

Technical Airworthiness Authority Advisory (TAA Advisory)	
Title	Airworthiness Approval and Certification Considerations for Navigation in Northern Domestic Airspace and Polar Regions
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1. Purpose

- 1.1 Both civil (ref 3.2.1.o) and military (ref 3.2.1.c., Book #1 of 2, Chapter 8, para 9) operational regulations require a means of establishing direction that is not dependent upon a magnetic source when operating within the Northern Domestic Airspace (NDA). These operational regulations exist because anomalies with the Earth's magnetic field in the Polar Regions cause erroneous magnetic heading indications. Aircraft, therefore, use True Heading information when flying in NDA. Appropriately certified navigation equipment, as well as special techniques and/or procedures, are critical to safe operation in polar areas, including the area of magnetic uncertainty (ref 3.2.1.n).
- 1.2 This Technical Airworthiness Authority (TAA) Advisory addresses the technical airworthiness approval requirements for navigation equipment providing True Heading outputs and long-range navigation capability (i.e., Inertial Navigation Systems (INS) and Global Navigation Satellite System (GNSS)), for use in the NDA during Night and Instrument Flight Rules (IFR) operations. It does not address the other equipment and operational requirements (i.e., surveillance equipment, flight or basic navigation instruments, cold temperature certification to limits other than those already defined in the Aircraft Operation Instructions (AOI) or Flight Manual (FM), gravel runway certification, etc.) that may be necessary for Department of National Defence/Canadian Armed Forces (DND/CAF) fleets to conduct NDA operations. Communications aspects associated with operations in NDA are also discussed.

2 Applicability

- 2.1 This advisory applies to all DND/CAF personnel, as well as their support contractors, who are seeking to obtain an Airworthiness Approval and Technical Airworthiness Clearance for night and/or IFR operations in NDA on DND-registered aircraft.
- 2.2 This guidance is not intended to apply to DND-registered aircraft that already have a clearance to operate in the NDA. However, if significant design changes are incorporated, which could affect the onboard navigation system capabilities in the NDA, these changes should be evaluated against the criteria in this document.
- 2.3 The methodology in this Advisory assesses the impact of high latitude (NDA and Polar) operating conditions on the function and performance of equipment required for Night and IFR operations. The FM will be annotated to identify any applicable limitation or restriction.
- 2.4 It is highly recommended that the TAA and the Operational Airworthiness Authority (OAA) staff be engaged early into, and throughout, the approval process.

3 Related Material

- 3.1 **Definitions.** Nil.

3.2 Regulatory References

3.2.1 The following references should be used in conjunction with this advisory, as appropriate:

- a. C-05-005-001/AG-001 – *Technical Airworthiness Manual*, Part 2, Chapter 3 – Technical Airworthiness Clearance;
- b. B-GA-104-000/FP-001 – *Operational Airworthiness Manual*;
- c. B-GA-100-001/AA-000 – *National Defense Flying Orders*;
- d. MIL-HDBK-516C, *Airworthiness Certification Criteria*, dated 12 December 2014;
- e. U.S. Title 14 Code of Federal Regulations (14 CFR), Chapter I, Subchapter C – Aircraft, Part 23, Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes.
- f. U.S. 14 CFR, Chapter I, Subchapter C – Aircraft, Part 25, Airworthiness Standards: Transport Category Airplanes;
- g. U.S. 14 CFR, Chapter I, Subchapter C – Aircraft, Part 27, Airworthiness Standards, Normal Category Rotorcraft;
- h. U.S. 14 CFR, Chapter I, Subchapter C – Aircraft, Part 29, Airworthiness Standards, Transport Category Rotorcraft;
- i. Transport Canada Civil Aviation (TCCA) Airworthiness Manual (AWM) Chapter 523 – Normal, Utility, Aerobatic and Commuter Category Aeroplanes;
- j. TCCA AWM Chapter 525 – Transport Category Airplanes;
- k. TCCA AWM Chapter 527 – Normal Category Rotorcraft.
- l. TCCA AWM Chapter 529 – Transport Category Rotorcraft.
- m. Federal Aviation Administration (FAA) Order 8900.1 – *FAA Flight Standards Information Management System*, Volume 4 – Air Navigation and Operational Authorizations, Chapter 1 – Air Navigation, Communications, and Surveillance, Section 5 – Safety Assurance System: Special Navigation Areas of Operation, paragraph 4-103 c.
- n. TCCA's Designated Airspace Handbook, TP1820E.
- o. TCCA Canadian Aviation Regulation (CAR) Part VI, Subpart 5, Paragraph 605.16(1)(g).

