Al-Chaahad: new concept for young moon sighting verification

Mohamed Laoucet Ayari
P.O. Box 20402, Boulder, CO80303

ABSTRACT

With an estimated two billion people worldwide dependent upon new moon sighting to establish the timeline of lunar months and festivals, there has long remained controversy regarding verification of naked-eye sightings. At no time in history have the technological pieces so readily aligned to solve this problem as the present. Al-Chaahad is a system which provides an opportunity to standardize the new moon sighting verification process in a reliable framework. Over the past few months, analysis and tests have assisted in the development of a scalable system that enables anyone located anywhere in the world to validate a naked-eye sighting of a new moon. The system utilizes the combined powers of proven technologies including elements of orbital mechanics, imaging, global positioning system, secure communication and image processing.

Keywords: young moon, sighting, lunar month

1. INTRODUCTION

Al-Chaahad (Arabic word for witness) is an instrument-based standard designed exclusively for verifying earth-based naked-eye new moon sightings. It is conceived to witness and substantiate claims for traditional naked-eye sightings, and therefore it is in full conformity with all voiced opinions on the matter.

The basic idea in new moon sighting verification is in the digital documentation of sighting claims. From anywhere in the world, documentation of a sighting is instantaneously achieved in a controlled process. Al-Chaahad is composed of distributed observation stations and a control center. An observation station is a remote new moon sighting station run by a technically qualified person. The control center is run by a competent authority, the body with final decision on sighting authenticity. The competent authority is a team composed of qualified technical experts. The responsibilities of the control center include receiving requests for documentation of sightings from observation stations, verification of such requests, documentation of sightings, and establishing sighting authenticity. The control center issues an official and final declaration of new moon sighting, following an evaluation process of all sighting claims.

Authentication of new moon sighting occurs in three steps. During the first step, an observation station operator sends a stream of data that includes GPS location, Universal Time, atmospheric condition and other visibility parameters to the control center and requests a permit to document a potential sighting. In the second step, the control center acknowledges receipt of the request and assigns a unique electronic stamp to the observation station, following a verification of its current observation elements. The control center then awaits further notification from the observation station and monitors the progress of its data elements. The control center handles multiple stations at a time and continuously assesses the potential for positive sightings in all active observation stations. In the third and final step, when a claim for positive sighting arrives at the control center, a notification of acknowledgment of claim reception is sent back to the observation with either an end of transmission signal or a request for further documentation.

During a sighting attempt, the observation station undergoes automatic calibration and locks on the predicted new moon path in the sky as predicted using JPL's Planetary and Lunar Ephemerides [1]. Electronic scanning then takes place for the light of the new moon. If the new moon is located it gets displayed on a computer screen attached to the observation system and illuminates the location in the sky for the observers to focus their attention to. When a decision is made by the observers that a positive sighting is in progress, an electronic image with a normal lens is acquired by the operator. The electronic image is automatically integrated with the initially received electronic stamp and forwarded back to the control center. Further assessment and checks of the image are made at the control center and an authentication level is assigned to the sighting.

Following reception of a number of sightings, the competent authority convenes and issues an authentic and final declaration of new moon sighting.

2. NEW MOON OBSERVATION

The top level requirement is to develop a standard single system capable of documenting anyone's naked-eye sighting of the first moon light, any month of the year from anywhere on earth.

Observation of the new moon occurs just after sunset low in the west where the glare from the sun and atmospheric distortions are a major challenge [3]. Valuable information on moon observation can be found in [4] and [5]. There are many contributions on when the youngest moon can be seen. There is a suggestion that an elongation of 7 degrees is a minimum [7]. Ahmed [8] made available a freeware computer program with multiple criteria for new moon visibility.

A typical observation station is equipped with several integrated capabilities including 1) an imaging system tuned specifically for the young crescent at the resolution power of the human eye, 2) a global positioning system that determines the location of the observation unit anywhere in the world and the Universal Time of observation, and 3) a communication system with a secure link to the control center to request and acquire instant permissions for new moon documentation from the control center in the form of a coded digital stamp. The observation station has a processing capability to associate the digital stamp, time and global position of the observing station with a digital image of the new moon. In addition, a scanning capability and sub arc-minute level new moon tracking accuracy are furnished to aid the observer point to right location in the sky.

