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System Flags Altimeter-setting Errors In Weather Observations

Canadian authorities were alarmed in 1997 by the unexpected rate of human errors in altimeter settings. They have succeeded in preventing nearly all types of these errors.

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FSF Editorial Staff

Undetected errors in altimeter settings prepared by weather observers can expose aircraft pilots to risks such as loss of vertical separation, collision with terrain or collision with obstacles on the ground. Human errors by observers can occur, for example, in misreading a mercury barometer or printed table, failing to correctly convert data, incorrectly hearing spoken information or mistyping data on a computer keyboard.

Altimeter-setting errors in aviation routine weather observations (METARs) become a serious safety concern for pilots conducting instrument flight rules (IFR) approaches in instrument meteorological conditions (IMC) or at night because a small error in the altimeter setting could cause an accident, said John Foottit, manager, Aviation Weather Services, Nav Canada.[1]

Canadian altimeter settings, for example, originate from automated weather observation systems (AWOS) and from observers at three types of weather-observation sites: community aerodrome radio stations primarily located in small arctic communities; contract weather observers whose only function is to report the weather; and flight service stations (FSSs) staffed by specialists who, in addition to conducting weather observations, have concurrent duties such as providing advisory services to pilots and controlling access to airport movement areas by vehicle drivers.

"If there is one thing that has to be correct in a METAR, it is the altimeter setting," Foottit said. "Second is accurate wind speed and wind direction, particularly for crosswind landings on a runway that may not be dry. Those two elements are safety-critical for IFR operations."

The air navigation system in Canada was privatized in November 1996, and an agreement between Nav Canada and the Meteorological Service of Canada (MSC), a government department, included an MSC performance-measurement system that initially was to provide monthly quality-assurance reports about weather services. The first reports were designed to quantify the following:

- Data errors within surface-weather observations, including altimeter-setting discrepancies;
- Accuracy of forecasts for specific airports; and,
- Timeliness of weather observations.

"When the first results from the performance-measurement system started arriving in September 1997, altimeter-setting errors leaped off the page," Foottit said. "An average nationwide rate of one altimeter-setting error per day was discovered. By mid-1998, the rate of altimeter-setting errors that showed up at human-observer sites was reduced by half, but 70 percent of all errors could have had the aircraft lower than its indicated altitude, sometimes by as much as 1,000 feet. Before this time, we had no altimeter-error-tracking software, and we just had assumed that our process was error-free. We also could not find any record of accidents or incidents caused by an erroneous altimeter setting from a weather-observation report in our joint research with the Transportation Safety Board of Canada."

At the time, mercury barometers were used with various types of data-entry software and transmission methods. The barometers required observers to perform a multi-step calculation[2] to obtain each QNH altimeter setting (the setting that causes the altimeter to indicate height above mean sea level; i.e., field elevation at touchdown on the runway). Sometimes, because of on-site equipment problems, weather observers relied on third parties to transmit METAR data sets, which increased the opportunity for error. Nav Canada and Environment Canada sent letters to observers with a reminder about strict adherence to operational procedures to prevent the transmission of erroneous altimeter settings.[3]

"We said that altimeter-setting errors have the potential to kill, that they are a very serious matter and that observers have got to pay very close attention when they do this part of their observations," Foottit said. "We saw some initial improvements, but usually these kinds of improvements in human behavior are temporary. We knew that we also had to systematically address the problem, including replacing mercury barometers with digital barometers."

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The Canadian Aeronautical Information Publication (AIP) similarly contained a notice about ensuring accurate altimeter settings, including the following recommendations:[4]

- "Pilots conducting instrument approaches in [IMC] or at night are advised to exercise extreme caution when an altimeter setting does not appear consistent with the most recent previous observation or with other altimeter settings from nearby sites;
- "Inconsistency with reports from nearby sites or a difference of greater than 0.12 [inch] of mercury [4.00 hectopascals] on an altimeter subscale in less than one hour is suggested as cause to seek a verification;
- "Pilots also are urged to report any apparent occurrences of erroneous altimeter settings … ; [and,]
- "Errors [detected during quality-assurance monitoring of METARs] are confined to human observers. … AWOS are equipped with a dual-pressure-sensor 'fail safe' system. No AWOS altimeter[-setting] errors which would have placed an aircraft lower than its indicated altitude have ever been detected."

