

A tall, white, cylindrical air traffic control tower with a glass-enclosed observation deck at the top, set against a blue sky with scattered white clouds.

26/09/2017

MAGNETIC VS TRUE NORTH

Vision to 2030

Captain Anthony MacKay
Director Flight Operations

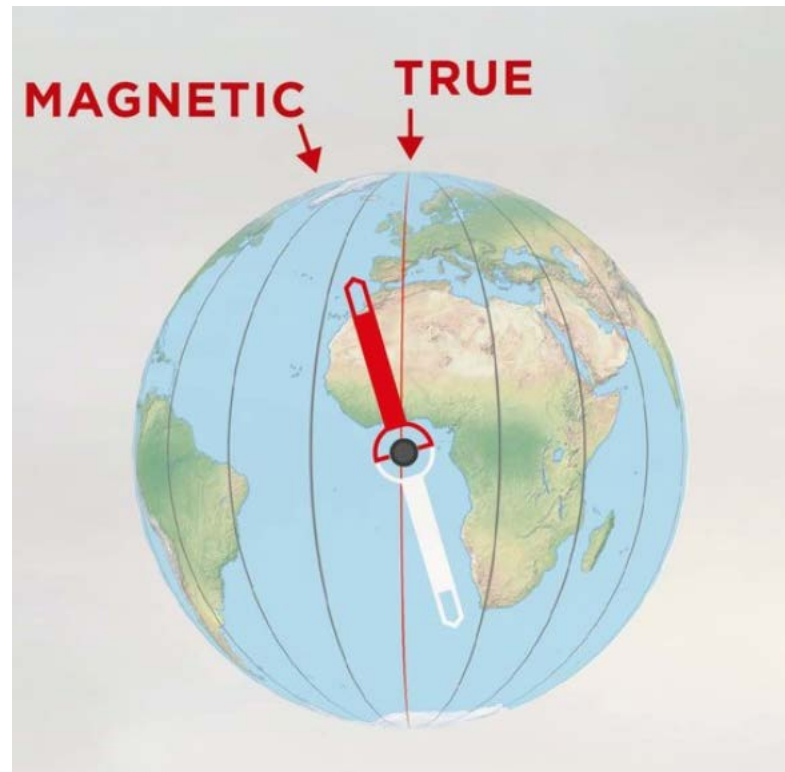
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THE ISSUE

Which way is North?

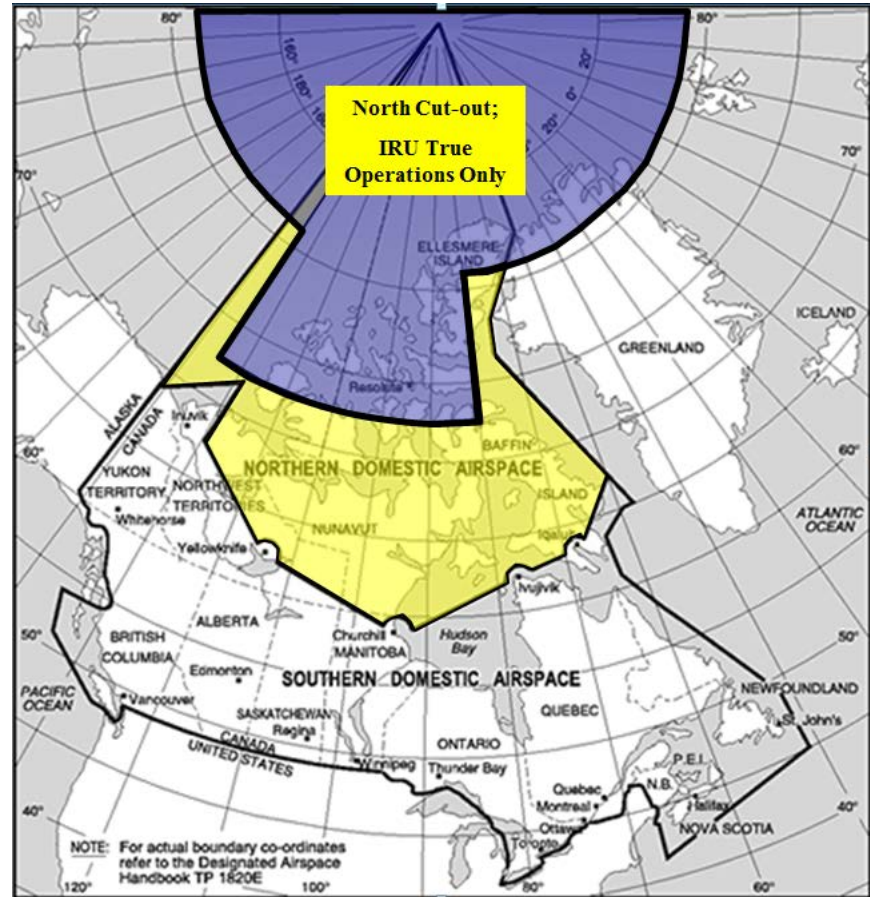
- › All of the aircraft, air traffic and IFR procedure design systems are built to function in TRUE
- › Tables are then devised to translate that data to magnetic for the user
 - Not all tables function exactly the same
 - Older tables in systems may not be updated
 - Translations may not be matched
- › Much effort has been expended to manage MAG VAR
- › The questions should be:
 - Why do we still navigate by reference to Magnetic North? Why do we not switch to TRUE?



