

## **Factual Report – Attachment 7**

Communication with the FAA, Vaisala and All Weather Inc. regarding Automated Weather Observing System clock drift, data dissemination and maintenance.

# **METEOROLOGY**

DCA18MM028

*Submitted by: Mike Richards  
NTSB, AS-30*

## **AJW-144/AJW-17 Responses to NTSB 19-015 Inquiry Questions**

### General Observations:

AWOS, both Federal and non-Federal, are designed and typically located for aviation use in the vicinity of an airport. They provide information regarding the current local conditions at the AWOS location. They do not provide any form of predictive information.

Depending on wind directions and speeds, an AWOS may observe a weather condition significantly before or after that condition is observed elsewhere. For that matter, a localized weather condition at one location may not even be observed by an AWOS at another location.

By design, AWOS do not report instantaneous information. The various weather parameters that are reported are averaged in accordance with National Weather Service defined averaging algorithms.

For Federal AWOS, this information is available as METARs issued once an hour, as SPECIs issued as needed and as one-minute observations available as voiced messages via dial up phone line or VHF radio transmissions.

For non-Federal AWOS, this information is available as METARs issued every 20 minutes (non-Federal AWOS do not issue SPECIs) and as one-minute observations available as voiced messages via dial up phone line or VHF radio transmissions.

METARs containing the word "AUTO" are generated automatically. METARs that do not contain the word "AUTO" have been augmented by a controller at a Limited Aviation Weather Reporting Station (LAWRS) or a Certified Weather Observer (CWO).

### Accident Related Observations:

Based on the accident location, as provided during the 11/13/18 telecon to be 36.5872666 N and 93.31855 W, the non-Federal AWOS located at Branson West Airport (FWB) is over 8 miles away and over 400 feet higher. These 8 miles include hills, open and wooded land areas and significant lake area. The Branson Airport (BBG) non-Federal AWOS is over 7 miles away and over 375 feet higher. These 7 miles include hills, open and wooded land areas and limited lake area.

### General Observations Regarding NTSB Questions:

Many of these questions are general in nature. They will be answered in general terms for the more than 1600 Federal and non-Federal AWOS in the National Airspace System (NAS).

1. NTSB:  
How many individual AWOS in the NAS have a "clock drift" issue that affects the time (relative to GPS time) that an observation will be disseminated longline?

AJW-144:

All Federal and Non-Federal AWOS clocks drift. This may or may not affect the time an observation will be disseminated to the long line network.

By design, AWOS use the computer's internal clock and system cycle time. (This clock does not have the same accuracy requirements as a GPS satellite clock or other national standard clock.)

This has negligible impact on Federal AWOS because their clock time is automatically updated to the nearest second through their ADAS connection once a day. (This is the same connection used to send METAR messages to the FAA weather network.) If a Federal AWOS is not connected to ADAS, the system clock standard is GMT  $\pm 10$  seconds.

Clock drift may have a potential impact on non-Federal AWOS. The non-Federal AWOS advisory circular currently does not have criteria for automated time updates from an external reference time source. Instead, the time is to be checked during the tri-annual maintenance checks and the annual inspection. The clock function should be accurate to within 15 seconds each month (or within 45 seconds during maintenance checks and annual inspections) when compared to an official time source, e.g., WWV, UTC, or GPS. For those type-certified, commissioned systems whose output is provided to the national weather network, i.e., AWOS III or IV only, AWOS clock errors in excess of 5 minutes may result in rejection of all data sent to the national weather network.

The responses to questions 8 and 9 below include additional information regarding the rejection of weather information.

2. NTSB:  
Is the severity of clock drift random, or is there a sense of how fast/slow these clocks will drift on every affected AWOS, and what is that?

AJW-144:

We have no way of determining this for the installed Federal and non-Federal AWOS.

3. NTSB:  
What are the largest drifts in clock time that you have seen over X days?

AJW-144:

Some members of our group recall seeing Federal AWOS clock drifts as large as 1-2 seconds per day. These sites received daily time updates from external sources.

