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WORKING PAPER

THIRTEENTH AIR NAVIGATION CONFERENCE

Montréal, Canada, 9 to 19 October 2018

COMMITTEE A

Agenda Item 3: Enhancing the global air navigation system
3.5: Other ATM issues

TRUE NORTH REFERENCE SYSTEM

(Presented by Canada)

EXECUTIVE SUMMARY

ICAO Annex 4 — *Aeronautical Charts* Eleventh Edition, section 9.81 requires bearings, tracks and radials to be published in degrees magnetic except under exceptional circumstances where bearings, tracks and radials may be aligned to True North or Grid. At the Twelfth Air Navigation Conference (AN-Conf/12), Canada introduced a motion in AN-Conf/12-WP/147, paragraph 4.3.5 to move from a magnetic to True North reference system.

With the switch from analogue to digital aircraft systems, magnetic variation discrepancies have and will continue to cause operational errors in performance-based navigation (PBN) procedures, CAT II/III auto-coupled approaches and landings and AIRAC 424 coding for all course and heading legs. Track legs will not suffer the same leg disconnect errors as course and heading legs but display errors may be present.

Eliminating the practise of using a magnetic north reference system for bearings, tracks and radials and instead publish and use the True North reference system only. Procedures are designed with reference to True North and converted to magnetic. Most large aircraft use inertial reference units and flight management systems that complete calculations using True North and add magnetic variation values from tables to display information to pilots. Cost competitive gyros for mid-size and small aircraft are now available using fibre optic gyroscope (FOG) and micro-electromechanical system (MEMS) technology. Small visual flight rules (VFR) aircraft calculate flight paths in true and convert tracks to magnetic prior to flight.

Air carriers, air navigation service providers (ANSPs) and avionics original equipment manufacturers (OEMs) spend millions annually managing magnetic variation.

Technology available today has rendered the use of a magnetic reference system obsolete, increases ANSP and air operator costs and introduces aircraft tracking instability where minor to moderate magnetic variation differences exist.

Action: The conference is invited to agree to the recommendation in paragraph 3.6.

1. INTRODUCTION

1.1 Magnetic variation has always posed a problem for the design and operation of instrument procedures from the enroute through to terminal and approach phases of flight. While attitude heading reference systems (AHRS) and magnetic heading reference systems (MHRS) use flux valves and a magnetic sense for directional guidance, inertial reference units (IRU), fiber optic gyroscope (FOG) and micro-electromechanical systems (MEMS) technology operate in TRUE and use a magnetic variation table to look up local values and then present magnetic data to the aircraft and pilot. AHRS are calibrated for magnetic error at least annually, IRU/flight management system (FMS)/SVS (Synthetic Vision System) may not have up to date magnetic variation tables and generally are not required to.

2. DISCUSSION

2.1 In Anchorage, Alaska in 2012, the Federal Aviation Administration (FAA) updated the magnetic variation of the airport and approaches to PANC (Ted Stevens Anchorage International Airport) to reflect current values. This caused a mismatch between the magnetic variation used in various aircraft systems and the navigation database in the flight management system. As a result, Boeing aircraft (with the exception of the 737) experienced unacceptable lateral guidance when conducting CAT II and CAT III approaches. To rectify the problem, the FAA returned the magnetic variation to the incorrect, but aircraft usable value until the aircraft operators could update their inertial reference system magnetic variation tables. Essentially the headings provided by the inertial reference units where arguing at a computer systems level with the aircraft auto flight system resulting in the aircraft rolling back and forth when flying the CAT II or III ILS.

2.2 Aircraft operators with inertial reference units for heading data were experiencing unstable CAT II and CAT III approaches at Canadian airports in their aircraft. Upon investigation, it was discovered that the aircraft magnetic variation tables were ten to fifteen years out of date. Changes in magnetic variation and EPOCH values are changing more rapidly. The National Oceanic and Atmospheric Administration (NOAA) has recommended a mid-cycle update to the World Magnetic Model 2015 as the forecast is deemed no longer valid out to 2020.

