Next Generation GPS Timing for the Mark 5 Era

[Trying to keep up with discontinued parts!]

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&

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With special thanks to

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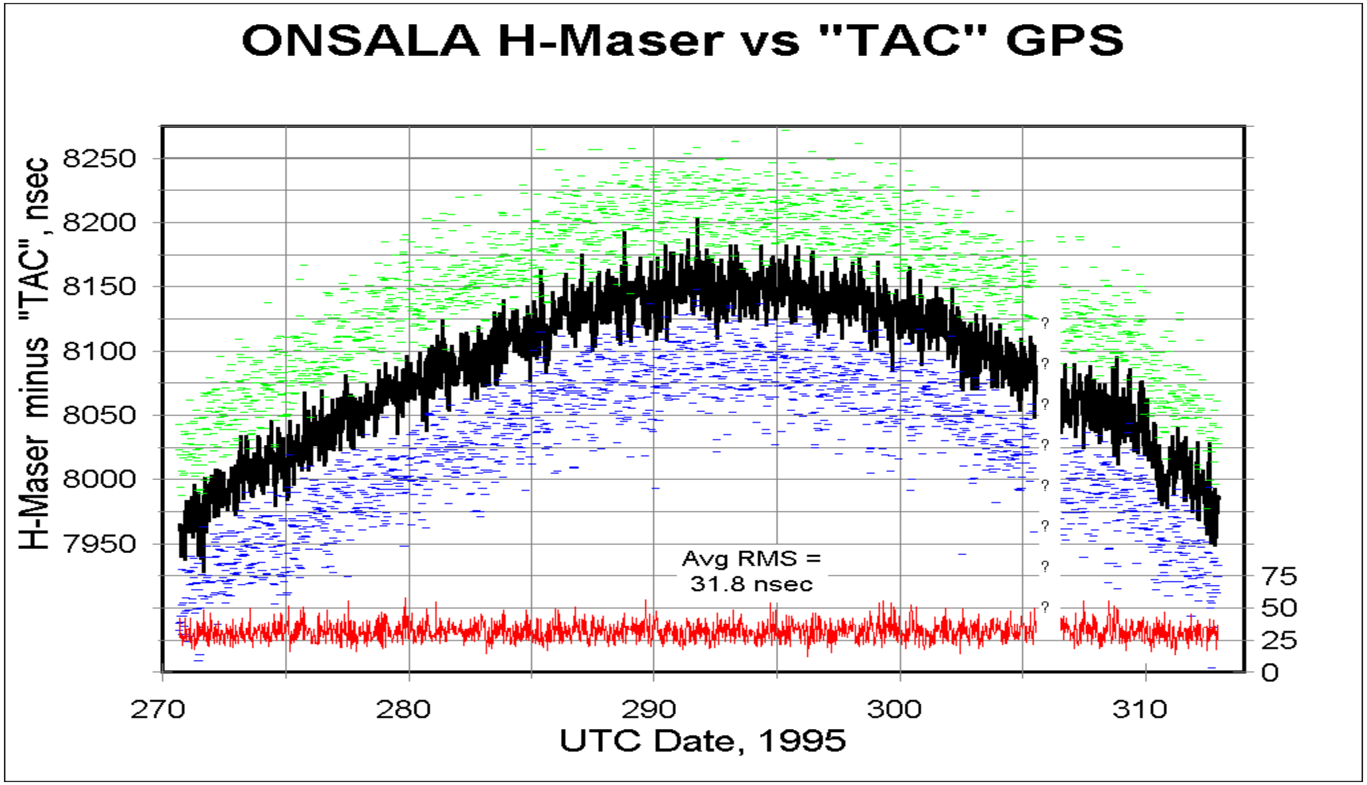
Mike Cizek, CNS Systems

Our Brief History of GPS Timing for VLBI

- The history of the 1990-2000 period can be found on www.gpstime.com in our 2000 ION paper *“**Low-cost, High Accuracy GPS Timing**”*
- In 1993, Tom started developing a low cost GPS Clock using the Motorola PVT-6 single board GPS while on sabbatical at Onsala. Onsala also introduced us to the idea of using the HP53131 Time-Interval Counter as a dedicated timing monitor.
- By 1995 TC & NASA/GSFC group had produced 50 copies of TC’s original “Totally Accurate Clock” (a.k.a. “TAC-1”). Motorola discontinued the PVT-6 series of receivers.



Our Brief History of GPS Timing for VLBI

- Motorola announced the 8-channel ONCORE receivers in 1995 and TC developed the new TAC-2 PCB. After producing about 25 TAC-2s, we assigned distribution in kit form to the Tucson Amateur Packet Radio (TAPR) group. Rick used his company (CNS Systems) to adopt the TAC-2 design as the basis of his original CNS Clock.

- By 2000, we estimate that over 1000 TAPR TAC-2 and CNS had been produced. By 2001, Motorola discontinued the ONCORE line and introduced the new M-12 series. Synergy introduced an adaptor board so that the the M-12 would work in place of an ONCORE.