4 Discussion

4.1 Background

4.1.1 Northern Domestic Airspace

4.1.1.1 Canadian Domestic Airspace (CDA) is divided into two main regions – Southern Domestic Airspace (SDA), and NDA (Figure 1). In the NDA, runway headings, tracks etc., are given in degrees true, rather than magnetic. This is due to the diminishing horizontal component of the earth's magnetic field in proximity to the magnetic North Pole and its effects on magnetic compass systems.

4.1.1.2 The NDA includes the Northern Control Area (NCA), the Arctic Control Area (ACA) (Figure 2) and all the airspace below the base of these control areas down to the surface of the earth. The Federal Aviation Administration (FAA) (ref 3.2.1.m.) designates Canada's NDA as an Area of Magnetic Unreliability (AMU). Although Canadian publications sometimes refer to it as the area of compass unreliability, they are the same. The NDA, NCA and ACA are depicted on all Canadian enroute charts and encompass the northernmost Canadian airspace.

4.1.2 Increased Alignment Times Due to Magnetic Variation and Convergence of the Meridians

4.1.2.1 Conventional magnetic compasses sense magnetic direction by detecting the horizontal component of the earth's magnetic field. Since this horizontal component vanishes near the magnetic poles, magnetic compasses are highly unreliable and unusable in an area of approximately 1,000 NM from each magnetic pole. Within these areas, air navigation tasks are further complicated by very rapid changes in magnetic variation over small distances. For example, when flying between the Magnetic North Pole and the True North Pole, a heading of True North results in a magnetic heading of south (a magnetic variation of 180 degrees).