An observation station designed for the sole purpose of tracking the new moon and performing a confirmation of an observation is different from traditional telescopes. Large aperture telescopes are certainly not needed for the task. An 80 mm has plenty of light gathering capacity and larger apertures may provided a handicap especially near sunset where the haze of the air is thicker. The focal length need not be too long. In summary, while there is plenty of choice, the best equipment seems to be between the super telephotography and the 80 mm range telescope. The quality of the optics is of paramount importance.

Moon filters are commonly used to reduce the glare of the moon during night observations of the surface features. They usually have a light transmission of 18 % and dramatically improve the overall contrast. Tracking the new moon is done however prior to sunset during a short window of time. Massey [3] suggested the use of red filters during daylight moon observations, darkening the lunar mare areas and improving the contrast of the terminator features by reducing the glare of the surrounding sky. Polarizing filters may also be used to reduce glare and giving the sky a deeper blue tone. A filter wheel is proposed with multiple filters as part of the observation system. The filters need to be used only during tracking and scanning. The documentation of sightings needs to be filter free.

For testing, a Panasonic 10.1 Megapixel LUMIX DMC-FZ50 imaging system is used. It has an f/2.8 LEICA DC lens and a 12x optical zoom (equivalent to 35 mm to 420 mm on a 35 mm film camera). The DMC-FZ50 has a 10.1-megapixel high resolution CCD for its image sensor and Venus Engine III for image processing LSI, making it possible to record an image at ISO 1600 high sensitivity setting at full resolution. The noise reduction makes the camera able to capture 10.1-megapixel full resolution images even in high sensitivity recording. The lens unit is comprised of fourteen elements including three aspherical lenses and an ED lens. All these are incorporated to generate low distortion and high optical performance.

Table 1. Sensor Capacity tracking a descending new moon based on a 1/1.8" type CCD (7.18 mm by 5.32 mm) .

35mm-Equivalent Focal Length (mm)	Angle of View (deg)	Coverage Capacity (minutes)	# of Moons in FOV	Moon Velocity pixel/s	1% illuminated moon (pixel)
35	63	381	123	0.2	4
45	51	308	99	0.2	5
50	47	281	90	0.3	5
100	24	147	47	0.5	10
200	12	74	24	1.0	19
300	8	50	16	1.5	29
420	6	35	11	2.1	40
800	3	19	6	4.1	76
1000	2	15	5	5.1	95
1200	2	12	4	6.1	114

The control center has the capacity to visualize and evaluate the conditions of each observation station, including exact astronomical predictions of crescent position, crescent age, visibility and local atmospheric conditions as seen from the observation station. The control center maintains direct contact with several observation stations at a time as sunset crosses from one longitude to another on the surface of the globe. The control center is equipped with large screens displaying the status of each observation station. New moon visibility algorithms are assessed for each observation station to estimate the potential for sightings. Other elements such as local visibility and local cloud cover are also assessed. Activities in the control center could be broadcast live due to the importance of the event.

3. TRACKING AND SCANNING THE NEW MOON

3.1 Tracking System

There is no need for a mechanical tracking mount to meet the key objectives of Al-Chaahad verification system. Instead, a large sensor is chosen for the task. Optionally, a mechanical mount may be used for alignment to center the origin of the Alt-Az coordinate system at sunset.

In any case, the sensor needs to have the following requirements:

- As large as possible
- Easily oriented to align with the descending new moon
- Low Noise to Signal ratio

The results of Table 1 assume that the sensor is oriented such that its diagonal is aligned with the descending angle of the new moon to maximize the coverage of the new moon without moving the observation station and increase the chance of achieving a sighting. The data assumes that the apparent motion of the moon above the horizon is about the mean angle of the moon every three minutes and a mean angular diameter of 31'07". The apparent motion of the moon is about 95 % due to earth rotation and 5 % due the actual movement of the moon [2].

