Sphinx mount driven by Starbook
Functional test

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Rev	Date	By	Description
1.00	2005-Jul-22	ALH/PH	Preliminary
1.02	2005-Aug-06	ALH/PH	Draft

1. Introduction.

This report is a complement to the preliminary report on the Sphinx system:
http://www.eurospacecenter.be/EquipTestSphinx01.31.doc.pdf
See in annex an extract of this report.

The report briefly compares the Sphinx to its declared predecessor - the GP-DX associated to the Sky Sensor 2000PC - and concentrates on the pointing accuracy of the Sphinx system. Complementary information is also provided on the system.
Autoguiding is not part of the test.

The tests started on the version 1.1, build 21 of the firmware, and, unless specified, it applies to the version available at the time of test closure: V1.2 build 27, released on 2005-Jun-23.

The serial number of the mount used for the tests is VSX051002759.

2. General Information

2.1. Mount - Sphinx

Item	Description
Tripod	Aluminum tripod made out of profiled legs. Height: 700..1100 mm / 28..44" Tripod, specially its connecting part to the mount, is specific to the Sphinx.
Type	German equatorial
Drive	For RA and DEC axis. Integrated servo motors.
Dimensions	320 x 320 x 120(170) mm / 13 x 13 x 5(7)“ without (with) RA/DEC screws head.
Weight	7 kg/ 15 lbs
Payload	10..11 kg / 22..24 lbs
Counterweight	2 x 1.9 Kg / 2 x 4 lbs
Wheel	D = 72 mm / 2.8”, 180 cogs in each RA & DEC axis
Polar axis range	0..70°
Polar Adjustment	By screw for each altitude and azimuth direction
Power supply	12VDC, 0.4..1.7A
Miscellaneous	Delivered with pointing device: the Starbook.

2.2. Control unit – Starbook

The following data are general information fetched from the supplied documentation. More detailed data are given in the later chapter “Sphinx’ Starbook in comparison to the SS2K"

Item	Description
Dimensions	195 x 145 x 28 mm / 7.7 x 5.7 x 1.1”
Weight	400 g / 0.9 lb
Screen	120 mm / 4.7” Color LCD screen. 320 x 240 pixels.
Working conditions	0..40 DegC
Interface	Ethernet Port
Power supply	12VDC Either by specific entry for standalone use, or through the port used to link the Starbook to the mount. In this later case, the mount provides the power supply.
Auto guider port	Yes, delivered as SBIG ST compatible. AGA-1 compatible by DIP switch settings.
Connection to the mount.	DB9 connector. DB9 female-female straight cable for connection to the mount.
Data base	Messier: 110 Solar system: 10 NGC/IC: 4980 Stars: 17635
Miscellaneous	Battery for internal clock.

3. Firmware and firmware update

The here tested system was delivered in March-2004 with the version 1.0 build 15.
It has been successfully updated to build 21, build 24 and build 26.
Finally, build 27 released 23-Jun-2005, has been loaded.

At the time of build update, new features are implemented. On the other hand, problems/bugs have been resolved.

Analysis of the firmware update leads to the conclusion that the maker concentrates on the product development:

- Build seems to be released every 3 months.
- New features implemented build after build
- On problems reported on the Sphinx newsgroup, Vixen provides neither information nor confirmation.
- At the time of build update, the official web site for download mentions the new available feature. No or few information on software correction is available. However, loading the new build will show that some problems have been resolved.
- No plan of future development is made public.
- No plan for chargeable optional software is made public. When the autoguider feature has been released, users had to discover that this option is chargeable.

4. Sphinx' Starbook in comparison to the SS2KPC
SS2KPC = SkySensor2000PC.

General features

Description	SS2KPC	STARBOOK
Display	2 lines 20 chars each, variable backlit	320*420 pixels, 4096 color graphic LCD display. Included planetarium software.
LCD Brightness adjustable	Yes	Yes But the display is too bright for astronomy application. 2 gray filters supplied. They must be stuck on the display. From build 26: automatic display turn-off after programmable delay.
Languages	6	6: Japanese, English, French, German, Italian and Spanish (From build 27).
Tour mode	Yes, per object type	No
Sun warning and avoidance	Yes	Yes
Timer	Yes, audible	No
Beep on actions	Yes	When goto has finished
Satellite alarm	Yes, audible	No
PC connection	Yes - PC control (LX200) comet/satellites parameters upload	Yes Ethernet 10 Base-T
Consumption under 12VDC	Tracking: 0.25 amps. Slewing: 1.2 amps. Data may vary according to mount load.	Tracking: 0.7 amps. Slewing: 2 amps at fast slew. The Starbook unit itself draws nearly 0.4 amps. Power supply condition does not affect the actual 'accuracy'. The mount is equipped with closed loop servomotors.
Resume after Power interruption	Yes, no realignment needed	No
LED for map	Yes	No. The display without filter is so bright that it could be used as light source
Setups	1 base + 9 for • Location and time • Telescope config.	1

	• Object selection • Display options	
Arrow Keys	Directions exchangeable	Starbook' key are softkeys. Their function depends upon the active panel.
Goto control adjustment	Servo loop factor adjustment.	No adjustment.

<u>Coordinate system</u>

Description	**SS2KPC**	**STARBOOK**
Display coordinates	In: - JNow - J2000 - AltAz	In - J2000 Target coordinates Scope coordinates
Goto coordinates	Yes, in: - JNow - J2000	Yes, in: - J2000
Alignment modes	- Equatorial - Polar equatorial - AltAz	- Equatorial - AltAz
Polar axis direction	Computed deviation from pole shown after aligning	No
Display time	Local time Sidereal time	Local time.

Pointing system

Description	SS2KPC	STARBOOK
Moves with keys	In RaDec, AltAz, XY	In RaDec, AltAz
Speeds	• Fast (0 to 1999x) • Medium (0 to 99x) • Slow (0.0 to 9.9x) • Guide (0.1 to 9.9x) Acceleration and deceleration can be specified	8 Speeds, selected by the zoom factor of the Starbook planetarium. Level 1: 798x Level 2: 396x Level 3: 198x Level 4: 96x Level 5: 48x Level 6: 24x Level 7: 12x Level 8: 2x Less than 1x not possible, unless the autoguide port signals are driven by a button box. No standard solution is available.
High Precision pointing	Yes, up to 3 stars alignment. High precision may be obtained by using a reference star identified to be close to target. See later “Pointing accuracy”	Yes, via – up to 20 – stars alignment. See later.” Pointing accuracy”
No goto under horizon	Yes	Yes
Scope reversal	Yes, on meridian flip 1 hour grace; override possible.	Yes, on meridian flip 0 hour grace, stop reverse possible.
Specific goto handling	Aberration: - Planets - Moon Parallax: - Planets - Moon Atmospheric refraction: - All	Aberration: - No Parallax: - Moon Atmospheric refraction: - No

Object database

Description	SS2KPC	STARBOOK
Stars	• 35 reference • 422 SAO	35 reference stars Approximately 17.600 additional stars, not accessible by menu.
Planets	8	8
Sun	1 (but can be removed from list for safety)	1
Moon	138 surface features	1; no surface feature

Jupiter Moons	4	0
Messier	108	108
NGC	7840	NGC & IC: 4980.
IC	5386	NGC & IC: 4980.
Celestial	Yes, 60 programmable	No. Celestial objects not programmable.
Comet	Yes, 30 programmable	By Internet download of updated firmware. Build 24: 2 comets Build 26: 1 comet Build 27: 1 comet (Tempel1) Comet not programmable. Announced in commercial leaflet: 30 maximum.
Asteroid	No	No. Not programmable.
Satellites	Yes, 30 programmable	No. Not programmable.
Land	Yes, 30 programmable	No. Not programmable.
Store coordinates of current location.	Yes	No.
Object details	Available: within radius, magnitude	Available at the time of object selection on a pop-up screen: name (partially available), catalogue number (partially available), magnitude, within radius
Filters (selection criteria)	By object type, direction, altitude, constellation, size, magnitude	No
Object data display	Coordinates, magnitude, type, name(s)	One field for either name or catalogue number. Automatically selected.

<u>CCD/ Astrophotography and special features</u>

Description	**SS2KPC**	**STARBOOK**
Autoguiding	Yes - ST4 plug - Speed independently adjustable in RA and DEC	Yes since build 24. SIBG ST and AGA-1 compatible. Chargeable option. Backlash and autoguiding are purchased as one option.
Backlash control	Yes, each axis independently	Yes since build 24. Each axis independently. Chargeable option. Backlash and autoguiding are purchased as one option.

PEC	Yes, with learn mode at adjustable speed; RA only	No

5. Starbook' database

5.1. General information

The following objects in the database are accessed by menu:

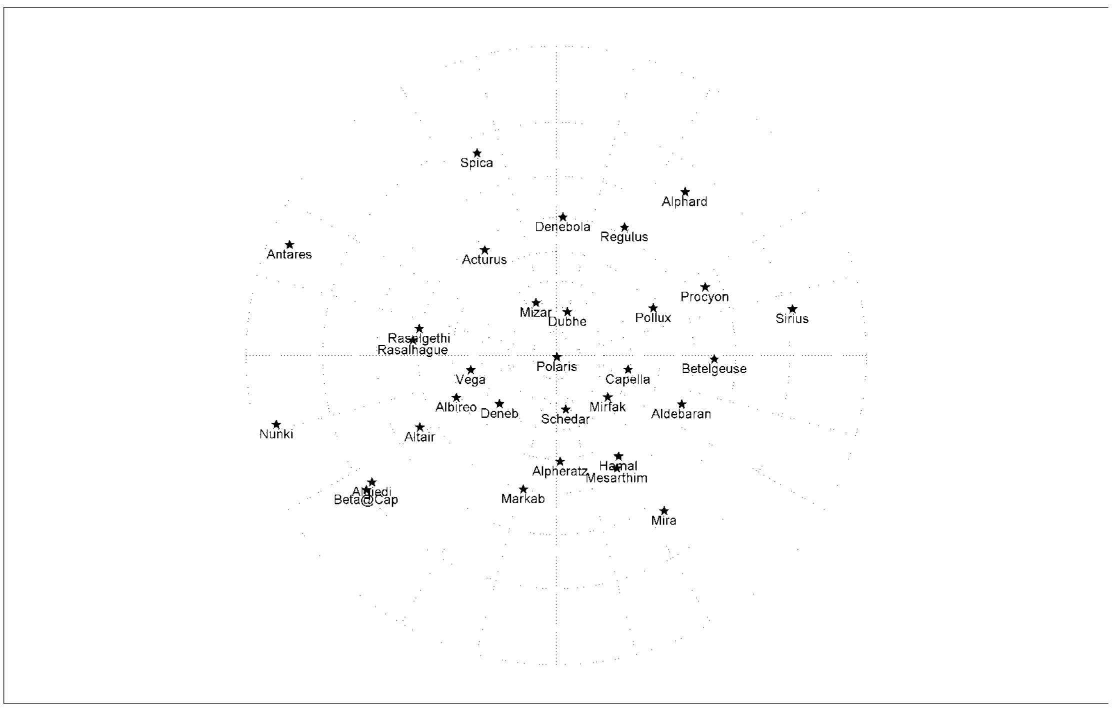
- Messier: 108 effective
- Solar system: 10
- NGC/IC: 4980
- Stars: 33 reference stars
- Constellations: all
- Famous objects: 34.

See also annex "Object in Starbook' data base"

Only a few "reference" stars are accessible by menu. The other 17600 stars are the ones of down to magnitude 7 displayed on the Starbook planetarium – available since the edition of build 27 only.
It is difficult to check if the 4980 NGC/IC objects are all accessible by menu.

5.2. Reference star location

Any object called from the database can be used for alignment of the system. However only punctual reference object are best used. The spread-over of reference stars in the sky is represented in following graph.



Some sectors of the sky seem to be under represented in reference stars, while others are well/over represented.

<u>Notes on database objects:</u>

- Discrepancy between database: The Pleiades, M45, are noted as being of magnitude 1.5 through the famous object menu. According to the Messier menu, Mag=5.0.

- Discrepancy between database: Little Dumbbell, M76, is located at DEC51°33' on the famous object database. Through the Messier menu, the data are: DEC51°34'. This last value is correct.

- M52 coordinates originally not correct. Correction is brought on build 27.

- M110 is not accessible through the Messier menu, but well through NGC menu: NGC205. Then finally, "M110" is displayed as name on the chart.

- Selecting an object through the famous object menu will display the following information on a pop-up display: name, number, type of object, magnitude and diameter. Selecting an object through the NGC menu will make the name not displayed, even if this name is available through an other menu. Ex. NGC7000/ North America Nebula.

