NAV CANADA

Moving From Magnetic to True North in Aviation

Anthony MacKay
Vice President & Chief Safety and Quality Officer
NAV CANADA

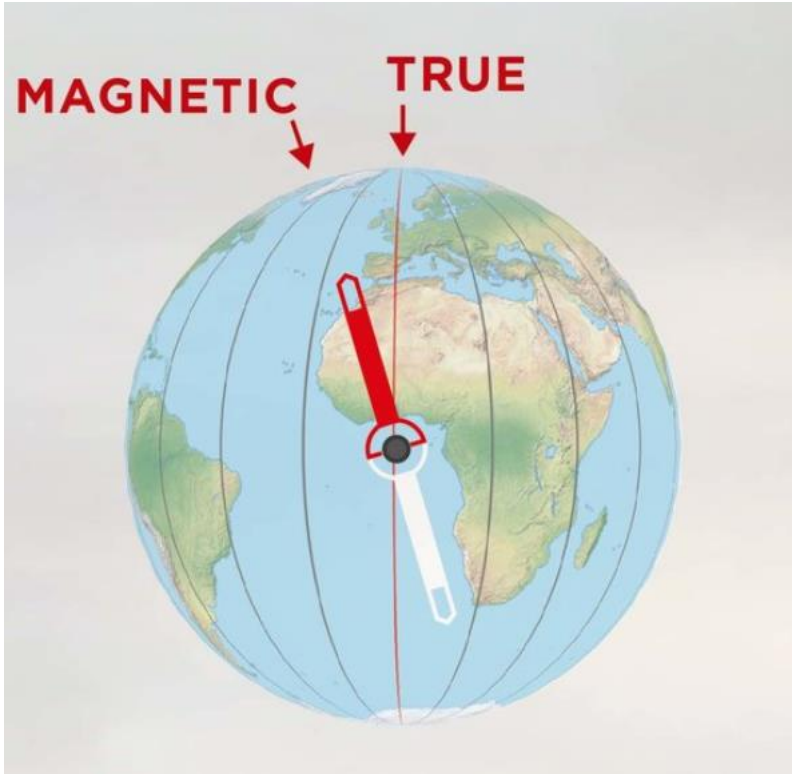
Bart Banning
ATM Architect LVNL and
President of NIN

Serving a world in motion
navcanada.ca

THE ISSUE

Which way is North?

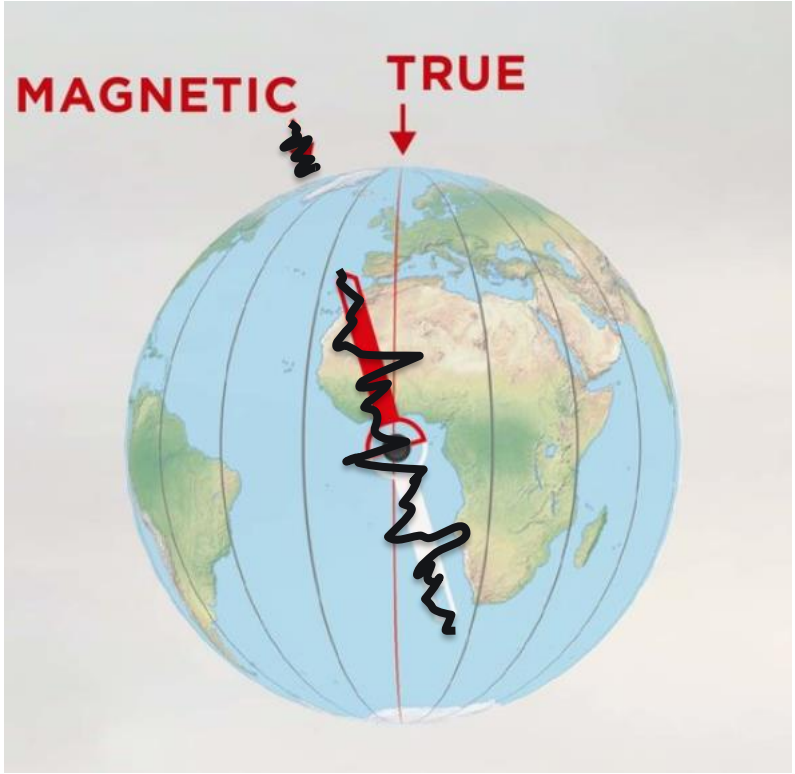
- Modern aircraft, air traffic and IFR procedure design systems begin in TRUE
- Tables are then devised to translate that data to magnetic for the user
  - Not all tables hold the same values
  - Older tables in systems may not be updated
  - Translations may not be matched
- Much effort is and has been 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?



THE ISSUE

Which way is North?

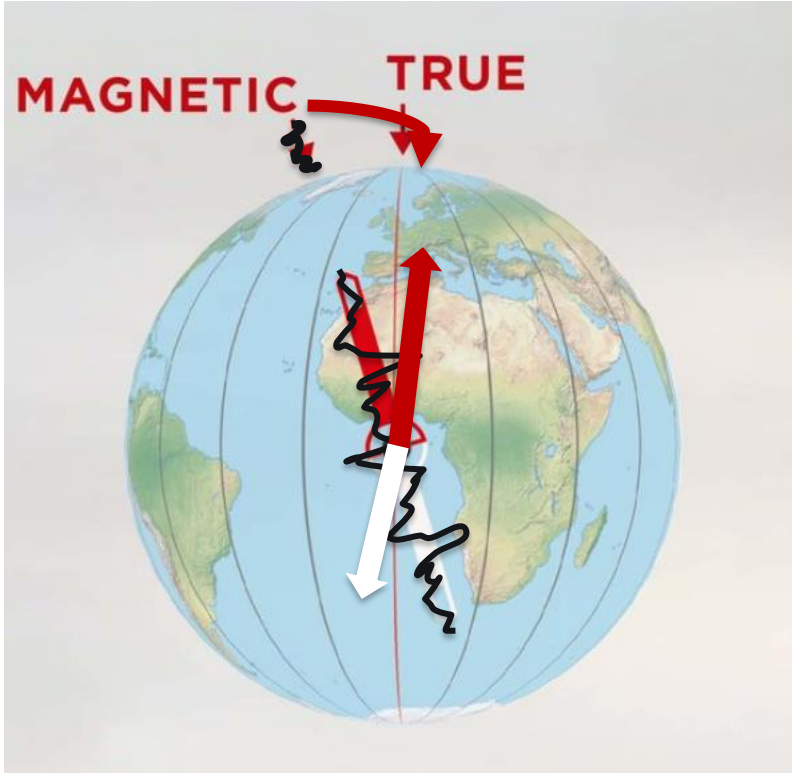
- Modern aircraft, air traffic and IFR procedure design systems begin in TRUE
- Tables are then devised to translate that data to magnetic for the user
  - Not all tables hold the same values
  - Older tables in systems may not be updated
  - Translations may not be matched
- Much effort is and has been 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?



