

# TimeSet: A Computer Program That Accesses Five Atomic Time Services on Two Continents

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## Abstract

*TimeSet is a shareware program for accessing digital time services by telephone. At its initial release, it was capable of capturing time signals only from the U.S. Naval Observatory to set a computer's clock. Later the ability to synchronize with the National Institute of Standards and Technology was added. Now, in Version 7.10, TimeSet is able to access three additional telephone time services in Europe — in Sweden, Austria, and Italy — making a total of five official services addressable by the program. A companion program, TimeGen, allows yet another source of telephone time data strings for callers equipped with TimeSet version 7.10. TimeGen synthesizes UTC time data strings in the Naval Observatory's format from an accurately set and maintained DOS computer clock, and transmits them to callers. This allows an unlimited number of "freelance" time generating stations to be created. Timesetting from TimeGen is made feasible by the advent of Becker's RightTime, a shareware program that learns the drift characteristics of a computer's clock and continuously applies a correction to keep it accurate, and also brings .01 second resolution to the DOS clock. With clock regulation by RightTime and periodic update calls by the TimeGen station to an official time source via TimeSet, TimeGen offers the same degree of accuracy within the resolution of the computer clock as any official atomic time source.*

## INTRODUCTION

The introduction of modem timing services for computers, first by the U.S. Naval Observatory, then by the National Institute of Standards and Technology, has created a need for software to interpret the data strings put out by these services and to set the computer clock with maximum accuracy.

Both the Naval Observatory and NIST are very helpful in supplying programs and programming code for accessing their modem time services, but my first exposure to such a program was early in 1987, when I downloaded a program called CallTime, written by a programmer in New England. As it turned out, the version I got was for a millisecond time service of the Naval Observatory that had already been discontinued.

At that point I decided to write TimeSet, which I first put out on computer bulletin boards in the summer of 1987. The appreciative response from the computing community, particularly on Compuserve, was most gratifying. Interest on the part of users has driven TimeSet development ever since. Ability to call the NIST's service was added in 1989, which for a time made TimeSet the only program of its kind that could work with both telephone time sources in the United States. Now, with Version 7.10, three European services — in Sweden (Swedish National Time and Frequency Laboratory), Austria (Technical University of Graz), and Italy (National Electrotechnical Institute) — have been added.

Inclusion of European services in TimeSet was at the suggestion of Mr. Erland Brannstrom of the Swedish National Time and Frequency Laboratory. He developed the modem time generator used in Sweden and

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participated in the establishment of the standard data string format used in Sweden, Austria, and Italy. The standard has also been adopted in The Netherlands, though it has not yet been installed there, and it is thought likely that other European time services will adopt it in the future. Of the three European services using this standard format, only the Swedish and Austrian services offer the capability of measuring line delays at this time. The long-term development goal for TimeSet is to include as many of the world's atomic time services as possible. As new modem-accessible time services come online, they will be added to TimeSet.

In addition to these official time sources, Timeset 7.10 can set computer clocks from time data strings generated by a companion program called TimeGen, which generates UTC time data strings in Naval Observatory format. TimeGen allows any PC computer to become in effect a "substation" of any official atomic time service transmitting over the telephone system. The computer running TimeGen automatically updates its own clock by means of periodic calls via TimeSet to a selected atomic time service. The rest of the time it waits for the phone to ring so it can transmit data strings by modem to other computers calling it with TimeSet. Details on TimeGen are presented later in this article.

## **TIMESET OPERATION**

### **Program Configuration**

A copy of TimeSet that has never been configured before presents a configuration menu screen when it is first run (Figure 1). Scrolling up or down the list of configuration items is done by pressing the Up and Down arrow keys to highlight the next line. For most configuration items, selections are made by pressing the Right or Left arrow keys when a particular configuration line is highlighted. For example, when the line for modem speed is highlighted, each press of the Right or Left arrow key brings a new modem speed into view. The selectable modem speeds range from 1200 bps to 115200 bps (the high-speed options are to accommodate newer modems that can be "locked" at high speed locally while allowing the line speed to drop to 1200 bps to match the usual speed of a time service's modem).