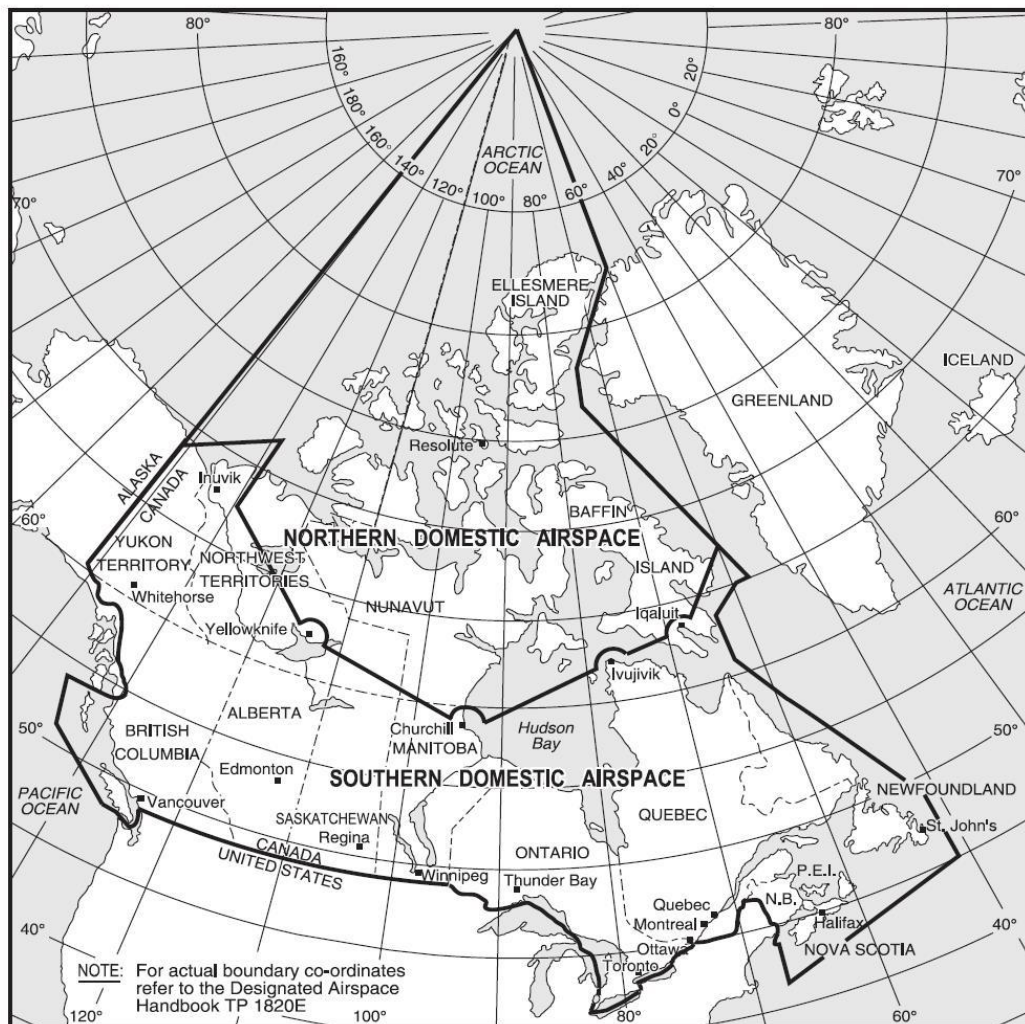


Figure 1. Northern and Southern Domestic Airspace

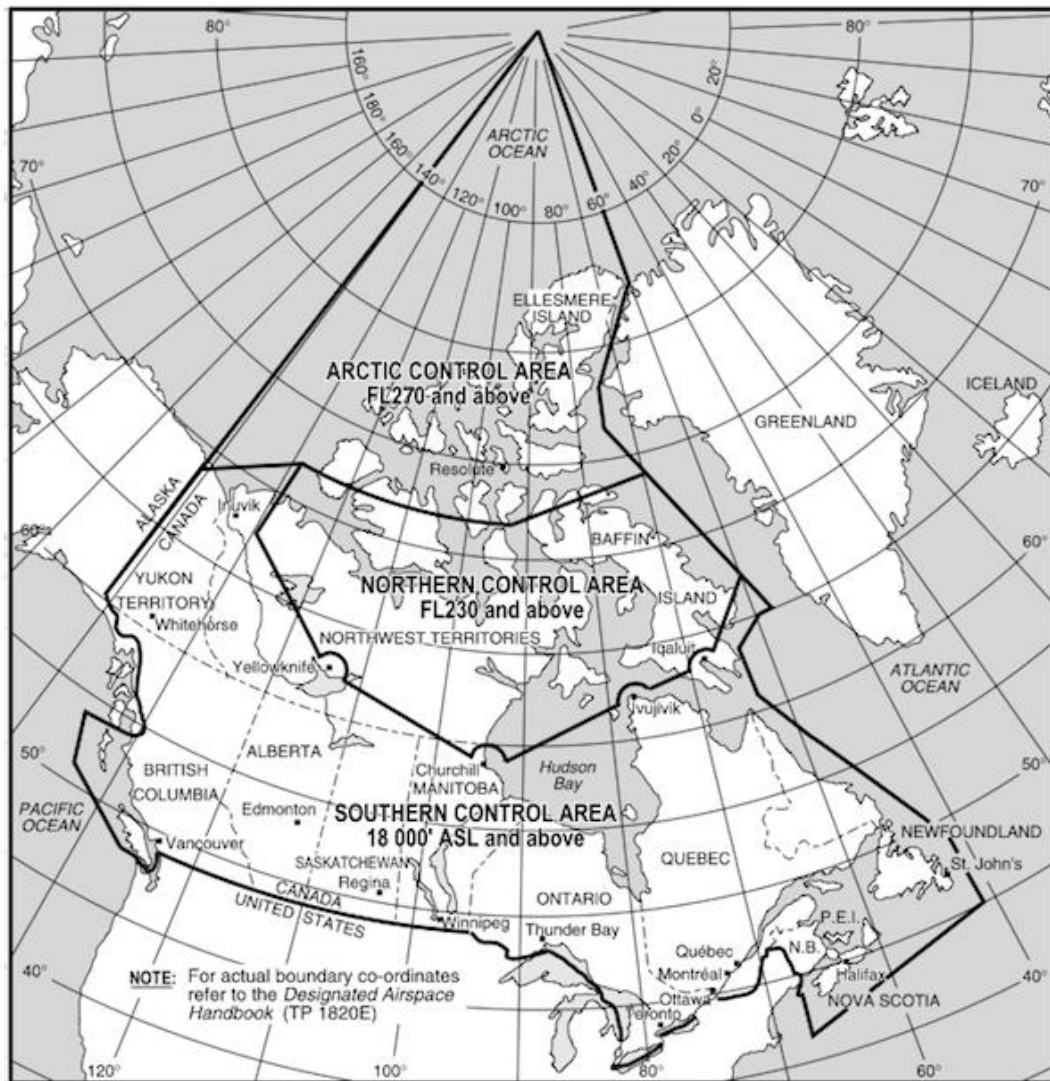


Figure 2. Arctic, Northern and Southern Control Areas

4.1.2.2 The convergence of the meridians (i.e., lines of longitude) presents additional directional complications. When flying "great circle" courses at latitudes greater than 67 degrees, convergence of the meridians can create rapid changes in true headings and true courses with small changes in aircraft position. As a result, relatively small errors in determining the aircraft's actual position can produce very large errors in determining the proper heading to fly and maintain the assigned flight path. When even small errors occur, very large navigation errors can develop over extremely short distances. An extreme example of this phenomenon occurs at the earth's geographic North Pole. Flight in any direction from the exact pole is initially due south.

4.1.3 Navigation in the NDA

4.1.3.1 Navigating in the NDA presents several issues not found anywhere else in the world (other than near the South Pole). Because of these issues, an acceptable method of navigating within the NDA is through the use of long-range navigation systems referenced to True North, using Inertial and/or GNSS:

- a. **Inertial Based Navigation Systems.** All Inertial Navigation Systems (INS) / Inertial Reference Systems (IRS) / Inertial Reference Units (IRU) are capable of calculating True North referenced outputs independently from other aircraft systems.
- b. **GNSS systems.** As of March 2020, according to Nav Canada's Aeronautical Information Publication – AIP Canada (ICAO) Part 2, Enroute 4.3, the only global operational GNSS systems approved for use in Canada are the United States NAVSTAR Global Positioning System (GPS) and the Russian GLONASS. Furthermore, the United States FAA Wide Area Augmentation System (WAAS) can