Statement of

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Hearing on

"Private Sector Weather Forecasting:
Assessing Products and Technologies"

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Good morning, Chairman Bridenstine, Ranking Member Bonamici, and Members of the Subcommittee. My name is Neil Jacobs, and I serve as the Chief Atmospheric Scientist for Panasonic Weather Solutions, a division of Panasonic Avionics Corporation, a global company operating in the United States with employees and offices in several states. I am honored to be invited to participate in today's hearing to examine the advancement and progress that has been made by the private sector in weather forecasting.

In 2003, the National Research Council reported in *Fair Weather: Effective Partnerships in Weather and Climate Services*, otherwise known as *The Fair Weather Report*, "that the commercial weather industry now has the capability to provide many of the products and services that were once the exclusive domain of the federal government…" [1]

Panasonic has a great public-private partnership to provide its TAMDAR Data to the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service through the National Mesonet Program, which is an example of a successful and sustainable business model for atmospheric data acquisition.

[1] Fair Weather: Effective Partnerships in Weather and Climate Services, Chapter Three, Page 43.

Panasonic is very pleased to continue our long-term relationship with NOAA to improve the quality of weather forecasting. The distinct advantages of our TAMDAR Data from aviation-based observations will enhance the National Weather Service's core mission "the protection of life and property."[2]

TAMDAR, which stands for Tropospheric Airborne Meteorological Data Reporting, provides real-time observations of wind, temperature, moisture, pressure, icing, and turbulence at spatial and temporal resolutions greater than both radiosondes and traditional ACARS (Aircraft Communications Addressing and Reporting System) data from a global network of regional airlines via the Iridium satellite network or Panasonic's high-throughput satellite system. Inherent within this system is real-time backchannel communication and flight tracking.

Last year, Dr. Louis Uccellini, director of NOAA's National Weather Service said, "The National Weather Service has long recognized the utility of TAMDAR data for analysis and numerical forecast models, and I'm

[2] National Weather Service, About NOAA's NWS, Our Mission, http://www.weather.gov/about

pleased about this path forward to incorporate these data in our day-to-day operations."[3]

Dr. Curtis Marshall, also at the National Weather Service has said, "The provision of this unique TAMDAR dataset continues to steer the National Mesonet Program in a direction consistent with the National Academy of Science's 'Network of Networks' vision of a broad range of non-federal data to improve situational awareness at National Weather Service forecast offices and to enhance our high-resolution modeling capabilities."[4]

Observations from the TAMDAR-equipped aircraft and US Air Force UAVs also include real-time icing and turbulence reports, which are vital to assist commercial, general and military aviation. TAMDAR icing data provides the first high-volume, objective icing reports available to the aviation industry.

Meteorologists at the National Transportation Safety Board (NTSB) routinely use TAMDAR data as part of their accident investigations,

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[3] Wings Magazine, Panasonic, NOAA sign deal for hi-res weather data, November 2015

[4] Wings Magazine, Panasonic, NOAA sign deal for hi-res weather data, November 2015

including high-profile incidents such as the Colgan Air flight 3407, which crashed near Buffalo, New York claiming the lives of 45 passengers and 4 crew (February 12, 2009), [5] and the de Havilland Otter, which crashed near Dillingham, Alaska, claiming the lives of 5 of the 9 passengers including, Alaska's late U. S. Senator Ted Stevens (August 9, 2010).[6]

In addition to collecting weather data from aircraft, Panasonic also runs a suite of numerical forecast guidance from rapid-cycling regional and tropical models to our very own global model, including an 80 member global ensemble.

These weather models were developed through long-standing collaborative partnerships with the National Center for Atmospheric Research (NCAR) and several universities. The forecast models use all publically available global weather observations, as well as Panasonic's proprietary TAMDAR data.

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[5] Colgan Air Submission to the NTSB, December 2009
http://www.airsafe.com/events/airlines/colgan-ntsb-submit.pdf

[6] NTSB Aircraft Accident Report, May 24, 2011
http://www.ntsb.gov/investigations/AccidentReports/Reports/AAR1103.pdf

Panasonic Weather Solutions is the *only* private entity in the world with a custom-developed, end-to-end global weather-modeling platform initialized from raw observations, and completely independent from NWS-produced global model data.