We have no information regarding non-Federal AWOS clock drifts.

4. NTSB:  
How long has this "clock drift" been present in AWOSs operating in the NAS?

AJW-144:

As discussed in the response to question one above, clock drift is inherent to all computers. Clock drift has been present in Federal and non-Federal AWOS from the beginning. This is why the Federal AWOS receive daily clock updates and non-Federal AWOS have periodic clock checks and drift limits.

5. NTSB:  
Aside from updating older model AWOS systems with newer GPS-syncing systems, what actions have been taken, by FAA and/or manufacturers, to mitigate the clock drift issue?

AJW-144:

The optional AWI GPS syncing capability is limited to their AWOS 3000 series and is used in situations where periodic updating of the time has been determined to be difficult.

Based on available information, the clock drift issue is felt to be suitably addressed.

6. NTSB:  
AC 150/5220-16E, section 3.19-a-4 states "Monitoring of the system should be performed by FAA authorized maintenance personnel to regularly review and analyze the locally archived operational and maintenance data. The technician should determine that all system parameters are being correctly reported, and that the real time clock is within the specified tolerance."

AC 150/5220-16E, section 4.4-a states that the approved maintenance technician should "Check system time and reset as needed" every 4 months (tri-annually) +/- 15 days.

Because this is an Advisory Circular and uses the word "should," to clarify, is there a requirement for certification in any documentation for clocks on AWOSs to be checked and reset within initial tolerance (15 seconds), and if so, how often shall that be conducted (either remotely or on site)?

AJW-144:

The criteria are identified in the advisory circular. No other document includes non-Federal AWOS clock checking criteria.

Section 1 of the introductory material at the start of the advisory circular states that the advisory circular "...also contains maintenance and annual inspection criteria that must be met throughout the system's life cycle in order for the system to continue to be an approved source of aviation weather information." The importance of the annual inspection requirement is reiterated in section 2.1.c.

In accordance with section 4 of the introductory material at the start of the advisory circular, "...the use of the specifications in this AC is mandatory for AWOS projects funded under the Airport Improvement Program (AIP) with revenue from the Passenger Facility Charges (PFC) program or for non-Federal AWOS projects for airports that are obligated to the Airport Sponsor Assurances."

AWOS advisory circular section 3.18.a.(4) discusses the authorized technician's ability to check and set the clock remotely.

In accordance with advisory circular section 3.18.a.(5), if the weather information is to be distributed to the national weather network, AWOS clock errors in excess of 5 minutes may result in rejection of all data. This time check and possible rejection is performed by WMSCR.

7. NTSB:

The attached All Weather Inc. AWOS Maintenance Manual 907-027 does not provide information on tri-annual maintenance but identifies "Check system clock; adjust if error >1 minute" in the AWOS Monthly Technical Performance Record form. According to All Weather Inc., this manual provides guidance that the clock on the -900 model AWOS (as an example) should be checked (and adjusted as needed) once per month.

The attached 3000-027 AWOS manual from All Weather Inc., does have tri-annual procedures, but the clock item is identified as a monthly item.

AC 150/5220-16E, section 4.4-a states "...maintenance checks should be accomplished by the assigned maintenance technician holding verification authority in accordance with manufacturer's provided and FAA approved maintenance manual at tri-annual intervals."

In this situation it appears that the AC may be providing guidance on the tri-annual maintenance that is recommended by the manufacturer. Or it could be saying that whatever is recommended to be included in a maintenance check, this should be conducted at tri-annual intervals.

What is the current guidance (or requirement) for AWOS technicians of record to check/reset an AWOS clock when the manufacturer recommends a different frequency than tri-annually?

AJW-144:

The All Weather AWOS Maintenance Manual 907-027, dated November 2008, discusses quarterly maintenance which is consistent with the advisory circular current at the time of its publication. Tri-annual maintenance was introduced in revision D of the non-Federal AWOS advisory circular dated April 28, 2011.