Nav Canada led the safety study with awareness of the typical extent of pilot dependency on accurate information from the observers.

"Without anything on the aircraft that would allow pilots to validate an altimeter setting, many were not in a position to question its accuracy — errors could go unchallenged that would have placed the aircraft 200 feet to 500 feet lower than indicated by the altimeter," Foottit said. "Pilots easily could question a huge change — such as an error of 1,000 feet — or an altimeter setting reflecting fairly high pressure for the kind of weather reported, and a temperature and dew point fairly close together."

Logbooks kept by specialists on duty at MSC's national quality assurance and monitoring desk assisted researchers in categorizing the human errors. Categories included observer error, transmission error, communication error, barometer misread, data-entry error, miscalculated QNH, procedural error, correction not sent, unknown, and typing errors by flight service station, coast guard station or other third party. They typically caught questionable altimeter settings by comparing them with METARs of the previous four hours at the same site and other sites.

"For example, when an altimeter setting showed that within the previous hour, the pressure had risen 0.3 inch of mercury [10.0 hectopascals, equivalent to 300 feet], that was considered a large change that might indicate an error," Foottit said. Researchers reviewed records and talked with observers to determine whether apparent altimeter-setting errors were real.

"If a cold-front passage caused a real change in the pressure, maybe the altimeter-setting change was normal," he said. "Researchers flagged every altimeter setting outside of normal tolerances as a definite error or a possible error. Comparisons might show a site 100 nautical miles [185 kilometers] away reporting an altimeter setting of X inches of mercury while the local site was reporting X plus 0.5 inch [17 hectopascals], which would be a very large pressure increase over a short distance."

The safety study then established priorities for preventing, trapping and mitigating these errors.

"Eliminating all procedural errors and typographical errors will eliminate approximately 95 percent of errors currently being detected," the report said. "It is estimated that the remaining errors described … will lead to, at most, one erroneous altimeter setting per 30 days. … Given these facts … the deployment of digital, triple-cell aneroid barometers, with an automatic output feed into [data-entry-terminal software], is the preferred option. … This option's only potential shortcoming is that the instrument could slowly become decalibrated without the knowledge of the observer. … Calibration errors, unlikely though they may be, would not be an issue since the three pressure sensors are independent [and] the probability of having simultaneous errors in two [sensors] or three sensors is negligible."

Nav Canada's first phase of corrective actions was completed in 2000. Another phase began during 2004, Foottit said.

"[In the safety study,] community aerodrome radio stations and contract weather-observation stations accounted for 70 percent of all altimeter-setting errors detected in Canada," the report said. "Observer typographical errors and errors in the process of manually calculating an altimeter setting accounted for approximately 80 percent of all errors detected. Community aerodrome radio stations, contract weather-observation stations and coast guard stations/lighthouses made a relatively higher proportion of [typographical] errors as opposed to barometer misreads or other errors. FSS [staff,] Environment Canada staff and contract weather-observation (CWO) stations made a relatively higher proportion of barometer-process errors [compared with] typographical [errors] and other errors."

The specialist analyzes the continual flow of METAR data to prevent distribution of an altimeter-setting error within a METAR for longer than a few minutes.

Currently, observers continue to form the first line of defense against altimeter-setting errors, using triple-sensor digital barometers and standard data-entry-terminal software at all 235 sites in Canada. Each observer reads a digital display on the barometer, transcribes data into a weather-observation data set and transmits the data set to the aviation-weather network.

Each observer's software automatically "looks back" at up to six previous weather observations during data entry and raises an alarm if the current-hour altimeter setting exceeds tolerances when compared with the preceding sequence of altimeter settings.

"The primary remaining problem is that many sites do not operate 24 hours a day, seven days a week," Foottit said. "If the station has been shut down overnight, there are no data for the automated comparison at the station in the morning. Reports from MSC show that the few current altimeter-setting errors sent out in METARs [about five per month nationwide][5] essentially involve incorrectly typing data on a computer keyboard for the first observation of the day."

Third-party transcription errors may occur when an observer cannot transmit a METAR data set directly to the network because the normally used computer and backup computer are unserviceable, or because failures occur on telephone lines or on the Aeronautical Fixed Telecommunication Network used by many airports. Procedures then call for the observer to call a "buddy station" and to dictate the data set by telephone. The spoken altimeter setting can be misheard.