- By 2002, it became obvious that the absolute (w.r.t. USNO) M-12 receiver timing had diverged by 10s of nsec thru several model changes. Rick took 4 CNS clocks equipped with M-12+ to the USNO for a zero-baseline intercomparison with the Master Clock; see www.gpstime.com for the paper "***Critical Evaluation of the Motorola M12+ GPS Timing Receiver vs. the Master Clock at the United States Naval Observatory, Washington DC*".** The original "prime" receiver from the USNO test is our "Gold Standard" reference.

Our Brief History of GPS Timing for VLBI

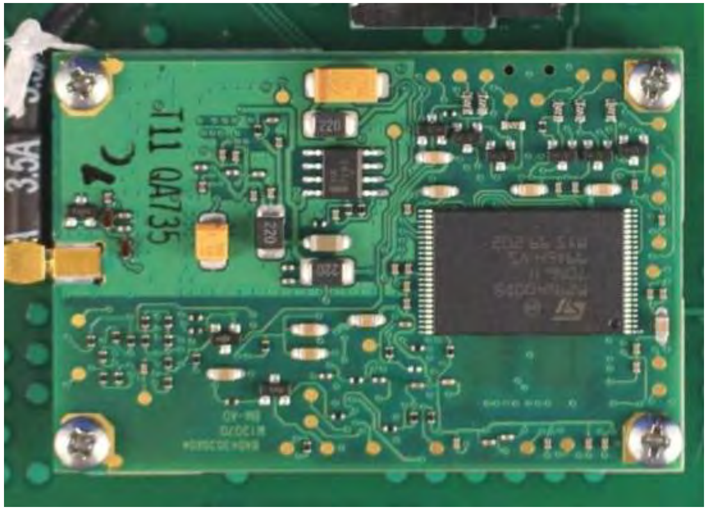
- Around 2005, Motorola made the corporate decision to quit the GPS business and the M-12 design was licensed to iLotus in Singapore. The current iLotus timing receiver is the M-12M.

- Anticipating the need for a M-12 replacement, Rick & Art Sepin (Synergy) examined the Swiss-built uBlox LEA-6 receiver. Because of the large installed base of Motorola/iLotus receivers, Rick developed a hybrid M-12 emulator; an M-12 sized board and a PIC µP to convert the uBlox binary command set to the Motorola @@ binary format.

All of which brings us to this paper.

