corp. ADT 200-A aeronautical transceiver, antenna, and LNA (Low Noise Amplifier); a Gandalf keyboard display terminal and a GPS antenna. The overall weight is 9.0 kg. The transceiver contains a GPS receiver card, operates from 28 V and is mounted in a standard ATR box that is 19 cm wide, 32 cm deep and 21 cm high. A doppler software modification allows the radio to be used on aircraft operating at speeds up to 1400 km/hr.

The data terminal consists of a standard QWERTY keyboard, numeric keypad and several special function keys for sending an emergency message or selecting menu items from the backlit 4X40 character liquid crystal display. The data terminal, which can be stored when not in use, is supplemented with a dash-mounted emergency message button and a dash-mounted "message waiting" lamp. An optional dash-mounted switch can be used to manually send takeoff/landing messages when they are not sent as a keyboard-entered coded message or when they cannot automatically be transmitted as they are in aircraft with retractable gear.

The LNA (13 cm W X 15 cm D X 4 cm H) is mounted inside near the transceiver antenna (16 cm diameter X 4 cm high). The transceiver antenna can also act as a GPS antenna although it has a null at the zenith. The GPS antenna is 9 cm in diameter and 1 cm high.

AeroKIT FLAG Dispatch Centre

The AeroKIT™ FLAG™ (Fleet Location and Graphics) dispatch centre (Figure 3) consists of an IBM-compatible PC, Unix operating system, messaging monitor, colour graphics monitor, keyboard, mouse, uninterruptible power supply and 2400 bps modem. The modem provides a permanent virtual circuit between the dispatch centre and the TMI hub via the datapac public packet-switched network. The FLAG™ dispatch centre developed by Ultimateast Data Communications of St. John's Newfoundland was already in use for various INMARSAT, AMSC and TMI mobile customers including the Canadian Coast Guard and Department of Fisheries and Oceans.

While the FLAG™ dispatch centre can display geographical maps of any dispatch area of interest in the world, a geographic display of North America is being used for the aeronautical data trials. The graphics screen displays on the map overlay the geographical position of all aircraft based on GPS position reports transmitted automatically from aircraft in the end-users own fleet. GPS worst-case accuracies are 100 metres horizontally and 156 metres vertically. The FLAG™ dispatch centre allows a dispatcher the capability to increase map detail by zooming in on any rectangular area chosen.

Other standard overlays include reference points such as city names, boundaries, roadways and road names and latitude/longitude grids (1 or 5 degree increments). A screen draw function allows the dispatcher to use the mouse as a white pencil to enter temporary information on the screen. Many other hardware and software options are available with FLAG™ dispatch centres.

End-to-end AeroKIT™ Service

The AeroKIT™ Beta trial service provides a 2-way dispatch and flight-following capability between a dispatch centre and a fleet of aircraft.

As with other mobiles using the TMI mobile data service, pilots can manually send/receive 3 types of messages to/from a dispatch centre using 3 different priorities. Messages can also be saved, retrieved and revised as required by either the pilot or dispatcher.

Flight Following

A very important feature of the service is that the mobile radio logs on to the satellite system automatically when the aircraft is powered up without any action by the pilot. Aircraft position reports are automatically transmitted at intervals prescribed by the dispatcher which can be as frequent as once every 3.75 minutes as configured for the Beta trials. A takeoff message, comprising all the information in the position report, can also be transmitted automatically for aircraft with an interface to the squat switch (wheels up/down indicator). For helicopters, float planes and other aircraft without retractable gear the automatic takeoff/landing messages can be sent manually using a dash-mounted switch, the keyboard or automatically using another interface such as a torque sensor to trigger the message. The foregoing embodies a reliable, automatic, highly accurate flight following capability that allows a pilot to concentrate on flying.

Cockpit Messaging

The Gandalf terminal can be used by the cockpit crew to send pre-programmed coded messages. With only 3 or 4 keystrokes a pilot can scroll through a list of coded messages, choose the appropriate message, and then transmit it. By default the message is sent as a routine message although the coded message can be sent priority or sent as an emergency coded message. Emergency messages overwrite the status line on the dispatch screen with a flashing message. Sample coded messages being used in the Beta trials include:

- out of chocks
- in chocks

- send destination weather
- send alternate weather
- arrived at destination
- 15 (30, or 60) minutes to arrival

In a similar manner, crew can also select a variety of fill-in-the-blanks form messages such as the following; flight plan, freight information and revised ETA. Free-form text messages, up to 128 characters in length, can also be sent to the dispatch centre.

