SHADOW-CALCULATION

The Calculations of the SHADOW calculation is based on the library “Systools” from the company TurboPower. The company give the following descriptions:

The STASTRO and STASTROP units feature functions and procedures that provide basic astronomical data including sun, moon, and planet positions, times of rising and setting, lunar phases, and more. It's presumed that you have a basic understanding of astronomical coordinate systems, Universal Time, and so forth. A detailed explanation of the terms and concepts is best left to a beginning astronomy book or guide.It is not required to include both units in the uses clause of your program or unit since neither unit depends on the other. For brevity in the following discussion, STASTRO refers to both units.Positions and Coordinate SystemsIn astronomy, there are several ways to indicate the position of the sun, moon, planets, and stars. The most familiar, and the one that can be directly translated to a sky map, is the equatorial coordinate system. In this system, Right Ascension is akin to longitude on the earth and is measured eastward from the point in the sky where the sun is on the first day of astronomical Spring (Spring in the northern hemisphere). Declination indicates the position north or south of the celestial equator, just as latitude gives the position north or south of the earth's equator.Unlike the earth's coordinate system with fixed reference points (the prime meridian and equator), astronomical coordinate systems have constantly changing reference points. In other words, the position relative to the stars of 0 hours R.A. and 0°° *declination changes over time. For this reason, positions are often referred to a standardized coordinate system, i.e., to fixed reference points as of a given date. The current common usage is that of J2000, meaning positions are referred to the mean equator and equinox as of the beginning of the year 2000. In addition, there are even sub-reference points based on other considerations. The FK5 system is the current one most often used. All positions reported by the SysTools functions are based on the J2000/FK5 system.Finally, positions can be geocentric or topocentric. Geocentric positions are those as would be seen by an observer at the Earth's center. Topocentric are those as seen by a person at a given point on the Earth's surface. For the stars and galaxies, there is no significant difference. For the sun, the difference (parallax) is small and, for most cases, can be ignored. The moon, however, is a different story. Here the parallax can be about one-half degree. In SysTools, all positions are geocentric. Many astronomy references provide the necessary formulae to convert a geocentric position to topocentric.TimeThere is no single time reference in astronomy. The time and dates used and returned by the STASTRO functions and procedures are based on Universal Time, i.e., the time and date at Greenwich, England. There are some algorithms in STASTRO that actually deal with Dynamic Time. This is time based on the actual motion of the earth which is not uniform. The difference between Universal Time and Dynamic Time is constantly changing and the rate of change is also not uniform. In 1990, Dynamic Time was about 57 seconds ahead of Universal Time. In SysTools, even if the algorithm returns or requires Dynamic Time, Universal Time is used and the difference ignored.Times are also based on standard time. This mostly means that no account is made for a person who is not exactly on one of the standard meridians (multiples of 15°°). For example, sun rise occurs about four minutes earlier for a person one degree east of a standard meridian than for a person on the standard meridian.If your application is to report local time, it must properly convert Universal Time to local standard (or mean time).Rise/Set Time ConsiderationsThe Rise and Set times for the Sun and Moon are the Universal Time of local rise and set. For example, if local moon rise is at 14:20 Mountain Standard Time, the MoonRise function returns a rise time of 21:20. This is as designed and based on the algorithm given by Meeus in Astronomical Algorithms. This can lead to some confusion and possibly incorrect interpretations of the results. A couple of examples serve to explain. In these examples, we presume local time is Mountain Standard Time which is seven hours behind Universal Time.Say the MoonRiseSet function is passed a date that represents July 25, 1996, and returns a U.T. of 04:10 for moon rise. The local time for moon rise is then 21:10 on July 24th. Did the function return the time of moon rise for the 24th or the 25th? According to the unaltered algorithm by Meeus (and used in SysTools), the time is for the 25th. This because the rise and set times are forced during internal calculations to be in the range of 0..0.99999999 days. In this example, the initial value of approximately 1.16 days is reduced to 0.16 days. Remember, the returned value is always Universal Time and Date. If your program needs to return local time and date, it must account for the possibilty that the local date may be a day earlier or later than Universal Time and Date indicates.Another special case usually concerns the moon. At mid-latitudes, moon rise on a given date is anywhere from 30 to 75 minutes later than the previous day. This becuase the moon is moving eastward at a rate of about 12°° per day. If, on a given date, the moon rises at 23:50 local time on July 25 and does not rise again until 00:45 local time the following night, it actually never rises on July 26 but early on July 27. Therefore, if computing the times of* *moon rise and set for July 26, one might assume there would be no time returned for moon rise. In fact, MoonRiseSet does return a time, 07:45, because based on Universal Time, the moon did rise on successive dates. When, in fact, based on Universal Time there is no rise or set on a given date, MoonRiseSet still reports a time. If the time in the example just given had been UT instead of local, MoonRiseSet would return 00:45 for July 26.How do you confirm if a rise or set actually took place? Probably the best method is to compute the rise and set times for the preceding date and compare them against those for the date in question. If the rise (or set) time for the date in question is less than the one for the previous date, you can correctly assume that the "midnight barrier" has been crossed and correct the date accordingly. For example, if the returned time for moon rise on the previous date is 23:50 and 00:45 for the date in question, the moon does not rise on the date in question but on the following date.Accuracy of ResultsPositionsTo find the precise position of the sun, moon, or planets requires dealing with hundreds of periodic terms. At some point, the increase in accuracy is far outweighed by the time to evaluate extra terms. The positions for the sun generated by SysTools are within 1 arcsecond (1/3600 of a degree) while those for the moon will be on the order of 5 arcseconds or less. The accuracy for the planets varies. For all but Jupiter and Saturn, the position is generally within one arcminute (1/60th of a degree). Because of much larger perturbations, the positions for Jupiter and Saturn are less accurate, being generally within five arcminutes (1/12th of a degree) of those given the Lunar and Planetary Tables from the U.S. Naval Observatory.Rise, Set, and Twilight TimesThe algorithm used to find the rise and set times uses an interpolation scheme based on three positions centered on a given date. For latitudes within 60°°* of the equator, the times are usually within 2 minutes of those predicted by more rigorous methods. Closer to the poles, the method works reasonably well but the accuracy decreases. Keep in mind, too, that the rise or set time can be affected by air temperature, barometric pressure, and other factors. Combined, these can change the rise or set time by almost a minute. Finally, the times are based for a person at sea level and will be significantly different from those for a person on top of a mountain.Lunar PhasesThe times for New Moon, First Quarter, Full Moon, and Last Quarter are within two minutes, usually less, of those listed in the Planetary Tables from the U.S. Naval Observatory.Equinoxes and SolsticesThe times for the equinoxes and solstices are usually within 5 minutes of those predicted by more rigorous methods, part of the error being the difference between Dynamic and Universal Time, the rest mostly due to approximations when computing the solar ecliptic coordinates.