The specialist on duty at the quality assurance and monitoring desk forms the second line of defense. The specialist analyzes the continual flow of METAR data to prevent distribution of an altimeter-setting error within a METAR for longer than a few minutes.

"The specialist's software looks at each altimeter setting in relation to others in the area," Foottit said. "This process traps errors right away and raises the alarm flag. The specialist then calls the observer, who might say, 'I did the temperature calculation incorrectly' or 'I misread the barometer' or 'I typed the altimeter setting as 29.90 when I meant to type 29.50.' Usually, the specialist obtains and distributes the corrected surface-weather observation within a matter of minutes. This temporary risk is acceptable to Nav Canada given the absence of related accident history, but we want to move as quickly as we can to data-entry-terminal software that directly imports the data from the digital barometers (i.e., with no routine transcription by the observer required)."

Implementation of barometer–software upgrades typically involves extensive testing; the first phase of the Nav Canada corrective actions required more than two years. In 2004, Nav Canada has begun a project with MSC to introduce the next generation of data-entry software.

"This solution directly will import as much of the weather-observation data as possible, such as temperature, dew point, runway visual range and wind velocity," Foottit said. "This method virtually should eliminate the altimeter-setting errors, as well as the less-critical errors."

Triple-sensor digital barometers currently used by observers — and the single-sensor devices and dual-sensor devices used for wind and altimeter digital display systems (WADDS) installed in Canadian air traffic service facilities — have proven to be as accurate and reliable as AWOS.

"In five years, none of the six spare sensors in storage was required for the 35 WADDS," Foottit said. "Pressure sensors inside our triple-sensor digital barometers have failed extremely rarely. Known vulnerabilities of these barometers can be low temperature extremes, failures in internal power supplies and electronic circuit failures that may cause the instrument to shut down. Small universal power supplies enable continued operation during short-term power failures."

The performance-measurement system also has been valuable to air carriers seeking quality-assurance data from the 175 sites that produce aerodrome forecasts (TAFs). Among other uses, accurate TAFs enable air carriers to operate their aircraft on a no-IFR-alternate basis (i.e., carrying a 30-minute fuel reserve rather than this reserve plus sufficient fuel to fly from the flight-planned destination to the alternate airport).

"To help air carriers risk-manage their flight-dispatch systems, MSC must track not only how accurate the forecasts are generally and seasonally, but exactly how inaccurate the forecasts have been," Foottit said. "If the performance scores for a particular site are problematic, the air carrier's dispatchers may decide not to file a no-alternate-IFR flight plan or to load additional fuel or to take other appropriate safety measures. The performance-management system can inform METAR/TAF users about actual performance based on minute-by-minute data collected 24 hours a day, seven days a week."

Planned improvements to the performance-management system include implementing a relational database, from which current data will be retrieved by air carrier specialists and others via Internet queries, and automatically generated graphical reports that more clearly show safety-related trends than the current columns of numbers, he said.

Functions of the ad hoc working group on altimeter-setting errors have been absorbed into Nav Canada's Office of Safety and Quality Management, which maintains formal safety plans and conducts hazard identification and risk analysis before any change in procedures, equipment or level of service, Foottit said.♦

Notes

1. Foottit, John. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Aug. 24, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.

2. At locations without software tools, weather observers formerly read the analog scale on the barometer and applied a local reduction factor from a printed table to manually calculate station pressure in hectopascals. The first table incorporated adjustments for barometer calibration, nonstandard conditions of temperature, and height difference between station elevation and barometer elevation. The observer then used a second table to look up the conversion of station pressure to the corresponding aircraft altimeter setting in inches of mercury.

3. Ouellet, Mario. *Risk Analysis: Altimeter Setting Error In Routine Aviation Weather Reports.* Safety and Service Design, Nav Canada. May 14, 1998.

4. Proulx, Pierre. "Aviation Notice: Altimeter Setting Errors in Aviation Surface Weather Observations." *Aeronautical Information Publication.* Jan. 29, 1998.

5. Macdonald, Ken. Telephone communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. Sept. 13, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S. Macdonald is director, aviation and defense services, Meteorological Service of Canada.