Survey Report

SURVEY ON MOVING FROM A MAGNETIC TO A TRUE NORTH REFERENCE SYSTEM FOR HEADING AND TRACKING IN AVIATION OPERATIONS

ICAO/ANB/OPS

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Table of contents

1. Executive Summary 3

2. Background 4

3. Objectives 4

4. Methodology 5

5. Survey analysis 5

5.1 Survey respondents 5

5.2 Level of Support for Moving to True North 8

5.3 Estimated timeframe of true north implementation 10

5.4 Frequency of magnetic variation (MAGVAR) related updates 13

5.5 Changes in operational activities 14

5.6 Cost analysis 16

5.7 Potential challenges 17

5.8 Foreseen benefits 19

5.9. Level of impact on stakeholders from State CAA perspective 21

5.10. True north operations in remote and oceanic airspace 22

5.11. OEM production of navigation equipment unable to function in true north 22

6. Conclusion 22

7. List of Acronyms 24

Appendix A: Survey results by stakeholders 26

1. Executive Summary

On 21 September 2022 ICAO sent State letter AN11/57-22/87 with a survey to States and their aviation industry on the topic of "True North". The survey aimed to investigate the level of support for changing the reference for aircraft heading and tracking from magnetic to true north in ICAO international standards and recommended practices (SARPs).

If true north reference for aircraft heading is implemented, it would mean the discontinuation of the existing practice of converting aeronautical data from its original format in true reference into magnetic reference. It would simplify charting and aircraft operations, improve operational safety, and may result in considerable cost savings for air operators, air navigation service providers (ANSPs), aerodromes, avionics manufacturers, and flight procedure designers.

The ICAO survey received substantial participation, with 564 responses from 103 States, accounting for 53% of the 193 ICAO Contracting States. There was a diverse group of responders which included individuals from State civil aviation authorities (CAAs), air operators, ANSPs, aerodromes, original equipment manufacturers (OEMs), flight procedures designers, training organizations, and the military.

The survey results show considerable support for moving to true north within a realistic timeframe, with 62% of total respondents either strongly supporting (38%) or somewhat supporting (23%) a change. 29% of respondents answered neutral and the remaining 9% either somewhat did not support (5%) or strongly did not support (4%) a change. State CAA support was higher than the overall trend, with 72% of the 141 CAA responses indicating support, while 25% were neutral and 3% were not in support. ASNPs and instrument flight procedure (IFP) organizations also gave strong support, with 74% and 79% indicating support, respectively. Air operators provided the most varied responses, with 48% supporting, 39% neutral, and 14% not in support.

Over 80% of respondents estimated that it would take their sectors 10 years or less to implement true north in their States.

The responses highlighted several key reasons to implement True North across stakeholders:

- Less financial and human resources spent on managing magnetic variation after a one-time investment cost to switch to true north.
- Improvements to aviation safety, such as eliminating magnetic variation-related errors that can lead to unsafe conditions during aircraft precision approaches and Autoland.
- Reduced maintenance to procedures for ANSPs and instrument flight procedure designers.
- Elimination of two systems of reporting weather (reported in magnetic by ATC and true by MET).
- Reduced workload, more simplified operations and improved accuracy of navigation systems.

The survey also identified several significant challenges that respondents believe need to be overcome for a transition to True North to be viable:

- The need for ICAO to develop a comprehensive transition plan supported by guidance and awareness activities (seminars, workshops, webinars etc.).

- Obtaining global acceptance among all States and industry stakeholders and achieving a harmonized transition to true north.
- Cost and effort to equip aircraft for True North operations, particularly older aircraft, and smaller general aviation aircraft.
- Potential unmanaged safety risks introduced during a transition to true north.

In the additional comments related question, about 50 respondents mentioned the need for ICAO to develop a comprehensive concept of operations (CONOPS) and transition plan as well as conduct further studies. Many respondents indicated that a CONOPS and transition plan is needed to fully assess the impact of moving to true north across their products or organizations. Based on these views, it is recommended that ICAO develop a CONOPS, along with a transition plan and timeframe, considering all stakeholders' needs, as a first step towards transitioning to a true north reference system. An ICAO inter-disciplinary group, such as a Study Group or inter-panel group, may be needed to assist the ICAO Secretariat with developing these documents and to assist in creating a realistic and safe framework for a true north transition.

2. Background

The topic of moving from a magnetic to a true north reference system was initially raised by Canada in November 2012 at the ICAO 12th Air Navigation Conference (AN-Conf/12-WP/147 refers). The conference made a recommendation 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.

After further studying the topic, Canada returned to the 13th Air Navigation Conference in October 2018 and presented a working paper on the feasibility and benefits of true north. The conference recommended that a detailed study be conducted on the topic. In October 2021, Canada submitted an information paper on the topic to the High-Level Conference (HLCC) with further updates on their study.

At the fifteenth meeting of the ICAO Instrument Flight Procedures Panel (IFPP/15), held in March 2022, Canada presented a working paper asking for the Panel to consider switching to a true north reference system for aviation operations. The Panel supported the initiative but expressed some concerns about the size of such a project, the challenges with implementing it globally and the need to do a robust safety assessment. The Panel recommended that ICAO should first investigate the level of support of States and industry on such an initiative before commencing any work.

As a result, in September 2022, ICAO sent State letter AN11/57-22/87 with a survey on true north.

3. Objectives

The aim of the survey was to determine the level of support of States and their aviation industry for ICAO to commence work on changing from a magnetic to a true north reference system for heading and track reference in aviation, as well as to identify any concerns or challenges that may need to be addressed during any transition to true north. The findings from the survey will assist ICAO in determining the viability of moving to true north and may be used to guide ICAO in developing plans and strategies for a future transition.

4. Methodology

The true north survey was conducted online using Microsoft Forms. However, several respondents (approximately 10) submitted the survey directly to ICAO by email in pdf, Word, or excel format. Those responses were manually added to Microsoft Forms to ensure they were included in the analysis. ICAO provided a link in the State Letter to an ICAO website with supporting information related to true north and organized two webinars on the topic, so that respondents were better informed of all considerations before responding to the survey.

In order to consider as much impacts as possible from different sectors, the survey did not limit an organization to one response. Some responses were collected from multiple respondents in the same organization, but different departments or sections (e.g. flight operations and ANSP section). Since there are several open questions designed in the survey, a content analysis approach was used to summarize the topics and themes to indicate the responses.

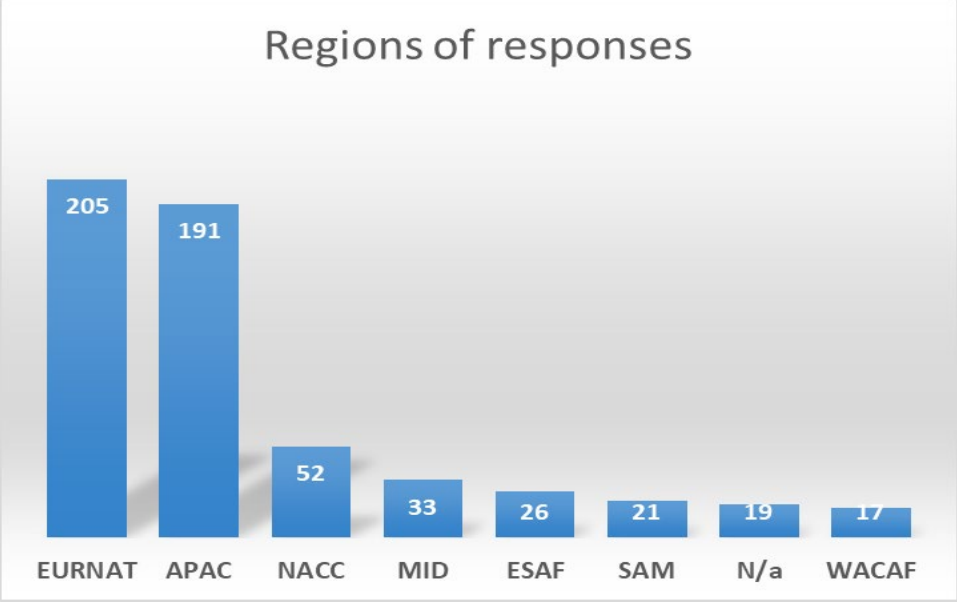
5. Survey analysis

5.1 Survey respondents

A total of 564 responses from 103 States were received during the survey period (21 September to 31 December 2022).

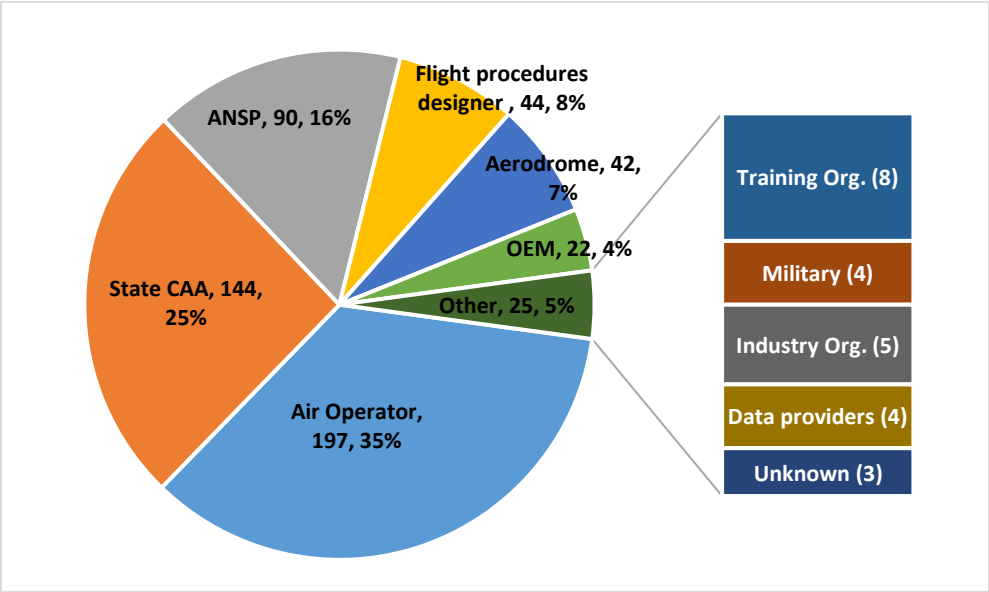
There were responses received from all the ICAO regions distributed, as shown in Figure 1 below.

Figure 1 – The ICAO region of respondents



The majority of responses came from EURNAT (36%) and APAC (34%). China accounted for 106 of the 191 APAC responses. The next States with the largest number of responses were the Russian Federation, with 32 and then the United States with 23.

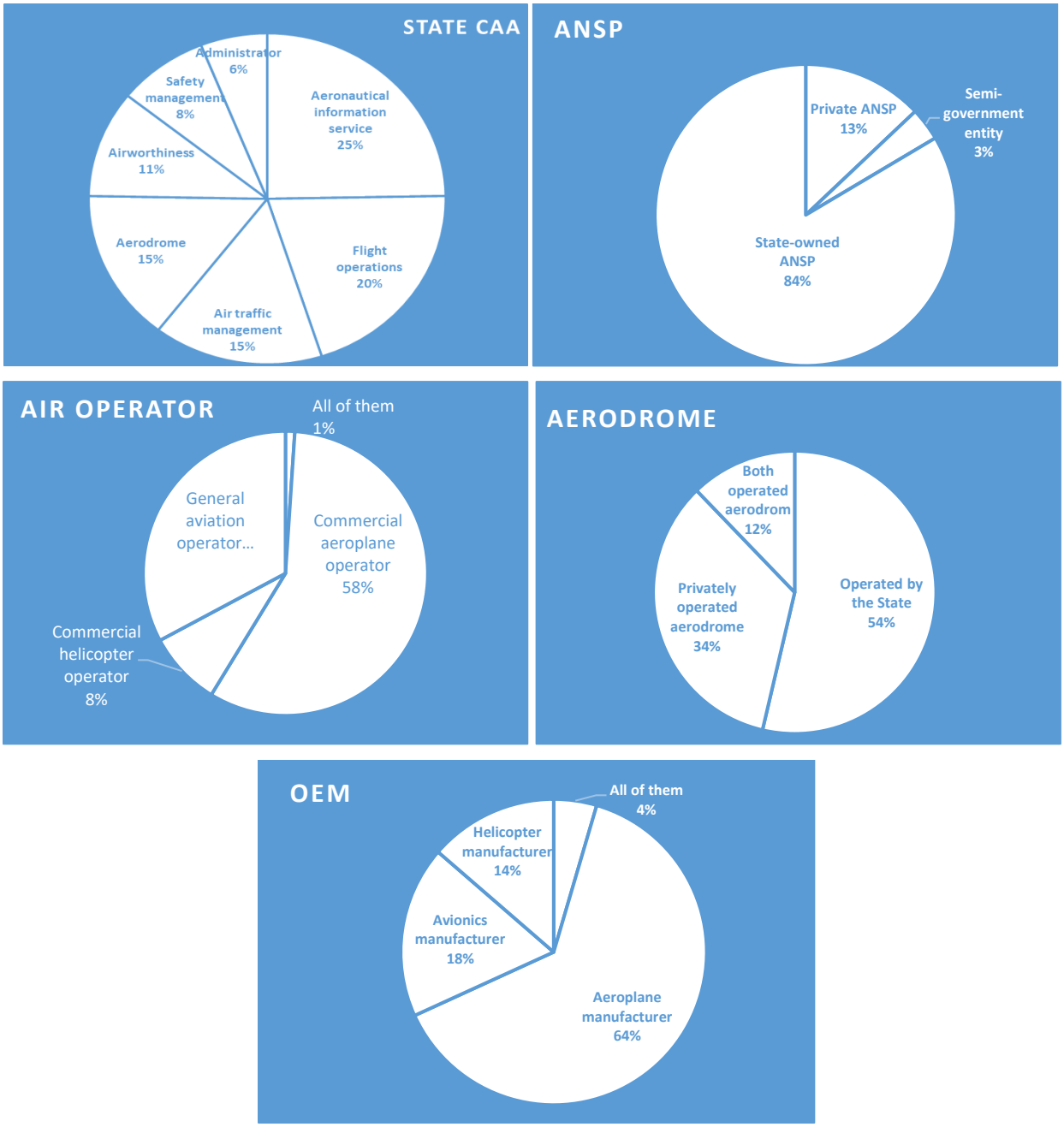
Figure 2 – Distribution of responses by stakeholders



The distribution of responders by type of stakeholder is shown in Figure 2 above. Air Operators, State CAAs and ANSPs made up the majority, with a combined 76% of responders.

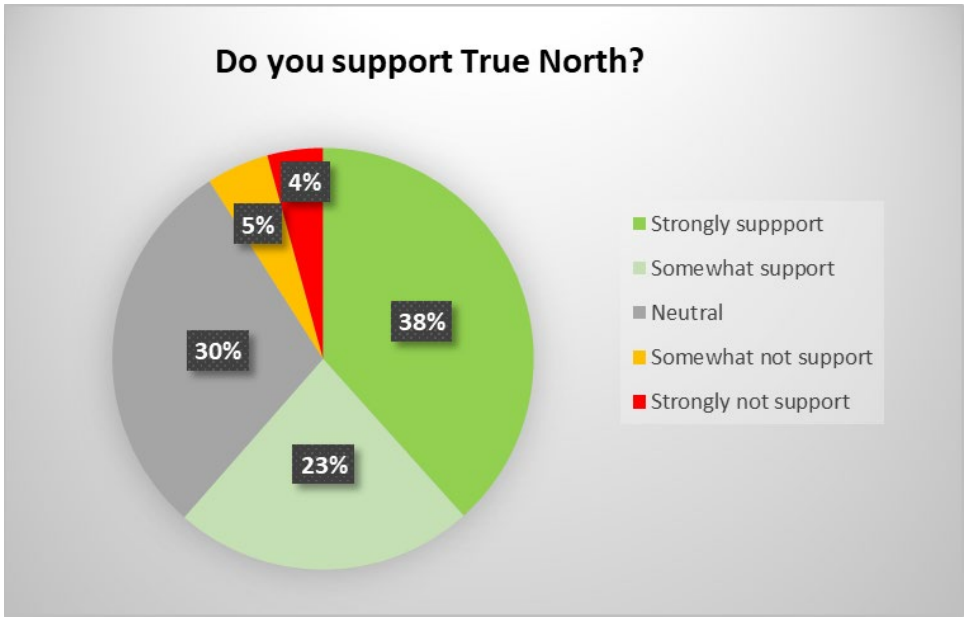
Figure 3 below shows the breakdown of responders within each stakeholder.

Figure 3 – Distribution of responders among stakeholders



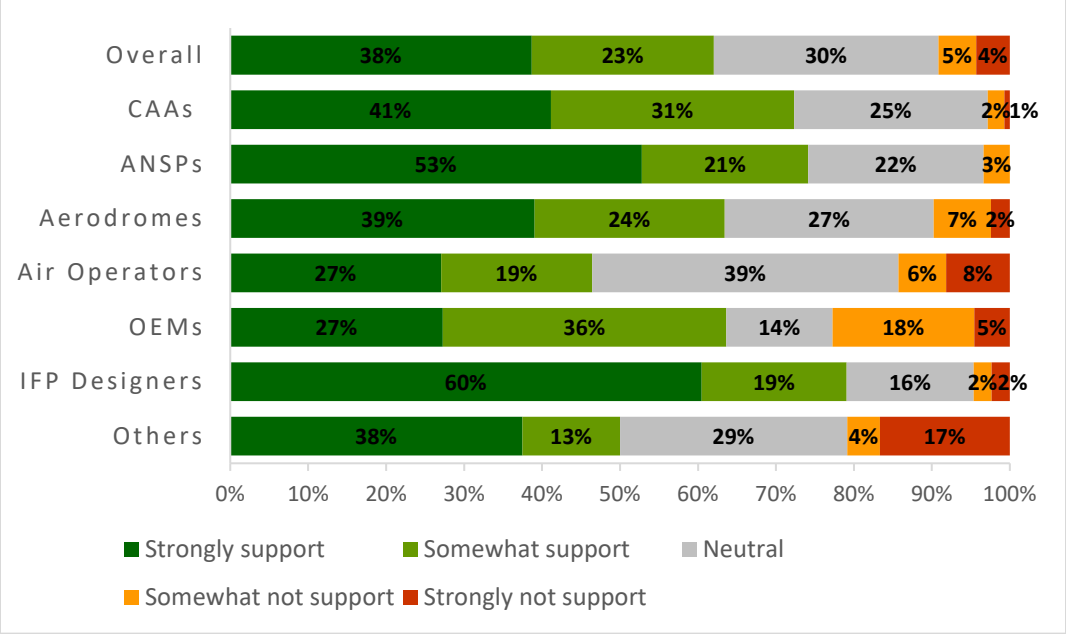
5.2 Level of support for moving to true north

Figure 4 – Overall level of support for changing the navigation reference from Magnetic to True North in aviation operations within a realistic time frame



As shown in Figure 4 above, 61% of total respondents either strongly support (38%) or somewhat support (23%) moving to True North, while 30% answered that they were neutral and the remaining 9% either somewhat did not support (5%) or strongly did not support (4%).

Figure 5 - Level of support for True North by stakeholder



Instrument flight procedure (IFP) organizations, ANSPs and State CAAs were the most in support of True North, as shown in figure 5. 72% of CAA responses indicated either strong support or somewhat support for true north while only 3% of States (4 total responses from 3 States) were not in support of moving to true north.

Air operators were the stakeholder that was most uncertain of moving to true north, as 39% of air operators were neutral, 10% higher than the overall response rate of neutral. In particular, almost 60% of the general aviation operators answered neutral.

Figure 6 - Level of support for True North by ICAO region

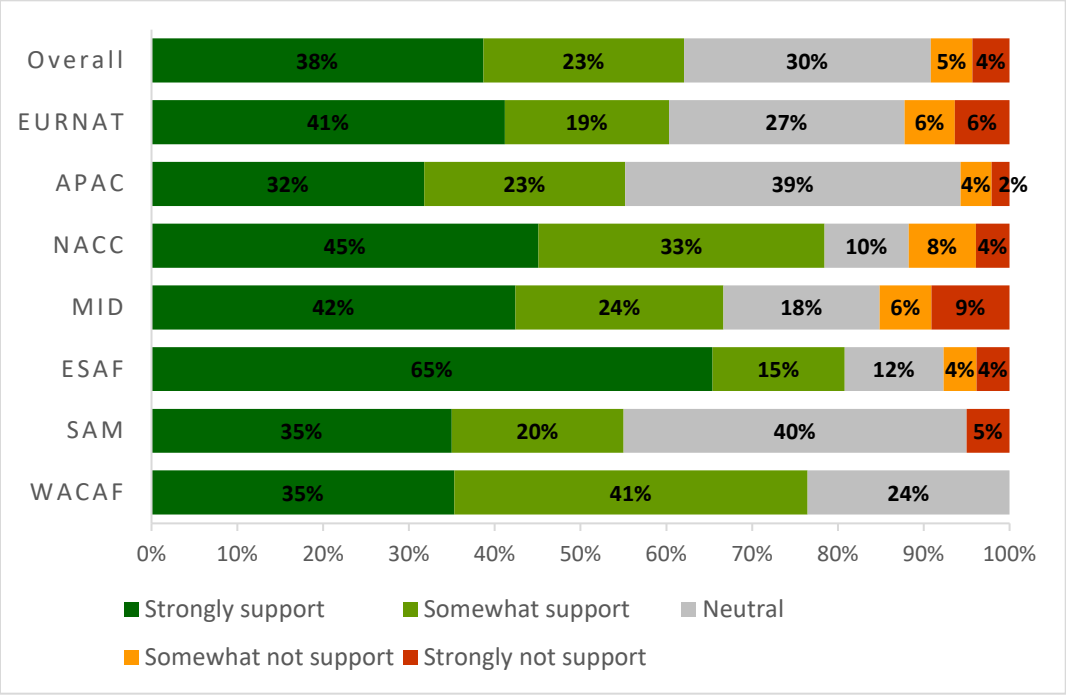


Figure 6 above shows that the ICAO regions with the strongest level of support were ESAF (80% strongly or somewhat support), NACC (78%) and WACAF (76%). The APAC and SAM regions indicated a strong response of neutral (39% and 40%, respectively), while the MID region had the largest percentage of respondents indicating a lack of support (15%).

