# National Transportation Safety Board

Washington, DC 20594

## Safety Recommendation

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**In reply refer to:** A-14-17 through -21

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We are providing the following information to urge the National Weather Service (NWS) to take action on the safety recommendations issued in this letter. These recommendations address the need for consistency among NWS products,[1] advisories relating to mountain wave activity (MWA), enhanced communication among NWS meteorologists to improve situation awareness, and standardized guidance for the weighting of pilot reports (PIREPs). The recommendations are derived from the National Transportation Safety Board's (NTSB) investigation of recent accidents and incidents. As a result of these investigations, the NTSB has issued nine safety recommendations, five of which are addressed to the NWS. Information supporting these recommendations is discussed below.

**Consistency among NWS Products**

NWS aviation weather products in the United States are issued mainly from the Aviation Weather Center (AWC) in Kansas City, Missouri; the Alaska Aviation Weather Unit (AAWU) in Anchorage, Alaska; the 21 center weather service units (CWSUs)[2] collocated with FAA ARTCCs; and the 122 individual Weather Forecast Offices (WFOs).[3] Standard NWS

[1] According to Federal Aviation Administration (FAA) Order 7000.2B, the FAA/NWS Memorandum of Understanding for Policy Agreements, Appendix 1, sections 4.1 through 4.4, the NWS "provides basic meteorological services; FAA establishes all users' requirements for aviation weather services; NWS provides mutually agreed upon aviation weather services; FAA ensures aviation weather services are provided." Appendix A, section 3, further states, "FAA establishes requirements for, and changes to, NWS-provided aviation weather services." FAA Order 7000.2B can be found at www.faa.gov/documentLibrary/media/Order/7000.2B.pdf.

[2] According to the statement of work (SOW) for the FAA and National Oceanic and Atmospheric Administration (NOAA)/NWS Interagency Agreement for the CWSUs, "The primary function and responsibility of the CWSU is to provide meteorological advice and consultation to center operations personnel and other designated FAA air traffic facilities, terminal and en route, within the [air route traffic control center] ARTCC area of responsibility."

[3] The WFOs also issue products directed to nonaviation users such as the marine community (for example, gale warnings) and other members of the public not necessarily interested in transportation-specific hazards (for example, red flag warnings, wind advisories, and high wind warnings).

aviation-specific forecasts and advisories include terminal aerodrome forecasts (TAFs),[4] area forecasts, significant meteorological information (SIGMETs), airmen's meteorological information (AIRMETs),[5] and center weather advisories (CWAs).

Outside of the TAF coverage area of 5 miles from the aerodrome,[6] area forecasts provide routine en route forecast information to the aviation community.[7] According to FAA Advisory Circular (AC) 00-45, "Aviation Weather Services," area forecasts are "used to determine forecast en route weather and to interpolate conditions at airports which do not have a Terminal Aerodrome Forecast." Area forecasts essentially identify specific weather phenomena within a certain geographic region in and/or adjacent to the United States.[8] Due to technological limitations with FAA systems, area forecasts can only include a limited amount of text and a certain character count; therefore, they are unable to address relatively small geographic areas or break down the larger areas.[9] AC 00-45 states that area forecasts are to be used *in conjunction* with other products (such as AIRMETs and SIGMETs) to determine forecasted en route weather, but AC 00-45 also indicates that certain hazards meeting AIRMET and SIGMET criteria (such as IFR conditions, icing, and turbulence) are *not* forecast in the CONUS or Hawaii area forecasts. Further, NWSI 10-811 restricts AIRMETs and SIGMETs from being issued for hazards of a spatial scale less than 3,000 square miles.[10] Thus, aviation hazards (such as adverse surface wind, dense fog, icing, turbulence, and low-level wind shear) that are less than 3,000 square miles and do not fall within 5 miles of a TAF site may not be identified by these NWS aviation weather products.

CWAs, which are issued by the CWSUs, advise of hazardous weather conditions and are issued for many of the same types of hazards that prompt advisories such as SIGMETs, convective SIGMETs, and AIRMETs. NWSI 10-803[11] provides direction to the CWSUs and outlines criteria for the CWSUs to issue CWAs for much of the same airspace as the AWC. According to AC 00-45, section 6.4, "the CWA is primarily used by aircrews to anticipate and avoid adverse weather conditions in the en route and terminal environments." However, CWAs

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[4] TAFs, which are issued by the WFOs, are the official NWS forecasts for an aerodrome and are applicable out to a distance of 5 statute miles from that aerodrome.

[5] AIRMETs and SIGMETs, which are issued by the AWC, are to be used in conjunction with area forecasts to determine hazardous weather (such as instrument flight rules [IFR] conditions, icing, or turbulence) for a flight.

[6] In some circumstances, TAFs can identify certain weather phenomena up to 10 miles from that aerodrome.

[7] Area forecasts for regions in and adjacent to the contiguous United States (CONUS) are issued by the AWC. Area forecasts for Alaska and Hawaii are issued by the AAWU and the WFO in Honolulu, Hawaii, respectively.

[8] National Weather Service Instructions (NWSIs) offer standard internal operating procedures for the NWS. NWSI 10-811, issued on August 27, 2013, discusses area forecasts and is available at www.nws.noaa.gov/directives/sym/pd01008011curr.pdf.

[9] Current examples of geographic coverage provided by area forecasts are available at http://aviationweather.gov/products/fa/.