The current guidance is discussed in chapter 4 of the current advisory circular. As mentioned in section 4.1, this chapter, "...provides the FAA's minimum desired and maximum acceptable operating standards, tolerances, and references for a commissioned non-Federal AWOS system." If a manufacturer feels additional checks, e.g. monthly, are needed that is their prerogative to add, as long as they continue to meet the advisory circular's tri-annual criteria. The manufacturer's maintenance manual is reviewed and approved by the FAA prior to its use in the field.

8. NTSB:

Are there procedures in place (possibly at WMSCR) that when an observation is received from a third-party vendor that is "off" by a certain number of minutes relative to GPS time, that that observation will be discarded, or other action will be taken? If so, what are those procedures and actions?

AJW-144 and AJW-17:

WMSCR discards METAR products if they are received with a WMO header/current time delta of 1 hour (configurable). In the event that a WMSCR user complains (by phoning the NEMC) about METAR delivery times, 2<sup>nd</sup> level will monitor the archive data to determine the nature of the problem. The NEMC will use the dial up number for the AWOS to determine the system time of the AWOS and contact the AOCC/MOCC as needed to prompt clock corrections.

9. NTSB:

We understand that WMSCR is an “FAA system that receives, processes, and stores WMO- formatted text-based aviation weather products (such as Surface Observations (METARs/SPECIs), PIREPS, AIRMETs, SIGMETs, TAFs, etc.) and disseminates these products to a variety of FAA and non-FAA users.” And that “WMSCR is the FAA’s collection point for the receipt of METARs sent in by authorized Non-Federal AWOS service providers for some 1100+ non-Federal AWOS locations in the CONUS.”

As we understand it, nonFed AWOS observations from third-party vendors are sent to WMSCR via an “SAUS” message, example below. We understand the timestamp on the SAUS message (0004 UTC on the 20<sup>th</sup> in the below example) is done by the third-party vendor and is the time that SAUS message is sent to WMSCR. How long does it normally take WMSCR to receive this SAUS message? How long from the SAUS timestamp does it normally take the contained observations to made available/disseminated publicly via WMSCR?

```
####  
SAUS27 RSYS 200004  
METAR KS32 200015Z AUTO 17006KT 10SM CLR 23/21 A2982 RMK AO2= METAR  
KBXK 192355Z AUTO 23010G16KT 10SM CLR 40/17 A2979 RMK AO1 = METAR KM25  
200015Z AUTO 00000KT 10SM SCT055 29/24 A2988 RMK AO2  
PWINO=  
METAR KFWB 192355Z AUTO 35027G45KT 7SM TS SCT055 BKN065 27/17 A3000 RMK  
AO2 LTG DSNT ALQDS =  
5f46936dd41a5e1bc5306cca4e093be6
```

AJW-144 and AJW-17:

Non-Federal AWOS Service Providers use WMSCRs FTP servers to upload METAR data to WMSCR at predetermined times. Every non-Federal AWOS generates METARs 3 times an hour, which are forwarded by the non-Federal AWOS service providers to WMSCR every twenty minutes, typically around minutes, 17, 37 and 57. Note however for one Non-Federal AWOS service provider that is handling over 600 non-Federal AWOS sites, these METARs are still uploaded three times an hour, but these uploads are spread out over the hour, around 10 METARs are uploaded every minute.

The WMO message is sent from the FTP server to the WMSCR application via TCP/IP in near real-time and then the WMO is sent out to requesting users immediately. The individual reports are parsed from the WMO and packaged for individual users based on a user-requested scheduled delivery time. If a report is received after the scheduled delivery time, it is sent out immediately.

Typically the WMOs are received at the ftp server, forwarded to WMSCR, and distributed all within the same minute of the WMO header of the product.

