

THE FUTURE OF ALMANAC DATA IN THE UNITED STATES

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Introduction

Numerous factors -- such as changes in technology, navigation policy, user requirements, and funding levels -- make it difficult to predict the future of almanac data in the U.S. In the last few years, there have been detailed discussions of the future of almanacs, both within the U.S. Naval Observatory (USNO), and between USNO and the staff of H.M. Nautical Almanac Office (HMNAO) of the UK. Some definite decisions emerged from these discussions. In some cases, the decisions are already being put into practice. In other cases, the decisions are forming the basis of long-term plans for changes in the products produced by the two almanac offices.

This paper will draw on the discussions mentioned above and present current plans for the future of almanac data produced or co-produced by USNO's Astronomical Applications (AA) Department. This paper will use a broad definition of "almanac data," to include not only printed almanacs, but also software almanacs and almanacs designed for use on the Internet. As with any attempt at making predictions, this paper will inevitably reflect the views and biases of the author.

Future of Celestial Navigation

The future of the navigational almanacs is tied to the future of celestial navigation. In certain respects, the general concept of celestial navigation is more important today than it was ten years ago. The great success and widespread use of the Global Positioning System (GPS) have resulted in the termination or proposed termination of older alternative electronic navigation systems. Prudent navigation practice requires both a primary and a secondary means of navigation, with the secondary independent of the primary. Celestial navigation remains one of the few independent alternatives to GPS.

Celestial navigation can encompass any method that utilizes observations of astronomical bodies -- bodies with known positions in a

standard celestial reference frame -- to determine the position of a platform in a standard terrestrial reference frame. The various methods for performing celestial navigation can be grouped into three general categories. *Traditional, manual methods* require use of the sextant, coupled with manual sight planning and reduction procedures (i.e. printed almanacs and forms). *Traditional, computer-based methods* also require use of the sextant, but sight planning and reduction are performed using a computer program. Finally, *fully automated methods* use some type of automatic electronic sextant or star tracker to make observations, which are then fed to software that performs the sight reduction.

The AA Department plans to be involved in all three of these methods. Prospects and proposals for the navigational almanacs -- both printed and computer-based -- will be discussed below. The AA Department is also engaged in a study of a fully automated system for celestial navigation¹, although further discussion of this topic is beyond the scope of this paper.

Almanacs for Marine Navigation

USNO's proposed plan for the future role of *The Nautical Almanac* in the U.S. is based on input from fleet navigators and our own vision of the role of celestial navigation in today's Navy. The goal of the plan is to promote a computer-based system for planning and reducing sextant observations as the preferred method for routine use, while retaining manual methods, including use of printed almanacs, for backup or emergency use.

Computer-based methods of sight planning and reduction have obvious advantages: they are much faster than manual methods, they eliminate math blunders, they can be made rigorous, and they allow the navigator to take more sights and improve skills in use of the sextant. Fleet navigators have made these points when commenting on USNO's own computer-based almanac for celestial navigation, STELLA.

However, some navigators have expressed great concern about over-reliance on computers and electronics, especially during hostilities. As one navigator stated in a 1997 survey of STELLA users: "A PC based system won't do me any good if I have to perform sight reduction after battle damage, or heaven forbid, in a lifeboat." Another navigator stated: "Electronics like this... [are] placing the Navy in serious jeopardy. Electronic warfare and other technology can easily disable these systems.

Until you have addressed all of these issues, any decent [quartermaster] will opt for conventional means."

In my opinion, both the advantages of computer-based tools and concerns involving over-reliance on technology are valid issues that must be addressed in any plan for the future of the navigational almanacs. Thus, we have proposed that the U.S. Navy fully approve and promote STELLA for routine use in celestial navigation. We also propose that a manual means of sight planning and reduction be retained, but relegated to a backup role. If this policy is adopted, USNO will likely produce an "Abridged Nautical Almanac" specifically for Navy use. This book will be published every three to five years (to be determined) without the hourly tabular data for the Moon and planets. Discussions with fleet navigators indicate that the Moon and planets are often avoided, due to additional complexities in reducing their observations. Of course, STELLA handles these complexities automatically, and STELLA has the capability to generate lunar and planetary almanac data in standard *Nautical Almanac* format on demand. HMNAO would continue to produce the current *Nautical Almanac* and ensure its availability in the U.S.

It is important to note that this plan is only a proposal at this time.