[10] Although an exception can be made for SIGMETs if a smaller area is expected to have a "significant impact on the safety of aircraft operations," AWC forecasters do not often leverage this exception. However, the AAWU will routinely issue SIGMETs for regions smaller than 3,000 square miles in the "Anchorage Bowl" area. The NTSB notes that NWS Pacific Region Supplement 12-2003 to NWSI 10-811 provides an exception to the 3,000 square mile rule for AIRMETs (www.nws.noaa.gov/directives/sym/pd01008011p122003curr.pdf).

[11] NWSI 10-803, issued on August 22, 2013, is available at www.nws.noaa.gov/directives/sym/pd01008003curr.pdf.

may also be issued for hazards that would not be addressed in SIGMETs or AIRMETs (for example, small areas of freezing precipitation) and hazards that are less than 3,000 square miles.

The NTSB has recently investigated several accidents in which aircraft operating under the provisions of 14 *Code of Federal Regulations* (CFR) Parts 121, 135, and 91 encountered weather conditions[12] that were not identified in NWS aviation weather products. On January 17, 2010, a Cessna 182R collided with mountainous terrain 9 miles northwest of Corvallis, Oregon, resulting in two fatalities. While several NWS aviation weather products were issued for wind for the state of Oregon that day, the NWS WFO in Portland, Oregon, had issued a nonaviation-specific high wind warning for wind much higher than that forecast in the aviation weather products.[13] On November 10, 2011, a Eurocopter EC130B4 helicopter collided with mountainous terrain near Pukoo on the island of Molokai, Hawaii, resulting in five fatalities. While NWS aviation weather products for wind and turbulence had been issued, two NWS nonaviation-specific weather products advised of wind magnitudes 13 to 15 knots higher than what had been advised in the aviation weather products.[14] On May 24, 2012, a Gulfstream American AA-5A impacted terrain about 40 miles northeast of Lakeview, Oregon, resulting in one fatality. While NWS aviation weather products advised of broken ceilings, rain showers, and moderate turbulence, an NWS nonaviation-specific weather product advised of wintry conditions and significant wind gusts.[15] On March 3, 2013, a Mooney M20E impacted terrain after departing Angel Fire Airport, Angel Fire, New Mexico, resulting in four fatalities. At the time of the accident, there was a substantial crosswind to the runway with a sustained wind of 33 knots and gusts to 47 knots; however, an NWS aviation weather product only advised of wind gusts to 25 knots, while two NWS nonaviation-specific weather products discussed stronger wind gusts.[16]

The NTSB is concerned[17] that although weather hazards are identifiable by NWS meteorologists, routinely issued aviation weather products may not alert the aviation community to the presence or full severity of these hazards. The accident investigations found that NWS nonaviation-specific weather forecasts and advisories can contain important information for the aviation community that is not found in the aviation weather products. As illustrated in the accidents above, NWS nonaviation-specific weather products advised of conditions more severe than NWS aviation weather products. While nonaviation forecasts and advisories are available to the public, they are not routinely made available to the aviation community via standard

[12] These conditions included adverse surface wind events, low visibility, and winter weather conditions.

[13] Low clouds, precipitation, and mist were noted in the probable cause for this accident. More information about this accident, NTSB case number WPR10GA113, can be found at www.ntsb.gov/aviationquery/index.aspx.

[14] This accident is still under investigation. More information about this accident, NTSB case number WPR12MA034, can be found at www.ntsb.gov/aviationquery/index.aspx.

[15] Adverse weather conditions were noted in the probable cause for this accident. More information about this accident, NTSB case number WPR12FA237, can be found at www.ntsb.gov/aviationquery/index.aspx.

[16] More information about this accident, NTSB case number CEN13FA183, can be found at www.ntsb.gov/aviationquery/index.aspx.

[17] The NTSB notes that the NWS in Alaska is currently working to address consistency among weather advisory products in Alaska; therefore, this discussion is limited to aviation weather services provided in the CONUS and Hawaii. This does not, however, intend to remove aviation weather services in Alaska from the intent of the NTSB's recommendations on NWS product consistency.

preflight weather briefings in the CONUS and Hawaii[18] and may not be known to the aviation community to contain important aviation-related weather information.[19]

The NTSB is further concerned that although the NWS is disseminating information vital to aviation interests, the forecaster responsible for identifying aviation weather hazards at the AWC or the WFO may not have a vehicle by which to provide this information to pilots. The NTSB notes that two current NWS products could potentially be enhanced to provide advisories on small-scale weather hazards on a routine basis to the aviation community: CWAs and the aviation section of the area forecast discussion (AFD). As mentioned previously, CWAs are not restricted to advising of aviation weather hazards of a certain minimum size. Further, NWSI 10-803 offers great flexibility regarding the hazards they may address. For example, in the Corvallis, Oregon, accident, NWSI 10-803 would have authorized a CWA to be issued for near-surface high wind and for smaller areas expected to receive the highest wind gusts. Regarding the Hawaii accident, had there been a CWSU responsible for Hawaii, NWSI 10-803 would have also authorized a CWA for the conditions discussed in the gale warning and wind advisory.

In addition, as compared to the AWC, individual CWSUs have a much smaller airspace for which they are responsible; thus, CWAs are likely a better vehicle for smaller-scale weather phenomena. However, the NTSB does not believe that CWAs are currently issued such that they would cover all small-scale aviation weather hazards, possibly due to current operational priorities for the CWSUs that may limit additional prioritization of customers outside of the local ARTCC.[20] However, the CWSUs do, by virtue of their responsibility to issue the CWA, *directly* serve the flying public *and* customers outside of the local ARTCC as well.