Another configuration item that allows options to be toggled is the one for manual or automatic operation. If manual operation is selected, the user initiates a call to one or another of the time services by pressing a certain key or key combinations at the main program menu, and on completion of a call the program remains loaded. If automatic operation is toggled, the program calls the selected time service, sets the computer clock, and immediately exits to DOS. A number of automatic options are available at the configuration screen. There are two options for each time service, specifically with or without line delay measurement. Thus one can select the NIST with or without line delay measurement, the Naval Observatory with or without line delay measurement, a selected European time service with or without line delay measurement, and a selected TimeGen service with or without line delay measurement. Automatic operation is mainly for the convenience of those who wish to include a TimeSet call in their AUTOEXEC.BAT file as part of the boot-up procedure.

A few lines may be edited. These include the lines containing time service telephone numbers, since it is not uncommon for telephone users in institutional settings to have to insert codes and pauses before and after an outside phone number, or, as in the case of those using the Federal telephone system, to revise the phone number to conform to that system's rules. One phone number configuration line is reserved for one of the European time services. Although the default for this line is "NULL", pressing the Right or Left arrow key successively produces current phone numbers for the Swedish, Austrian, and Italian time services, which, as noted, share the same data format. If a European phone number is selected on this line, it must be edited to remove the '+' sign in front of the phone number if one is calling from the host country, or to replace it with an international calling code if one is calling from another country. The last telephone number line is for calling a computer equipped with TimeGen. Here one simply types a phone number to replace the default "NULL."

Another line that allows editing is the one where users select their local time zone, which the program needs to know to convert UTC to local time. Although any of the named North American time zones can be obtained by toggling with the Right or Left arrow key while that line is highlighted, provision is made for TimeSet users outside North America to write in their time zone's offset from UTC (a positive number if east of 0 degrees longitude, negative if west of 0 degrees longitude).

Another line that often requires editing is the modem initialization string. Two alternative strings for modem initialization are built into version 7.10 of Timeset. The string '&C1&D2X4' is the default and is intended for users who have simple basic asynchronous modems, with no speed option higher than 2400 bps and no error checking/data compression protocols. &C1 instructs the modem to wait for a carrier, not to assume one is already present. &D2 instructs the modem to hang up when the DTR status is set to 0, which is TimeSet's method of hanging up quickly after it has obtained a time data string for parsing and clock setting. X4 selects a result code set that includes CONNECT, NO CARRIER, BUSY, and NO DIALTONE.

Toggling with the Right or Left arrow key while user's modem initialization line is highlighted will bring another modem initialization string for users who have one of the new high-speed modems that use data compression and error-checking protocols such as MNP or LAP-M. These protocols must be turned off and the modem placed in basic asynchronous mode when TimeSet makes a call to one of the time services. The string, '&Q0&B1&C1&D2X4' accomplishes this with the majority of high-speed modems. &Q0 is the modem command for basic asynchronous mode in most high-speed modems (a few brands use &M). &B1 is the command most high-speed modems use to keep the local speed high while allowing the line speed to adjust to match the speed of the remote modem; it is essential that &B1 be present if the TimeSet user has selected a high dial-up speed such as 38,400 bps. (It is also essential, if a high dial-up speed is selected, that the line that allows toggling YES or NO for locking the local speed be toggled to YES, because it will prevent any attempt to adjust the serial port to 1200 bps after connection is made.)

A variety of other options exist on the configuration screen. For example, users in the United States can select automatic adjustment for time season changes. Installing this feature would have been no problem with the data strings from the NIST, since that service has a time season flag embedded in its data string. However, since many TimeSet users have requested automatic season adjustment for the Naval Observatory data as well, and since the Naval Observatory has no flags for it in its data string, it was necessary to develop an algorithm to calculate when switches to daylight savings time and standard time will occur. To reduce code size, TimeSet applies this algorithm to both the Naval Observatory data and the NIST (ignoring the flag for season changes in the NIST string). This algorithm is good for the next 74 years, or until Congress changes the switch days again, whichever comes first.

No automatic time season adjustments are available for the European services, since it is not certain that all countries that might adopt the current European standard in the future will change time seasons on the same day. However, with any of the time services a season adjustment can be made manually from TimeSet's main menu merely by pressing function key F7. Whatever the current time season, a press of F7 reconfigures the program to the opposite season and adjusts the computer's clock accordingly.)

When the user has finished configuring TimeSet, a press of F10 saves the configuration to TimeSet's own file and brings the user to the program's opening menu.

