TIME VERSUS DATE

by Dick Suiter

A long time ago I wrote an article about daylight time and the analemma (it's in the club website archives) where I discussed the way that solar day varies around the earth's rotational period. We have gone to a mean time system based more on the rotational time than the solar day, and when we plot the position of the sun as a function of mean time, the sun appears to execute a path shaped like a bowling-pin or a long figure 8 in the sky at the same time of day. In other words, if we took a picture of the sun at noon every day, it would move in a long figure 8 instead of just moving north and south with the seasons.

The reason for this strange behavior is the tilt of the ecliptic with respect to the equator (about 60% of the effect is due to this) and the elliptical orbit of the earth around the sun (the remaining 40%). The tilt effect happens in two cycles per year and the elliptical orbit happens in one cycle with a small offset, so the net effect is that wonderful distorted bowling pin [*Mathematical Astronomy Morsels*, by Jean Meeus].

In any case, the solar position is a very complicated function of the day of the year, and further complicating it is the concept of the time zone. All of us have heard at various times the statement "Panama City would be perfect if we stayed on Daylight Time all of the time!" But it is obvious that this wouldn't be the complaint everywhere.

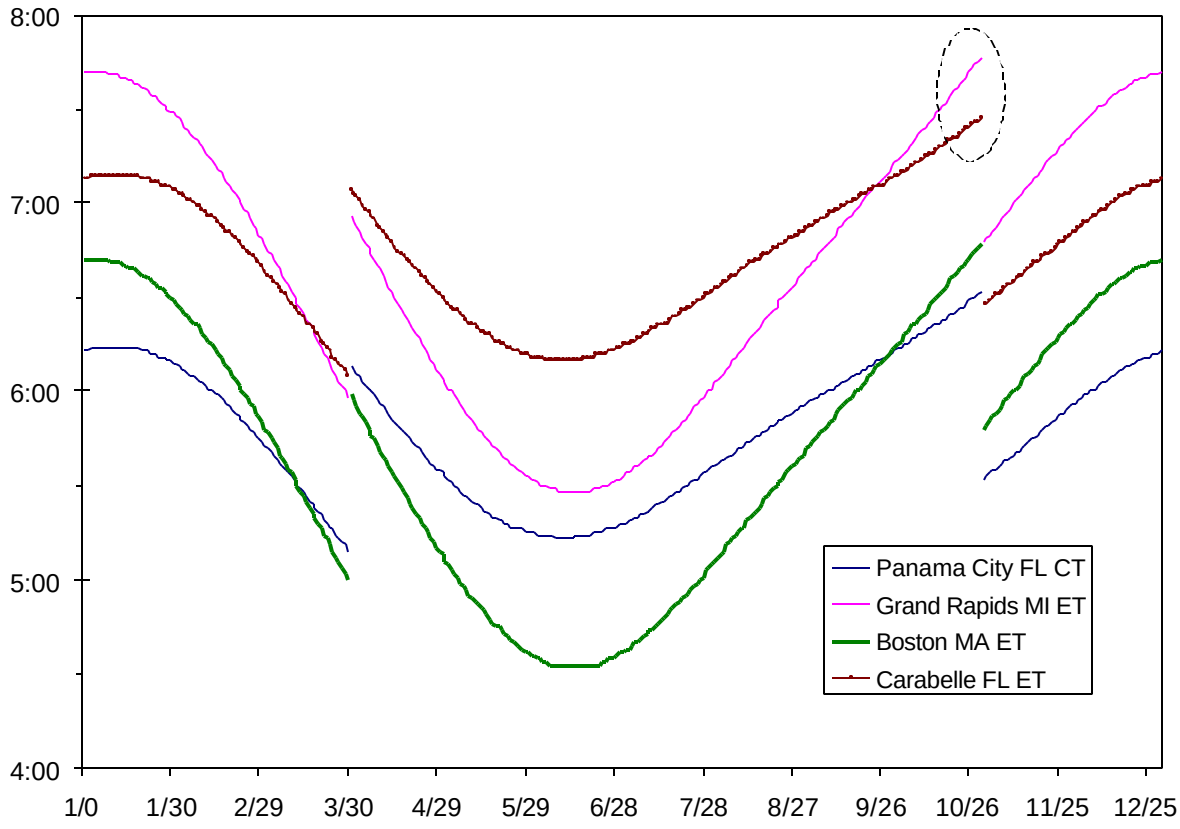

Figure 1. Beginning of dawn (30 min before sunrise) at four locations throughout year

I have plotted the dawn times and dusk times of four locations in Figures 1 and 2. I have chosen three locations to be in the Eastern time zone: Boston MA because it is the northeast of the time zone, Grand Rapids MI because it is in the northwest of the time zone, and Carrabelle FL because it is in the

southwest of the time zone. The southeast corner of the eastern time zone is in the middle of the ocean, so I translated the situation to the southeast corner of the central time zone by choosing Panama City FL.