THE ISSUE

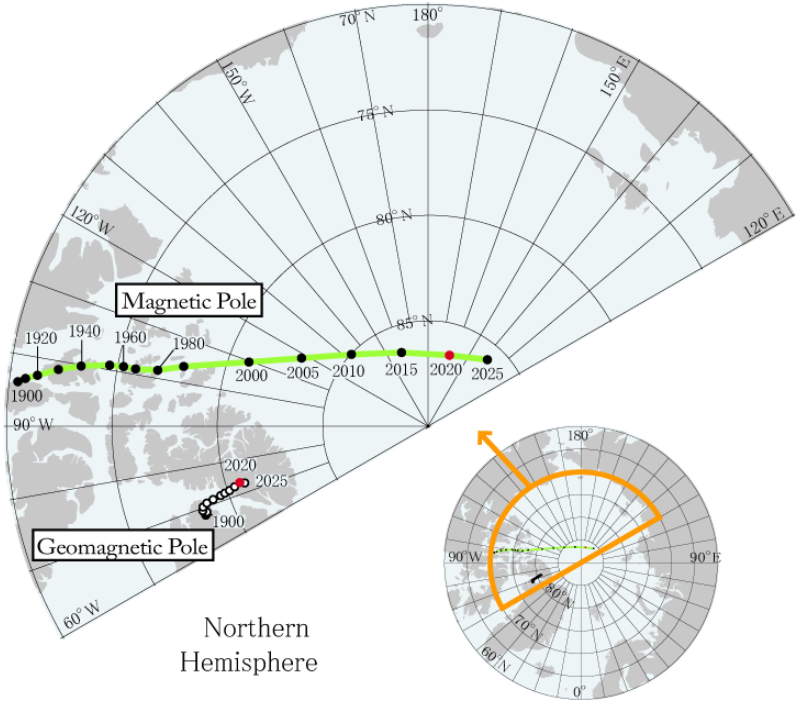
Which way is North?

- Modern aircraft, air traffic and IFR procedure design systems begin in TRUE
- Tables are then devised to translate that data to magnetic for the user
  - Not all tables hold the same values
  - Older tables in systems may not be updated
  - Translations may not be matched
- Much effort is and 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?



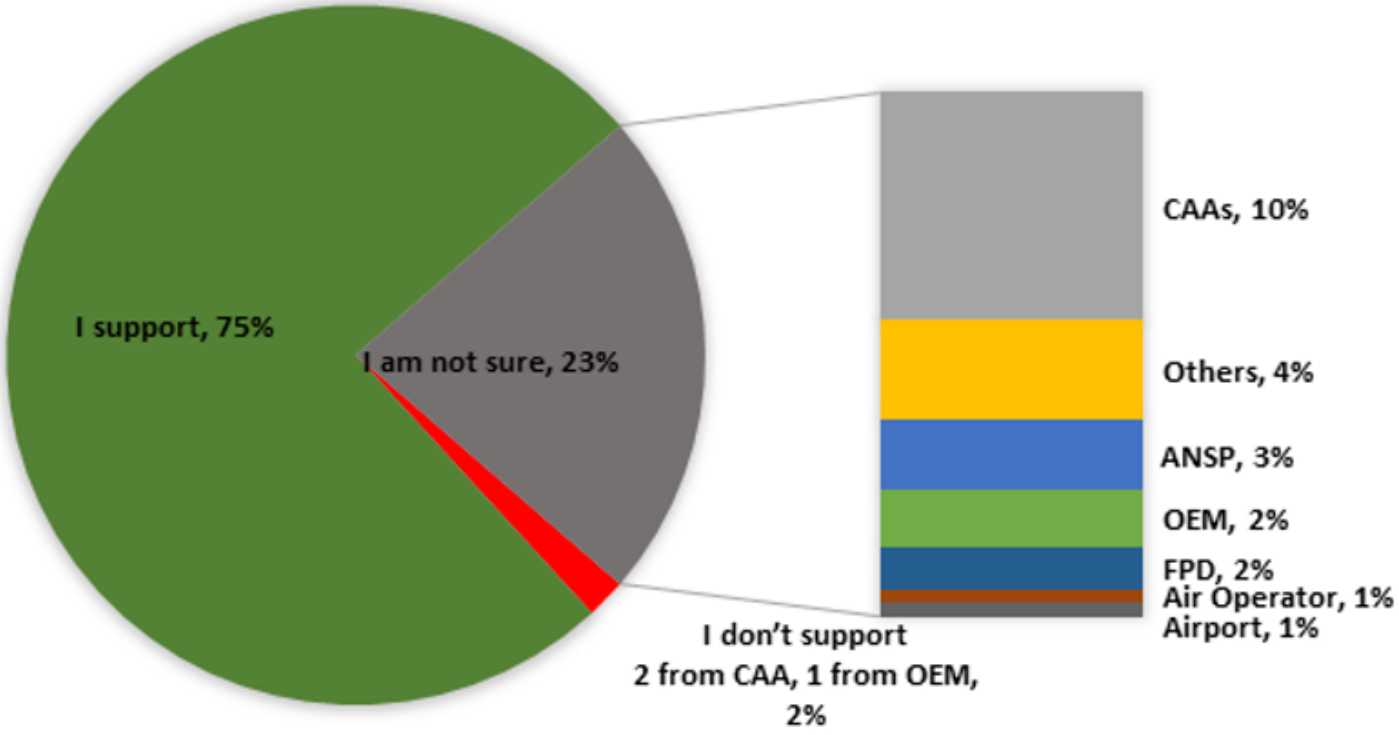
WORK SINCE 2019…

- **International Association Of Institutes Of Navigation (IAIN)**
  - International working group to work the problem
- NAV CANADA & Transport Canada
  - National working group to work the problem (CPAAT)
    - Concept of Operations complete
    - Implementation Plan draft developed
- Instrument Flight Procedures Panel (IFPP)
  - Briefed and voted to move ahead with True North
- ICAO
  - State letters released and survey of States, ANSP, Air Operators, Airports and OEMs complete – initial response positive



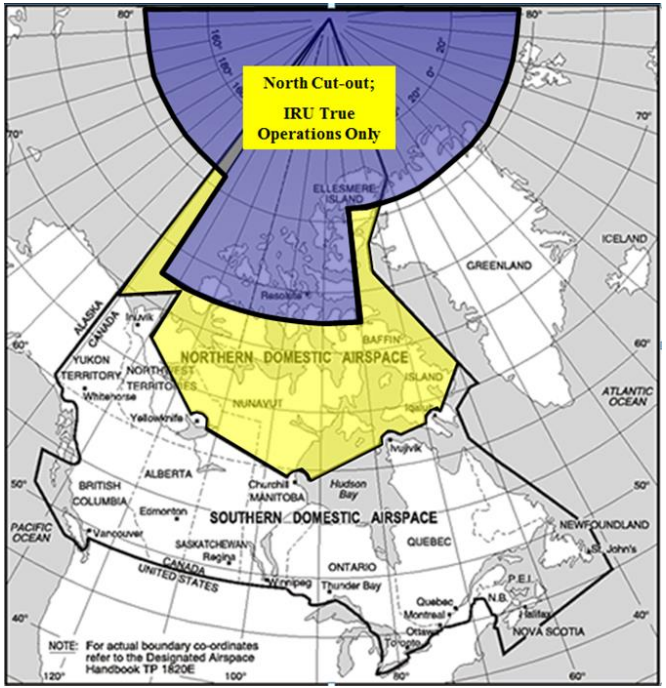
pole_ns.gif (722×636) (kyoto-u.ac.jp)