provide position augmentations for use in the CDA. Coverage of the FAA WAAS augmentations is subject to visibility of at least one of the WAAS geostationary satellites. GNSS systems can output tracks referenced to degrees True, but generally do not provide any heading information. Operationally, a GNSS and an Automatic Direction Finder (ADF) can be used to determine aircraft heading. This heading can then be used to manually set a Directional Gyro, for example.

4.2 **Airworthiness Considerations**

4.2.1 The applicant is responsible for verifying that the installed navigation equipment and overall avionics architecture continues to provide its intended function while operating in NDA. Certain CAF aircraft use a civil certification basis, while others use MIL-HDBK-516, or the aircraft design specification. The appropriate airworthiness certification basis needs to be identified to ensure that the correct means and methods of compliance are incorporated into the project objectives, safety assessment, test plans and flight manual amendments.

4.2.2 For aircraft designed and certified to civil airworthiness standards, as a minimum, the following Federal Aviation Regulation (FAR) or Canadian Airworthiness Manual (AWM) requirements should be included:

- a. XX.1301 *Function and Installation*;
- b. XX.1309 *System Safety*;
- c. XX.1501, 1583 and 1585 *Flight Manual (FM)*; and
- d. XX.1529, *Instructions for Continued Airworthiness*.

The certification basis should be carefully assessed to determine whether any additional airworthiness standards and requirements need to be addressed as a result of any specific design peculiarities.

4.2.3 For aircraft designed and certified to MIL-HDBK-516, the typical requirements should include:

- a. Section 4.5 – *Operator's and Maintenance Manual*;
- b. Section 10 – *Diagnostics Systems*;
- c. Section 11 – *Avionics*; and
- d. Section 14 – *System Safety*.