BACKGROUND

Canada's Experience

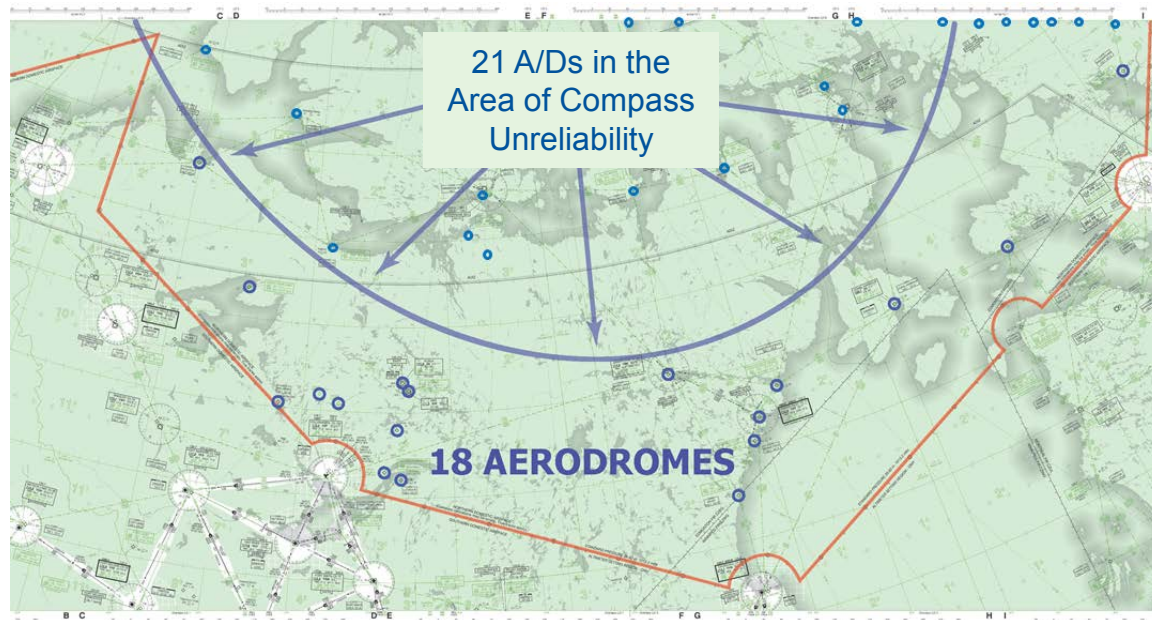
- › Canada has always operated with airspace referenced to True and Magnetic
 - Northern Domestic Airspace = True
 - Southern Domestic Airspace = Magnetic
- › In NDA all ILS, VOR and NDBs are set to TRUE with 0 degrees declination
- › All airways are reference to True
- › All terminal procedures are referenced to True
 - ILS, LOC, NDB, TACAN
 - RNAV – LNAV, LNAV/VNAV, RNP AR, LPV



BACKGROUND

What is in NDA?