The second potential NWS product that could be enhanced is the aviation section of the AFD. The AFD, which is issued by individual NWS WFOs, is a nonaviation, semitechnical text product intended to provide insight and scientific rationale into NWS products and advisories issued by that WFO. The content of the AFD can focus on smaller geographic areas than the products issued by the AWC. According to NWSI 10-503,[21] section 2.3.5.1, AFDs are to be issued at least twice per day and can contain a section labeled “Aviation” to highlight aviation-specific material. Regional supplements[22] to NWS directives indicate that the aviation section is to be written to aviation customers such as flight service stations, dispatchers, CWSUs, the AWC, and GA pilots. Currently, the aviation section of the AFD is optional and is not

[18] Routine availability of nonaviation-specific weather forecasts and advisories via preflight briefing services in Alaska is unknown.

[19] Anecdotal evidence suggests, however, that some pilots in Alaska rely on NWS marine weather products for important weather information not found in NWS aviation weather products.

[20] Such customers include general aviation (GA) pilots, airline/company dispatchers, and other meteorologists.

[21] NWSI 10-503, issued on February 24, 2012, is available at www.nws.noaa.gov/directives/sym/pd01005003curr.pdf.

[22] See www.nws.noaa.gov/directives/sym/pd01008001w092003curr.pdf, www.nws.noaa.gov/directives/sym/pd01005003c052007curr.pdf, and www.nws.noaa.gov/directives/sym/pd01005003e102004curr.pdf.

standardized across the NWS.[23] The NTSB notes that to be able to address the needs discussed in this letter, the aviation section of the AFD would need to be modified so that it is standardized, enhanced in scope, briefed routinely by FAA-contracted weather briefers, and perhaps become an unscheduled and, likely, more frequently issued product.[24]

The NTSB concludes that the NWS is not ensuring consistency among its weather advisory products and that the aviation community is missing important advisory information disseminated through nonaviation-specific weather products, as evidenced in the recent accident investigations. Ideally, this consistency would occur through modification or enhancement of an existing NWS aviation weather product that is known to the aviation community and can be routinely provided in preflight weather briefings. Therefore, the NTSB recommends that the NWS modify NWS aviation weather products to make them consistent with NWS nonaviation-specific advisory products when applicable, so that they advise of hazardous conditions including aviation hazards less than 3,000 square miles in area that exist outside of TAF coverage areas.

**Mountain Wave Activity**

For the purposes of this letter, a mountain wave is the wave-like effect, characterized by updrafts and downdrafts, that occurs above and mainly to the lee of a mountain range when rapidly flowing air encounters the mountain range’s steep front in a near-perpendicular fashion within a supportive vertically stable atmosphere (referred to as a mountain wave-supporting environment). MWA refers to these updrafts and downdrafts, their associated turbulence, and other wind phenomena[25] that can occur in association with a mountain wave-supporting environment. According to AC 00-57, “Hazardous Mountain Winds and Their Visual Indicators,” atmospheric disturbances from mountain interaction “can range in size from a few centimeters to tens or hundreds of kilometers, and can present the pilot with relatively smooth air, or with turbulence of potentially destructive intensity, and the likelihood of loss of control.”

While turbulence and high surface wind generated by different environments[26] may already be identified through NWS aviation weather products, the unique and adverse characteristics of MWA need to be uniquely identified, even if the different environments coexist. AC 00-57 warns pilots “to be aware of the potential for wave development, assess its likely strength and location, and prepare for an encounter (reduce airspeed to turbulent air penetration speed, secure loose objects, etc.) or plan an appropriate diversion to avoid the area containing the disturbance.”

The identification of imminent or existing MWA is critical because of the adverse operating conditions that are sometimes associated with it. Hazards posed by MWA to airborne aircraft are not limited to severe or extreme turbulence or adverse wind near the surface. The

[23] While the aviation section of the AFD is generally intended to provide discussion on conditions affecting aviation, several NWS regional supplements specifically direct the NWS forecaster to use the aviation section of the AFD to “provide details not permitted in the TAF,” which often allows for details outside of terminal areas.

[24] Additional training on aviation weather hazards may also be needed by WFO meteorologists.

[25] Other wind phenomena include rotors, hydraulic jumps, and downslope wind events.

[26] For instance, turbulence can be generated by wind shear associated with the jet stream, known as clear air turbulence.

FAA's *Airmen's Information Manual*, section 4-6-6, discusses MWA in the context of aircraft operating within reduced vertical separation minimum (RVSM) airspace,[27] where aircraft may only be separated vertically by 1,000 ft of altitude, and states, "wave action can produce altitude excursions and airspeed fluctuations accompanied by only light turbulence. With sufficient amplitude, however, wave action can induce altitude and airspeed fluctuations accompanied by severe turbulence." Because MWA can cause vertical deviations that jeopardize safe aircraft separation in turbulent or nonturbulent conditions both inside and outside of RVSM airspace, pilot knowledge of potential areas of MWA will enhance situation awareness and also allow flight crews the opportunity to prepare a response should an encounter occur.