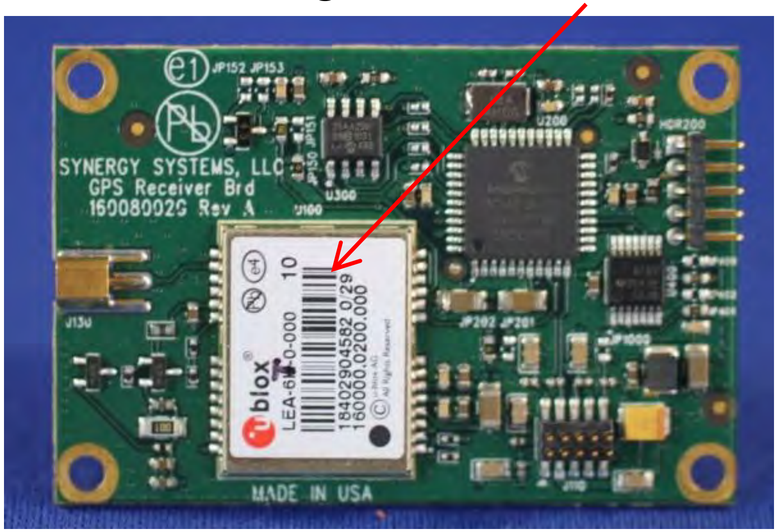
Comparing an M12+, M-12M & uBlox LEA-6

An iLotus M-12M module. The M12+ looks just the same

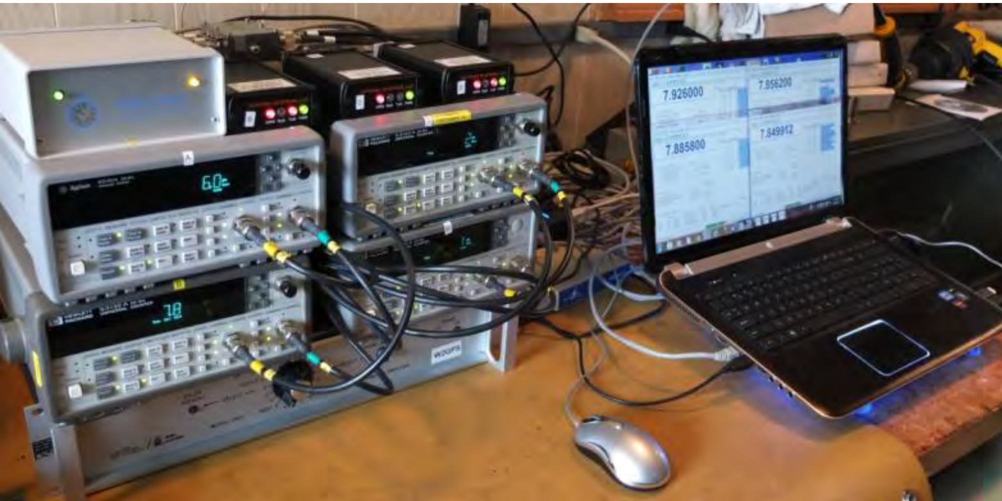


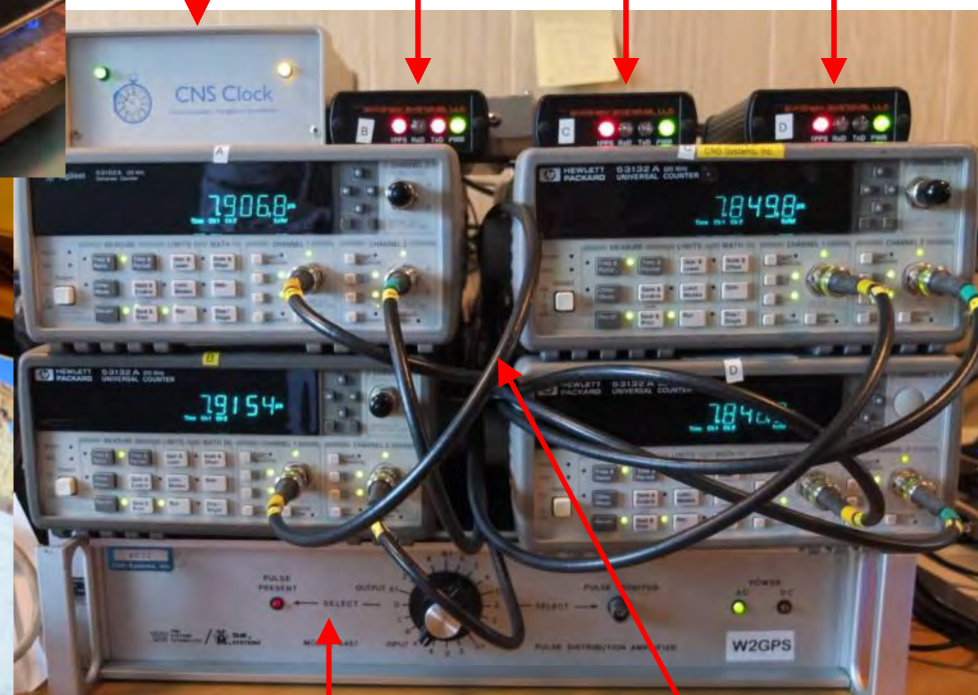
Top side **The Synergy uBlox LEA6T module** All the guts are on Bottom

Side



The 4 Receiver test at GGAO:





"Gold" Motorola M12+

iLotus M12-M

Synergy uBlox Moto Emul .