10. NTSB:  
Additional question:

As far as we can tell, FWB was a site without a human observer and had an AWOS without SPECI capability. We understand publicly-disseminated/accessible METARs from these types of sites are limited to a frequency of 20 minutes, according to the 7900.5. Do not recall if this is a third-party dissemination, FAA collection infrastructure-based, or instrument-level restriction.

Sometimes, important information can be observed by a non-augmented AWOS between the 20-minute dissemination times. In the case of FWB and the duck boat event, based on its one-minute logs, the FWB AWOS (according to its clock at that time, right or wrong) first observed a wind condition (approaching the accident location) that exceeded the USCG restrictions for the accident vessel at 2340 UTC. Because FWB disseminates to its third-party vendor at :15, :35 and :55, information from FWB would not have been sent to its third-party until 15 minutes after this observation of approaching wind exceeding the USCG regulations.

Is it possible for such AWOS/site types to disseminate (make available to the public through normal channels) observations in between the normal 20-minute METARs, or somehow make certain information available? This could provide better lead time to the public and private notifications services for impending wx. Or is there an instrument-specific limitation here (depending on models)?

AJW-144:

The non-Federal AWOS METAR distribution frequency of every 20 minutes has been in place since before 2001.

Verbal METAR messages containing the current one minute METAR information are available to the public directly from the site's AWOS via dial up phone lines and VHF broadcasts. Neither of these sources require any form of listener input. These messages include coordinated universal time. (VHF reception is line of sight. In accordance with the AWOS advisory circular, the reception range is 25 nautical miles radius and up to 10,000 above the surface, however local hills and structures may obstruct its reception by a ground based receiver.)

Please keep in mind, this information is intended for aviation, not maritime, purposes and is the current averaged information, not instantaneous information. For wind information, The sensor is sampled every 5 seconds. Every minute, the algorithm computes a 2-minute average for the wind report. Gusts and squalls utilize more complex logic that involves 10-minute holds and averages.

Changing the long line reported frequency would constitute a significant standards change. Implementing such a change for over 1600 Federal and non-Federal AWOS would constitute a significant programmatic and technical effort requiring changes to the fielded AWOS as well as to the various third-party provider and FAA WMSCR/ADAS networks. Also, existing end users would need to make the necessary changes to accommodate the increased weather updates.

Good morning Mike,

Here is the additional information that you requested on AWOS. See below.

NTSB Additional Question:

- In response to question # 9, the FAA stated (in part): "Note however for one Non-Federal AWOS service provider that is handling over 600 non-Federal AWOS sites, these METARs are still uploaded three times an hour, but these uploads are spread out over the hour, around 10 METARs are uploaded every minute."

This was read that there is a service provider that collects over 600 nonFed AWOS observations at a given time but does not upload all those observations immediately to WMSCR, rather those uploads are spread out over the following 60 minutes. Such that an observation taken at 0215Z may not be uploaded to WMSCR until an hour later in the extreme, but realistic case.

It is possible our interpretation of this is very wrong. Can we clarify what this statement is saying in that context. If the interpretation is correct, is it known why this schedule occurs? Is it a limitation of the service provider or other system to upload all quickly?

FAA Response:

- #9: The NTSB's interpretation is wrong. This Non-Fed AWOS service provider is spreading out the workload it takes them to receive a METAR from each of the 600+ locations every 20 minutes, process that METAR (store to file) and then upload these files to WMSCR's FTP server. They perform this cycle three times an hour for every one of these 600+ locations. (In other words WMSCR receives a METAR from every one of these 600+ sites every 20 minutes, but not all at once).

NTSB Additional Question:

- In response to question #6, the FAA stated (in part): "In accordance with advisory circular section 3.18.a.(5), if the weather information is to be distributed to the national weather network, AWOS clock errors in excess of 5 minutes may result in rejection of all data. This time check and possible rejection is performed by WMSCR."