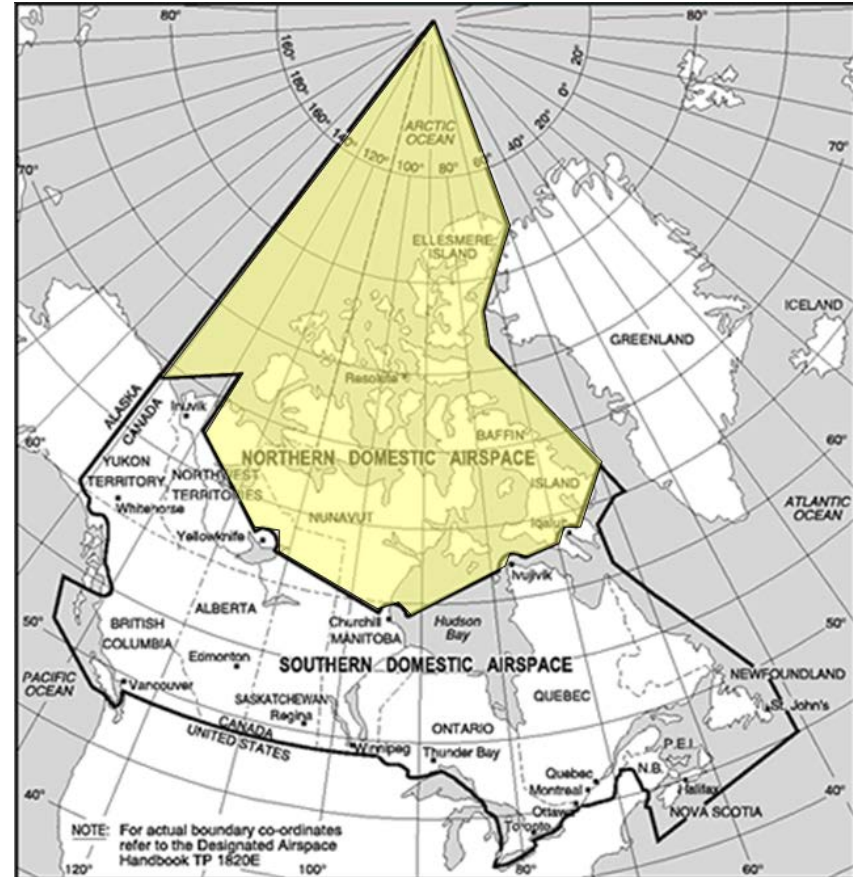
- › 21 Aerodromes with IAPs in the Area of Compass Unreliability
- › 18 Aerodromes with IAPs outside the Area of Compass Unreliability in NDA still referenced to True



BACKGROUND

Canada's Experience

- › In SDA all procedures are referenced to Magnetic. Mag Var is maintained:
 - ILS, VOR & NDB maintained within $\pm 2^\circ$
 - › CAT II/III ILS maintained within $\pm 1^\circ$
 - Airways/routes maintained within $\pm 2^\circ$
 - IAPs maintained within $\pm 2^\circ$
 - Surveillance RADAR, ADSB, MLAT maintained IAW Mag Var tables reference date and time.
- › Hence we have the same issues in SDA as other ANSPs