5.3 Estimated timeframe of true north implementation

Figure 7 - Estimated timeframe to implement true north in the respondents' State

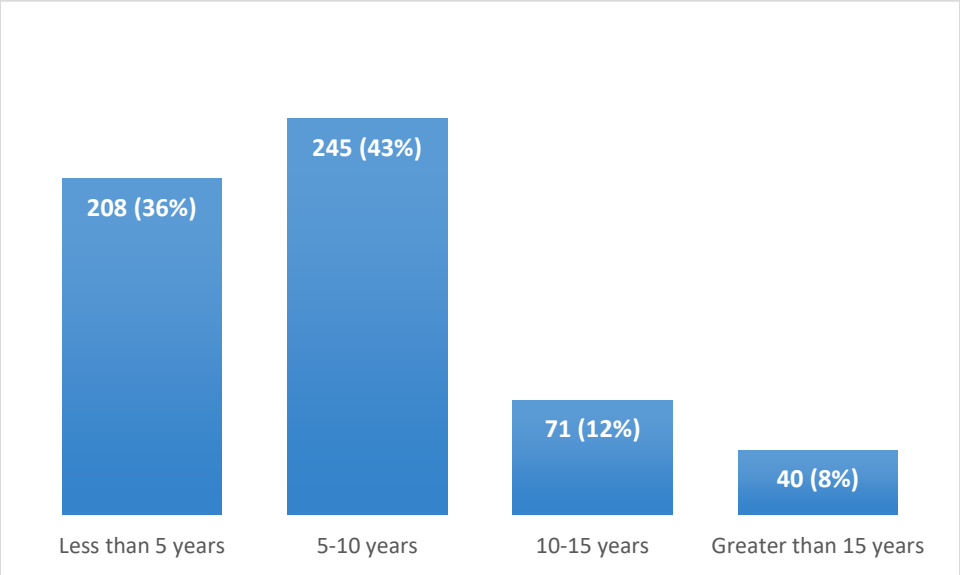


Table 1 - Heat map of estimated timeframe to implement true north by stakeholder

	Less than 5 years	5-10 years	10-15 years	Greater than 15 years
Overall	36%	43%	12%	8%
State CAAs	36%	47%	13%	4%
ANSPs	48%	40%	8%	4%
Aerodrome	44%	37%	12%	7%
Air Operators	32%	43%	16%	10%
OEM	27%	27%	14%	32%
Flight procedures	41%	43%	11%	4%
Others	19%	52%	11%	19%

As shown in Figure 7 and Table 1 above, the majority of respondents estimated that it would take 10 years or less to implement true north in their States. The OEM's were the only outlier to the overall trend, with 32% indicating it will take greater than 15 years.

5.4 Analysis by magnetic declination

Using the latest US/UK World Magnetic Model (Epoch 2020), an analysis was performed to determine how the responses compare with the level of magnetic declination in each State. The World Magnetic Model (WMM) is the standard model for navigation, altitude, and heading referencing systems using the geomagnetic field. A map of the 2020 WMM is shown below in Figure 8.

Figure 8 - World Magnetic Model, Epoch 2020

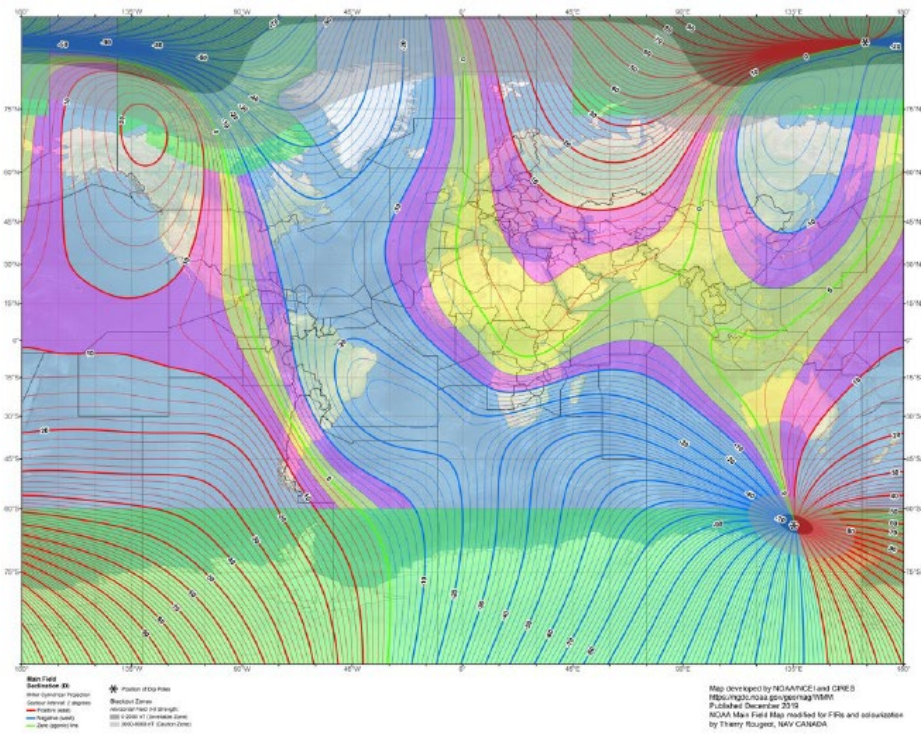


Figure 9 - Distribution of responses by level of magnetic declination

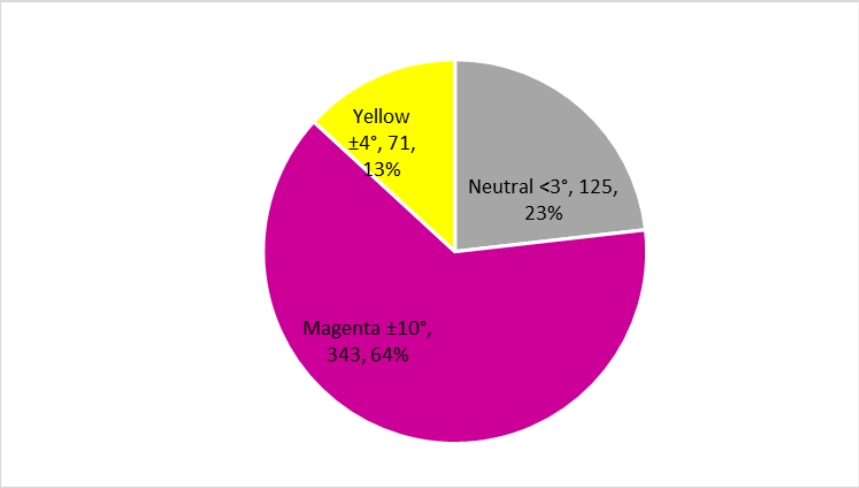


Figure 10 - Level of support by level of magnetic declination

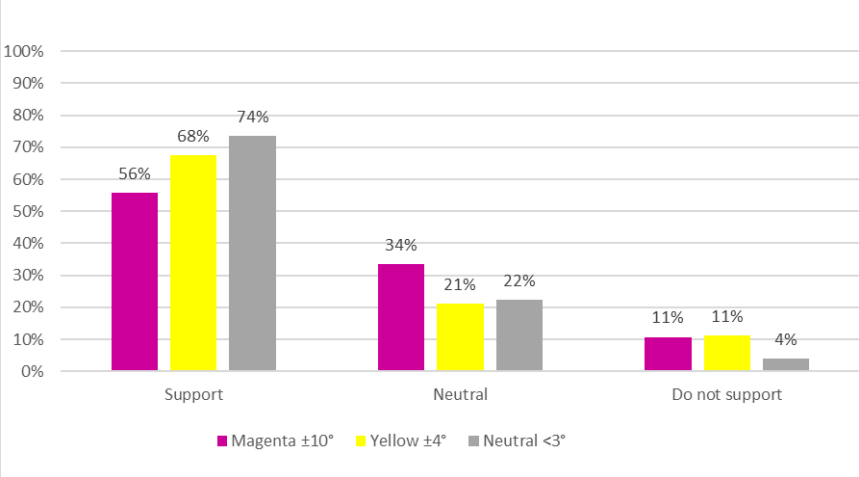
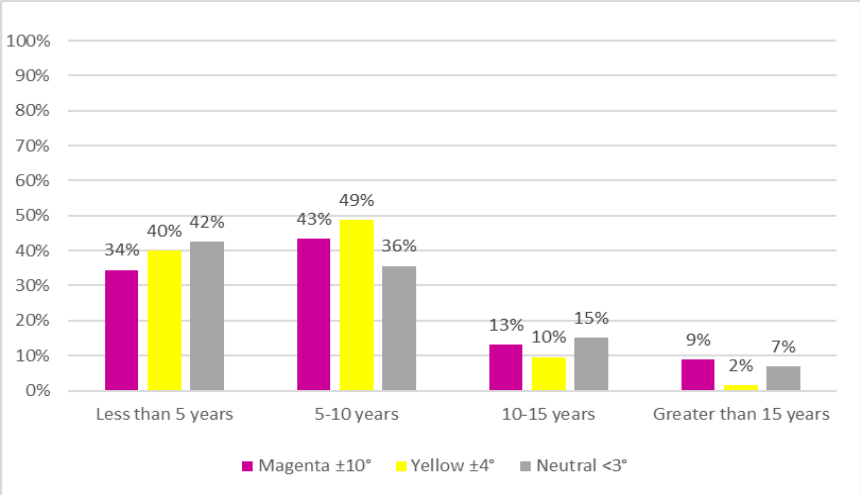


Figure 11 - Estimated timeframe to implement true north by level of magnetic declination

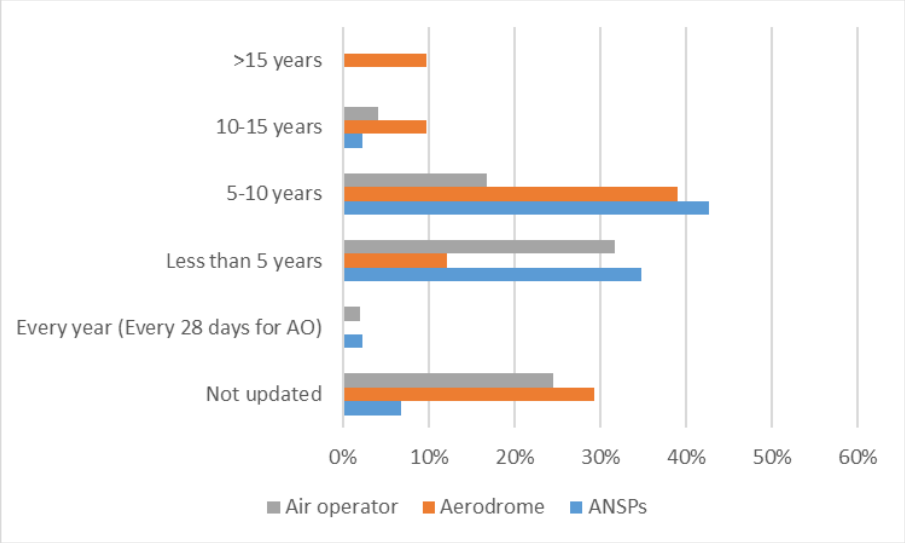


In the Figures above, The States included in the "Magenta" category are those with 10% of their navaids with greater than 5 degrees magnetic declination (*Source: Fly true north assessment tool provided by NAV Canada and Jeppesen*). The "Yellow" category are States mostly within 3 to 5 degrees magnetic declination. The "Neutral" category are States with 0-3° magnetic declination. Figure 10 shows that "Neutral" respondents represented the highest percentage of support for a true north transition, with 74% in support.

5.5 Frequency of magnetic variation (MAGVAR) related updates

Some stakeholders have to regularly make updates to databases, systems, and documentation to compensate for MAGVAR. The survey asked ANSPs, aerodromes, and air operators to indicate the frequency of these updates. ANSPs need to regularly update charts due to MAGVAR changes across navigation, surveillance, and aircraft systems. Aerodromes need to periodically change runway numbering and signage. Air operators need to update MAGVAR tables in the aircraft FMS and IRU systems, as well as carry out compass and AHRU alignments. A summary of the frequency of MAGVAR related updates for these three stakeholders is presented in Figure 12 below.

Figure 12- Frequency of MAGVAR-related updates



Air operators largely perform updates on a less than 5-year basis, while ANSPs and Aerodromes mostly perform updates every 5-10 years. However, 48 operators (56% general aviation operators) indicated that MAGVAR tables are not updated at all.

5.5 Changes in operational activities

Table 2 below presents a summary of how stakeholders answered questions related to what activities they currently do to maintain MAGVAR and what activities they foresee would need to be changed to move to true north. The percentage of respondents of each stakeholder are listed by order from largest to smallest.

Table 2 – Changes in operational activities for stakeholders if true north is implemented

ANSP:

MAGVAR	Updating IAPs	Updating en-route charts	Rotating VORs & TACANs	Maintaining MAGVAR in data systems	Adjusting runway numbering	Training personnel	Updating IRUs & FMSs for flight check aircraft
Totals	87%	84%	63%	61%	54%	35%	13%
True North	Amend docs, data, and systems	Training personnel	Easier map/chart development and saving cost due to no MAG	No impact due to small MAG deviation areas	Develop transition plan	Change management /Promotion awareness	Investment for one-time change
Totals	57%	17%	13%	9%	7%	4%	2%

Aerodrome:

MAGVAR	Updating aerodrome data and documentation	Maintaining signage and runway numbering	Training personnel	
Totals	93%	63%	49%	
True North	Amend docs, data, and systems	Revise once TN Runway markings & signage	Training Personnel	Update procedures
Totals	59%	49%	15%	12%

Air Operator:

MAGVAR	Updating FMS	Annual Compass/AHRU alignment	Training personnel	Managing operating restrictions & ADs	Updating IRU MAGVAR tables
Totals	54%	51%	41%	27%	16%
True North	Training personnel	Retrofit aircraft equipment	IRUs would need to enable the MAG/TRUE functions	Magnetically Slaved AHRS would have a one-time change	
Totals	69%	63%	44%	39%	

OEM (were only asked about what activities will change after True North implementation):

True North	Redesign & certification	Upgrade existing equipment	Impact assessment	Amend manuals & publications	Reduce verification testing & no need to upload MAGVAR tables	Training Personnel	Coordinate with suppliers
Totals	45%	41%	32%	32%	32%	9%	9%

Instrument flight procedures designers:

MAGVAR	Periodically amend instrument flight procedures	Updating MAGVAR	Maintaining alignment between aerodrome data and ANSP IFP	Training personnel
Totals	98%	84%	79%	53%
True North	Simplification of data acquisition	Ensuring design tools can bypass MAGVAR values	No need to amend procedures, charts etc.	
Totals	79%	72%	63%	

5.6 Cost analysis

In the survey, respondents were asked two questions related to cost:

1) What is the approximate annual cost to maintain MAGVAR (Ref. Q15, Q24, Q35, Q36, and Q51).

2) What is the approximate investment to implement True North (Ref. Q17, Q26, Q38, Q46, and Q53).

Figures 13 and 14 below, display the results of the responses to these questions by ANSPs, aerodromes, air operators, and IFP designers. Many respondents did not provide a quantitative cost or indicated they do not know, which is why the number of responses is low compared to the total survey responses received. Only approximately 30% of respondents provided usable data for the cost related questions.

Figure 13 – Approximate annual cost to maintain MAGVAR in US dollars

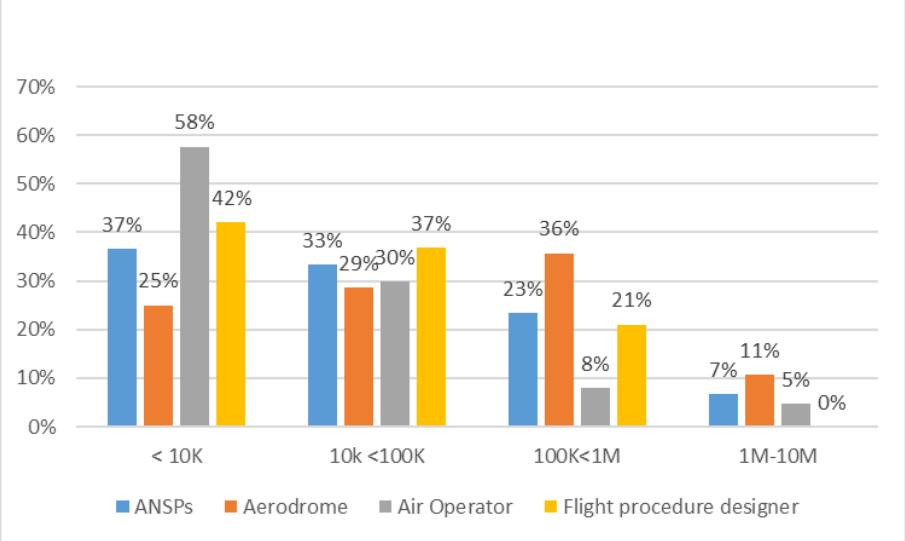
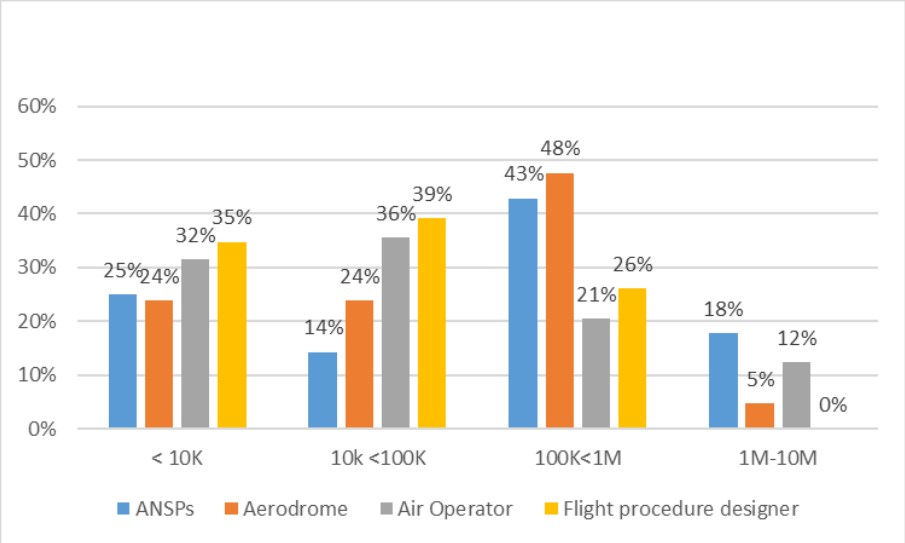


Figure 14 - Approximate cost to implement true north in US dollars



According to Figure 13, air operators, IFP designers and ANSPs predominantly spend less than $10K(USD) per year to maintain MAGVAR, while 36% of Aerodromes indicated spending between $100K and $1M.

Figure 14 shows that 33% of air operators and 39% of instrument flight procedure designers estimated spending between $10K and $100K to implement true north. ANSPs and aerodromes largely estimated spending between $100K and $1M.

5.7 Potential challenges

In transitioning from magnetic to true north, the top potential challenges identified by each stakeholder are summarized in Table 3 below. The response rate refers to percentage of respondents of each stakeholder. In addition, all the potential challenges with response rates is presented in appendix A (Refer to survey questions 8, 11, 27, 39, 47, 54, and 61).

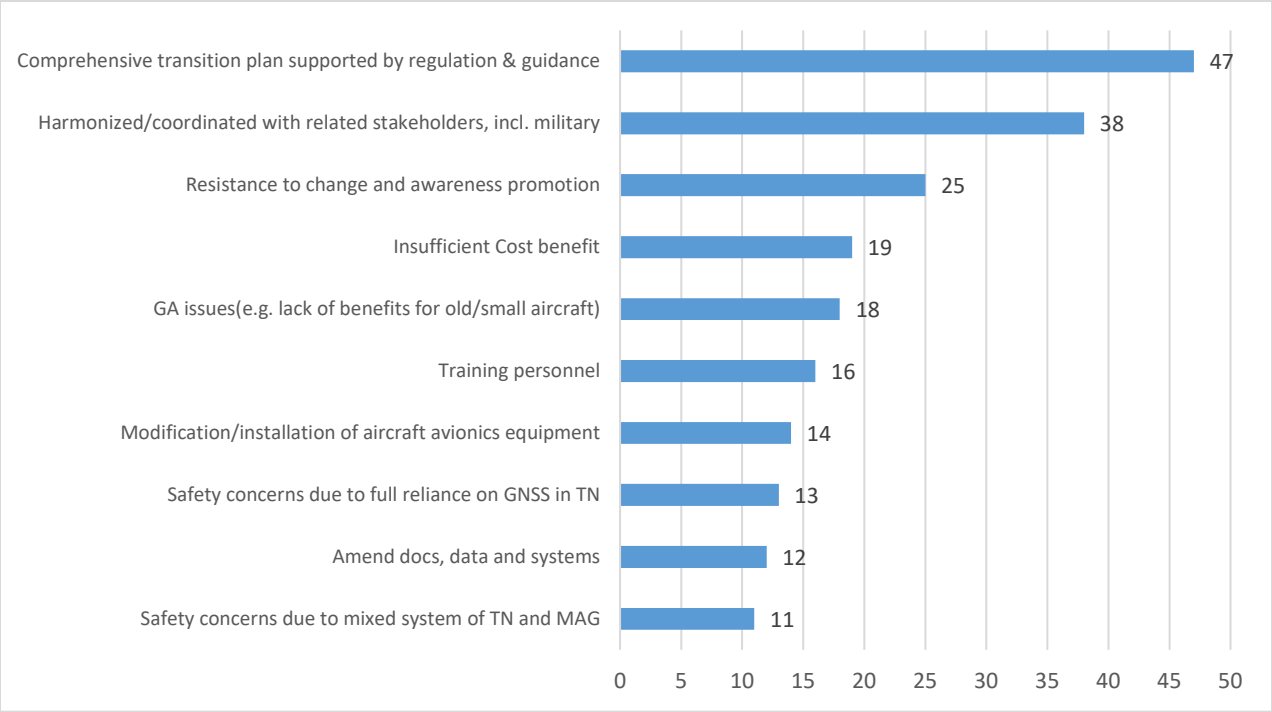
Table 3 - Top potential challenges indicated by stakeholder

Stakeholder	Top potential challenges selected by stakeholder	Response rate
State CAAs	(1) Managing the one-time implementation cost in my State vs. the ongoing costs over time of managing MAGVAR	57%
	(2) Lack of concept of operations (CONOPS) and Transition Plan unless provided by ICAO	55%
	(3) Potential unmanaged safety risks introduced during the transition to True North	52%
ANSPs	(1) Time frame to safely effect the change	61%
	(2) Lack of CONOPS and Transition Plan unless provided by ICAO	48%
Aerodromes	(1) Lack of financial resources	46%
	(2) The complexity of removing MAGVAR Corrections	44%
Air Operators	(1) Aircraft downtime related to retrofitting aircraft equipment	57%

	(2) Make adjustments required to navigation equipment to adjust for MAGVAR	46%
	(3) Challenges with required equipment in non-IRU-equipped air operators	46%
OEMs	(1) Cost and efforts associated with certifications of modified avionics equipment	59%
	(2) Cost of converting magnetic sense inputs to the AHRU to True North heading outputs	55%
Flight Procedure designers	(1) The ability of data warehouses to manage a large-scale data reference change unless managed appropriately	47%
	(2) Workload management in updating flight procedures for this one-time change vs. continual periodic MAGVAR updates	47%

The survey also provided the opportunity for respondents to offer any other potential challenges they would expect to encounter in their States which were not offered in the survey responses. The comments received were reviewed and placed into corresponding categories. The categories and number of responses related to each category is presented in Figure 15 below.