4.2.4 Specific functional ground and flight test, system safety and Flight Manual (FM)/Aircraft Operating Instructions (AOI) requirements, criteria and guidance are identified in this advisory's Annexes A, B and C, respectively. Fleets seeking airworthiness approval and Technical Airworthiness Clearance (TAC) to operate in the NDA need to address these requirements as part of their airworthiness certification program.

**Ground and Flight Functional Requirements and
Considerations for Verification of Intended Function**

Item	Requirements, Considerations and Guidance Certification Requirements: FAR/AWM 1301 or MIL-HDBK-516 sections 10 and 11
1	<p>The Applicant must evaluate any switching (automatic or manual) from magnetic to true heading when entering the NDA, and from True to Magnetic Heading, while exiting the NDA. If the switching between Magnetic/True Heading is not sufficiently self-evident, a suitable alerting or other annunciation should accompany the switching.</p> <p>Test the ability to switch heading from magnetic to true and back, on primary and standby heading displays (if applicable to the standby heading indicator, as some older equipment may not have this feature). Ensure that the switch works effectively for both the magnetic and true positions.</p> <p style="text-align: center;">Notes</p> <ol style="list-style-type: none"> 1. <i>In certain implementations, the switching occurs automatically. Under those circumstances, observe the switching when transitioning between NDA and SDA and vice-versa.</i> 2. <i>FAA Advisory Circular AC 20-138D Paragraph 14-7 Interface to Magnetic/True Switch provides the following guidance:</i> <i>“If a magnetic/true heading reference switch is installed in the aircraft, the positioning and navigation equipment should be driven by the same switch to maintain consistency in the displays and operation for both manual and automatic heading reference changes.”</i>
2	<p>The aircraft navigation equipment must ensure a means is provided to identify when True Heading is selected, such as information on the primary flight and/or navigation display or marking on a control panel.</p>
3	<p>Test the ability of the inertial based system to align in heading and attitude (both on the ground and in the air – if the Inertial system has the capability of in-air alignment).</p> <p>Test each alignment mode (e.g., Gyrocompass (GC), Stored Heading (SH), Best Available True Heading (BATH), Shipboard Inertial Navigation System (SINS)) available at various latitudes.</p> <p>Ensure the alignment time is less than 30 minutes, or as specified in the aircraft type/equipment specification (record the time taken to align at various latitudes for each alignment mode tested).</p>
4	<p>Test the ability of primary gyro system (e.g., Embedded GPS/INS (EGI)) and standby to align in attitude (to show that attitude alignment of primary and standby is not impacted by northern latitudes and that primary and standby align independently in attitude from heading).</p>
5	<p>Test INU only capability (i.e., disable GPS input to one EGI or monitor an INU only output, if provided).</p>

Item	Requirements, Considerations and Guidance Certification Requirements: FAR/AWM 1301 or MIL-HDBK-516 sections 10 and 11
	<p>Assess INU only drift rate.</p> <p>Use truth data to assess INU drift (i.e., compare against remaining EGI/GNSS given good GPS constellation availability to provide valid truth data).</p>
6	<p>Assess the performance of the standby heading instrument in magnetic mode.</p> <p>Assess the performance of the standby heading instrument in Directional Gyro mode and document its drift rate.</p> <p>Assess the performance of any other backup heading instrument.</p>
7	<p>Test the ability of the standby instrument to accept a true heading automatically or manually set/derived from a primary non-magnetic heading source (e.g., EGI).</p>
8	<p>Monitor and document GPS constellation coverage along route.</p>
9	<p>Test and document ability of aircraft Automatic Direction Finder (ADF) to detect Non Directional Beacon (NDB) at varying distances, on an opportunity basis.</p>
10	<p>The Very High Frequency (VHF) – line of sight communications is likely to be limited owing to sparsity of ground based settlements.</p> <p>Test ability of aircraft beyond line of sight Communications Systems (e.g., High Frequency (HF) and Satellite Communication (SATCOM)) during NDA Flight Test.</p>
11	<p>Assess quality and content of Navigation Database for use within the NDA.</p> <p>Ensure that the airport coverage in the Navigation Database is appropriate for the intended NDA operations.</p> <p>Ensure procedures contained in the Navigation Database and pilot defined procedures are referenced to degrees True in NDA.</p>
12	<p>Assess quality and content of digital maps and associated displays in NDA. Assess any geographic limitations associated with the digital maps.</p>
13	<p>Assess quality, coverage and limitation of Terrain Awareness and Warning System (TAWS) terrain/obstacle database if applicable/installed.</p>
14	<p>If heading performance degrades in the polar region, a visual indication should be provided to the flight crew as a minimum.</p> <p>Test ability of navigation equipment and displays to provide a visual and/or aural warning of a heading difference between pilot and co-pilot systems (if applicable, as older equipment may not have this capability).</p> <p style="text-align: center;">Note</p> <p><i>An aural annunciation may be provided, as well, depending on the specific system design and overall flight deck philosophy. Any annunciation should be:</i></p> <ol style="list-style-type: none"> 1. <i>clear, unambiguous, timely and attention getting;</i> 2. <i>indicated only while the condition exists;</i> 3. <i>consistently located in a specific area of the electronic display; and</i> 4. <i>in the flight crew's primary field of view, when immediate flight crew awareness is required.</i>