BACKGROUND

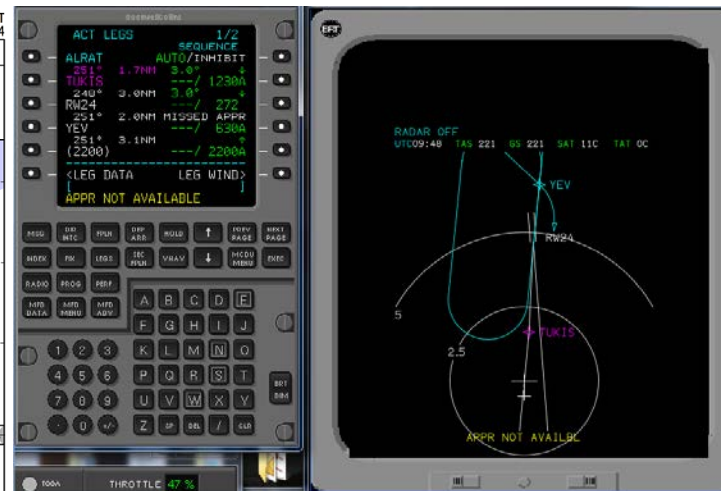
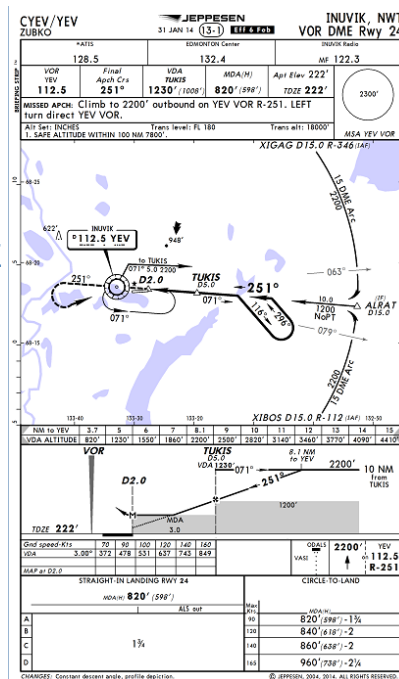
The Issue with Magnetic Variation

- › In the analogue world it was not as important. In the digital world it is.
 - Magnetic variation/station declination doesn't have to be right but it must match across databases
 - › Anchorage ILS CAT II/III issue - aircraft unstable in heading during approach
 - › Vancouver and St. John's CAT II/III issue same as Anchorage
 - › Autoland aircraft moving off the centreline when the aircraft enters the flare
 - Leg disconnects on non TF/RF legs
 - SVS and EVS images superposed on the real world?
 - › Runways not aligned
- › Sources of mag var on a modern aircraft and its use (at times they don't perfectly match)
 - IRUs – internal mag var tables
 - Flight Management systems
 - › Base mag/var tables; VHF NAV aid reference mag var; Airport reference mag var; Procedure design mag var
 - SVS systems, displays and charted mag var (static)

The Issue with Magnetic Variation – An example

- YEY dec = 23°E
- CYEV var = 25°E
- FMS Epoch = 26°E
- Design mag var = 24.92°E

- › Difference in values cause leg disconnects on the approach and track change 251° to 248° at TURKIS. A second track change occurs in the GA for the hold



- › This happens to a greater or lesser degree on all approaches and at all airports where mag var is in play.

CHANGING TO TRUE

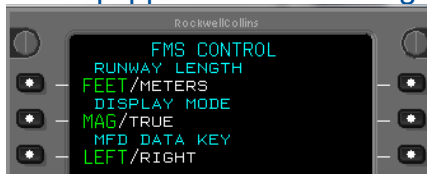
The case for change

- › Modern aircraft, surveillance systems, IAPs are all designed to function in true
 - Everything under the hood in a modern aircraft does the 'math' in True and then converts the information to magnetic for the pilot
 - All of Canada's surveillance systems operate in True and then add in magnetic variation to display to the controller
 - All IAPs in Canada are designed in True and then have magnetic variation/declination added to the design file for charting and nav databases
- › This introduces cost and potential error into the system
 - › Updating aircraft FMS and IRU mag var tables every five years
 - One carrier reported (2016) a cost of \$21m for 200 aircraft; another reported \$1.2m for one fleet type of 32 aircraft. Costs are aircraft age dependent (field loadable or repair facility). Our DH8-100 was \$500k.
 - › Updating IAPs, Enroute Charts (VFR & IFR) and rotating VORs
 - For Canada ~\$800k per year
 - › Updating Airport data, runway numbering, signage
 - Est. \$10,000 per hold line (Paint, Signs, Data) (L) CYYZ ~ \$1.1m, (M)CYHZ ~ \$150k, (S)CYDF ~ \$40k

CHANGING TO TRUE

When and how?

