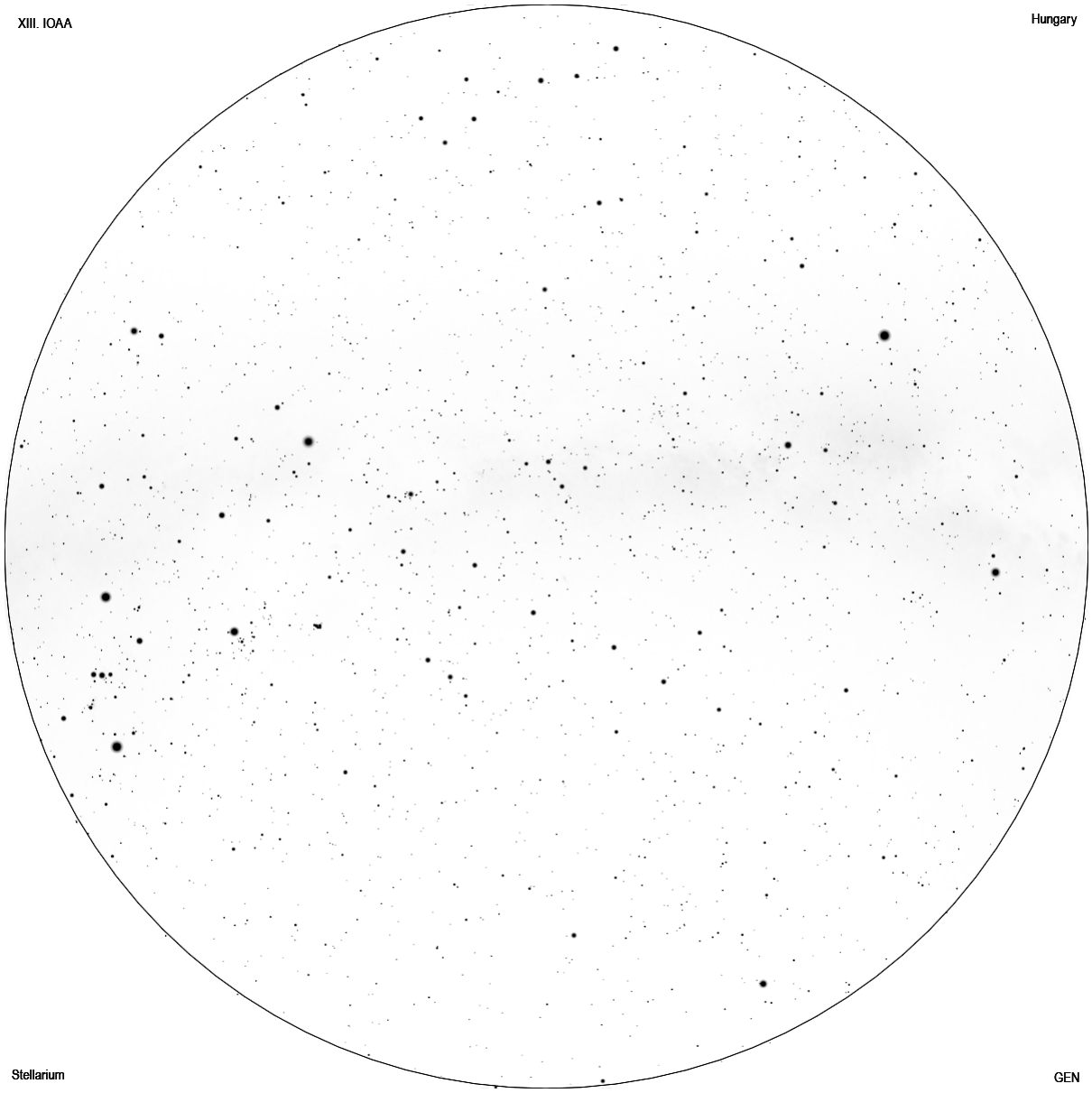
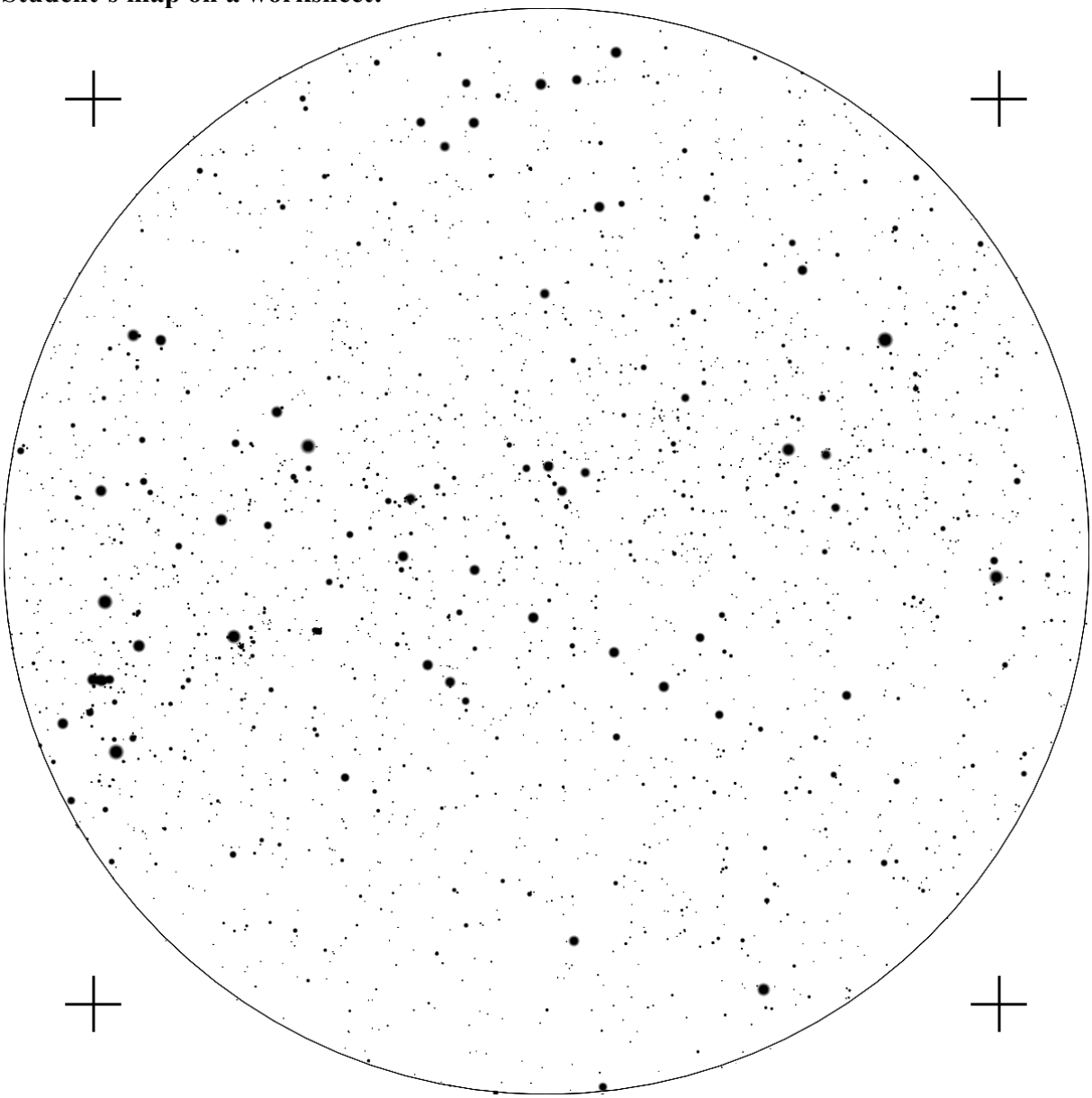
PLANETARIUM ROUND – SOLUTIONS AND MARKING SCHEME