Figure 15 - Other challenges raised by overall respondents



A breakdown by each stakeholder is also provided in Table 4. A big red dot (🔴) indicates more than 25% respondents mentioned this challenge, the medium yellow dot (🟡) indicates a response of 10%-25% and a small blue dot (🔹) indicates less than 10% response.

Table 4 - Other challenges breakdown by stakeholder

	State CAAs	ANSPs	Aerodromes	Air Operators	OEMs	Flight procedures designers
Comprehensive transition plan supported by regulation & guidance	●	●	•	●		●
Insufficient funding	●	•	●	•	●	●
Amendment of docs, data and systems(e.g. charts, maps, AIPs, signages)	●	●	●	●	•	●
GA issues(e.g., lack of benefits for old/small aircraft)	●	•		•	●	
Harmonized/coordinated with related stakeholders, incl. military	●	●	●	•	●	●
Training personnel	•	●		●		
Resistance to change and awareness promotion	•	•		•		•
Mix system safety concern	•	•		•	●	●
Full reliance on GNSS in TN		•		•		
Aeronautical vendor challenge	•					
Aircraft retrofit (downtime, parts logistics)				●		

Figure 15 and Table 4 shows that “having a comprehensive global transition plan supported by regulations and guidance” was the biggest additional challenge raised by respondents, followed by “insufficient cost benefit”, “amendment of docs., data and systems”, and “harmonization/coordination with all stakeholders, including military”.

The biggest additional challenge for aerodromes and flight procedure designers was related to amending documents, data, and systems (particularly for aerodromes it was renumbering airport designators and runway signs). The cost of equipping aircraft and integrating it with other systems was a big concern for OEMs. Air operators are more evenly distributed, and aircraft retrofit downtime is a particular concern for them.

5.8 Foreseen benefits

The top benefits foreseen by each stakeholder are summarized in Tables 5 and 6 below. In addition, all of the foreseen benefits with response rates is presented in Appendix A (Refer to questions 8, 11, 27, 39, 47, 54, and 61).

Table 5 - Top potential benefits indicated by stakeholder

Stakeholder	Top potential challenges selected by stakeholder	Response rate
State CAAs	(1) Less financial and human resources spent on updating related magnetic variation (MAGVAR) tables, aeronautical charts, airports, navigation aids, flight management system (FMS)/inertial reference unit (IRU) tables in state owned aircraft, and other documentation	75%
	(2) Improvements to aviation safety by eliminating errors caused by MAGVAR	71%
ANSPs	(1) After a one-time cost with making the change to True, no future costs related to updating MAGVAR across all ANSP systems or data provided to air operators	80%
	(2) ANSPs can focus on new procedure development instead of issuing corrections for MAGVAR on current procedures (reduced procedure maintenance)	70%
	(3) Improvements to aviation safety by eliminating errors caused by MAGVAR	64%
Aerodromes	(1) Managing the one-time implementation cost in my organization versus the ongoing costs over time of managing MAGVAR	78%
	(2) Improvements to aviation safety by eliminating errors caused by MAGVAR	71%
Air Operators	(1) The elimination of two systems in aviation because All Weather products and charting products (currently produced in TRUE) would match air operations without conversion to MAGVAR values	59%
	(2) Less cost due to elimination of periodical FMC/IRU Epoch updates	54%
	(3) Removal of data discrepancies between aircraft and ATS systems as our future ATC and Air Operations data becomes tightly coupled	53%
OEMs	(1) Simplicity of future avionics design	73%
	(2) Less financial resources spent on updating MAGVAR	55%
Flight Procedure designers	(1) Flight procedure service providers can focus on new procedure development instead of corrections for MAGVAR on current procedures (reduced procedure maintenance)	91%
	(2) Simplification of IFP design work with all data suppliers and users on a common heading/track reference system instead of various EPOCH data currently used in different levels of aviation	88%

In Table 6 below, a big red dot (●) indicates greater than 75% of respondents of each stakeholder identified this benefit, a medium yellow dot (●) indicates a response of 60%-75% and a small blue dot (•) indicates less than 60% response.

Table 6 – Top benefits indicated by stakeholder

	States CAAs	ANSPs	Aerodromes	Air operators	OEMs	Flight procedure designers
Less financial and human resources for the long run	●	●	●		●	
Improvements to aviation safety	●		●			
Reduced procedure maintenance		●				●
The elimination of two systems in				•		

aviation for weather reporting						
Simplification of IFP design work						●

As seen in Table 5 and 6 above, “Less financial and human resources in the long run” and “improvements to aviations safety” were the top mentioned benefits. “Simplification of avionics design” and “simplification of IFP design are other benefits specific for OEMs and IFPs, respectively.

An additional four benefits were identified in the other comments question (Question 65). They included:

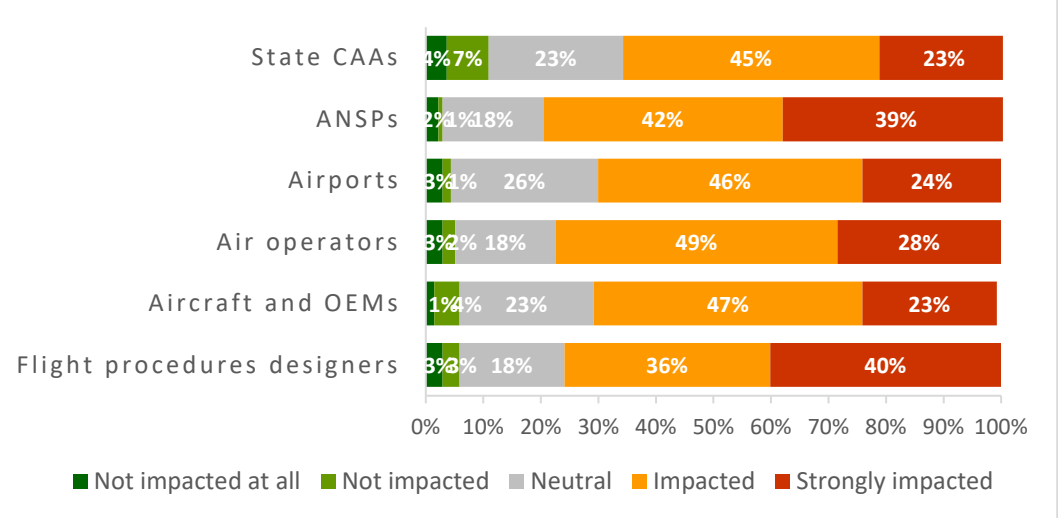
- Reduced workload and more simplified operations (13 related comments).
- Improved accuracy of navigation systems (7 related comments).
- Long-term cost savings (3 related comments).
- Makes use of today’s advanced technology (3 related comments).

5.9. Level of impact on stakeholders from State CAA perspective

In the survey, State CAA respondents were asked to what extent they consider stakeholders in their State would be impacted by moving to a true north reference. As seen in Figure 16 below, the ANSPs and Air Operators were considered to be the biggest impacted with combined ‘impacted’ and ‘strongly impacted’ response rates of 88% and 77% respectively.

States CAAs also identified some additional organizations that would also be impacted, such as data providers, training organizations, military, general aviation, maintenance, and ground handling organizations.

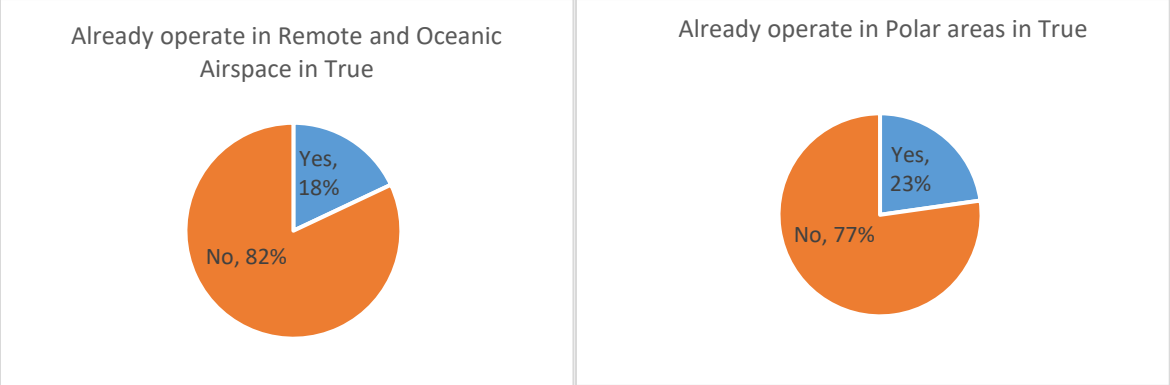
Figure 16 - The level of impact on stakeholders from State CAAs' perspective



5.10. True north operations in remote and oceanic airspace

In the survey**,** air Operators were asked whether they already conduct some operations in true north in remote and oceanic airspaces. Figure 17 below shows that 18% of air operator respondents already operate in remote and oceanic airspace in true north already, while 23% operate in true north in polar regions.

Figure 17 - Air operators already operating in True North



5.11. OEM production of navigation equipment unable to function in true north

OEMs were asked whether they currently produce any attitude and heading reference units (AHRUs) or other navigation equipment that is unable to function or be modified to function in true north. 3 out of the 22 OEM respondents answered that they do produce equipment that is unable to function in true north, accounting for 14%. The respondents were requested to provide details and those comments are as follows:

> **OEM 1**: *Three units currently produced are unable to function in True North. However, other equipment is impacted. Significantly, the Primary Flight Displays and Input/Output Concentrators, among others, would be impacted.*
>
> **OEM 2:** *MEMS-based AHRS utilized in General Aviation, and most Business Aviation applications do not have the ability to gyrocompass or measure True North.*
>
> **OEM 3:** *The vast majority of our aircraft can switch between magnetic and true north. However, some older model airplanes that may still be flying post-2030 may not readily function in True North.*

6. Conclusion

The survey was aimed at investigating the current State and industry support for transitioning to a true north reference system for heading and tracks in air operations sometime in the future. The survey found that 61% of total respondents supported a transition to true north, while only 9% indicated negative support and the remaining 30% were neutral.

Although there is strong support for the initiative, the survey also identified many implementation related challenges that will need to be overcome. As mentioned in the comments by over 50 respondents, an ICAO CONOPS and transition plan will be key to allaying many of the concerns. Many respondents stated that these documents will be essential to fully determine the impact to their State or organization. Several OEMs also commented that a CONOPS and transition plan are necessary to fully analyze the impact on aircraft equipment and systems.

The survey provided inconclusive data related to the costs of implementing true north versus the costs to maintain MAGVAR. Only approximately 30% of respondents provided useable data for those related questions. ICAO may need to conduct further studies on the costs to aviation, in coordination with relevant stakeholders, particularly OEMs and air operators.

Additionally, several other stakeholders responded to the survey, including training schools, military, NGOs and data service providers, but due to the limited data collected, there is a need to further explore the impacts on these types of organizations.

The survey also identified many important questions about a global ture north transition. Some key questions include:

- What timeframe will be needed to transition to true north globally?
- How will global acceptance and a harmonized transition be achieved?
- Should a transition to true north take a phased approach on a regional basis or be done concurrently across States and industry?
- What are the safety risks associated with a change to true north and how can they be identified and mitigated?
- What is the scope of impact, including equipment changes and operational changes, for general aviation and small aircraft operations?
- What will be the impact on large aircraft systems, equipment and operations?

Many of these questions will take extensive efforts and coordination with stakeholders to fully answer. ICAO is in the preferred position to carry out this coordination but it will need the support of an inter-disciplinary group made up of experts from all affected stakeholders. This group could also be tasked to develop an ICAO CONOPS and transition plan and assist ICAO in developing a realistic and safe framework for implementing true north globally.

7. List of Acronyms

A/C: Aircraft

AHRU: Attitude and Heading Reference Unit

APAC: Aisa and Pacific

AIM: Aeronautical Information Manual

CAT: Category

ESAF: Eastern and Southern African

EURNAT: European and North Atlantic

FMS: Flight Management System

FOG: Fibre Optic Gyro

IAP: Instrument Approach Procedure

IFR: Instrument Flight Rules

ILS: Instrument Landing System

IRU: Inertial Reference Unit

IRS: Inertial Reference System

MAGVAR: Magnetic Variation Table

MEMS: Micro Electromechanical Systems

MID: Middle East

MLS: Microwave Landing System

NACC: North American, Central American and Caribbean

NDB: Non-directional Beacon

NGOs: Non-governmental organizations

NOTAM: Notice to Air Missions

OEM: Original Equipment Manufacturer

PARC: Performance-based Operations Aviation Rulemaking Committee

RNP: Required Navigation Performance

SAM: South American

SVS: Synthetic Vision System

TF/RF: Track-to-Fix/Radius-to-fix legs

VFR: Visual flight rules

VOR: Very High-Frequency Omnidirectional Range

VNC: VFR Navigation Chart

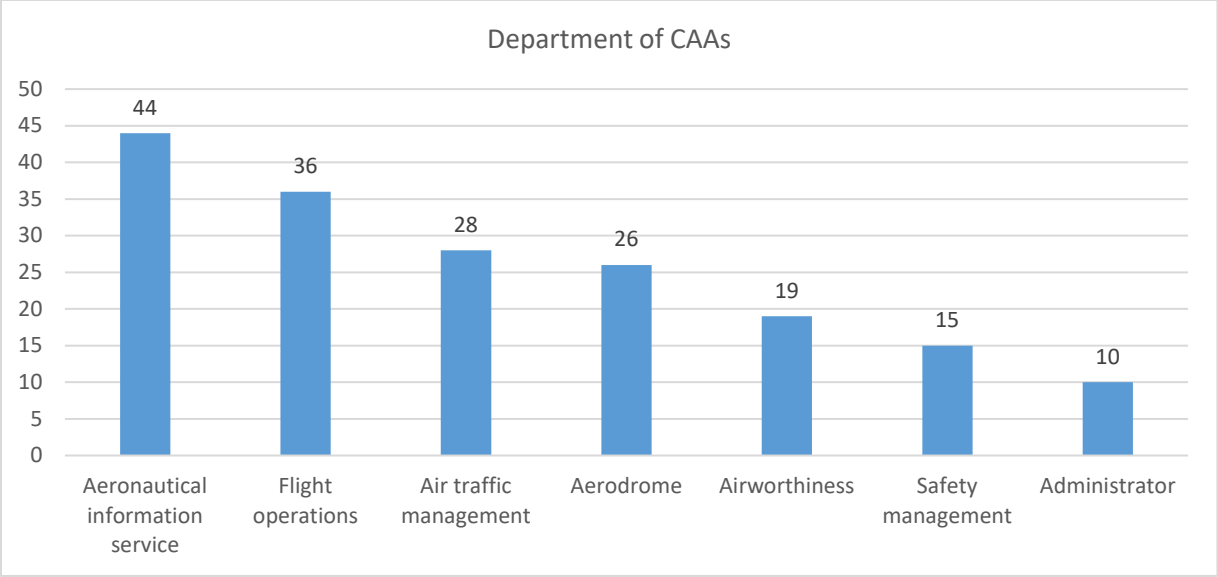
WACAF: Western and Central African

WMM: World Magnetic Model

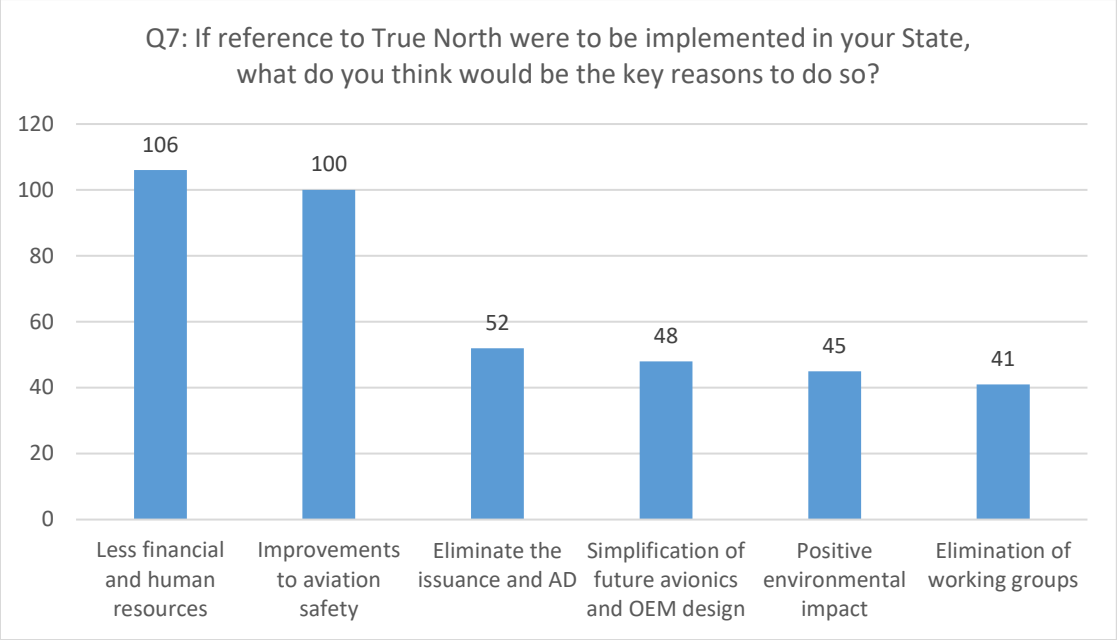
Appendix A: True north survey results by stakeholder

1. State civil aviation authority (CAA)

Q6. What department do you represent in your State CAA?

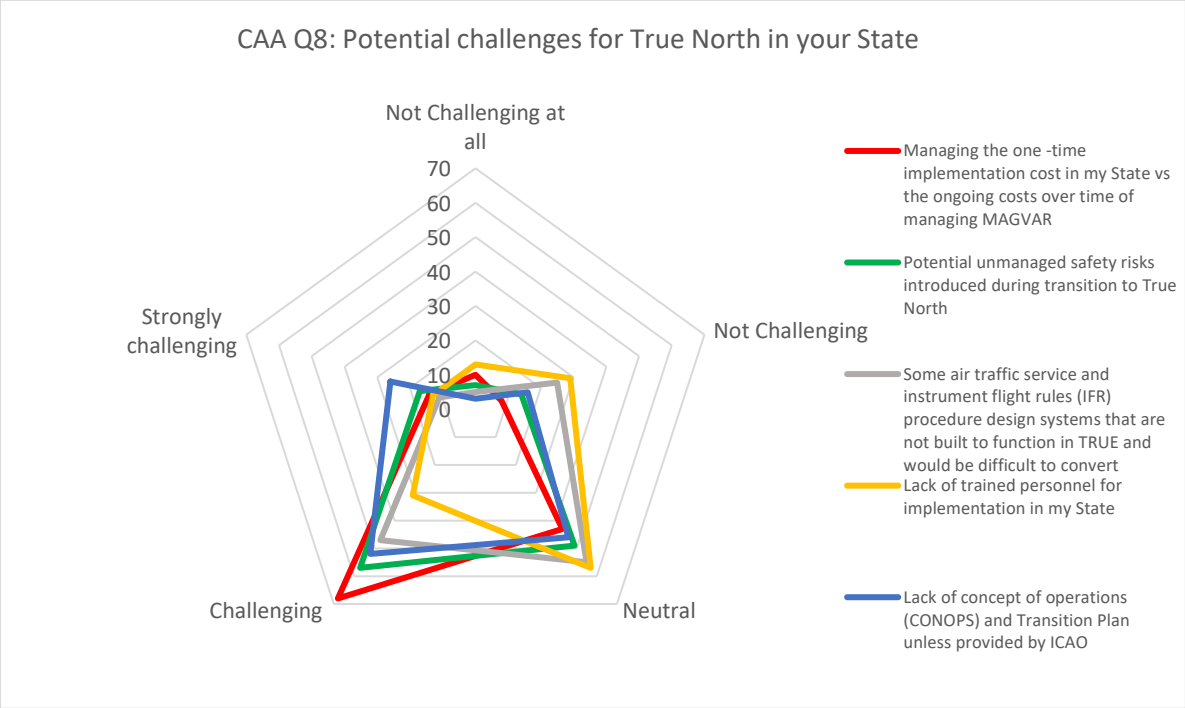


Q7. If reference to True North were to be implemented in your State, what do you think would be the key reasons to do so?

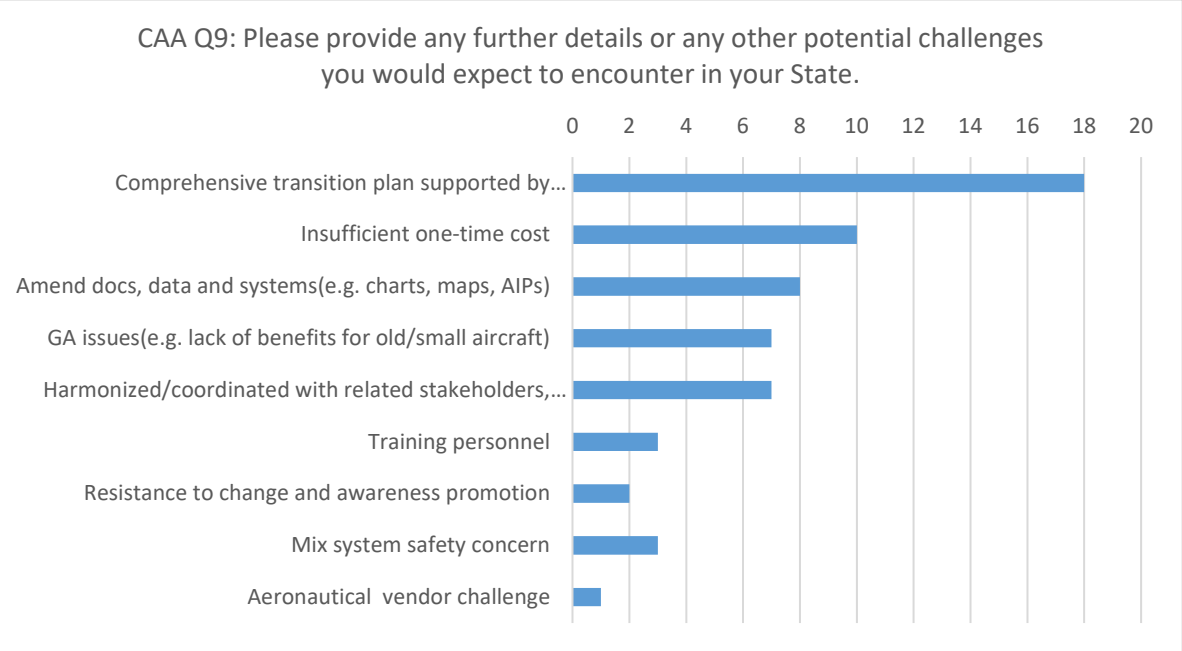


Q8. In transitioning from magnetic to True North, how would you rate the potential challenges you would expect to encounter in your State?