Position Reports

Regularly scheduled GPS position reports, and supplementary GPS position reports automatically sent along with the chocks messages, takeoff/landing messages and emergency messages all contain the following information:

- date and time (UTC)
- latitude/longitude
- horizontal velocity
- vertical velocity
- altitude
- bearing relative to true North
- GPS reliability report

Emergency Messaging

Transmission of an emergency message, by pressing the dash-mounted emergency button or the "E" and "TX" keys, receives special treatment. The emergency message is broken into 2 messages. Emergency message 1, which is transmitted twice for increased reliability, provides the position in latitude/longitude, reliability of position report, and heading. After emergency message 1 is re-transmitted, emergency message number 2 is sent containing horizontal speed, altitude, vertical speed and date/time.

Dispatch Messaging/Monitoring

The dispatcher also has the capability to send coded and form messages as well as free-form

text messages up to 121 characters per message. Dispatchers can also retrieve the detailed position report of an aircraft by placing the mouse cursor over the desired aircraft on the screen. The most recent position report, along with its date/time, is displayed as well as the distance and direction from the nearest reference location based on a user-determined list of place names and associated coordinates.

The "Aircraft Proximity" feature displays the identification of all aircraft within a specified radius of a selected location in order of the closest aircraft. The "Fleet Stats" feature lists the location of all aircraft in the fleet. "View Trips" allows the dispatcher to display, on the geographic overlay, the historical position reports for any aircraft for a time period specified in hours, days, weeks or months. The "View Trips" function provides important information about any overdue aircraft.

BETA TRIALS

The first Beta trial involved the installation of the CAL ADT 200 in a 4-place high performance single engine Cessna 177 RG (Retractable Gear) for test and demo purposes. The aircraft, owned by Gralen Communications and used for travel to customer sites, successfully demonstrated the full range of services including automatic takeoff/landing messages. This Beta trial indicated more EMI work was required resulting in the subsequent use of improved cable shielding and connectors. This trial led to Transport Canada (DO 160C) and Communications Canada approvals for the implementation of end-user trials commencing in March '93.

A second temporary installation in an Aerospatiale Astar 350 series light single engine helicopter demonstrated no communications problems from the antenna rotor.

Gralen Communications Inc. will be installing the CAL ADT in an Ontario Ministry of Natural

Resources DeHavilland Twin Otter used for resource management and occasionally by the Ontario Provincial Police. Hydro Quebec is participating in the Beta trial with an installation in an AS 350 helicopter used for high voltage power line distribution surveillance. (The results of these trials, implemented after submission of the paper, will be reported at the conference).

FUTURE DEVELOPMENT WORK

Future work will focus on the development of a more appropriate keyboard/display for cockpit applications. The requirement for additional graphics overlays for specific end-user applications is under discussion. Ontario MNR dispatchers would benefit from an overlay displaying Ontario lakes suitable for Canadair CL-215 water bomber access. Overlays displaying remote airstrips and fuel caches may also be desirable features for the MNR dispatch computer. Implementation of a dispatch software feature to initiate a dispatch centre alarm after a prescribed number of regularly scheduled position reports were missed would be desirable. This would be an important safety improvement for accidents where ELT (emergency locator transmitter) signals may not be detected for up to 2 hours, where ELTs don't operate at all because of extensive ELT damage or the ELT antenna is damaged or upside down.

CONCLUSIONS AND BENEFITS

A reliable wide-area fleet management and flight-following system has been demonstrated in small general aviation fixed and rotary wing aircraft. The system offers automatic position reporting and takeoff/landing messages.

Service benefits include more reliable flight following, improved safety, capability for realtime re-routing, more efficient cockpit and dispatch communications and more timely information for better management decisions and customer invoicing.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the following for their constructive feedback; Mr. Graham Smith, President of Gralen Communications Inc. and Mr. Paul Holder Northeast Region Aviation Program Manager Ontario Ministry of Natural Resources.