## **The Main TimeSet Menu**

If TimeSet is configured for manual operation, the program will always show the main menu (Figure 2) and will wait there for the user's keyboard input. If the user has configured TimeSet for automatic operation, however, as from a batch file, the main TimeSet menu normally will not be seen. Instead, the program will immediately begin initializing the modem and dialing the phone number of the selected time service. (The main menu is accessible even while dialing is in process, however, just by pressing the Back Space key.)

The main menu screen features a running time display with numbers for hours, minutes, and seconds typically 3/4" to 1" high, depending on monitor size. Fractions of seconds, to two decimal places, are displayed with standard characters.

Keystrokes needed to call one of the time services, with or without line delay measurement, are also displayed. The keys for each service are mnemonic: pressing W calls Washington (USNO) without line delay measurement, Alt-W calls the USNO with line delay measurement; pressing B calls Boulder (NIST) without line delay measurement, Alt-B calls Boulder with line delay measurement; pressing E calls the selected European time service (identified by country name on the menu screen) without line delay measurement, pressing Alt-E calls the selected European service with line delay measurement (except for the Italian service, which does not provide it); pressing T calls the selected TimeGen service, Alt-T with line delay measurement.

A variety of function key options are available at the main menu. F1 produces a help screen. F2 brings the configuration screen, allowing the user to change any configuration item. F7 toggles daylight saving time and standard time, simultaneously adjusting the computer clock by one hour. F8 toggles monochrome and color display. F9 allows a pulse to be generated at the parallel port at the instant of timesetting, useful for calibrating external equipment.

Figures 4 and 5 show a call in progress to the NIST, with line delay measurement requested.

After a call to a digital time service is completed, TimeSet summarizes the results on its final screen (Figure 6). The summary screen displays the last data string captured, the UTC information extracted from it, the measured line delay (if that option was chosen), and the local computer's time and date before and after.

## Interaction with RighTime

RighTime is a remarkable program developed by Tom Becker of Air System Technologies, Inc. (see Mr. Becker's paper elsewhere in these Proceedings). It is a small memory-resident program that overcomes two glaring deficiencies in the PC's timekeeping system: (1) the typically appalling drift rate of the DOS clock, which can be as much as 15 seconds a day or more, and (2) the poor resolution of the DOS clock, no better than 55 ms. Mr. Becker's program makes getting highly accurate time from an atomic source with a program like TimeSet meaningful, because RighTime learns the computer clock's drift rate and refines a correction for it over a series of precision clock settings with TimeSet, and it applies this correction incrementally every few seconds as long as the computer is turned on. It can even learn the drift rate when the computer is turned off and only the CMOS clock, driven by a battery, is maintaining the time. As a result, RighTime can, after only a few TimeSet calls spaced over a few days, hold both the CMOS and DOS clocks within a few hundredths of a second of true time for a week or more. In addition, the latest version of RighTime breaks the .055 second granularity of the DOS clock and gives it true .01 second resolution.

Version 7.10 of TimeSet is able to detect the presence of RighTime and interact with it. If RighTime is loaded, TimeSet presents another function key option (F5) at its main menu screen that allows the user to see the current RighTime correction and the time that has elapsed since the last time set, which is useful in judging whether it is time to call a time service (Figure 3). The F5 option also allows the user to control certain functions of RighTime, including disabling RighTime learning for the next time and date set, forcing the system to ignore the next time and date sets completely, suspending all of RighTime's DOS clock maintenance actions, and suspending RighTime's maintenance of .01 second resolution in the DOS clock. All keys controlling RighTime functions in TimeSet have a toggle action; that is, pressing a designated key once changes the state of a RighTime function, and pressing the same key again causes reversion to the previous state.

## THE TIMEGEN PROGRAM

RighTime's ability to bring sustained high accuracy to the computer clock, together with the ability of the latest version (version 2 or higher) to provide .01 sec resolution in the DOS clock, has stimulated further development of TimeGen, a program that allows any DOS computer to serve as a time source for any other computer equipped with TimeSet ver. 7.10 and a modem. I developed an early version of TimeGen several years ago, but abandoned it in consideration of the typically high drift rate of computer clocks. Computers with such a serious limitation would need to call an atomic time source several times a day to maintain only moderate accuracy.