- Some names are not fully displayed on the chart/scope screen, which is limited to 11 char. And also not fully displayed on the information pop-up. Example: Hubble's Variable Nebula / NGC2261, etc.

- M40 is not accessible. Seems to be usual in amateur astronomy.

- No size is given for: Hyades, Pelican Nebula, Rose Nebula & Pinwheel Galaxy

- Magnitude for some objects - here bellow a sample check; there is always a difference.
  Alphard: Starbook -> Mag = 2.2   SkyMap Pro -> Mag = 1.98
  Markab: Starbook -> Mag = 2.6   SkyMap Pro -> Mag = 2.45
  Algiedi: Starbook -> Mag = 3.7   SkyMap Pro -> Mag = 3.57
  Mesarthim: Starbook -> Mag = 4.7   SkyMap Pro -> Mag = 4.59

- And finally, a little funny thing happened when traveling through the object menu, from object to object. If the cursor was on an object name, then moved away, a few cyan pixels remained on the left side of the object name, close to the black pixels.

These notes lead to the following questions:
- Are each data accessible from the menu store in different database? Why?
- Are the data put in by hand in the Starbook?
- On which reference database is based the Starbook?

6. Pointing accuracy

The major part of the tests was made while checking the accuracy of the system.

Test after test, the following questions were raised:
- How is the Sphinx compared to a reference telescope?
- What is the use of alignment on more than 3 stars?
- Is the mount responding to its advertisement?
- Which pointing precision can be expected?
- Test 5: Starbook Goto' precision versus software solution
- What's up with the latest revision?

The display and computer interface to the Sphinx passes/returns positions in RA as hh mm.m and Dec as ddd mm. There is no way to read the RA/Dec more accurately than:
- RA accurate to 6 arc seconds
- DEC accurate to 1 arc minute.

6.1. Test 1: How is the Sphinx compared to a reference telescope?

6.1.1. Test aims
- Setup procedure test
- Primary comparison with a reference scope

6.1.2. Global results

On the Sphinx system:
- The target object is always found in the finder
- The target object is often found in the eyepiece, at widest FOV (24 mm): 80% of success
- After 3 alignments, the average pointing precision on 8 objects is: 13.1 Arcmin, ranging from 3 to 30 Arcmin.

On the reference system:
- The target object is always found in the finder
- The target object is always found in the eyepiece. 80% of success at the narrowest FOV (3 mm); remaining 20% at a slightly higher FOV (4 mm)
- After 3 alignments, the average pointing precision on 8 objects is: 7.7 Arcmin, ranging from 0 to 15 Arcmin.

6.1.3. Conclusions
After alignment process, objects are found in the eyepiece at magnification of 80x (F=1950 mm; f=24 mm) with 80% of success, which is comfortable. The Sphinx system shows a reasonable pointing accuracy of 13.1 Arcmin, however the leak of repeatability in pointing gives an impression of erratic behavior.

6.1.4. Details about test
Equipment data - Maker is Vixen, unless specified:

	Sphinx system	**Reference Telescope**
Mount	Sphinx	New Atlux
Pointing device	Starbook	Sky Sensor 2000
OTA	VMC200L F= 1950 mm; D=200 mm	Televue NP127 F=660 mm ; D=127 mm

Ocular 1	Zoom 8..24 mm FOV: 55..40°	Zoom 8..24 mm FOV: 55..40°
Ocular 2		Televue Zoom 3..6 mm FOV: 50°

The reference system is a class higher than the Sphinx, but:

- It responds to the request of reference scope because it is supposed to be less subject to mechanical deformation.
- It uses similar components of the Sphinx
  - Same polar finder
  - Wheel of 180 cogs
- It uses similar components of the GP-DX, which is also used to compare
  - Same Pointing device
  - Same motors

Sphinx system setting-up:

- Starbook Software Revision: V1.1, build 21
- Mount precise setting-up
- Polar alignment with polar finder

Reference system setting-up:

- Reference telescope has been first aligned by mean of 3 stars, according to pointing device specifications, with an 8 mm eyepiece. Probably better precision could be reached with a low focal reticular eyepiece.
- For pointing comparison, a 3..6 mm eyepiece is used on the reference telescope in order to get a similar field of view as with the Sphinx system.

See annex for test data list.

6.2. Test 2: What is the use of alignment on more than 3 stars?

6.2.1. Test aims

Check of accuracy with:

- No alignment
- Reasonable/usual amount of alignment
- High amount of alignment

6.2.2. Global results

Test	**Accuracy [Arcmin]**	**Remark**
No Align	Average: 25.9	
Align on 4 stars	Average: 9.1	Test provided only on 5 stars.
Align on 9 stars	Average: 6.0	

Test	**Result [Arcmin]**	**Remark**
Pointing repeatability: point several time to the same star and check position	3 positioning on the following stars were made with the following results: - Markab: 13,8; 12,4; 13.4 - Dubhe: 4.5; 6.1; 4.6 - Vega: 3.2; 4.6; 4.9	Test provided after alignment on 9 stars

6.2.3. Conclusions

- Better average results as per test 1
- First alignments increase grandly the pointing accuracy
- Additional alignments increase pointing accuracy
- Pointing accuracy – good or bad - on one part of the sky is repeatable.

6.2.4. Details about test

- Starbook Software Revision: V1.1, build 21
- Mount precise setting-up
- Polar alignment with polar finder

See annex for test data list.

6.3. Test 3: Is the scope responding to its advertising?

6.3.1. Test aims

According to leaflet on the Sphinx from Vixen Europe, dated 9-Sep-2003:
"After centering the first and additional 1-2 reference stars, you can immediately start enjoying your sky observations".

The Sphinx is basically not delivered with polar scope. It has then been here tested with rough set-up and without polar alignment.

6.3.2. Global results

Pointing accuracy: Average of 33.9 Arcmin, ranging from 11.1 to 73.7.

6.3.3. Conclusions

In the case of the here tested system, a Sphinx mount equipped with VMC200L (F=1950 mm) and usual eyepiece (Here 8..24 mm), the FOV is 14..30 Arcmin. The target objects have been found in the FOV/24 mm 50% of the time. This leads to the conclusion that the advertising not wrong, since the user can enjoy, but the probability that the user enjoys the desired object is 50%.

6.3.4. Details about test

- Starbook Software Revision: V1.1, build 21
- Mount rapid setting-up, but with water level
- No polar alignment with polar finder, but eye adjustment with the polar star

See annex for test data list.

6.4. Test 4: Which pointing precision can be expected?

6.4.1. Test aims

Check which precision can be gathered from the system while using its high-end features: polar alignment & high number of aligns.

6.4.2. Global results

After 14 alignments, the pointing accuracy is: Average of 10.7 Arcmin, ranging from 1.0 to 36.4

One must note that pointing on one star, Dubhe, is ‘erratic’: 36.4 Arcmin accuracy. Excluding this star from the test leads to: Average of 8.3 Arcmin, ranging from 1.0 to 15.3

Dubhe is located close to Mizar on the sky map; for Mizar, accuracy of 4.5 Arcmin is reached.

6.4.3. Conclusions

Global accuracy of the system is good, but some points are left open:

- Why the repeatability of the system is low?
- More accurate results were obtained in test 2: 6.0 Arcmin, instead of 10.7 (or 8.3) Arcmin here. Is the quality of the mount setting-up influencing final results?
- Why are there big errors in accuracy for some stars located in the same sky area?

6.4.4. Details about test

- Starbook Software Revision: V1.1, build 21
- Mount precise setting-up: North direction, water leveled, polar alignment.

See annex for test data list.

6.5. Test 5: Starbook Goto' precision versus software solution

6.5.1. Test aims

Can a better pointing accuracy be expected?

The more the alignments, the better the precision of the goto is. However, the owner of the tested mount faces 2 problems:
1. The previous tests of goto precision shows that there is no guarantee for a target objects to fall on his CCD chip, for astrophotography. The here considered CCD is 5*4 mm sized. For the pointing device to put the object on the CCD, a precision of 9*7 Arcmin would be required. The practice confirms this.
2. Previous tests show also that the precision is unpredictable; and that 15% of the time, the target object is far from being in the FOV of the ocular at 250x (Vixen VMC200L (D=200 mm, FL=1950 mm), Vixen zoom 8-24 at 8 mm -> field of view = 13.5 Arcmin).

A good model of the mount reaches good pointing. Here below, the Starbook capability is compared to market software: MaxPoint.

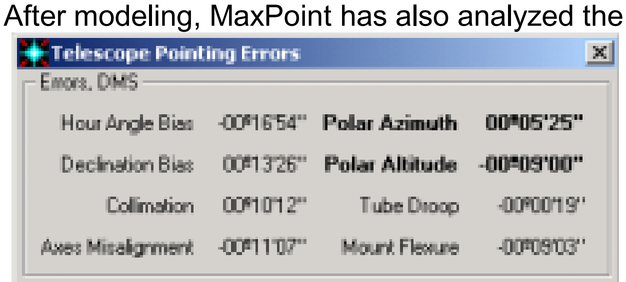
The test is made in 3 phases:
Phase 1: pointing precision without alignment; mount model
Phase 2: pointing precision with alignment through the Starbook
Phase 3: pointing precision with alignment through MaxPoint

6.5.2. Global results

<u>Phase 1: pointing precision without alignment; mount model</u>
<u>Note:</u> alignment on 1 star was made.

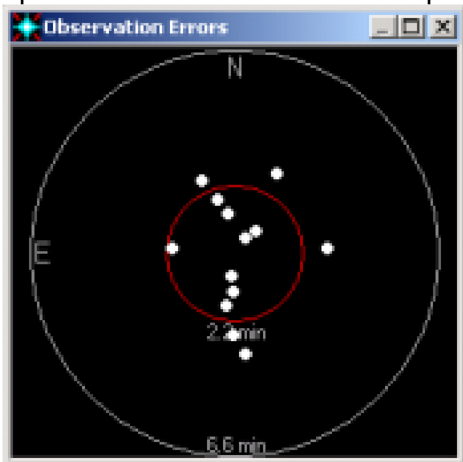
MaxPoint has analyzed the Sphinx and calculated its pointing precision: 23 Arcmin, with a standard deviation of 16.55 Arcmin.

After modeling, MaxPoint has also analyzed the telescope pointing errors:



With:
- Hour Angle Bias: The constant bias error in the telescope's Hour Angle. This is equivalent to the negative of Right Ascension bias error.
- Declination Bias: The constant bias error in Declination.
- Collimation: The collimation error in Right Ascension; i.e. how far the optical axis is from being perpendicular to the declination axis. Any collimation error in Declination is handled by the Declination Bias.
- Axes Misalignment: The deviation from perpendicularity between the Right Ascension and Declination axes.
- Polar Azimuth: The deviation of polar alignment in Azimuth.
- Polar Altitude: The deviation of polar alignment in Altitude.
- Tube Droop: The droop of the telescopes tube or superstructure due to gravity.
- Mount Flexure: Structural flexure in the rest of the mount.

Would the MaxPoint pointing algorithm be used, a pointing accuracy of 2 Arcmin could be expected. This will be checked in phase 3.

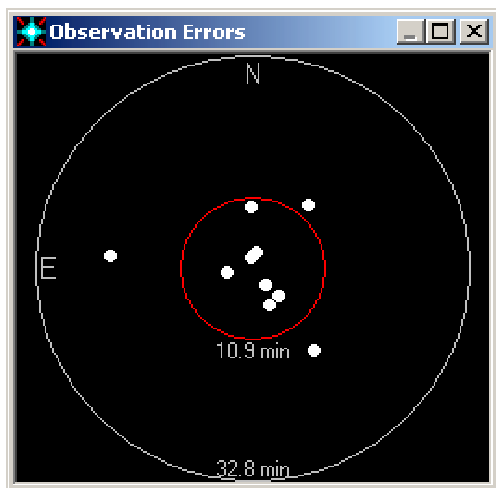


The two circles are the 1-sigma and 3-sigma error circles. The red inner circle contains about 68% of the observations, and the white outer circle contains approximately 99% of the observations. The text displayed at the bottom of each circle gives their diameters in arc-minutes.

Phase 2: pointing precision with alignment through the Starbook

The pointing accuracy of the Sphinx mount was tested via MaxPoint, by a 10 stars alignment, followed by a slew to each of the 10 alignment stars chosen.
The average pointing error is about 11 arcmin, with a standard deviation of 5.98 arcmin.

Would the Maxpoint pointing algorithm be used, a pointing accuracy of 11 arcmin could here be expected.



