http://www.siranah.de/html/sail008e.htm

Celestial Navigation: Special Techniques

Rise and Set Times of celestial objects

The Sight Reduction Tables give the Altitude (H) and Azimuth angle (Z) for a celestial object calculated from the Declination of the object, the Local Hour-Angle (LHA) between the object and the observer (which is related to time) and the Latitude of location of the observer.

A special case in these Tables is the case when H=0°. When the Altitude of a celestial object is 0° in the location of the observer, the object is on the horizon of the observer and thus this moment is the local Rise Time or local Set Time of this object. The actual time is derived from the LHA. The LHA of a celestial object increases continuously with time (principally through the rotation of the Earth) by an amount of about 15°/h. So a LHA can be translated into a time difference. These principles may be used to obtain the Rise and Set Times of celestial objects from the data of Nautical Almanac and the Sight Reduction Tables.

In the following scheme the procedure for obtaining the Rise and Set Times is described. The procedure is based on calculating the Rise or Set time first for a location on the Prime Meridian of Greenwich and then "translating" this obtained time to the Longitude of the observer's location. Notice that this method is not so accurate for the Moon since it's Declination changes significantly within the couple of hours related to the "translation" of the Rise and Set Times.

Here are the different steps for the procedure to obtain the Rise and Set Times of a celestial object in an arbitrary position.

- From the Nautical Almanac, get the Declination at 12:00 UT (**Dec**) and the Greenwich Culmination Time (**T*culmination***) of the celestial object for which the Rise and Set Times have to be determined.

- Enter the Sight Reduction Tables with the integral values of your Latitude and with the Declination found in the previous step (select the correct part of the Sight Reduction Tables with respect to *declination SAME AS/CONTRARY TO Latitude*).
  Search for the LHA value for which H is approximately 0° (at the correct Latitude/Declination combination).
  Record this LHA value (**LHA*H=0***).

  This LHA (for which H=0°) can also be calculated with an electronic calculator (provided the celestial object is not circumpolar nor below the horizon):

LHA*H=0* = acos (- tan(Dec) * tan(Lat))

- Convert the LHA*H=0* value from the previous step into a time difference **Tdh**=LHA*H=0*/15.
  Remember that 15° of LHA corresponds to 1 hour of time or one minute-of-arc of LHA corresponds to 4 seconds of time. Alternatively you can use the Time - Hour-Angle Conversion Tables and the Interpolation Tables for Celestial Navigation for this conversion.

  This value **Tdh** is the time span from minimum Altitude (H=0°) to maximum Altitude (local noon) and can be described as "half-the-length-of-the-day".

- Convert your Longitude into the time difference between Greenwich (local) Time and your local time.
  Again you can use the Time - Hour-Angle Conversion Tables and the Interpolation Tables for Celestial Navigation for this conversion.
  The result **Td*local*** is positive for West Longitudes and negative for East Longitude positions.

- Calculate the approximate Set and Rise Times (at the given location in UT!!) according to:

T*rise* = T*culmination* - Tdh + Td*local* T*set* = T*culmination* + Tdh + Td*local*

- The Trise/Tset calculated up to now are approximate values (the accuracy is about ±10 minutes). This is sufficient for e.g. planning a fix using the planets shortly before sunrise or after sunset, but for e.g. checking the chronometers on board this accuracy is insufficient.

To improve the accuracy you have to repeat the previous steps for Rise and Set times separately, using the approximate Trise/Tset values to determine the Declination at these times and also use interpolation for both Declination and Latitude in the Sight Reduction Tables (or use an electronic calculator for deriving LHA*H=0* as mentioned above).