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THE ROMANIAN ASTRONOMICAL NAVIGATION THERMS AND ABBREVIATIONS ANDTHE NEED OF IMPROVE AND CHANGE THEM

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***Abstract**: Romanian astronomical navigation is based on the books authors Chirita M., Pavica V. and Balaban Gh. These known authors have influenced the training of the Navy and merchant officers from our country. The maritime industry, by definition, is international. The mariners from all corners of the earth are required to work together, communicate and interact. They are also required to train and be trained. For this purpose, the IMO, in 1995, designated one language, English, as the official language for mariners. Currently, due to the use of national nautical documentations, the Romanian Marine officers on board the ships encountering difficultiesinto using nautical documents, specific astronomical navigation terms and abbreviations to determine their fix position or to control the compasses corrections.This paper aim is to present how certain terms and abbreviations should be renamed for their correlation with international nautical documentations.*

1.Introduction

Astronomy was born of the need for people to understand the movement of the stars in the sky, the sky representing an inexhaustible source of questions, myths, and legends. Once theventuring off the seas and oceans of the world when it was losing sight of shore, seafarershave used the stars for guidance.

Thus, it appeared celestial navigation, compulsory underlying the specialized training of naval officers.

Shipboard Marine officer uses observations from the Sun, Moon, planets or stars to determine the fix ship's position and to achieve control ofthe compasses.

Romanian astronomical navigation is based on the book's authors Chirita M., Pavica V., and BalabanGh. These known authors have influenced the training of the Navy and merchant officers from our country.

The maritime industry, by definition, is international. The mariners from all corners of the earth are required to work together, communicate and interact. They are also required to train and be trained. For this purpose, the IMO, in 1995, designated one language, English, as the official language for mariners.

Currently, due to the use of national nautical documentations, the Romanian Marine officers on board the ships encountering difficultiesinto using nautical documents, specific astronomical navigation terms and abbreviations to determine their fix position or to control the compasses corrections.

For training of the MNBA students at Astronomical Navigation discipline were used the following documentations:

- Russian tables M.T.-53 (until Romanian tables are entered in service);
- Romanian Nautical Tables D.H.-90 (Hydrographic Direction);
- astronomical bookmarks;
- Brown's Nautical Almanac;

2. Data and methodology

Determining of an astronomical line of position (LOP) requires the following calculations:

1. Finding the Universal Time (U.T.);
2. Finding the meridian angle (t) and declination (Dec.) of the star;
3. Finding the calculated altitude (Hc) of the start using the cosine formula;
4. Finding the azimuth of the star using cotangent formula;
5. Finding the true altitude from sextant altitude;
6. Finding the difference between the true altitude and the calculated altitude.

The use of these documents involved memorizing in advance all types of calculations.

To determine the altitude and azimuth of a celestial body were used the logarithms tables from the D.H.-90 documentation, an activity that requires both experience and a long time to extract values and to interpolate them.

In working with Brown's Nautical Almanac, the students often enroll Romanian abbreviations over nautical ephemeris abbreviations.

The altitude corrections measured with the sextant is done using tables of corrections from D.H.-90. These nautical tables D. H.-90 does not

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exist on board the vessels from the international fleet, so ambiguities and difficulties that may arise. According to The STCW 25 January 2013, Model Course – *Officer in Charge of a Navigational Watch*, to compute the altitude of the celestial body, three methods are available:

- the cosine formula and a pocket calculator
- the haversine formula and logarithmic tables
- pre-computed altitude and azimuth tables.

„Which of these should be chosen is optional. After having introduced these methods, it is recommended to select one of them and specialize on that particular method. These days, with easy access to inexpensive pocket calculators, the first method may be preferable".

3. Results and discussions

To comply with these recommendations, in the current training of the MBNA students have been introduced the following changes:

- it wasremoved the use of nautical publication D.H.- 90;
- it was introduced in use the publication Norie's Nautical Tables;
- have changed the astronomical terms and abbreviations according to Table 1;
- the determining the calculated altitude and the azimuth of a star is made using a pocket calculator;
- it wasabandoned the training activities which required memorize by the studentsof all kinds ofcomputations;
- it was introduced some forms of calculation to facilitate the determination of LOP.