When comparing to a previous test (where 1 star was used for alignment only, and 13 pointed successively), we note:

- Pointing accuracy is enhanced (was Average: 23.01 arcmin/StdDev: 16.55 arcmin; now Average: 10.91 arcmin/StdDev: 5.98 arcmin)
- Should MaxPoint be correcting as well, the effect is worse here (1-sigma now at 10.9 instead of 2.2 previously; in fact MaxPoint and the Starbook counteract/jeopardize each other)

Phase 3: pointing precision with alignment through Maxpoint

The pointing accuracy of the Sphinx mount was tested when driven by MaxPoint using the following steps:

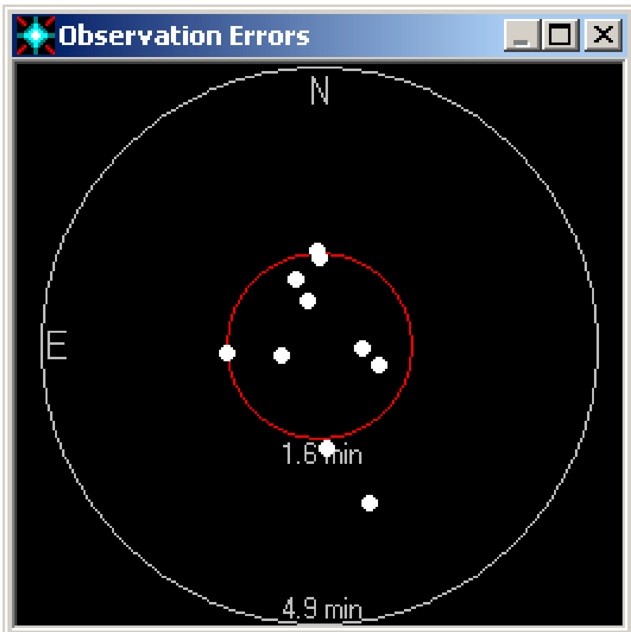
- A 10 stars calibration was done in MaxPoint and activated
- This was followed by a slew via MaxPoint to each of the 10 stars chosen
- Although each object was within the selected eyepiece (250x magnification), it was recentered using the Starbook

- And noting the difference between resulting (MaxPoint corrected) coordinates and real ones.

The average pointing error is about 2.92 arcmin, with a standard deviation of 1.24 arcmin.

Comparing to a previous test where a 10-stars alignment with the Starbook was performed (average 10.91, sigma 5.98 arcmin), the accuracy via MaxPoint appears substantially better; this indicates that the Sphinx mechanics is capable of accurate pointing but that the alignment/pointing software of the Starbook is a candidate for enhancement.

The next map shows the residual error as MaxPoint corrections are turned on (so without recentering).



The two circles are the 1-sigma and 3-sigma error circles. The red inner circle contains about 68% of the observations, and the white outer circle contains approximately 99% of the observations. The text displayed at the bottom of each circle gives their diameters in arc-minutes.

6.5.3. Conclusions

Alignment sequence on the Starbook has proven some efficiency, however, the Maxpoint algorithm gives definitely more precise results: 2 to 3 time more accurate.
After the measuring sequence of the phase 3, a slew was made to several objects (M13, 81, 27, 57, 104, NGC4565…); each object was within the selected eyepiece (F1950 mm & f=8 mm; 240x magnification)…
A personal interpretation of the pointing accuracy would be “Dead center!”

In the case of use of a 5*4 mm CCD ship, the target object would also have been found on the chip.

6.5.4. Details about test

- Starbook Software Revision: V1.2, build 26
- Mount precise setting-up
- Polar alignment with polar finder

See annex for test data list.

6.6. Test 6: What's up with the latest revision?

6.6.1. Test aims

Build 27 has been released on 23-Jun-2005. Hereafter, the major changes published on Vixen's Internet site:

- "Display Comet Tempel (9P/Tempel)"
- "Display stars down to 7.0 magnitudes"
- "Dialog in Spanish"
- "Corrections:
  (1) Incorrect coordinates for the Messier 52. An error in the coordinates for the Messier 52 has been modified correctly.
  (2) A bug in telescope control by a remote PC…"

Have other improvements been made?

6.6.2. Global results

Besides the here above mentions published by Vixen, no noticeable other changes appear to have been brought on the software: no other data base problem correction, no reference start added to the data base, etc.

Regarding the pointing accuracy, after alignment on 10 stars, the average pointing error on the 10 stars where the system was aligned shows a remarkable error of 5.6 Arcmin. This value is the same as the one measured on the test 2.
When considering the 4 additional Messier objects, the precision is: 7.3 arcmin.
This spot test can't lead to the conclusion that the align algorithm has been improved on build 27.

6.6.3. Conclusions

The build 27 seems more a normal evolution of the Starbook product, than an 'improved version'.

6.6.4. Details about test

- Starbook Software Revision: V1.2, build 27
- Mount precise setting-up
- Polar alignment with polar finder

See annex for test data list.

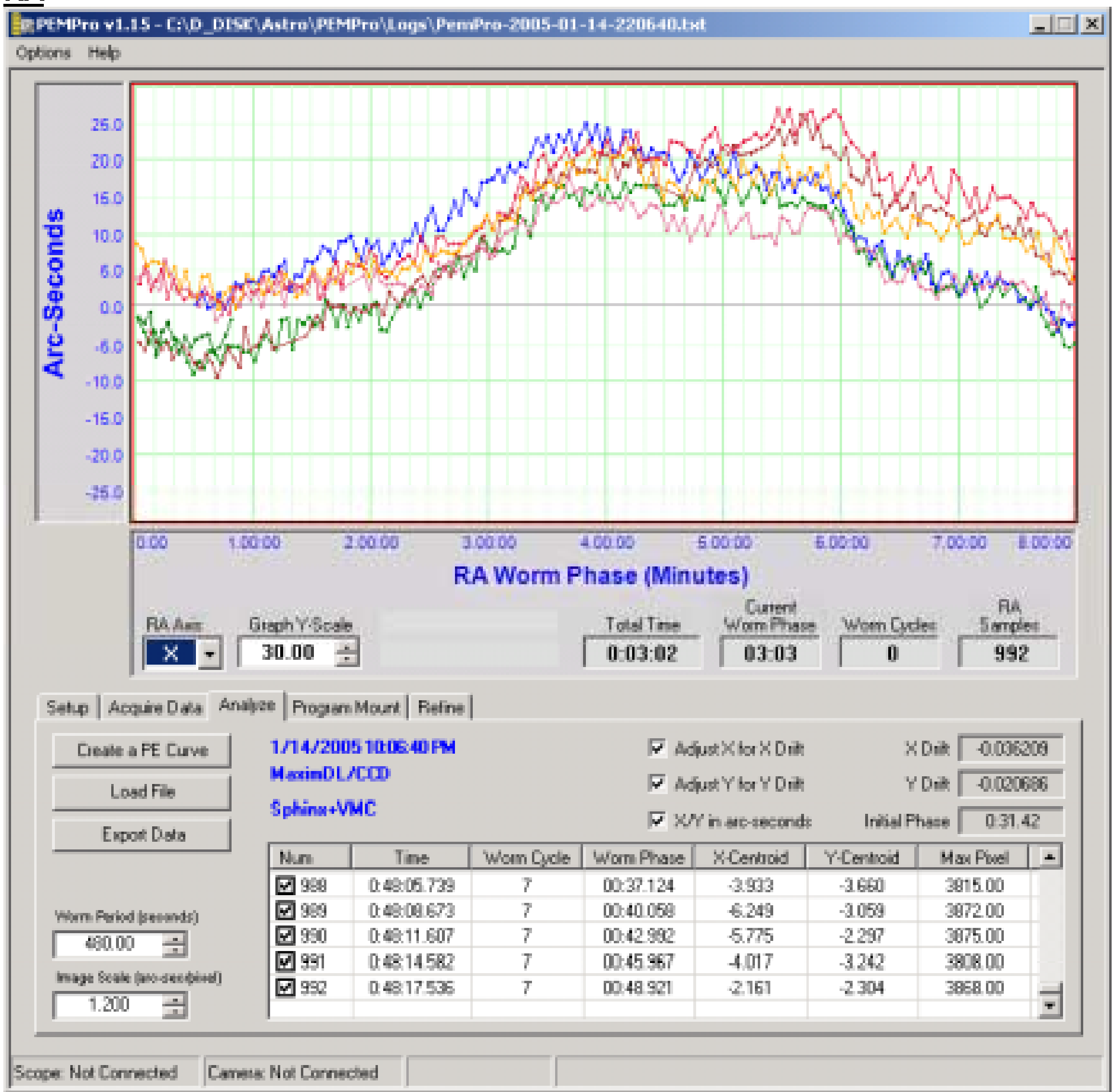
7. Periodic Error

7.1.1. Test aims

PE check.

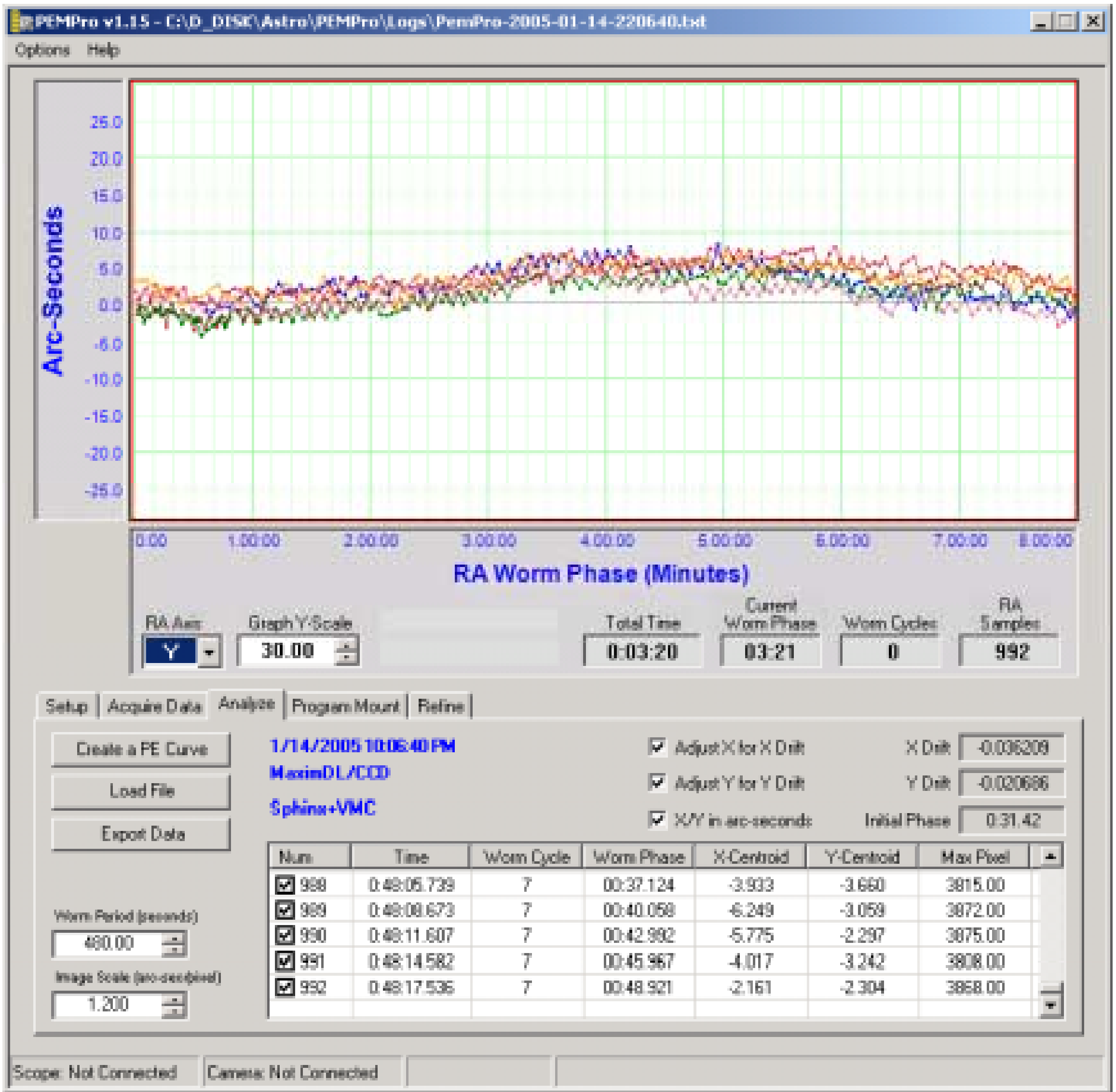
7.1.2. Global results

RA



Num	Time	Worm Cycle	Worm Phase	X-Centroid	Y-Centroid	Max Pixel
988	0:49:05.739	7	00:37.124	-3.933	-3.660	3815.00
989	0:49:08.673	7	00:40.058	-6.249	-3.059	3872.00
990	0:49:11.607	7	00:42.992	-5.775	-2.297	3875.00
991	0:49:14.582	7	00:45.967	-4.017	-3.242	3808.00
992	0:49:17.536	7	00:48.921	-2.161	-2.304	3868.00

