Orbital Data on the WWW

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Figure 1. New *Celestial WWW* Home Page.

A lot can change between columns here at ***Satellite Times***. Last time, we began a series of articles on benchmarking of satellite tracking software and were supposed to finish it up in this issue. Little did I realize as we were putting that last issue to press that by the time I got around to writing the next one, I'd be doing so from a new house.

Moving is always a great opportunity for change. It forces changes in patterns that we've grown accustomed to—sometimes whether we like it or not. Of course, every time I've moved since 1985, one of the big changes has been to quickly set up the ***Celestial BBS*** at its new home. Over the years, the ***Celestial BBS***—a major source of orbital elements and satellite tracking software—has moved from Sunnyvale, CA to Austin, TX to Fairborn, OH to Wright-Patterson AFB, OH and finally to Montgomery, AL.

At first, it seemed that this move would be a relatively painless one for the BBS. After all, we were only moving a distance of a mile or so and could actually transfer the telephone number. Except for a couple of hours to pack everything, move it, and set it back up, it looked like it could be done without much impact on the BBS's users.

We hit the first snag, however, when we discovered that the new house was only wired for two lines. Since my wife and I both do a lot of work at home and most of it has some aspect of remote communications, we already needed both lines. Having ***BellSouth*** come out and install a new line would add cost and cause delay of a week in getting the new BBS back up and operating.

That's when I began to realize it was time to consider Plan B. Traffic on the ***Celestial BBS*** had been dropping precipitously as the popularity of the Internet and the World Wide Web (WWW) rocketed. From an average daily high of 70 calls a day (and 100-130 calls a day during many US space shuttle missions—not bad for a one-line BBS), traffic had dropped to only a handful of calls each day. Many users were getting the data via ***anonymous ftp*** at archive.afit.af.mil in the ***pub/space*** directory ***[this site is no longer available]*** and wondering why they couldn't access the rest of the material from the ***Celestial BBS*** via the Internet. Many of these users were looking for ways to avoid considerable long-distance charges while calling from places as far away as Australia and Japan.

The solution, of course, seemed obvious. Why not set up a WWW site to replace the BBS? After all, that would avoid the need to install a new telephone line and allow me to begin operation before the BBS shut down. It would also remove many of the problems with BBS operations, such as noisy phone lines or system lock ups while I was away from home. In addition, I would avoid major hardware and software upgrades which were needed to remove some operating limitations (the ***Celestial BBS*** was still running on a 386 machine running ***MS-DOS***).

A WWW site seemed the ideal solution. After all, I am responsible for (and do a lot of development on) the Air University WWW home page (http://www.au.af.mil/)—one of the largest WWW systems in the US Air Force. Writing in HTML (HyperText Markup Language) had become second nature and I had some pretty good ideas of how to start off. Plus, our local Internet service provider (ISP) offered personal home pages as part of their package.

Well, Plan B didn't get too far when I began to realize that the five free megabytes of transfers a day offered by our ISP wouldn't be nearly enough to support the traffic I anticipated for such a site. In fact, that would only be about a hundred downloads a day of the master two-line orbital elements list. I've always been a strong proponent of free access to information and believe the payback for operating the BBS out of pocket, with the generous donations of a few financial supporters, has been instrumental in helping satellite tracking to evolve to where we are today. The thought of charging for access put a major crimp in Plan B.

Grove to the Rescue

That's where the great folks at ***GroveLink*** and ***Satellite Times*** came to my rescue. I approached them with a proposal to host the WWW site for the ***Celestial BBS*** on their new WWW server. Having immediate access to the most current orbital element sets for the ***Satellite Times*** readers would be a real plus. And what better column than ***Computers & Satellites*** to kick it off. To my delight, they were every bit as enthusiastic about the idea as I was! As a result, within a matter of days, we had the new ***Celestial WWW*** site stood up and operating at http://www.grove.net/~tkelso/ ***[now at http://celestrak.com, the CelesTrak WWW site]***.

A Guided Tour

The initial design of the ***Celestial WWW*** is pretty basic right now, providing primarily NORAD two-line orbital element sets and some supporting documentation. Even at that, though, the site is receiving 100-150 hits a day. Let's take a quick look at what's already available before talking about what's to come.

The home page will be the stepping-off point for our tour. The adventure begins right below the newly-designed logo for the WWW site (see Figure 1). Besides having links to our hosts and an easy way to send me feedback, ask questions, or make suggestions, there are currently three major sections to the site (see Figure 2):

- Current Data
- Historical Archives
- Documentation

NORAD Two-Line Element Sets		
Current Data	Historical Archives	Documentation

Figure 2. Links to NORAD Two-Line Element Sets.

The ***Current Data*** page contains just that: the most current data from the NORAD two-line orbital element sets. This data is normally updated every US government work day. The master list contains orbital data for a wide range of satellites—everything from amateur radio satellites to constellations such as GPS, Glonass, GOES, and many others. In addition, it also includes element sets for all new launches for the first thirty days after they are catalogued, making the data available as soon as possible after launch.

Perhaps more useful are the functional element sets which cover specific groups of satellites—amateur radio, weather, navigation, and various geosynchronous constellations (see Figure 4). These sets make it easy for users to quickly find the data they need. Of particular note are the special-interest element sets near the top of the page—element sets for things like the Mir space station, US space shuttle missions (while on orbit), and other satellites which are making the news (such as TSS 1—the tethered satellite that got away from STS 76).

