U.S. Department
of Transportation

**Federal Aviation
Administration**

Memorandum

Subject: **INFORMATION**: Policy Statement on Standardization of Application of 14 CFR Part 23, § 23.1309 Regarding Hazardous Misleading Heading Information for Attitude-Heading Reference Systems (AHRS); PS-ACE100-2002-003

Date: May 30, 2003

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Purpose

The purpose of this memorandum is to clarify Federal Aviation Administration (FAA) certification policy on the application of Advisory Circular (AC) 23.1309-1C, Equipment, Systems, and Installations in Part 23 Airplanes, regarding hazardous misleading heading information.

The issue in question is specifically about the application of AC 23.1309-1C for an airplane with a certification basis of amendment 23-41 or later. This clarification is limited to installations approved for operation in Instrument Meteorological Conditions (IMC) under Instrument Flight Rules (IFR).

For operations in Visual Meteorological Conditions, a misleading heading indication is not considered hazardous.

Current Regulatory and Advisory Material

- 14 CFR part 23, § 23.1309, Equipment, systems, and installations.
- Technical Standard Order (TSO) TSO-C151b, Terrain Awareness and Warning System.
- AC 23.1309-1C, Equipment, Systems, and Installations in Part 23 Airplanes.
- AC 23-17A, System and Equipment Guide For Certification of Part 23 Airplanes.

- AC 23-18, Installation of Terrain Awareness and Warning System (TAWS) Approved for Part 23 Airplanes.

Summary

A Functional Hazard Assessment (FHA) and the related safety assessments should be made for the specific airplane type and configuration, as there can be a large number of combinations of failures, various mitigating factors, and other functions available to a pilot. Because of the numerous factors that affect the criticality of the heading indication, a safety assessment process using AC 23.1309-1C should be used to classify the failure conditions for misleading heading information.

A hazardously misleading heading is usually when the accuracy error is greater than 10 degrees on the primary heading instrument and it is an undetected error from the Attitude-Heading Reference Systems (AHRS). The safety assessment process should consider appropriate mitigating factors that might alleviate failure conditions effects, including:

- availability, accuracy, and reliability of magnetic compass;
- independent heading instrument;
- independent navigation information;
- moving map if approved for IFR operations;
- TAWS, if approved (for design and performance) in accordance with TSO-C151b, Class A or B, and following AC 23-18 (for airworthiness approval for the installation);
- air traffic control monitoring of the aircraft; and
- exposure time.

Safety Assessment Process

A hazardously misleading heading is usually when the accuracy error is greater than 10 degrees due to a malfunction on the primary heading system using the AHRS. The normal accuracy should be within the guidelines under section 23.1301 in AC 23-17A, dated June 27, 2002. For part 23 airplanes, the failure condition for misleading hazardous heading is usually considered major per AC 23.1309-1C.

For a major failure condition on Class I airplanes, the probability for the system to provide hazardously misleading heading information to the display should be less

than or equal to 10^{-4} per flight hour due to undetected or latent failures. For Class II, III, and IV airplanes, the probability for the system to provide hazardously misleading heading information to the display should be less than or equal to 10^{-5} per flight hour due to undetected or latent failures. For major failure conditions, a qualitative analysis is usually sufficient.

Note: There is a difference between hazardous as used in general policy or regulations and hazardous failure condition as used in an FHA. When the term "hazard" or "hazardous" is used in general policy or regulations, it is generally defined as follows:

"Any condition that compromises the overall safety of the airplane or that significantly reduces the ability of the flight crew to cope with adverse operating conditions."

When used in an FHA, "hazardous failure condition" is one of the five different failure condition classifications in AC 23.1309-1C. Hazardous failure conditions would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions to the extent that there would be the following:

(1) A large reduction in safety margins or functional capabilities;

(2) Physical distress or higher workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely; or

(3) Serious or fatal injury to an occupant other than the flight crew.