ICAO WEBINAR + VOTE SEPT. 8, 2022



CANADA'S EXPERIENCE

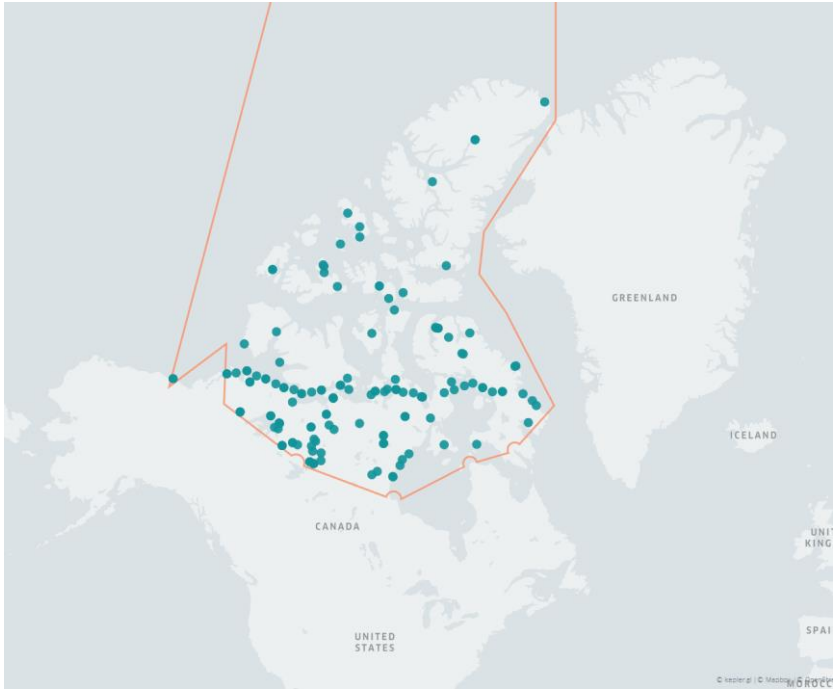
- Canada has always operated with airspace referenced to True and Magnetic
  - Northern Domestic Airspace = True
  - Southern Domestic Airspace = Magnetic
- In NDA all ILS, VOR and NDBs at set to TRUE with 0 degrees declination
- All conventional and PBN airways are reference to True
- All terminal procedures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



CANADA'S EXPERIENCE

Aircraft Types Using True

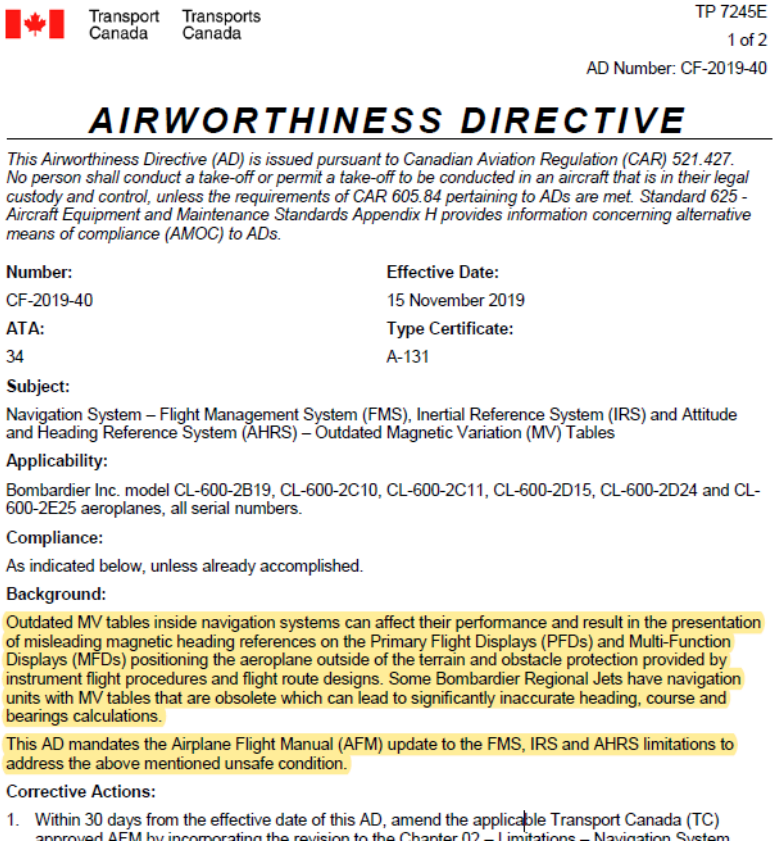
- O&D within NDA = 75 aircraft types in a six-month period:
  - ATR – AT43, 45, 72, 75
  - Beech – B190, BE10, 20, 30, 55, 350
  - Boeing – 732, 733, 734, 737, 738, 752
  - Military – C130J, C17, A310, L188
  - Bombardier/DeHavilland – CL60, CRJ2, DH8A, DCH2, 6, 7
  - Other - Cessna's, D228, FA10, 20, JS31, JS32, PA31, SW4, Multiple Helicopter types.



MAG VAR ISSUES

Regional Aircraft

- Airworthiness directives limiting operations for out of date magnetic variation are becoming more common.
  - Loss of CAT II/III operations in regional aircraft fleet
  - Airborne holding operations restricted if using the flight management system
  - Leads to navigation errors and an unsafe condition that must be managed by the flight crew



Transport Canada Transports Canada

TP 7245E
1 of 2
AD Number: CF-2019-40

AIRWORTHINESS DIRECTIVE

This Airworthiness Directive (AD) is issued pursuant to Canadian Aviation Regulation (CAR) 521.427. No person shall conduct a take-off or permit a take-off to be conducted in an aircraft that is in their legal custody and control, unless the requirements of CAR 605.84 pertaining to ADs are met. Standard 625 - Aircraft Equipment and Maintenance Standards Appendix H provides information concerning alternative means of compliance (AMOC) to ADs.

Number: CF-2019-40

Effective Date: 15 November 2019

ATA: 34

Type Certificate: A-131

Subject:

Navigation System – Flight Management System (FMS), Inertial Reference System (IRS) and Attitude and Heading Reference System (AHRS) – Outdated Magnetic Variation (MV) Tables

Applicability:

Bombardier Inc. model CL-600-2B19, CL-600-2C10, CL-600-2C11, CL-600-2D15, CL-600-2D24 and CL-600-2E25 aeroplanes, all serial numbers.