In response to question #8, the FAA stated; "WMSCR discards METAR products if they are received with a WMO header/current time delta of 1 hour (configurable). In the event that a WMSCR user complains (by phoning the NEMC) about METAR delivery times, 2nd level will monitor the archive data to determine the nature of the problem. The NEMC will use the dial up number for the AWOS to determine the system time of the AWOS and contact the AOCC/MOCC as needed to prompt clock corrections."

Just looking for clarification here. Is there an automatic protocol currently in place that will reject nonFed AWOS observations with AWOS clock errors in excess of 5 minutes? Are there any other automated protocols currently in place that will reject nonFed AWOS observations deemed to be "off" (referencing the WMO "SAUS" file header time or some other timestamp) by less than one hour? If so, how do these work specifically?

FAA Response:



- #8: There is no automated procedure in place that WMSCR uses to reject a METAR from a non-Fed AWOS (or from any source) if the timestamp is in excess of five minutes. As stated previously, WMSCR's criteria for rejecting METARs is if the time of the observation is more than one hour different than the current time.

Regards,

*Anne*

Anne Torgerson  
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202 [REDACTED]

## Richards Michael

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**From:** Laine Tapani <[REDACTED]@vaisala.com>  
**Sent:** Monday, March 11, 2019 12:29 PM  
**To:** Richards Michael <[REDACTED]@ntsb.gov>  
**Cc:** [REDACTED]@faa.gov; Nelson Lee <[REDACTED]@vaisala.com>  
**Subject:** RE: Vaisala AWOS questions

Hello Mike,

Sorry about the delay in this response. As you know, Vaisala divested the North America AWOS business few years ago to DBT. Therefore we no longer have access to the subject matter experts who could provide detailed answers to your questions. The information below is all what we can provide.

**- Though it may be different for different models of your AWOS, can you describe the clock and time-syncing system? We believe that there is an internal clock (perhaps the “internal hardware clock”) that determines what time the collected information should be sent longline to the FAA via a 3<sup>rd</sup> party vendor (e.g., at :55 past the hour). This clock would also set the timestamp observations. And syncing this clock to “real-time” is ultimately the responsibility of the local maintenance or airport person. Are we close here?**

A: The Vaisala non-Fed AWOS system commonly employs two clocks (or “times”), a Real Time Clock (RTC) and System Time (clock in the AWOS processor). The RTC is an accurate hardware clock that is used to set the System Time once a day. The RTC is more accurate than the clock in the AWOS processor. The System Time is what the AWOS system uses to timestamp data and perform any timed actions. Various designs of time syncing were used over the years. They were based on a hardware clock components (RTC) and required changes due to obsolescence and/or availability. An early clock syncing method used the 60Hz AC line frequency to maintain accuracy, later versions used a new accurate temperature controlled crystal oscillator (TCXO) real time clock (RTC) circuit. Additionally, a new single board computer (SBC) replacement CPU was selected and tested by Vaisala. Amongst other things, the replacement CPU will further improve clock drift characteristics. This was not installed in new systems but is intended as a field replacement in case of CPU failure.

**- If an internal AWOS clock were to drift uncorrected by 15 minutes, what would be the ramifications to data collection, timestamping and dissemination (we just want to make sure we have the right understanding of the results)?**

A: Data collection would continue normally but data time stamps would be off compared to actual time. Any timed actions such as data dissemination would not occur at expected times. The AWOS Advisory Circular FAA AC15-5220-16C states: “The clock function should be accurate within 15 seconds each month. For those systems whose output is provided to the national weather network, AWOS clock errors in excess of 2-minutes and 59-seconds may result in rejection of all data.”.

**- We have heard there are nonFed AWOSs that will automatically synch the local clock(s) to GPS “real” time, removing the need for human synching and essentially almost eliminating adverse clock drift. Did you make these systems or are you familiar with them? If these types of systems are out in the field, do you know how many, Vaisala or not?**

A: Vaisala did not manufacture non-Fed AWOS systems with GPS clocks and we are not familiar with such AWOS systems. We do not know if these systems have been fielded by others.