Mitigating Factors

During the safety assessment process, mitigating factors should be considered if they are independent of the AHRS. These factors should provide additional qualitative and quantitative credit and alleviate failure conditions. The mitigating factors may include the following:

- availability, accuracy, and reliability of magnetic compass;
- independent heading instrument;
- independent navigation information;
- moving map if approved for IFR operations;
- TAWS, if approved (for design and performance) in accordance with TSO-C151b, Class A or B, and following AC 23-18 (for airworthiness approval of the installation);

- air traffic control monitoring of the aircraft; and

- exposure time.

Some of these factors may not be appropriate for higher performance and complex airplanes.

Normally, the pilot should be scanning the instruments for cues to determine misleading information. Therefore, the locations of primary instruments and secondary instruments should be within the primary and secondary fields-of-view. This is defined in the General Aviation Manufacturers Association (GAMA) Publication No. 10, Recommended Practices and Guidelines for Part 23 Cockpit/Flight Deck Design, dated September 2000.

GAMA Publication No. 10 is available free of charge from the GAMA web site: www.generalaviation.org.

Magnetic Compass or Independent Heading Instrument

The usability of the magnetic compass, as a mitigating factor, is dependent on the airplane installation on a case-by-case basis. The following guidelines should be considered. A magnetic compass or independent heading instrument is considered acceptable if the accuracy is within 10 degrees and it is located in the secondary field-of-view. However, the compass may not be usable if it is susceptible to large errors induced by other onboard equipment. For example, an airplane approved for known icing may have an unusable compass when a windshield heater is affecting the compass; therefore, additional mitigating factors may be necessary to meet the appropriate safety level.

One general concern is that Class II airplanes may have a number of systems that can affect the magnetic compass that are not typically found in Class I airplanes. For this reason, the magnetic compass should be usable for many Class I airplanes, but it may not be usable for many Class II airplanes or higher. An evaluation should be conducted to determine if the magnetic compass is usable and accurate within 10 degrees.

Navigation Information

Credit should also be given for moving maps displaying position information from independent navigation systems such as Global Positioning Systems (GPS) that are approved for IFR operations. The moving map should depict the airplane relative to the desired navigation track and the navigational track's heading.

Navigation systems such as IFR-approved GPS systems can provide an independent relative heading source that can be used to verify the primary heading indication. Furthermore, the FAA expects that pilots will naturally

crosscheck their moving map displays because they are easier to use for navigation than traditional deviation needles.

The moving map should be in the primary field-of-view (preferably) or the secondary field-of-view to get credit for the safety assessment process by AC 23.1309-1C.

TAWS

TAWS with a display provides the pilot with sufficient information and alerts to detect potentially hazardous terrain situations so that the pilot may take effective action to prevent Controlled Flight Into Terrain (CFIT) events. Although a TAWS with a display is not approved for navigation under normal circumstances, under emergency conditions TAWS provides acceptable situational awareness to prevent CFIT.

TAWS may not be usable to determine misleading heading information, but TAWS should reduce or prevent a CFIT accident, which will mitigate the failure effect. TAWS that meet TSO-C151b, Class A or B, and AC 23-18 should be acceptable when pilot proficiency is achieved.

Air Traffic Control Monitoring

For most IFR operations, the airplane will be in controlled airspace and under radar coverage. Air Traffic Control (ATC) has been the primary mitigating factor for heading indicator accuracy for many decades. ATC maneuvers airplanes based on a ground track. Heading errors in traditional mechanical directional gyros (DG) are still identified by ATC when pilots do not maneuver in the direction ATC expects. Most of the time ATC will identify heading errors when the pilot fails to adequately update their DG or their Horizontal Situation Indicator has failed.

However, there are locations at some airports where radar coverage is not available. In these situations, there is usually some type of navigation signal that pilots can use to get into and out of the airport. These are the types of departures and approaches where heading accuracy may be important. Although ATC may be a mitigating factor, specific guidelines are not being provided at this time. Also, this may not be a mitigating factor under Free Flight operation concept.

Exposure Time and Risk Assessment

Exposure time and risk factors that may be considered are as follows:

- automatic pre-engagement self test;
- monitoring capabilities;

- maintenance intervals; and
- phase of flight, and so forth.

In the Society of Automotive Engineers Standard ARP4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment, exposure time is defined as:

> "The period of time between when an item was last known to be operating properly and when it will be known to be operating properly again."

In this policy statement, risk is also being considered.