PROBLEM 1

The first projected planetarium image:



Student's map on a worksheet:



This is the sky above Keszthely at 24^h. The map does not show Solar System objects.

Warning and request for national translators:
Please don't move this image from the center of page of student's worksheet.
Please don't resize this image of student's worksheet.
Thank you.

TASKS, SOLUTIONS, MARKING:

1.1. There are 3 novae on the projected sky at 2 magnitude. Find them, and label them by circles on your answer sheet's stellar map, at their right position. See the map on next page. (Each circle at wrong position(s) causes 1 point decrease.)

Solution: See the stellar map below.

Marking: 3 points/each nova (wrong position: minus 1 point) **maximum: 9 points**

1.2. Mark all globular clusters with X signs on the stellar map attached to your answer sheet, which are members of the Messier catalogue and visible in the projected sky. Write the Messier number of these objects near the X labels.

Solution: See the stellar map below. Visible globular clusters: M2, M13, M15, M30, M56, M71, M72, M92.

Marking: good position (signed by X): max. 3 points/each. There will be a transparent checking mask (inner circle 5° and outer circle 10° in diameter). X inside the inner circle = 2 points, outer circle 1 point. Good Messier number 1 point/each.

maximum: 24 points

1.3. In which month can you see these constellations (at midnight) in Keszthely?

Solution: October 19, 2019.

Marking: October = 2 points, September or November = 1 point **maximum: 2 points**

1.4. What is the sidereal time? (To the accuracy of 15 minutes.)

Solution: sidereal time is 1h 00m. Suggested method: Gamma Cassiopeiae is near upper culmination. Its RA is 00h 57m. See the stellar map below (meridian).

Marking: 1h 00m = 3 points, ±15m (1h 15m or 0h 45m) = 2 points, ±30m (1h 30m or 0h 30m) = 1 point **maximum: 3 points**