Compliance:

As indicated below, unless already accomplished.

Background:

Outdated MV tables inside navigation systems can affect their performance and result in the presentation of misleading magnetic heading references on the Primary Flight Displays (PFDs) and Multi-Function Displays (MFDs) positioning the aeroplane outside of the terrain and obstacle protection provided by instrument flight procedures and flight route designs. Some Bombardier Regional Jets have navigation units with MV tables that are obsolete which can lead to significantly inaccurate heading, course and bearings calculations.

This AD mandates the Airplane Flight Manual (AFM) update to the FMS, IRS and AHRS limitations to address the above mentioned unsafe condition.

Corrective Actions:

1. Within 30 days from the effective date of this AD, amend the applicable Transport Canada (TC) approved AFM by incorporating the revision to the Chapter 02 – Limitations – Navigation System

MAG VAR ISSUES

Airline Narrow Body and Wide-body Aircraft

› Limitations to operations with out of date magnetic variation tables

A319/A320/A321 AIRCRAFT TECHNICAL BULLETINS

ATB 271: OEB 151-ST JOHNS (CYYT) IMMEDIATE RESTRICTIONS

06-12-12

EFFECTIVITY: AIRCRAFT [redacted]

In addition to Anchorage and Fairbanks, effective immediately, the autoland and rollout restrictions of OEB 151 will also be applicable to those aircraft operating into.

St Johns (CYYT) without an updated ADIRU MAGVAR table.

SPECIFICALLY:

- Autoland is not allowed
- Roll out is not allowed
- CAT II approaches without autoland are still allowed

Affected aircraft will not be subject to the restrictions once their ADIRU MAGVAR tables are updated. These aircraft will be identified by a logbook sticker on the inside cover stating:

MAGVAR TABLE UPDATED - OEB 151 CANCELLED FOR THIS AIRCRAFT

It is expected that the ADIRU MAGVAR tables on the affected aircraft will all be updated by July 2008. Once all aircraft are modified, this ATB will be cancelled, a new ATB will be issued stating that all aircraft are modified, and all logbook placards will then be removed.

ATB 320 - NEW IRS LIMITATIONS - REVISED

2022-FEB-15

THIS ATB CANCELS AND SUPERSEDES ATB 312

The reason for revising this ATB is to identify aircraft fin[redacted]as being retrofitted with latest IRS MagVar tables.

The purpose of IRS limitations is to prohibit certain flight operations in geographic areas where the accuracy of the magnetic north-referenced parameters in older IRS MagVar tables are no longer sufficient to satisfy the airplane type design requirements. IRS MagVar tables are revised every 10 years.

The fleet is in process of being retrofitted with new IRS MagVar tables to remove the area and airport restrictions mentioned below. **Currently, all 787-9s have been retrofitted but not all 787-8s. The retrofit completion of the 787-8s is expected in 2022.** Once a specific aircraft has completed this retrofit, it will be identified on the OFP through a Crew Alert and this ATB will revised.

AOM 1.01.34 P4 is revised as follows:

INERTIAL REFERENCE SYSTEM (IRS)

All flight operations based on magnetic heading or magnetic track angle are prohibited in geographic areas where the loaded IRS Magnetic Variation (MagVar) table errors are greater than **5 degrees**. *

[redacted]

* To comply with this limitation, Flight Crew shall select HEADING REF switch to TRUE when operating north of **65N of latitude** instead of 70N of latitude per FOM 8.9.2.4.

[redacted]

* All aircraft are compliant with this limitation.

All autopilot/flight director ILS (excluding GLS) approach and landing operations that use magnetic north referenced courses or bearings are prohibited in geographic areas where the loaded IRS MagVar table errors are greater than **3 degrees**. **

[redacted]

** To comply with this limitation, the following table lists the airports affected by IRS MagVar table errors greater than 3 degrees. **Any ILS and LOC approaches are prohibited at these airports.** All other types of approaches are not affected.

Airport code	Airport name and location
SFJ / BGSF	Kangerlussuaq, Greenland
KEF / BIKF	Keflavik, Iceland
YFB / CYFB	Iqaluit, Canada
YXY / CYXY	Whitehorse, Canada
LYR / ENSB	Longyear, Norway
EDF / PAED	Elmendorf AFB, USA
FAI / PAFA	Fairbanks, USA
AKN / PAKN	King Salmon, USA
ANC / PANC	Anchorage, USA

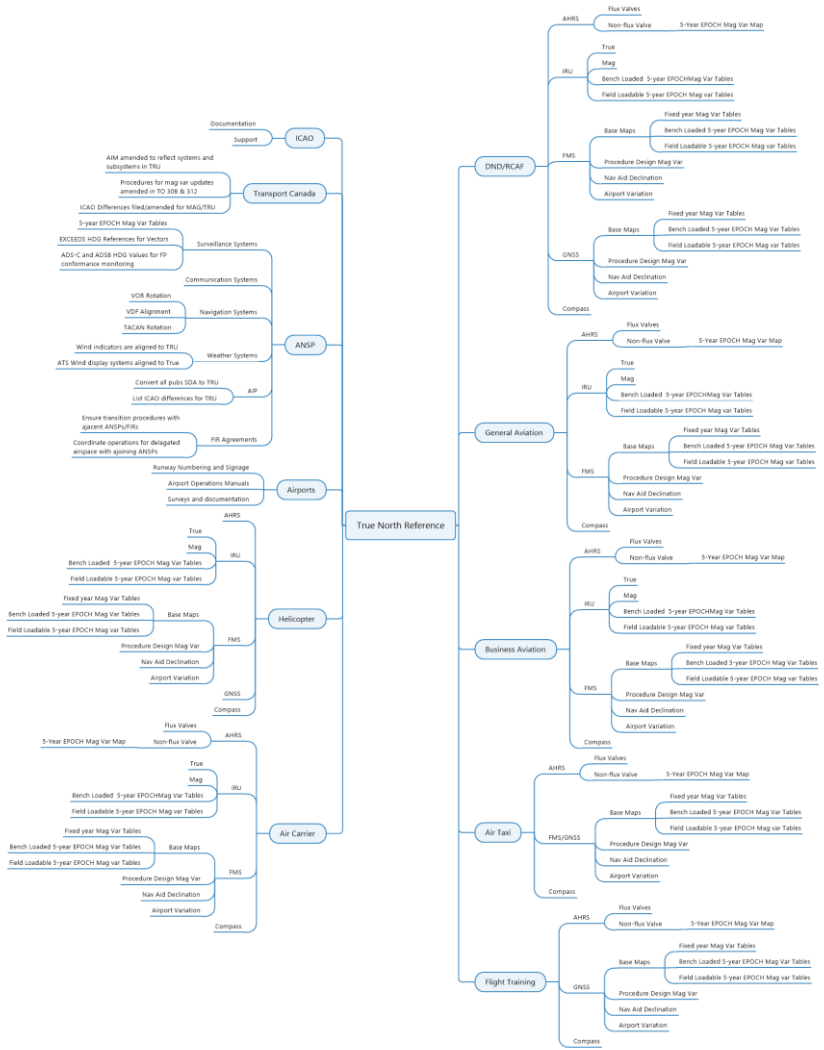
[redacted]