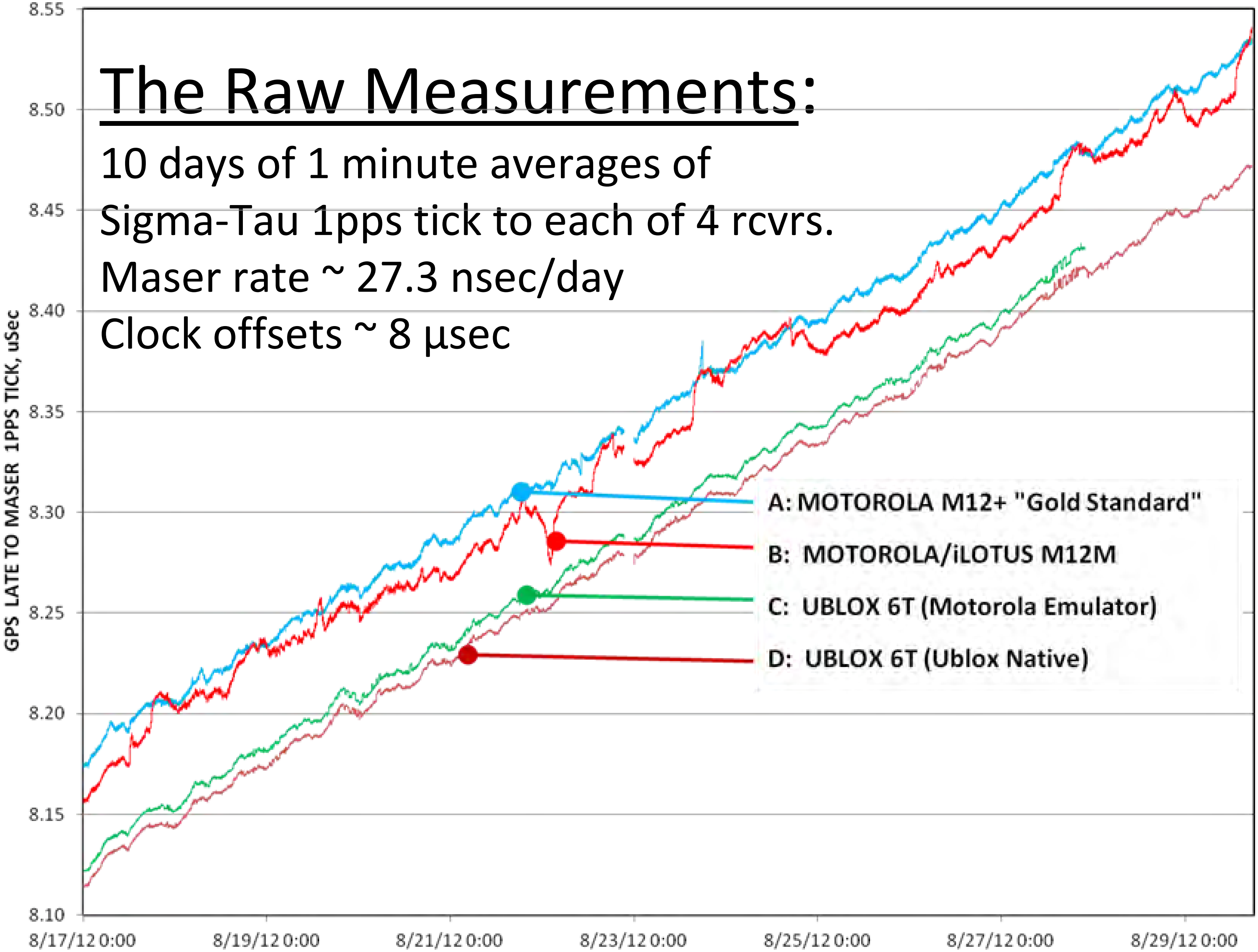
LEA-6Ts uBlox Native Cmds

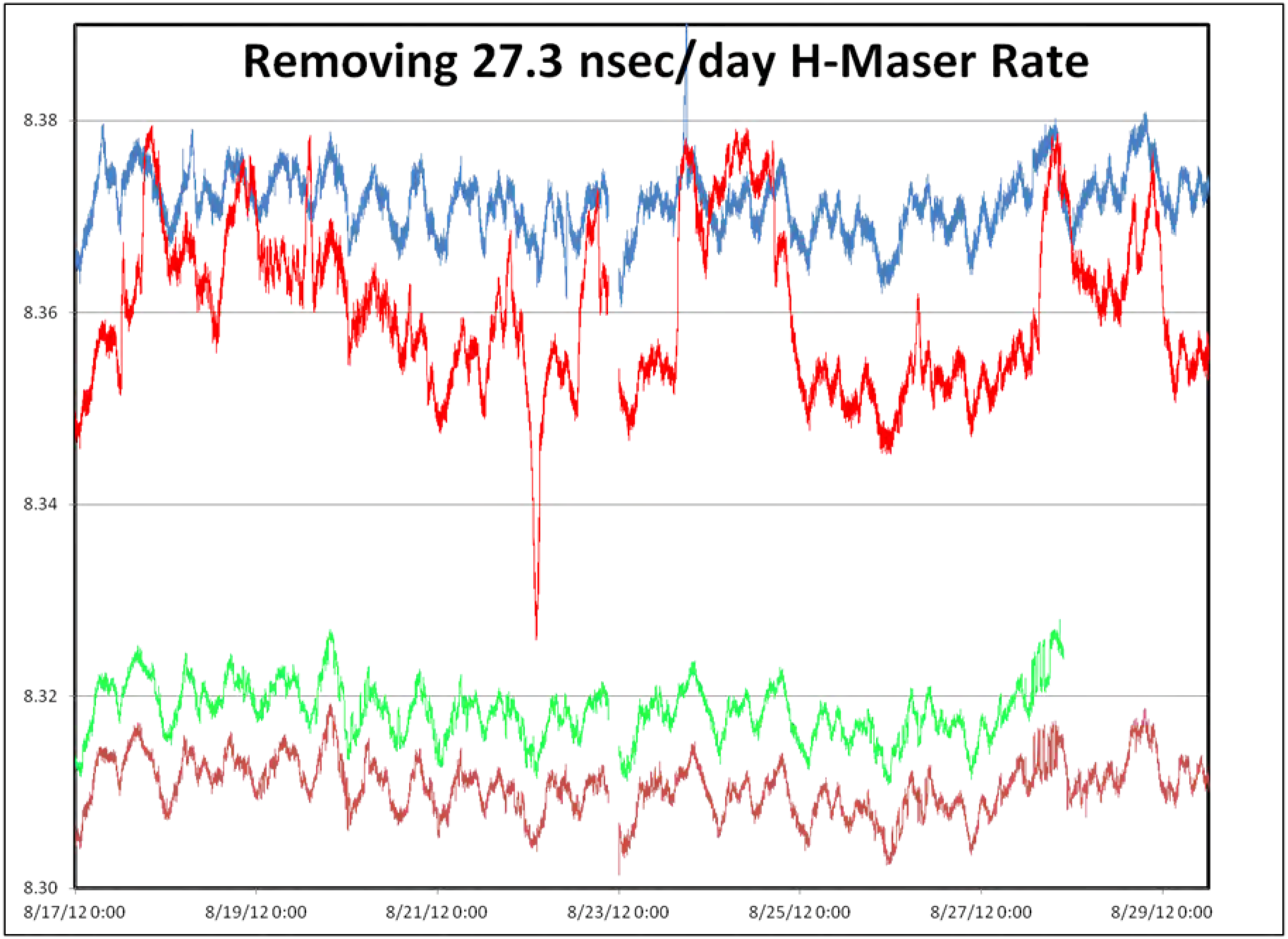
Maser 1PPS Distributor

4@ HP53132 Counters