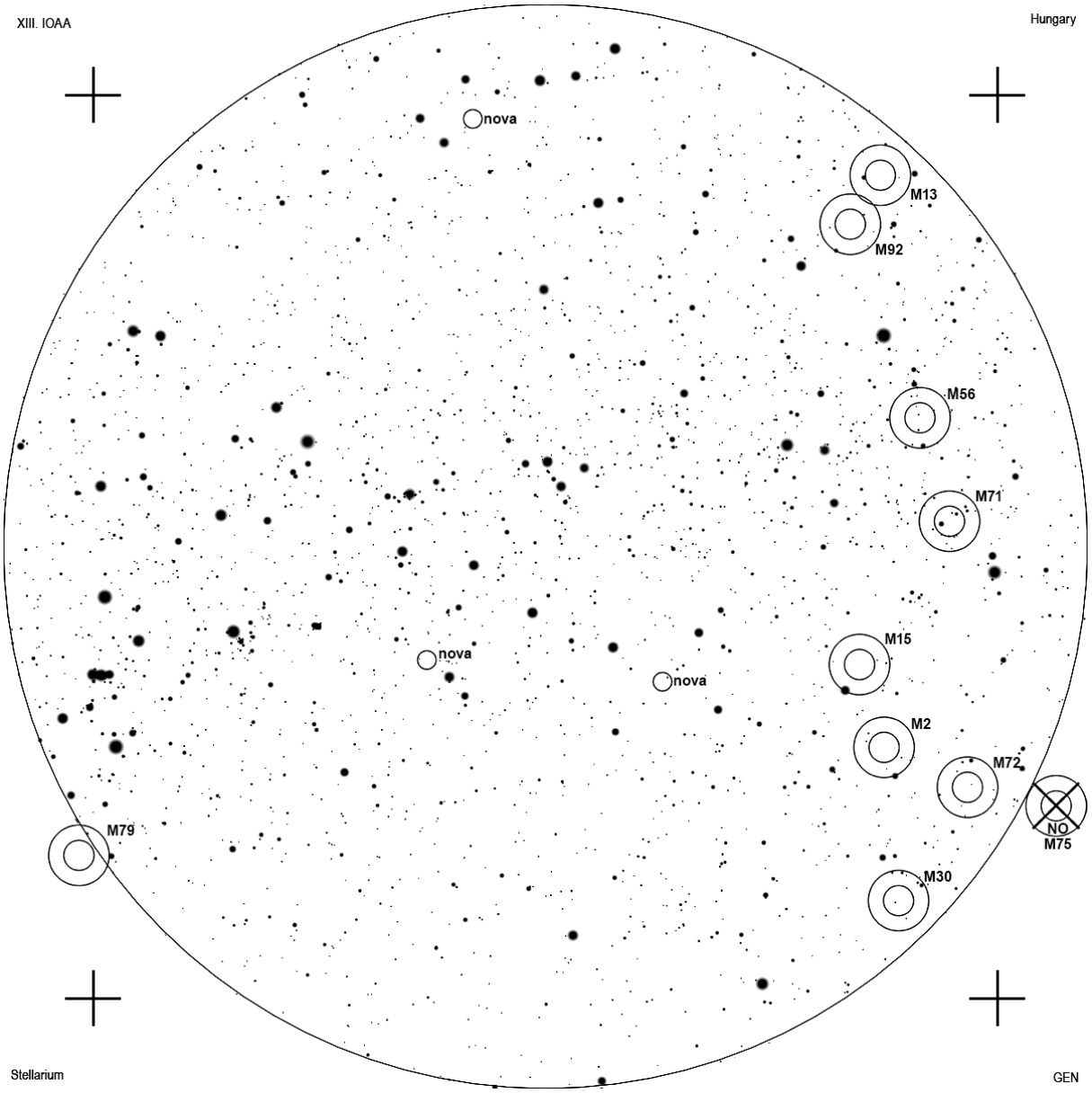
1.5. List at least six zodiacal constellations, which partly or entirely can be seen in the shown sky. (Use the official IAU names or abbreviations.)

Solution: Sagittarius (Sgr), Capricornus (Cap), Aquarius (Aqr), Pisces (Psc), Aries (Ari), Taurus (Tau), Gemini (Gem), Cancer (Cnc).

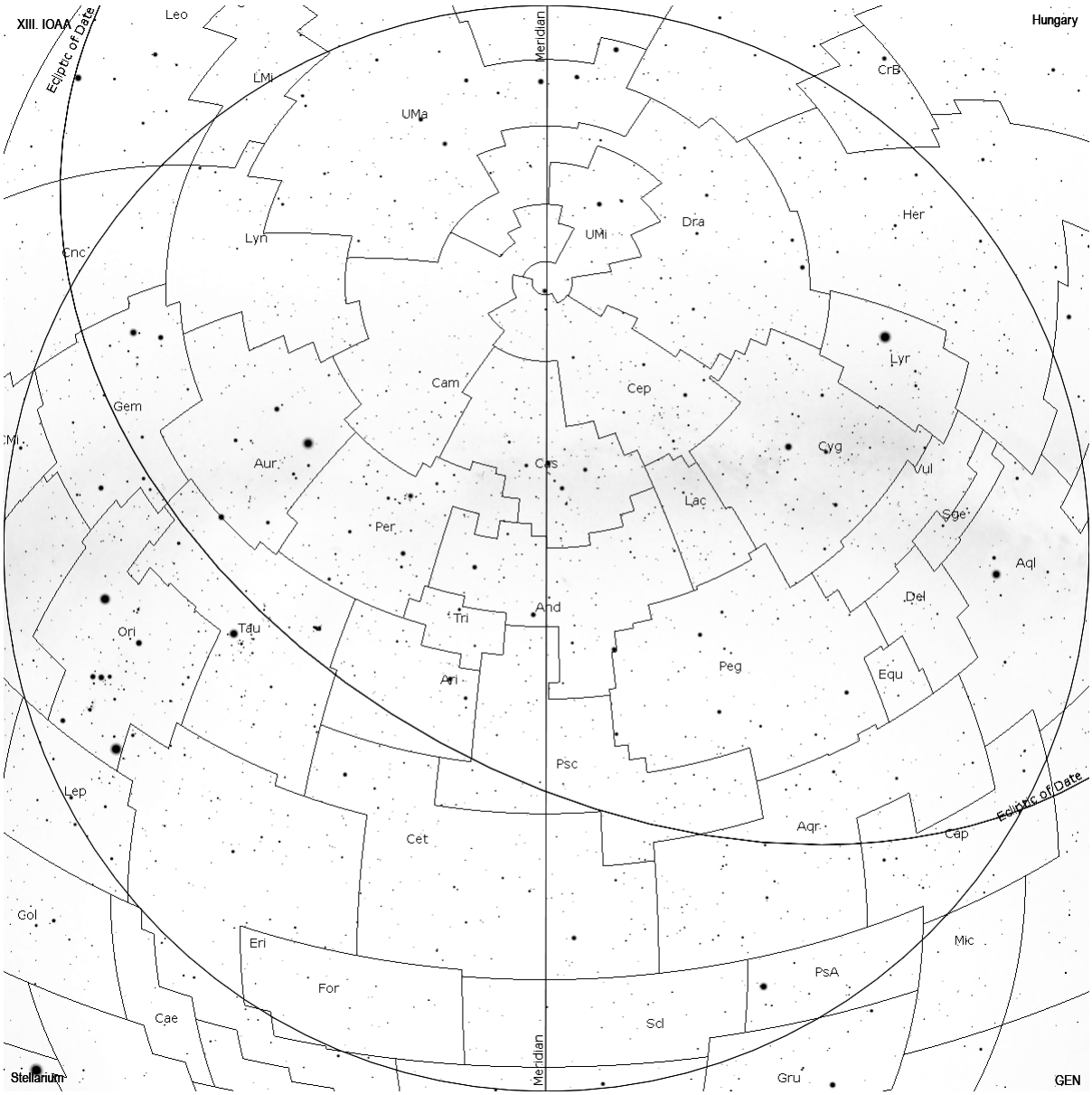
See the stellar map below.