Almanacs for Air Navigation

The future of the U.S. *Air Almanac* is uncertain. Without a doubt, use of celestial navigation aboard U.S. military aircraft is in rapid decline. New aircraft, replacing existing aircraft, are being built without sextant ports. GPS and inertial navigation systems are becoming dominant. Reflecting this situation, there has been a major reduction in celestial navigation training for military air navigators. "Undergraduate" training has essentially been eliminated, and "post-graduate" training has been reduced to a computer-based course. Furthermore, we have been unable to identify any specific U.S. Navy or Air Force requirements for continued publication of *The Air Almanac*. The AA Department undertook a survey of users of *The Air Almanac* in 1998. The survey results are still being analyzed, but preliminary results indicate that there currently is a need for the book. Furthermore, it appears that there will be at least several types of military aircraft that will use celestial navigation for the foreseeable future. Additional study is needed to understand the requirements. However, it is quite possible that the U.S. *Air Almanac* will be reduced in scope or terminated within the next five to ten years.

USNO has offered to produce for the U.S. military a version of STELLA specifically designed for air navigation, but so far there has been no formal interest.

The Astronomical Almanac

The Astronomical Almanac has not undergone a major review and revision since the edition for 1984. The recent adoption of the International Celestial Reference System (ICRS)² by the International Astronomical Union (IAU) will require changes in the book, so there is now an excellent opportunity for a complete review of the contents of the volume. In fact, the AA Department and HMNAO have already begun the process. A survey of users of *The Astronomical Almanac* was undertaken in 1998. While the results are still being analyzed, it is clear that there is strong support for continued production of a printed *Astronomical Almanac*. Numerous survey respondents expressed thoughtful suggestions concerning material in the book that could be added, deleted, or revised. The almanac offices have given, and will continue to give, careful consideration to these suggestions in making decisions concerning the future of the volume.

Changes to *The Astronomical Almanac* will take place gradually, with the first revisions likely to be incorporated into the edition for year 2002. Both content and presentation will be affected. IAU standards will be adopted whenever possible. One of the most interesting changes will be the addition of an "electronic component" to the book. This electronic component will likely take the form of Uniform Resource Locators (URLs) placed throughout the book. These URLs will refer the user to World Wide Web (WWW) sites and services that extend the usefulness of the printed reference data. For example, Section A (Phenomena), which contains extensive tables of sunrise and sunset times, may include the URL of a WWW service that computes times of sunrise and sunset for a specific date and location. Section D (Moon) may include the URL of a File Transfer Protocol (FTP) server from which the lunar ephemeris polynomials can be downloaded and subsequently used in a computer application.

In the long term, the fundamental ephemerides produced by the Newcomb project³ are expected to form the basis of *The Astronomical Almanac*.

In addition to changes in content and presentation, both almanac offices are adjusting the production schedule for *The Astronomical Almanac*. Our survey results indicate that most users would like to have the book one year prior to the cover year. This is our goal and we have already made great progress in attaining it.

The AA Department and HMNAO are also considering replacing *Astronomical Phenomena* with an expanded publication aimed at a more general market.

Computer-Based Almanacs

At first thought, it may seem as if computer-based almanacs and printed almanacs are competing products. I am often asked if our computer-based almanacs, MICA⁴ and STELLA, will allow us to stop production of their printed counterparts. I view the computer almanacs and the printed almanacs not as competing products, but as complementary products. There are many instances when it is much more convenient to look up a value in a book, rather than obtain it from a computer program. Books also stand the test of time, transcending changes in technology that can render a computer program useless. On the other hand, computer almanacs can provide information that is difficult to obtain from a printed book. For example, the topocentric coordinates of the Moon are much easier to obtain from a computer program -- they are computed on demand for a specified location and time -- than from a book, where tabulated geocentric values must be interpolated and transformed to the location of interest. Furthermore, the long time span of a computer almanac makes it very useful for planning purposes.

Also, in my opinion, the widespread availability of astronomical data on the Internet does not eliminate the need for or the usefulness of computer almanacs, although this situation could change as technology advances. Computer almanacs are still usable when an Internet connection is not available. Furthermore, a richer set of user interface features is available in a modern personal computer (PC) program than is currently available in an Internet data service. This allows the almanac developer to create easier and more powerful methods for interacting with the user, and more flexible options for presenting the computed data.

Thus, the AA Department plans to continue improving and supporting MICA and STELLA. They will continue to be targeted to operate on PCs, which enjoy widespread use throughout the world. We are

currently engaged in projects to convert the programs from their current MS-DOS underpinnings, to full compliance with the latest Microsoft Windows operating systems. The printed almanacs generally provide high-precision data in tabular form, and our computer almanacs will continue to follow this prescription. No attempts will be made to compete with the numerous planetarium-type programs that are currently available, although graphics may be introduced if deemed appropriate.

