4.1 FAA – NASA COLLABORATION ON AUTOMATED AIRCRAFT WEATHER OBSERVATIONS CULMINATING IN TAMDAR

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1. INTRODUCTION

This paper outlines the historical background for the Tropospheric Airborne Meteorological Data Reporting (TAMDAR) project and provides the basis for the aviation requirements for collecting TAMDAR-type data.

1.1 Background

The need for a national system to collect automated weather reports from aircraft dates to September 1986 and the recommendations from the NCAR "Final Report of the Aviation Weather Forecasting Task Force" which was sponsored by the National Science Foundation. The Task Force placed their highest priority on recommendations to develop a national capability to collect and use automated reports from aircraft.

Today, collection of Meteorological Data Collection and Reporting System (MDCRS) reports from major air carriers operating from the major hub airports stands as a testament to the Task Force recommendations. The MDCRS reports are an essential input to aviation weather support, especially the NOAA Rapid Update Cycle (RUC) model. Even so, the MDCRS reports do not cover much of the national airspace, particularly the lower altitudes below 20,000 feet.

The need for automated weather reports from aircraft has continued to be repeatedly recognized and supported through federal and public forums. Examples include the National Aviation Weather Program Council that was established by the Office of the Federal Coordinator for Meteorology (OFCM) in 1989, and the OFCM sponsored National Aviation Weather User's Forum held in 1993.

2. NEXT STEPS

The FAA, NASA, and NOAA have conducted collaborative research efforts to develop, prototype and validate technologies designed to collect and disseminate weather data from low altitude aircraft operations through on-board automation and data link communications. This capability has been designated by several titles over time including Electronic Pilot Reporting (E-PIREP), Automated Meteorological Reporting (AUTOMET) and the currently Tropospheric Airborne Meteorological Data Reporting (TAMDAR).

The government-sponsored research has covered such areas as advanced sensors; communication and data link technologies; system architectures, including system standards and operations; human error and workload, and integration modeling. The goal of this research is to provide TAMDAR-type data coverage in the lower altitudes below 20,000 feet to supplement that available through MDCRS and the associated World Meteorological Organization (WMO) Aircraft Meteorological Data Reports (AMDAR).

2.1 NASA Advanced General Aviation Transportation Experiments (AGATE)

The initial research efforts began in 1994 under NASA's Advanced General Aviation Transportation Experiments (AGATE) program. Through AGATE, NASA formed a consortium of government, industry and academia to focus on technology development supporting general aviation that would lead to increased safety, affordability and ease-of-use. One of the requirements for an AGATE aircraft was that it be equipped with additional sensors that could automatically report usable weather data without pilot intervention.

2.2 Gore Report

New and added emphasis on the need for TAMDAR-type data came in 1997 with publication of the White House Commission on Aviation Safety and Security report, known as the Gore Report. That report established a national goal of reducing the fatal aircraft accident rate by 80% by 2007. The FAA and NASA responses to the Gore Report both included recommendations to include increased collection of aircraft weather reports as a mitigation strategy to reduce the weather factor in fatal aircraft accidents.

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NASA developed recommendations through the Aviation Safety Investment Strategy Team (ASIST) which involved over 200 people from industry, government, and academic organizations. The top priority of the ASIST recommendations for weather research was data dissemination which included collection of aircraft weather reports. Based on the ASIST recommendations, NASA established the Aviation Safety Program (AvSP), and the Weather Accident Prevention (WxAP) project became a component of the AvSP (later changed to the Aviation Safety and Security Program). The development of the TAMDAR sensor and system capabilities have been sponsored through the NASA WxAP.

The FAA established the Weather Joint Safety Implementation Team (JSIT) under their Safer Skies initiative. The Weather JSIT identified General Aviation Automatic Downlink of Weather Data as a key JSIT program element. The Weather JSIT included representation from FAA, NASA and NOAA, and it recognized and supported the joint activities needed to meet the goals of the Gore Report. In 1998, the FAA also published an Airborne Flight Information Services (FIS) Policy statement that committed the FAA to conducting "… an investment analysis to determine the feasibility of establishing an electronic Pilot Report system …"

3. DEVELOPMENT STRATEGY

Through Interagency Agreements and contracts, the FAA, NASA and NOAA established cooperative research efforts with industry and universities to develop the TAMDAR technology. One of the initial studies of this joint effort was to respond to the FAA need for an investment analysis.

3.1 TAMDAR Feasibility Study

A TAMDAR Feasibility Study was conducted by Old Dominion University (ODU) and resulted in changing the focus from gathering such TAMDAR-type reports from unscheduled general aviation aircraft flight operations to scheduled low-altitude commuter and package carrier operations. The initial concepts under the AGATE program and the Weather JSIT proposed collection of such TAMDAR-type reports from unscheduled Part 91 general aviation flight operations. However, a major application of the TAMDAR-type reports is ingest into the NOAA RUC model which requires predictable and consistent data sources.

