

GPS Carrier Phase and TWSTFT comparisons of clock ensembles based at UWA and NMI



THE UNIVERSITY OF WESTERN AUSTRALIA



Australian Government
National Measurement Institute

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Project

- TWSTFT between UWA and NMI to link tightly the clock ensembles available at both organisations
- Integrity of the TWSTFT link will be demonstrated and continuously monitored by a GPS carrier-phase timing link
- Generation of a new national time scale exploiting the complementary facilities of the two research groups
- Preparation for future ACES mission

Infrastructure

- Ku-band two way satellite time transfer system including SATRE modems and associated communications equipment
- Earth station for UWA, including 2.4 metre diameter Andrew antenna installed in January 2006, transceiver being tested at NMI
- Earth Station upgrade for NMI completed November 2005
- TimeTech SATRE (**S**atellite **T**ime and **R**anging **E**quipment) modems at both facilities
- NMI Dual frequency GPS Carrier Phase time transfer system
- GIPSY software for data analysis
- Hydrogen masers and Cs beam clocks at NMI
- Hydrogen Maser from Kvarz installed in July 2005 at UWA; existing Cs beam clock
- Experimental Yb ion clock at NMI
- Ca clock at UWA underdevelopment
- Helium cooled cryogenic sapphire oscillators (CSO) at both locations

ACES mission: atomic clocks in space (2010?)



Columbus (ESA)

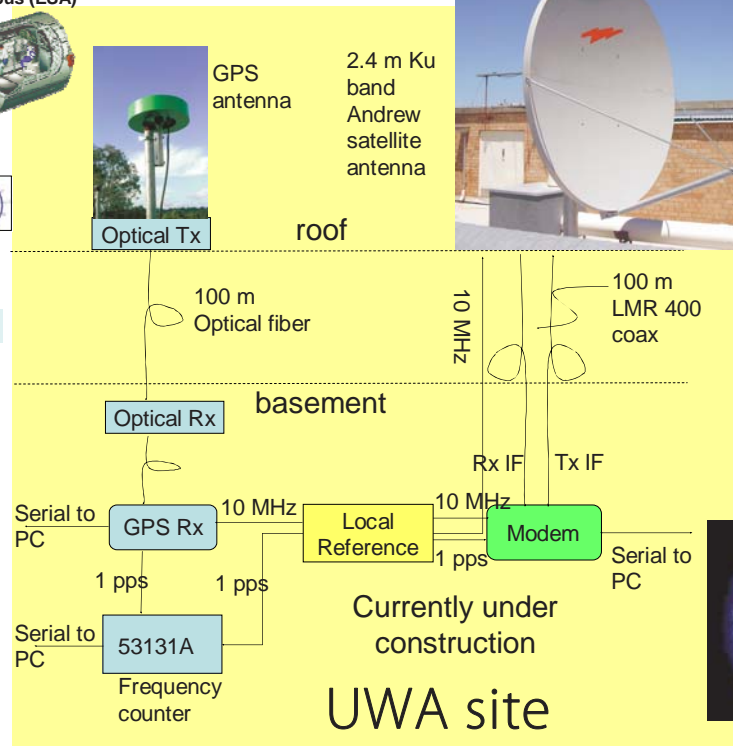


PHARAO & Space H-Maser

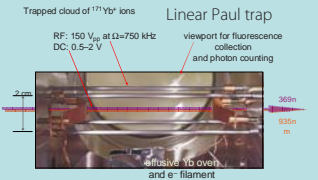


GPS antenna

2.4 m Ku band Andrew satellite antenna



NMI: Developing tomorrow's standards



Stability:

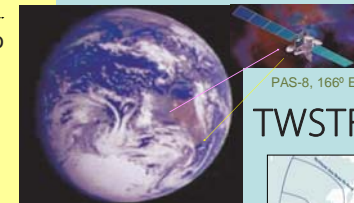
$\sigma_y(t) < 5 \times 10^{-14} t^{-1/2}$ demonstrated (buffer gas)

$\sigma_y(t) = 4 \times 10^{-14} t^{-1/2}$ projected (10^4 ions, laser cooling)

- Based on $^{171}\text{Yb}^+$ ions held in an electromagnetic trap and cooled with laser light
- Working towards an accuracy of a few parts in 10^{15} , equivalent to measuring the distance to the moon with an uncertainty less than the width of a human hair
- A key contribution to international metrology and fundamental science

Primary standards

- NMI maintains an ensemble of atomic clocks (caesium clocks, hydrogen masers)
- One clock is designated the Australian realisation of Coordinated Universal Time, or UTC (AUS)

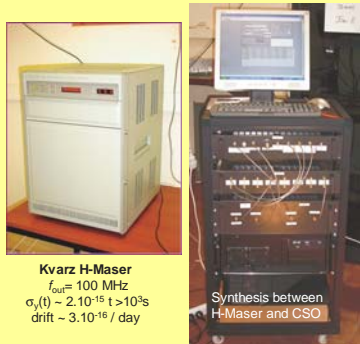


NMI site

TWSTFT



NMI Sydney:
2.2 m antenna
4 W transmit power
NICT modem

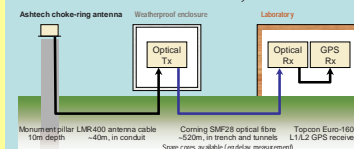


Kvarz H-Maser
 $f_{\text{out}} = 100 \text{ MHz}$
 $\sigma_y(t) \sim 2 \cdot 10^{-15} t > 10^5 \text{ s}$
drift $\sim 3 \cdot 10^{-16} / \text{day}$



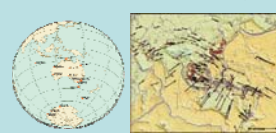
Liquid He CSO
 $f_{\text{out}} = 9.732 \text{ GHz}$
 $\sigma_y(t) \sim 2 \cdot 10^{-15} t < 40 \text{ s}$
drift $\sim 10^{-13} / \text{day}$

NMI Geodetic Receiver System



ViaSat GPS fibre-optic transmitter (Tx) and receiver (Rx) propagate GPS antenna signal over long distances without attenuation

GPS monitoring for geodesy



Monitoring stations in the Australian Regional GPS Network (ARGN)