Item	Requirements, Considerations and Guidance Certification Requirements: FAR/AWM 1301 or MIL-HDBK-516 sections 10 and 11
15	<p>Assess impact and demonstrate continued functionality of operating in true heading mode on other required systems, such as: Flight Management Systems (FMS); Automatic Flight Control Systems (AFCS); Flight Director (FD); Displays; Weather Radar; etc. If necessary, define any applicable limitations.</p>
16	<p>Assess the FMS or standalone navigation system heading/track input data entry requirements for parameters that are sensitive to either a magnetic or true reference (e.g., some FMS require heading/track information be entered with a suffix "T", for true heading/track inputs. If not entered with the suffix "T", the procedure would be flown incorrectly using a magnetic heading reference).</p>
17	<p>Assess any other procedures, such as approach, go around procedures, etc. that are sensitive to an input heading/track (e.g., some FMS or standalone navigation systems provide enhanced Visual Meteorological Conditions (VMC) situational awareness by allowing the creation of a straight in segment based on the insertion of a Final Approach Fix (FAF).</p> <p>Ensure that the location of the FAF is based on True North in NDA and Magnetic North in the SDA. Otherwise the final approach segment may not be properly aligned with the runway centerline).</p>

**ANNEX B
TO TAA ADVISORY 2017-02
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System Safety Requirements

The safety analysis performed for operations in the SDA must be reviewed and assessed for operations in the NDA.

The review of the design should identify all required systems that use heading and the impact on the aircraft of the use of True Heading versus Magnetic Heading by those systems. The review should also consider component design limitations that apply to the NDA but did not apply to the SDA. This review will assist in formulating a comprehensive test plan.

The review should also include operational assumptions made in the original Functional Hazard Assessment (FHA) or SSA that may be impacted/affected by operations in the NDA.

In general, it is anticipated that the following systems may be affected: Navigation, Communication and Flight Controls.

Example:

In the SDA, it is considered that the aircraft is always within VHF range of an appropriate Air Traffic Controller (ATC), but this is not the case in the NDA. What impact does this have on the availability of communications?

The hazards listed below are a generic set of hazards that may be impacted. A detailed review of the specific design being assessed will identify whether other hazards exist which need to be addressed.

Note

The definitions of probability classifications have evolved over time. It is, therefore, important to determine the certification basis amendment level applicable to the aircraft being assessed. For example, early type design certifications typically required that a "Major" failure condition meet the probability classification of improbable. More recent type designs require that a "Major" failure condition meet the probability classification of remote. For the purpose of this advisory, where there are differences between early and more recent probability classifications, the earlier classification will be denoted in square brackets (e.g., [improbable]).

Where there is no design change associated in establishing whether the aircraft meets the requirements of this TAA Advisory, it is acceptable to use the original definitions of probability classifications (i.e., there is no requirement to re-assess already established FHA or SSA items). However, if there is a design change required to ensure the aircraft meets the requirements associated with this TAA Advisory, it is then recommended to use the currently published probability classifications when deriving new FHA or SSA items.