DEC

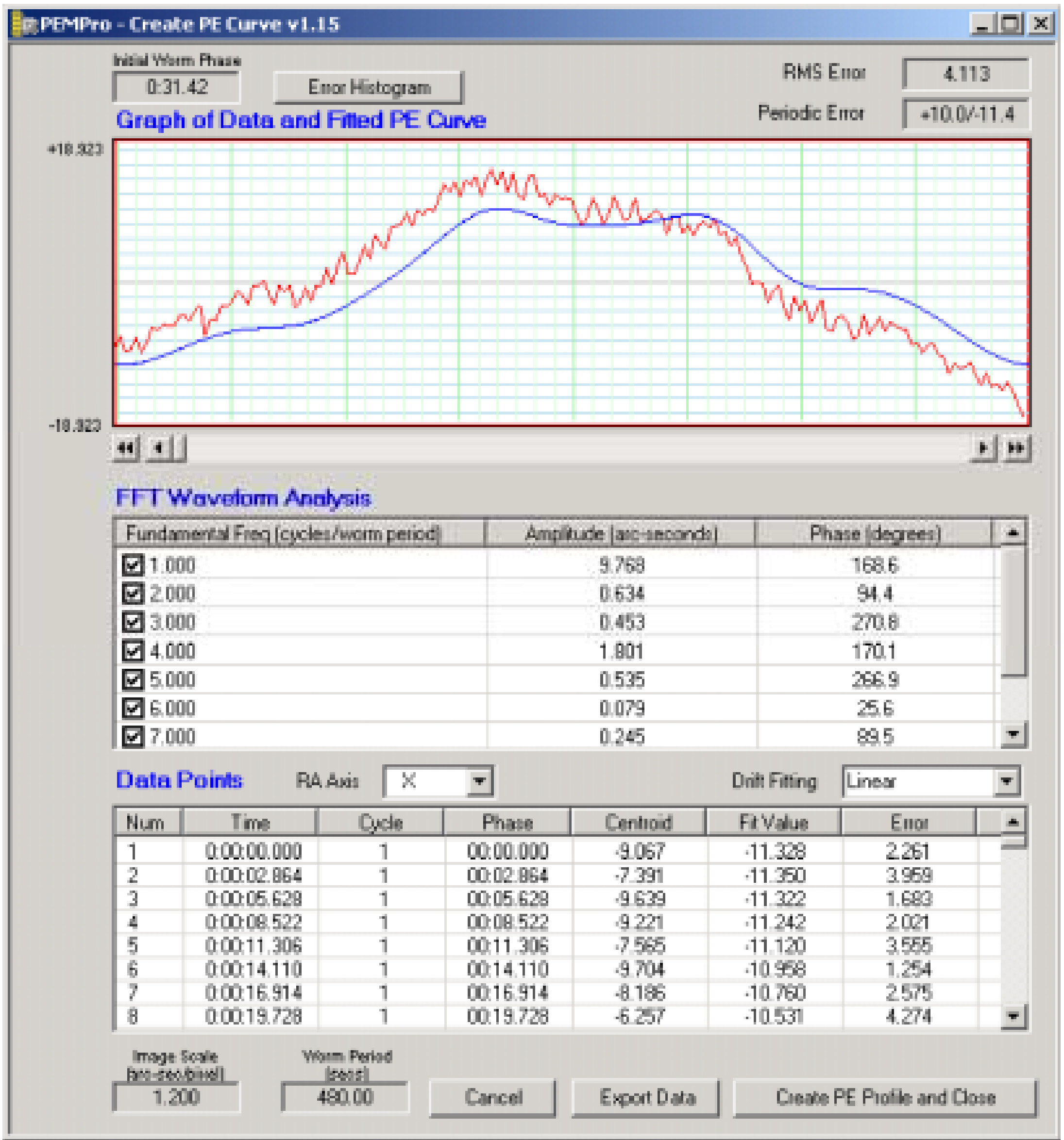


PEMPro v1.15 - C:\D_DISK\Astro\PEMPro\Logs\PemPro-2005-01-14-220640.txt
Options Help
Arc-Seconds
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
0.00
1:00.00
2:00.00
3:00.00
4:00.00
5:00.00
6:00.00
7:00.00
8:00.00
RA Worm Phase (Minutes)
RA Axis
Y
Graph Y-Scale
30.00
Total Time
0:03:20
Current Worm Phase
03:21
Worm Cycles
0
RA Samples
992
Setup
Acquire Data
Analyze
Program Mount
Refine
Create a PE Curve
Load File
Export Data
1/14/2005 10:06:40 PM
MaximDL/CCD
Sphinx+VMC
Adjust X for X Drift
Adjust Y for Y Drift
X/Y in arc-seconds
X Drift
-0.036209
Y Drift
-0.020686
Initial Phase
0:31.42
Worm Period (seconds)
480.00
Image Scale (arc-sec/pixel)
1.200
Num
Time
Worm Cycle
Worm Phase
X-Centroid
Y-Centroid
Max Pixel
988 0:48:05.739 7 00:37.124 -3.933 -3.660 3815.00
989 0:48:08.673 7 00:40.058 -6.249 -3.059 3872.00
990 0:48:11.607 7 00:42.992 -5.775 -2.297 3875.00
991 0:48:14.582 7 00:45.967 -4.017 -3.242 3808.00
992 0:48:17.536 7 00:48.921 -2.161 -2.304 3868.00
Scope: Not Connected
Camera: Not Connected

Trend and Fourier analysis

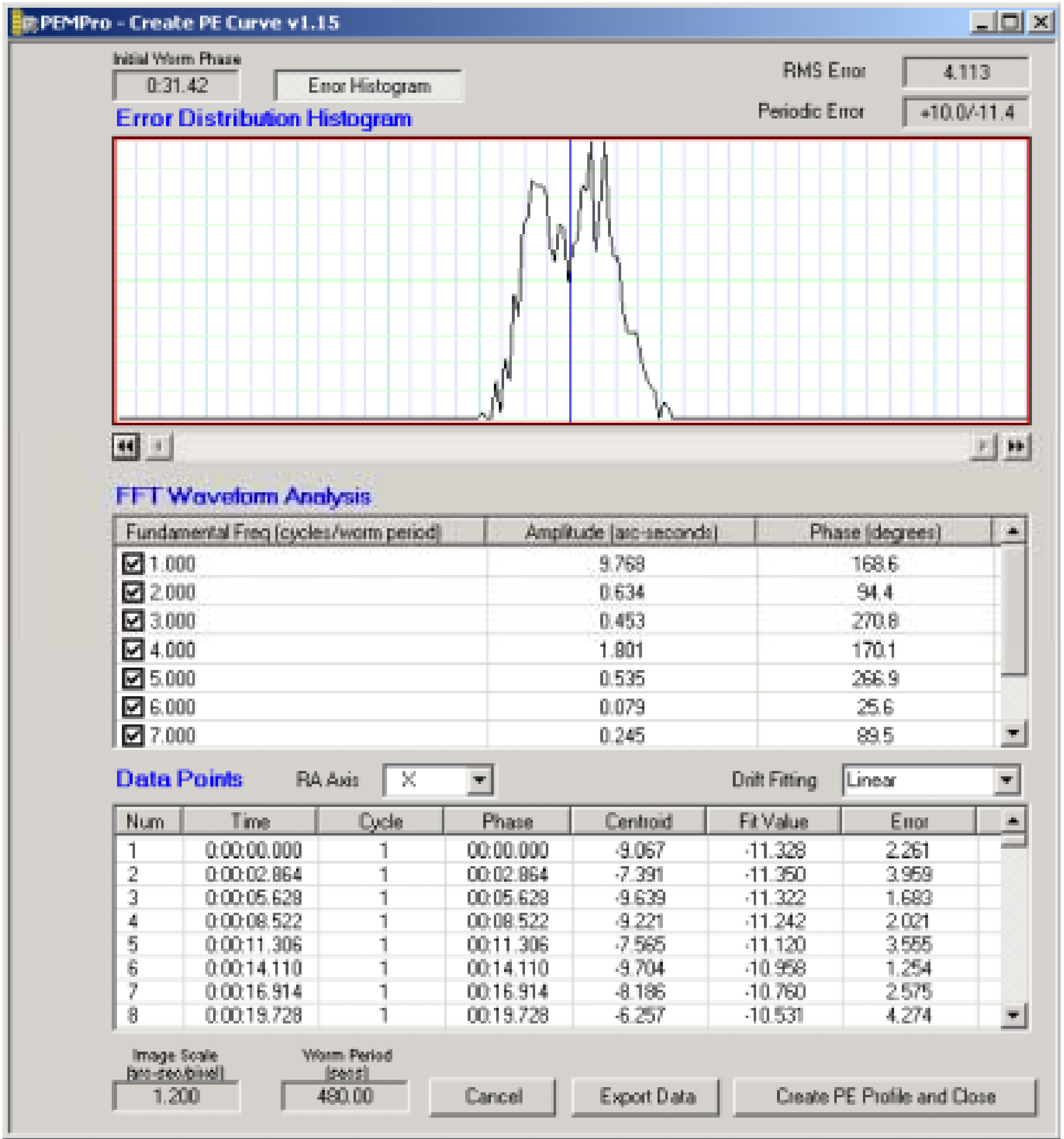
Linear fitting (See picture)
PEC = +10/-11.4
RMS error = 4.113

Quartic fitting:
PEC = +9.8/-11.1
RMS error = 2.682



Error Histogram

X: 1 graduation =2.5 arcsec
Y: number of instances



7.1.3. Sphinx compared to GPDX

Typical GPDX PE for comparison can be found under:
1. Without PEC: http://arnholm.org/astro/periodic_error/pe1_20040824.gif
2. With PEC: http://arnholm.org/astro/periodic_error/pe2_20040824.gif

Here, the author mentions that without PEC, the GPDX periodic error is ± 15 arcsec. For the PEC, he mentions the use of an MTS-3SDI controller, and so reaches a ± 2 arcsec PE.

The next other reference shows typical PE of +/- 15 arcsec for the GPDX and +/- 10 arcsec for the Sphinx:
1. GPDX: http://astrosurf.com/demeautis/ep/gpdx.htm
2. Sphinx: http://astrosurf.com/demeautis/ep/Sphinx.htm

7.1.4. Conclusions

At the test condition, for the used camera, 1 pixel represents 1.2 arcsec.
A precision of 2 pixels, 2.4 arcsec, should be sufficient for astrophotography. This is also due to the fact that in the area of the test – Spa/Belgium – a better seeing than 2 arcsec can't be expected.

On the PE graph, the peak error is approx. 10 arcsec over a quarter of the 8 min. cycle =2 min. Roughly, this means that the exposure time for being in the 2.4arcsec error tolerance would be 2*2.4/10 min = 30 sec.

Furthermore, the PE curve is not exactly sinusoidal, but shows a more flat section, which could lead to the conclusion that longer exposure is applicable under good synchronization of the worm position and the CCD.

PEC seems to bring good results on other mounts and it sound strange that the Starbook doesn't support such a function. Longer astrophotography exposure could be expected…

7.1.5. Details about test

Local condition:

- Location: Verviers, Belgium
  Lat 50 deg 35 min N
  Long 5 deg 51 min E
- Date: 14-Jan-2005

Equipment:
- OTA: Vixen VMC200L, F = 1950 mm
- CCD: Starlight MX916, 752x580 pixels, 1 pixel = 11.6x11.2 microns. 1 pixel=1.2 arcsec
- Sphinx Mount over 6 periods of 480 s
- PemPro V1.5 + MaxIm V4.06

Settings:
- Reference star: close to 0°DEC
- Alignment on 1 star: Betelgeuse

8. One year review

After one year of use, having patiently been waiting for good weather conditions and after having worked out the system many times, the results are as follow:

- The Sphinx is definitely transportable. No flight case was available at the time of purchase, but is now available. See later.
- The system setup is without surprise
- Water leveled, and polar alignment could be roughly made. However, this will affect the goto precision. With high focal length, a precision mount setup, with polar seeker is highly recommended.
- System is reliable: no crash occurred during operation or software update

The followings minor problems can be mentioned:

- Several screws fixing the mount' head to the tripod use to get loose. Stainless steel grower washers solved this.
- One protection cover of the altitude axis of the mount got loose; some glue will fix this.
- No water level integrated in the mount, despite the GPDX has one
- The next point is not directly a mount issue, but has probably affected the goto accuracy. The system was fit with a 2" Televue diagonal; this diagonal fit in the 60 mm connecting part of the OTA. However this connecting part is so short that finally the diagonal can't be kept properly in the optical axis.