The NTSB has, for some time, been concerned with the effects of MWA and other terrain-induced turbulence phenomena on aircraft and issued recommendations relating to a 1991 event in Colorado Springs, Colorado;[28] a 1993 event near Anchorage, Alaska;[29] and a 2008 event in Denver, Colorado,[30] as well as noted a 2009 event in Turkey.[31] Further, the NTSB has investigated recent accidents in which air carrier and GA aircraft operating under the provisions of 14 CFR Parts 121, 135, and 91 encountered MWA that was not addressed through weather products issued by the NWS. On August 1, 2008, a Long Lancair ES disappeared from radar contact 40 miles northwest of Yakima, Washington, and crashed, resulting in two fatalities. MWA was likely present around the accident site near the accident time; however, no CWA or SIGMET advisory was valid at the accident time for the accident site (an AIRMET advised of moderate turbulence below 16,000 ft).[32] On December 20, 2008, Continental Airlines flight 1404, a Boeing 737-500, departed the left side of runway 34R during takeoff from Denver International Airport, Denver, Colorado, resulting in 6 serious injuries and 41 minor injuries. In its report, the NTSB notes that meteorological conditions might have been favorable for MWA.[33]

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[27] RVSM airspace is between flight level (FL) 290 and FL410 (inclusive).

[28] On July 20, 1992, the NTSB issued Safety Recommendations A-92-57 and -58, asking the FAA to develop meteorological programs to observe, document, and analyze aviation weather hazards at airports in or near mountainous terrain. National Transportation Safety Board, *Uncontrolled Collision with Terrain for Undetermined Reasons, United Airlines Flight 585, Boeing 737-291, N999UA, Colorado Springs, Colorado, March 3, 1991*, AAR-92/06 (Washington, DC: National Transportation Safety Board, 1992).

[29] On November 15, 1993, the NTSB issued Safety Recommendation A-93-142, asking the NWS to use weather radar to analyze mountain-generated wind fields and to enhance low-altitude turbulence forecasts in the Anchorage area. National Transportation Safety Board, *In-Flight Engine Separation, Japan Airlines, Inc., Flight 46E, Boeing 747-121, N473EV, Anchorage, Alaska, March 31, 1993*, AAR-93/06 (Washington, DC: National Transportation Safety Board, 1993).

[30] On July 29, 2010, the NTSB issued Safety Recommendation A-10-105 to the FAA on furthering understanding of the effects of MWA and related wind events. National Transportation Safety Board, *Runway Side Excursion During Attempted Takeoff in Strong and Gusty Crosswind Conditions, Continental Airlines Flight 1404, Boeing 737-500, N18611, Denver, Colorado, December 20, 2008*, AAR-10/04 (Washington, DC: National Transportation Safety Board, 2010).

[31] During the event, the airplane lost about 3,500 ft of altitude, and its maximum recorded descent rate was about 12,000 ft per minute. The Bureau d'Enquêtes et d'Analyses (BEA) quantified general mountain wave conditions and indicated that "Making the crew aware of potential mountain waves meteorological conditions over high ground would have made them more vigilant..." *Report, Incident on 2 May 2009, On Approach to Antalya (Turkey), to the Boeing 737-300, Registered F-GFUG, operated by Europe Airport* (Le Bourget Cedex, France: BEA, 2011).

[32] More information about this accident, NTSB case number LAX08LA253, can be found at www.ntsb.gov/aviationquery/index.aspx.

[33] See AAR-10/04.

On February 13, 2010, a Cessna CE-680 encountered turbulence during cruise flight near Eagle, Colorado; the NTSB determined that the probable cause of the accident was the airplane's encounter with localized severe to extreme mountain wave turbulence, which resulted in substantial damage to both wings. There were no SIGMETs or CWAs valid for the accident time at the accident location (AIRMETs advised of moderate turbulence below FL380).[34] On December 18, 2012, a Piper PA-31-350 was lost from FAA radio and radar contact about 10 miles southwest of Payson, Arizona, during an IFR flight, resulting in one fatality. Air traffic control (ATC) recordings revealed the pilot had reported that he was encountering "heavy up and down drafts." There was no CWA or SIGMET valid for the accident location at the accident time (AIRMETs advised of moderate icing, IFR conditions, mountain obscuration, and moderate turbulence).[35]

Although MWA advisory products from private industry are currently made available to some ATC facilities for enhanced situation awareness, most of the accidents that the NTSB has investigated in which MWA was present involved GA aircraft or other types of operations that did not have direct access to such guidance. While MWA is identifiable by NWS meteorologists, alerting the aviation community to the presence of MWA does not often occur through routinely issued aviation weather products.[36]

Currently, the NWS does not require the issuance of advisories specifically for MWA.[37] Although the NWS routinely issues products intended to advise pilots, air traffic controllers, and other aviation weather customers of known or expected severe turbulence associated with the jet stream or thunderstorms (indirectly), no standardized NWS product is available to specifically highlight mountain wave turbulence or other phenomena associated with MWA. NWSI 10-811 directs NWS aviation meteorologists at the AWC to issue AIRMETs and SIGMETs for moderate and severe (or greater) turbulence, respectively, but does not require MWA to be an advisory-initiating event.[38]

Presently, the CWA is the only NWS-issued aviation weather product that effectively advises of imminent or existing weather hazards of a certain spatial scale outside of terminal areas. However, NWSI 10-803 does not specify MWA as CWA-prompting criteria. Current NWS directives would allow for the CWSUs to issue their products to cover the hazards associated with MWA. Further, even if an AWC advisory was active for turbulence in a certain area,

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[34] More information about this accident, NTSB case number CEN10LA204, can be found at www.ntsb.gov/aviationquery/index.aspx.