The advent of RighTime has made further development of TimeGen feasible and desirable, and TimeGen is now included in the TimeSet version 7.10 distribution package. Once RighTime has learned the drift rate of the clock and has optimally refined its correction for it, a single call daily to an atomic time source should be sufficient to maintain accuracy high enough to be worth sharing with other computers via TimeGen and TimeSet. Indeed, since the latest version of RighTime provides .01 second resolution for the DOS clock, timesetting from a TimeGen source is as precise as timesetting from the NIST, the USNO, or any other atomic time source, provided the calling computers also have TimeGen installed and therefore have .01 second resolution. Although atomic clocks are accurate in the nanosecond range, this extremely high accuracy has no practical use in a device like a computer that can resolve time to no better than two decimal places. For this reason, when two computers are connected via modem, with one of them running TimeGen and the other running TimeSet, and both obtaining clock stability and .01 second clock resolution from RighTime, computer timesetting via TimeGen can be just as accurate as from a telephone time service based directly on a cesium beam clock.

To ensure accuracy of TimeGen's generated data strings, the program features daily automatic clock update calls to a preselected atomic time service. The trigger for these timed calls is a memory resident program called AutoDial, which can be loaded into memory with instructions to generate an alarm signal to TimeGen at a specified time each day. The alarm signal includes information on which service is to be called — the NIST, USNO, a selected European time service, or even another TimeGen service. On receipt of this signal, TimeGen runs TimeSet through a shell to call the specified time service and update the computer's clock. If RighTime is installed and its clock correction value has been well learned, this daily setting is sufficient to maintain very high accuracy for the rest of the day. As soon as TimeSet has completed its update work, which takes less than a minute, TimeGen regains control and resumes its wait for incoming calls. As soon as the phone rings, TimeGen begins to generate UTC time signals in Naval Observatory format. If the caller is TimeSet version 7.10 installed on another computer, TimeSet captures a data stream, extracts the time information, and uses it to set the calling computer's clock.

(Note: The memory-resident trigger program AutoDial also interacts with TimeSet, causing TimeSet to dial a specified time service at a specific time each day. If AutoDial is loaded, all that is necessary is to have TimeSet loaded and waiting when the specified time arrives.)

Repeated tests in which TimeSet, using line delay adjustment, alternately called the NIST, USNO, a European service, and a TimeGen service (maintained by RighTime and a daily update call to an atomic service) produced practically identical before/after decimal time readings on the final summary screen (within .01 second, which is the variance usually encountered even with purely atomic time sources in this version of TimeSet). Only the minutes and seconds were different on successive calls, reflecting the time it takes to place and complete a timesetting call. The fractional times at the instant of timesetting were practically identical in all cases, indicating the feasibility of using TimeGen to make any RighTime-equipped personal DOS computer the equivalent of an atomic time service "substation".

It remains to be seen how many individuals will find practical uses for TimeGen. A number of possibilities come to mind. The majority of countries in the world lack a digital time service accessible to the general computing public; even in Europe only three countries provide them. It is conceivable that individuals in

many countries could set up TimeGen "substations" to distribute accurate time from another country's publicly available atomic time service locally. Commercial and governmental organizations with multiple branch offices in a metropolitan area — banks, utilities, precinct police stations, for example — could provide a central TimeGen service available through a local call to computers in the various outposts. In both situations, only one computer would need to make a periodic long-distance or international call, but TimeGen and TimeSet would allow the accurate time to be shared by many others. Although a computer could be dedicated full time to this function, it is also feasible to provide TimeGen services only during specific hours, freeing the host computer for other uses the rest of the time. Finally, we will soon begin development of a computer bulletin board version of TimeGen that will allow any caller to a BBS to access TimeGen from a menu to set his computer clock.

Since the UTC time data streams synthesized by TimeGen are based on DOS time, they can be no more accurate than the DOS clock itself. Therefore, in all instances it will be the responsibility of the TimeGen operator to ensure that RightTime is installed for clock stability and that the host computer's clock is updated regularly, preferably daily, with a call to an atomic time source.

## PERFORMANCE

A reasonable test to perform with a program that can call as many time services as TimeSet version 7.10 is to see how much agreement exists in the decimal portion of the time before and after clock setting when several calls are made to the same time source in quick succession, and when calls are alternated between different time sources in quick succession. Such a test requires line delay adjustment with each time service to cancel out varying distance and modem effects. The results of several such tests, involving calls to the NIST, the USNO, and the Swedish National Time and Frequency Laboratory from a site 60 miles north of Seattle, are shown in Tables 1-6.

