PTTI 2030 – SYSTEM APPLICATIONS OF ADVANCED CLOCKS

Ryan Dupuis
Excelitas Technologies

Bryan Owings
Symmetricom

Abstract

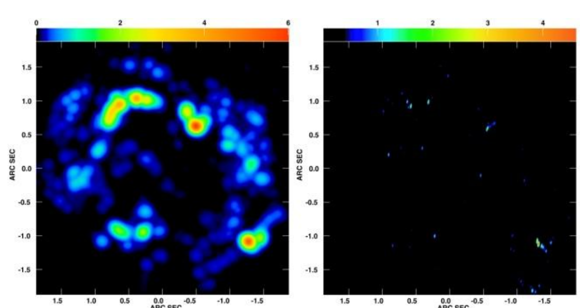
This poster explores the technology required to drive seven topics presented as possible advancements in a session on System Application of Advanced Clocks at the 2009 PTTI Meeting and set standards that industry should be expecting as goals in the near future.

INTRODUCTION

This poster topic came about during the breakout session of PTTI 2009. All participants were challenged to come up with ideas of what PTTI 2030 would be like. What accomplishments could be achieved with technological advancements from the timing community? In the *System Application of Advanced Clocks* breakout session, several ideas were presented as possible advancements.

MOON-BASED VLBI USING HIGH-PRECISION CLOCKS

Long recognized as the gold standard for VLBI work, the hydrogen maser continues to be the work horse of the radio astronomy community. Continued advances in miniaturization, low phase noise, and excellent short-term stability have allowed the hydrogen maser to develop to the point that use on the moon as a VLBI reference clock is now possible. Since the moon can provide a radio shield from the earth's EMI, new observations with unprecedented clarity of distant sources and galaxies are now possible. Scientists now are able to see further back in time than even optical telescopes allow as radio telescopes permit viewing of wavelengths not visible to optical telescopes.



http://www.jive.nl/astronomers-demonstrate-global-internet-telescope

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
NOV 2010	**N/A**	**-**

4. TITLE AND SUBTITLE
PTTI 2030 â System Applications of Advanced Clocks

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Excelitas Technologies

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR’S ACRONYM(S)

11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADA547222 . Precise Time and Time Interval (PTTI) Systems and Applications Meeting (42nd Annual) Held in Reston, Virginia on November 15-18, 2010, The original document contains color images.

14. ABSTRACT
This poster explores the technology required to drive seven topics presented as possible advancements in a session on System Application of Advanced Clocks at the 2009 PTTI Meeting and set standards that industry should be expecting as goals in the near future.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**4**	

Additional advances in data compression, transmission, and high-speed correlation have allowed the moon station to work in concert with other VLBI observatories in orbit and on the earth, and allow the possibility of VLBI with deep space probes working as additional observatories, thus extending the effective baseline by millions of miles.

This paper will explore the required advances to the current generation of clocks needed to advance the current moon- and earth-based systems to allow VLBI over distances approaching millions of miles.

http://deepspace.jpl.nasa.gov/dsn/gallery/images/

AUTONOMOUS VEHICLE NAVIGATION

Autonomous vehicle navigation was an idea that could only be conceptualized during the mid 1900s. At the turn of the century, the conceptualized idea became a reality thanks to increased accuracy of the GPS constellation, whose performance was made possible through the use of Rubidium Atomic Frequency Standards. While the sub-meter position accuracy was acceptable for navigation on open roads, the GPS signal was never strong enough to navigate on roads obstructed by tall buildings, tree cover, and tunnels.

Today, technology advancements in atomic clocks have made them more affordable, less power hungry, and more accurate. Through the use of Navigational Urban Beacon Systems (or NUBS), navigation can now be obtained through the longest of tunnels or roadways of New York. Using a methodology similar to that of GPS, NUBS are positioned strategically throughout low coverage GPS areas to ensure that vehicles have visibility to a minimum of three NUBS at any given time. NUBS and GPS complement each other to provide a seamless transition into any environment keeping your vehicle safely on the road while you enjoy the freedom of hands-free driving.

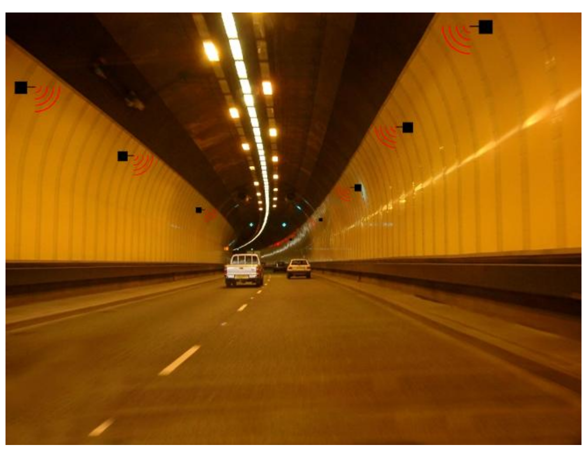


PLATE TECTONICS MONITORING

Ultra-stable clocks have been recognized for some time as great tools to calibrate plate movement on the earth's crust. In combination with a means of measuring accurately the path length from one clock to another via multiple possible techniques, one may discern the change in clock position after a seismic event. The addition of multiple clocks to a worldwide monitoring system has allowed improved accuracy of these measurements as multiple measurements before and after a seismic event allows three dimensional measurements to high precision. With these capabilities now in place, scientists are beginning to look at the possibility of predicting seismic events in advance so the populace may be warned to prepare.