Marking: 1 points/each constellation **maximum: 6 points**

1.1. and 1.2. Places of novae, globular clusters and check masks on transparent checking foil:

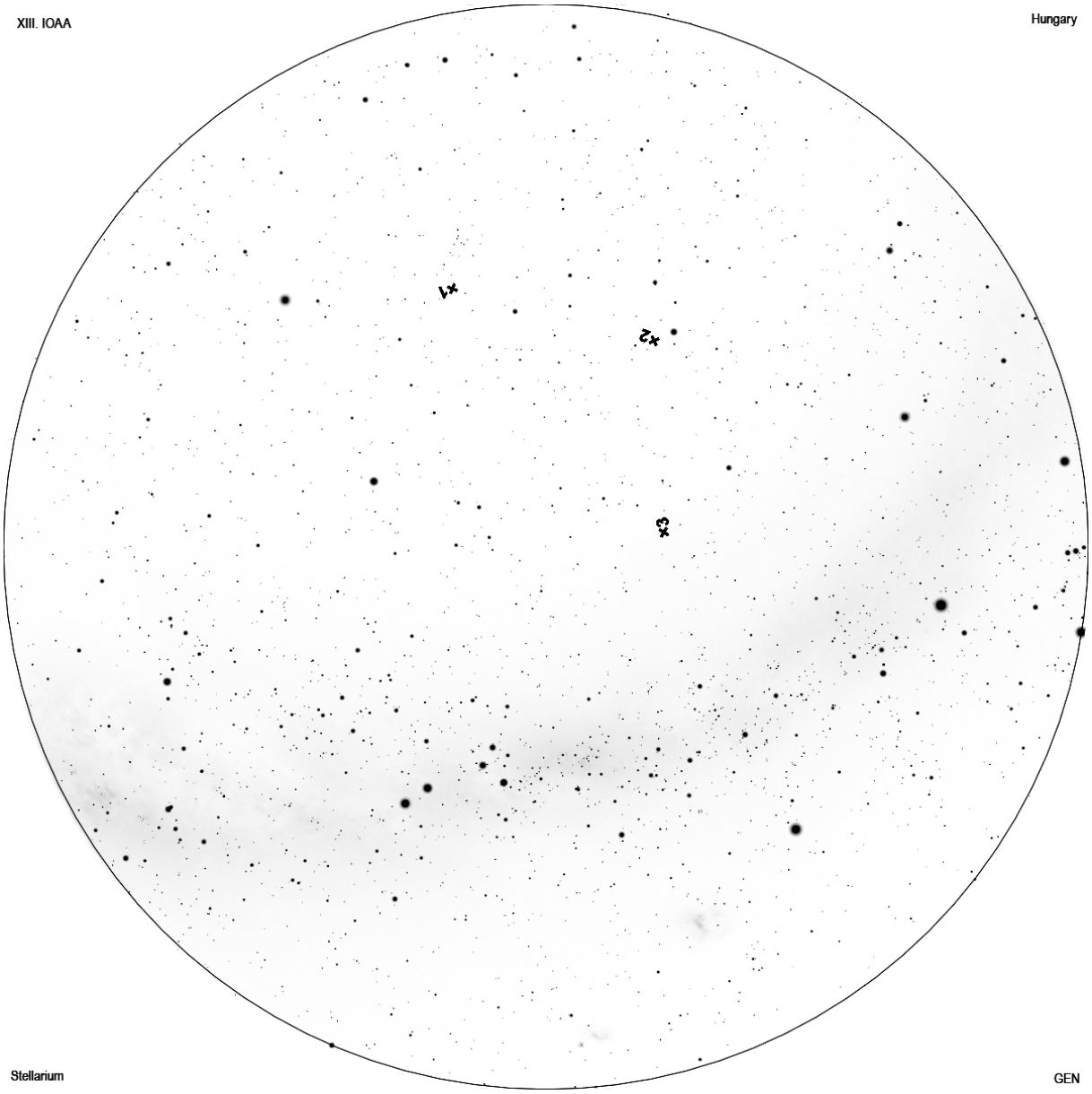


1.5. Visible zodiacal constellations:



PROBLEM 2

The second projected planetarium image:



We are standing somewhere on the Earth. The map does not show Solar System objects.