	Not Challenging at all	Not Challenging	Neutral	Challenging	Strongly challenging
Managing the one -time implementation cost in my State vs the ongoing costs over time of managing MAGVAR	10	8	43	68	14
Potential unmanaged safety risks introduced during transition to True North	7	14	49	57	17
Some air traffic service and instrument flight rules (IFR) procedure design systems that are not built to function in TRUE and would be difficult to convert	5	25	55	47	11
Lack of trained personnel for implementation in my State	13	29	57	31	13
Lack of concept of operations (CONOPS) and Transition Plan unless provided by ICAO	3	16	46	52	26

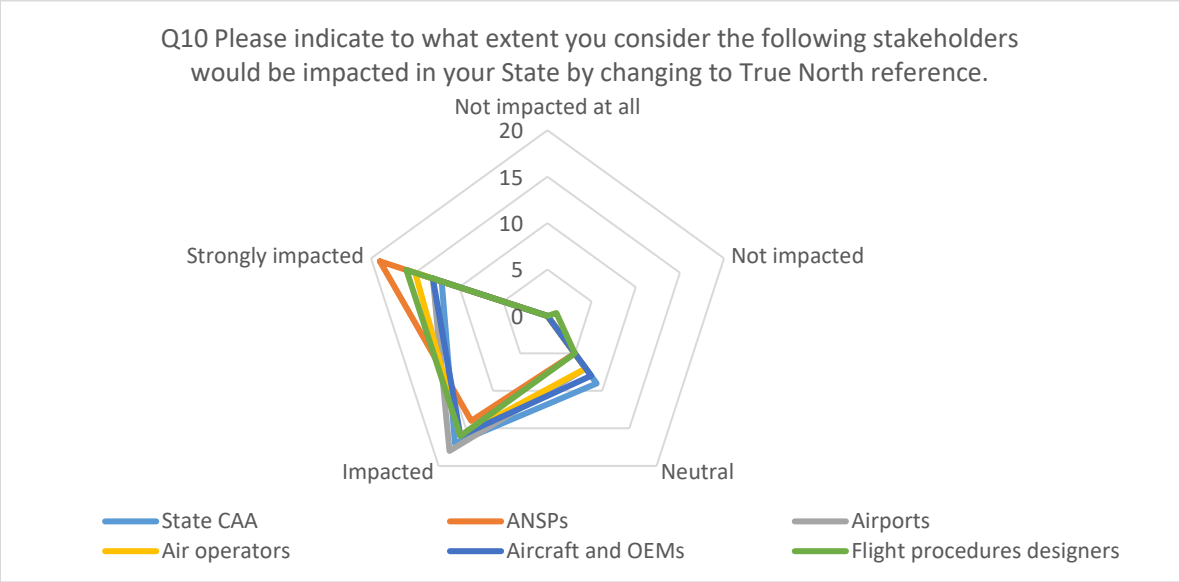


Q9. Please provide any further details or any other potential challenges you would expect to encounter in your State.

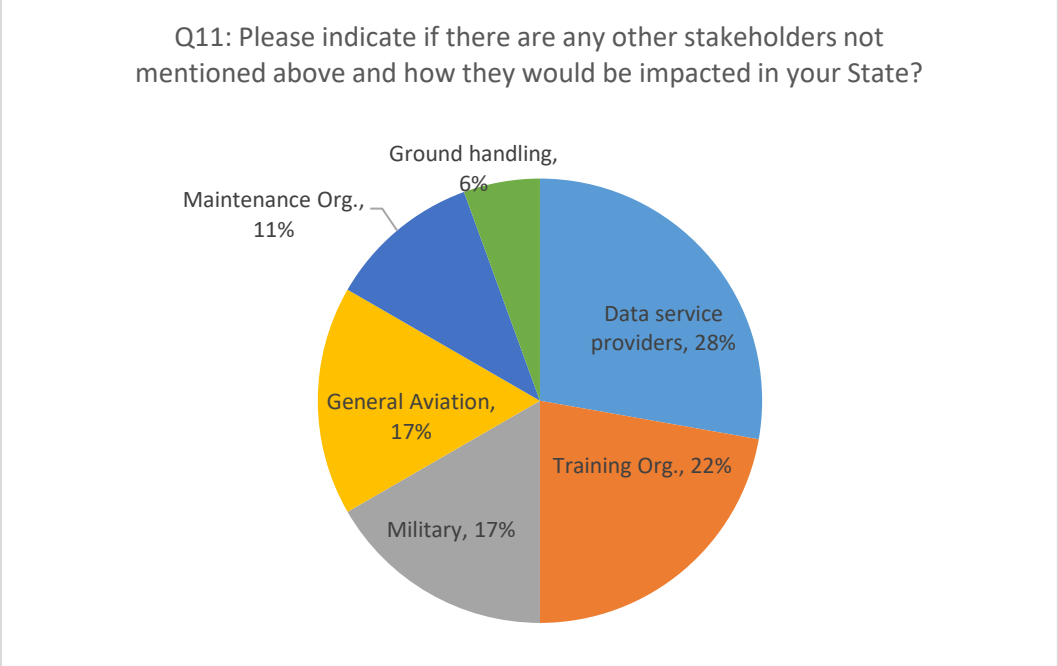


Q10. Please indicate to what extent you consider the following stakeholders would be impacted in your State by changing to True North reference.

	Not impacted at all	Not impacted	Neutral	Impacted	Strongly impacted
State CAA	0	0	9	17	12
ANSPs	0	0	5	14	19
Airports	0	0	7	18	13
Air operators	0	0	7	16	15
Aircraft and OEMs	0	0	8	16	13
Flight procedures designers	0	1	5	16	16

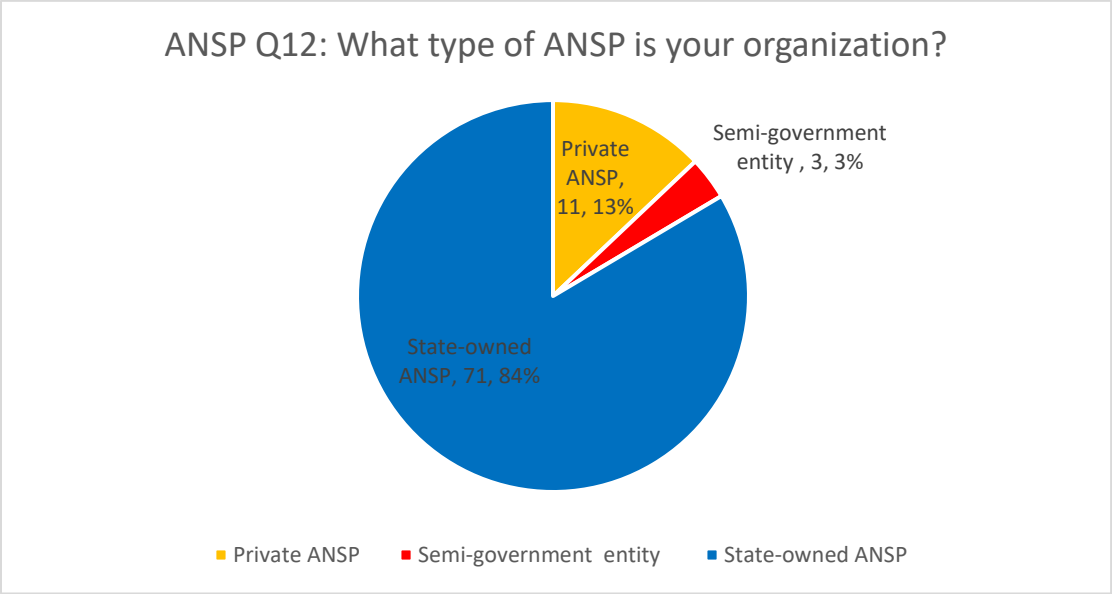


Q11. Please indicate if there are any other stakeholders not mentioned above and how they would be impacted in your State.

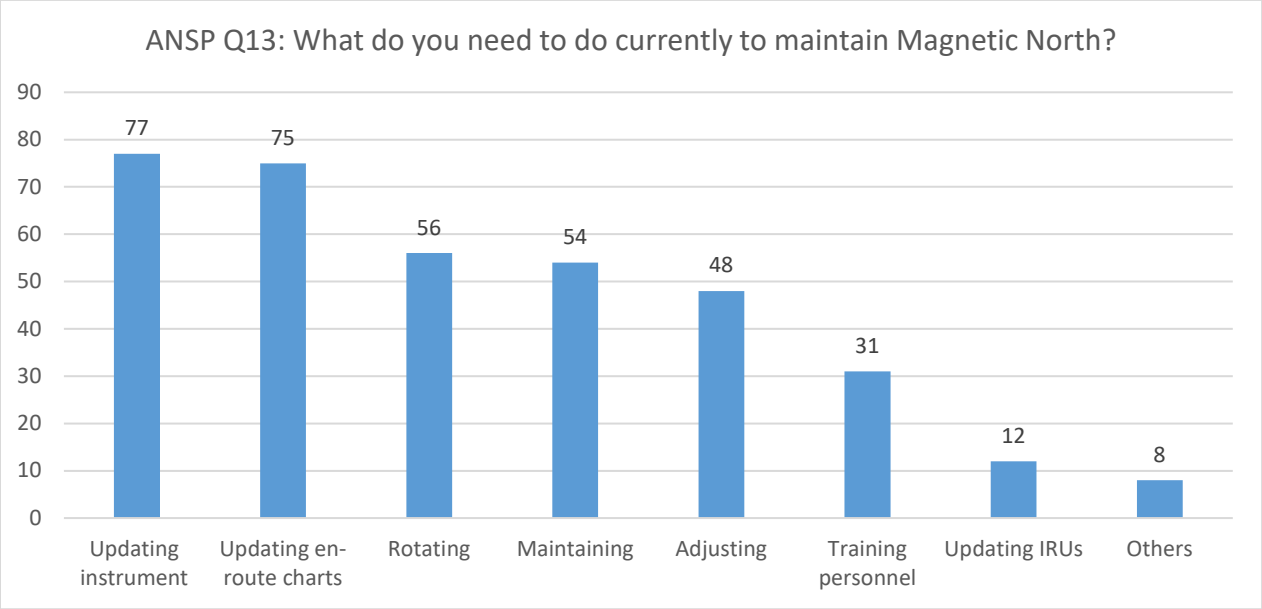


2. Air navigation service provider (ANSP)

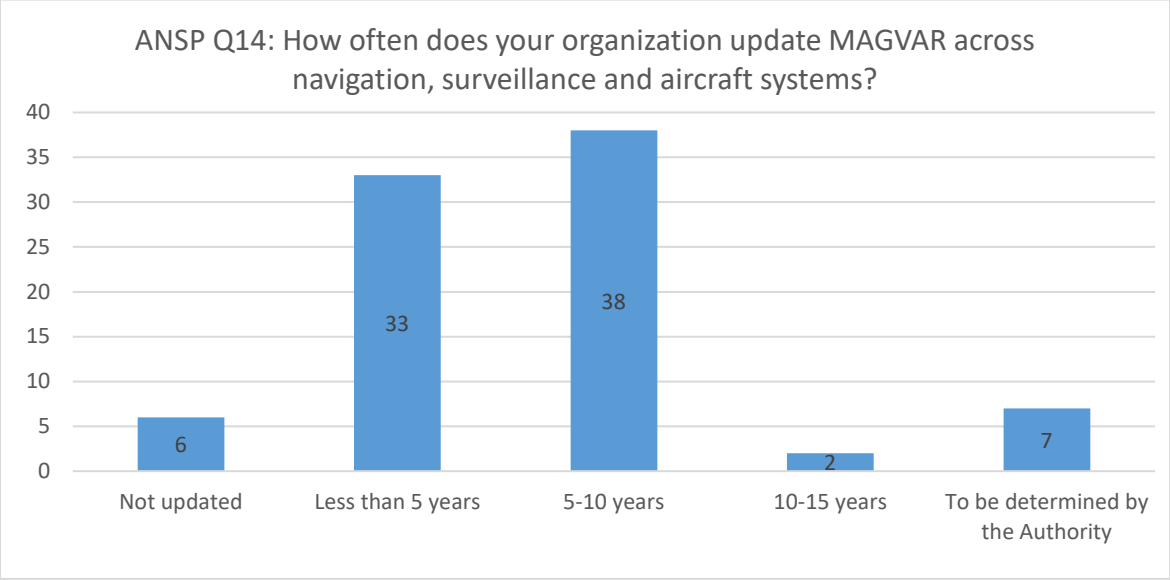
Q12. What type of ANSP is your organization?



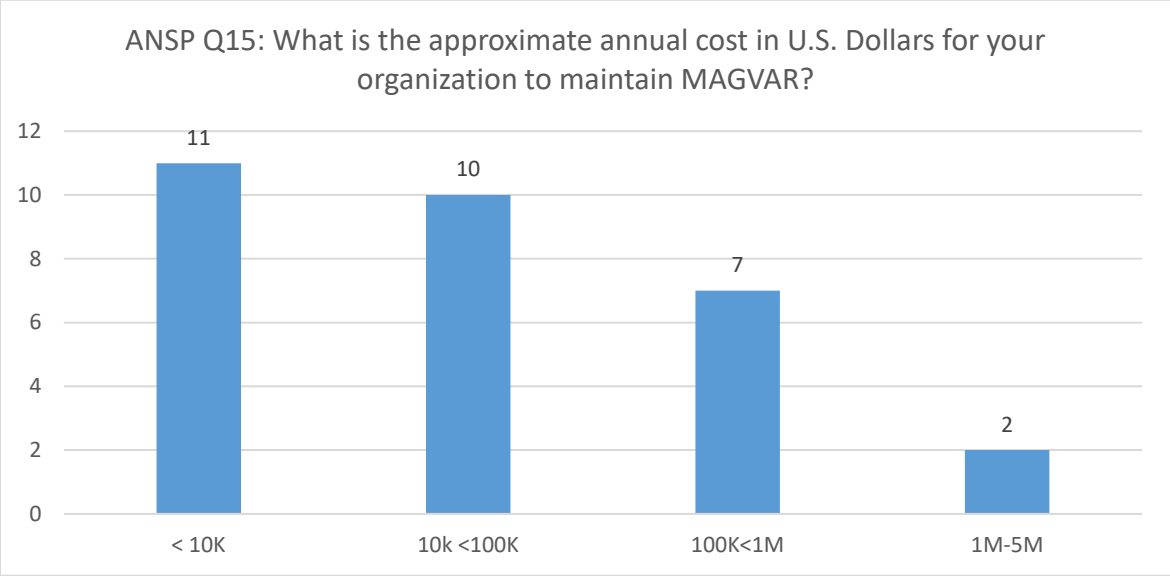
Q13. What do you need to do currently to maintain Magnetic North?



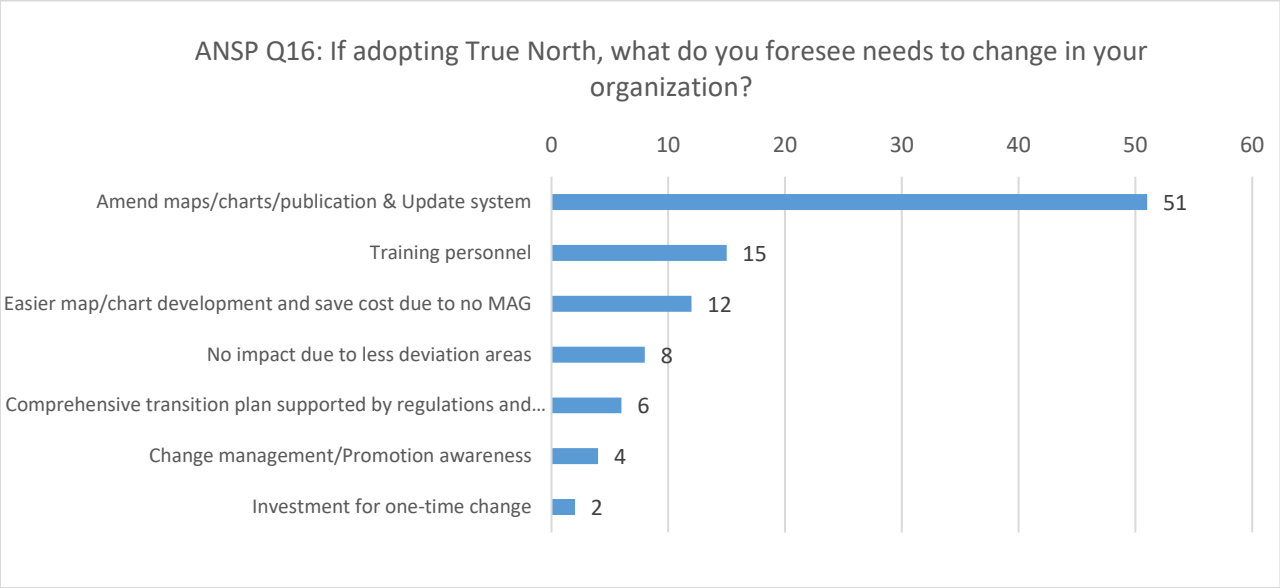
Q14. How often does your organization update MAGVAR across navigation, surveillance and aircraft systems?



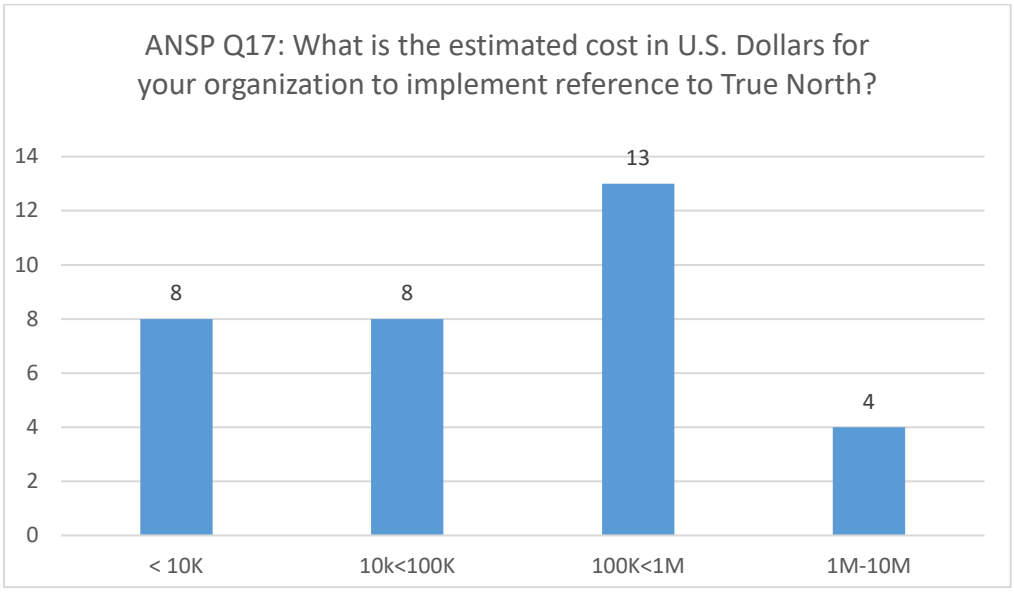
Q15. What is the approximate annual cost in U.S. Dollars for your organization to align to the latest World Magnetic Map to ensure a precise magnetic model across all ANSP systems and data used by air traffic service?



Q16. If adopting True North, what do you foresee needs to change in your organization?

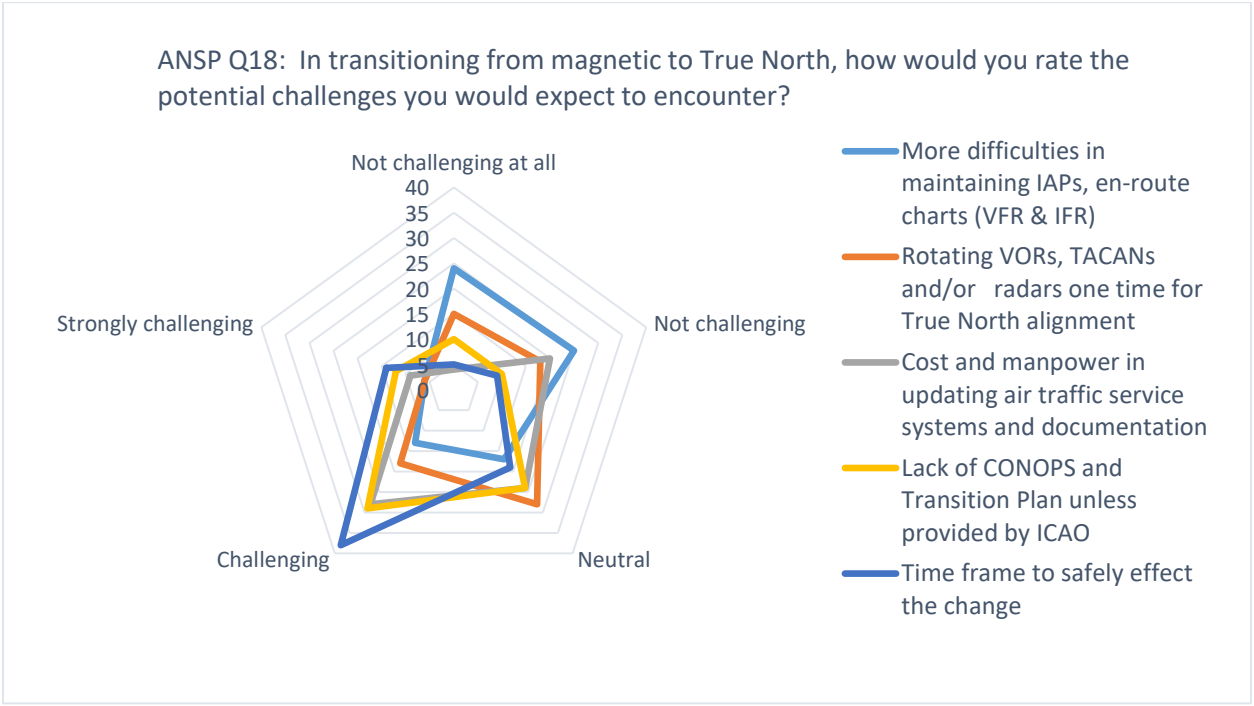


Q17. What is the estimated cost in U.S. Dollars for your organization to implement reference to True North?