Item	Requirements, Consideration & Guidance Certification Requirements: FAR/AWM 1309(b) or MIL-HDBK-516 Section 14
1	Loss of all attitude (primary and standby) is considered a Catastrophic failure condition.
2	Loss of all Communications is considered a Major failure condition, but credit can be taken for

Item	Requirements, Consideration & Guidance Certification Requirements: FAR/AWM 1309(b) or MIL-HDBK-516 Section 14
	<p>availability of VHF communication.</p> <p>As such, the safety analysis should document that the implemented design meets the criteria associated with a Major failure condition (i.e., loss of all communications should be remote [improbable]).</p> <p>In the SDA, aircraft are generally equipped with dual VHF communication transceivers which allow the aircraft to meet the intent of this requirement. Within the NDA (unless otherwise required by operational regulations) it is considered acceptable to equip with one HF communications transceiver and one VHF communications transceiver. (Fully certified SATCOM installations are also acceptable). Position reports can still be made on the common enroute VHF frequency (126.7 MHz) and there are a number of Peripheral Stations (PAL) and Community Aerodrome Radio Stations (CARS) available. In an emergency where the HF and/or SATCOM have failed, contacting overflying flights on 121.5 MHz is acceptable.</p>
3	<p>Loss of all Navigation is considered a Major failure condition.</p> <p>As such, the safety analysis should document that the implemented design meets the criteria associated with a Major failure condition (i.e., the loss of all navigation should be remote [improbable] and there is no single failure which would cause the loss of all available navigation equipment).</p> <p>The analysis may have to be supported by test showing that the aircraft's primary navigation system is capable of providing a navigation solution (e.g., EGI), given fewer ground based Navigation Aids in the NDA.</p>
4	<p>Loss of all Navigation and Communication is considered a Catastrophic failure condition.</p> <p>As such, the safety analysis should document that the implemented design meets the criteria associated with a Catastrophic failure condition, (i.e., the loss of all navigation and communications should be extremely improbable).</p>
5	<p>Loss of all heading (primary and standby) in the NDA can be considered a Major failure condition provided that the aircraft is equipped with a fully functional area navigation system capable of navigating in degrees true. This area navigation system must be certified according to the requirements of the airspace being utilized.</p> <p>As such, the safety analysis should document that the implemented design meets the criteria associated with a Major failure condition (i.e., the loss of all heading should be remote [improbable]).</p> <p>Credit is being provided for an area navigation system that can provide track guidance. This credit is based on the fact that, in an emergency situation where all heading information is lost but attitude and position information is still available, navigation will still be possible. Furthermore, if the aircraft is equipped with an ADF and an area navigation system that provides bearings to NDB's, an aircraft heading can be determined and used to manually update the heading reference system in cases where the design supports a free Directional Gyroscope mode.</p>

**ANNEX C
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FM/AOI and Master Minimum Equipment List Requirements – Considerations and Guidance Material

Item	Certification Requirements	Requirements, Considerations & Guidance
1	FAR/AWM XX.1501 (a); XX.1583; XX.1585 MIL HDBK 516, Section 4.5	<p>The maximum northerly latitude at which heading, attitude and positional alignment was demonstrated during the certification program will be documented in the FM and/or AOI's.</p> <p>Any additional NDA limitations resulting from the certification program must be reflected in FM and/or AOI's.</p> <p>Changes to the normal, abnormal and emergency operating procedures identified during the certification program will be documented in the relevant sections of the FM and/or AOI's.</p> <p>As required the system description section of the FM and/or AOI's will be amended to address operations in NDA.</p>
2	FAR/AWM XX.1529 TAM, Part 2, Chapter 6 – Master Minimum Equipment List (MMEL)	<p>The information in the aircraft MMEL should be validated for flight in the NDA. Such flight may reveal MMEL changes that should be made to allow safe operations in the NDA.</p> <p>The following are examples that highlight the need for a review of the MMEL:</p> <ul style="list-style-type: none"> a. The Magnetic Standby Compass may be required in the SDA but is not required in the NDA, thus a note to this effect may need to be added in the MMEL. b. If an aircraft in motion alignment is required, then the definition of a serviceable EGI may need to be more clearly stated (i.e., EGI must be aligned in attitude - but does not need to be aligned in heading before takeoff - in order to allow In Motion Alignment to occur). c. Standby Instrument may not (need not) be aligned in heading until EGI (primary) is aligned in heading.