

Re: Does motion affect the operation of clocks or not ?

Source: <http://sci.tech--archive.net/Archive/sci.physics.research/2007-11/msg00185.html>

- *From:* Thomas Smid <thomas.smid@xxxxxxxxxx>
 - *Date:* Sun, 25 Nov 2007 08:54:05 +0000 (UTC)
-

The figures you are quoting would apply if one would compare the satellite clock directly with the receiver clock. However, this is not how GPS works in practice. The receiver clock is in fact very much irrelevant, as the position is obtained by observing the difference between the time signals obtained from a number of different satellites.

Consider for simplicity a one dimensional problem where the receiver is located somewhere on the line connecting the two transmitters. In this case the signal from transmitter 1 reaches the receiver at time

$$(1) t_1 = t_0 + x_1/c$$

and the signal from transmitter 2 reaches the receiver at time

$$(2) t_2 = t_0 + x_2/c ,$$

where t_0 is the time the signal is being sent out (assuming both transmitter clocks are synchronized), x_1 is the distance of the receiver from transmitter 1, x_2 the distance of the receiver from transmitter 2, and c the speed of light.

Now if one subtracts Eqs.(1) and (2) one gets

$$(3) x_1 - x_2 = c \cdot (t_1 - t_2) .$$

One knows therefore the position of the receiver just by comparing the time signals from the two transmitters (if $t_1 = t_2$, the receiver would be exactly in the middle between the two transmitters). The receiver clock is thus completely irrelevant for determining the position.

If one assumes now that the transmitter clocks are running fast or slow by a relative factor $(1+r)$, one has instead:

$$(4) x_1 - x_2 = c \cdot [(1+r) \cdot t_1 - (1+r) \cdot t_2] = c \cdot (1+r) \cdot (t_1 - t_2)$$

which means that the position will simply be wrong by a relative factor r , but there is obviously no accumulation as the transmitter clocks run at the same rate relatively to each other.

Re: Does motion affect the operation of clocks or not ?

Now the usually quoted relativistic overall correction of 38 microseconds/day corresponds to $r=4.4 \cdot 10^{-10}$. As the satellites are at a distance of around 20000 km ($=2 \cdot 10^9$ cm), the positional error due to relativity should actually only be $4.4 \cdot 10^{-10} \cdot 2 \cdot 10^9$ cm = 0.8 cm. This is much less than the presently claimed accuracy of the GPS of a few meters, so relativistic effects should actually not be relevant at all (which would be anyway largely due to General Relativity, i.e. not be associated with the motion).

Thomas