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MDCRS: AIRCRAFT OBSERVATIONS COLLECTION AND USES

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1. MDCRS OVERVIEW

The Meteorological Data Collection and Reporting System (MDCRS) was designed for the Federal Aviation Administration (FAA) and the National Weather Service (NWS) to collect, decode, store and disseminate aircraft meteorological observations. The system, targeted primarily at improving upper air wind forecasts, was fielded in 1991.

1.1 Background

In the spring of 1986, the ad hoc Aviation Weather Forecasting Task Force, headed by Dr. John McCarthy of the National Center for Atmospheric Research (NCAR), made 20 recommendations for improving aviation weather products and services provided to the aviation community by the NWS (McCarthy 1986). These recommendations were made with the belief "that relatively simple changes in the collection, processing, and dissemination of weather data can greatly improve the safety and efficiency of the National Airspace System (NAS)." One of the six recommendations with *vital* technical priority was to implement, nationwide, an automated aircraft weather data reporting system. The Task Force reported that "a modest investment in an automated airborne weather data collection system in the United States would have an enormous impact on the accuracy and specificity of aviation weather forecasts and warnings. In fact, *the group placed the highest priority on a recommendation to develop a national capability to collect and use automated reports from aircraft.*"

Subsequent actions on this recommendation by the FAA led to the development and deployment of the MDCRS by Aeronautical Radio, Inc. (ARINC).

Although the primary purpose of the Aviation Weather Forecasting Task Force's recommendation was to use aircraft observations to improve upper air forecasts, other uses of MDCRS have been identified:

- MDCRS data is passed onto the United Kingdom Meteorological Office (UKMO) for use in their forecast models;
- Massachusetts Institute of Technology (MIT), Lincoln Laboratory is integrating MDCRS data into the Integrated Terminal Weather System (ITWS);
- Forecast System Laboratory (FSL) plans to integrate MDCRS data within the Aviation Gridded Forecast System (AGFS);
- NCAR plans on using MDCRS data in the Commercial Aircraft Sensing Humidity (CASH) program and, indirectly through AGFS, in the Aviation Weather Product Generator (AWPG) program; and
- Battelle Pacific Northwest Laboratory uses MDCRS data within the Energy Atmospheric Radiation Measurement research project.

1.2 MDCRS System Overview

The MDCRS, depicted in Figure 1, collects, decodes, and disseminates automated aircraft position and weather reports. Aircraft that serve as sources for MDCRS are operated by numerous airlines and corporate aircraft. Airlines report meteorological data over Aircraft Communication, Addressing and Reporting System (ACARS) in various formats and frequencies (typically every 5-7 minutes during each flight). The aircraft observations are in various formats because airlines implement software consistent with their own operational requirements. MDCRS receives and converts aircraft observations into a standard format specified by the NWS and stores them in a data base. MDCRS observations are then encoded for dissemination in the Binary Universal Form for the Representation of Meteorological Data (BUFR), which is the World Meteorological Organization's (WMO) standard code designed to optimize the communication of