All of the two-line element sets are formatted using the standard ***MS-DOS*** format where each line ends with a carriage return/line feed (CR/LF). This should make the process of downloading the elements, for direct use in various satellite tracking packages, pretty straightforward.

The ***Historical Archives*** are a treasure trove of information for many satellite users. Do you need orbital data for a weather or earth resources satellite (e.g., NOAA or Landsat) in order to geolocate an image? Well, you can find those and much more in this section. Historical element sets are available for various classes of satellite missions (e.g., weather and earth resources) from 1980 to the present. In most cases, this means that you can find ***all*** the two-line element sets generated for a particular satellite since launch!

Maybe you don't need every element set for these satellites. Instead, you're simply looking for element sets for 1994 for NOAA 11. At the bottom of the ***Historical Archives*** page are links to yearly archives for each of the satellites on this page. To find the 1994 data for NOAA 11, simply click on '1994' and then click on 'NOAA 11' in the 'NOAA' section of the 'Weather Satellites' table.

All this data wouldn't be of much use without appropriate documentation and that's where the final section comes in. The ***Documentation*** page presently contains some fundamental information for using the NORAD two-line element sets. The first item is a description of the NORAD two-line element set format. While most satellite tracking software already knows how to translate the two-line element set at input, users are often curious as to what each field represents. Here's where you can find out.

Of course, you should remember that you still need to use the NORAD SGP4 orbital model with these data to get the most accurate results. Orbital elements such eccentricity do not have exactly the same mathematical meaning in different orbital models and the user should not assume otherwise. For a complete description of the NORAD orbital models, including FORTRAN source code, look at the link titled ***Project Spacetrack Report Number 3***.

You may notice that the format of this document is different than what you're used to. Many documents you'll find on the WWW are in either HTML or plain ASCII text. But this report contains many mathematical equations used to describe the various orbital models and neither HTML or ASCII can adequately represent these equations. Enter the portable document format (PDF) created by ***Adobe*** (the creators of ***PostScript***) called ***Acrobat***. This format permits true WYSIWYG on the WWW and **free** viewers are available from ***Adobe*** for not only ***Microsoft Windows*** but ***Macintosh*** and ***Unix*** platforms, as well. Links for further information on ***Adobe Acrobat*** and to download the ***Acrobat*** viewers are included on this page.

The ***Documentation*** section also provides links to some timely information about recent and upcoming satellite launches. The ***SPACEWARN Bulletin*** is a monthly publication which gives basic information about each satellite launch. The site maintained by the ***Committee on Space Research (COSPAR)*** contains archives of these bulletins going back several years. ***Jonathan's Space Report*** is a weekly newsletter with information on current launches, decays, and discussion of various satellite news items. It is an excellent resource for staying up on what's in orbit.

Plans For the Future

It may seem that the ***Celestial WWW*** already has quite a lot of information, but we've only just begun! Let me leave you with just a hint of things to come. One of the major items currently missing from the system are the vast software archives on satellites and astronomy which were available via the ***Celestial BBS***. I will be reviewing those archives and either putting the programs online or adding links to the most current versions. Obviously, this will be a major effort, but one that should be well worth the effort.

In the ***Historical Archives*** section, we'll be adding a form for special requests. While the current archives are quite extensive, I'm sure many users will have special requirements and we want to be able to respond to special requests in a timely fashion. Once the form is online, you'll know we're ready to supply this service.

Help and additional reference materials will be a major addition to the new site. Soon, there will be a ***Help*** page which mirrors the ***Current Data*** page. Here, when you click on NOAA 11, you'll find links to basic information describing the satellite, operating frequencies, operational status, images, and other related information. The Internet is a gold mine of such information, but finding what you need can be tough. We hope to tie it all together for you.

Of course, being a professor, one of my basic missions is education. Past issues of this column have served as a basic tutorial on satellite tracking and will continue to do so. For those of you who have missed some of the earlier issues, I'll be putting them out in ***Adobe Acrobat*** format to serve as a major reference. And, to supplement these issues, I'll provide the source code and executables discussed in my columns (such as our last issue) to help you follow along. I'll also be building a Frequently Asked Questions (FAQ) list to address basic recurring issues.

One final note on the technology. While the tables on the new Celestial WWW look best under Netscape Navigator 2.0 because of its incorporation of the HTML 3.0 standards for tables, this browser, with its plug-ins, will allow us to push the envelope with new technologies like ***Java***, ***Amber*** (an enhanced ***Acrobat***), and ***VRML***. Imagine interactive demonstrations of basic orbital theory to help you get up to speed on a particular topic—it's coming!

Conclusion

Hopefully, the things we've just discussed will make it easier for you to learn about and understand orbital mechanics and to get the software and data to be able to apply what you've learned. Of course, it isn't a substitute for ***Satellite Times*** (it's still hard to do this Internet stuff while waiting in the doctor's office), which has a wealth of other outstanding material, but I think you'll find it provides considerable enhancement to each issue.

As always, if you have questions or comments on this column, feel free to send me e-mail at my ***new*** e-mail address: TS.Kelso@celestrak.com or write care of ***Satellite Times***. And be sure to let the folks at ***Satellite Times*** know how you feel about the new WWW site and thank them for their support. Until next time, keep looking up!

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