- › Pick a date way out in the future (2030 – 2035)
 - IRU equipped aircraft could go to True with MAG/TRUE switch

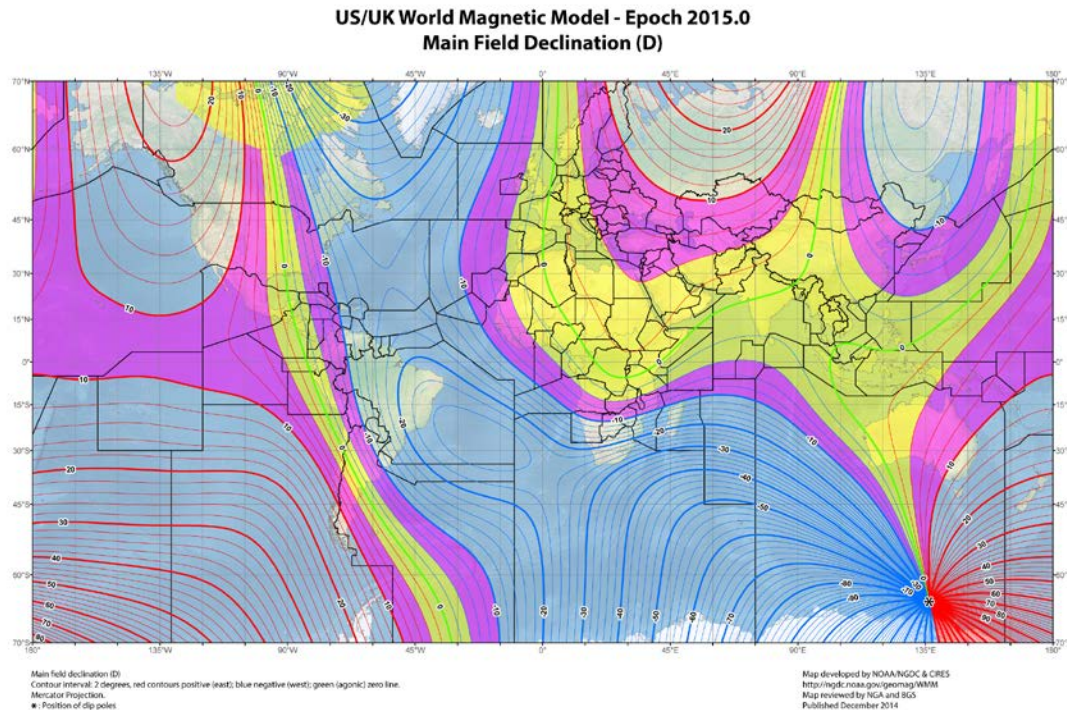


- New AHRUs (Fibre Optic Gyro (FOG), Micro Electromechanical Systems (MEMS) technologies do not need flux valves for magnetic sense)
 - › Honeywell Super AH-2100; Northrop Grumman LCR-100, 110, 200, 300; Collins AHS-4000
 - › Light aircraft GNSS equipped (GNSS functions in True)
- VFR aircraft can still use a magnetic compass and convert to True
 - › Set runway heading prior to take-off
 - › Circular slide rule with E&W variation
 - › GPS/NDB Method
 - Direct to a NDB, note bearing, rotate heading for 'bearing to' on ADF needle

CHANGING TO TRUE

States (ANSPs) Affected

- › Yellow = $\pm 4^\circ$ variation
- › Magenta = $\pm 10^\circ$ variation
- › Reducing impact of the change
 - Procedures within $\pm 4^\circ$ variation could be left as is until the next review date
 - Airports within the $\pm 10^\circ$ could update numbering, signage and data at their convenience.