Tables 1-3 show the results from quickly repeated measures made with the NIST, the USNO, and the Swedish National Time and Frequency Laboratory. In nearly every instance, and with all three services, the difference between the time reading before and after the time set was either .00 or -.01 second.

Table 4 shows the results of calls alternating between the Swedish National Time and Frequency Laboratory and the NIST. Again the before/after discrepancy is either .00 or -.01 second. The results suggest that if the clock is set by the Swedish service, a call to NIST moments later produces the same setting that another call to Sweden would have produced, and vice versa.

Table 5 shows the results from calls alternating between the Naval Observatory and the NIST. Again, the discrepancy ranged between .00 and -.01 second. It is very gratifying to see this level of agreement, since line delay measurement with the NIST is made by that sophisticated service, which then advances its on-time mark to compensate for it. In contrast, line delay measurements with the Naval Observatory are made by TimeSet using the modem's remote digital loopback feature, and TimeSet adds the measured one-way delay to the time just before setting the system clock. To make these RDL measurements with high accuracy, Timeset reprograms the system timer to produce a tick rate such that the successive ticks are only about 838 nanoseconds apart. Measuring line delay is a matter of counting the ticks between the transmission of a character to the Naval Observatory's modem and the arrival of its echo, dividing the result by two, and applying appropriate factors to convert the result to time (to four decimal places). The excellent agreement between the results of calls alternating between the two services indicates the accuracy and precision of TimeSet's line delay measurement procedure.

Finally, Table 6 shows the results of alternating calls to the Naval Observatory, the NIST, and the Swedish time service made in rapid succession through four cycles. Before/after time readings never varied by more than .02 second and usually less, despite the widely disparate distances of the three services from the Seattle area and the apparent involvement of a satellite link with the Swedish service (as suggested by a consistent line delay measurement of approximately .14 second).

## CONCLUSION

TimeSet is a shareware program that has reached a mature stage of development since its inception and initial release in 1987. With version 7.10, TimeSet can now access by telephone five atomic time resources on two continents, as well as freelance time sources operating the companion program TimeGen, which generates UTC data in Naval Observatory format and thus can act as a substation of the Naval Observatory or any other atomic time service. TimeGen ensures the accuracy of its synthesized UTC data strings by regularly running TimeSet through a shell to call a selected atomic time service and update the system clock. Its accuracy can be further ensured by installation of the clock regulating program RightTime. TimeGen can thus provide for many a reliable local alternative to an official atomic time source that might be a continent or an ocean away. They need only call a local TimeGen station with TimeSet and set their computer clock from it with the same accuracy they would get by calling an atomic time service themselves (provided the TimeGen service operator takes the necessary steps to maintain accuracy).

Two major factors limiting the utility of setting a computer clock to an atomic time service, namely the notorious drift rate in computer clocks (which often made the effort to get highly accurate atomic time seem not worthwhile) and their poor time resolution, have been eliminated by the release of version 2 of Becker's RightTime clock-regulating program, which learns and continually corrects for the drift and also provides .01 second resolution to the DOS clock. TimeSet version 7.10 is aware of the presence of RightTime and is designed to interact with it for maximum timesetting accuracy.

Table 1. Repeated Measures with the NIST

Conditions: Line delay enabled  
RightTime 2 installed, optimal correction  
System clock resolution: .01 second  
Calls made in rapid succession

| Time before set | Time after set | Error* |
|-----------------|----------------|--------|
| 15:02:40.02     | 15:02:40.02    | .00    |
| 15:04:51.02     | 15:04:51.02    | .00    |
| 15:06:00.01     | 15:06:00.02    | -.01   |
| 15:07:09.02     | 15:07:09.02    | .00    |
| 15:08:18.01     | 15:08:18.02    | -.01   |
| 15:09:20.02     | 15:09:20.02    | .00    |
| 15:10:26.01     | 15:10:26.02    | -.01   |
| 15:11:31.01     | 15:11:31.02    | -.01   |
| 15:12:36.01     | 15:12:36.02    | -.01   |
| 15:13:47.02     | 15:13:47.02    | .00    |

Calls with zero error: 50%

Calls with -.01 error: 50%

\* Error is difference between set time and previous time.