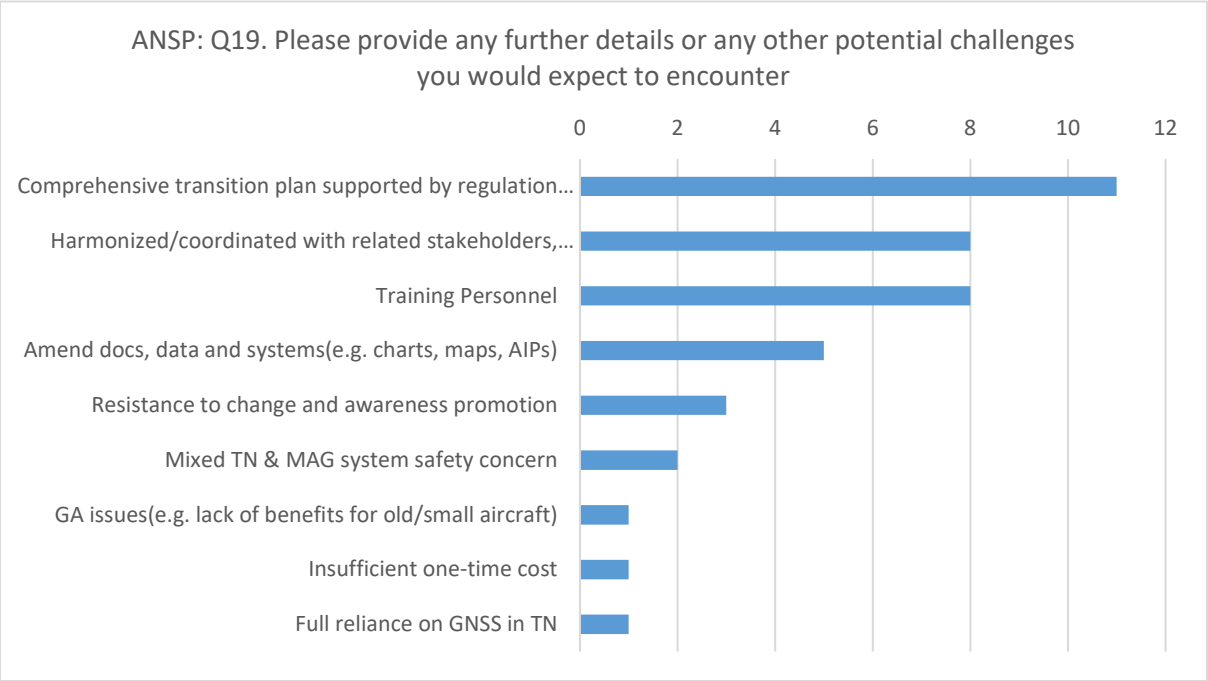


Q18. In transitioning from magnetic to True North, how would you rate the potential challenges you would expect to encounter?

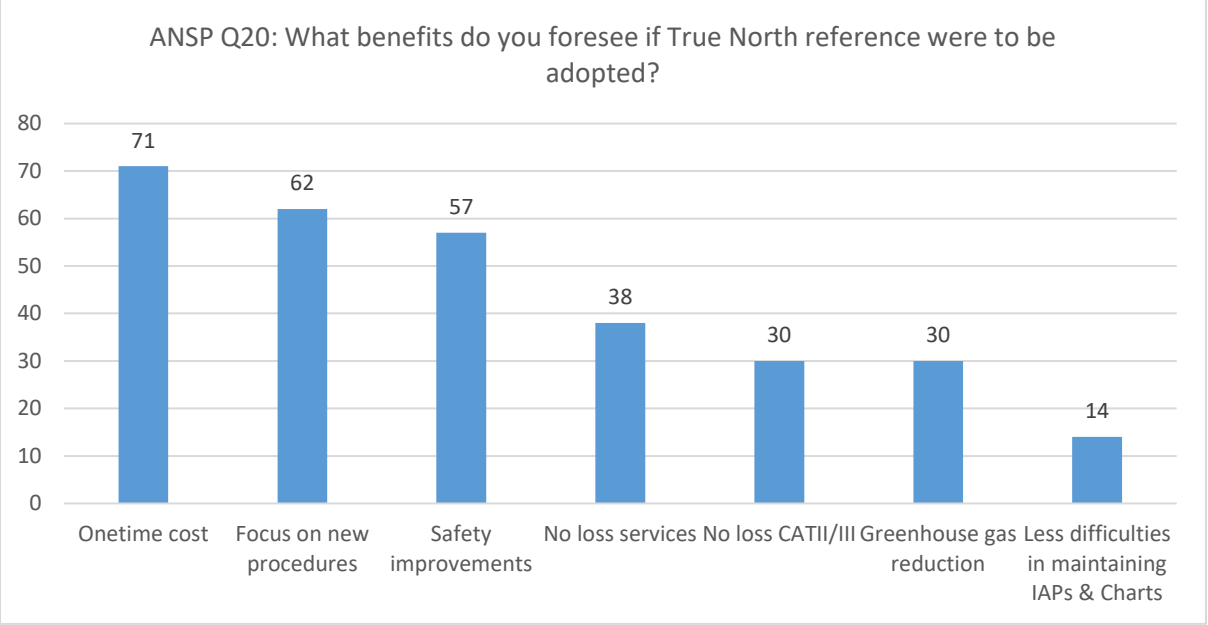
	Not challenging at all	Not challenging	Neutral	Challenging	Strongly challenging
More difficulties in maintaining IAPs, en-route charts (VFR & IFR)	24	25	17	13	6
Rotating VORs, TACANs and/or radars one time for True North alignment	15	18	28	18	6
Cost and manpower in updating air traffic service systems and documentation	4	20	24	28	9
Lack of CONOPS and Transition Plan unless provided by ICAO	10	10	24	29	12
Time frame to safely effect the change	5	9	19	38	14



Q19. Please provide any further details or any other challenges you would expect to encounter.

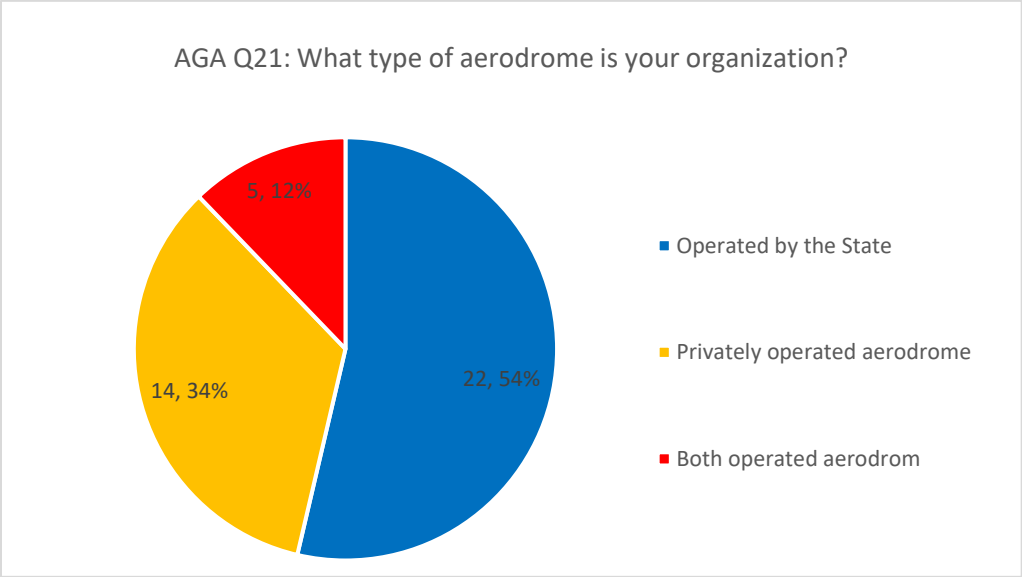


Q20. What benefits do you foresee if True North reference were to be adopted?

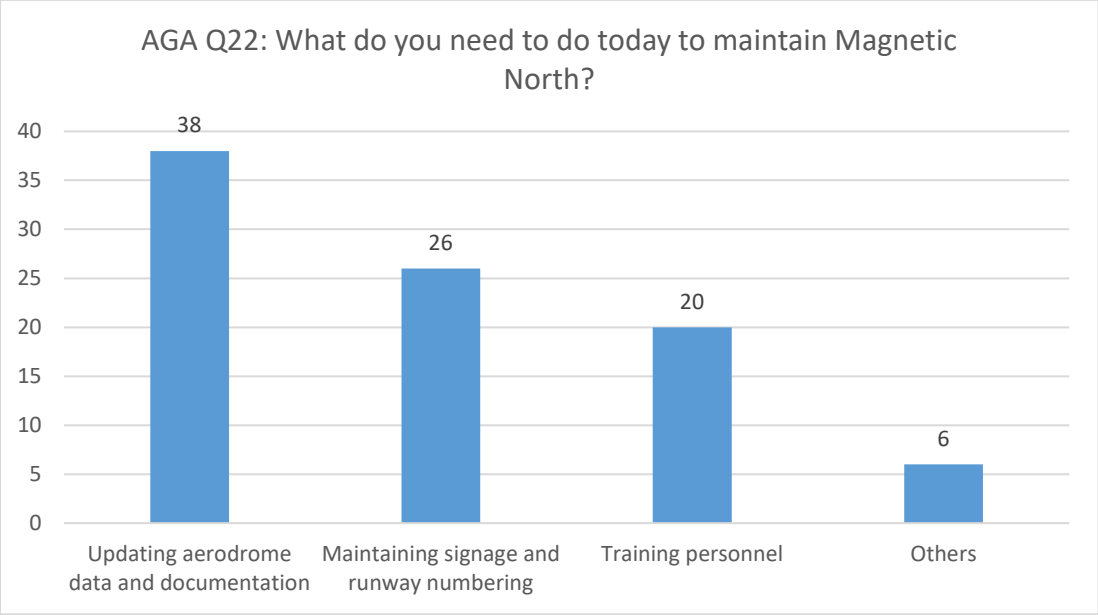


3. Aerodrome

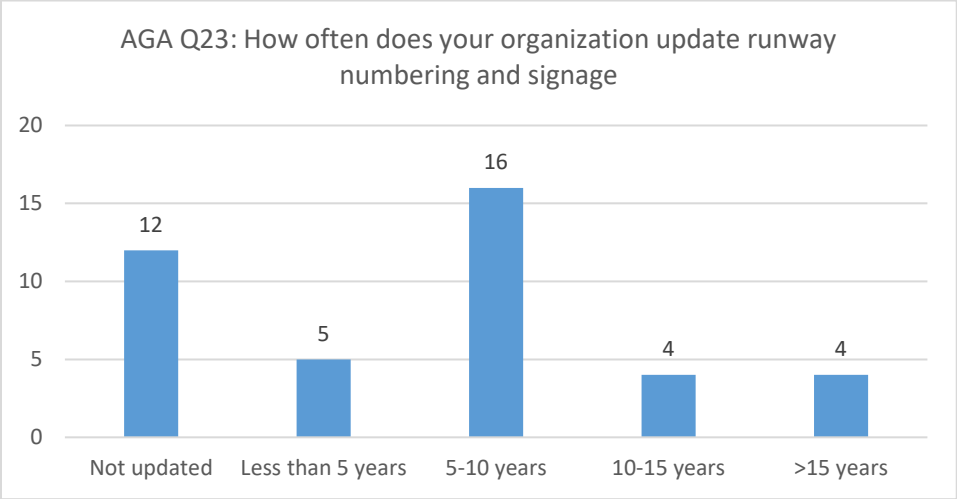
Q21. What type of aerodrome is your organization?



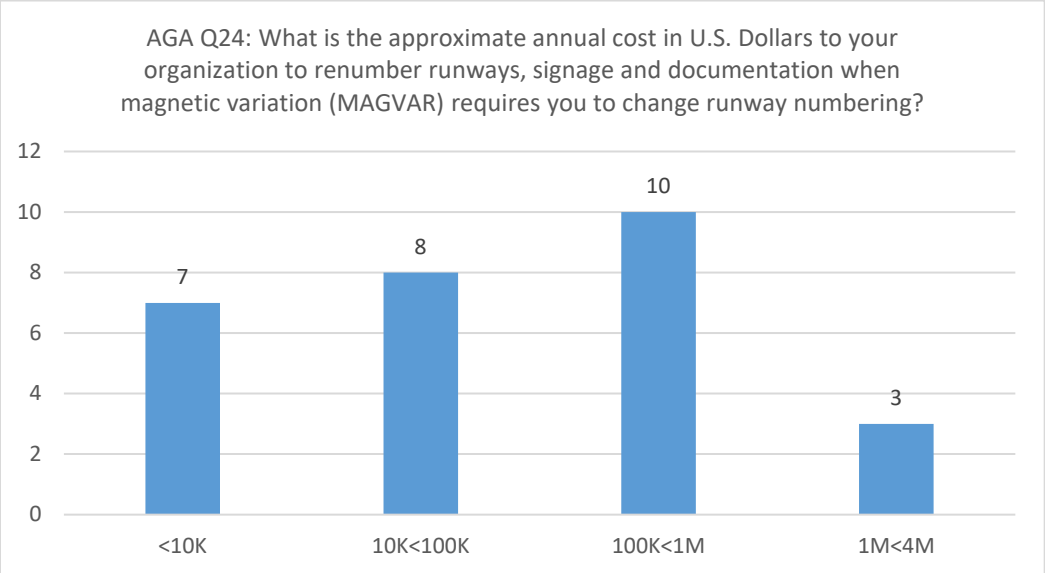
Q22. What do you need to do today to maintain Magnetic North?



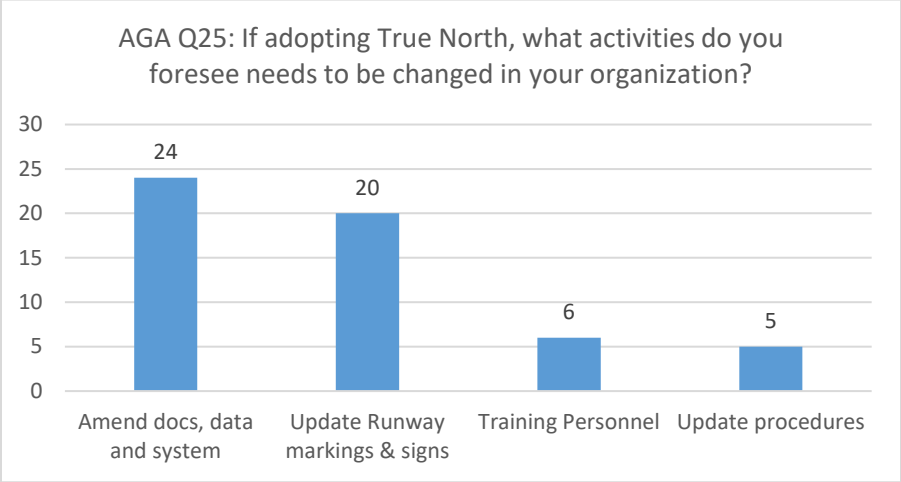
Q23. How often does your organization update runway numbering and signage?



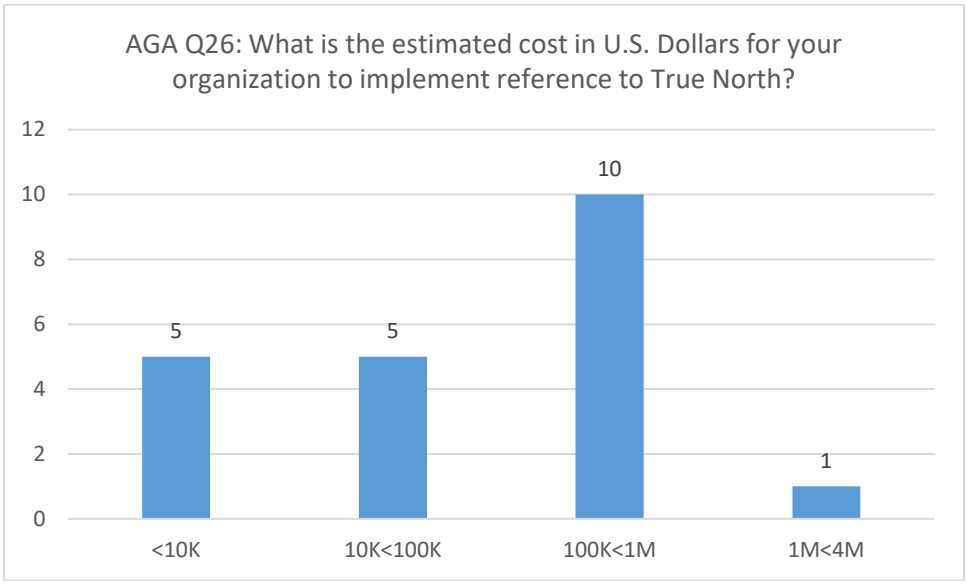
Q24. What is the approximate annual costs in U.S. Dollars for your organization to renumber runways, signage and documentation when magnetic variation requires you to change runway numbering?



Q25. If adopting True North, what activities do you foresee need to be changed in your organization?

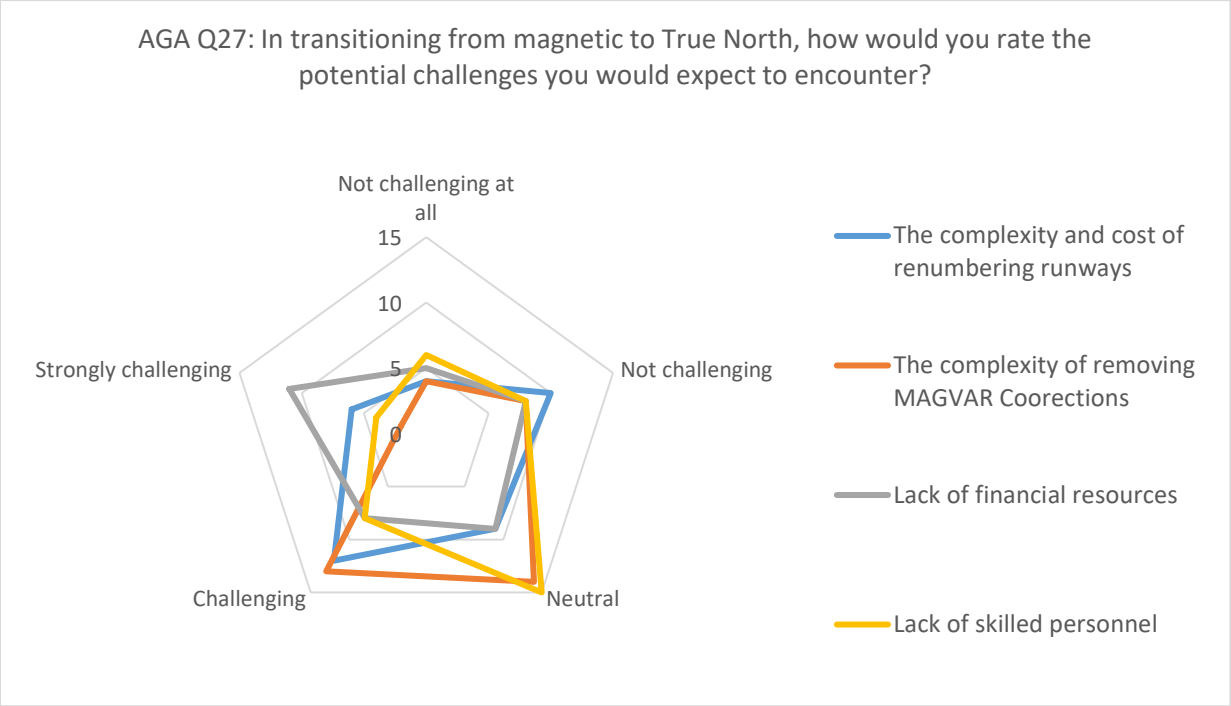


Q26. What is the estimated cost in U.S. Dollars for your organization to implement reference to True North?

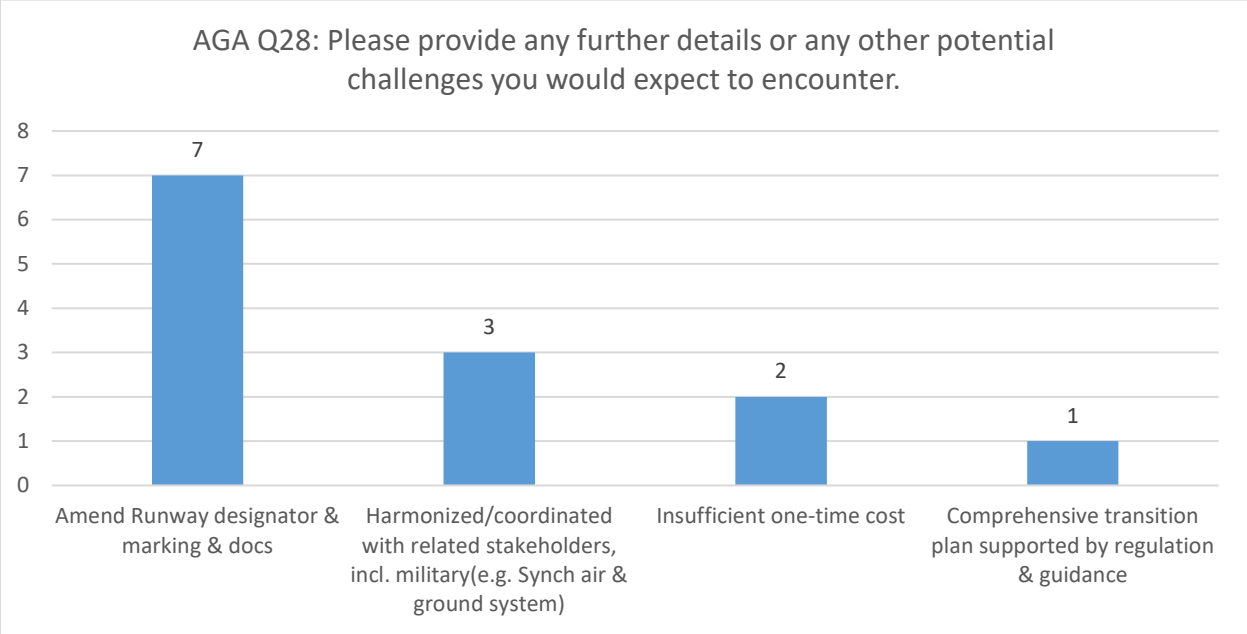


Q27. In transitioning from magnetic to True North, how would you rate the potential challenges you would expect to encounter?