CHANGING TO TRUE

Building support

- › Beginning with the users – Can IATA and its carriers validate the costs for Epoch updates and support the change with representation to the ICAO FLTOPSP
- › ICAO – at the 12th Air Navigation Conference, Canada presented WP/147 of which the following was included in final report – Section 6.4.25 which states:
 - *“The meeting was informed that currently a significant effort is expended to update aeronautical information with changing magnetic variation (MAGVAR). Modern avionics carry out navigation calculations with reference to true north, and then convert the information for pilot displays to Magnetic (by applying a magnetic variation based on a magnetic model), or True heading or true Track, depending on aircraft capability. It was suggested that having all operations referenced to true north would enhance the overall safety floor and save considerable effort in maintaining MAGVAR tables. The meeting noted the information and concluded that any States interested in the matter could conduct further studies of the technical and operational impact of the proposal, and of the expected costs and benefits to all aviation stakeholders. 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 Heading Reference System use flux valves and a magnetic sense for directional guidance, Inertial Reference Units operate in TRUE and use a magnetic variation table to look up local values and then present magnetic data to the aircraft and pilot.”*

Reference: AN-Conf/12-WP/162

CHANGING TO TRUE

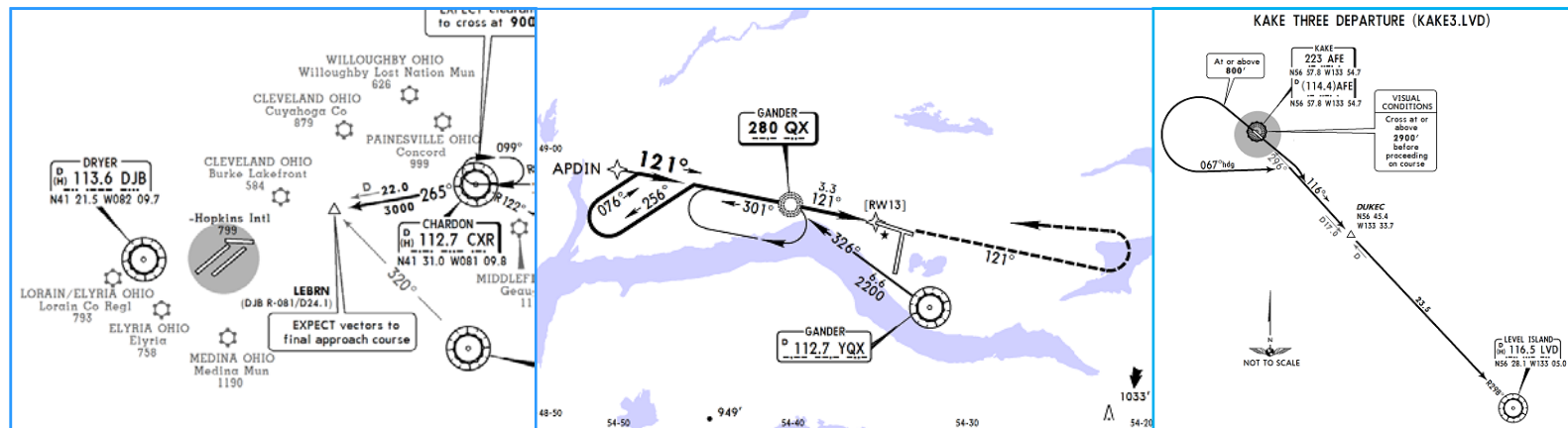
Overcoming years of magnetic pull

- › Working with the International Association Of Institutes Of Navigation (IAIN) to gain worldwide exposure
 - An IAIN member is briefing the International Symposium on Precision Approach and Performance Based Navigation in Munich November 2017
- › We will consult with other ANSPs through CANSO based on support from the operator community.
- › Regional and light aircraft associations
 - Assist them in seeing the benefits of changing to AHRS units that do not rely on flux valves and magnetic alignment
- › Educate industry groups; IATA members, ICAO, CANSO
- › How do we raise this topic with the FAA?