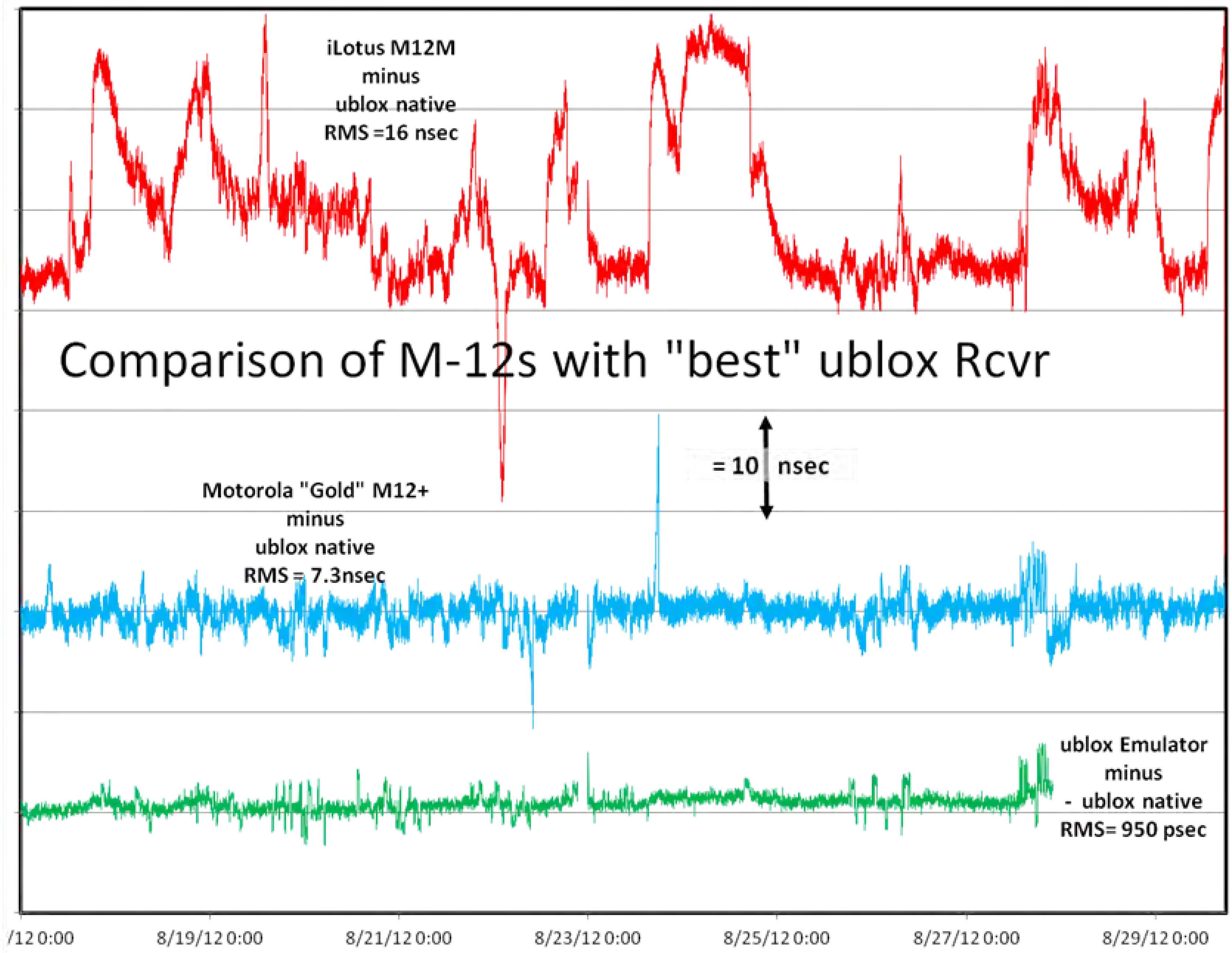
The Raw Measurements:

10 days of 1 minute averages of
Sigma-Tau 1pps tick to each of 4 rcvrs.
Maser rate ~ 27.3 nsec/day
Clock offsets ~ 8 µsec