** All aircraft are compliant with this limitation.

CANADAs TRUE NORTH WG MAKEUP

Canadian Performance-based Aviation Action Team (CPAAT)

- True North Sub-working group members:
  - Transport Canada
  - Nav Canada
  - Airlines
  - Business Aviation
  - General Aviation - COPA
  - Air Taxi
  - Flight Training
  - Airports
  - Helicopter Association
  - DND/RCAF



CANADIAN CON OPS – AREAS OF STUDY

CON-OPS TOC

Table of Contents

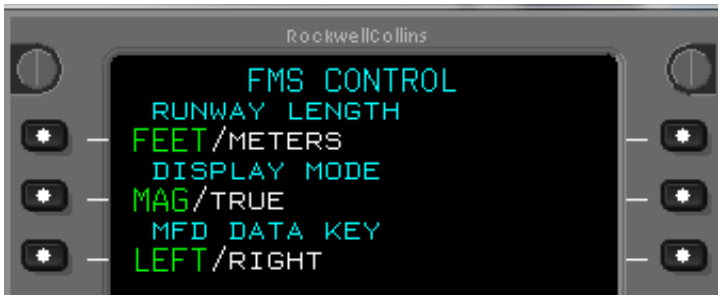
ARINC 424 – CHANGES AT 424-20

ARINC 424-20 included changes to allow TRUE in all PBN and conventional procedure coding

- MAG/TRUE Indicator
- Source content in TRUE
- Removed “T” from runway suffix for RWY Indicator and replaced with MAG/TRUE indicator
- When source data is provided as TRUE, MAG and TRUE bearing/headings will be identical
- Procedure Design MAG VAR coded as E-east, W-west, T-TRUE
- For TRUE bearings the tenths position will be replaced with a T
- These changes were the last step to coding LPVs in TRUE airspace correcting past FAS datablock Issues.

CRJ-200

- MSN 7529 & 7526 Built 2001
- Collins Proline IV, Dual FMS 4.2, CAT III with HGS
- LaseRef V Inertials
- Fully functional for all PBN and Conventional procedures in both MAG and TRUE
- Pilot procedure – select MAG/TRUE switch as required transitioning from one airspace to the other
- Charted HDGs and Bearings Match Database in TRUE



DH8-100

- MSN 028 Built 1986
- Analogue flight instruments, Dual Universal 1eW FMS, CAT II
- LaseRef IV Inertials
- Fully functional for all PBN and Conventional procedures in both MAG and TRUE
- Pilot procedure – select MAG/TRUE switch as required transitioning from one airspace to the other
- Charted HDGs and Bearings Match Database in TRUE

GRUMMAN CHEETAH

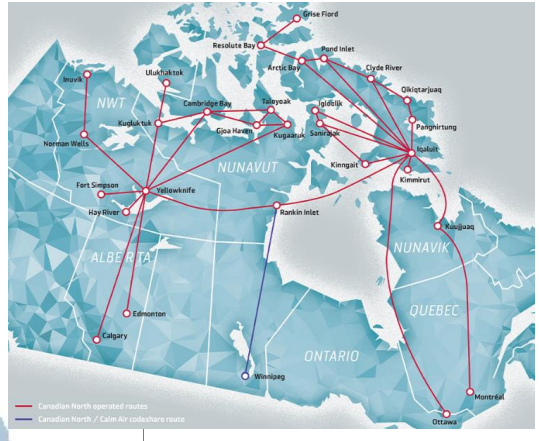
- Built 1972
- Garmin 430w
- Manually set DG to TRUE (-13°W) from Compass (compass correction value + magvar)
- Fully functional for all PBN and Conventional procedures in both MAG and TRUE
- Pilot procedure – select MAG/TRUE switch as required transitioning from one airspace to the other

OTHER AIRCRAFT

- Flight Inspection Aircraft replacements
- TRUE is an Operating Requirement
- Aircraft types that have responded as capable
  - King Air 360
  - Embraer Praetor
  - Cessna Longitude
- Fully functional for all PBN and Conventional procedures in both MAG and TRUE
- Collins Fusion Flight Deck
- LITEF LCR 100/110; Honeywell Super AHRS AH-2100 TRUE Capable; LaseRef VI

OTHER AIRCRAFT

- Boeing and Airbus
- Briefed their capabilities at the May AEEC meeting in Denver
- In production aircraft have a MAG/TRUE switch or a Standard Order Option for one
  - However – still need to investigate to fully understand any other issues that may arise



CON OPS – HOW? – JEPPESEN HELPED

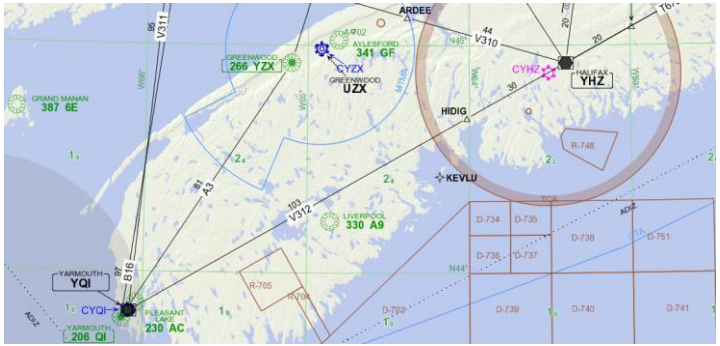
Nav Canada conducted a Change Flight Test

- Flight Test ‘True’ database
  - The current ARINC 424 navigation database data records and data fields can be maintained with 0° entered as the mag var value in columns 52 thru 56 AND column 86 set to TRUE Indication. In this manner, navigation data will be reflected as TRUE regardless of the FMS method to determine and operate in True.
  - While this ensures the navigation database records will reflect TRUE values only, the FMS/IRU would still need to be operated in TRUE to provide TRUE heading from the IRU or AHRS heading source and to allow the FMS to not use the main embedded mag var map in the FMS.
  - Some ANSPs are publishing True and Magnetic on charts now and that could be an interim step leading to up to the day of change globally or regionally as determined by the TRUE North implementation plan (yet to be determined).

CON OPS – HOW?