THREE USER SEGMENTS

General Aviation – Light Aircraft

- › VFR users technically still use track/drift lines on VNCs although most use some form of GPS and electronic moving map
- › IFR GA aircraft would need to have a procedure to deal with East/West variation between the heading observation from the wet compass to setting the HSI
 - Most procedures are now track based with the exception of vectors, NDB IAPs and heading based legs in vector SIDs and downwind legs on STARs



THREE USER SEGMENTS

Regional Aircraft

- › The challenge is most current aircraft use a magnetic sense to feed the AHRU
 - One regional airline in Canada has been searching for options to do this based on AHRS obsolescence (AH-600) and repair costs.
 - Low wing aircraft (CRJs) have had issues with flux valves and interference from rebar in runways (KORD) where they have to depart in free gyro mode.
- › The addition of an IRUs to replace current AHRUs would also be the foundation for RNP operations
 - Assist them in seeing the benefits of changing to AHRUs that do not rely on flux valves and magnetic alignment, lower life cycle costs, additional operational capability
- › With an implementation date out to 2030-2035 the regional carriers should be able to adapt
 - Lobby manufacturers to switch to non-magnetic AHRUs in new aircraft or new certifications

THREE USER SEGMENTS

Airline Narrow Body and Wide-body Aircraft

- › Large aircraft generally have Inertial Reference Units on board today
- › Just need the ability to switch from MAG to TRUE to bypass the mag var values
- › Some operators indicate they operate in Oceanic Airspace in True
- › Operators on Polar Routes operate in the Keyhole in True but not necessarily in Canadian NDA in True
- › Savings to be had for IATA carriers with the elimination of 5 years Epoch updates

ICAO INTERESTS

Considerations

› Safety Impact - Positive.

- The charts will match the FMS database, procedure design file, ATS systems. Everyone will have the same data instead of dealing with differences as described in this FAA INFO LETTER 12009 (06/26/12) excerpt
 - › *It is important to understand, however, that RNAV systems, (with the exception of VOR/DME RNAV equipment) navigate by reference to true north and display magnetic course only for pilot reference. As such, a **properly functioning** RNAV system, containing a **current and accurate navigational database**, should still fly the correct ground track for any loaded instrument procedure, despite any differences in magnetic course that may be attributed to magnetic variation application.*
- Accuracy Example Honeywell LaseRef V

Magnetic Mode

Between 50°S and 50°N	±2°
Between 50°N and 73°N	±3°
Between 73°N and 79°N	±5°
Between 79°N and 82°N	±8°

True North Mode

Worldwide	±1°
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ICAO INTERESTS

Considerations

- › Financial Impact – Positive for aircraft, airports and ANSPs in the long term.
 - Airports and ANSPs will have a ONE TIME charge to make the change to True that can be managed. Data and signage will not need to change for mag var again.
 - Aircraft operators with IRUs would need to enable the MAG/TRUE functions if not currently active. Aircraft operators that need a slaved AHRS would have a one time charge. Light aircraft without a slaved system would use a cost neutral procedural method.
 - No more working groups to look at Magnetic Variation issues – PARC, RTCA
 - Simplification of avionics design in the long term

ICAO INTERESTS

Considerations

- › Security Impact - Neutral
- › Environmental Impact – Positive
 - Less energy of all types expended for mag var updates
 - GHG reduced to 0 for VOR Rotations and airway flight checks after mag var changes
- › Efficiency Impact – Positive
 - No loss of services due to procedures notam'd out of service for mag var issues
 - No loss of CAT II/III services due to mag var differences
 - ANSPs can focus on new procedure development instead of running the tread mill of corrections for mag var on current procedures (reduced procedure maintenance)
- › Expected Implementation Time – Positive
 - 2030 to 2035 to allow ANSPs to enact a plan and for aircraft operators with slaved gyro's to replace obsolete units with non-magnetic north seeking units.

NAV CANADA

Next Steps

- › Flight Test 'True' database
 - Jeppesen took all the data (flight test database) for airports, airways, IAPs and changed all the magnetic variation to '00' for a flight test area in eastern Canada
 - NAV CANADA flight test aircraft will fly a mixed flight plan of V/J airways, T/Q routes, NDB, VOR and RNAV procedures in True Mode to see if switching the database would be that easy.
 - Reasoning – KRFD has a magnetic variation value of 0 (= True). All of KFRDs associated procedures work within a MAG system.





THANK YOU

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