Since its founding in 1998, Panasonic Weather Solutions (formerly AirDat) has worked cooperatively with federal agencies by providing its TAMDAR data to NOAA and the FAA, and -- many times at no cost. While we are a commercial company responsible to our shareholders -- we at Panasonic also have another responsibility – to help share our technological expertise with national meteorological agencies around the world.

In closing I would like to call the subcommittee's attention to NOAA Administrative Officer Document: NAO 216-112: Policy on Partnerships in the Provision of Environmental Information. This policy is intended to strengthen the partnership among government, academia and the private sector to provide the nation with the highest quality environmental information. The NOAA Partnership Agreement was approved in 2006 by then NOAA Administrator Dr. Conrad C. Lautenbacher, Jr., VADM USN

(ret.). It was developed in response to recommendations from the National Academy of Science and the publication of *The Fair Weather Report*. I recommend that the Subcommittee work closely with NOAA and America's Weather Industry on any revisions to this important agreement.

Mr. Chairman and Members of the Subcommittee, thank you again for inviting me to participate today. I would be pleased to answer any questions you may have about Panasonic Weather Solutions.

Additional Background Information

The Origins of TAMDAR

In response to a government aviation safety initiative in the early 2000's, NASA, in partnership with the FAA, NOAA, and private industry, sponsored the early development and evaluation of a proprietary multi-function in-situ atmospheric sensor for aircraft. The predecessor to Panasonic Weather Solutions, AirDat (formerly ODS of Rapid City, SD), was formed in 2003 to develop and deploy the Tropospheric Airborne Meteorological Data Reporting (TAMDAR) system based on requirements provided by the Global Systems Division (GSD) of NOAA's Earth System Research Laboratory, the FAA, and the World Meteorological Organization (WMO).

The TAMDAR sensor was originally deployed in December 2004 on a fleet of 63 aircraft operated by Mesaba Airlines in the Great Lakes region of the United States as a part of the NASA-sponsored Great Lakes Fleet Experiment (GLFE). Over the last twelve years, equipage of the sensors has expanded beyond the continental US (CONUS) to include airlines flying over Alaska, Caribbean, Mexico, Central America, Europe, and Asia. The

TAMDAR system has been in continuous operation since initial deployment in December 2004.

What is TAMDAR?

TAMDAR observations include temperature, pressure, winds aloft, relative humidity (RH), icing and turbulence that are critical to both aviation safety and the operational efficiency of the U.S. National Airspace System (NAS) and other world airspace management systems as well as other weather-dependent operational environments such as maritime, defense and energy. Additionally, each observation includes GPS-derived horizontal and vertical (altitude) coordinates, as well as a time stamp to the nearest second. With a continuous stream of observations, TAMDAR provides higher spatial and temporal resolution compared to the Radiosonde (RAOB) network, as well as better geographic coverage, and a more complete data set than sent over Aircraft Communication Addressing and Reporting System (ACARS), which lacks RH, icing, and turbulence.

Upper-air observing systems are normally subject to latency based on the communication networks used and quality assurance protocol. TAMDAR observations are typically received, processed, quality controlled, and available for distribution or model assimilation in less than one minute

from the sampling time. The sensor requires no flight crew involvement; it operates automatically and sampling rates and calibration constants can be adjusted by remote command from a US-based operations center. TAMDAR sensors continuously transmit atmospheric observations via a global satellite network in real-time as the aircraft climbs, cruises, and descends.

The system is normally installed on fixed-wing airframes ranging from small, unmanned aerial systems (UAS) to long-range wide-body aircraft. Emphasis has been placed on equipping regional carriers as these flights tend to (i) fly into more remote and diverse locations and (ii) be of shorter duration thereby producing more daily vertical profiles while remaining in the boundary layer for longer durations.