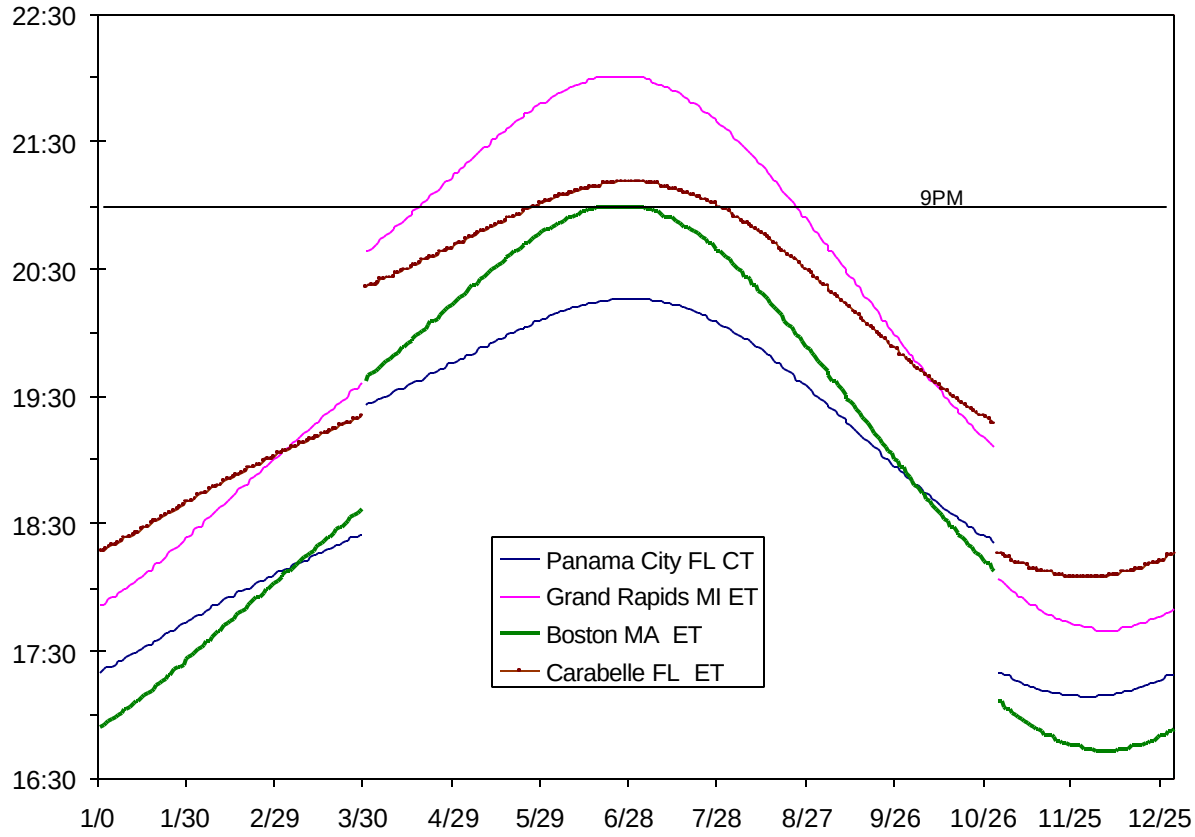

Figure 2. End of dusk times (30 min after sunset) at four locations throughout year

The program that calculated them was the Multiyear Interactive Computer Almanac (MICA) by the Naval Observatory [distributed by Willmann-Bell]. Actually, by dawn or dusk I don't mean anything as hazy as the colloquial terms, but rather the beginning of *civil twilight* in the morning and the end of civil twilight in the evening. That is the time when the solar disk is 6 degrees below the horizon – roughly a half-hour before and after sunrise and sunset respectively. It is the time when clear-sky illumination has deteriorated to 1 lux and newspapers are becoming difficult to read. For astronomical purposes the limit is 12 degrees below the horizon, or *nautical twilight* – about another half hour either way. Nautical twilight is when the horizon becomes difficult to see.

Note that at the beginning of daylight time Grand Rapids MI (magenta curve) maps into Boston (green curve) and Carrabelle FL (brown curve) maps into Panama City (dark blue). This is because they are at opposite sides of time zones but at nearly the same latitude.

Let's look at these curves and see what they tell us. The first thing that we notice is that daylight times "flatten" mornings. In Figure 1 we see a serious dip (particularly in northern latitudes) around the middle of the summer. Were it not for daylight time, Boston would begin to lighten at 3:30 AM in the summer!

Daylight time has downsides too. Look at the dusk chart (Fig 2) to locate the best time for 4th of July fireworks in Grand Rapids MI. Assuming the fireworks directors really should wait for civil twilight, it is 10 o'clock at night. I have located a possible problem area with dawn (Fig 1) with a broken ellipse.

When daylight time is extended 2 weeks at the instigation of the lawn-recreation industry later this year, these sharply rising curves will push the time of dawn dangerously close to 8 o'clock on the western side of time zones. Full sunrise is not until a half-hour later, so people in these locations will have to pick up kids in buses and get to work largely in the dark.