Table 1. Correlation of terms and abbreviations

Romanian abbreviations	English abbreviations	Romanian signification	English signification
φ	Lat.	Latitude	
λ	Long.	Longitude	
ℓ	Col.	Colatitude	
t	L.H.A.	Orar angle or Local Hour Angle	
$P_{E/W}$	$t_{E/W}$	Polar angle	Meridian angle
α	R.A.	Right ascension	
τ	S.H.A.	Siderial Hour Angle	
δ	Dec.	Declination	
h_e	Hc	Estimated altitude	Calculated altitude
T	G.H.A	Greenwich time or Greenwich Hour Angle	
t	L.H.A.	Local time or Local Hour Angle	
Ts	G.H.A. Aries	Greenwich siderial time or Greenwich Hour Angle of Aries	
ts	L.H.A. Aries	Siderial local time or Local Hour Angle of Aries	
Ta	G.H.A. Sun	True solar time at Greenwich or Greenwich Hour Angle of Sun	
ta	L.H.A. Sun	Local true solar time or Local Hour Angle of Sun	
Tm	U.T./G.M.T.	Universal time / Greenwich Mean Time	
tm	L.M.T.	Local Mean Time or Local Time	
-	Z.T.	Time Zone	
λ_f	ZM	The longitude of the sprindle	Zone Meridian
t_f	Z.D.	Spindle time	Zone Description
-	SLT	Standard Legal Time	
O_V	DST	Summer time	Daylight Saving Time
O.B.	D.W.T.	Aboard time	Deck Watch Time
-	I.D.L.	International Date Line	
A, B, C, ..	C	Chronometer time	
(Tm-A)	CE	Absolute state of the chronometer	Chronometer error
k	CR	Chronometer rate	
Ha	Ho	True altitude	Observed altitude / True altitude
Hi	Hs	Instrumental altitude	Sextant Altitude
ε	IE	Sextant error	Index error
Depr.	Dip.	Depression	
ρ	Ro.	Atmospheric refraction	
π	P.A.	Parallax	

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hv	H	Visible altitude	Apparent altitude
Δh	p	The difference between ha and he	intercept

For determining the LOP for a star have been introduced the following sheets:

- the Sun’s LOP (Fig. 1);
- the Moon’s/Planets LOP (Fig. 2);
- the star’s LOP (Fig. 3)

Completing this form of calculation is done line by line as indicated. These forms contain rules of signsfor applying the spherical trigonometry formulas and accounting rules for determining meridian angle and azimuth angle for a celestial body.

Correcting the sextant altitude using D.H.-90 documentation wasperformed using the tables from 19 to 28.

At this time,correctingthe sextant altitude of a celestial body is made using the tables from Brown’s Nautical Almanac or Norie’s Nautical Tables

Using the same principle, to solve astronomical navigation problems have been introduced paper sheets for:

- determining the meridian passage of a celestial body (Sun, Moon stars);
- determining the moment of rising/set/Twilight of the Sun/Moon;
- fix position using the Sun at the meridian passage;
- determining the latitude and the azimuth from the Polaris;
- determining the compass errors.

On board, the ship, one of the duties of the officer of the watch is to check and record gyro and magnetic compass errors at least once a watch, where possible, and after any significant course alteration.