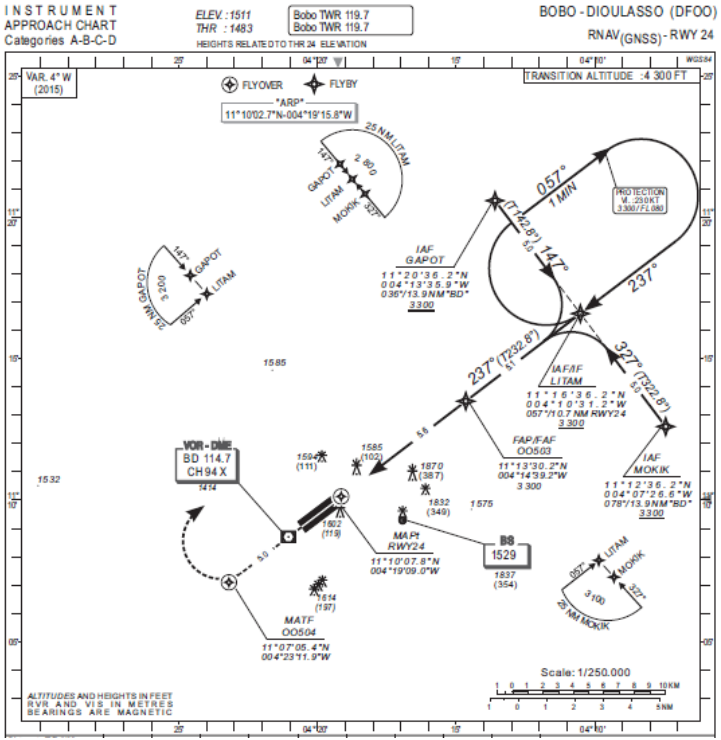
Nav Canada conducted a Change Flight Test

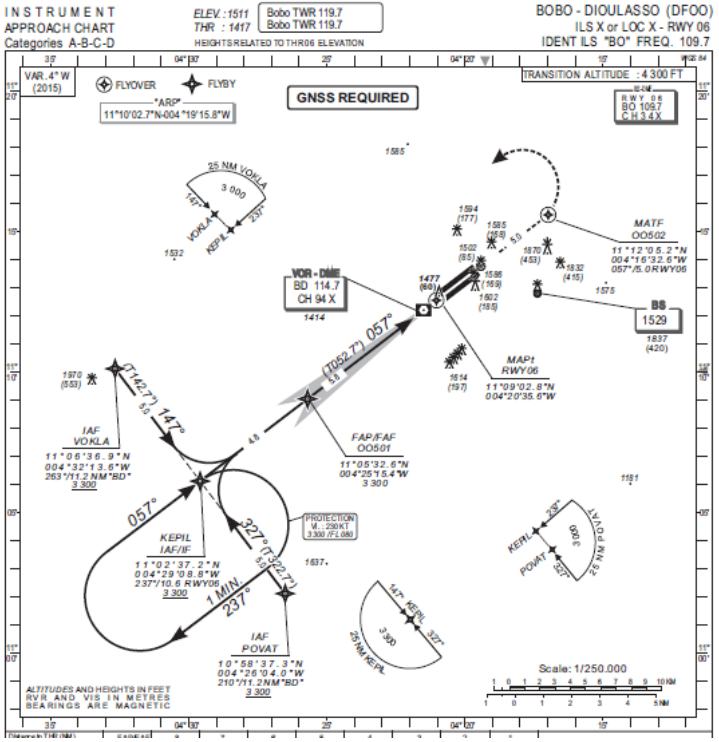
- Flight Test ‘True’ database
  - Jeppesen took all the data (flight test database) for airports, airways, IAPs and changed all the magnetic variation to ’00’ for a flight test area in eastern Canada
  - NAV CANADA flight test aircraft flew a mixed flight plan of V/J airways, PBN airways, NDB, VOR and PBN procedures in True Mode to see if switching the database would be that easy.
  - Flight Test was successful for all aircraft systems – conventional, PBN, EGPWS, EFB, HGS. No off nominal events observed.