[35] More information about this accident, NTSB case number WPR13FA072, can be found at www.ntsb.gov/aviationquery/index.aspx.

[36] Information about additional cases (LAX99FA138, DEN99LA008, LAX00LA250, LAX02FA031, FTW03FA036, LAX03FA142, LAX05FA092, DEN05FA074, CHI06LA099, LAX06LA249, DEN06FA132, LAX08FA043, and CEN13FA183) can be found at www.ntsb.gov/aviationquery/index.aspx.

[37] While MWA may occur both in the CONUS and Alaska, the NTSB believes that the NWS facilities in Alaska may address the MWA hazard better than the NWS facilities in the CONUS. Therefore, this discussion is limited to aviation weather services provided in the CONUS. This does not, however, intend to remove aviation weather services in Alaska from the intent of the NTSB's recommendations on MWA products.

[38] Discussions with AWC management revealed that their meteorologists do not normally issue AIRMETs and SIGMETs specifically for mountain wave turbulence or MWA. However, AWC meteorologists have issued advisories that discuss MWA. For more information, see NTSB case numbers DEN05FA074 and FTW03FA036, available at www.ntsb.gov/aviationquery/index.aspx.

NWSI 10-803 also allows CWAs to be issued for "anything that in the judgment of the CWSU forecaster will add value to an existing advisory." In addition, the 21 CWSU facilities have enhanced knowledge of local terrain, and the CWSU meteorologists' collocation with air traffic controllers at the ARTCCs allows in-person communication of hazards with the FAA.

The NTSB notes that the CWSUs at the Denver ARTCC (ZDV) and Salt Lake City ARTCC (ZLC) already produce CWAs to advise of MWA within the ZDV and ZLC airspaces, respectively.[39] Along with alerting pilots to the presence of MWA, these products enhance the situation awareness of air traffic controllers to these aviation weather hazards. In addition to the ZDV and ZLC CWSUs, the CWSU at the Anchorage ARTCC (ZAN) is also engaged in the monitoring of MWA. The ZAN CWSU currently uses a "decision tree" to help its forecasters recognize MWA and determine the need for a CWA (see figure 1).

[39] The NTSB notes that the catalyst for production of MWA advisories by the ZDV CWSU was the local air traffic controllers' request for enhanced weather support specifically for the identification of MWA.

**Mountain Wave Decision Tree**

1) Is Mountain Wave activity forecasted or suspected as a possibility?
   → If yes, continue to 2
   → If no, monitor

2) Is Mountain Wave Activity with light to moderate turbulence reported by Pilots and/or visible on satellite?
   → If yes, continue to 3.
   → If no, monitor

3) Is Moderate or greater turbulence with Mountain Wave activity reported by Pilots?
   → If yes, continue to 4.
   → If no, continue to monitor situation. *Mountain waves can destabilize quickly.*

4) Is it between 5:30am & 7pm?
   → If yes, issue a CWA
   → If no, continue to 4.

5) Is it >7pm and expected to continue past 9pm, start overnight, or start the next morning ?
   → If yes, issue an MIS.
   → If no, issue a CWA

**Figure 1.** ZAN CWSU mountain wave activity decision tree.

The NTSB concludes that the aviation hazards associated with MWA are significant enough to indicate the need for an NWS aviation weather advisory product to forecast and identify these hazards. The NTSB further concludes that current scientific knowledge and forecasting skill enables NWS meteorologists to forecast and identify mountain wave-supporting environments and MWA. While the NTSB considers CWSUs to be a practical and available facility to provide this much-needed product, the NTSB notes that there are potential limitations to the CWSUs' ability to address this need.[40] However, the NTSB still considers the CWSUs to be the most appropriate NWS aviation weather facility to provide a primary aviation weather product aimed at identifying present and future aviation weather hazards associated with MWA. The NTSB recognizes that the NWS will make the final determination for which NWS facility or combination of facilities would provide the most efficient and effective aviation weather product to address MWA. Therefore, the NTSB recommends that the NWS provide a primary aviation weather product that specifically addresses both the potential for and the existence of MWA and the associated aviation weather hazards (as recommended in Safety Recommendation A-14-14 to the FAA).

The work performed by the NWS CWSUs for the FAA is defined in a SOW under an Interagency Agreement between the FAA and NOAA/NWS. It is not clear if the development of these MWA products or the addition of nonaviation-specific advisory information (as discussed in Safety Recommendation A-14-17) to existing aviation weather products would already be covered by these agreements currently in place between the FAA and NOAA/NWS. For example, the SOW notes that "turbulence" identification is a responsibility of the CWSU meteorologist; however, given the unique environment required for MWA, the NTSB is not certain whether this reference to turbulence specifically includes MWA. It would be important to clarify the scope of work tasks like this in the SOW to ensure that resource needs are understood as the number of products produced by CWSU staff and their corresponding workload may need to increase to meet the needs highlighted in Safety Recommendations A-14-17 and/or A-14-18. The NTSB is also uncertain whether current resource levels are adequate to accomplish these recommendations without detracting from the existing duties and responsibilities of the CWSUs, which include a number of highly beneficial safety-related weather products for both FAA ARTCCs and individual pilots. As a result, the NTSB concludes that it is important to ensure these additional operational responsibilities, if assigned by the NWS to the CWSUs, are addressed in the existing SOW to clarify resource needs and priorities. Therefore, the NTSB recommends that the NWS, in cooperation with the FAA, revise the Interagency Agreement between the FAA and NOAA/NWS for the CWSUs and its accompanying SOW if needed to add the new responsibilities of CWSU personnel in response to Safety Recommendations A-14-17 and/or A-14-18 to the NWS, which are in addition to the other responsibilities currently performed by the NWS under this agreement.