TASKS, SOLUTIONS, MARKING:

2.1. Determine the geographical latitude of this observing site: …….°
Its hemisphere: N / S (Circle the right one.)

Solution: Geographical latitude of this observing site: **25°**. Constellation Crux shows us the direction the southern celestial pole. The altitude of pole give us our latitude.

Marking: latitude between 24–26° = 2 points, within ±3° (22°, 23°, 27°, 28°) = 1 point
Marking: Southern hemisphere = 1 point

maximum: 3 points

2.2. Determine the Azimuth of the 3 brightest star on the projected sky. Azimuth is measured from South to the direction West 0-360°. Write the name of these stars in English or using their Bayer name. (Incorrect star position in a list or on the map causes 1 point decrease.)

1st brightest star / name: …… Az: ……°
2nd brightest star / name: …… Az: ……°
3rd brightest star / name: …… Az: ……°

Solution:
1st. brightest star / name: **Sirius (α CMa) Az: 82°** (74°-90° = 2 points, 64°-74° and 90°-100° = 1 point)
2nd brightest star / name: **Canopus (α Car) Az: 42°** (34°-50° = 2 points, 24°-34° and 50°-66° = 1 point)
3rd brightest star / name: **Toliman (α Cen) Az: 331°** (324°-339° = 2 points, 314°-324° and 339°-349° = 1 point)

Rank	Visual magnitude (m_V)	Proper name[1]	Bayer designation
1	−26.74	Sun	
2	−1.46	Sirius	α CMa
3	−0.74	Canopus	α Car
4	−0.27 (0.01 + 1.33)	Rigil Kentaurus & Toliman	α Cen
5	−0.05	Arcturus	α Boo
6	0.03 (−0.02–0.07var)	Vega	α Lyr
7	0.08 (0.03–0.16var)	Capella	α Aur
8	0.13 (0.05–0.18var)	Rigel	β Ori
9	0.34	Procyon	α CMi
10	0.46 (0.40–0.46var)	Achernar	α Eri

Source: https://en.wikipedia.org/wiki/List_of_brightest_stars

Marking:
Proper name on a dotted line (in a list) = 2 points each.

Azimuth angles within ±2° = 2 points each, within ±5° 1 point each.
Incorrect position in a list = -1 point.

maximum: 12 points

2.3. Yellow × signs show the positions of 3 comets. Witch comet is in the closest position to ecliptic? (Write the number of nearest comet on the dotted line.)

Solution: The number two comet is in closest position to ecliptic. (Distances of our comets from ecliptic: No. 1 = 20°, No. 2 = 0°, No. 3 = 30°). The connecting line between Regulus and Spica approximately shows us the direction of ecliptic.

Marking: Number two comet = 2 points **maximum: 2 points**

2.4. List the circumpolar constellations seen from the given observing site, using their IAU abbreviations or 'standard' names.

Solution and Marking:

1 point for each of: Octans (Oct), Mensa (Men), Chamaeleon (Cha), Apus (Aps), Hydrus (Hyi), Volans (Vol), Carina (Car), Musca (Mus), Circinus (Cir), Triangulum Australe (TrA), Pavo (Pav), Indus (Ind), Tucana (Tuc), Horologium (Hor), Ara (Ara)