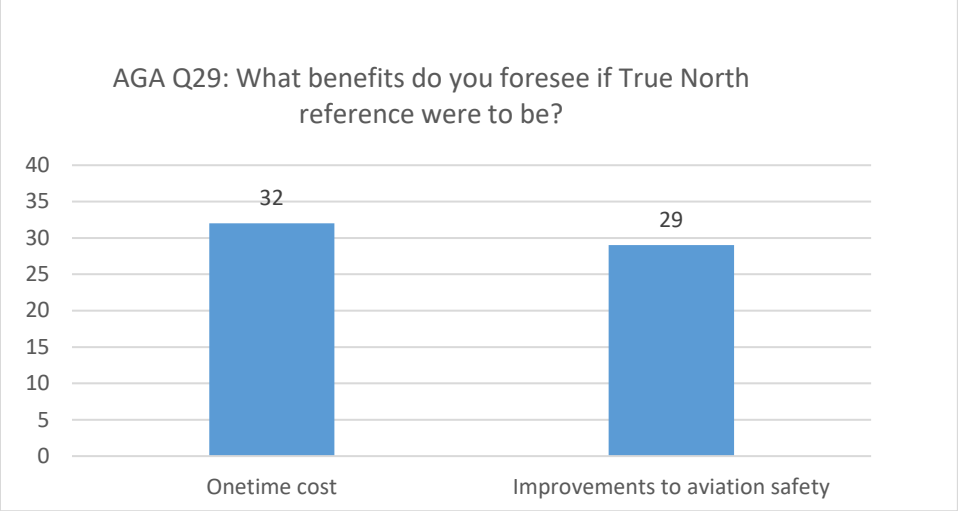
	Not challenging at all	Not challenging	Neutral	Challenging	Strongly challenging
The complexity and cost of renumbering runways	4	10	9	12	6
The complexity of removing MAGVAR Corrections	4	8	14	13	2
Lack of financial resources	5	8	9	8	11
Lack of skilled personnel	6	8	15	8	4



Q28. Please provide any further details or any other potential challenges you would expect to encounter.

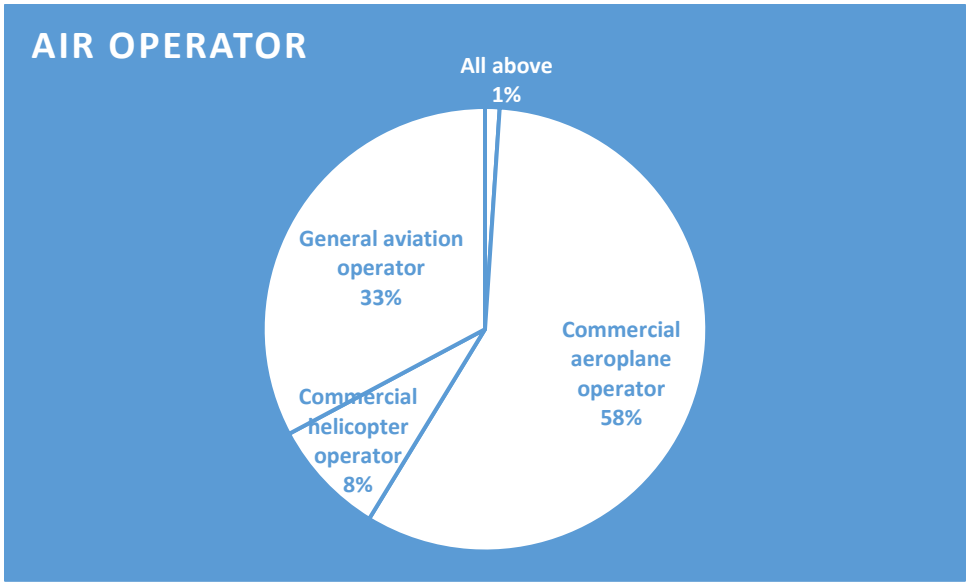


Q29. What benefits do you foresee if True North reference were to be?

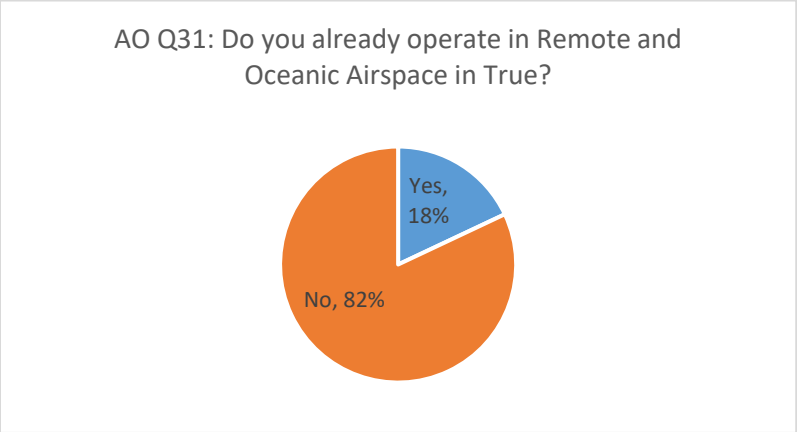


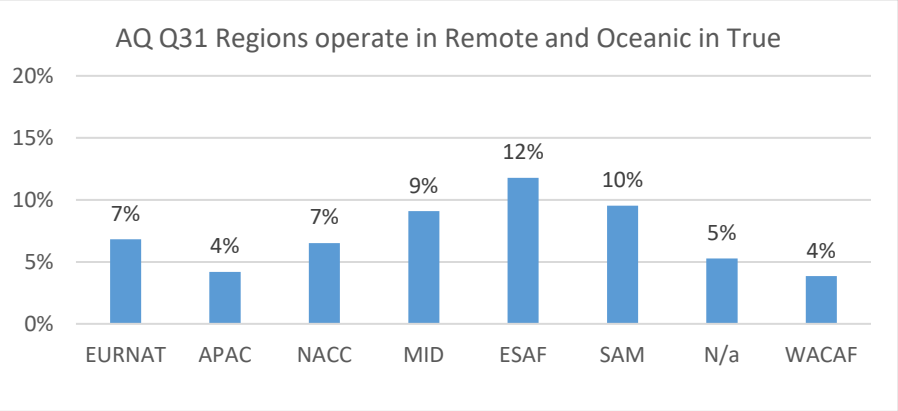
4. Air operator

Q30. What type of air operator is your organization?

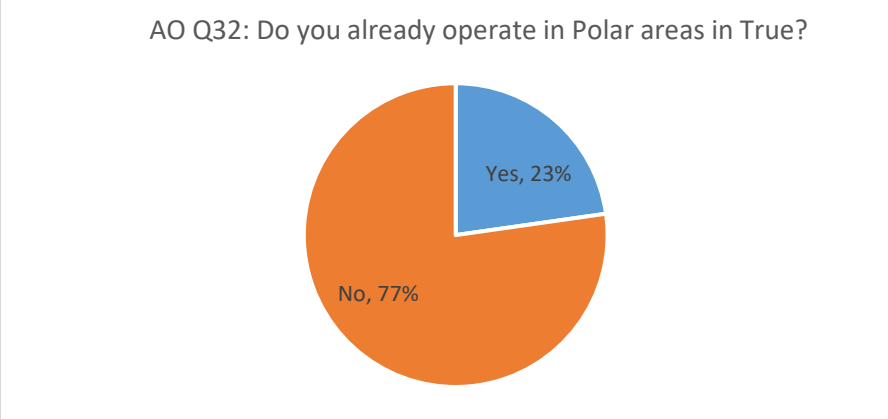


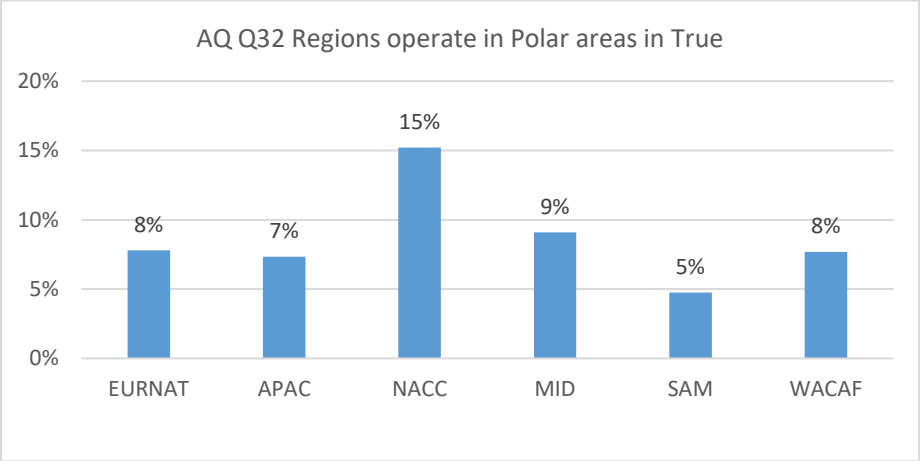
Q31. Do you already operate in Remote and Oceanic Airspace in True?



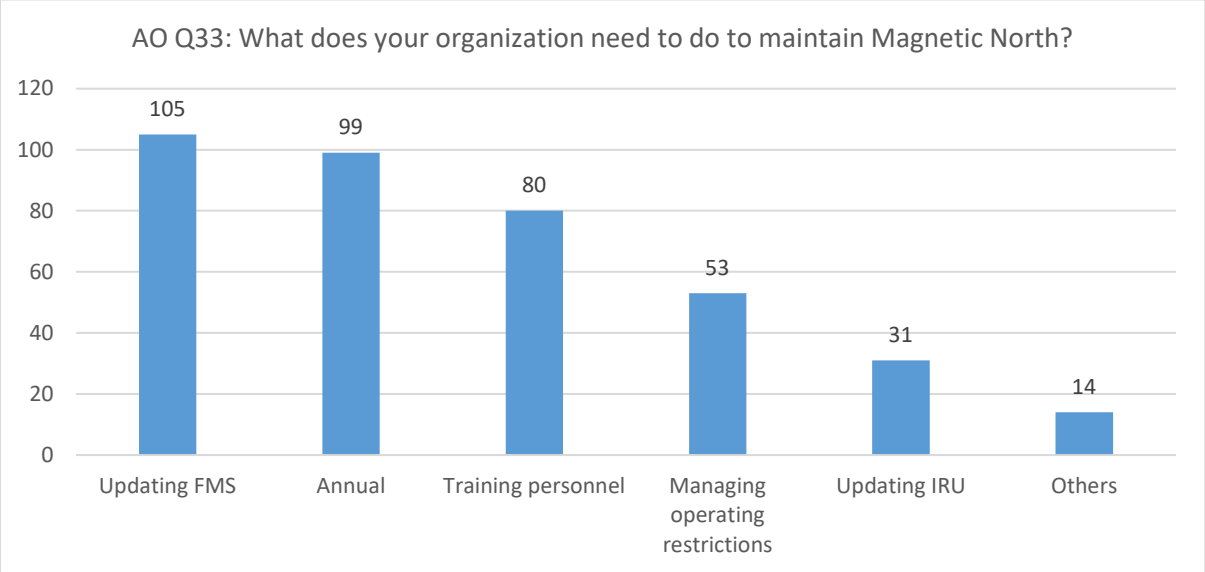


Q32. Do you already operate in Polar areas in True?

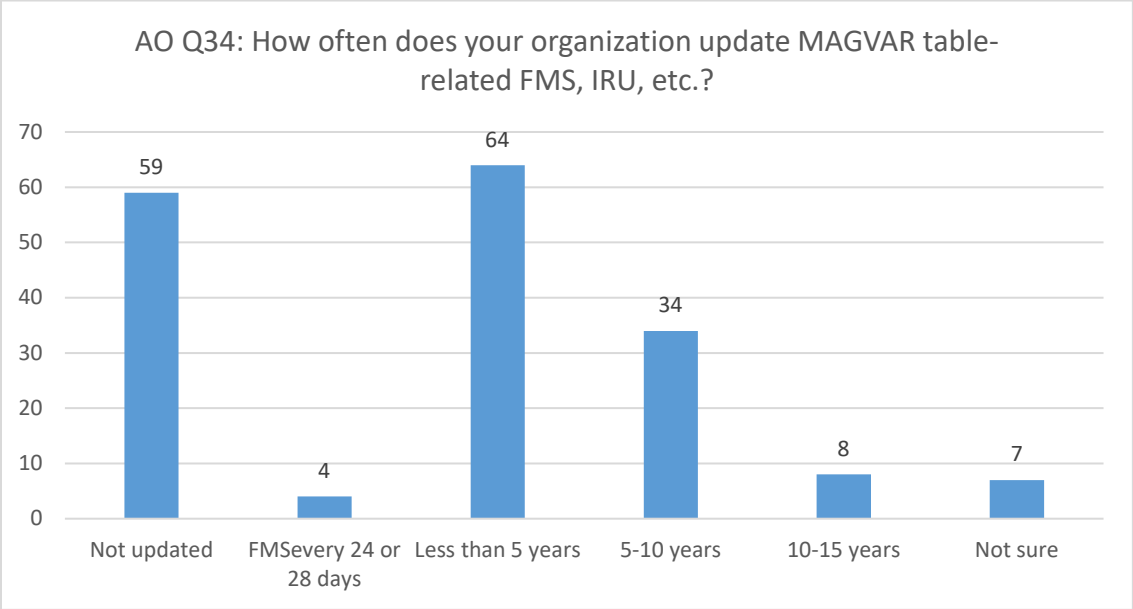




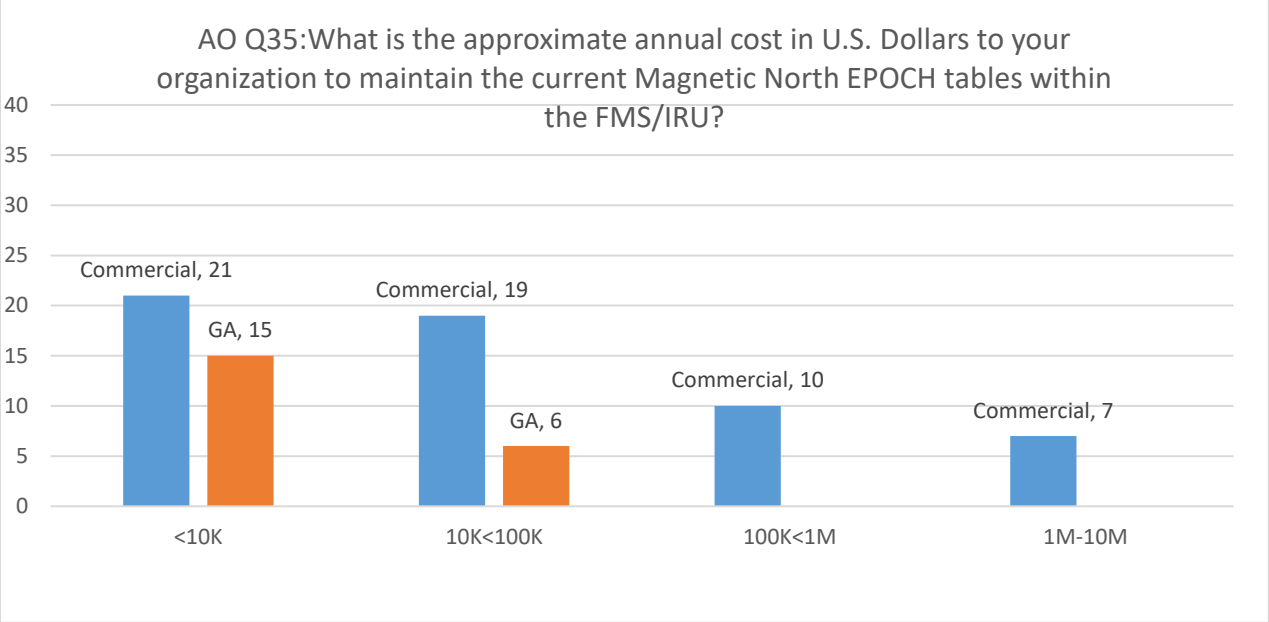
Q33. What does your organization need to do to maintain Magnetic North?

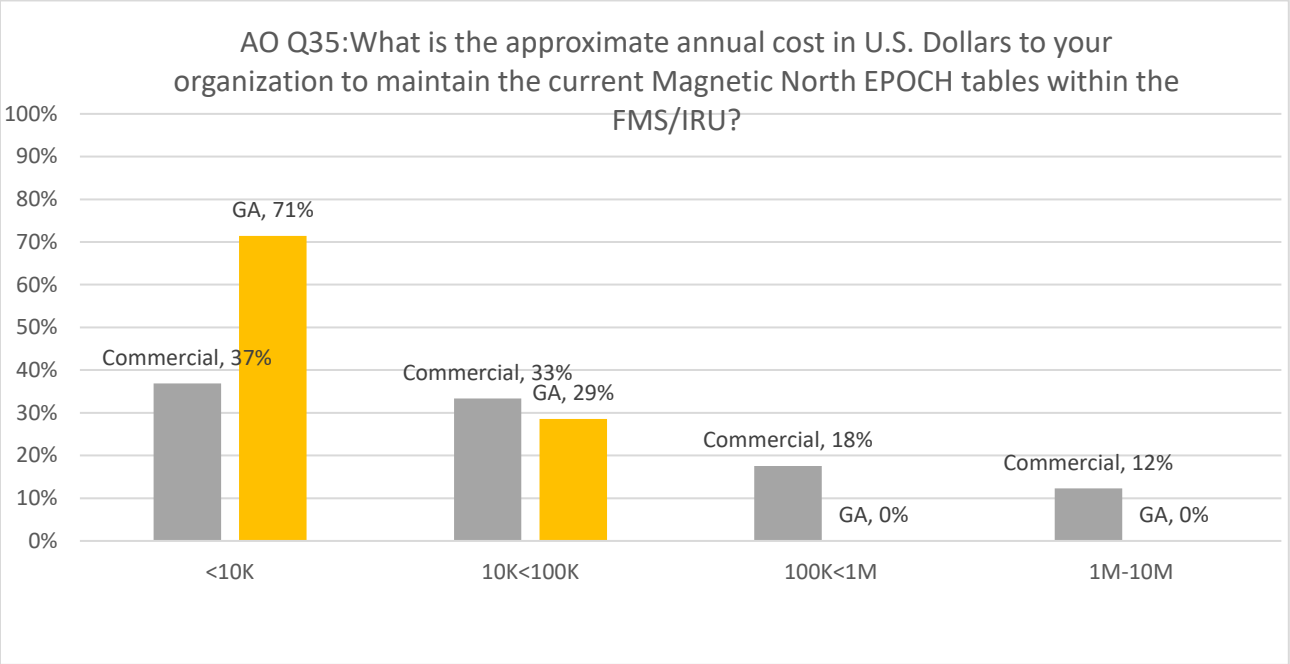


Q34. How often does your organization update MAGVAR table-related FMS, IRU, etc.?

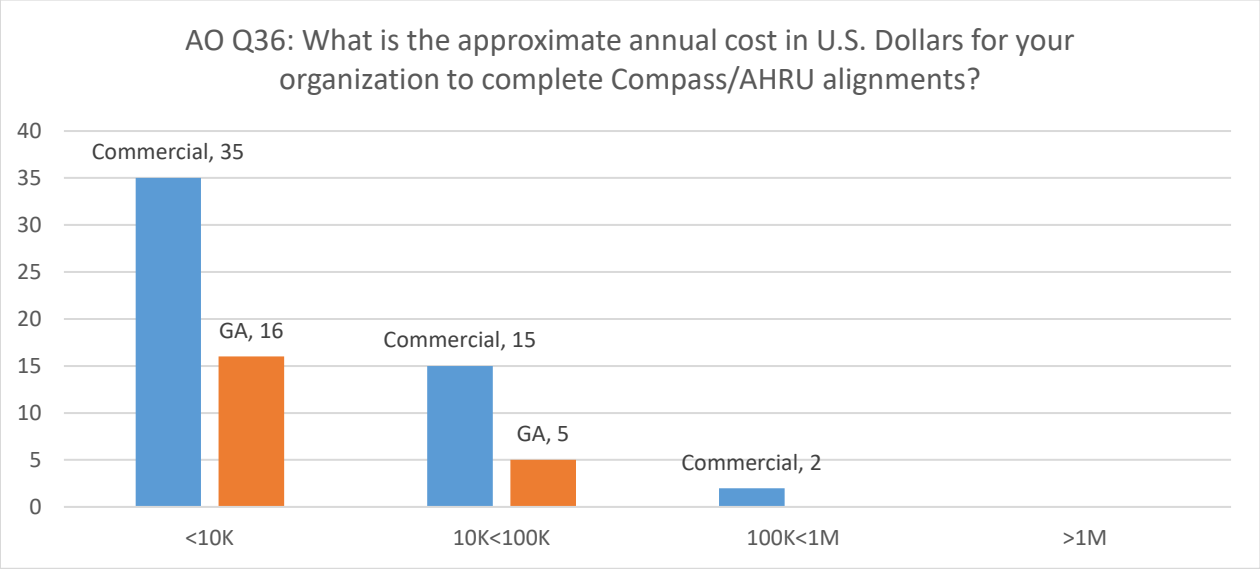


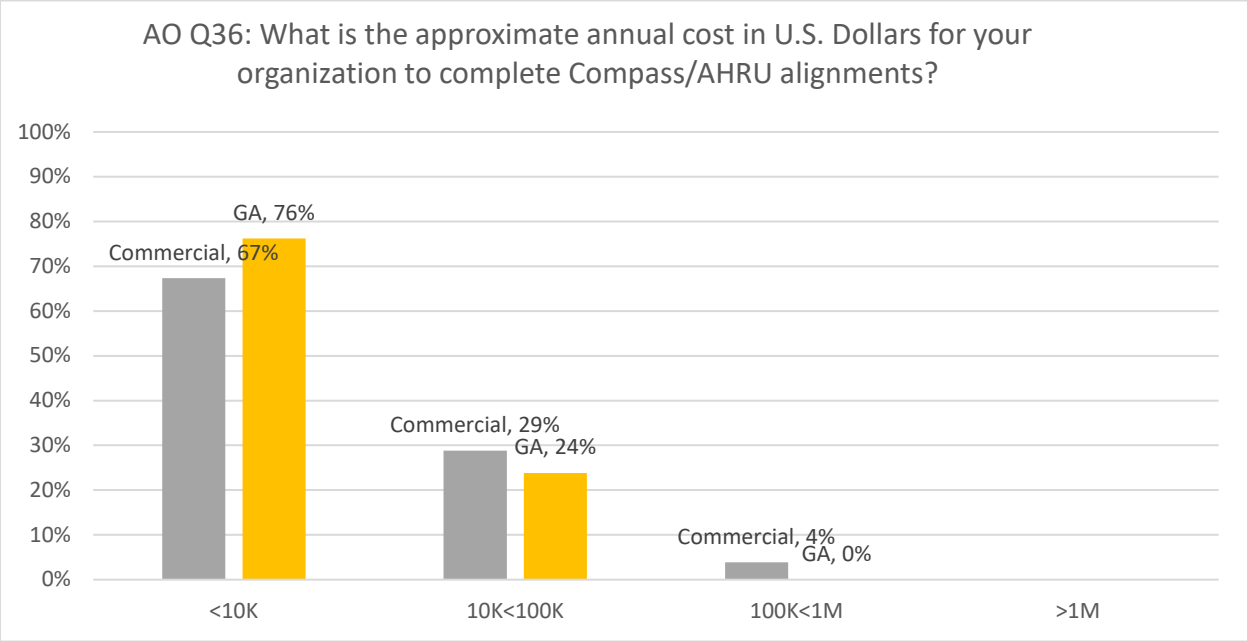
Q35. What is the approximate annual cost in U.S. Dollars for your organization to maintain the current Magnetic North EPOCH tableswithin the FMC/IRU?