**Communication among NWS Forecasters and PIREP Issuance**

Recent NTSB accident and incident investigations have identified situations in which differing levels of situation awareness of aviation weather hazards have occurred between NWS facilities and meteorologists responsible for advisory issuance. The NTSB recognizes that because meteorologists at NWS facilities often have individual focuses, multiple taskings, and high workloads, they cannot identify and analyze all meteorological information all of the time. Situation awareness and communication between meteorologists at NWS facilities is important for NWS aviation meteorologists to remain aware of developing and present threats.

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[40] Such potential limitations may include overnight hours that the CWSUs are closed, possible technological limitations, enhanced coordination that may need to occur between the AWC and CWSUs, and the lack of priority for customers outside of the local ARTCC. While the CWSUs are funded by the FAA to support the ARTCCs, *they still have obligations to customers outside of the local ARTCC* who are interested in these aviation weather products.

***Recent Investigations***

December 20, 2011, Morristown, New Jersey

On December 20, 2011, about 1005 eastern standard time, a Socata TBM 700 collided with terrain following an in-flight loss of control near Morristown, New Jersey.[41] The NTSB determined that the probable causes of this accident were the airplane's encounter with unforecasted severe icing conditions that were characterized by high ice accretion rates and the pilot's failure to use his command authority to depart the icing conditions in an expeditious manner, which resulted in a loss of airplane control. About 2 hours before the accident airplane departed, a Cessna Citation and an MD-83 operating in the region issued urgent PIREPs that advised of moderate to severe rime icing at altitudes between 13,000 to 14,000 ft and 14,000 to 16,500 ft, respectively. Both PIREPs occurred in or very close to the New York ARTCC (ZNY) airspace. Although AIRMETs for moderate icing were active in the region, no SIGMETs or CWAs for icing were issued before the accident. About 35 minutes after the accident, an urgent PIREP from "multiple" types of aircraft at 14,000 ft over Schooley's Mountain, New Jersey, reported moderate to severe icing between 14,000 and 17,500 ft.

In a postaccident interview, the AWC forecaster responsible for issuing advisories for the accident location at the accident time stated that he saw the two preaccident PIREPs indicating moderate to severe icing conditions and determined that a SIGMET for severe icing was not warranted. The AWC forecaster indicated that he anticipated a phone call from the ZNY CWSU about the situation but did not receive one. Because a CWSU may issue a CWA without communicating with the AWC, the forecaster at the AWC thought the ZNY CWSU forecaster also believed no advisory was warranted. Although the two facilities often communicate with one another, the AWC forecaster did not contact the ZNY CWSU before the accident, nor was he required to do so per NWSI 10-811. The AWC forecaster stated that a decision of when to communicate between the facilities is at the discretion of the forecasters. After the accident, the AWC forecaster called the ZNY CWSU to suggest the issuance of a CWSU advisory.

The forecaster on duty at the ZNY CWSU indicated that he had been aware of only one preaccident PIREP that identified moderate to severe rime icing. The forecaster stated that a PIREP of "moderate to severe" intensity would be treated as a severe report; however, one report of severe conditions would not prompt him to issue a CWA unless hazardous conditions were expected to be experienced "continuously" or conditions were believed to be "intermittent" but would continue for some time. The ZNY CWSU forecaster stated that if he had been aware of more than one report of severe icing conditions before the accident, it would have prompted a discussion with the AWC. The ZNY CWSU forecaster indicated that after a call from the AWC about 1 hour after the accident, a CWA for moderate icing with "isolated severe icing possible especially with smaller aircraft" was issued. The ZNY CWSU forecaster indicated that there was no consideration of issuing a CWA before the accident.

[41] More information about this accident, NTSB case number ERA12FA115, is available at www.ntsb.gov/aviationquery/index.aspx and at www.ntsb.gov/investigations/dms.html.

March 5, 2012, Anchorage, Alaska

On March 5, 2012, about 2154 Alaska standard time (AKST), a Bombardier Learjet model 35A sustained minor damage while landing on runway 7R at Ted Stevens Anchorage International Airport (ANC), Anchorage, Alaska. During a postincident interview, the captain said that as the airplane passed over the runway threshold, just before touchdown, his windscreen abruptly iced over, and he had no forward visibility. The NTSB determined that the probable cause of this incident was the flight crew's loss of visual reference to the runway after encountering severe in-flight icing conditions, which resulted in a loss of control while landing and exceedence of the capabilities of the airplane's windscreen anti-ice systems. Contributing to this incident was the failure of the approach controller to relay a PIREP of severe icing conditions near the route of flight to the incident flight crew.[42]