Date	__/__/____	Lat. = ° ′	Long. = ° ′
Chronometer time	C = h m s		d sign:
Chronometer error	+ CE = □ m s		+if Dec. increasing
Universal Time	UT = h m s		- if Dec. decreasing
Finding the meridian angle and the declination of the Sun			d =□ ′
Daily page table →	UT = h	GHA = ° ′	Dec. = ° ′
Inc. & Corr.page →	UT = m s	+ Inc. GHA= ° ′	+Corr. Dec. =□ ′
±360° if required		GHA = ° ′	Dec.= ° ′
+for E Long. / - for W Long.		+ Long.=□ ° ′	
±360° if required		LHA = ° ′	if LHA<180°; t_W=LHA
Meridian angle		t □= ° ′	if LHA>180°; t_E=360°-LHA
Finding the calculated altitude (H_C) and the azimuth (Az)			
Lat. = ° ′	Dec.= ° ′		t □= ° ′
$\sin(H_C)$=	if Lat. and Dec. same names	$\sin(he)=\sin(Lat.)\cdot\sin(Dec.)+\cos(Lat.)\cdot\cos(Dec.)\cdot\cos(t)$	
	if Lat. and Dec. diff. names	$\sin(he)=-\sin(Lat.)\cdot\sin(Dec.)+\cos(Lat.)\cdot\cos(Dec.)\cdot\cos(t)$	
$H_C=\sin^{-1}$(value) = ° ′			
ctg(Zs) =	if Lat. and Dec. same names	$\mathrm{ctg}(Zs)=\frac{\mathrm{tg}(Dec.)\cdot\cos(Lat.)}{\sin(t)}-\frac{\sin(Lat.)}{\mathrm{tg}(t)}$	
	if Lat. and Dec. diff. names	$\mathrm{ctg}(Zs)=-\frac{\mathrm{tg}(Dec.)\cdot\cos(Lat.)}{\sin(t)}-\frac{\sin(Lat.)}{\mathrm{tg}(t)}$	
$\mathrm{tg}(Zs)=\frac{1}{\mathrm{ctg}(Zs)}=$	Z'$_S$ = tg^{-1}(value) = ° ′	if ctg $Z_S>0$, Zs = Z'$_S$	Z_S= °.
		if ctg $Z_S<0$, Z_S=Z'$_S$+180°	Z_S= °.
Finding the azimuth using Norie’s tables			
$Zs=\frac{N}{S}\cdot\frac{E}{W}$	$\frac{N}{S}$ – same as Lat.	Lat. = ° ′	A = $\frac{N}{S}$
		Dec.= ° ′	& B = $\frac{N}{S}$ — Norie’s rules
	$\frac{E}{W}$ - same as t□	t □= ° ′	C = $\frac{N}{S}$
			Zs = $\frac{N}{S}\cdot\frac{E}{W}$ Az = °.
Az = °.	if Z_S = Nα°E then Az = α°	if Z_S = Sα°E then Az = 180° - α°	
	if Z_S = Nα°W then Az = 360°-α°	if Z_S = Sα°W then Az = 180° + α°	
Finding the true altitude of the Sun’s lower limb (Brown’s altitude corections tables)		Index error	IE = □ ′
		Height of eye	h = m

With four tables		With two tables	
Sextant altitude	H_S= ° ′	Sextant altitude	H_S = ° ′
Index error	+ IE = □ ′	Index error	+ IE = □ ′
Dipression of Sea Horizon	-Dip = ′	Apparent altitude	H = ° ′
Apparent altitude	H= ° ′	Correction	+ Corr.= □ ′
Refraction	- Ro = ′	Month correction	+M. Corr.= □ ′
Sun’s parallax	+PA = ′	True Altitude	H_O = ° ′
Semi Diameter	+SD= ′		
True Altitude	H_O= ° ′		

Astronomical line of position (LOP)			
True altitude	H_O = ° ′	Az = °.	is a line of bearing drawn thrue geographical position
Calculated Altitude	- Hc = ° ′		
Intercept	p = □		
LOP	if p>0 LOP is ploted perpendicular on the azimuth to the geographical position if p<0 LOP is ploted perpendicular on the azimuth from the geographical position		