**Table 2. Repeated Measures with the Naval Observatory**

Conditions: Same as in Table 1

| Time before set | Time after set | Error |
|-----------------|----------------|-------|
| 15:15:32.11     | 15:15:31.11    | .00   |
| 15:19:41.10     | 15:19:41.12    | -.02  |
| 15:21:11.11     | 15:21:11.11    | .00   |
| 15:22:37.10     | 15:22:37.11    | -.01  |
| 15:24:07.11     | 15:24:07.11    | .00   |
| 15:25:32.10     | 15:25:32.12    | -.02  |
| 15:27:02.11     | 15:27:02.12    | -.01  |
| 15:28:38.12     | 15:28:38.12    | .00   |
| 15:30:02.11     | 15:30:02.11    | .00   |
| 15:31:28.10     | 15:31:28.12    | -.02  |

Calls with zero error: 50%

Calls with -.01 error: 20%

Calls with -.02 error: 30%

**Table 3. Repeated Measures with Swedish Time Service**

Conditions: Same as in Table 1

| Time before set | Time after set | Error |
|-----------------|----------------|-------|
| 20:33:10.12     | 20:33:10.12    | .00   |
| 20:35:41.10     | 20:35:41.11    | -.01  |
| 20:38:33.11     | 20:38:33.12    | -.01  |
| 20:40:34.12     | 20:40:34.12    | .00   |
| 20:41:54.12     | 20:41:54.12    | .00   |
| 20:43:12.11     | 20:43:12.12    | -.01  |
| 20:44:34.11     | 20:44:34.12    | -.01  |
| 20:46:14.12     | 20:46:14.12    | .00   |
| 20:47:34.11     | 20:47:34.12    | -.01  |
| 20:48:50.12     | 20:48:50.12    | .00   |

Calls with zero error: 50%

Calls with -.01 error: 50%

**Table 4. Calls Alternating between Swedish National Time & Frequency Laboratory and NIST**

Conditions: Same as in Table 1

Baseline calls to Sweden  
from Seattle, Washington

|        | Error |
|--------|-------|
| Sweden | .00   |
| Sweden | -.01  |
| Sweden | .00   |
| Sweden | -.01  |

Begin alternating calls

|         | Error |
|---------|-------|
| Boulder | .00   |
| Sweden  | -.01  |
| Boulder | .00   |
| Sweden  | -.01  |
| Boulder | .00   |
| Sweden  | -.02  |

Calls with zero error: 50%

Calls with -.01 error: 33%

Calls with -.02 error: 17%

**Table 5. Calls Alternating between the Naval Observatory and the NIST**

Conditions: Same as in Table 1

Baseline calls to NAVOBS  
from Seattle, Washington

|            | Error |
|------------|-------|
| Washington | -.01  |
| Washington | .00   |
| Washington | .00   |
| Washington | -.01  |

Begin alternating calls

|            | Error |
|------------|-------|
| Boulder    | -.01  |
| Washington | .00   |
| Boulder    | -.01  |
| Washington | -.01  |
| Boulder    | -.01  |
| Washington | .00   |

Calls with zero error: 33%

Calls with -.01 error: 67%

**Table 6. Results of "round-robin" calls to Naval Observatory, NIST, and Swedish National Time and Frequency Laboratory, from Seattle, Washington.**

Conditions: Same as in Table 1

| Call to:   | Time before set | Time after set | Error |
|------------|-----------------|----------------|-------|
| Washington | 01:08:34.11     | 01:08:34.11    | .00   |
| Boulder    | 01:09:46.01     | 01:09:46.02    | -.01  |
| Sweden     | 01:11:08.12     | 01:11:08.13    | -.01  |
| Washington | 01:14:33.12     | 01:14:33.11    | +.01  |
| Boulder    | 01:15:42.01     | 01:15:42.02    | -.01  |
| Sweden     | 01:17:01.11     | 01:17:01.12    | -.01  |
| Washington | 01:18:39.11     | 01:18:39.11    | .00   |
| Boulder    | 01:19:54.00     | 01:19:54.02    | -.02  |
| Sweden     | 01:21:16.11     | 01:21:16.12    | -.01  |
| Washington | 01:22:56.12     | 01:22:56.11    | +.01  |
| Boulder    | 01:24:04.01     | 01:24:04.02    | -.01  |
| Sweden     | 01:25:24.11     | 01:25:24.13    | -.02  |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| Outside phone: NULL<br>Naval Observatory: 12826538351<br>NIST: 13834944774<br>European service: 81143316472366 AUSTRIA<br>TimeGen service: NULL<br><br>Your time zone: PACIFIC<br>Your time season: STANDARD<br><br>.Serial port: COM1 3FB IRQ4 (ALL)<br>Dialing method: TONE<br>Dialing baud rate: 38400<br>Lock modem speed: YES<br>User's commands: AQBAB1AC18D2X4<br><br>Computer clock: DOS CLOCK-CALENDAR<br><br>Auto time season: AUTOMATIC SEASONS<br>Manual/auto dial: MANUAL<br>Video type: MONOCHROME | ← Editing or toggling.<br>Press Enter to edit,<br>or ++ to toggle. |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|