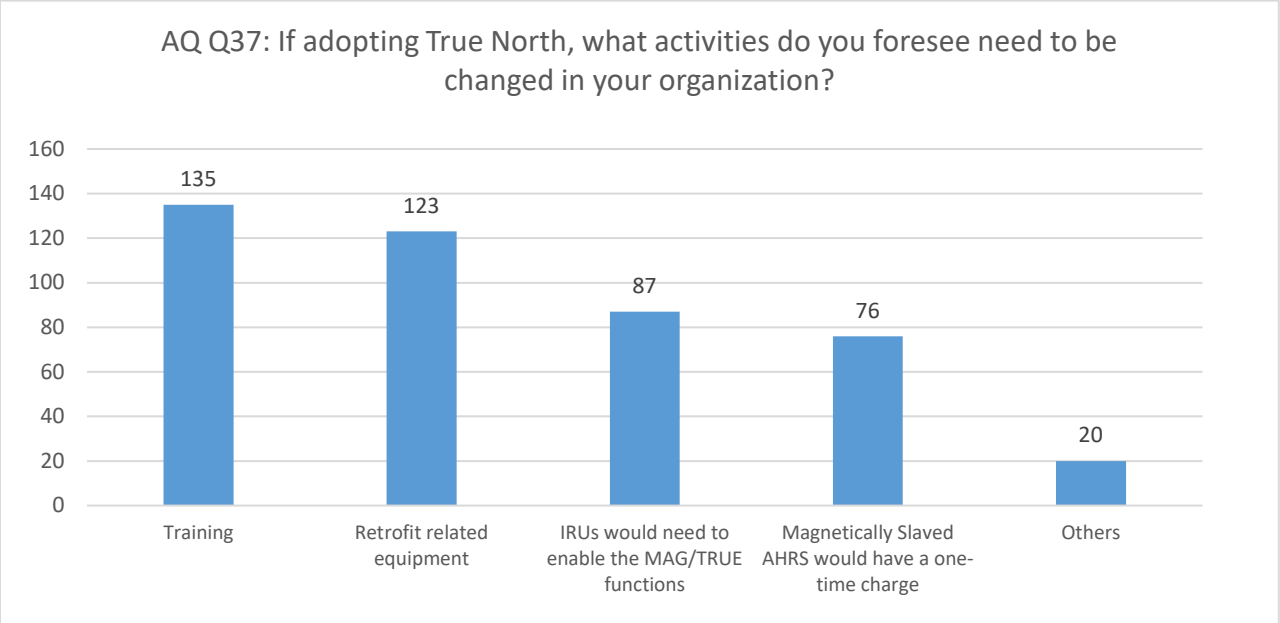


Q36. What is the approximate annual cost in U.S. Dollars for your organization to complete Compass/AHRU alignments?

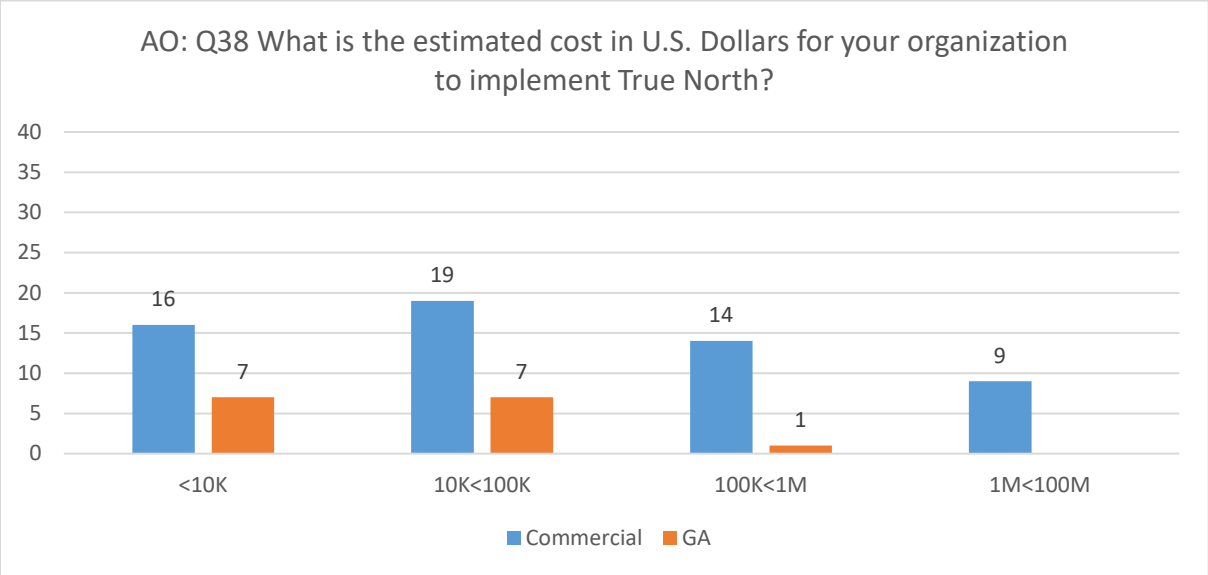


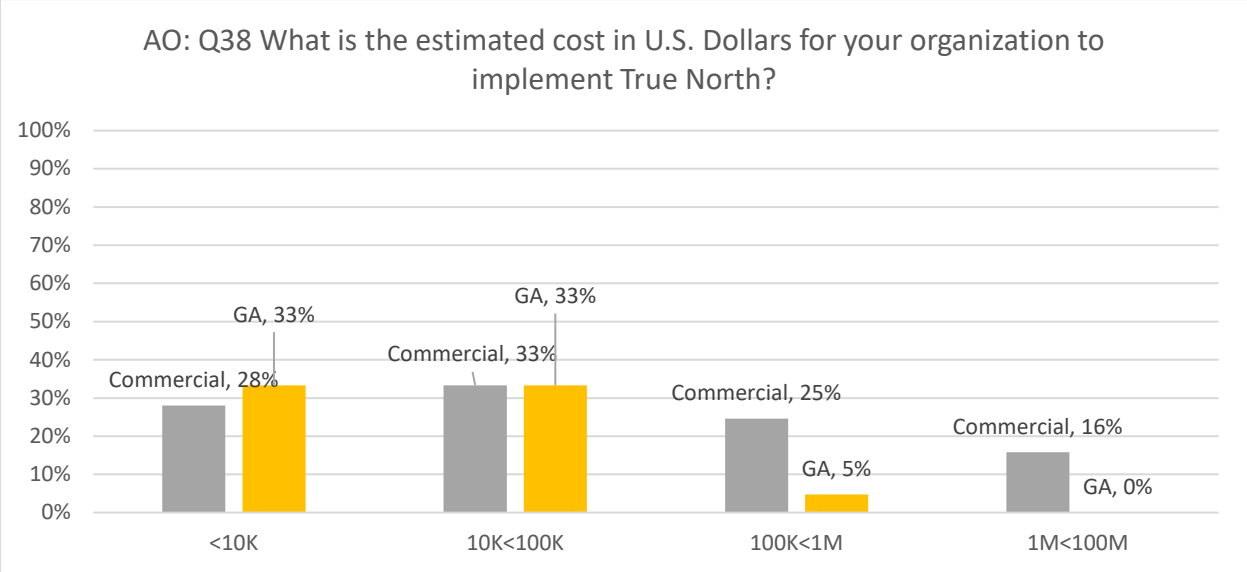


Q37. If adopting True North, what activities do you foresee need to be changed in your organization?



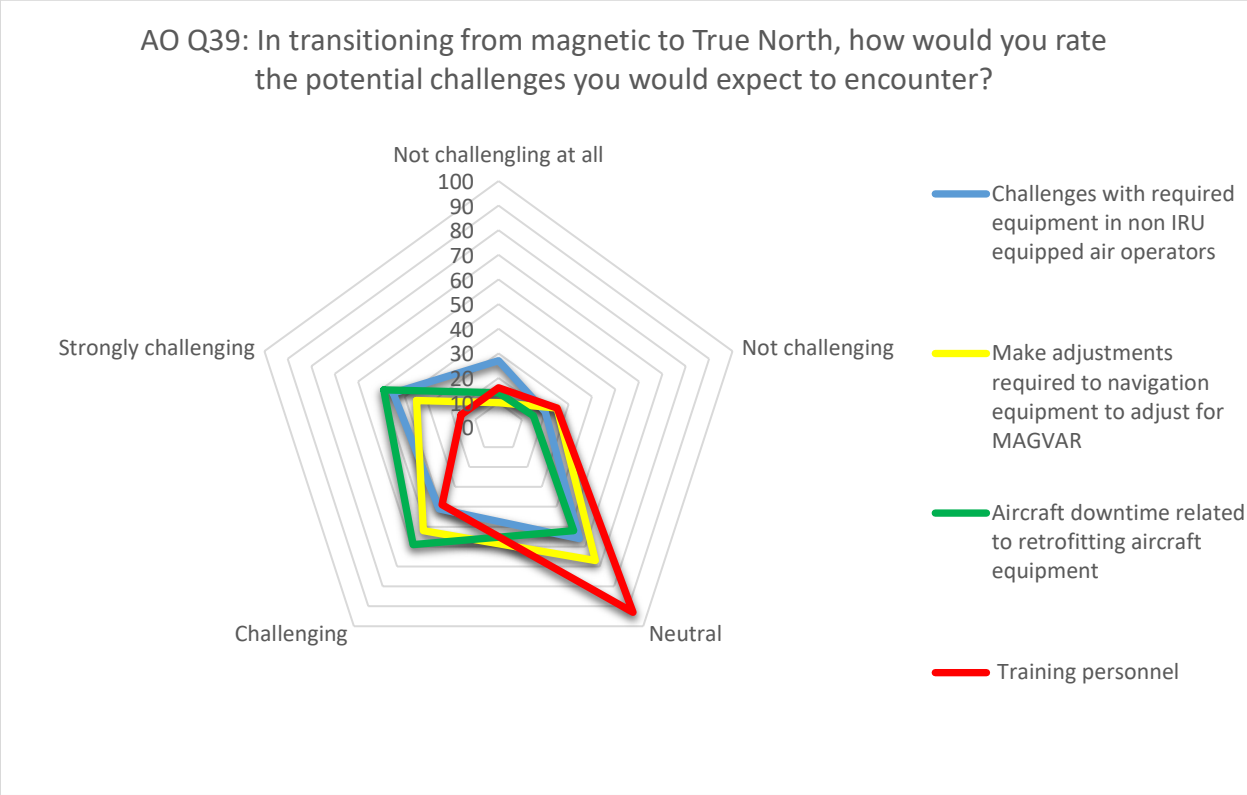
Q38. What is the estimated cost in U.S. Dollars for your organization to implement True North?



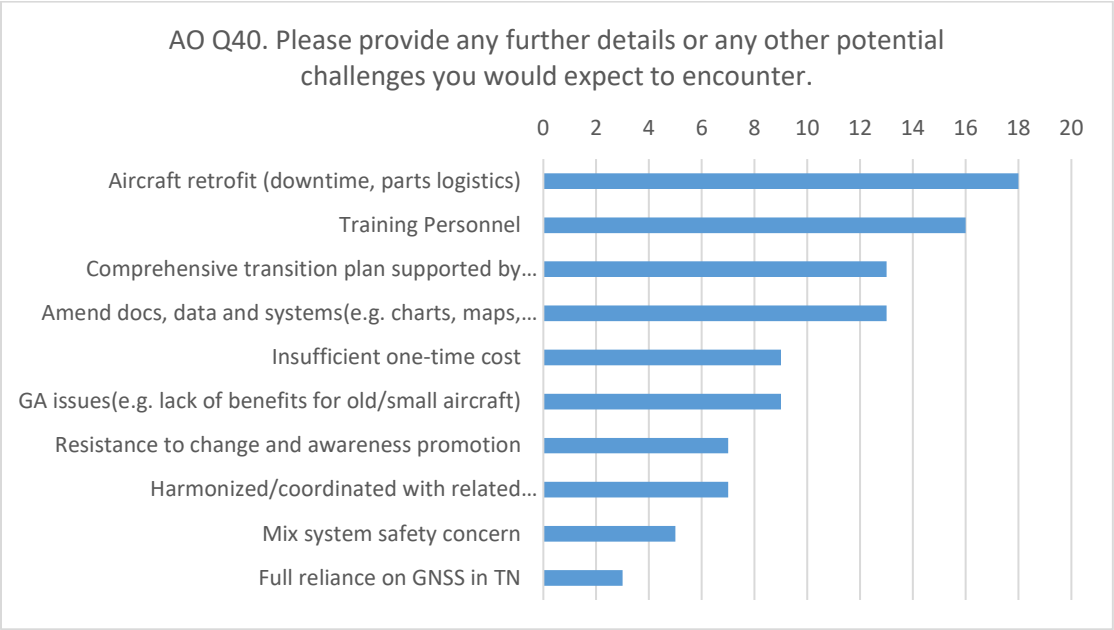


Q39. In transitioning from magnetic to True North, how would you rate the potential challenges you would expect to encounter?

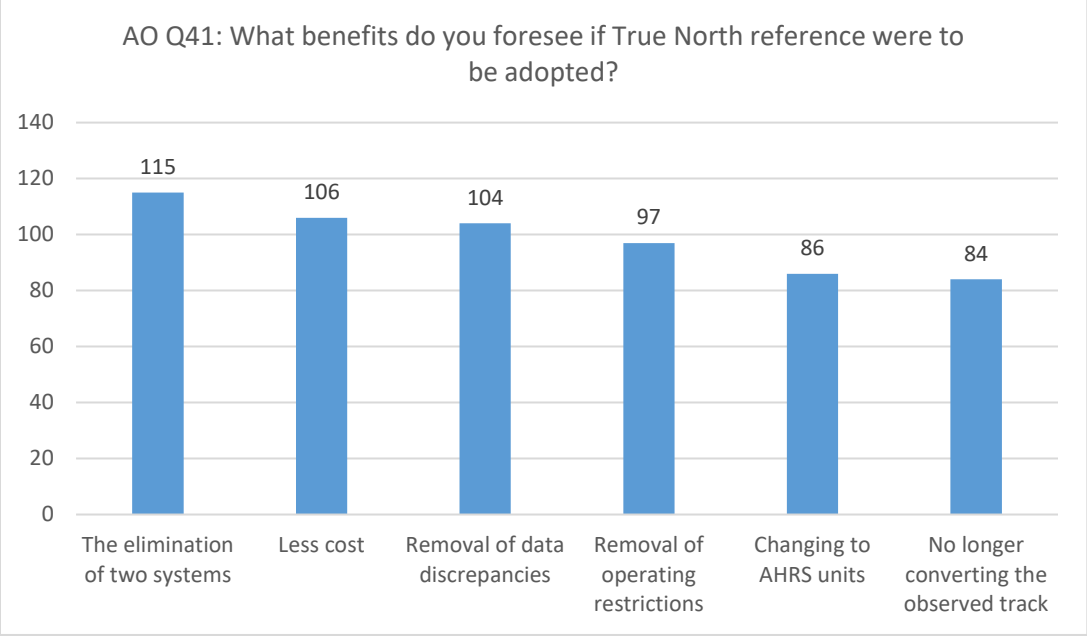
	Not challenging at all	Not challenging	Neutral	Challenging	Strongly challenging
Challenges with required equipment in non-IRU-equipped air operators	27	20	56	41	45
Make adjustments required to navigation equipment to adjust for MAGVAR	10	25	67	52	35
Aircraft downtime related to retrofitting aircraft equipment	14	15	52	59	49
Training personnel	16	25	93	39	16



Q40. Please provide any further details or any other potential challenges you would expect to encounter.

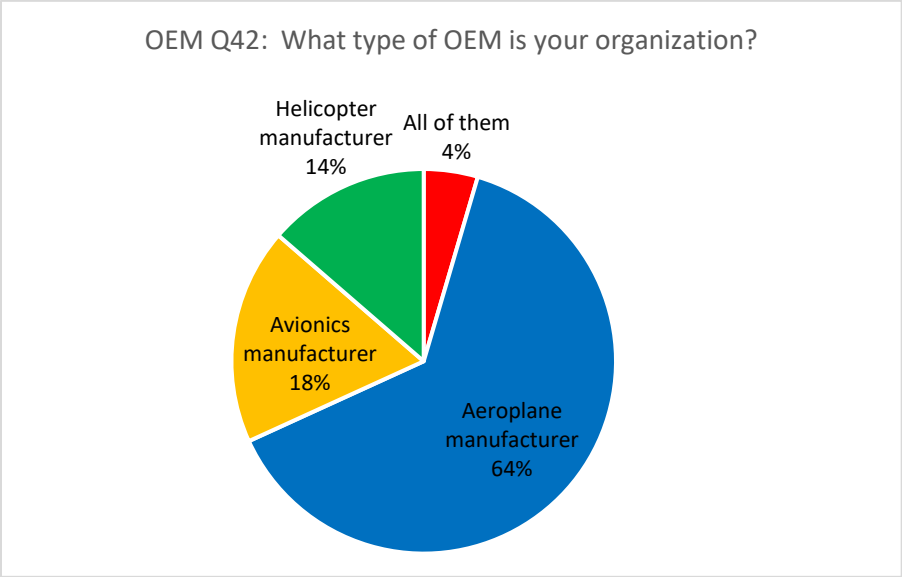


Q41. What benefits do you foresee if True North reference were to be adopted?

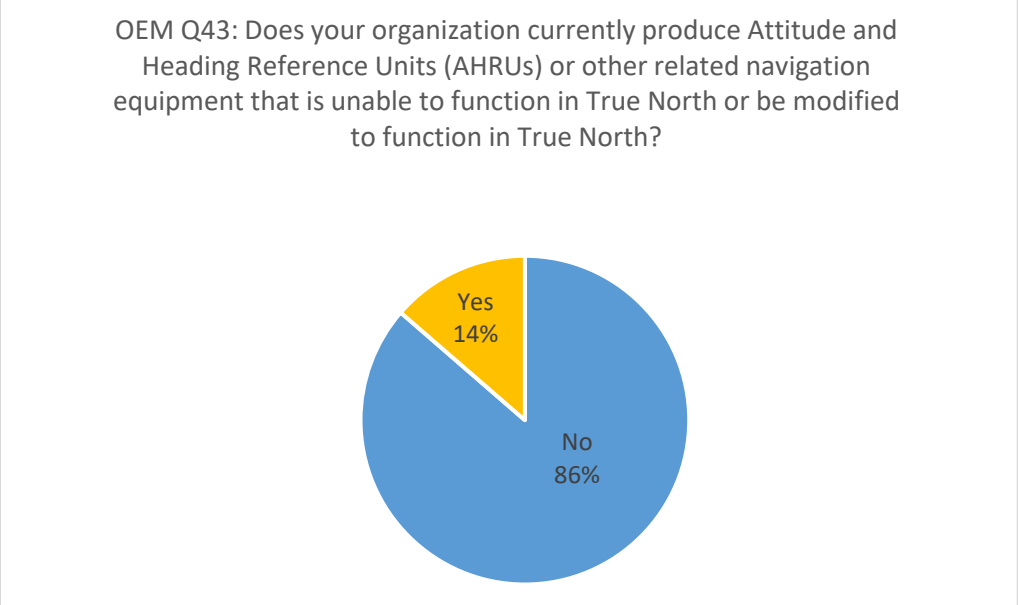


5. Aircraft or another original equipment manufacturer (OEM)

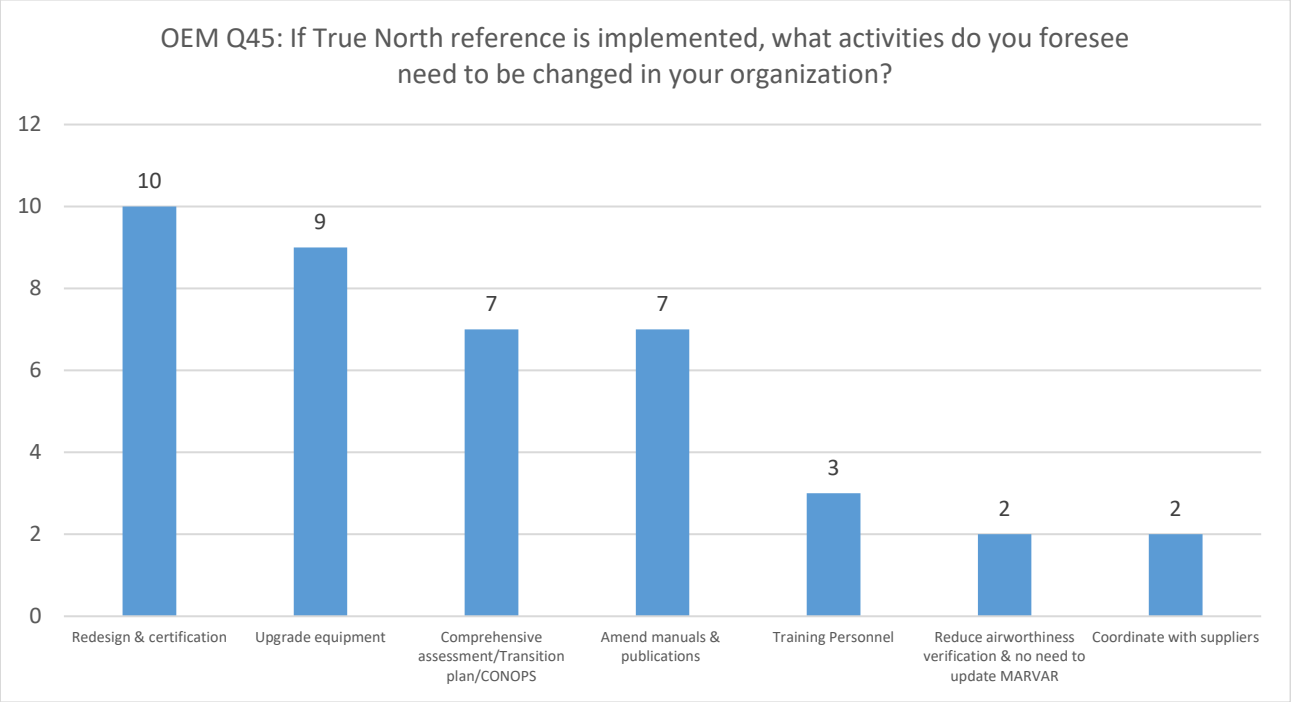
Q42. What type of OEM is your organization?



Q43 & Q44. Does your organization currently produce Attitude and Heading Reference Units (AHRUs) or other related navigation equipment that is unable to function in True North or is modified to function in True North? Please specify if you ansered “Yes”.



Q45. If True North reference is implemented, what activities do you foresee need to be changed in your organization?



Q46. What is the estimated cost in U.S. Dollars for your organization to implement reference to True North?

Most OEMs indicate that the necessary assessment of the aircraft design can not be done without a detailed concept of operations and how the transition periods will be. Therefore, no data is available at this moment, but the cost is probably significant. 6 out of 22 responses have provided USD10-500 million, depending on the number of aircraft under manufacturing and aircraft configuration for retrofiting.