3.2 Observation unit alignment

A simple, yet efficient, alignment scheme is devised for Al-Chaahad observation stations. Because only few degrees in the Altitude and Azimuth directions need to be covered during moon sightings, near linearity of the path of the moon, and use of large sensors for imaging no advanced alignments are required. The following steps are taken to provide highly accurate tracking.

1/ the observation unit is set level using a simple leveling tool.

2/ the position of the sun is identified on the sensor coordinate system multiple times, 5-15 minutes prior to sunset. This step can be automatically achieved through an image processing algorithm. The position of the sun at sunset is then determined and the origin of a two-dimensional reference frame is located such that it coincides with a pixel in the lower corner side of the detector ensuring coverage of the moon path all the way until the moon sets.

3/ the unit is then gimbaled to maximize the travel of the new moon on the physical the detector

4/ the path of the moon is then drawn on a computer screen frame.

3.3 Scanning for new moon

During a scanning mode, images of the descending moon are acquired either in a raw or jpeg format. Automatic processing of the images is then carried to extract the new moon features from the background sky. This is done even in a cloudy sky as illustrated in Figure 1. The process is done at any magnification/resolution deemed necessary. This does not violate the documentation requirement. Once the scanning procedure results in a positive identification of the new moon, a visual identification is made, the observer switches to a normal lens and obtains a confirmation of the sighting.

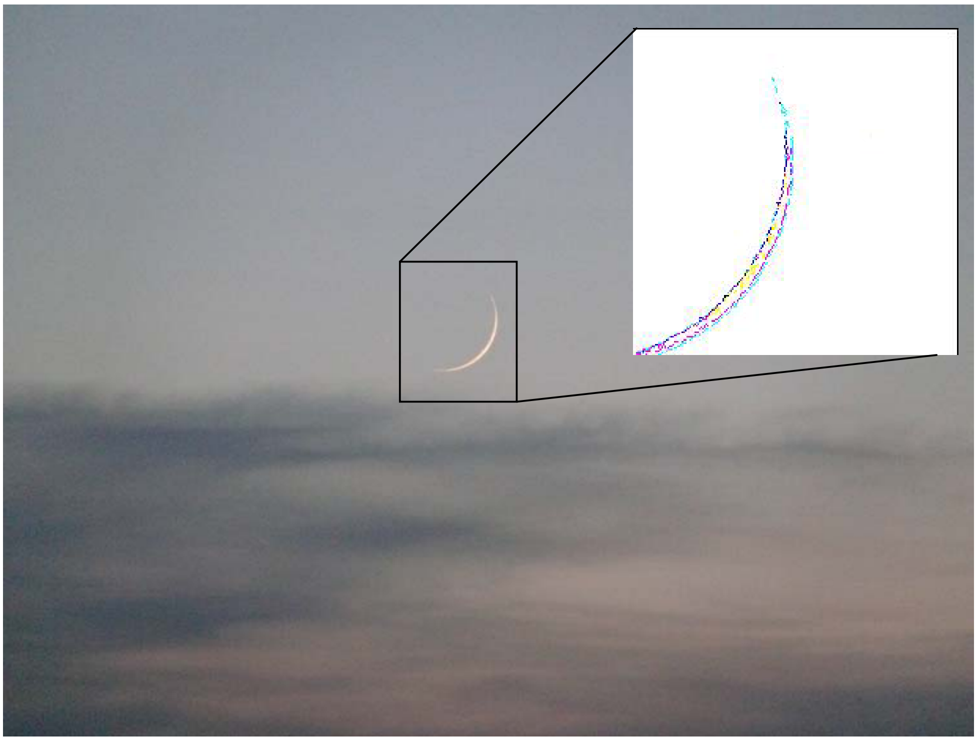

Fig. 1. Figure captions Fort Morgan , Morgan County, Colorado, 2007, experimental test 002-frameP1000124 RGB/24 latitude N40.3 . longitude W103.