|                       |            |          |         |                       |
|-----------------------|------------|----------|---------|-----------------------|
| I, I, PgU, PgD=Scroll | F2=No save | ESC=Quit | F1=Help | F10 = Save to TIMESET |
|-----------------------|------------|----------|---------|-----------------------|

Figure 1. TimeSet 7.10 configuration screen. Most selections are made by toggling new values with the right or left arrow key. A few are made by editing existing values.

|                                                                                                                                                                                                                                                                                          |                                                                                                                                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PROFESSIONAL<br><b>TIMESET</b> ™<br>Version 7.10<br>Precision timesetting for computers                                                                                                                                                                                                  | RightTime detected<br><div style="border: 2px solid black; padding: 5px; font-size: 2em; font-weight: bold;">15:49:18</div> Date: 12-31-1992, Thursday .91<br>STANDARD TIME |
| AutoDial detected: NIST/delay<br>BB:00:00 daily<br>W, Alt-W - U.S. Naval Observatory, Washington, D.C.<br>B, Alt-B - National Institute of Standards & Technology, Boulder, Colo.<br>E, Alt-E - Selected European time service (AUSTRIA)<br>T, Alt-T - Selected TimeGen(tm) time service |                                                                                                                                                                             |
| F1 - Help screen<br>F2 - View/change configuration<br>F7 - Toggle daylight/standard time<br>F8 - Toggle color/monochrome display<br>F9 - Pulse generation<br>BACKSPACE - Previous screen<br>DELETE - Toggle 1-sec ticks<br>ESC - Quit the program                                        |                                                                                                                                                                             |

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Figure 2. TimeSet 7.10 menu screen. Selecting and calling a time service is done by mnemonic key strokes (e.g., W = Washington, Alt-W = Washington with line delay measurement; B = Boulder, Alt-B = Boulder with line delay measurement; etc.). Several control options are available by pressing function keys.

|                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                            |                               |
|-------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| PRO<br>T<br><br>Preci<br><br>DIAL<br><br>W,<br>B,<br>E,<br>T,<br><br>F1<br>F2<br>F7<br>F8<br>F5 | RightTime® CURRENT STATUS<br>Time since last time set: 0 days, 8.86 hours<br>Warm correction: +9.97 sec/day<br>Cool correction: +8.88 sec/day<br>RightTime learning: Learning enabled<br>Ignore next time/date set: Time/date sets enabled<br>DOS clock maintenance: All functions enabled<br>0.01 second resolution: 0.01-sec resolution enabled<br>Automatic daylight/standard: Disabled | lo.<br><br><br><br><br><br>ks |
|                                                                                                 | RightTime CONTROL PANEL<br>(Note: These functions can be toggled) Equiv.<br>1 → RightTime Learning (/10)<br>2 → Ignore 1 Setting of time/date (/12)<br><br>4 → DOS clock Maintenance (/TD)<br>5 → 0.01-sec DOS clock Resolution (/TH)                                                                                                                                                      |                               |
|                                                                                                 | Select, then press Enter to save and return to Timeset<br>(or press F5 to return without saving)                                                                                                                                                                                                                                                                                           |                               |
|                                                                                                 | (* RightTime is a trademark of Air System Technologies, Inc.)                                                                                                                                                                                                                                                                                                                              |                               |

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Figure 3. Pop-up window showing current RightTime settings and control options. Control options include temporarily disabling RightTime learning for the next call to a time service, ignoring the next pair of time and date sets, suspending RightTime's maintenance of the DOS clock, and suspending 0.01-sec DOS clock resolution. This window does not appear unless TimeSet detects the presence of RightTime.