**- Related to the previous question, has there been discussion or action taken toward mitigating or eliminating clock drift on the nonFed AWOS systems? Is it needed, why or why not?**

A: As mentioned above, the AC frequency syncing method became unreliable in some areas after the line frequency accuracy degraded (possibly due to deregulation of the electricity supply). Improved methods were developed to use an accurate TCXO RTC circuit, and further a replacement CPU SBC was made available. Vaisala is no longer developing non-Fed AWOS solutions.

**- Have you ever come across issues related to excessive clock drift on the nonFed AWOSs? Either way, what are the largest drift rates you have seen?**

A: Maintaining the FAA AWOS clock accuracy of 15 seconds per month (3min/year) is difficult especially in extreme weather (temperature) conditions. We do not have information on the specific drift rates but perhaps they sometimes exceeded the 15s/mo requirement to cause us to abandon the AC line sync method and make improvements.

**- Anything else you think we should understand about the clocks on Vaisala (now DBT) AWOS systems?**

A: Nothing else we can think of.

**- Do you have a contact at DBT that you think could answer the same questions for us?**

[REDACTED]

Thanks,  
Tapani

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**Tapani Laine | Program Manager**

Vaisala Inc, [REDACTED]

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## RECORD OF CONVERSATION

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**Date:** March 11, 2019  
**Time:** about 1100-1130 Pacific daylight time  
**Location:** Telephone  
**Person Contacted:** Mr. Neal Dillman  
Chief Technology Officer  
All Weather Inc.  
**Persons Present:** Mr. Mike Richards  
Senior Meteorologist  
National Transportation Safety Board  
**Subject:** Accident Investigation DCA18MM028

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On March 11, 2019, at approximately 1000 Pacific daylight time (PDT), Mr. Mike Richards of the National Transportation Safety Board had a telephone conversation with Mr. Neal Dillman, Chief Technology Officer with All Weather Inc. (AWI). During the conversation Mr. Dillman reported the following:

The AWI Automated Weather Observing System (AWOS) -900 model has one clock that controls the timestamping of observations and when observations are disseminated from the machine (e.g., to a third-party vendor). These clocks are susceptible to drift but were engineered to meet the clock accuracy requirements established in the Federal Aviation Administration's Advisory Circular 150/5220-16. Regarding the Branson West Municipal Airport/Emerson Field (FWB) non-Fed AWOS, Remote Systems Integration (RSI) and/or the local airport authority would be responsible for ensuring the FWB AWOS clock is appropriately synched or making sure the local customer accomplishes that. The AWOS 900 Maintenance Manual monthly maintenance and related Monthly Technical Performance Record (p15) require validation of the clock on the system. He believes all non-Fed AWOSs operating in the field with the exception of the AWI AWOS 3000 do not have GPS-synching systems for their clocks and that Automated Surface Observing Systems are in the same boat.

Clocks can be adjusted by either (1) "slamming" the clock, which moves the time instantly from (for example) 1300 to 1400, or (2) "slewing" or "skewing" the clock, which moves the clock quickly through a time period (for example 1300-1400).

In extreme cases, he has heard of clock drifts of hours, however the rates of drift have not been determined. Issues that can cause these types of clock drifts include a failure of the clock and power supply problems (including brownouts). Environmental temperature swings can also affect clock drift, but because the AWOS -900 model clock is housed indoors or in temperature-controlled conditions, environmental temperature swings should not be an issue.

AWI can dial in to their AWOSs and adjust the clock automatically, however the extent of this mitigation can be limited by the telephone technology used to communicate with the AWOSs.

The AWI AWOS 3000 model, which was certified in 2010, has GPS integrated so it is not affected by the clock drift issue that affects the 900 model (the GPS capability of the 3000 model keeps the clock in synch).

Conversation ended at approximately 1130 PDT.

Mike Richards  
Senior Meteorologist  
Operational Factors Division  
National Transportation Safety Board