CHARTING IN TRUE

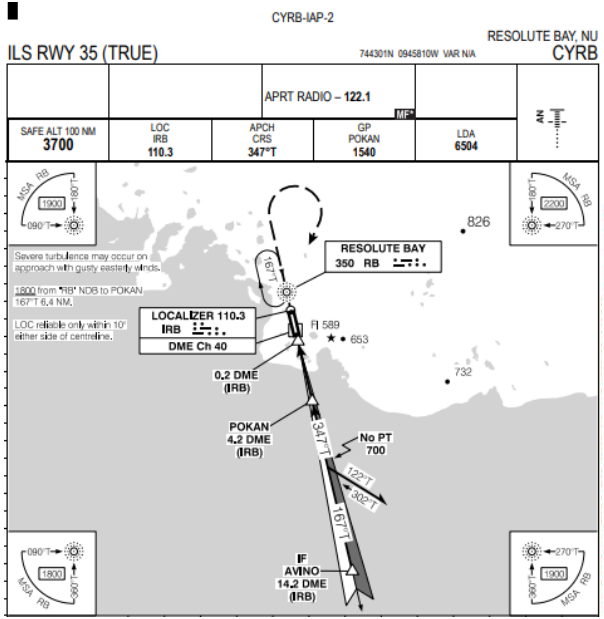
ASECNA member States do this today

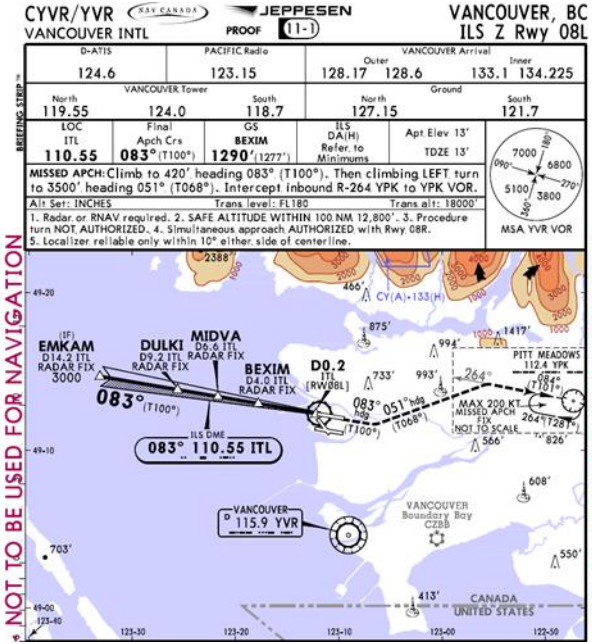


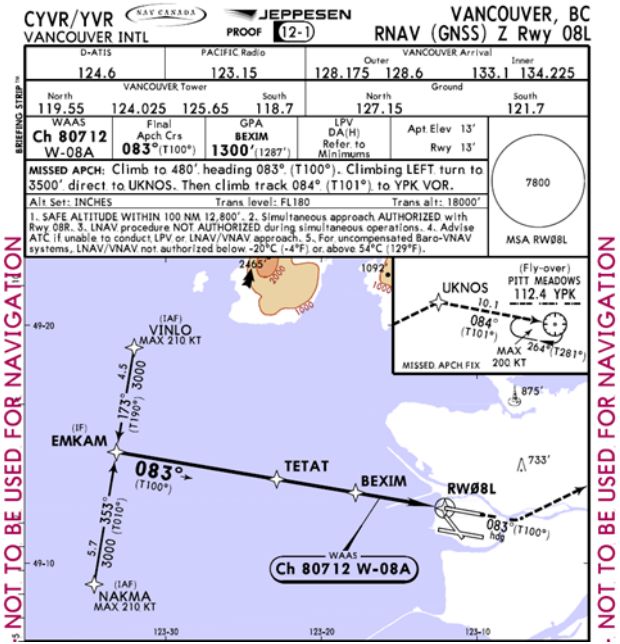


CHARTING IN TRUE

Canada does this today. Jepp concept charts to support the transition







CON OPS – WEATHER

All weather wind reports are referenced to True

- Pilots would no longer have to convert winds from True to Mag in printed weather
- Tower systems to report wind for take-off and landing would not need to convert winds from True to MAG
- ATIS and AWOS systems would not need updated magnetic variation to convert winds from True to Mag

CON OPS – ATS SYSTEMS

MAG VAR is table driven and can be set to “0”

System	LOE per update	# Sites	Frequency	Method
AWOS	0.5 hour per site	101	When required	Site config
HWOS: WIDS	0.5 hour per site	55	When required	Site config
ATIS-NG & D-ATIS	0.5 hour per site	31	When required	Site config
ADAPS-R	0.5 hour per site	40	When required	Site config
EXCDS/NARDS/IWP	0.25 day per site & 6.25 days nationally	103 -	5-yr IGRF model update 5-yr IGRF model update	FM software update
CAATS & GAATS+	4 hours per FIR & 4 days nationally	7+1 -	Every 56-days 5-yr IGRF model update	Data file update
VGM	0.25 hour per site	11	Annual PM trip	Site config
WADDS	0.25 hour per site	12	Annual PM trip	Site config
NAVCANlink	1 hour per site	5	When required	Site config
Aeroview	5 hours per site	38	When required	FM software update
A-SMGCS	1 day per site	9	When required	Adaptation
CFPS	10 days nationally	-	5-yr IGRF model update	FM software update

+ Chart Updates
  -3 cycles

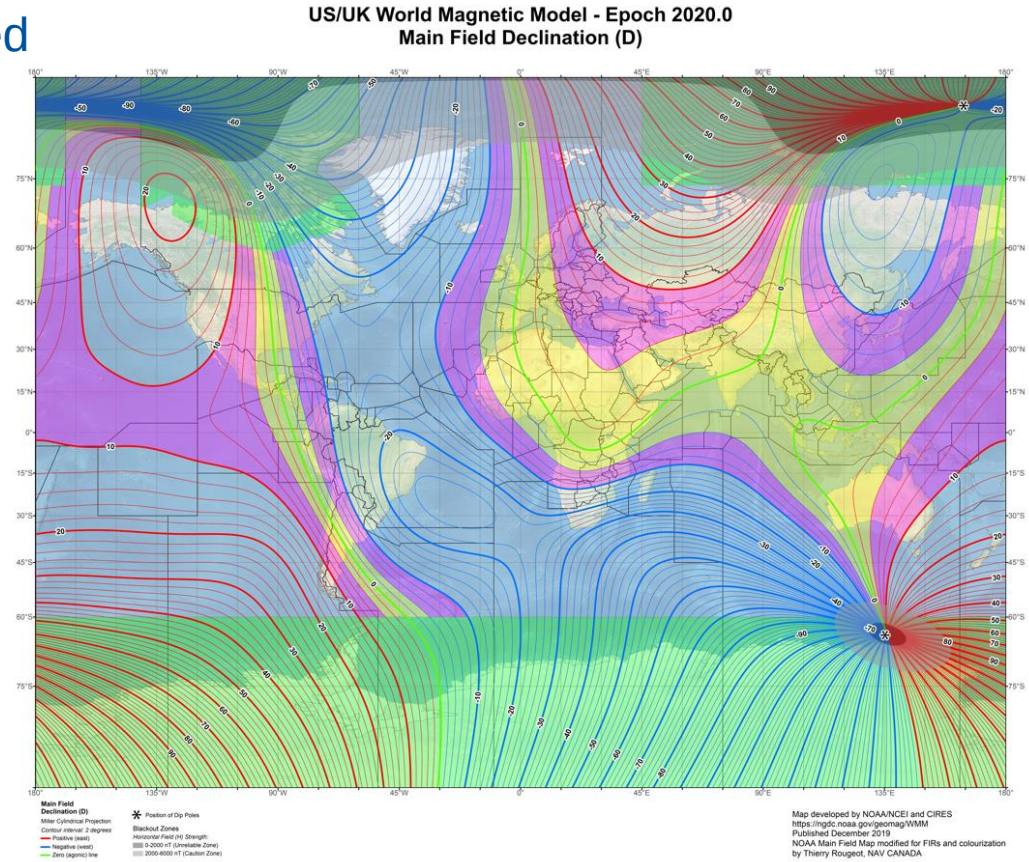
+ VOR Rotation
  - enroute
  - terminal

CON OPS - CHANGING TO TRUE

States (ANSPs/Airports) Affected

- Yellow = ±4° variation
- Magenta = ±10° variation
- Green = Ops in True Today

- Reducing impact of the change
  - Procedures within ±4° variation could be adjusted early or left as is until the next review date
  - Airports within the ±10° could update numbering, signage and data at their convenience prior to, or, after the transition to True.



2030 WORLD WIDE AIRPORT IMPACT

AIRAC cycle 21-11/2020 EPOCH NAV CANADA

GET COUNT

Runway Category	Country Code
HARD	WORLD

Country Selection

WORLD

Runway Length categories			Requiring changes		
From	To	# of RWY's	With True	With Mag	Now with Mag
0 ft	4000 ft	8133	4826	2622	2046
4000 ft	6000 ft	8144	4902	2717	1822
6000 ft	8000 ft	3867	2082	1165	791
8000 ft	10000 ft	3183	1499	890	561
10000 ft	12000 ft	1633	774	411	271
12000 ft	14000 ft	698	287	217	153
14000 ft	16000 ft	68	40	20	10
16000 ft	25000 ft	6	6	2	2
	Total	25732	14416	8044	5656