This paper will look at the data available from these measurements over the past several years, with an eye toward prediction of seismic events such as earth quakes, volcanoes, and tsunamis.

REPLACEMENT OF CELL -PHONE BACK-HAUL TIMING

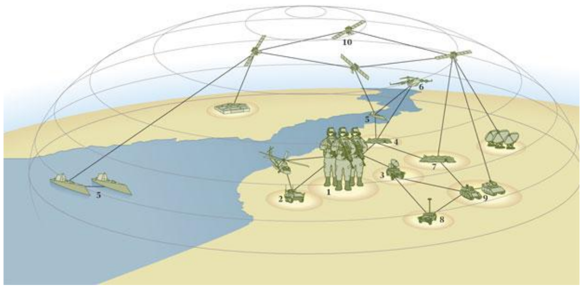
Though recent advances in miniature atomic clocks have resulted in multiple applications and cost reductions impossible to conceive of just a few years ago, cost still prohibits installation of such clocks in cell handsets as a practical way to minimize the need for back-haul timing in cellular networks.

However, in cellular networks, the base stations are either frequency or frequency + time synchronized, and then the handsets just lock to the BTS signal for reception, so there is no great advantage to increasing accuracy at the handset. With this in mind, this paper explores the advantages of improved timing at the base station using newly developed, more cost-effective atomic clocks. Realization of this new system allows the system operator to solve today's "frequency" back-haul problem, which has been solved historically by passing sync through the network for traceability, and locking an inferior oscillator to it at the BTS. In combination with GNSS, we believe synchronization to ±100 ns is a practical limit. This time synchronization allows for more efficient (bits/sec/Hz) networks and location services. Improvements are also seen with holdover. Additional benefits of such a system could include integrating signal for a longer time coherently with the local atomic clock, which would enable GNSS signal acquisition and tracking at lower levels.

DEPLOYED SOLDIER LOCATION SYSTEM

The protection of our soldiers has always been the number one priority for any country. Unfortunately, during times of war, that protection cannot always be guaranteed. Locating our soldiers in the field has been a challenging task for decades. Delivering the news to friends and family that a loved one was killed in the line of duty is heartbreaking enough without the news that the body was never recovered.

Fortunately, times have changed. With ultra-stable timing devices that consume minimal amounts of power, each soldier is now equipped with a personal receiver/transmitter that has a holdover time of 12 months on nominal battery operation. This exciting new technology is called Deployed Soldier Location System, or DeSoLoS for short. When GPS in unavailable or ground stations are destroyed, each soldier can act as a signal relay, keeping in contact with other soldiers, ships, tanks, and bases. The super-ruggedized construction of each DeSoLoS can withstand the catastrophic events of war.

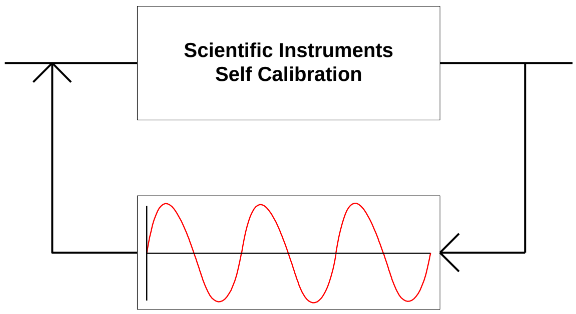


http://www.popularmechanics.com/technology/military/4215715

SELF-CALIBRATING SCIENTIFIC INSTRUMENTS

Continued advancements in miniature and chip-scale atomic clocks (MAC and CSAC respectively), begun in the early 2000s, have resulted in the development of advanced instruments for laboratory use with decreased calibration cycles, as well as improved accuracy and functionality. Additionally, miniaturized GPS receivers have allowed internal diagnostics and calibration "on the fly" for instruments such as frequency counters, spectrum analyzers, and measurement equipment to evaluate frequency stability or accuracy, with no other references needed.

This paper will provide an overview of the last 20 years of clock advancements and a look toward the future of high-performance test equipment.



AUTHOR INFORMATION

Ryan Dupuis
RAFS Electronics Engineer
Excelitas Technologies
(Formerly PerkinElmer)
ryan.dupuis@perkinelmer.com
Phone: 978-224-4311
Fax: 978-741-4923
35 Congress Street, Salem, MA 01970
www.excelitas.com

H. Bryan Owings P.E.
Electronics Engineer
SYMMETRICOM
BOwings@symmetricom.com
Sigma Tau Standards Group
1711 Holt Road, Tuscaloosa, AL 35404
Phone: 205-553-0038
Fax: 205-553-2768
www.symmetricom.com