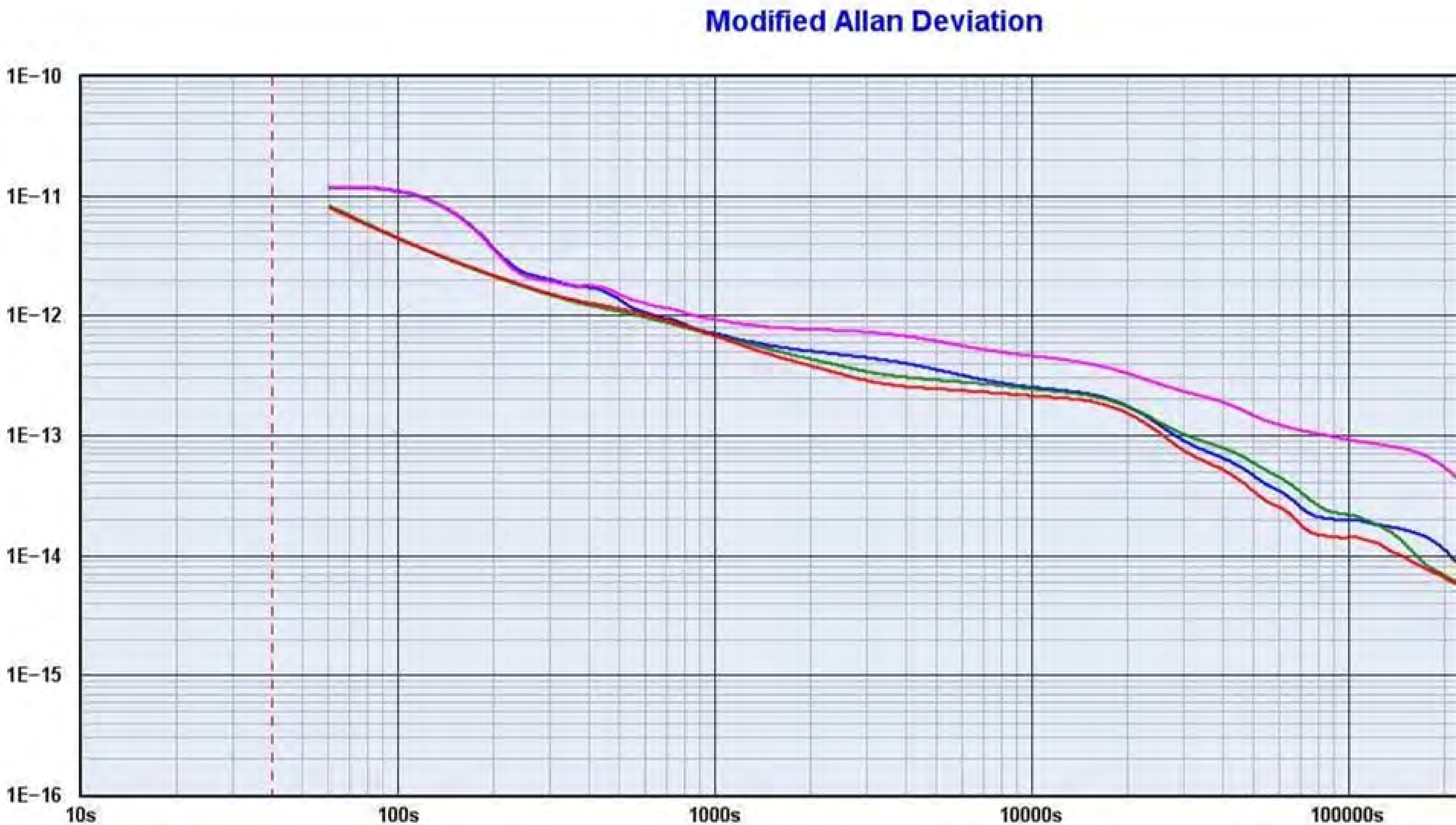




Removing 27.3 nsec/day H-Maser Rate
8.38
8.36
8.34
8.32
8.30
8/17/12 0:00
8/19/12 0:00
8/21/12 0:00
8/23/12 0:00
8/25/12 0:00
8/27/12 0:00
8/29/12 0:00



iLotus M12M
minus
ublox native
RMS =16 nsec
Comparison of M-12s with "best" ublox Rcvr
= 10 nsec
Motorola "Gold" M12+
minus
ublox native
RMS = 7.3nsec
ublox Emulator
minus
- ublox native
RMS= 950 psec
/12 0:00
8/19/12 0:00
8/21/12 0:00
8/23/12 0:00
8/25/12 0:00
8/27/12 0:00
8/29/12 0:00



Trace	Notes	Filename	Pathname	Input Freq	Sample Interval	MDEV at 40s
GGAA_A (Unsaved)	Motorola "Gold" M12+			60 Hz	60 s	
GGAA_A (Unsaved)	iLotus M12M			60 Hz	60 s	
GGAA_A (Unsaved)	uBlox 6T, Motorola Emulator			60 Hz	60 s	
GGAA_A (Unsaved)	uBlox 6T, uBlox native			60 Hz	60 s	

Conclusions

1. Small, low cost GPS receivers can provide timing needed for VLBI anywhere in the world. This is not a new statement, it's been true since the 1990's! See www.gpstime.com for Tom's "Timing for VLBI" notes from the IVS TOWs for more details.
2. The current production iLotus M12M we tested showed jumps at the 10 nsec level. Some more M12M's need to be tested to see if this just a problem of this particular unit.
3. Even if (/when?) the Motorola/iLotus M12's become unavailable, the uBlox LEA6T can step in as a replacement.
4. Existing designs based on Motorola/iLotus M12s should have no problem in making the change to uBlox by using the Synergy M12 emulator. Ask Rick for details.
5. **In fact, the uBlox we tested were a factor ~5 BETTER than the old M12's in all tests except for a "DC" bias ~30 nsec.**

More Obsolescence Problems

Agilent has announced “End-of-Life” for the 53131 and 53132 counters that have been the standard VLBI Time Interval Counter.