2.3 While the Status of magnetic variation tables of other air operators is unknown, each operator is provided with information from their IRU manufacturer on their magnetic variation status and the operator has to determine how it affects their operation.

2.4 While operating on tracks through the FMS, the aircraft will normally fly en-route tracks correctly regardless of the magnetic variation table and presentation to the pilot. To the pilots it looks like a crosswind that is not confirmed through the true wind presentation on the multi-function display (MFD) and charted tracks will vary from the displayed track in the aircraft. However, on some aircraft the use of IRU when mixed with the FMS position will cause the aircraft to start ‘rolling back and forth’ with approach levels of required navigation performance (RNP), i.e., a DH8-100 using IRUs with 1985 magnetic variation tables had 12 degrees of error at Iqaluit Airport (CYFB). With the best computed position in the FMS, the aircraft would roll back and forth on approach in calm wind as the incorrect heading generated an artificial system crosswind. It is unclear if this ‘roll’ would have been more pronounced at tighter RNP levels.

2.5 With incorrect heading information, synthetic runways generated by head-up display (HUD) and synthetic vison guidance systems do not overlay the real runway.

2.6 With incorrect magnetic variation information, approach tracks displayed in the FMS will vary from charted until the leg becomes active and uses the procedure design magnetic variation instead of the aircraft system magnetic variation.

2.7 Aircraft will fly an incorrect heading in vector to final operations. Depending on the system architecture, a stable intercept to final may be delayed (waffling) until the aircraft can sort out the difference between the heading determined by the course deviation indicator (CDI), and the guidance being received from the FMS while the capture is active.

2.8 True North heading reference in a performance-based navigation (PBN) operation would simplify the charting, aircraft operation and reduce costs going forward. In Canada alone, it costs roughly 500,000.00 CAD per year to manage magnetic variation in various publications. Another 300,000.00 CAD per year is spent rotating VHF omnidirectional radio ranges (VORs) and flight checking modified instrument procedures for magnetic variation changes. In reality, this is potentially redundant work to maintain magnetic variation within Annex 4 — *Aeronautical* Charts requirements that does not improve the safety of the procedure. Other magnetic variation costs include:

— Airport signage and runway renumbering.

— RADAR alignments.

— Aircraft magnetic variation table updates for IRU, FMS (note – if an older IRU cannot accept a new magnetic variation table, IRU upgrade and replacement is necessary.

— Industry standards meetings and certification efforts to deal with the current magnetic variation issues affecting the world-wide fleet (database inconsistencies, loss of CAT II and CAT III certification, RNP issues).

2.9 The world-wide fleet of aircraft that have IRU could switch to True North with an aircraft switch selection or one-time software change. Regional aircraft fleets that still use magnetic flux valves to feed AHRS/MHRS compass data could switch to non-magnetic based systems given enough lead time (2030) or use a low-cost converter between the flux valves and the attitude heading reference unit (AHRU).

2.10 Many non-flux valve systems are now available using MEMs and LITEF technology which are competitively costed compared to traditional magnetic stabilized AHRS/MHRS systems.

2.11 A large percentage of light aircraft are now GPS-equipped and would still be required to set directional gyros with the wet magnetic compass as reference. With time (2030) compensators could be added to select local magnetic variation to the wet magnetic compass or, for those that did not want to install a new compass, electronic flight bag (EFB) apps could be used as an intermediate step for corrections. This would still be more cost-effective effort than the continuous data changes in the air navigation services (ANS) and large aircraft fleets.

2.12 No regulation exists to ensure IRU/FMS are using current magnetic variation tables.

2.13 Many standby compass monitoring programs use the aircrafts IRU as their programs standard heading reference system; possibly using incorrect data for their monitoring program.