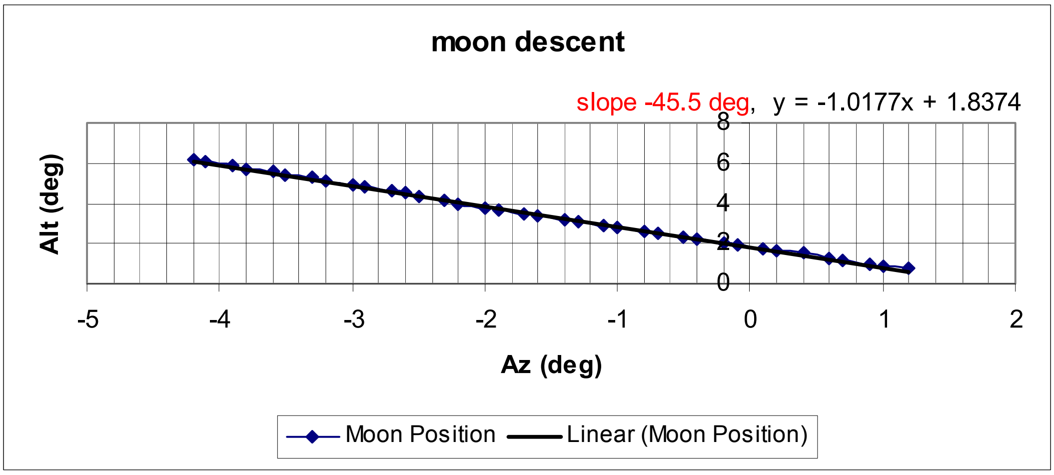

Fig. 2. New moon descent along a near 45 deg. The origin is the point of sunset Fort Morgan , Morgan County, Colorado, 2007, latitude N40.3 . longitude W103.

4. COMMUNICATION SUBSYSTEM

In order to ensure maximum reliability, a broadband link to the control center is incorporated in each observation station. Each observation station, fix or mobile, is required to be pre-registered within the network and has a unique account. Whenever possible, this is made possible through a Virtual Private Network (VPN) solution. The VPN solution securely connects remote observation stations to the control center. The data and voice between the two ends are kept confidential across non trusted networks such as a public Internet and private WAN networks. VPN is a more cost effective mean than Frame Relay or leased-line WAN connections.

Using IP Security in a VPN solution for connecting remote locations to headquarters will provide advanced encryption to secure information in transit. This premiere solution for VPN connections produces the required trust in sending new moon images to the control center.

Inmarsat's Broadband Global Area Network service is accessible via lightweight satellite terminals incorporated in each mobile observation station and driven from the same computer interface. Inmarsat's BGAN service is the current prime choice due to its ability to handle most of the requirements needed for the concept.

Inmarsat plc owns and operates a fleet of mobile communications satellites in a geostationary orbit and includes the latest generation satellites, the Inmarsat-4s (I-4s), which were launched in 2005. Together, they provide coverage to around 85 per cent of the world's landmass and 98 per cent of the world's population. Inmarsat is also planning to launch a third I-4 satellite in 2008. This will deliver complete mobile broadband coverage of the planet, except for polar region.

For now, at a minimum, guaranteed 32, 64 kbps for both send and receive for streaming IP provides the necessary mean to upload images of new moon. In addition, exchange of communication between observation stations and the control center is performed through an SMS 640 character web interface capability. In addition voice services are provided for a complete solution connectivity.

5. CONCLUSIONS

The concept of Al-Chaahad presented in this paper is a first cut at providing a verification system for naked-eye ground-based first moon sighting by common observers. The problem of new moon sighting verification is a difficult one and requires the integration of different advanced technologies. These technologies that used to be available only for the few are now available in separate commercial applications.

Al-Chaahad shall eliminate all confusions associated with erroneous sightings. The standard will reinforce a competent authority in its task to assess and declare official sightings. The system is scalable, can be deployed over an area and later expanded even worldwide. Al-Chaahad is in full conformity with naked-eye sighting principles and in accordance with astronomic predictions. Even if an observation station is equipped with a new moon tracking system, it is the observers who decide if they have achieved a sighting.

Al-Chaahad is intended to provide world leadership in the matter of new moon sighting. The competent authority shall be the single reliable source that people everywhere will look at for the declaration of authentic new moon sighting.

The control center as well as the observation stations may be used during the entire year for educational activities & Tourism. The control center may expand to have laboratories for research on new moon sighting and calibration of hardware for observation stations. Images of new moon as seen from different regions around the world can be broadcast to personal computers via Internet and Television stations.