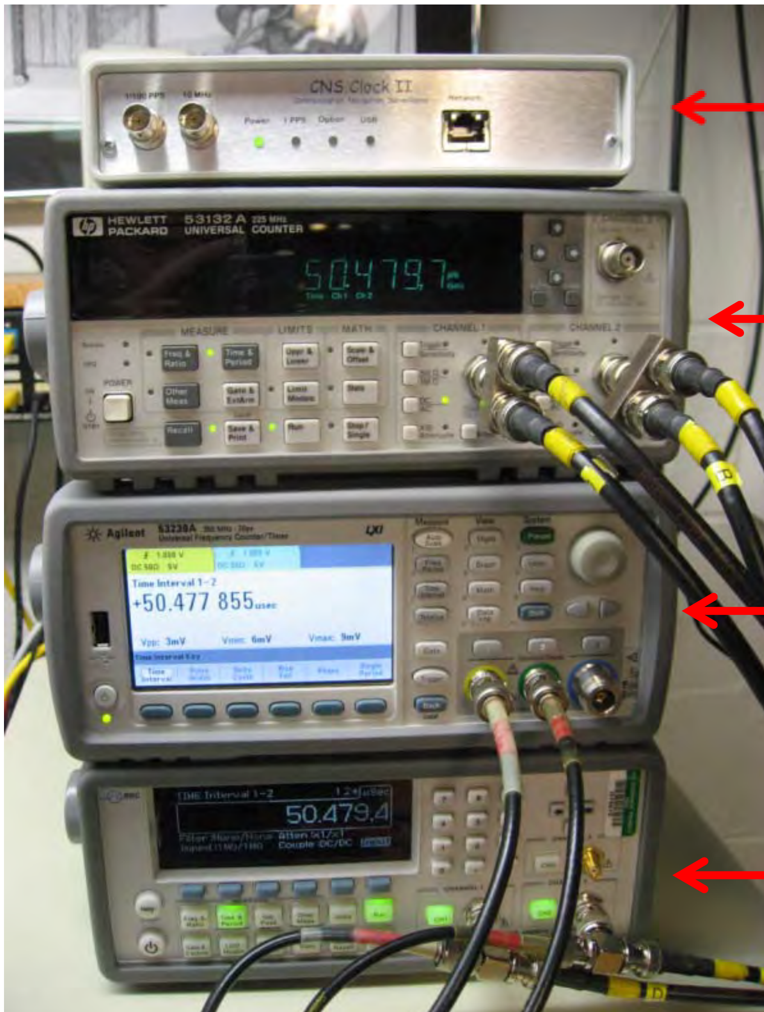
The 53131/132 has been very easy to use since it has an RS232 printer port that streams the readings. TAC32 was built around this capability.

Agilent is recommending the 53230A as their suggested replacement for the 131/132.

Berkeley Nucleonics offers their model Model 1104 as an alternative.

Both these counters suggest their use as “Net Appliances” on the station LAN using their Ethernet ports.

Tac32Plus v2.7.11 Now Supports Time Interval Counters via Ethernet.