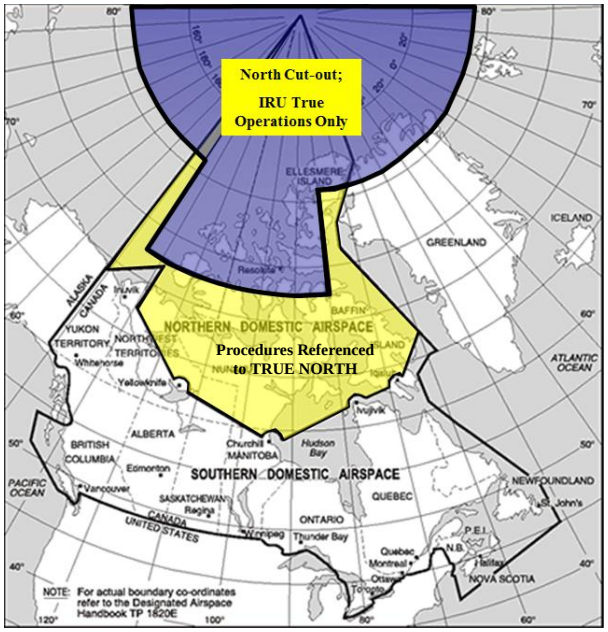
2.14 In Canada, the ANSP maintains airway, terminal and approach procedures to plus or minus two degrees for CAT I or lower integrity systems.

2.15 In Canada, the ANSP maintains CAT II/III ILS approaches to plus or minus one degree.

2.16 The magnetic variation assigned to instrument procedures by the state is coded in navigation databases and may not match with aircraft system magnetic variation, leading to discrepancies between aircraft systems and state source charts.

2.17 RTCA SC-227, the group managing DO-236B (C), Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation, and, DO-238A, Minimum Operational Performance Standards for Required Navigation Performance for Area Navigation has been tasked to address the magnetic variation issue for RNP operations for inclusion in minimum operational performance specification (MOPS) and minimum aircraft system performance specification (MASPS).

2.18 Canada has operated conventional and PBN based procedures using True North as the heading reference throughout a vast area of Canadian Northern Domestic Airspace for quite some time. This has served as a test bed for True North PBN operations in Enroute, Terminal and RNP, LPV, LNAV and LNAV/VNAV operations. Leg disconnects seen with conventional ARINC 424 legs caused by magnetic variation discrepancies do not exist with operations conducted in this airspace when operating in True North.



2.19 Canada has conducted a conversion test in southern domestic airspace where all FMS data used a magnetic variation value of "0" to prove conversation to True North on a single database cycle was possible. A full mix of conventional and PBN procedures were successfully flown using this method.

3. CONCLUSION

3.1 Magnetic variation errors affect different aircraft and their ability to navigate accurately in a multitude of ways. Each operator must understand how much magnetic variation error is within their navigation system and what those impacts are to various approaches types and levels of RNP.

3.2 Magnetic heading references are no longer required in aircraft that use True North in navigational computations. Converting the heading and track solutions to magnetic as the last step for autopilot use, display, and pilot reference introduces errors at the machine level and causes discrepancies between charted data and aircraft display data.

3.3 Even light aircraft that are solely dependent on a magnetic compass use Visual Navigation Charts and Upper Wind Forecasts that are computed in True North. With the exception of the direct reading of the wet magnetic compass, light aircraft could operate in True North. Easy to procure cost effective aids could be used for this correction.

3.4 Modern PBN operations and conventional operations have been proven in Canadian Northern Domestic Airspace through instrument procedure flight validation using a True North reference system. A test to convert southern domestic airspace to true on a single cycle was successful.

3.5 Operating the ANS with reference to True North would eliminate cost and busy work from the ANS, aircraft operators, airport operators, certification and database providers and greatly simplify the navigation systems.

3.6 In light of the above, the Conference is invited to agree to the following recommendation:

Recommendation 3.5/X True North Reference System

That the Conference request that States and regions adopt a True North reference system by 2030.

— END —