|                                                                                                             |
|-------------------------------------------------------------------------------------------------------------|
| <b>Connected</b><br>BOULDER, COLORADO<br>BACKSPACE = Cancel call    SPACEBAR = Redial    ESC = Quit program |
|-------------------------------------------------------------------------------------------------------------|

READING DATA ...

```

4898B 93-01-01 00:00:50 00 0 +.1 B45.8 UTC(NIST) *
4898B 93-01-01 00:00:51 00 0 +.1 B45.8 UTC(NIST) *
4898B 93-01-01 00:00:52 00 0 +.1 B45.8 UTC(NIST) *
4898B 93-01-01 00:00:53 00 0 +.1 B45.8 UTC(NIST) *
4898B 93-01-01 00:00:54 00 0 +.1 B45.8 UTC(NIST) *
4898B 93-01-01 00:00:55 00 0 +.1 B78.1 UTC(NIST) *
4898B 93-01-01 00:00:56 00 0 +.1 B78.1 UTC(NIST) *
4898B 93-01-01 00:00:57 00 0 +.1 B78.1 UTC(NIST) *
4898B 93-01-01 00:00:58 00 0 +.1 B78.1 UTC(NIST) *
4898B 93-0
  
```

Local speed 38400 bps. Line speed 1200 bps

Figure 5. Data string capture in progress. Unless there is line noise, TimeSet receive nine data strings and captures the tenth for parsing and timesetting.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Calling</b><br>NATIONAL INSTITUTE OF STANDARDS & TECHNOLOGY<br>Boulder, Colorado<br>BACKSPACE = Cancel call    SPACEBAR = Redial    ESC = Quit program                                                                                                                                                                                                                                                                                                                                                                                |
| Line delay measurement enabled<br><div style="display: flex; justify-content: space-between;"> <div>           DOS time:<br/>16:05:19<br/>12-31-1992         </div> <div>           Modem Initialization<br/>           ATZ<br/>           ATBA<br/>           ATQBULS12=5857+5518=108<br/>           ATQBAB1AC18D2X4<br/>           DONE         </div> <div>           Dialing method: TONE<br/>           ATDT13834944774<br/> <div style="border: 1px solid black; padding: 2px; display: inline-block;">RINGING</div> </div> </div> |
| Port configuration: COM1, 3FB, IRQ4    RightTime detected<br>Professional Timeset (tm) Version 7.10<br>Copyright 1987-1992 Life Sciences Software<br>Stanwood, Washington, U.S.A.<br>All rights reserved<br><b>TIMESET</b> ™                                                                                                                                                                                                                                                                                                             |

Figure 4. Modem initialization and dialing the NIST with line delay request.

From NIST. Connect time: 14.88 sec.

DATA FOR TIME CALCULATIONS (all data pertain to Coordinated Universal Time)  
 Time data string: 4898B 93-01-01 00:14:48 00 0 +.1 B72.9 UTC(NIST)  
 Date: 01-01-1993  
 Julian date: 2448988  
 Day of year: 001  
 Hour: 00 Minute: 14 Second: 48  
 The United States mainland is on standard time.  
 U.S. daylight time begins on 01-04-1993 at 02:00:00 local time.

Current DOS time: 16:14:53.22

| ACTION SUMMARY (at instant of timesetting) |                                              |
|--------------------------------------------|----------------------------------------------|
| Internal delay adjustment:                 | .01 sec. (added to set time)                 |
| Line delay adjustment:                     | .0729 sec. (precompensated by time service)  |
| Universal Time Coordinated:                | 00:14:48.01 (time at 0° longitude)           |
| UTC Date:                                  | 01-01-1993, Wednesday (date at 0° longitude) |
| Local computer time was:                   | 16:14:48.00 (RightTime-assisted)             |
| Set to:                                    | 16:14:48.01 Pacific Standard                 |
| Local computer date was:                   | 12-31-1992                                   |
| Set to:                                    | 12-31-1992, Thursday, Day 366 of 1992        |

BACKSPACE = Opening menu    SPACEBAR = Redial    ESC = Quit program

Figure 6. TimeSet 7.10 summary screen. If the program is configured for automatic operation it exits to DOS at this point.

## QUESTIONS AND ANSWERS

**Ralph Partridge: Los Alamos National Laboratory:** We have tried your program before. We have a need to work with a rather different time format using the same thing. We have written our own program to do it but we wondered if it is feasible to work with you recompiling with a different time format?

**R. Petrakis:** Yes. I will give you my phone number and we can talk.