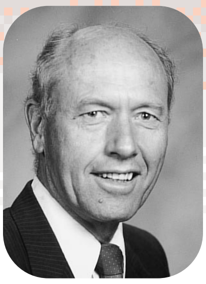
"GPS improvements rely and depend upon atomic clock technology. In its success, GPS has placed itself in jeopardy!" William J. Klepczysnski



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As we look to the future, I suggest that there are two major timing opportunities that could greatly benefit systems like GPS and Galileo, as well as many other timing-sensitive systems. These suggestions have not been fully utilized to date, one being a breakthrough invention. I propose a better utilization of clock ensembles and a new invention called "Synchronistic Modulation Detection (SMD)."

As an example, both in the application of GPS and in the planning of Galileo, one of the most significant concerns for their use is integrity. In the case of GPS, integrity has been primarily worked from the top–down rather than from the bottom–up. By "top–down" I mean that integrity is primarily a system responsibility in guaranteeing that all signals transmitted by the system are consistent with specifications as to both position and timing. By "bottom–up" I mean that the user could also take responsibility for integrity in a very inexpensive, robust, and reliable way.

Those working integrity with GPS have brought the response time down to six seconds, during which interval the user would be informed of faulty data coming from the system. Galileo design calls for a one-second response time. Of course, the goal is to have the response time as short as possible while having the highest integrity reasonably attainable as to the validity of that response.

We have a great opportunity to increase the integrity and to shorten the response time by utilizing inexpensive, quartz-crystal oscillator ensembles in the user sets. Clock ensembles have the great advantage that they are self-characterizing; hence, they can sense statistical outliers very quickly and with great integrity. This concept was introduced a year ago using theory and simulations demonstrating significant cost-effectiveness. The concept has not been implemented to date. Such ensembles could be made very small as well as inexpensively. We can easily envision high integrity response times well under a second using this "bottom–up" approach.

By working the "top–down" and the "bottom–up" approaches together, we can produce both a great improvement in integrity as well as a significant decrease in the response time. In a cooperative mode, these two approaches could be integrated and made totally compatible. Legal issues may arise as to where to place responsibility for the data's integrity — with the system or with the user — but in a well-designed system that responsibility could be clearly delineated. The benefits versus the costs for this combined approach are anticipated to be very significant and well worth the effort to bring it about.

The first simulations of the new "Synchronistic Modulation Detection" have affirmed the theory allowing effective transfer of time and frequency over various media. In its theoretical limit, SMD shows that the transfer medium does not limit synchronization accuracy and precision. Application opportunities for this approach exist in mobile telephony, synchronization of satellite clocks, and new research experiments.

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Ever stop to think who sets the clock in your meeting room? Do you accept it as correct? Time is one of those things we take for granted!

GPS has done a great job in supplying time to the world. So great that it may find it has created a major problem for itself in planning for the next generation of GPS. GPS supplies the world with time that has the accuracy and precision of an atomic clock for a small fraction of its cost. Because of this, the market for atomic clocks has eroded. GPS fills that need.

In the future, augmentation systems (WAAS, EGNOS, MSAS, Galileo, etc.) as currently planned will provide real-time, global time synchronized to within several tens of nanoseconds. This will further eat into the market for atomic clocks. It seems as if the need for atomic clocks is diminishing at an alarming rate. Will any manufacturer remain to make them for the next generation of GPS satellites?

Only two commercial manufacturers of high performance atomic clocks (cesium beam frequency standards) operate in the United States. Several U.S. government laboratories are developing new devices but they face difficult times. The current generation of scientists, engineers and craftsmen who make these very key devices will soon go away as the need for their service declines. Who will be around to develop new, more accurate, commercially available devices?

Action must be taken. I believe that some type of private and government consortium should be formed to address the survival of