Panasonic Forecast Models

Third-party studies have been conducted by NOAA-GSD (Global Systems Division), the National Center for Atmospheric Research (NCAR), and various universities and government agencies to verify the accuracy of TAMDAR data against that of weather balloons and aircraft test instrumentation, as well as quantifying the TAMDAR-related impacts on Numerical Weather Prediction. Ongoing data denial experiments show that

the inclusion of TAMDAR data can significantly improve forecast model accuracy with the greatest gains realized during more dynamic and severe weather events.

Upper-air observations are the single most important data set driving a forecast model. Fine-scale regional forecast accuracy is dependent on a representation of the mid and upper-level atmospheric flow, moisture, and wave patterns. If these features are properly analyzed during the model initialization period, then an accurate forecast will ensue. TAMDAR data has been shown to increase forecast accuracy over the U.S. on the order of 30- to 50-percent for a monthly average, even for 3D-Var (GSI) models.

The FAA funded a four-year TAMDAR impact study that was concluded in January 2009. The study was conducted by the Global Systems Division (GSD) of NOAA under an FAA contract to ascertain the potential benefits of including TAMDAR data to the 3D-Var Rapid Update Cycle (RUC) model, which was the current operational aviation-centric model run by National Centers for Environmental Prediction (NCEP). Two parallel versions of the model were run with the control withholding the TAMDAR data. The results of this study concluded that significant gains in forecast skill were achieved with the inclusion of the data despite using 3D-Var assimilation methods. The reduction in 30-day running mean RMS error

averaged throughout the CONUS domain within the boundary layer for model state variables were:

- Up to 50% reduction in RH error
- 35% reduction in temperature error
- 15% reduction in wind error

This study was conducted using a 3D-Var model on a 13 km horizontal grid. Likewise, the nature of the 30-day mean statistics dilutes the actual impact provided by TAMDAR's higher resolution data during critical weather events. The forecast skill gain during dynamic events is typically much greater than what is expressed in a CONUS-wide monthly average. In other words, the increase in model accuracy is greatest during dynamic weather events where air traffic and other operational impacts are greatest.

The Panasonic Weather Solutions RT-FDDA-WRF forecast runs on a North America domain with 4 km grid spacing and can include multiple nested 1 km domains. A four-year collaborative study with NCAR using the same data as in the studies referenced above has shown that the FDDA/4D-Var assimilation methodology can nearly double the improvement in forecast skill over an identical model running a 3D-Var configuration. Results from this study are summarized below using the same 30-day

running mean verification statistics as employed by NOAA. TAMDAR impact using FDDA/4D-Var resulted in:

- Reduction in humidity forecast error of 74%
- Reduction in temperature forecast error of 58%
- Reduction in wind forecast error of 63%

Forecast skill, like the example presented above, is made possible by having (i) an asynoptic in-situ observing system like TAMDAR that streams continuous real-time observations to (ii) a forecast model (deterministic or probabilistic) that has the ability to assimilate asynoptic data in four dimensions.

Weather Products for the Aviation Industry

Icing Data

In addition to our forecasting and modeling expertise, Panasonic Weather Solutions also excels in the collection of Icing and Turbulence Data, which is vital to assist commercial, general and military aviation. TAMDAR icing data provides the first high volume, objective icing data available to the airline industry. Ice reporting is normally available via pilot reports (PIREPs); while helpful, these subjective reports do not provide objective accuracy and density. High-density, real-time

TAMDAR icing reports provide accurate spatial and temporal distribution of icing hazards, as well as real-time observations where icing is not occurring. The icing data can be made available in raw observation form, or it can be used to improve icing potential model forecasts.

Turbulence Observations

The TAMDAR sensor provides objective, high-resolution eddy dissipation rate (EDR) turbulence observations. These data are collected for both median and peak turbulence measurements and are capable of being sorted on a finer (7-point) scale than current subjective pilot reports (PIREPs), which are reported as light, moderate, or severe. The EDR turbulence algorithm is aircraft-configuration and flight-condition independent, thus it does not depend on the type of plane, nor does it depend on load and flight capacity. This high-density real-time in-situ turbulence data can be used to alter flight arrival and departure routes. It also can be assimilated into models to improve predictions of threatening turbulence conditions, as well as being used as a verification tool for longer-range numerical weather prediction (NWP) based turbulence forecasts. As

with the icing observations, potential utility of this data in air traffic control decision-making for avoidance and mitigation of severe turbulence encounters can be significant.