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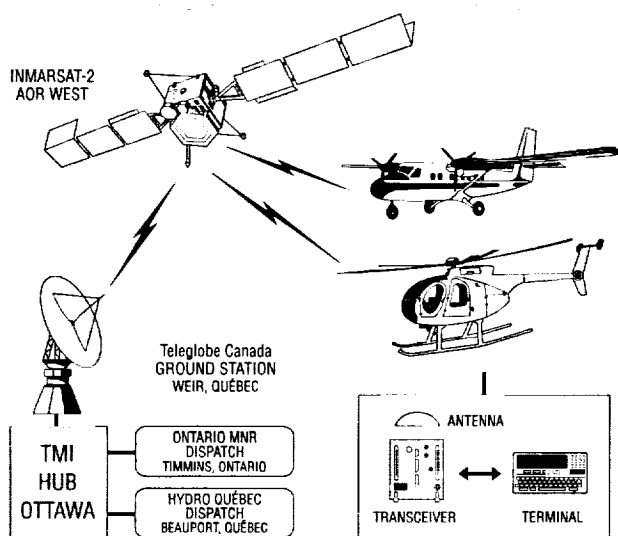


Figure 1 System Concept

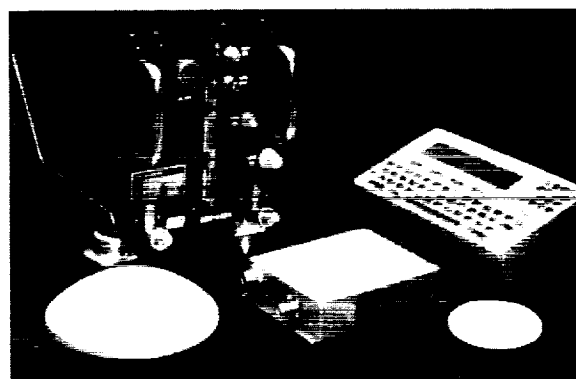


Figure 2 Aeronautical Data Radio

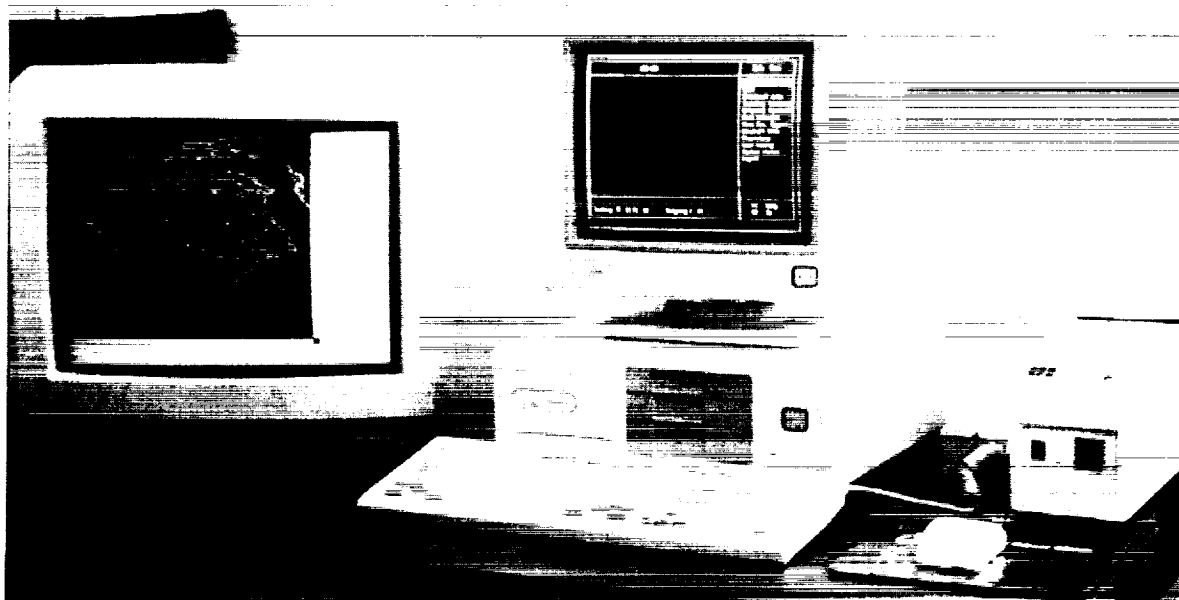


Figure 3 Dispatch Centre