Some other feedback are listed for reference:

Feedback 1: *Some mention that testing alone for each aircraft type of similarity analysis for types no longer in production would be in the millions of dollars.*

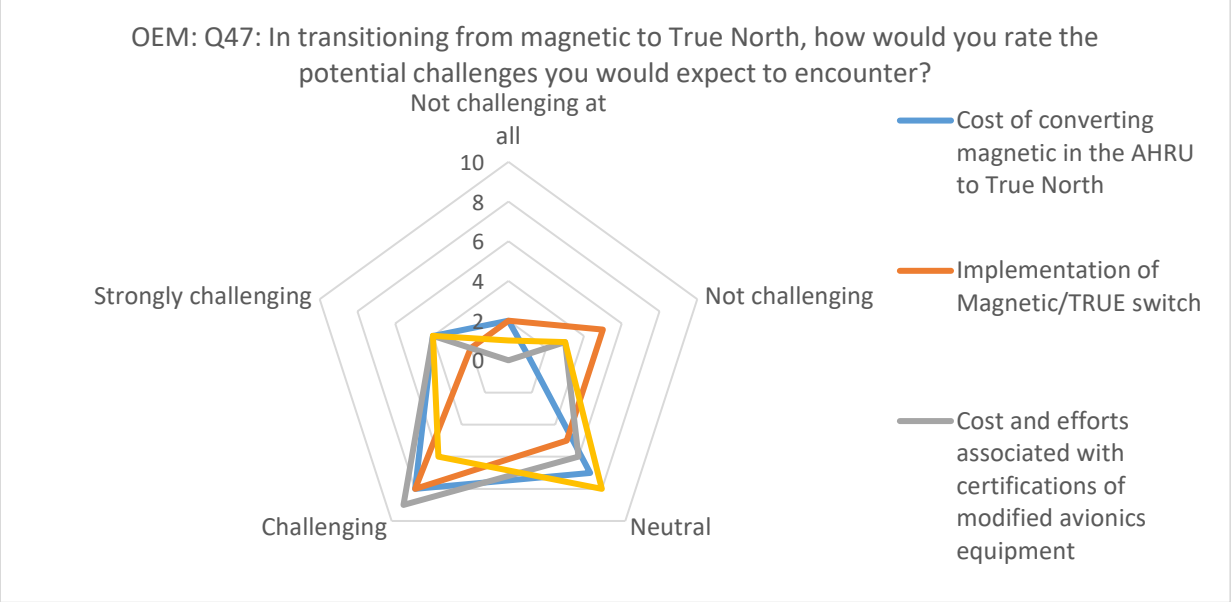
Feedback 2: *There are approximately 3500 aircraft operating worldwide, representing approximately 12 different major models, with technology dating as far back as the 1950s that would need to be supported. A very rough order of magnitude estimate of $70 to $100+ million (USD) would be possible, just in design and certification effort within one State alone, as well as an additional effort to update all foreign certification validations in effect.*

Feedback 3: *The cost of converting the actual AHRU to have a True North heading may only be a small fraction of the impact of making the change. There are likely to be significant integration challenges where other systems on the aircraft are likely to need to be changed. This is especially true if the airplane will be*

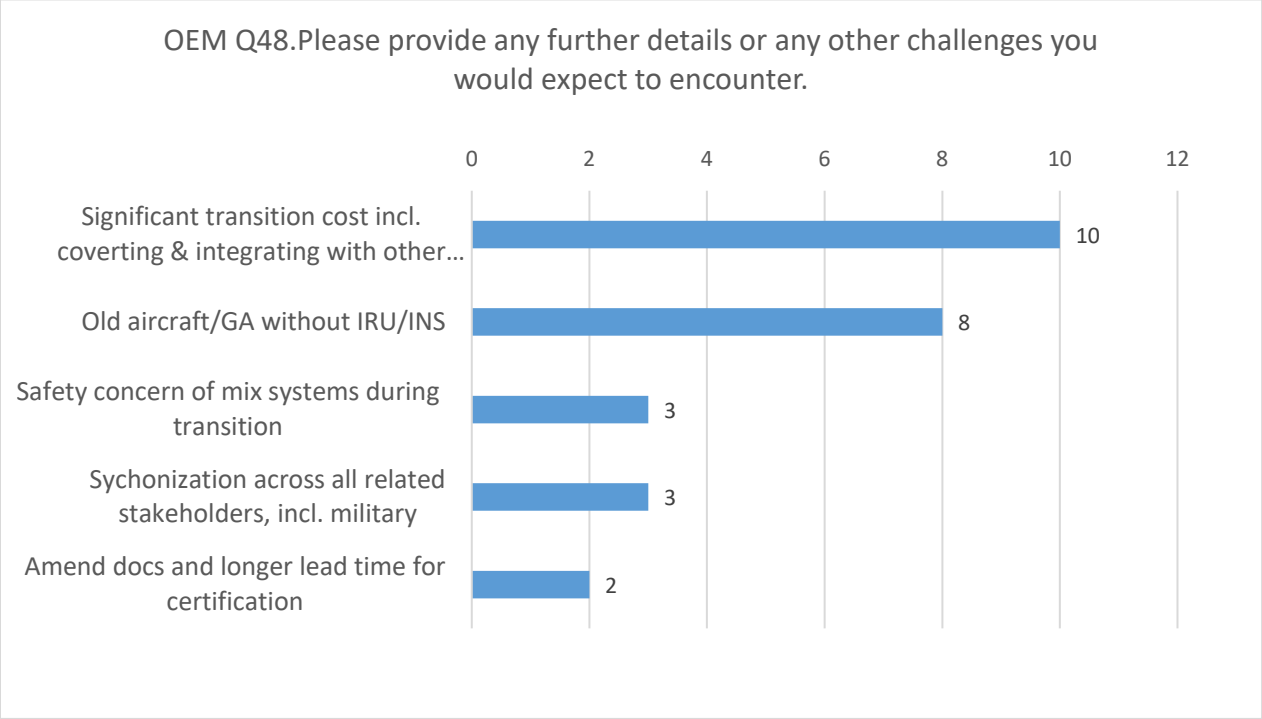
expected to have some sort of switch that will allow the reference to be changed from magnetic to true etc. Helicopters and many other aircraft may not have means to operate with a true north reference. Such aircraft may require significant modifications to add the ability to switch between references.

Q47. In transitioning from magnetic to True North, how would you rate the potential challenges you would expect to encounter?

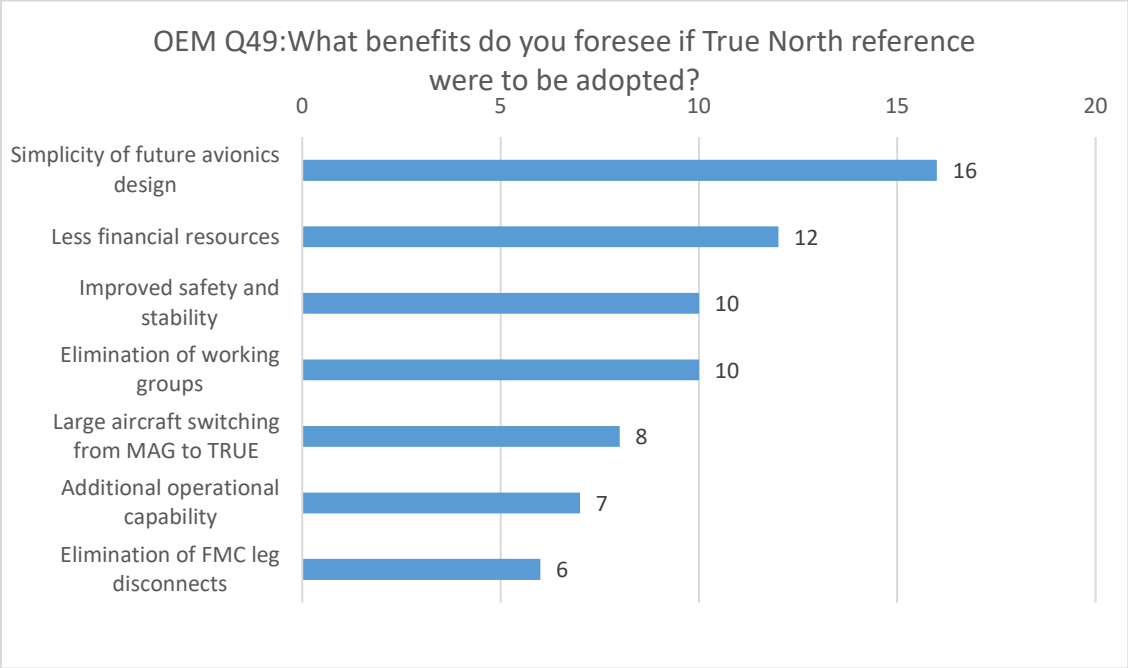
	Not challenging at all	Not challenging	Neutral	Challenging	Strongly challenging
Cost of converting magnetic in the AHRU to True North	2	1	7	8	4
Implementation of Magnetic/TRUE switch	2	5	5	8	2
Cost and efforts associated with certifications of modified avionics equipment	0	3	6	9	4
Logistics or procurement-related issues	1	3	8	6	4



Q48. Please provide any further details or any other challenges you would expect to encounter.

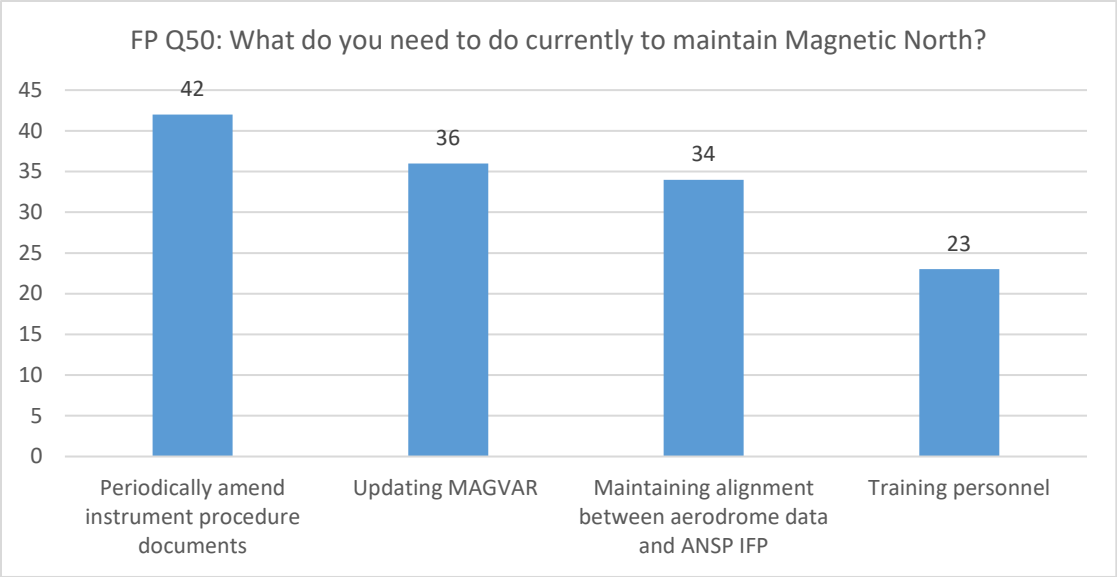


Q49. What benefits do you foresee if True North reference were to be adopted?

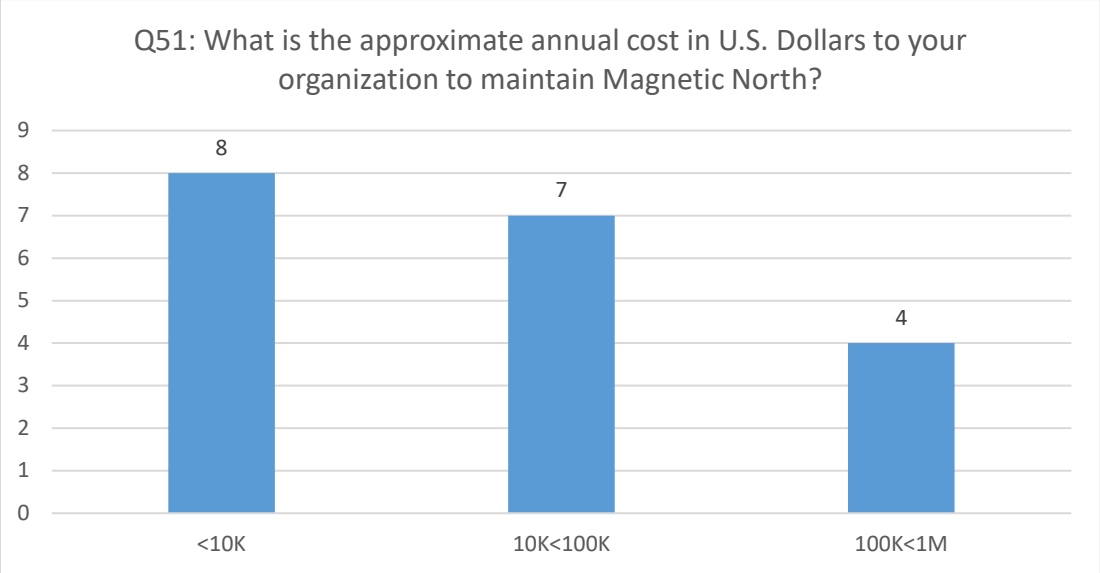


6. Instrument flight procedures designer

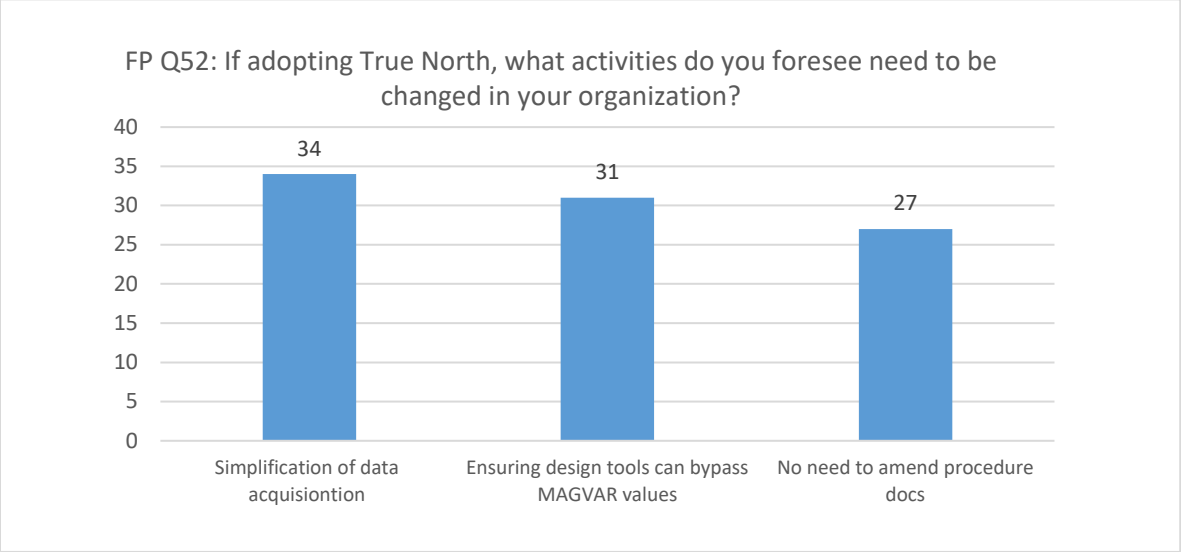
Q50. What do you need to do currently to maintain Magnetic North?



Q51. What is the approximate annual cost in U.S. Dollars for your organization to maintain Magnetic North?

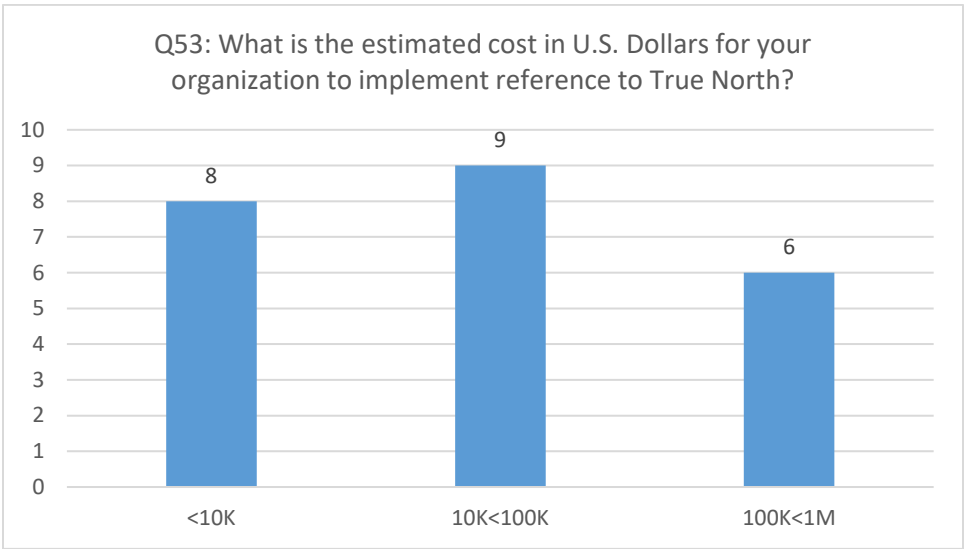


Q52. If adopting True North, what activities do you foresee need to be changed in your organization?



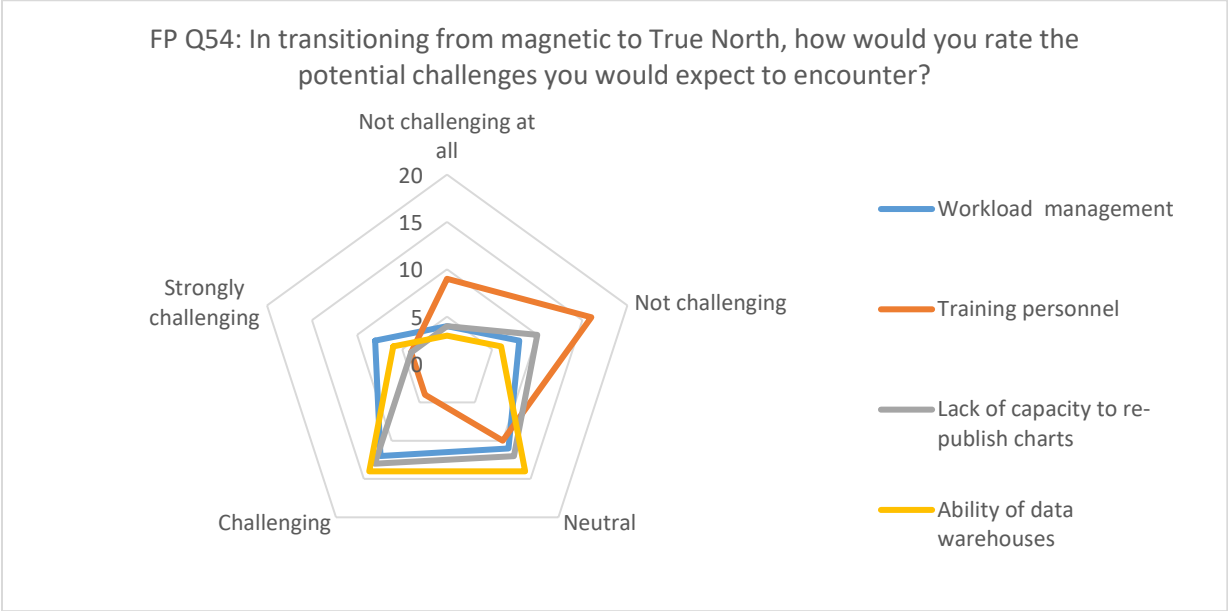
Others: *simplification/bypassing MAGVAR values in coding, simplification in assessing NOTAMs. Update existing instrument procedure charts once from Magnetic Values to True Values; systems, operational doctrine, aeronautical information, etc.*

Q53. What is the estimated cost in U.S. Dollars for your organization to implement reference to True North?

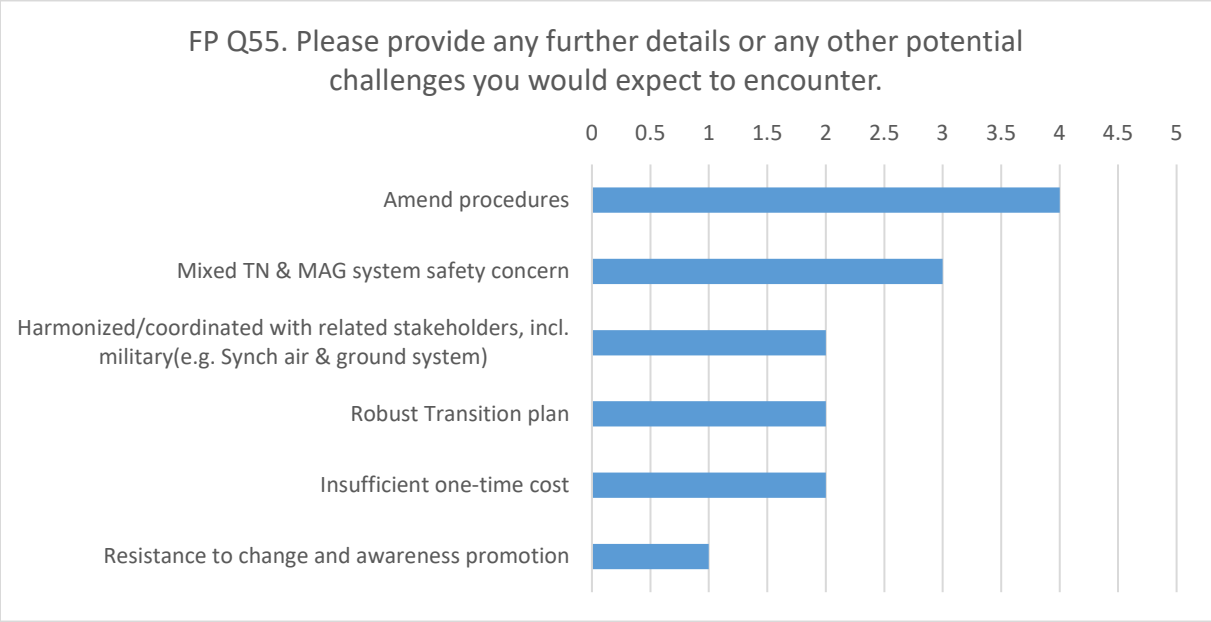


Q54. In transitioning from magnetic to True North, how would you rate the potential challenges you would expect to encounter?

	Not challenging at all	Not challenging	Neutral	Challenging	Strongly challenging
Workload management	4	8	11	12	8
Training personnel	9	16	10	4	4
Lack of capacity to re-publish charts	4	10	12	13	4
The ability of data warehouses	3	6	14	14	6



Q55. Please provide any details or any other potential challenges you would expect to encounter.



Q56. What benefits do you foresee if True North reference is to be adopted?