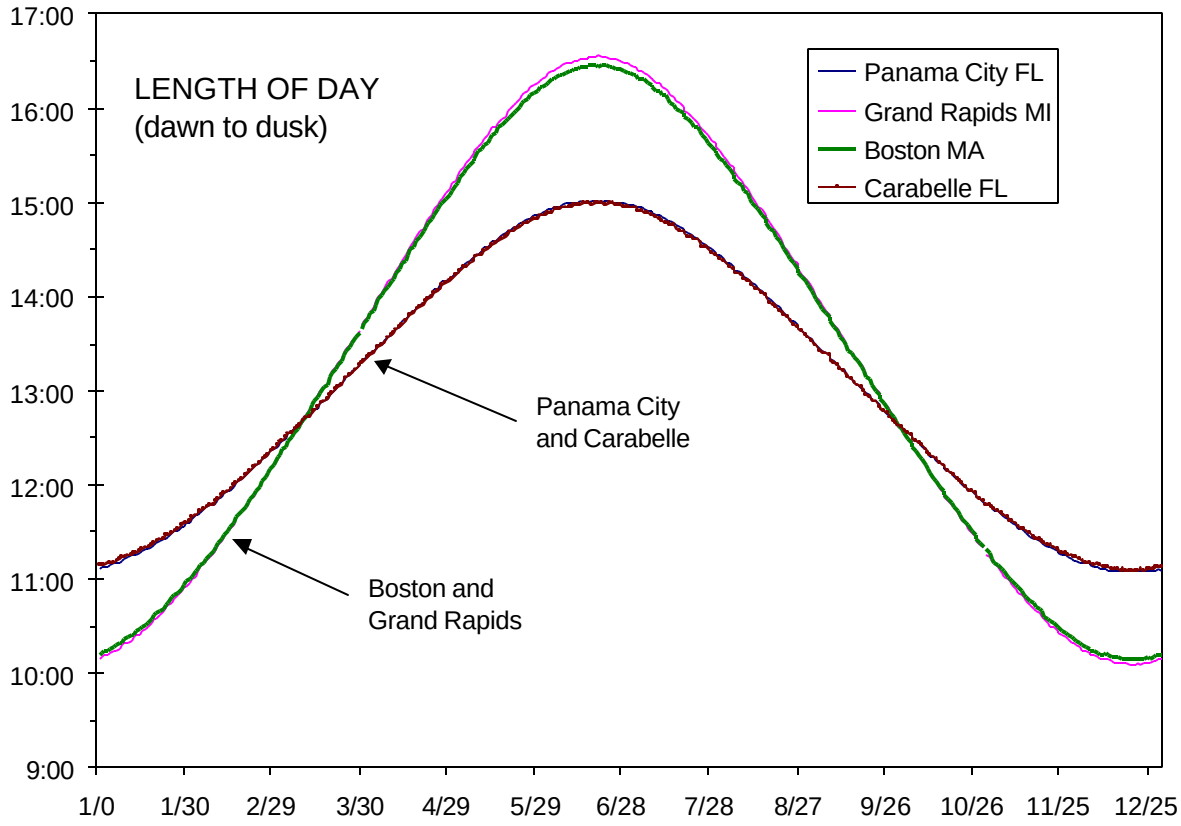

Figure 3. Length of day at calculated locations

Can we envision a less-coarse grid of time micro-changes that would completely regularize dawn and allow both commuting to and from work in the light? If we work an 8-hour day, take a 1-hour lunch, and commute a half hour at each end, we need 10 hours. Examining the length of day (Fig 3) for Boston and Grand Rapids, we see that only 10 hours exists at winter solstice. What with the plus or minus half hour slop in time zones and the plus or minus half hour of working start times, it is not possible to have a complete year with illuminated commutes, especially in the far north.

But take a look at the 11-hour minimum daylight window for Panama City and Carrabelle. It should be possible to hit this window even with some slop, or at least minimize the amount of time one end or the other would be dark. The fact that we spend many months with evening darkness is an artifact of the infrequent and heavy-handed way we apply the daylight correction.

How could the politicos talk people into changing their clocks, say, 8 to 16 minutes a month when the hour shift twice per year causes so much uproar? The answer is that they can't; voluntary compliance is politically impossible. However, the situation may become moot in a few decades. With more and more cell phones getting satellite time, there will come a time when it is cheaper to just make all clocks set time from GPS or local cell towers than to fit them with many mechanical buttons. These cell towers could be bumped by a central time service the additional time every day to make dawn occur at a

uniform time. In the central time zone, it might be desired to make the average dawn occur at 6:15 AM. Panama City is 18 minutes ahead of the center of the time zone, so here dawn would occur at 5:57 AM. Dusk (not sunset) would take place about 5 PM on Dec 21 and just shy of 9 PM on June 21. In the north, it may be impractical to put dawn at the same time, so the time zones may split into a checkerboard pattern of Northern time versus Southern time as well as the time zones. We may encounter a summer/winter time-of-dawn change, rather than a Daylight time change.

Of course, such a policy is a nightmare for an astronomer. It will change all the algorithms for computer planetariums and make timing astronomical events (such as occultations and eclipses) problematical. I don't know if any of this has even been contemplated and it certainly is not in the works, but it represents an interesting philosophical transformation. Such a shift would be the first time in hundreds of years that our clock system would be rigidly controlled by the sun.