Risk assessment is the composite of:

- the outcome or effect of the failure condition;
- the average probability of the failure condition per flight hour; and
- the exposure time.

For risk assessments, a credit should be factored into the analysis that is proportional to the probability that a given failure condition will occur on the aircraft. This credit is related to the system level of the failure condition, the operational and environmental conditions, and the phase of flight.

To determine exposure time, the actual time that the pilot would only be using heading information to navigate should be considered. Only a percentage of a typical IFR flight is flown navigating solely on the heading instrument. The critical times for heading are when the pilot is not navigating with a navigation instrument but is only using the heading instrument.

The details on how to calculate the "Average Probability Per Flight Hour" for a Failure Condition are given in Appendix C of AC 23.1309-1C. A common assumption for 14 Code of Federal Regulations (CFR) part 23 airplanes is that the average flight duration is one hour.

The FAA's General Aviation and Air Taxi Activity Survey gives estimated flight hours for IMC operations for specific airplanes. When researching the operations of specific airplane models, the result indicates that Class I airplanes are operated in IMC conditions about 20 percent of their total flight hours and Class II airplanes about 30 percent. Also, the FAA believes that only portions of most IFR flights are flown by navigating solely on the heading instruments.

Using the percentages for "phases of flight" from a Boeing accident study, the FAA estimates that on any given IFR flight, navigation solely by the heading instrument would only occur about 20 percent of the time. For this analysis, Class III and Class IV airplanes are assumed to be operating IFR nearly 100 percent of the time.

Acceptable Configurations for IFR Use

Some acceptable configurations for IFR approval include:

Configuration A:

(1) One dependable magnetic compass.

(2) A reliable magnetic gyroscopically stabilized heading system that together meets the AC 23.1309-1C reliability levels, such as 10^{-4} per flight hour for Class I airplane.

Configuration B:

(1) A magnetic compass that meets the airworthiness requirements but cannot be given credit for AC 23.1309-1C purposes for the reasons stated above.

(2) One magnetic gyroscopically stabilized heading system that meets the AC 23.1309-1C reliability levels, such as 10^{-4} per flight hour for Class I airplane, alone or in combination with one or more of the mitigating factors addressed above such as moving map or TAWS with a display.

Configuration C:

(1) A magnetic compass that meets the airworthiness requirements but cannot be given credit for AC 23.1309-1C purposes.

(2) Two magnetic gyroscopically stabilized heading systems that together meet the AC 23.1309-1C reliability levels, such as 10^{-4} per flight hour for a Class I airplane.

Configuration D:

(1) A magnetic compass that meets the airworthiness requirements but cannot be given credit for AC 23.1309-1C purposes.

(2) Two magnetic gyroscopically stabilized heading systems with each being less reliable than required by AC 23.1309-1C (such as 10^{-4} or 10^{-5}).

(3) A comparator monitor. In this case, the warning from the comparator monitor would alleviate a hazardous misleading heading. However, if the system

still has a reliability problem, numerous nuisance alarms would cause the pilot to ignore the warnings.

Effect of Policy

The general policy stated in this document does not constitute a new regulation or create what the courts refer to as a "binding norm." The office that implements policy should follow this policy when applicable to the specific project. Whenever an applicant's proposed method of compliance is outside this established policy, it must be coordinated with the policy issuing office, for example, through the issue paper process or equivalent.

Applicants should expect that the certificating officials will consider this information when making findings of compliance relevant to new certificate actions. Also, as with all advisory material, this policy statement identifies one means, but not the only means, of compliance.

Conclusion

There are numerous factors that affect the severity of hazardously misleading heading indication, so a safety assessment process using AC 23.1309-1C should be used to classify this failure condition.

The safety assessment process should consider appropriate mitigating factors that might alleviate failure conditions, including:

- availability and reliability of magnetic compass;
- independent heading instrument;
- navigation information;
- moving map;
- terrain awareness warning system;
- air traffic control monitoring of the aircraft; and
- exposure time.

For questions and assistance regarding this matter, please contact Mr. Ervin Dvorak at (816) 329-4123, by fax (816) 329-4090, or by e-mail at erv.dvorak@faa.gov.

s/

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