Vixen proposes now a transportation case for Sphinx mount, 500x470x220 mm.
The author built his own case, 450x370x220 mm size, able to carry all necessary to setup the system and for one night of operation: Sphinx' head, 2 counterweights1.9Kg, Starbook, Battery 10Ah, Cables & co., water level, space for documents: maps, etc.
See representation in annex.

9. General conclusion

The objectives of the author while buying this mount was to get: a transportable mount, reliable, without difficulty to set up, goto, suitable for astrophotography, with evolution capability.

Basically, the mount responds to all these criteria. The mechanics show good capabilities. Regarding the software, several reported issues of the first report have been improved.

A comparison of the Sphinx to the sky sensor 2000 shows that this last one – older product - is richer in functionalities. Several functions are useful, and additional features on the Starbook will be an asset: hibernate, park the DEC axis so that the polar axis optic axis will be free at next start, monochrome screen, spiral function to search an object, etc.

The comparison of the Sphinx alignment algorithm to a market software solution shows that improvement of the Sphinx system pointing can be made. The Starbook is provided with a 32 RISC processor and has the capability of resolving complex algorithms.

Final conclusion remains the same as in the first report: “Will the Sphinx be adapted to the requirement of experienced astronomy amateur? Hopefully this will be done along with the future upgrade of the Starbook software”.

10. Annexes

10.1. Extract of report version 1.31, translated from French

Report was based on build 18.

10.1.1. The SX mount – Sphinx

10.1.1.1. Pros

- The rod for the counterweights enters inside the setting for the transportation.
- The fixing of the optic tube: screw for tightening + safety screw.
- Dampering: 1,5 to 2 seconds, with the VMC200L
- Quick Installation and without surprise
- Discreet working noise
- Polar seeker light integrated in the mount; the Starbook supplies the power.
- Triangular Tray, consolidating the foot and for deposits of oculars

10.1.1.2. Cons

- The tripod: weak range of adjustment in height. Note: additional pilar is available in option.
- No integrated water level
- The pack of batteries of origin is little use. The cable to connect to a battery is not originally delivered
- The polar seeker light intensity is driven through the Starbook. The first level is too dark; the second is nearly too luminous. All following levels are useless (overbright).
- The serial number is not engraved on the instrument but delivered separately on a sticker.

10.1.2. The control – The Starbook

10.1.2.1. Pros

- Reliable working, without surprise
- Possibility of evolution by uploading of the updates
- Integrated planetarium
- Easy use
- The function of the push buttons is displayed to the screen
- Possibility to display the constellations

10.1.2.2. Cons

- Young product
- There is space to put a bigger LCD screen
- The hardware of the Starbook is not 100% adapted to the astronomy: glaring LCD at night, minimal temperature of service of 0º (*1)
- Connector for power supply specific, spare part difficult to find
- Ethernet cable connection not optimal; difficult to disconnect the cable with the fingers
- The delivered system is configured in Japanese
- Only 2 languages are available, Japanese and English (*2)
- A faster CPU would be more comfortable. Indeed, a light delay appears during the refresh of the screen (*3)
- A dim lightering of the push buttons would be more comfortable
- Port Ethernet underexploited, not driving by PC available (*4)

- No system for fixing the Starbook on the tripod (*5)
- Data entry of a target star not possible, unless a reference star. Access not possible to the 17635 stars and their description, because not foreseen in the menu.
- The objects of Messier are represented on the planetarium, but not the most important NGC/IC, even while zooming in. As there are few Messier objects in the southern hemisphere, there are few interesting objects displayed for the south.
- It is not possible to enter the coordinates of an object directly
- No PEC (Periodic Error Correction) available
- Not autoguider available yet (autoguider port unused) (*6)
- WinNT, Win2000 (and Mac either?) is not valid as support of update

(*) Improvement available now on currently available version (V1.2, build 27):
1. LCD light switch off function available; gray filter delivered
2. 6 Languages
3. Screen refresh time faster
4. Thanks to P. Enzerink, an ASCOM driver is now available.
5. A thin strap seems to be delivered now.
6. Available as chargeable feature

10.2. Object in Starbook' database.

The hereunder objects data are accessible from the followings menus: Messier, Stars (reference stars) and Famous objects.

Types: S= Star; Sr=Ref Star; Sd=Star-Double; EN=Emission Nebula; PN=Planetary Nebula; OC=Open Cluster; GC=Globular Cluster; G=Galaxy

Name	Number	Type.	Mag	Size [']	Target RA [h]	Target RA [m]	Target DEC [°]	Target DEC [']
Hyades	---	---	0.5	0	4	28.0	16	41
Pelican Nebula	---	---	7.0	0	20	47.8	44	21
Club Nebula	M001	EN	8.4	6	5	34.5	22	0
	M002	GC	6.5	12.9	21	33.5	0	48
	M003	GC	6.4	16.2	13	42.2	28	22
	M004	GC	5.9	26.3	16	23.6	-26	31
	M005	GC	5.8	17.4	15	18.6	2	4
Butterfly Cluster	M006	OC	4.2	15	17	40.1	-32	12
	M007	OC	3.3	80	17	53.9	-34	48
Lagoon Nebula	M008	EN	5.8	90	18	3.8	-24	22
	M009	GC	7.9	9.3	17	19.2	-18	30
	M010	GC	6.6	15.1	16	57.1	-4	5
	M011	OC	5.8	14	18	51.1	-6	15
	M012	GC	6.6	14.5	16	47.2	-1	56
Hercules Globular Cluster	M013	GC	5.9	16.6	16	41.7	36	27
	M014	GC	7.6	11.7	17	37.6	-3	14
	M015	GC	6.4	12.3	21	30.0	12	9
Eagle Nebula	M016	EN+OC	6.0	35	18	18.8	-13	46
Omega Nebula	M017	EN+OC	6.0	46	18	20.8	-16	10
	M018	OC	6.9	9	18	19.9	-17	7
	M019	GC	7.2	13.5	17	2.6	-26	15
Trifid Nebula	M020	EN+OC	6.3	29	18	2.3	-23	1
	M021	OC	5.9	13	18	4.6	-22	29

	M022	GC	5.1	24	18	36.4	-23	53
	M023	OC	5.5	27	17	56.8	-19	0
	M024	OC	11.0	5	18	18.4	-18	24
	M025	OC	4.6	32	18	31.6	-19	14
	M026	OC	8.0	15	18	45.2	-9	23
Dumbbell Nebula	M027	PN	8.1	15.2	19	59.6	22	42
	M028	GC	6.9	11.2	18	24.5	-24	51
	M029	OC	6.6	7	20	23.9	38	31
	M030	GC	7.5	11	21	40.4	-23	10
Andromeda Galaxy	M031	G	3.5	178	0	42.7	41	15
	M032	G	8.2	7.6	0	42.7	40	51
Triangulum Galaxy	M033	G	5.7	62	1	33.9	30	38
	M034	OC	5.2	35	2	42.0	42	46
	M035	OC	5.1	28	6	8.9	24	19
	M036	OC	6.0	12	5	36.1	34	7
	M037	OC	5.6	24	5	52.4	32	32
	M038	OC	6.4	21	5	28.7	35	49
	M039	OC	4.6	32	21	32.2	48	25
	M041	OC	4.5	38	6	47.0	-20	43
Orion Nebula	M042	EN	4.0	66	5	35.4	-5	26
	M043	EN	9.0	20	5	35.6	-5	15
Praesepe/beehive	M044	OC	3.1	95	8	40.1	19	58
Pleiades	M045	OC	1.5	0	3	47.5	24	6
	M046	OC	6.1	27	7	41.8	-14	48
	M047	OC	4.4	30	7	36.6	-14	29
	M048	OC	5.8	54	8	13.8	-5	47
	M049	G	8.4	8.9	12	29.8	7	59
	M050	OC	5.9	16	7	3.2	-8	19
Whirlpool Galaxy	M051	G	8.4	11	13	29.9	47	11
	M052 Build<27	OC	6.9	13	23	58.0	61	34
	M052 Build 27	OC	6.9	13	23	24.2	61	34
	M053	GC	7.7	12.6	13	12.9	18	9
	M054	GC	7.7	9.1	18	55.1	-30	28
	M055	GC	7.0	19	19	40.0	-30	57
	M056	GC	8.3	7.1	19	16.6	30	10
Ring Nebula	M057	PN	9.0	2.5	18	53.6	33	1
	M058	G	9.8	5.4	12	37.7	11	48
	M059	G	9.8	5.1	12	42.0	11	38
	M060	G	8.8	7.2	12	43.7	11	32
	M061	G	9.7	6	12	21.9	4	27
	M062	GC	6.6	14.1	17	1.2	-30	6
	M063	G	8.6	12.3	13	15.8	42	1
Blackeye Galaxy	M064	G	8.5	9.3	12	56.7	21	40
	M065	G	9.3	10	11	18.9	13	4
	M066	G	9.0	8.7	11	20.2	12	58
	M067	OC	6.9	30	8	50.4	11	48
	M068	GC	8.2	12	12	39.5	-26	44
	M069	GC	7.7	7.1	18	31.4	-32	20
	M070	GC	8.1	7.8	18	43.2	-32	17
	M071	GC	8.3	7.2	19	53.8	18	46
	M072	GC	9.4	5.9	20	53.5	-12	31

	M073	OC	9.0	3	20	59.0	-12	37
	M074	G	9.2	10.2	1	36.7	15	46
	M075	GC	8.6	6	20	6.1	-21	54
Little Dumbell	M076	PN	12.0	4.8	1	42.3	51	33
	M077	G	8.8	6.9	2	42.7	0	0
	M078	EN	8.0	8	5	46.7	0	2
	M079	GC	8.0	8.7	5	24.5	-24	32
	M080	GC	7.2	8.9	16	17.0	-22	58
	M081	G	6.9	25.7	9	55.6	69	3
	M082	G	8.4	11.2	9	55.8	69	40
	M083	G	7.6	11.2	13	37.0	-29	51
	M084	G	9.3	5	12	25.1	12	52
	M085	G	9.2	7.1	12	25.4	18	10
	M086	G	9.2	7.4	12	26.2	12	56
	M087	G	8.6	7.2	12	30.8	12	23
	M088	G	9.5	6.9	12	32.0	14	24
	M089	G	9.8	4.2	12	35.7	12	32
	M090	G	9.5	9.5	12	36.8	13	9
	M091	G	10.2	5.4	12	35.4	14	29
	M092	GC	6.5	11.2	17	17.1	43	7
	M093	OC	6.2	22	7	44.6	-23	51
	M094	G	8.2	11	12	50.9	41	6
	M095	G	9.7	7.4	10	44.0	11	41
	M096	G	9.2	7.1	10	46.8	11	48
Owl Nebula	M097	PN	11.2	3.2	11	14.8	55	0
	M098	G	10.1	9.5	12	13.8	14	53
	M099	G	9.8	5.4	12	18.8	14	24
	M100	G	9.4	6.9	12	22.9	15	48
	M101	G	7.7	26.9	14	3.2	54	20
	M102	G	10.0	5.2	15	6.5	55	45
	M103	OC	7.4	6	1	33.2	60	41
Sombrero Galaxy	M104	G	8.3	8.9	12	40.0	-11	36
	M105	G	9.3	4.5	10	47.8	12	34
	M106	G	8.3	18.2	12	18.9	47	17
	M107	GC	8.1	10	16	32.5	-13	2
	M108	G	10.1	8.3	11	11.5	55	39
	M109	G	9.8	7.6	11	57.6	53	22
	M110 (NGC205)	G	8.0	17.4	0	40.4	41	40
Sculptor Galaxy	NGC0253	G	7.1	25.1	0	47.6	-25	16
Double Clustor h	NGC0869	OC	4.0	30	2	19.0	57	8
Double Clustor x	NGC0884	OC	4.0	30	2	22.4	57	6
Rose Nebula	NGC2237	EN	6.0	0	6	30.3	5	2
Hubble's Variable Nebula	NGC2261	EN	10.0	2	6	39.2	8	43
Cone Nebula	NGC2264	EN+OC	3.9	60	6	41.1	9	52
Eskimo Nebula	NGC2392	PN	10.0	0.7	7	29.2	20	54
Spindle Galaxy	NGC3115	G	9.2	8.3	10	5.2	-7	42
Jupiter Nebula	NGC3242	PN	9.0	20.8	10	24.8	-18	37
Pinwheel Galaxy	NGC5454	G	14.0	0	14	4.7	14	22
Barnard's Galaxy	NGC6822	G	9.0	10.2	19	44.9	-14	47

Blinking Nebula	NGC6826	PN	10.0	2.3	19	44.8	50	30
Veil Nebula NGC6960	NGC6960	EN	9.0	70	20	45.7	30	42
Veil Nebula NGC6992	NGC6992	EN	8.0	60	20	56.4	31	42
North America Nebula	NGC7000	EN	5.0	120	20	58.8	44	19
Saturn Nebula	NGC7009	PN	8.0	1.7	21	4.2	-11	21
Helical Nebula	NGC7293	PN	7.0	12.8	22	29.6	-20	47
Blue Snowball	NGC7662	PN	9.0	2.2	23	25.9	42	32
Acturus		Sr	0.2	0	14	15.7	19	10
Albireo		Sr	3.2	0	19	30.7	27	57
Aldebaran		Sr	1.1	0	4	35.9	16	30
Algiedi		Sr	3.7	0	20	18.0	-12	32
Alphard		Sr	2.2	0	9	27.6	-8	39
Alpheratz		Sr	2.1	0	0	8.4	29	5
Altair		Sr	0.9	0	19	50.8	8	51
Antares		Sr	1.1	0	16	29.4	-26	25
Beta@Cap		Sr	3.2	0	20	21.0	-14	46
Betelgeuse		Sr	0.5	0	5	55.2	7	24
Capella		Sr	0.2	0	5	16.7	45	59
Deneb		Sr	1.3	0	20	41.4	45	16
Denebola		Sr	2.2	0	11	49.1	14	33
Diphda		Sr	2.2	0	0	43.6	-17	58
Dubhe		Sr	2.0	0	11	3.7	61	44
Formalhaut		Sr	1.3	0	22	57.7	-29	37
Hamal		Sr	2.2	0	2	7.2	23	27
Markab		Sr	2.6	0	23	4.8	15	12
Mesarthim		Sr	4.7	0	1	53.5	19	17
Mira		Sr	2.0	0	2	19.3	-2	58
Mirfak		Sr	1.8	0	3	24.3	49	51
Mizar		Sr	2.3	0	13	23.9	54	55
Nunki		Sr	2.1	0	18	55.2	-26	17
Polaris		Sr	2.1	0	2	30.7	89	11
Pollux		Sr	1.1	0	7	45.3	28	1
Procyon		Sr	0.5	0	7	39.3	5	13
Rasalgethi		Sr	3.5	0	17	14.7	14	23
Rasalhague		Sr	2.1	0	17	34.9	12	33
Regulus		Sr	1.3	0	10	8.4	11	57
Schedar		Sr	2.5	0	0	40.5	56	31
Sirius		Sr	-1.6	0	6	45.1	-16	42
Spica		Sr	1.1	0	13	25.2	-11	9
Vega		Sr	0.1	0	18	36.9	38	46

Status: Goto01.02.xls/ Object DB 2004Dec25
No object added on build 27.

10.3. Detail results of pointing tests

10.3.1. Test 1: How is the Sphinx compared to a reference telescope?

Local condition:

- Location: Spa, Belgium
  Lat 50 deg 28 min N
  Lon 5 deg 52 min E

- Date: 21-Aug-04
- Time: 19:30..23:00 UT

Raw results for Sphinx system:

Nr	Test	Star	Star In Seeker?	Star In ocular? (1)	Target RA [h]	Target RA [m]	Target DEC [°]	Target DEC [']	Scope RA [h]	Scope RA [m]	Scope DEC [°]	Scope DEC [']	Delta RA [ArcM]	Delta DEC [ArcM]	Delta Vector [ArcM]	Align
1	1st: Align Scope	Deneb	Yes	No	20	41.4	45	16	20	38.0	45	19	51	-3.0	51.1	Yes
2	1st: Align Scope	Vega	Yes	Yes, 24mm	18	36.9	38	46	18	37.3	38	47	-6	-1.0	6.1	Yes
3	1st: Align Scope	Acturus	Yes	No	14	15.7	19	10	14	14.5	19	5	18	5.0	18.7	Yes
4	1st: Align Scope	Dubhe	Yes	Yes, 15mm	11	3.7	61	44	11	4.4	61	53	-10.5	-9.0	13.8	Yes
5	1st: Align Scope	Schedar	Yes	Yes, 24mm	0	40.5	56	31	0	38.9	56	37	24	-6.0	24.7	Yes
6	1st: Align Scope	Albireo	Yes	Yes, 8mm	19	30.7	27	57	19	30.5	27	57	3	0.0	3.0	Yes
7	1st: Align Scope	Altair	Yes	Yes, 8mm	19	50.8	8	51	19	50.7	8	48	1.5	3.0	3.4	Yes
8	1st: Align Scope	Rasalhague	Yes	No	17	34.9	12	33	17	34.3	12	22	9	11.0	14.2	Yes
9	1st: Align Scope	Mizar	Yes	Yes, 8mm	13	23.9	54	55	13	23.7	54	54	3	1.0	3.2	Yes
10	1st: Align Scope	Alpheratz	Yes	Yes, 17mm	0	8.4	29	5	0	7.6	29	2	12	3.0	12.4	Yes
11	1st: Align Scope	Mirfak	Yes	No	3	24.3	49	51	3	22.4	50	0	28.5	-9.0	29.9	Yes
12	2nd: Test Goto	Deneb	Yes	Yes, 8mm												
13	2nd: Test Goto	Vega	Yes	Yes, 8mm												
14	2nd: Test Goto	Acturus	Yes	Yes, 9mm												
15	2nd: Test Goto	Dubhe	Yes	Yes, 8mm												
16	2nd: Test Goto	Schedar	Yes	No												
17	2nd: Test Goto	Albireo	Yes	Yes, 8mm												
18	2nd: Test Goto	Altair	Yes	No												
19	2nd: Test Goto	Rasalhague	Yes	Yes, 8mm												
20	2nd: Test Goto	Mizar	Yes	Yes, 8mm												
21	2nd: Test Goto	Alpheratz	Yes	Yes, 20mm												
22	2nd: Test Goto	Mirfak	Yes	Yes, 8mm												

(1)% value = from the center to the side of the FOV.

Raw results for Reference system (New Atlux):

Nr	Test	Star	Star In ocular? (1)	Target RA (1)	Target DEC (1)	Scope RA (1)	Scope DEC (1)	Delta RA [h:m:s]	Delta RA [h:m]	Delta RA [m]	Delta DEC [ArcM]	Delta Vector [ArcM]	Align (3)
1	1st: Align Scope	Deneb											Yes
2	1st: Align Scope	Vega											Yes
3	1st: Align Scope	Acturus											Yes
4	1st: Align Scope	Dubhe	Yes, 3..6mm	11:04.0	61°44'	11:04.3	61°44'	00:00.3	0.3	4.5	0	5	
5	1st: Align Scope	Schedar	Yes, 3..6mm	00:40.8	56°34'	00:40.2	56°29'	00:00.6	0.6	9	5	10	
6	1st: Align Scope	Albireo	Yes, 3..6mm	19:30.9	27°58'	19:31.4	27°57'	00:00.5	0.5	7.5	1	8	
7	1st: Align Scope	Altair	Yes, 3..6mm	19:51.0	8°53'	19:51.7	8°51'	00:00.7	0.7	10.5	2	11	
8	1st: Align Scope	Rasalhague	Yes, 3..6mm	17:35.1	12°33'	17:36.0	12°39'	00:00.9	0.9	13.5	6	15	
9	1st: Align Scope	Mizar	Yes, 3..6mm	13:24.1	54°54'	13:24.1	54°54'	00:00.0	0	0	0	0	
10	1st: Align Scope	Alpheratz	Yes, 3..6mm	00:08.6	29°07'	00:08.5	29°04'	00:00.1	0.1	1.5	3	3	
11	1st: Align Scope	Mirfak	Yes, 3..6mm	03:24.6	49°53'	03:24.0	49°47'	00:00.6	0.6	9	6	11	
12	2nd: Test Goto	Deneb	Yes, 3mm, 95%										
13	2nd: Test Goto	Vega	Yes, 3mm, 80%										
14	2nd: Test Goto	Acturus	Yes, 3mm, 50%										
15	2nd: Test Goto	Dubhe	Yes, 3mm, 75%										
16	2nd: Test Goto	Schedar	Yes, 3mm, 30%										
17	2nd: Test Goto	Albireo	Yes, 3mm, 85%										
18	2nd: Test Goto	Altair	Yes, 3mm, 90%										
19	2nd: Test Goto	Rasalhague	Yes, 4mm										
20	2nd: Test Goto	Mizar	Yes, 3mm, 95%										
21	2nd: Test Goto	Alpheratz	Yes, 4mm										
22	2nd: Test Goto	Mirfak	Yes, 3mm, 80%										

(1)% value = from the center to the side of the FOV.

10.3.2. Test 2: What is the use of alignment on more than 3 stars?

Local condition:

- Location: Eupen, Belgium
  Lat 50 deg 37 min N
  Lon 6 deg 1 min E

- Date: 26-Aug-04
- Time: 20:00..23:30 UT

Nr	Test	Star	Star In ocular? (1)	Target RA [h]	Target RA [m]	Target DEC [°]	Target DEC [']	Scope RA [h]	Scope RA [m]	Scope DEC [°]	Scope DEC [']	Delta RA [ArcM]	Delta DEC [ArcM]	Delta Vector [ArcM]	Align
1	1st: No align	Deneb	24mm, 90%	20	41.4	45	16	20	40.2	45	16	18	0.0	18.0	No
2	1st: No align	Schedar	No	0	40.5	56	31	0	38.6	56	30	28.5	1.0	28.5	No
3	1st: No align	Markab	No	23	4.8	15	12	23	3.5	15	14	19.5	-2.0	19.6	No
4	1st: No align	Altair	24mm, 99%	19	50.8	8	51	19	49.8	8	54	15	-3.0	15.3	No
5	1st: No align	Albireo	No	19	30.7	27	57	19	28.4	27	51	34.5	6.0	35.0	No
6	1st: No align	Acturus	No	14	15.7	19	10	14	13.7	19	10	30	0.0	30.0	No
7	1st: No align	Mizar	24mm, 90%	13	23.9	54	55	13	22.5	54	55	21	0.0	21.0	No
8	1st: No align	Rasalhague	No	17	34.9	12	33	17	32.6	12	28	34.5	5.0	34.9	No
9	1st: No align	Vega	No	18	36.9	38	46	18	34.7	38	36	33	10.0	34.5	No
10	1st: No align	Dubhe	24mm, 90%	11	3.7	61	44	11	2.2	61	43	22.5	1.0	22.5	No
11	2nd: Align on 4 stars	Deneb	24mm, 90%	20	41.4	45	16	20	40.3	45	14	16.5	2.0	16.6	1st
12	2nd: Align on 4 stars	Schedar	24mm, 70%	0	40.5	56	31	0	40.0	56	34	7.5	-3.0	8.1	2nd
13	2nd: Align on 4 stars	Rasalhague	No	17	34.9	12	33	17	35.0	12	18	-1.5	15.0	15.1	3rd
14	2nd: Align on 4 stars	Mizar	8mm, 100%	13	23.9	54	55	13	24.1	55	2	-3	-7.0	7.6	4th
15	2nd: Align on 4 stars	Markab	No	23	4.8	15	12	23	5.9	15	8	-16.5	4.0	17.0	No
16	2nd: Align on 4 stars	Vega	8mm, 90%	18	36.9	38	46	18	37.3	38	45	-6	1.0	6.1	No
17	2nd: Align on 4 stars	Altair	8mm, 90%	19	50.8	8	51	19	50.5	8	47	4.5	4.0	6.0	No
18	2nd: Align on 4 stars	Dubhe	8mm, 70%	11	3.7	61	44	11	3.5	61	38	3	6.0	6.7	No
19	2nd: Align on 4	Albireo	8mm, 100%	19	30.7	27	57	19	30.8	27	57	-1.5	0.0	1.5	No

	stars														
20	3rd: Align on 9 stars	Markab	24mm, 105%	23	4.8	15	12	23	5.9	15	7	-16.5	5.0	17.2	5th
21	3rd: Align on 9 stars	Vega	8mm, 75%	18	36.9	38	46	18	37.1	38	49	-3	-3.0	4.2	6th
22	3rd: Align on 9 stars	Dubhe	8mm, 90%	11	3.7	61	44	11	3.5	61	40	3	4.0	5.0	7th
23	3rd: Align on 9 stars	Altair	8mm, 80%	19	50.8	8	51	19	50.5	8	52	4.5	-1.0	4.6	8th
24	3rd: Align on 9 stars	Albireo	8mm, 30%	19	30.7	27	57	19	30.8	27	54	-1.5	3.0	3.4	9th
25	4th: Check Align	Schedar	8mm, 60%	0	40.5	56	31	0	40.4	56	31	1.5	0.0	1.5	No
26	4th: Check Align	Deneb	8mm, 5%	20	41.4	45	16	20	41.4	45	20	0	-4.0	4.0	No
27	4th: Check Align	Markab	24mm, 100%	23	4.8	15	12	23	5.7	15	9	-13.5	3.0	13.8	No
28	4th: Check Align	Mizar	11mm, 100%	13	23.9	54	55	13	23.5	54	53	6	2.0	6.3	No
29	4th: Check Align	Altair	8mm, 80%	19	50.8	8	51	19	50.6	8	52	3	-1.0	3.2	No
30	4th: Check Align	Dubhe	8mm, 30%	11	3.7	61	44	11	3.4	61	44	4.5	0.0	4.5	No
31	4th: Check Align	Altair	8mm, 70%	19	50.8	8	51	19	50.6	8	53	3	-2.0	3.6	No
32	4th: Check Align	Rasalhague	8mm, 100%	17	34.9	12	33	17	34.6	12	41	4.5	-8.0	9.2	No
33	4th: Check Align	Vega	8mm, 60%	18	36.9	38	46	18	36.7	38	45	3	1.0	3.2	No
34	4th: Check Align	Capella	17mm, 100%	5	16.7	45	59	5	16.2	46	10	7.5	-11.0	13.3	No
35	4th: Check Align	Albireo	8mm, 90%	19	30.7	27	57	19	30.5	27	56	3	1.0	3.2	No
36	5th: Test Goto on the same location	Markab	24mm, 90%	23	4.8	15	12	23	5.6	15	9	-12	3.0	12.4	No
37	5th: Test Goto on the same location	Dubhe	8mm, 100%	11	3.7	61	44	11	3.3	61	43	6	1.0	6.1	No
38	5th: Test Goto on the same location	Vega	8mm, 100%	18	36.9	38	46	18	36.6	38	45	4.5	1.0	4.6	No
39	5th: Test Goto on the same	Markab	24mm, 80%	23	4.8	15	12	23	5.6	15	6	-12	6.0	13.4	No

	location														
40	5th: Test Goto on the same location	Dubhe	9mm, 100%	11	3.7	61	44	11	3.4	61	43	4.5	1.0	4.6	No
41	5th: Test Goto on the same location	Vega	9mm, 100%	18	36.9	38	46	18	36.6	38	44	4.5	2.0	4.9	No

(1)% value = from the center to the side of the FOV.

10.3.3. Test 3: Is the scope responding to its advertising?

Local condition:

- Location: Eupen, Belgium
  Lat 50 deg 37 min N
  Lon 6 deg 1 min E

- Date: 14-Sep-04
- Time: 20:00..21:30 UT

Nr	Test	Star	Target RA [h]	Target RA [m]	Target DEC [°]	Target DEC [']	Scope RA [h]	Scope RA [m]	Scope DEC [°]	Scope DEC [']	Delta RA [m]	Delta RA [ArcM]	Delta DEC [ArcM]	Delta Vector [ArcM]	Align
1	1st: Align Scope	Markab	23	4.8	15	12	23	0.3	15	14	4.5	67.5	-2.0	67.5	1st
2	1st: Align Scope	Deneb	20	41.4	45	16	20	43.4	45	28	-2.0	-30	-12.0	32.3	2nd
3	1st: Align Scope	Rasalhague	17	34.9	12	33	17	33.8	11	43	1.1	16.5	50.0	52.7	3rd
4	2nd: Test Goto	Mizar	13	23.9	54	55	13	22.9	55	16	1.0	15	-21.0	25.8	No
5	2nd: Test Goto	Altair	19	50.8	8	51	19	50.6	8	29	0.2	3	22.0	22.2	No
6	2nd: Test Goto	Alpheratz	0	8.4	29	5	0	7.3	29	14	1.1	16.5	-9.0	18.8	No
7	2nd: Test Goto	Mirfak	3	24.3	49	51	3	21.3	50	21	3.0	45	-30.0	54.1	No
8	2nd: Test Goto	Acturus	14	15.7	19	10	14	15.4	19	37	0.3	4.5	-27.0	27.4	No
9	2nd: Test Goto	Altair	19	50.8	8	51	19	50.6	8	31	0.2	3	20.0	20.2	No
10	2nd: Test Goto	Dubhe	11	3.7	61	44	10	58.8	61	49	4.9	73.5	-5.0	73.7	No
11	2nd: Test Goto	Vega	18	36.9	38	46	18	38.8	38	39	-1.9	-28.5	7.0	29.3	No
12	2nd: Test Goto	Rasalgethi	17	14.7	14	23	17	14.6	14	34	0.1	1.5	-11.0	11.1	No
13	2nd: Test Goto	Hamal	2	7.2	23	27	2	5.7	23	44	1.5	22.5	-17.0	28.2	No
14	2nd: Test Goto	Capella	5	16.7	45	59	5	13.8	46	43	2.9	43.5	-44.0	61.9	No

10.3.4. Test 4: Which pointing precision can be expected?

Local condition:

- Location: Eupen, Belgium
  Lat 50 deg 37 min N
  Lon 6 deg 1 min E

- Date: 22-Oct-04
- Time: 20:00..22:15 UT

Nr	Test	Star	Target RA [h]	Target RA [m]	Target DEC [°]	Target DEC [']	Scope RA [h]	Scope RA [m]	Scope DEC [°]	Scope DEC [']	Delta RA [m]	Delta RA [ArcM]	Delta DEC [ArcM]	Delta Vector [ArcM]	Align
1	1st: Align Scope	Vega	18	36.9	38	46									1st
2	1st: Align Scope	Deneb	20	41.4	45	16									2nd
3	1st: Align Scope	Altair	19	50.8	8	51									3rd
4	1st: Align Scope	Rasalhague	17	34.9	12	33									4th
5	1st: Align Scope	Beta@cap	20	21.0	-14	46									5th
6	1st: Align Scope	Mizar	13	23.9	54	55									6th
7	1st: Align Scope	Dubhe	11	3.7	61	44									7th
8	1st: Align Scope	Schedar	0	40.5	56	31									8th
9	1st: Align Scope	Markab	23	4.8	15	12									9th
10	1st: Align Scope	Hamal	2	7.2	23	27									10th
11	1st: Align Scope	Capella	5	16.7	45	59									11th
12	1st: Align Scope	Mirfak	3	24.3	49	51									12th
13	1st: Align Scope	Alpheratz	0	8.4	29	5									13th
14	1st: Align Scope	Formalhaut	22	57.7	-29	37									14th
15	Test Goto	Vega	18	36.9	38	46	18	36.6	38	42	0.3	4.5	4.0	6.0	No
16	Test Goto	Schedar	0	40.5	56	31	0	41.3	56	32	-0.8	-12	-1.0	12.0	No
17	Test Goto	Albireo	19	30.7	27	57	19	30.3	27	54	0.4	6	3.0	6.7	No
18	Test Goto	Alpheratz	0	8.4	29	5	0	8.4	29	9	0.0	0	-4.0	4.0	No
19	Test Goto	Deneb	20	41.4	45	16	20	41.0	45	14	0.4	6	2.0	6.3	No
20	Test Goto	Diphda	0	43.6	-17	58	0	43.6	-17	57	0.0	0	1.0	1.0	No
21	Test Goto	Dubhe	11	3.7	61	44	11	2.8	62	13	0.9	13.5	-29.0	32.0	No
22	Test Goto	Aldebaran	4	35.9	16	30	4	35.7	16	44	0.2	3	-14.0	14.3	No
23	Test Goto	Mizar	13	23.9	54	55	13	23.6	54	55	0.3	4.5	0.0	4.5	No
24	Test Goto	Altair	19	50.8	8	51	19	50.4	8	48	0.4	6	3.0	6.7	No
25	Test Goto	Mirfak	3	24.3	49	51	3	24.5	49	48	-0.2	-3	3.0	4.2	No

26	Test Goto	Hamal	2	7.2	23	27	2	6.8	23	24	0.4	6	3.0	6.7	No
27	Test Goto	Aldebaran	4	35.9	16	30	4	35.7	16	38	0.2	3	-8.0	8.5	No
28	Test Goto	Capella	5	16.7	45	59	5	16.3	45	55	0.4	6	4.0	7.2	No
29	Test Goto	Vega	18	36.9	38	46	18	36.2	38	45	0.7	10.5	1.0	10.5	No
30	Test Goto	Markab	23	4.8	15	12	23	4.2	15	10	0.6	9	2.0	9.2	No
31	Test Goto	Schedar	0	40.5	56	31	0	41.4	56	32	-0.9	-13.5	-1.0	13.5	No
32	Test Goto	Albireo	19	30.7	27	57	19	30.1	27	54	0.6	9	3.0	9.5	No
33	Test Goto	Dubhe	11	3.7	61	44	11	2.0	62	10	1.7	25.5	-26.0	36.4	No
34	Test Goto	Deneb	20	41.4	45	16	20	40.4	45	13	1.0	15	3.0	15.3	No
35	Test Goto	Hamal	2	7.2	23	27	2	6.7	23	25	0.5	7.5	2.0	7.8	No
36	Check Pointing	Betelgeuse	5	55.2	7	24	5	54.9	7	36	0.3	4.5	-12.0	12.8	No

10.3.5. Test 5: Starbook Goto' precision versus software solution

10.3.5.1. Phase 1: No alignment

Local condition:

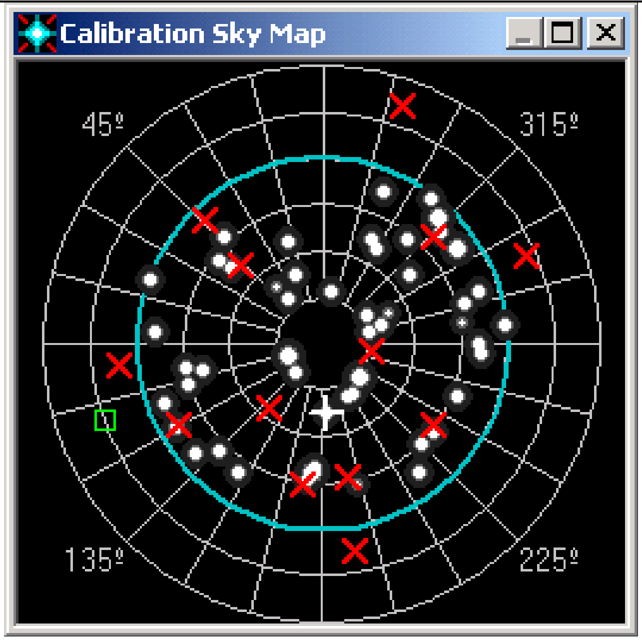
- Location: Spa, Belgium
  Lat 50 deg 28 min N
  Lon 5 deg 52 min E

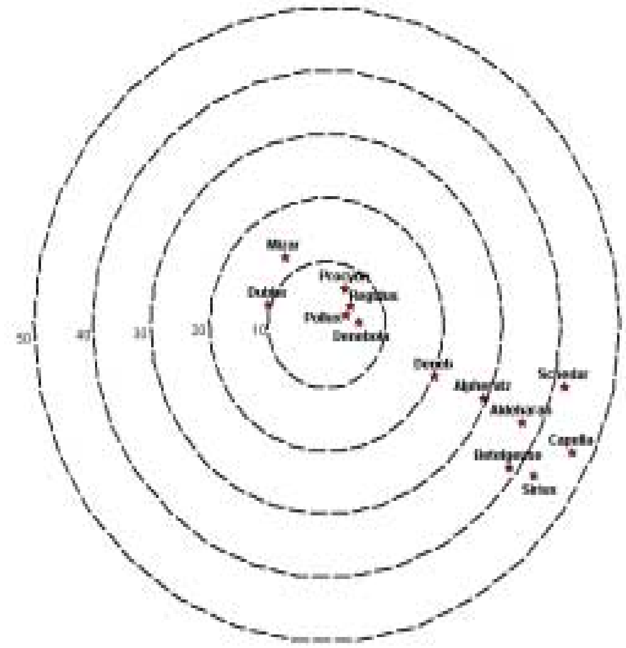
- Date: 7-Feb-05
- Time: 20:20..22:30 UT
- Temperature: -3°C, clear sky, no Moon, little turbulence

Miscellaneous:

- Starbook Software Revision: V1.2, build 26
- ASCOM 4.01
- Sphinx Driver 4.2.30 (P. Enzerink, 20041029)
- MaxIm V4.06 // MaxPoint V1.0.13 (www.cyanogen.com)

All the stars in the MaxPoint Visible Bright Star list on the Control Panel are shown as white dots. Actual calibration observations made are shown as red X's. The second graph beside shows the error distribution (in arc minutes), while depicting for each reference star the RA error (X) and the DEC error (Y).





Nr	Test	Star	Target RA [h]	Target RA [m]	Target DEC [°]	Target DEC [']	Scope RA [h]	Scope RA [m]	Scope DEC [°]	Scope DEC [']	Delta RA [m]	Delta RA [ArcM]	Delta DEC [ArcM]	Delta Vector [ArcM]	Align
1	1st: Align Scope	Procyon	7	39.3	5	13									1st
15	Test Goto	Betelgeuse	5	55.2	7	24	5	53.10	7	47.00	2.1	31.5	-23.0	39.0	No
16	Test Goto	Pollux	7	45.3	28	1	7	45.10	28	0.00	0.2	3	1.0	3.2	No
17	Test Goto	Alpheratz	0	8.4	29	5	0	6.60	29	17.00	1.8	27	-12.0	29.5	No
18	Test Goto	Dubhe	11	3.7	61	44	11	4.40	61	42.00	-0.7	-10.5	2.0	10.7	No
19	Test Goto	Schedar	0	40.5	56	31	0	37.80	56	42.00	2.7	40.5	-11.0	42.0	No
20	Test Goto	Mizar	13	23.9	54	55	13	24.40	54	45.00	-0.5	-7.5	10.0	12.5	No
21	Test Goto	Capella	5	16.7	45	59	5	13.90	46	20.00	2.8	42	-21.0	47.0	No
22	Test Goto	Deneb	20	41.4	45	16	20	40.20	45	25.00	1.2	18	-9.0	20.1	No
23	Test Goto	Aldebaran	4	35.9	16	30	4	33.70	16	46.00	2.2	33	-16.0	36.7	No
24	Test Goto	Regulus	10	8.4	11	57	10	8.10	11	55.00	0.3	4.5	2.0	4.9	No
25	Test Goto	Denebola	11	49.1	14	33	11	48.70	14	34.00	0.4	6	-1.0	6.1	No
26	Test Goto	Procyon	7	39.3	5	13	7	39.10	5	8.00	0.2	3	5.0	5.8	No
27	Test Goto	Sirius	6	45.1	-16	42	6	42.80	-16	41.00	2.3	34.5	1.0	34.5	No

10.3.5.2. Phase 2: Alignment through the Starbook

Local conditions:

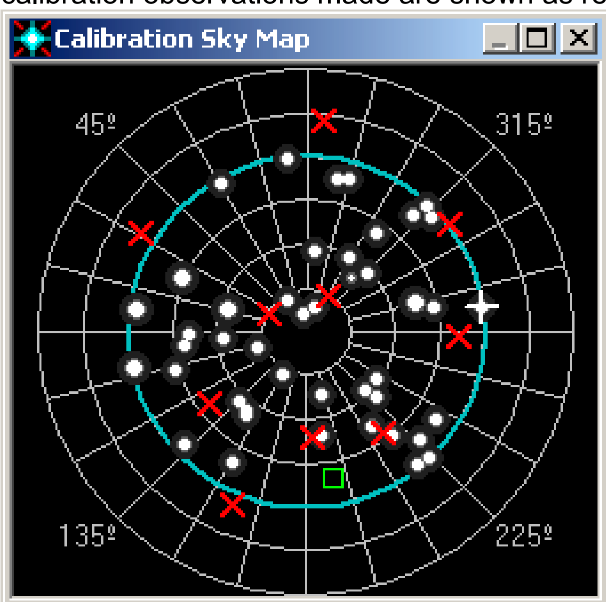
- Location: Spa, Belgium
  Lat 50 deg 28 min N
  Lon 5 deg 52 min E

- Date: 22-Apr-05
- Time: 20:20..21:45 UT
- Temperature: 5°C, clear sky, Full Moon, little turbulence

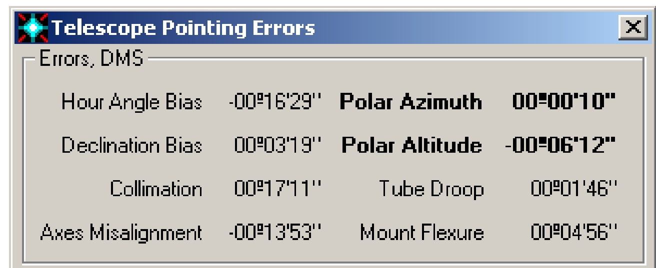
Miscellaneous:

- Starbook Software Revision: V1.2, build 26
- ASCOM 4.01
- Sphinx Driver 4.2.30 (P. Enzerink)
- MaxIm V4.06 // MaxPoint V1.0.13 (www.cyanogen.com)

All the stars in the MaxPoint Visible Bright Star list on the Control Panel are shown as white dots. Actual calibration observations made are shown as red X's.



Telescope Pointing errors:



Nr	Test	Star	Target RA [h]	Target RA [m]	Target DEC [°]	Target DEC [']	Scope RA [h]	Scope RA [m]	Scope DEC [°]	Scope DEC [']	Delta RA [m]	Delta RA [ArcM]	Delta DEC [ArcM]	Delta Vector [ArcM]	Align
1	Test Goto	Regulus	10	8.4	11	57	10	7.7	11	48	0.7	10.5	9.0	13.8	10 made
2	Test Goto	Capella	5	16.7	45	59	5	15.90	46	1.00	0.8	12	-2.0	12.2	10 made
3	Test Goto	Mizar	13	23.9	54	55	13	24.10	54	54.00	-0.2	-3	1.0	3.2	10 made
4	Test Goto	Pollux	7	45.3	28	1	7	44.80	28	6.00	0.5	7.5	-5.0	9.0	10 made
5	Test Goto	Denebola	11	49.1	14	33	11	50.40	14	32.00	-1.3	-19.5	1.0	19.5	10 made
6	Test Goto	Acturus	14	15.7	19	10	14	15.50	19	9.00	0.2	3	1.0	3.2	10 made
7	Test Goto	Spica	13	25.2	-11	9	13	25.10	-12	56.00	0.1	1.5	13.0	13.1	10 made
8	Test Goto	Dubhe	11	3.7	61	44	11	3.10	61	40.00	0.6	9	4.0	9.8	10 made
9	Test Goto	Schedar	0	40.5	56	31	0	40.10	56	23.00	0.4	6	8.0	10.0	10 made
10	Test Goto	Vega	18	36.9	38	46	18	35.90	38	59.00	1.0	15	-13.0	19.8	10 made

10.3.5.3. Phase 3: Alignment through Maxpoint

Local conditions:

- Location: Spa, Belgium
  Lat 50 deg 28 min N
  Lon 5 deg 52 min E

- Date: 27-May-05
- Time: 20:30..22:45 UT
- Temperature: 20°C, clear sky, no moon, little turbulence

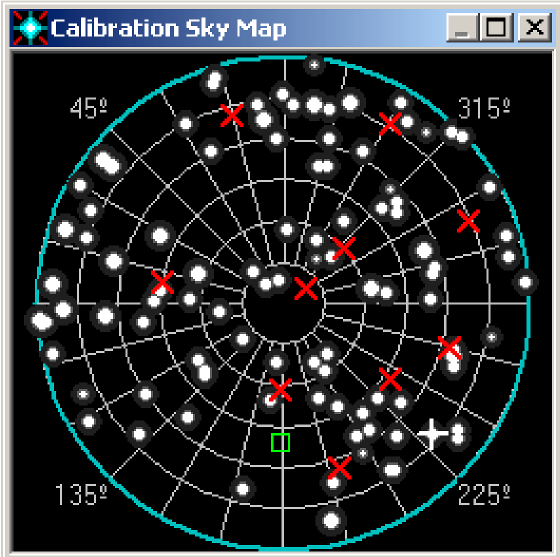
Miscellaneous:

- Starbook Software Revision: V1.2, build 26
- ASCOM 4.01
- Sphinx Driver 4.2.68 (P. Enzerink)
- MaxIm V4.06 // MaxPoint V1.0.13 (www.cyanogen.com)
- Vixen VMC200L (D=200 mm, FL=1950 mm) // Eyepiece: Vixen LV zoom 8-24 mm

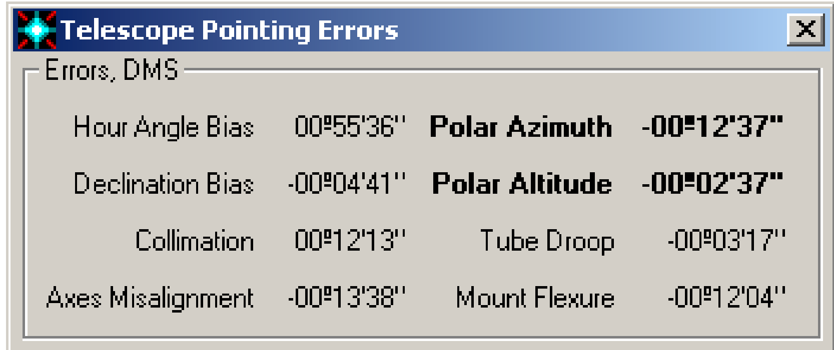
The following table shows the errors for the reference stars (difference between real coordinates and MaxPoint-corrected coordinates after recentering).

Star	RA error arcmin	DECerror arcmin	Error arcmin
Regulus	2.810855	-1.93227	3.410949
Capella	0.239623	3.448379	3.456694
Mizar	2.598978	0.441372	2.63619
Pollux	3.465393	-0.70476	3.53633
Denebola	2.180069	-0.54177	2.246379
Arcturus	0.144139	1.123443	1.132652
Spica	4.196679	-2.57015	4.921159
Dubhe	-0.37815	0.761194	0.849948
Schedar	3.259099	-1.7829	3.714896
Vega	0.7511	-3.25806	3.343514

All the stars in the MaxPoint Visible Bright Star list on the Control Panel are shown as white dots. Actual calibration observations made are shown as red X's.



Telescope Pointing errors



10.3.6. Test 6: What's up with the latest revision?

Local condition:

- Location: Eupen, Belgium
  Lat 50 deg 37 min N
  Lon 6 deg 1 min E

- Date: 09-Jul-05
- Time: 21:00..22:30 UT
- Temperature 17°C, Clear sky, No Moon, little turbulence

Miscellaneous:

- Vixen VMC200L (D=200 mm, FL=1950 mm)
- Eyepiece: Vixen LV zoom 8-24 mm

Nr	Test	Star	Target RA [h]	Target RA [m]	Target DEC [°]	Target DEC [']	Scope RA [h]	Scope RA [m]	Scope DEC [°]	Scope DEC [']	Delta RA [ArcM]	Delta DEC [ArcM]	Delta Vector [ArcM]	Align
1	1. Align	Vega												1st
2	1. Align	Altair												2nd
3	1. Align	Deneb												3rd
4	1. Align	Acturus												4th
5	1. Align	Denebola												5th
6	1. Align	Dubhe												6th
7	1. Align	Mizar												7th
8	1. Align	Albireo												8th
9	1. Align	Rasalhague												9th
10	1. Align	Schedar												10th
11	2. Test Goto	Vega	18	36.9	38	46	18	37.1	38	44	-3	2.0	3.6	10 made
12	2. Test Goto	Altair	19	50.8	8	51	19	50.70	8	59.00	1.5	-8.0	8.1	10 made
13	2. Test Goto	Deneb	20	41.4	45	16	20	41.50	45	16.00	-1.5	0.0	1.5	10 made
14	2. Test Goto	Acturus	14	15.7	19	10	14	15.50	19	14.00	3	-4.0	5.0	10 made
15	2. Test Goto	Denebola	11	49.1	14	33	11	48.90	14	28.00	3	5.0	5.8	10 made
16	2. Test Goto	Dubhe	11	3.7	61	44	11	3.50	61	46.00	3	-2.0	3.6	10 made
17	2. Test Goto	Mizar	13	23.9	54	55	13	23.60	54	54.00	4.5	1.0	4.6	10 made
18	2. Test Goto	Albireo	19	30.7	27	57	19	31.50	28	6.00	-12	-9.0	15.0	10 made
19	2. Test Goto	Rasalhague	17	34.9	12	33	17	34.90	12	37.00	0	-4.0	4.0	10 made
20	2. Test Goto	Schedar	0	40.5	56	31	0	40.80	56	30.00	-4.5	1.0	4.6	10 made
21	2. Test Goto	M005	15	18.6	2	4	15	17.70	2	5.00	13.5	-1.0	13.5	10 made

22	2. Test Goto	M011		18	51.1	-6	15	18	50.70	-6	14.00	6	1.0	6.1	10 made
23	2. Test Goto	M012		16	47.2	-1	56	16	46.20	-2	7.00	15	-11.0	18.6	10 made
24	2. Test Goto	M013		16	41.7	36	27	16	42.00	36	21.00	-4.5	6.0	7.5	10 made

10.3.7. Flight case

End of document.