Figure 1 Finding the Sun’s LOP

Date	__/__/____	Lat. = ° ′	Long. = ° ′
Chronometer time	C = h m s		d sign:
Chronometer error	+ CE = □ m s		+if Dec. increasing
Universal Time	UT = h m s		- if Dec. decreasing
Finding the meridian angle and the declination of the Moon/Planets (___)			d =□ ′
Daily page table →	UT = h	GHA = ° ′	Dec. = ° ′
Inc. & Corr.pages→	UT = m s	+ Inc. GHA= ° ′	+Corr. Dec. =□ ′
Inc. & Corr.pages: UT= m and v=□ ′ →		+ Corr.GHA=□ ° ′	Dec.= ° ′
±360° if required		GHA = ° ′	
+for E. Long. / - for W. Long.		+ Long.=□ ° ′	
±360° if required		LHA = ° ′	if LHA<180°; t_W=LHA
Meridian angle		t □= ° ′	if LHA>180°; t_E=360°-LHA
Finding the calculated altitude (H_C) and the azimuth (Az)			
Lat. = ° ′	Dec.= ° ′		t □= ° ′
$\sin(H_C)$=	if Lat. and Dec. same names	$\sin(he)=\sin(Lat.)\cdot\sin(Dec.)+\cos(Lat.)\cdot\cos(Dec.)\cdot\cos(t)$	
	if Lat. and Dec. diff. names	$\sin(he)=-\sin(Lat.)\cdot\sin(Dec.)+\cos(Lat.)\cdot\cos(Dec.)\cdot\cos(t)$	
$H_C=\sin^{-1}$(value) = ° ′			
ctg(Zs) =	if Lat. and Dec. same names	$\mathrm{ctg}(Zs)=\frac{\mathrm{tg}(Dec.)\cdot\cos(Lat.)}{\sin(t)}-\frac{\sin(Lat.)}{\mathrm{tg}(t)}$	
	if Lat. and Dec. diff. names	$\mathrm{ctg}(Zs)=-\frac{\mathrm{tg}(Dec.)\cdot\cos(Lat.)}{\sin(t)}-\frac{\sin(Lat.)}{\mathrm{tg}(t)}$	
$\mathrm{tg}(Zs)=\frac{1}{\mathrm{ctg}(Zs)}=$	Z'$_S$ = tg^{-1}(value) = ° ′	if ctg $Z_S>0$, Zs = Z'$_S$	Z_S= °.
		if ctg $Z_S<0$, Z_S=Z'$_S$+180°	Z_S= °.
Finding the azimuth using Norie’s tables			
$Zs=\frac{N}{S}\cdot\frac{E}{W}$	$\frac{N}{S}$ – same as Lat.	Lat. = ° ′	A = $\frac{N}{S}$
		Dec.= ° ′	& B = $\frac{N}{S}$ — Norie’s rules
	$\frac{E}{W}$ - same as t□	t □= ° ′	C = $\frac{N}{S}$
			Zs = $\frac{N}{S}\cdot\frac{E}{W}$ Az = °.
Az = °.	if Z_S = Nα°E then Az = α°	if Z_S = Sα°E then Az = 180° - α°	
	if Z_S = Nα°W then Az = 360°-α°	if Z_S = Sα°W then Az = 180° + α°	
Finding the true altitude of the Moon (Brown’s altitude corections tables)		Index error	I = □ ′
		Height of eye	h = m
Sextant altitude	H_S = ° ′	daily pages of ephemeris	
Index error	+ IE = □ ′		
Dipression of Sea Horizon	- Dip. = ′		
Apparent altitude	H = ° ′		
Correction	+ Corr.= □ ′	HP = ′	
True Altitude	H_O= ° ′		

Astronomical line of position (LOP)			
True altitude	H_O = ° ′	Az = °.	is a line of bearing drawn thrue geographical position
Calculated Altitude	- Hc = ° ′		
Intercept	p = □		
LOP	if p>0 LOP is ploted perpendicular on the azimuth to the geographical position if p<0 LOP is ploted perpendicular on the azimuth from the geographical position		

Figure 2 Finding the Moon’s/Planets LOP

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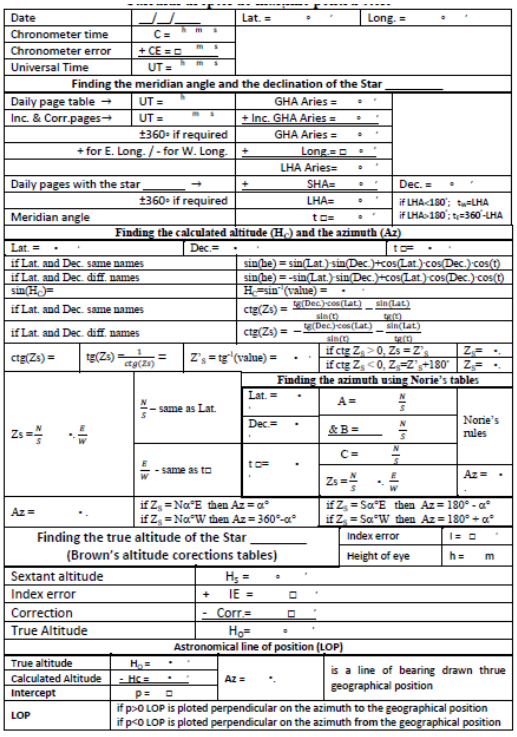

Figure 3 Finding the star's LOP

Conclusions

Due to the use of national nautical documentations, the Romanian Marine officers on board the ships encountering difficultiesinto using nautical documents, specific astronomical navigation terms and abbreviations to determine their fix position or to control the compasses corrections.

Between the two types of abbreviations given in Table 1 there are similarities and differences which requires changing the Romanian terms and abbreviations for their correlation.

In the present,determining the LOP for a staris made using the paper forms and for calculating the altitude or the azimuth of a star is made by a pocket calculator;

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