The ODU study also identified key market factors affecting the adoption of TAMDAR technology and developed initial estimates for costs versus benefits, incentives, and business models for technology adoption. Coincident with the ODU feasibility study was the development of applications for TAMDAR data, research on TAMDAR data impacts on numerical weather prediction and local forecasting, and research on a strategy for achieving deployment and implementation of TAMDAR on a large national scale.

3.2 Operational Concepts

A tri-agency Product Leadership Team (FAA, NASA and NOAA) was established to develop an operational concept for implementation and application of a national TAMDAR-type capability. That concept identified the principle users and key benefits or applications of the data, the system requirements, and key issues and concerns. Four key benefits were identified: 1) fill current data void regions; 2) improve quality of models/forecasts to include warnings and advisories; 3) alert NAS users of weather hazards; and 4) confirm existing weather conditions. The key issues and concerns included: 1) quality and coverage of the TAMDAR-type data; 2) accuracy of the sensors; and 3) development of the business case to support the system architecture.

3.3 Sensor Requirements

Shown in the tables below are the TAMDAR sensor requirements for the measured and derived parameters that were established by the tri-agency Product Leadership Team. These requirements provided the basis for the design reviews during the development of the TAMDAR sensor.

4. CURRENT STATUS

TAMDAR sensor data are being collected through the FAA-NASA sponsored Great Lakes Fleet Experiment (GLFE). That data are being used for sensor validation and impact studies. The NOAA Earth System Research Laboratory (ESRL) under the Global Systems Division (GSD), formerly Forecast System Laboratory, is conducting three studies: 1) sensor validation; 2) data impact/benefit on RUC model; and 3) optimal data collection. The National Weather Service is evaluating the value of TAMDAR data on forecasts for local and area products. Finally, NCAR is evaluating the value of TAMDAR data in forecasting convection, icing and turbulence.

The results of these studies will be key inputs in determining national TAMDAR implementation.

5. ACRONYMS

AGATE	Advanced General Aviation Transportation Experiments
AMDAR	Aircraft Meteorological Data Reports
ASIST	Aviation Safety Investment Strategy Team
AUTOMET	Automated Meteorological Reporting
AvSP	Aviation Safety Program
E-PIREP	Electronic Pilot Reporting

ESRL	Earth System Research Laboratory
FIS	Flight Information Service
GLFE	Great Lakes Fleet Experiment
GSD	Global Systems Division
JSIT	Joint Safety Implementation Team
MDCRS	Meteorological Data Collection and Reporting System
NCAR	National Center for Atmospheric Research
OFCM	Office of the Federal Coordinator for Meteorology
RUC	Rapid Update Cycle
TAMDAR	Tropospheric Airborne Meteorological Data Reporting
WxAP	Weather Accident Prevention

6. REFERENCES

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TAMDAR Feasibility Study, Dr Paul Kauffman and Erol Ozan, Old Dominion University, September 2001

Operational Concepts for Collection and Dissemination of Aircraft Derived Meteorological Information, FAA/NASA/NOAA-NWS, October 2001

TAMDAR Great Lakes Fleet Experiment (http://www.crh.noaa.gov/tamdar/), November 2005

Parameter	Range	Accuracy	Resolution	Latency (See Note 1)	Comments
Pressure	10 -101 kPa	3 hPa	0.05 hPa	10 sec	(See Note2)
Temperature	-70 to +65°C	±0.5°C	0.1°C	10 sec	
Humidity	0 to 100%RH	±2% static ±5% (typical) ±10% (typical)	1% (RH>10%) 0.1% (RH<10%)	10 sec	Dual RH sensors Below Mach 0.4 Mach 0.4 - 0.6
Heading	0-360°	±3°	0.1°	10 sec	@ < 30° pitch & roll
Ice Detection		0.020 inch			

Table 1: TAMDAR Measured Parameters; Aircraft Altitudes to 50,000 Feet

Parameter	Range	Accuracy	Resolution	Latency (See Note 1)	Comments
Pressure Altitude	0 – 25,000 ft.	±150 feet	10 feet	10 sec	(See Note2)
Pressure Altitude	25,000 – 50,000 ft.	±250 feet	10 feet	10 sec	(See Note2)
Indicated Airspeed	70-270 knots ±3 knots 1 knot 10 sec (See Note2)				
True Airspeed	70-450 knots	±4 knots	1 knot	10 sec	(See Note2)
Turbulence (eddy dissipation rate-- $\varepsilon^{1/3}$); Peak and Median	0-20 $cm^{2/3}$ sec^{-1}		3 sec	Reported as single encoded character (See Note3)	
Winds Aloft		± 4 to 6 kt vector magnitude error	1 knot, 1 deg	10 sec	Accuracy depends on relative magnitude and direction of vectors (See Note4)

Table 2: TAMDAR Derived Parameters; Aircraft Altitudes to 50,000 Feet

Notes:
1. 10-second latency is caused by digital filtering of the data as recommended in the AMDAR reference manual.
2. Accuracy specified for angles of attack less than 30°.
3. Turbulence determination: calculation of eddy dissipation rate in accordance with MacReady. Atmospheric Calculated from 32 point DFT of TAS (3 sec block).
4. Winds aloft calculation will require use of GPS and magnetic heading.