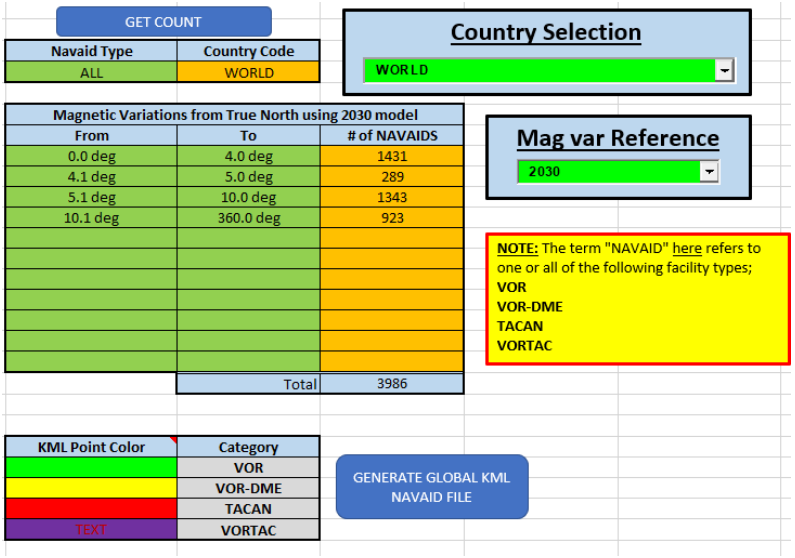
KML Point Color	Category
TEXT	HARD
TEXT	SOFT
TEXT	WATER/ICE/SNOW

GENERATE GLOBAL KML AIRPORT FILE

25732 World-wide hard surface runways analyzed
8044 would need to renumbered in MAG
11316 would be left alone switching to TRUE

14416 would need to be renumbered in TRUE
5656 are out of MAG alignment today
25732 will be renumbered over time

2030 VOR/TACAN IMPACT



GET COUNT

Navaid Type	Country Code
ALL	WORLD

Country Selection

WORLD

Magnetic Variations from True North using 2030 model		
From	To	# of NAVAIDS
0.0 deg	4.0 deg	1431
4.1 deg	5.0 deg	289
5.1 deg	10.0 deg	1343
10.1 deg	360.0 deg	923
	Total	3986

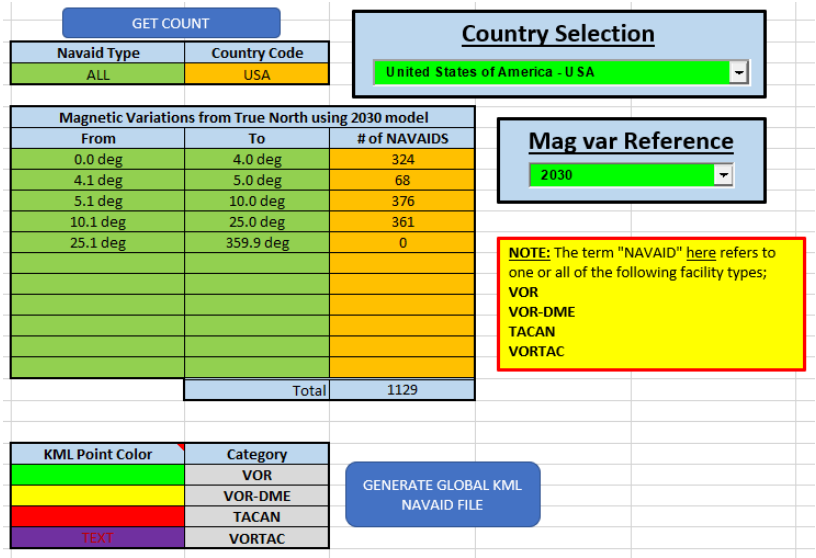
Mag var Reference

2030

NOTE: The term "NAVAID" here refers to one or all of the following facility types;
VOR
VOR-DME
TACAN
VORTAC

KML Point Color	Category
	VOR
	VOR-DME
	TACAN
TEXT	VORTAC

GENERATE GLOBAL KML NAVAID FILE



GET COUNT

Navaid Type	Country Code
ALL	USA

Country Selection

United States of America - USA

Magnetic Variations from True North using 2030 model		
From	To	# of NAVAIDS
0.0 deg	4.0 deg	324
4.1 deg	5.0 deg	68
5.1 deg	10.0 deg	376
10.1 deg	25.0 deg	361
25.1 deg	359.9 deg	0
	Total	1129

Mag var Reference

2030

NOTE: The term "NAVAID" here refers to one or all of the following facility types;
VOR
VOR-DME
TACAN
VORTAC

KML Point Color	Category
	VOR
	VOR-DME
	TACAN
TEXT	VORTAC

GENERATE GLOBAL KML NAVAID FILE

3946 World-wide VORs analyzed
289 are between 4°and 5° of True Today

1431 are within 4° of True Today
1343 are between 5°and 10° of True Today

New VORs rotated electronically. Older VOR systems typically limited to 8-10° of electronic rotation.
TACANs generally a physical rotation.

STATE INTERESTS

ICAO Annex Impact

- Canada has filed minimal ICAO differences for its long standing True North Operations
  - 1 difference in Annex 5
  - 1 difference in Annex 15
  - 6 differences to PANS-AIM
- A through review of all ANNEXs has found minor areas of amendment to ANNEX 2, 4, 5, 6, 10, 11, 12, 14, 15 with the majority in Annex 4 regarding the charting of bearings and tracks I.E.
  - ANNEX 4, Chapter 7. ENROUTE CHART – ICAO
    - iii. 7.8 Bearings, tracks and radials
    - 1) 7.8.1 Bearings, tracks and radials **shall** be magnetic, *except as provided for in 7.8.2*. Where bearings and tracks are additionally provided as true values for RNAV segments, they shall be shown in parentheses to the nearest tenth of a degree, e.g. 290° (294.9°T).
    - *2) 7.8.2 Recommendation.— In areas of high latitude where it is determined by the appropriate authority that reference to Magnetic North is impractical, another suitable reference, i.e. True North or Grid North, should be used.*

ICAO INTERESTS

Considerations

- Safety Impact - Positive.
  - ANSP data and 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 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		*True North Mode*	
Between 50°S and 50°N	*±2°*	*Worldwide*	*±1°*
Between 50°N and 73°N	*±3°*		
Between 73°N and 79°N	*±5°*		
Between 79°N and 82°N	*±8°*		

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 with mag seeking AHRUs would have a one time charge for north seeking AHRUs or low cost converters. Example – DH8-100 AH-600 (high mtc cost) change to AH-2100
  - 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, State WGs, AIM data processes
  - Simplification of avionics design and procedure 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 Rotation 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 mar var differences
  - ANSPs can focus on new procedure development instead of procedure churn to correct mag var on current procedures (reduced procedure maintenance)
- Expected Implementation Time – Positive
  - 2030 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.

THE ASK

Improve Safety, efficiency and reduce long term aviation sector costs by STOPPING a past practise.

- Stop converting TRUE data for ATS, Weather and Aircraft Operations to Magnetic for end use
- Stop renumbering runways to follow a moving target
- Stop realigning navigation aids to follow a moving target
- Stop reissuing aeronautical charts due a MAG VAR change by a final change to TRUE
- Stop sending aircraft navigation equipment back to the avionics manufacturer for mag var updates
- Stop never ending aviation working groups to discuss and deal with never ending mag var changes

Thank You

Serving a world in motion
navcanada.ca

NAV CANADA