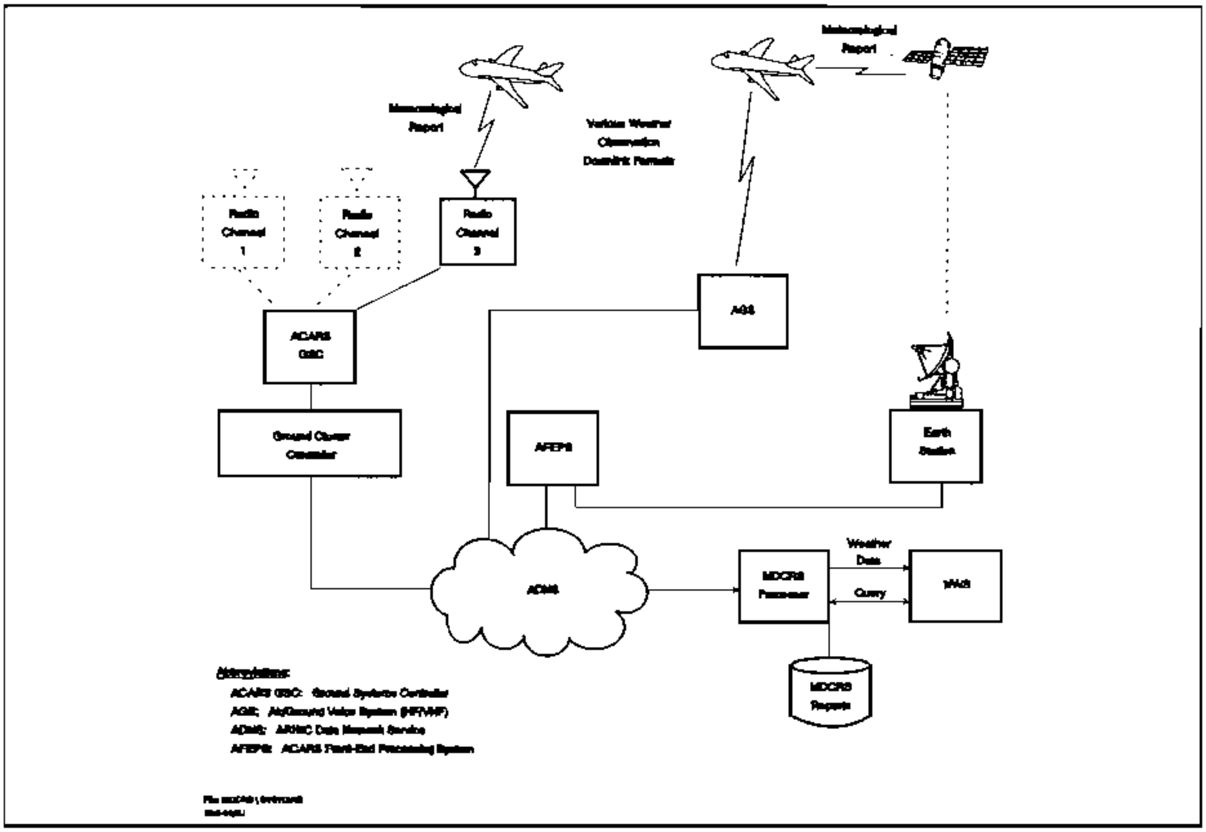

Figure 1: MDCRS System Diagram

meteorological observational data. Major MDCRS features include:

- Receiving Aircraft weather observations in multiple formats and forwarding to users in a one standard format;

- Observations clustered along airline flight routes;

- Ability to add new airline formats without writing a new decoder for each one;

- Query capability allows scheduled transmission of predefined geographical areas, routes and altitudes; and

- ARINC's Tandem Fault-tolerant computer provides high reliability and availability.

Today, aircraft meteorological observations generally provide a subset of the fields shown in Figure 2. Although turbulence, airframe icing and humidity are not currently automatically reported via MDCRS, work is in process to develop the appropriate sensors and algorithms to provide this valuable information.

2. USES OF MDCRS

MDCRS real-time winds and temperature data provide valuable input to the NWS models and to the FAA weather programs.

2.1 NWS Uses

In the past, the National Meteorological Center (NMC) received raw ACARS data via the Forecast System Laboratory (FSL) and decoded the data for use in the Global Data Assimilation System (GDAS)/Aviation Forecast Model and the Regional Data Assimilation System (RDAS)/Nested Grid Forecast Model. With the implementation of the MDCRS system, NMC was relieved of the responsibility of decoding data for different airlines in a variety of formats that change as airlines modify/enhance their aircraft avionics. In addition, the redundancy in MDCRS will ensure consistent and timely delivery of operational data at NMC. The timely delivery is especially important, because the goal of NMC's Mesoscale Analysis and Prediction

Aircraft Flight Number*	Vertical Gust Acceleration
Year, Month, Day, Hour, Minute*	Roll Angle
Latitude/Longitude*	Airframe Icing
Aircraft Navigation System	Phase of Flight
	Aircraft Tail Number
Time-Average or Instantaneous Measurements	Reported Precision of Lat./Long.
Wind Speed*	Reported Precision of Temperature
Wind Direction*	
	Degree of Turbulence
Temperature*	
	Pressure
	GPS Altitude

Figure 2. MDCRS Report Fields. Fields currently reported by most airlines are noted with asterisks.

System (MAPS) implementation is to produce hourly analyses within 30 minutes of the nominal hourly data times. In addition to the flight-level data, ascent and descent profiles of wind and temperature data will be used to construct soundings at almost three hundred airports in North America.

MDCRS data, together with Wind Profiler data and surface observations, provide the primary *off-time* data to the RDAS. Use of MDCRS data in the RDAS has reduced errors in the short-range forecast and guess fields used in the analysis system by 25-30 percent (Dey et al. 1991). MDCRS also provides the primary source of off-time data for NMC implementation of MAPS.