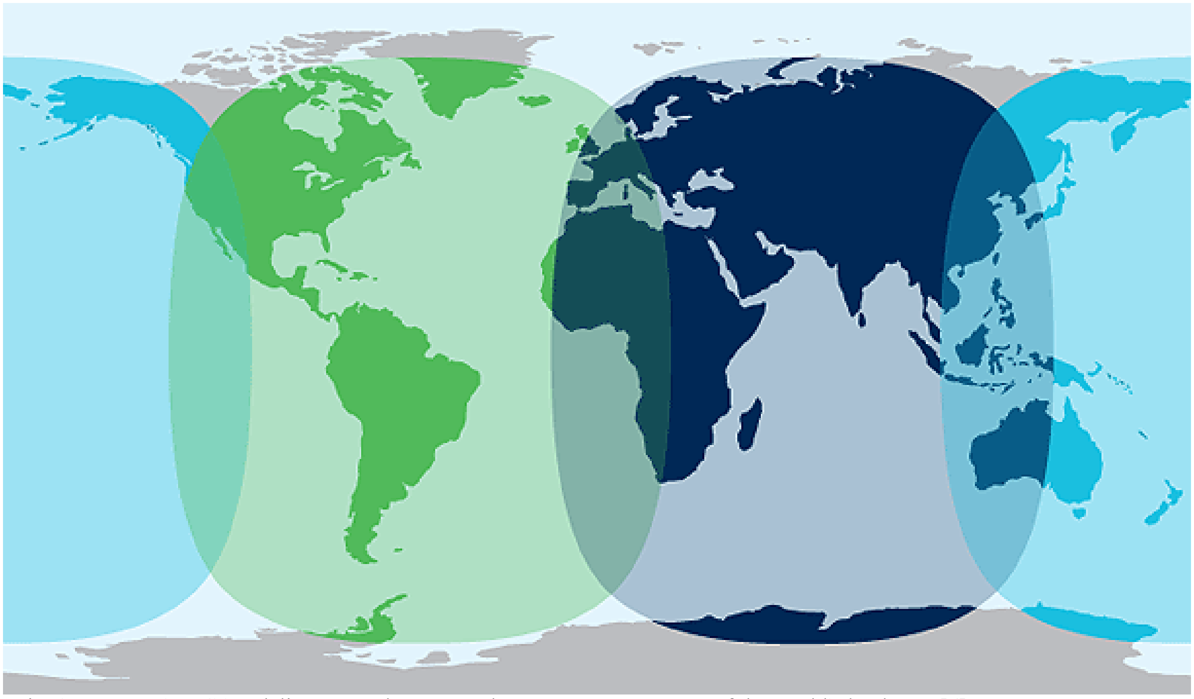

Fig. 3. Inmarsat's BGAN delivers seamless network coverage across most of the world's landmass [6].

Lease services may also be negotiated if the system is expanded. A lease channel may be dedicated and shared amongst Al-Chaahad user group - provided on a multi-year basis or for shorter periods.

ACKNOWLEDGEMENTS

Special thanks are extended to Mr. Frank Dirico for the use of his ranch in Fort Morgan, Colorado. Also, this proposal would not have seen the light if not for the continuous encouragement of the author's family.

REFERENCES

[1] NASA JPL Planetary and Lunar Ephemerides, version July 8, 1997.
[2] Long, K., "The moon Book," Johnson Books, 1988.
[3] Massey, S., "Exploring the Moon," New Holland Publishers, 2004.
[4] Cherrington, E.H., "Exploring the Moon through Binoculars and Small Telescopes," Dover Publications, 1984.
[5] Gerald, North, "Observing the Moon, The modern astronomer's guide," Cambridge University Press, 2000.
[6] Inmarsat plc, www.Inmarsat.com, 2008.
[7] Schaaf, F., "The 50 Best Sights in Astronomy and How to See Them," John Wiley & Sons, Inc. 2007.
[8] Ahmed, M., "Moon Calculator, Version 6.0," freeware, users manual, 2001