Panasonic's Technological Advancement & Progress

Panasonic Weather Solutions announced in April 2016 that its Tropical 4D weather forecasting service would be available for the start of the 2016 tropical season. Tropical 4D will provide partners with detailed tropical system forecasting information, including Panasonic's proprietary tropical cyclone forecast tracks, for multiple regions around the globe. Tropical 4D is powered by Panasonics Global 4D Weather, the commercial industry-leading global weather prediction platform, which takes full advantage of Panasonic's exclusive atmospheric datasets including TAMDAR.

Panasonic Weather Solutions is the *only* private entity in the world with a custom-developed, end-to-end global weather-modeling platform initialized from raw observations, and completely independent from NWS-produced global model data.

Recent weather events, such as Hurricane Joaquin, highlight the superiority of Panasonic Weather Solutions' weather forecasting capabilities - from atmospheric data collection to high-performance numerical models that consistently run on an 11,000-core supercomputer named *Sora*. Panasonic is partnering with governments to enhance public safety, as well as leading corporations in multiple vertical markets to improve operational performance and become more environmentally friendly, with best-in-class weather forecasting. [7]

Global Interest in Panasonic Weather Models

Since the recent introduction of Panasonic's Global 4D Weather System, Panasonic Weather Solutions has received many requests for additional information about its weather modeling systems from meteorological agencies around the world.

This summer Panasonic Weather Solutions has been invited by the European Centre for Medium-Range Weather Forecasts (ECMWF) which is an independent intergovernmental organization supported by most of the nations of Europe; the Met Office of the United Kingdom (UKMET), the

[7] PR Newswire, Panasonic Weather Solutions Introduces Tropical 4D - Global Tropical Cyclone Forecasting, April 2016

official government meteorological agency for the United Kingdom; and the NOAA National Center for Environmental Prediction (NCEP) to make presentations on Panasonic weather modeling expertise.

Panasonic Corporate Information

Panasonic Weather Solutions is based in Morrisville, NC with additional offices in Lakewood, CO.
Panasonic Avionics Corporation is based in Bothel, WA with additional offices in Lake Forest, CA.

Panasonic Corporation of North America, based in Newark, NJ, is the principal North American subsidiary of Osaka, Japan-based Panasonic Corporation and the hub of its branding, marketing, sales, service, product development and R&D operations in the U.S. and Canada. Panasonic operations in North America include R&D centers, manufacturing bases, the award-winning Panasonic Customer Call Center in Chesapeake, VA, business-to-business and industrial solutions companies, and consumer products with sales and service networks throughout the U.S., Canada and Mexico.

Panasonic Corporation of North America and its subsidiaries and affiliates employ some 15,000 people in the region.

Bio for Dr. Neil Jacobs – Panasonic Avionics Corporation

Dr. Jacobs directs the research and development of both the tropospheric airborne meteorological data reporting system (TAMDAR), as well as the numerical models run by Panasonic. His areas of expertise include mesoscale dynamics, numerical weather prediction, and data assimilation. He is the chair of the American Meteorological Society's Forecast Improvement Group (FIG), and also serves on the World Meteorological Organization's (WMO) aircraft-based observing systems expert team. Prior to joining Panasonic (AirDat) in 2005, Dr. Jacobs worked on various analyses and modeling projects including NASA's Earth Systems Science Program, GOES satellite imagery, Department of Energy's Ocean Margins Program, and the National Weather Service's Atlantic Surface Cyclone Intensification Index. He has a BS in mathematics and a BS in physics from the University of South Carolina, a MS in air-sea interaction from North Carolina State University, and a PhD in numerical modeling from North Carolina State University.

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