2.2 FAA Uses

The FAA is sponsoring R&D aimed at improving aviation weather information as part of its Aviation Weather Development Program (AWDP; Sankey and Hansen 1993). There are three major system components of the AWDP: AGFS, AWPG, and ITWS (mentioned in section 1.1). Since the provision of up-to-date weather information is the goal of all three subprograms, MDCRS provides an ideal data source.

2.2.1 AGFS

The AGFS being developed by FSL (Sherretz 1991; Kraus 1993) is a high resolution, data assimilating model based on improvements to MAPS. The goal is to increase model temporal resolution to 1 hour or better and a spatial resolution to 15-30 km. The output of the AGFS will be a "translated" version of atmospheric state variables (e.g., temperature, humidity, winds) useful to aviation (e.g., winds aloft, ceiling, visibility). MDCRS data become even more important to the quality of model forecasts when resolution requirements are so demanding.

2.2.2 AWPG

The AWPG being developed by NCAR takes information from AGFS and transforms it into products for use primarily in pre-flight and enroute phases of flight (McCarthy 1991; Carmichael 1993). Although AWPG is only an indirect user of MDCRS, NCAR is studying methods for measuring clear-air turbulence (Cornman et al. 1993) and humidity (requires a new sensor) for inclusion in the MDCRS message.

2.2.3 ITWS

The ITWS being developed by MIT Lincoln Laboratory is designed to integrate all the weather data available in the terminal area, and provide products to pilots, controllers, traffic managers, and the airlines (Evans 1991; Ducot 1993). ITWS products include detections with update rates from 1 to 15 min, and short term predictions (up to 60 min) of weather such as ceiling, visibility, microbursts, gust fronts, runway winds and snowfall rate. ITWS will use the MDCRS wind data in combination with other sources of wind data such as the Terminal Doppler Weather Radar (TDWR), WSR-88D Radars, Automated Surface Observing Stations, and profilers, to provide a gridded representation of winds in the terminal area (Wilson et al. 1993). The Terminal Air Traffic Control Automation (TATCA) program, also being developed at Lincoln Laboratory (Andrews and Welch 1989), will use these winds in an automated system to simultaneously increase airport capacity and reduce controller workload. ITWS will also use the MDCRS temperature data to provide a real-time measure of sounding parameters such as the temperature lapse rate and height of the freezing level (Figure 3) that are needed for the ITWS Microburst Prediction Algorithm.