A general forecaster working the day of the incident at the Anchorage WFO indicated in a postincident interview that when considering a forecast for that evening, he published a short-term forecast that afternoon that included the following: "It is possible in the early morning freezing drizzle could be the predominant precipitation type for short periods." However, the short-term forecast is not an aviation-specific NWS product, and no mention of freezing precipitation was included in the ANC TAF issued before the incident (snow was included). In addition, this forecaster added a note about freezing precipitation in the Anchorage WFO's shift log for that day that was intended to be read by the oncoming shift that evening.[43] Along with the Anchorage CWSU, the AAWU[44] is responsible for issuing aviation weather advisories for Alaska; however, the Anchorage CWSU closes at 2100 AKST. The lead forecaster at the AAWU (referred to as "forecaster A") who was on duty the evening of the incident until about 1 hour after the incident indicated that nothing had alerted him to freezing rain. Forecaster A had issued an advisory for isolated moderate rime icing in-cloud between 3,000 and 10,000 ft that was included in the area forecast for ANC. At 2155 and 2205 AKST, two PIREPs from Boeing 737s identified severe icing at 4,000 and 3,000 ft mean sea level, respectively, 10 miles from ANC. Forecaster A indicated that the NWS did not receive these PIREPs until 2222 AKST.

Another lead forecaster at the AAWU (referred to as "forecaster B") who relieved forecaster A at 2300 AKST stated in a postincident interview that when a forecaster comes on duty and relieves another forecaster, a shift change briefing[45] is performed. Forecaster B also stated that during the shift change briefing on the night of the incident, forecaster A told him that he was unaware of any significant icing. Because forecaster B had experienced freezing precipitation on his drive to the AAWU that night, upon finishing his briefing from forecaster A, he immediately checked for PIREPs and issued a SIGMET for severe icing at 2306 AKST. Forecaster B indicated that he was not aware of any situation awareness on freezing precipitation at his office (including the WFO) that evening leading up to the event.

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[42] More information about this incident, NTSB case number ANC12IA024, is available at www.ntsb.gov/aviationquery/index.aspx and at www.ntsb.gov/investigations/dms.html.

[43] A portion of the note indicates that "…Since Bethel, Dillingham, and King Salmon all reported freezing drizzle with this feature, decided to include it in the 101, 111, and 121 forecasts for tonight along with the snow."

[44] The Anchorage WFO and the AAWU are physically collocated. The AAWU issues area forecasts for Alaska and will routinely issue SIGMETs for regions smaller than 3,000 square miles in the "Anchorage Bowl" area.

[45] Forecaster B indicated that such a briefing would normally consist of the outgoing forecaster identifying situations out of the ordinary to the incoming forecaster.

***Discussion***

Although the NTSB has not identified a lack of an NWS advisory as a factor in either the accident or incident described above, the NTSB is concerned because these investigations have highlighted that situation awareness of the potential for or existence of an aviation weather threat can be maintained by one NWS meteorologist but not by another NWS meteorologist, despite identical jurisdictions for identifying adverse weather. Complete situation awareness of all potential and present hazards cannot be maintained by one meteorologist all of the time because of wide-ranging workload. However, methods of direct communication and information sharing via the Internet or telephone do exist to facilitate mutual situation awareness of hazardous environments. The NTSB believes that the Morristown, New Jersey, accident identifies the need for improved situation awareness and communication between the CWSUs and the AWC. Had communication between the two facilities occurred before this accident, such dialogue would have enhanced situation awareness at the ZNY CWSU by alerting the forecaster to the existence of a second urgent PIREP for icing in the region and may have prompted an advisory to the pilot. Further, the events surrounding the Anchorage, Alaska, incident emphasize that NWS forecaster awareness of other forecasters' thoughts and actions concerning their area of responsibility is paramount.[46] Had forecaster A been aware of the WFO's product suggesting possible freezing rain, he may have weighted the severe icing PIREPs more heavily when considering advisory issuance.

NWSI 10-811 does not discuss communication between the AWC and the CWSUs. NWSI 10-803, which is directed to the CWSUs, states, "Coordination with AWC should take place before issuing a CWA to avoid a duplicate advisory being issued simultaneously by AWC"; however, this directive reads as a best practice rather than a requirement and emphasizes the need to avoid duplicating advisories by the facilities.[47] The directive does not emphasize the fact that when information becomes available that might necessitate an advisory (for example, a severe PIREP), brief communication between the meteorologists at NWS facilities can foster mutual situation awareness of the information and ensure that any lack of advisory issuance is due to mutual forecaster discretion and not because one facility thought the other facility was going to, or should have, handled it. This issue is particularly critical between the AWC and the CWSUs because the difference between the issuance of a SIGMET for severe conditions and the issuance of a CWA for the same conditions for the same airspace may hinge on the subjective evaluation of the spatial extent of a present and/or potential hazard (the 3,000 square mile rule).

The NTSB recognizes that communication before the timely issuance of a critical advisory may not always be possible. In addition, current NWS directives appropriately direct their facilities to issue advisories when conditions warrant, independent of another facility's potential action and collaboration. Preservation of this standard is essential. However, the NTSB concludes that improved interfacility communication is necessary to ensure that situation awareness of aviation weather hazards is maintained when information is being deliberated

[46] Because forecaster B became aware of the potential for a freezing rain/icing threat due to his commute experience, he was aggressive in identifying the need for an advisory.