The AA Department also produces another type of specialized computer-based almanac that I will call an "almanac engine." An example of this is the Solar-Lunar Almanac Core (SLAC), available only to our U.S. military customers. In recent years, there has been an increasing demand for illumination data, largely to support planning for night operations and for use in simulators. SLAC is a self-contained, integrated set of C-language functions that computes all important quantities related to illumination: times of sunrise, sunset, moonrise, moonset, twilight, and transit, fraction of the Moon illuminated, and an estimate of the illuminance. SLAC is not a stand-alone program -- rather, it was designed for incorporation into larger software systems, such as ones that do operations planning, mission scheduling, or simulations. SLAC has been quite popular and will continue to be supported and improved. The AA Department will also consider developing similar specialized almanac engines to support specific requirements.

Almanac Data on the Internet

The AA Department has already developed a strong presence on the Internet, and that presence will almost certainly increase. We use our Web site for several key tasks. First, we use the site to advertise, and help customers obtain, the printed and computer-based almanacs. Second, we use the site to describe basic astronomical phenomena and to provide answers to frequently asked questions about our products and the information that they contain. Finally, our site offers numerous interactive data services that provide customized almanac data on demand, free of charge. Prior to the establishment of our Web site, the latter two tasks had to be handled by staff astronomers, resulting in less time available for mission work.

As already implied, our Web site will grow by providing services that complement existing products, especially *The Astronomical Almanac*.

We also plan to further develop and improve a restricted part of our site that specifically serves the needs of our U.S. military customers.

Use of the World Wide Web as a means of disseminating almanac data is perhaps the most important component of our plan for the future.

Summary and Conclusions

The Astronomical Applications Department of the U.S. Naval Observatory plays a unique role in providing practical astronomical data in the U.S. I am unaware of any other organization in the U.S. that provides high precision almanac data via printed books, computer applications, and the Internet. The department will continue to work toward its traditional goals of providing data of high precision and accuracy, to present those data in useful and usable formats, and to provide those data in a reliable fashion. Furthermore, the department plans to undertake new initiatives to revise its products to meet changing user needs. The key elements of our plans can be summarized as follows:

- Despite the widespread use of computers and the rapid development of the Internet as a mechanism for disseminating data, there are still valid reasons and strong demand for printed almanacs.

- USNO has proposed that the U.S. Navy make our STELLA software the primary tool for routine use in celestial navigation, and relegate manual means of sight planning and reduction to a backup role. If this occurs, the AA Department will likely produce an "Abridged Nautical Almanac" for Navy use, to be published every three to five years. HMNAO would continue to produce the current *Nautical Almanac* and ensure its availability in the U.S.

- The future of the U.S. *Air Almanac* is uncertain. Due to declining use of celestial techniques for air navigation, it is likely that the *Air Almanac* will be reduced in scope or terminated within five to ten years.

- In a cooperative venture between the AA Department and HMNAO, *The Astronomical Almanac* will be revised. Planned improvements include incorporating the ICRS, a new ephemeris of the solar system, some improved tables and new material, and elimination of outdated material. The book will also include an electronic component, likely in the form of links to WWW services that extend the usefulness of the printed material. The two offices will also explore replacement of *Astronomical Phenomena* with an expanded publication aimed at a broader market.

412 BANGERT: FUTURE OF ALMANACS IN THE U.S.

-The AA Department will continue to improve and support its computer-based almanacs, MICA and STELLA. Both programs are being revised to be fully compliant with the latest PC operating systems, and new features and functions will added.

-The AA Department is fully committed to making almanac data available via the WWW. Our Web site will continue to be expanded and improved, and will help customers obtain the traditional products, provide answers to frequently asked questions, and provide selected almanac data, especially those data that extend the usefulness of print material.

Last, but certainly not least, the AA Department looks forward to continued successful collaboration with HMNAO and its new parent organization, the Rutherford Appleton Laboratory. Our desire to collaborate has recently been affirmed via a new Memorandum of Understanding between the two organizations to guide our cooperative work.

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NOTES

1. G. H. Kaplan, "New Technology for Celestial Navigation," these *Proceedings*.
2. For a concise discussion of the ICRS and its practical consequences, see: M. Feissel and F. Mignard, "The Adoption of the ICRS on 1 January 1998: Meaning and Consequences," *Astronomy and Astrophysics*, **331**, (1998), L33-L36.
3. The Newcomb project is an AA Department effort to produce new fundamental ephemerides of major solar system bodies. Additional

information can be found in the Research section of the AA Department World Wide Web site (<http://aa.usno.navy.mil/AA/>).

4. MICA is USNO's computer-based almanac for high precision applications. For more information concerning MICA (and STELLA), see J. A. Bangert, "The Astronomical Applications Department Today," these *Proceedings*.