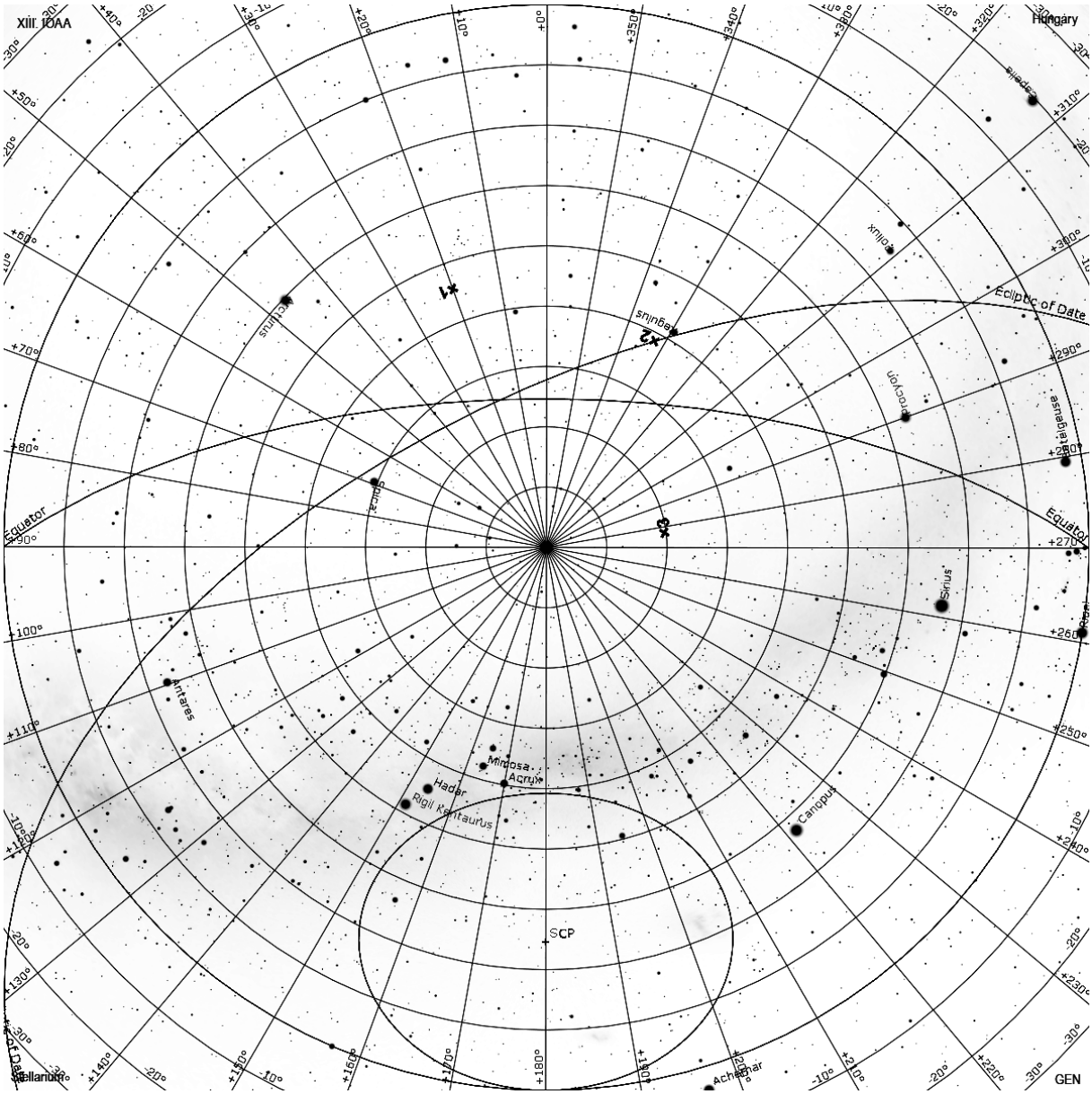
maximum: 9 points

2.5. Mintaka (δ Orionis = delta Orionis) is setting at this moment. How many hours earlier did it rise? (To the accuracy of 15 minutes.)

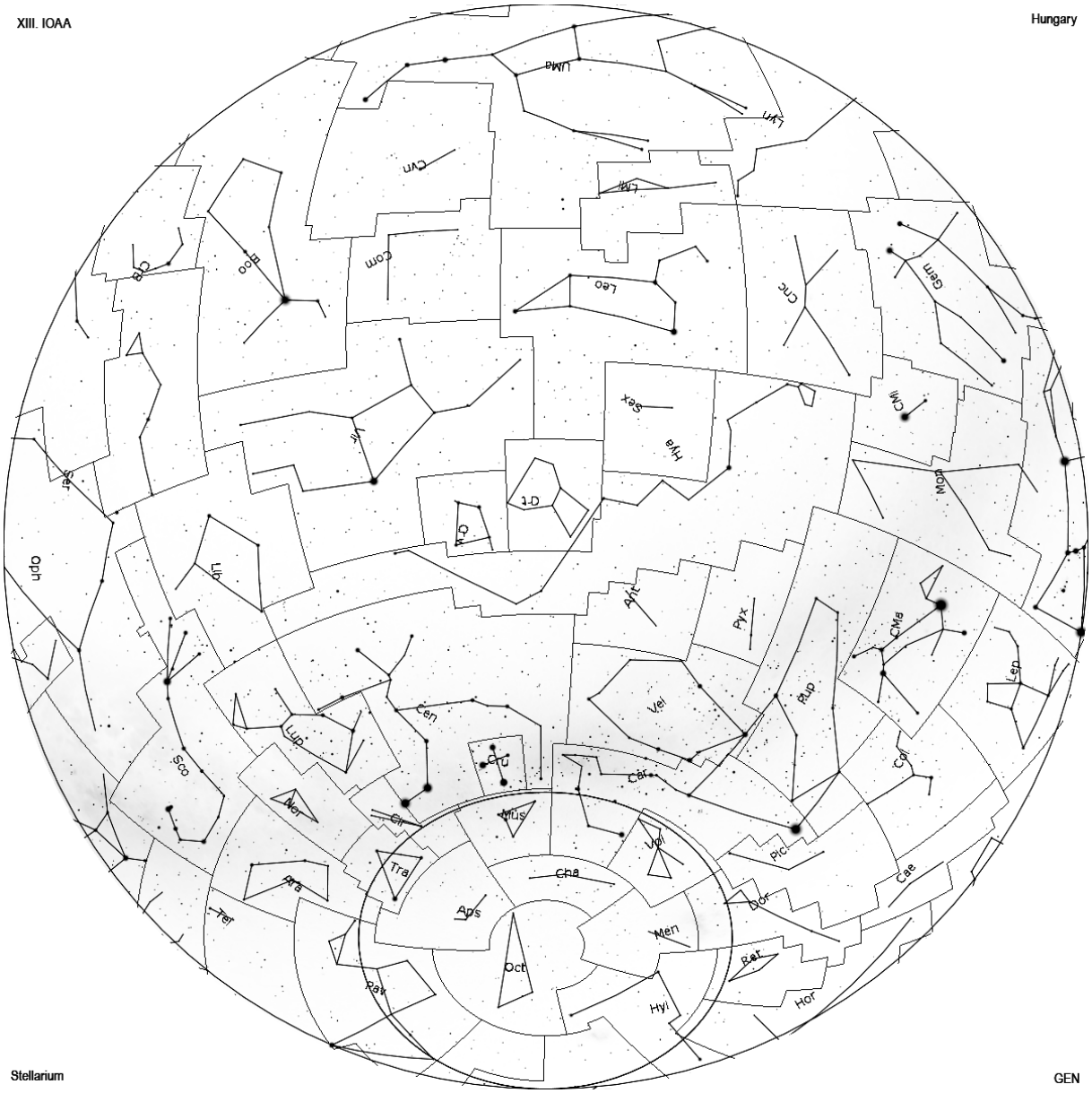
Solution: 12h. delta Orionis is approximately located on celestial equator (D = -0° 18′).

