ABSTRACT. The Astronomical Almanac (AsA), a joint publication of Her Majesty’s Nautical Almanac Office (HMNAO) and the Nautical Almanac Office of the U.S. Naval Observatory (USNAO), is a worldwide reference standard for astronomy. As such, the offices strive to adhere to the standards set forth by the larger astronomical community. However, sometimes the astronomical community is not clear as to what standards should be followed. There are standards that are promulgated formally, such as via IAU resolutions, some are informal but generally recognized as customary and common practice, while others seem to be adopted only within a particular field. This paper looks at various ephemerides, constants, parameters and models used in the AsA and the decision-making process that determines how they are selected for inclusion in the book.

1. THE MAIN STANDARDS FOR THE ASTRONOMICAL ALMANAC

The standards to which the AsA adheres may be divided into four areas. These are formal standards, informal but widely recognized standards, informally recognized practices and lastly the requirement to be consistent. Clearly, there should not be competing formal standards.

Our aim is to always follow formal standards. These are set down by the International Astronomical Union (IAU) via its resolutions and working groups (WG) and the Technical Notes of the International Earth Rotation and Reference Systems Service (IERS). The International Association of Geodesy (IAG) also provide various formal standards which are relevant to astronomy (e.g., the radius of the Earth).

Examples of pertinent IAU resolutions are those on the use of the International Celestial Reference System (ICRS) and ICRS-based catalogues and ephemerides, time scales, and precession-nutation. In recent years there have been WGs that have reported on “nomenclature” and “precession and the ecliptic”. This work and the resulting resolutions all feed into the almanac. There is also the IAU-SOFIA software which provides definitive algorithms for many of these models. Then there are examples like photometric standards and the rotational elements for the planets. The latter come from the IAU inter division WG on Cartographic and Coordinates and Rotational Elements.

There are many data sources and computational techniques that are not formalized within resolutions, but are world-recognized; most have been documented in refereed journals. Choosing between competing standards is done via numerical comparisons, usability, origin, and wider astronomical community acceptance. For example there is no IAU resolution that prescribes which planetary ephemeris to use. We have been using the Jet Propulsion Laboratory’s (JPL) ephemeris since the 1984 edition (DE200/LE200). This was updated, for the 2003 AsA prepared in 2001, to JPL’s DE405/LE405 ephemeris. This not only provided improvement in planetary positions but was also referred to the ICRS. Other recognized standards relate to satellite orbital parameters and magnitude coefficients. Similarly, rise and set times are only given to the nearest minute of time and the standard amount of refraction at the horizon is 34′.

The requirements of astronomers, our customers, also matter. Often there are similar data sources and computational methods that have scientific justification. Other times new, formally recognized techniques have not been fully accepted by users. Selection of which to use and maintain is made by customary practices within HMNAO and USNAO, or a clearly-defined user need to maintain past data sets.

An example where the user community have specific requirements, which maintains links with the past, is for the solar physical ephemeris. Here Carrington’s elements and reference system is still the reference system of choice. On the other hand, currently, the almanac is still publishing apparent places,
i.e. right ascension and declination with respect to the true equator and equinox of date. This is despite the fact that the IAU has recommended that right ascension should be measured from the celestial intermediate origin (CIO).

Within all these standards and practices it is necessary to try to be consistent. An example of inconsistency occurs in eclipse calculations, where old constants and IAU values are still being used as they are the required standard. On the other hand, with the requirements of more accurate positions and need to include relativity, it is becoming clear that constants must be scaled so that their units are consistent within the system that is being used.

The following table contains a selection of some of the standards that the AsA follows. A full list, valid for the 2009 edition of the AsA may be found on HMNAO’s website at http://www.hmnao.com.

<table>
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<th>Quantity</th>
<th>Reference, Comment</th>
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IAU 2000 Resolutions B1.3 and B1.4, respectively, *Trans. IAU, XXIVB.* |
TT | IAU 2000 Resolution B1.9, TT = TAI + 32°184.  
TDB | IAU 2006 Resolution B3. |
| Standard epoch; century; day; secs | IAU 1976 J2000-0, JD2451545-0 TT, 2000 Jan 1 12º TT, Julian cy = 36525 A, day of 86400° |
| Software | USNO/HMNAO, NOVAS v3, IAU-SOF library. |
| Vector/Matrix approach | IAU 1976 |
| Positions | Apparent (not intermediate) places tabulated at 0º TT.  
Stars space motion | Minor planets and Pluto astrometric positions tabulated at 0º TT.  
Transit times | No light time included; NOVAS v3 includes simple light time formulation.  
Mars - Pluto | Transit over the ephemeris meridian.  
| Categorizing Pluto | rₜ = 499-0047 8380 61 ms⁻¹, cₜ = 1495 9787 0691 m.  
| Minor planet ephemerides | Resolutions 5 & 6: Pluto is a dwarf planet.  
| Sun, Planets and Pluto; for Sun | Hipparcos, Tycho-2, UCAC2, USNO-B; many other object catalogues are used.  
| Lunar librations (but using IAU inclination) | IAU 1976 |
| Earth rotation angle / UT1 | IAU 2000 Resolution B1.8, *Trans. IAU, XXIVB.*  
Equation of Origins | IAU WG on Nomenclature, *Trans IAU, XXVIB.* |
| Nutation Δψ, Δε | IAU 2000A Resolution B1.6, *Trans. IAU, XXVIIB.* Implementations:  
| CIP & CIO Locator; X, Y, & s | IAU 2006 Resolution B1 due to IAU 2006 precession, included by IAU-SOF in NUT06A.  
| Rise/Set phenomena | IAU Nearest minute of time. Upper limb on the horizon with 34’ of refraction.  

Figure 1: Some of the main standards for *The Astronomical Almanac*