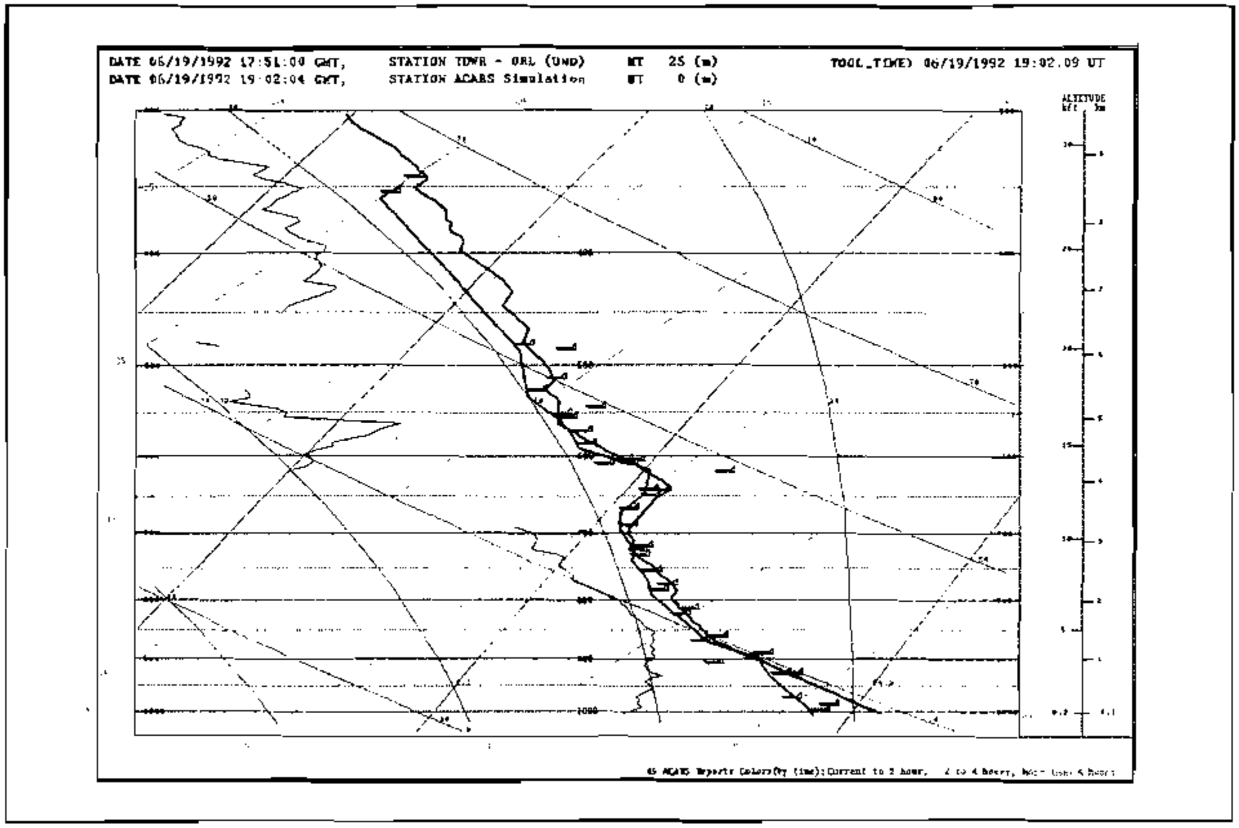

Figure 3: Display of true balloon sounding (temperature and dew point), MDCRS data (small aircraft icons), and ITWS interpolated temperature profile using *sounding_tool* software utility. The interpolated curve is based on a linear weighted interpolation in time (0-6 hours) and space (0-100km from airport center) of MDCRS data. The black MDCRS icons represent data that are 0-2 hours old and the grey icons, 2-6 hours old. Notice that major features of the temperature profile, including an inversion around 650 mb, are captured by the interpolated curve.

3. FUTURE OF MDCRS

3.1 Increase in MDCRS Observations

The number of MDCRS observations is expected to increase from a current level of approximately 8,000 per day to a estimated 45,000 observations per day. Several activities will assist in reaching this goal:

- **Add new airlines.** Delta, Northwest and United airlines are currently participating in MDCRS. United Parcel Service and Global Wulfsburg, who service business aircraft, have agreed to participate. Other airlines are in the process of justifying participation;

- **Add SATCOM reports.** United Airlines currently has 32 aircraft satellite equipped producing approximately 500 per day. The addition of these aircraft will expand the current data base to include Pacific and Atlantic observations; and

- **Increase reporting frequency.** An effort is underway to establish a standard for frequency of reporting aircraft observations. Included in this effort is the development and implementation of ascent and descent reporting frequency. A recommendation by the World Meteorological Organization (WMO) included an ascent report format providing an observation every 300 feet from ground level to 3,000 feet above ground level (AGL) and every 1,000 feet from 3,000 to 20,000 feet AGL, for one aircraft per hour. This ascent report will provide valuable soundings at over 300 airports in North America. Optimally, the FAA and NWS systems could use ascent *and* *descent* profiles sampled at this recommended rate from not one, but from four to 12 aircraft per hour. And, although there is no WMO recommendation for enroute reporting frequency, a higher frequency than is currently used (5-7.5 min) such as 3 minute reporting would be very helpful to MAPS with the envisioned rapid (1 hour) update cycle. Work is in progress to define descent and enroute reporting frequencies.

3.2 Planned System Enhancements

Enhancements currently under evaluation for the MDCRS system include:

- Provide users with selective data retrieval capability in order to allow retrieval by geographical, altitude, time and other parameters;
- Provide users with dial-up access to MDCRS data base; and
- Investigate the feasibility of implementing command and control. This concept would provide the capability for MDCRS to uplink messages to the aircraft to set the frequency of reporting for that particular flight. This feature will become valuable as the number of observations increase by providing the capability to "turn on" reporting by aircraft in data sparse airspace and "turn off" aircraft in data rich airspace.

4. SUMMARY

MDCRS is a rich source of meteorological data providing critical input to upper air forecasts and to several FAA programs. The improvements made possible by MDCRS and other new automatic observational systems contribute to more efficient and safe aircraft operations.

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