[47] A review of the majority of CWSU station duty manuals (SDMs) revealed that some local CWSU directives encourage preadvisory communication between the AWC and the CWSUs and/or refer back to NWSI 10-803; however, only a few SDMs use language that suggests such communication is required when the appropriate in-flight advisory (for example, a SIGMET for severe conditions) is not in place.

and/or appropriate action is believed to be another facility's responsibility and to prevent failure of advisory issuance while preserving professional forecaster discretion. This will become even more critical should the scope of the CWA become expanded. Therefore, the NTSB recommends that the NWS establish a protocol that will enhance communication among meteorologists at the CWSUs, the AWC, and, as applicable, other NWS facilities to ensure mutual situation awareness of critical aviation weather data among meteorologists at those facilities.

While the NTSB believes that enhanced situation awareness in the above accidents could have increased potential advisory issuance, the NTSB recognizes that professional forecaster discretion is essential to the evaluation of meteorological data and the issuance of any advisory product and that establishing strict criteria for what data (for example, the number and/or severity of PIREPs) constitutes forecaster action may undermine professional forecaster discretion. The NTSB does note that the NWS has taken some action to establish guidance for forecasters on how to weight PIREPs in consideration of an advisory issuance. The Anchorage, Alaska, CWSU currently uses a decision tree to help its forecasters weight PIREPs and determine the need for a CWA for severe icing (see figure 2).

**CWSU PANC Icing Decision Tree**

1) Is severe icing forecasted?
   → If yes, continue to 4.
   → If no, continue to 2.

2) Is severe icing reported?
   → If yes, continue to 3.
   → If no, stop.

3) Is Aircraft size medium or bigger?
   → If yes, continue to 4.
   → If no, stop

4) Is it between 5:30am & 7pm and within 2 hours of event?
   → If yes, issue a CWA.
   → If no, continue to 5.

5) Is it >7pm and expected to continue past 9pm, start overnight, or start the next morning ?
   → If yes, issue an MIS.
   → If no, issue a CWA.

**Figure 2.** Anchorage, Alaska, CWSU icing PIREP decision tree.

This decision tree is only a guide; the decision to issue a CWA is still at the forecaster's discretion. However, if other NWS offices had been following the criteria outlined in the Anchorage, Alaska, CWSU decision tree, the ZNY CWSU forecaster in the Morristown, New Jersey, accident would have been guided to issue a CWA following the single PIREP of icing from the MD-83. Likewise, similar guidance for the AAWU would have emphasized that an advisory on icing was prudent following the two PIREPs for severe icing near Anchorage, Alaska. The NTSB does not believe that other CWSUs currently use such guidance to weight PIREPs to help in decision-making and situation awareness. The NTSB concludes that the decision tree clearly helps forecasters make decisions about advisory issuance, and the use of such standardized guidance for weighting PIREPs would also help aviation weather forecasters become consistent in recognizing and maintaining situation awareness of "severe" conditions as reported by pilots.[48] Therefore, the NTSB recommends that the NWS establish standardized guidance for all NWS aviation weather forecasters on the weighting of information reported in PIREPs that will (1) promote consistent determination of hazard severity reported in a PIREP and (2) assist in aviation weather product issuance.

Therefore, the National Transportation Safety Board makes the following recommendations to the National Weather Service:

> Modify National Weather Service (NWS) aviation weather products to make them consistent with NWS nonaviation-specific advisory products when applicable, so that they advise of hazardous conditions including aviation hazards less than 3,000 square miles in area that exist outside of terminal aerodrome forecast coverage areas. (A-14-17)

> Provide a primary aviation weather product that specifically addresses both the potential for and the existence of mountain wave activity and the associated aviation weather hazards (as recommended in Safety Recommendation A-14-14 to the Federal Aviation Administration). (A-14-18)

> In cooperation with the Federal Aviation Administration (FAA), revise the Interagency Agreement between the FAA and the National Oceanic and Atmospheric Administration/National Weather Service (NWS) for the center weather service units (CWSU) and its accompanying statement of work if needed to add the new responsibilities of CWSU personnel in response to Safety Recommendations A-14-17 and/or A-14-18 to the NWS, which are in addition to the other responsibilities currently performed by the NWS under this agreement. (A-14-19)

> Establish a protocol that will enhance communication among meteorologists at the center weather service units, the Aviation Weather Center, and, as applicable, other National Weather Service facilities to ensure mutual situation awareness of critical aviation weather data among meteorologists at those facilities. (A-14-20)

[48] Some aviation weather forecasters may view a "moderate/severe" PIREP of turbulence to be a definitive "severe" report and will treat it as such, while other aviation weather forecasters determine this type of PIREP to mean more "moderate"-severity turbulence with occasional severe-level turbulence. Reporting aircraft type may also play a role in this weighting.

> Establish standardized guidance for all National Weather Service aviation weather forecasters on the weighting of information reported in pilot reports (PIREPs) that will (1) promote consistent determination of hazard severity reported in a PIREP and (2) assist in aviation weather product issuance. (A-14-21)

The NTSB also issued four safety recommendations to the Federal Aviation Administration.

Acting Chairman HART and Members SUMWALT, ROSEKIND, and WEENER concurred in these recommendations.

The NTSB is vitally interested in these recommendations because they are designed to prevent accidents and save lives. We would appreciate receiving a response from you within 90 days detailing the actions you have taken or intend to take to implement them. When replying, please refer to the safety recommendations by number. We encourage you to submit your response electronically to correspondence@ntsb.gov.

[Original Signed]

By: Christopher A. Hart,
Acting Chairman

cc: Federal Aviation Administration