Marking: 2 points for exact value. **maximum: 2 points**

2.1. – 2.5. Coordinates of stars and comets:

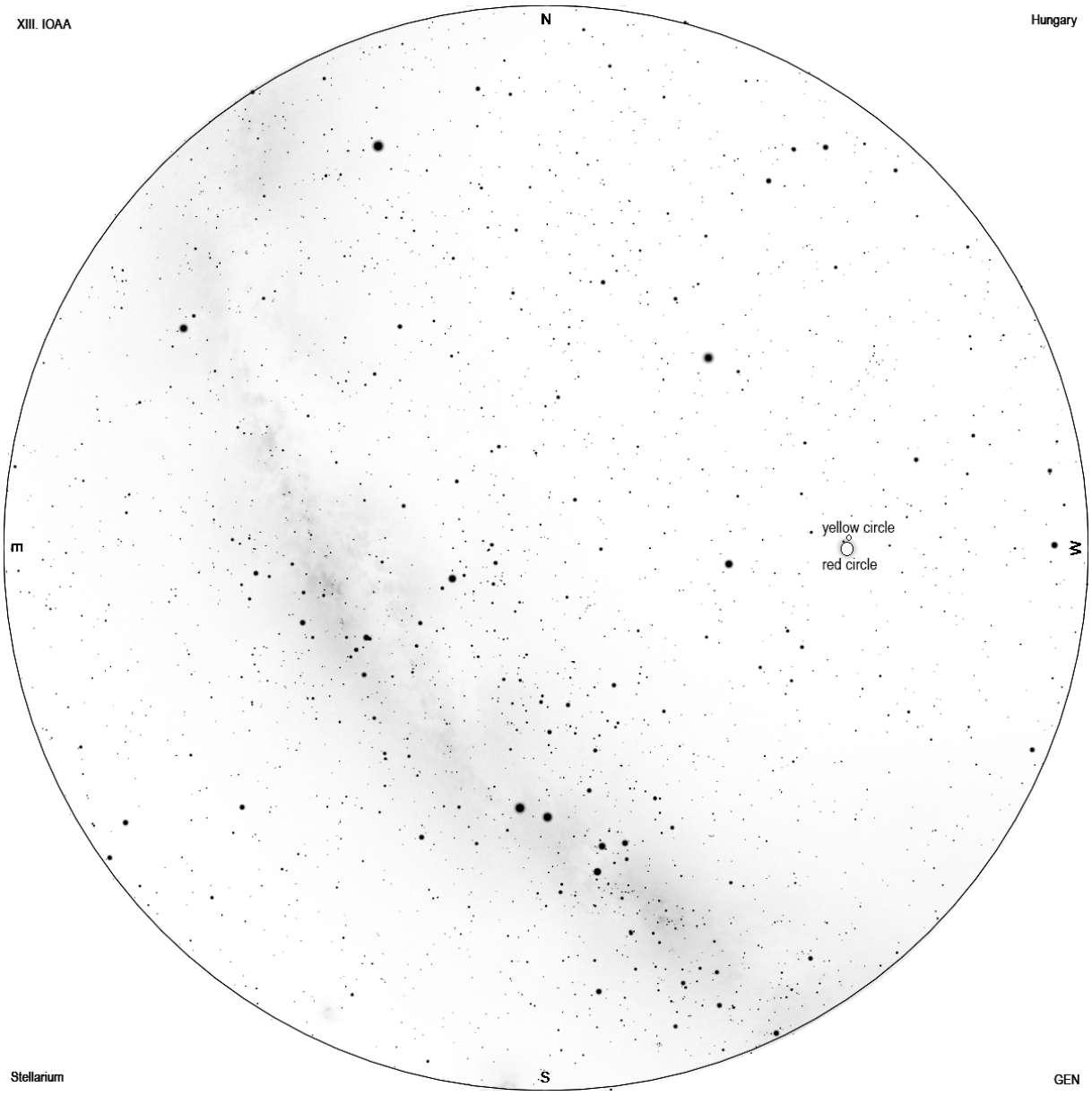


2.4. Circumpolar constellations:



PROBLEM 3

The third projected planetarium image:



We are standing on the Moon now. As seen at this moment, the Earth is centrally eclipses the Sun (see the red circle on the sky). Consequently, the Moon is in one of its nodes now. Assume the longitudinal and latitudinal librations are exactly 0° at this moment.

TASKS, SOLUTIONS, MARKING:

3.1. Which season is taking place at this moment in Hungary?

Solution: Autumn (fall). The Moon, Earth and Sun are located on a same line. The Sun can be observed in Virgo constellation from Earth, next to the Autumnal equinox point.

Marking: right answer (Autumn) is 2 points. **maximum: 2 points**

3.2. There is a yellow circle on the projected sky (next to the red circle), which denotes minor planet Juno, which is at a distance of 3 AU from the Sun at this moment. Estimate its distance to the Moon now? (Rounded to 0.1 million km.) (Consider all orbits as circles.)

Solution: 598.8 (~599) million km. All of the students need to know is that Juno-Sun-Earth-Moon are nearly on the same line. Thus, the distance is: 3 AU + 1 AU + d(Earth-Moon) = cca. (4 x 149.6) + 0.4 million km = 598.8 million km.