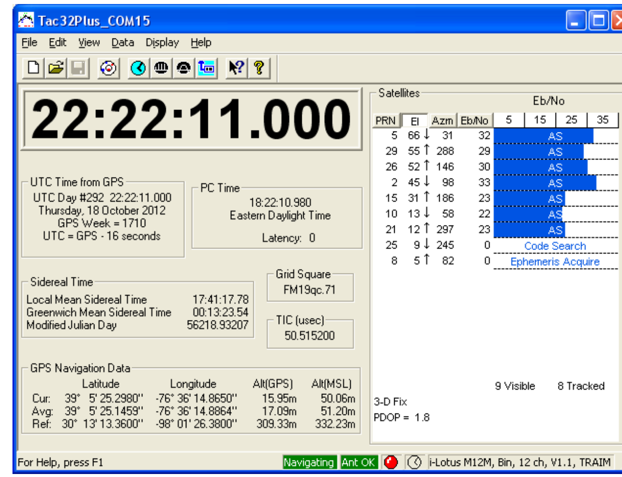


CNS Clock II

HP/Agilent 53132A Serial Port

Agilent 53230A Ethernet

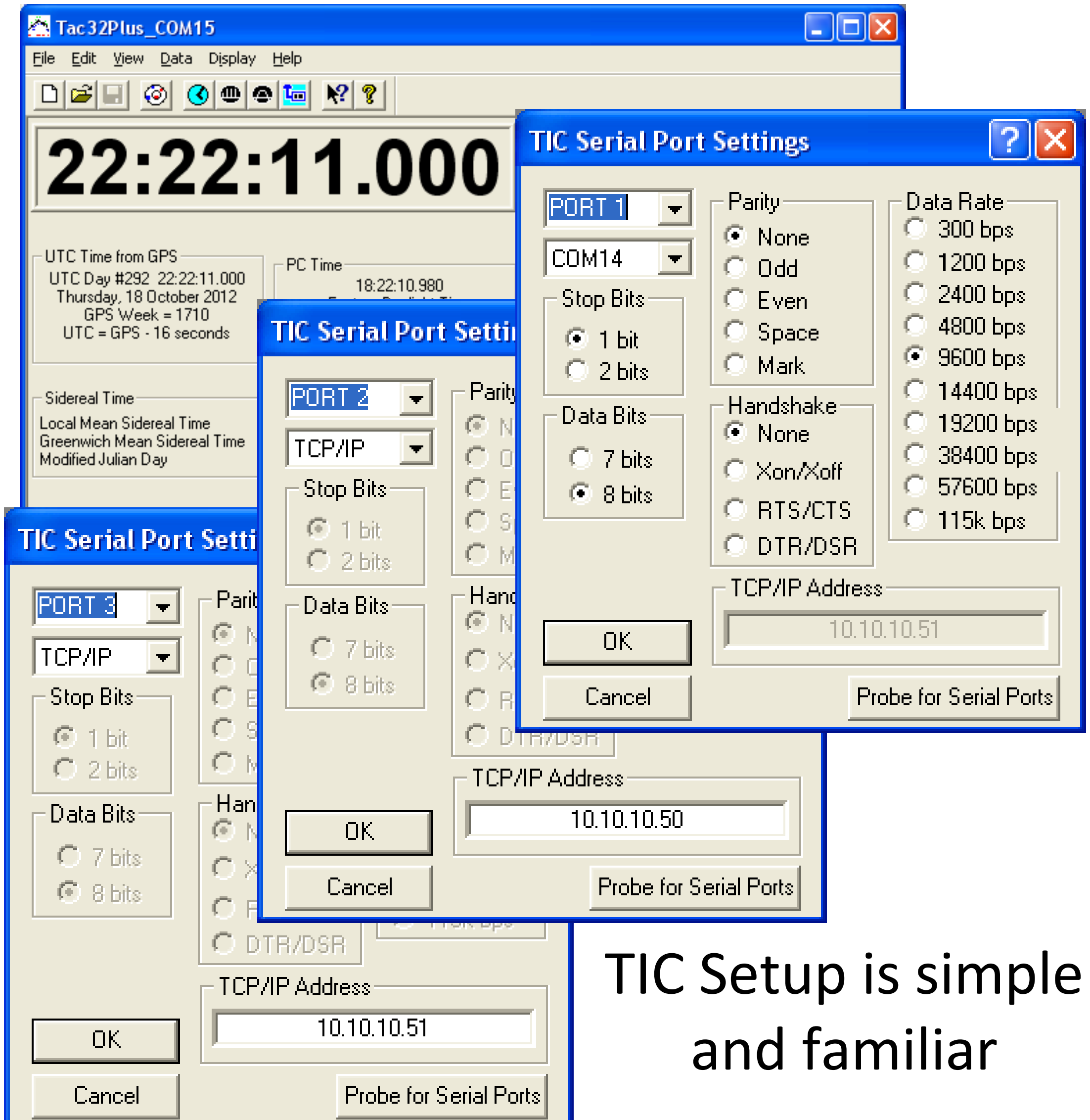
Berkeley Nucleonics Model 1104 Ethernet



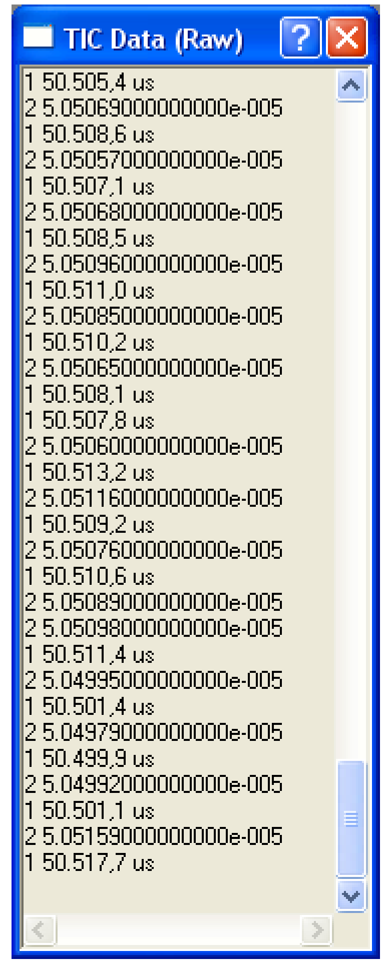
Tac32Plus V2.7.11

Note: GPS time vs. HP5065A Rubidium CNS Systems' time standard

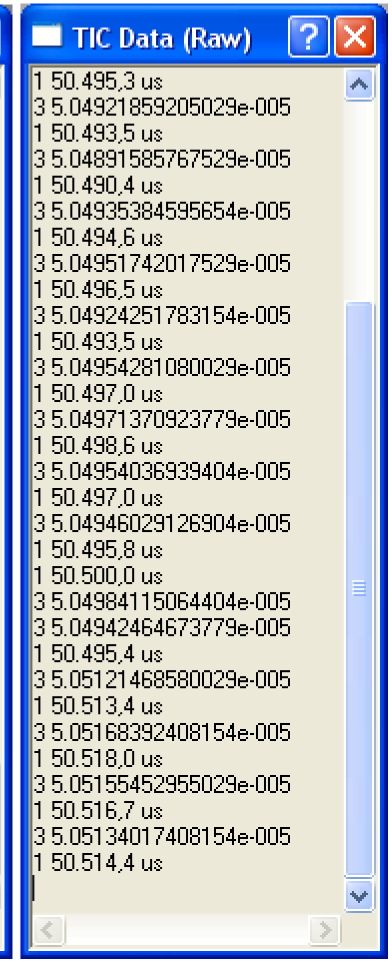
Tac32Plus V2.7.11 Now Supports Time Interval Counters via Ethernet.



TIC Setup is simple and familiar



53132A vs. BN1105



53132A vs. 53230A

Questions?