Marking:
2 points for $\pm$1 million km,
1 point for $\pm$2 million km. **maximum: 2 points**

3.3. Estimate how much time after the projected event will …
…the Sunset at your observing site? ……
…the Earth set at your observing site? ……

Solution 1: Sunset can be observed about 3-4 days later (meaning in terrestrial time, i.e. Mean Solar Days). The length of the day on the Moon is equal with the period of the lunar phases (synodic month), i.e. 29.53 days (708.72 hours). Thus, the Sun moves 360°/29.53° = 12.2°/day on the Lunar sky from East to West. Since at the projected situation the Sun is located 40° above the horizon, and we are exactly on the equator – so 40°/12.2° days are needed for setting = 3.28 days = 78.7 hours. The extent of the Solar disc is not considered here, that makes half an hour more until complete sunset.

Marking: between 3-4 days: 4 points, 2 or 5 days: 2 point **maximum: 4 points**

Solution 2: Earth set can be observed: never. (The Earth-Moon system has synchronous rotation. Our observing site there is on the near side of the Moon, but we are outside the libration zone. The Earth is continuously observable from this place.)

Marking: the good answer is 2 points. **maximum: 2 point**

3.4. Determine the Lunar (Selenographic) coordinates of the observing site (where you made your present observations):
……° , ……°
What is the name of the large lunar surface area where your observing site belongs to? (See lunar map on next page.)

Solution 1: latitude: 0° , longitude: 50° E

If we were sitting in the origin of the Selenographic coordinate system, then the Solar Eclipse (by the Earth) would happen at the Zenith. Since the event is seen almost exactly to the direction West, at a horizontal altitude of 40°, this means that we are located on the Lunar equator, about 50° East from the origin of the coordinate system.

Marking 1:
for latitude: within ±2° (between S 2°-N 2°) 3 points, ±5° (S 3-5° or N 3-5°) 2 point,
for longitude: within ±2° (between 48-52°) 3 points, ±5° (45°-47° or 53°-55°) 2 point,

maximum: 6 points

Solution 2: Mare Fecunditatis, or „Sea of Fecundity", or „Sea of Fertility"

Marking 2: any one of the above names: 6 points **maximum: 6 points**

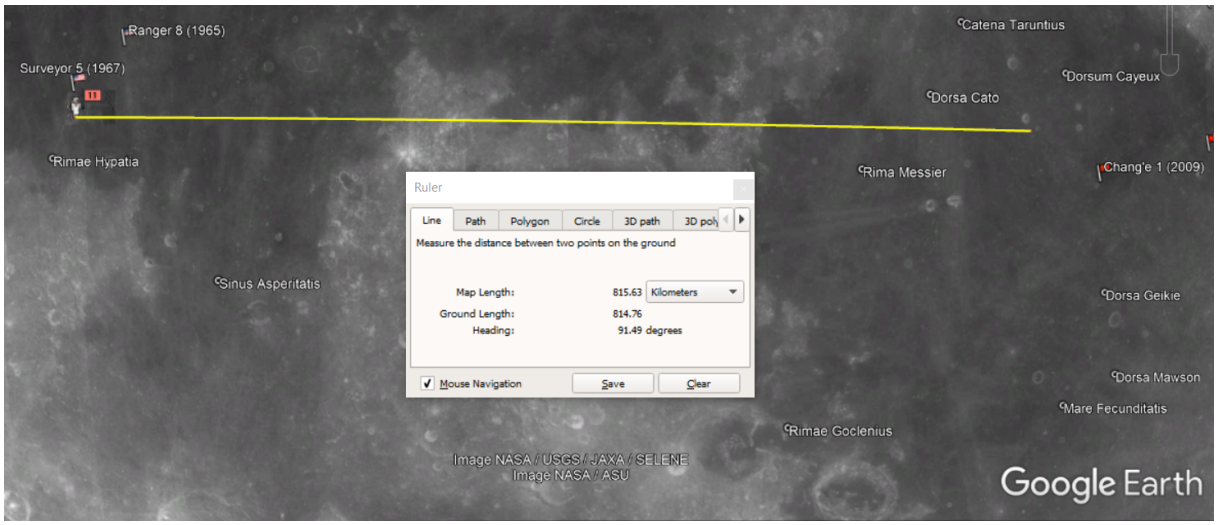
3.5. Estimate the distance of the observing site to the Apollo-11 landing place: …… km.

Solution: about 800 km.

This is a tribute to the Apollo-11 astronauts, on the occasion of the 50 years anniversary of the first Lunar Landing, a few days before the IOAA2019 olympiad.

Let us disregard the latitudinal difference of the Apollo-11 landing site from our observing site (it is less, than 1°). If we do so, we can calculate only with the longitudinal difference, and we can consider, that both sites are on the equator, which is a "great circle" on Moon. The circumference of the Moon's equator is $D_{Moon}*\pi$ = 3474 km*3.14 = 10914 km. This belongs to 360°, whilst the longitudinal difference between our sites are 50°-23.473° = 26.527°. Thus, the proportional arc length is: 803.7 km.

Marking:
±100 km (between 700-900 km) 6 points,
±200 km (600-699 km or 901-1000 km) 5 points,
±300 km (500-599 km or 1001-1100 km) 4 points,
±400 km (400-499 km or 1101-1200 km) 3 point. **maximum: 6 points**



Source: Google Moon

Lunar map in a student's worksheet: