

NRC TimeLink™ – Traceable Time Dissemination with Nanosecond Accuracy

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ITSF 2017

Timescales

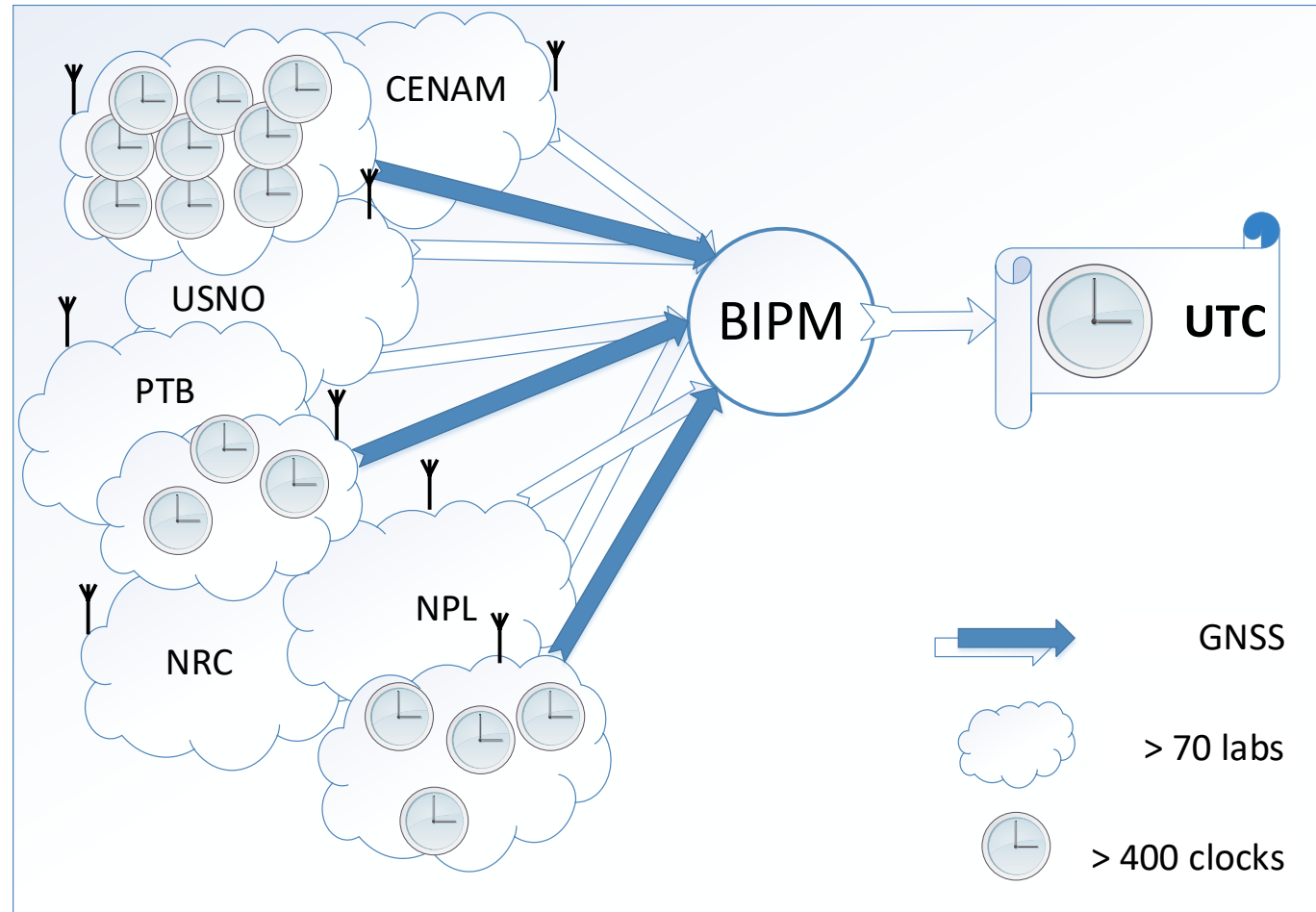
- **Stable Frequency**

- Precise positioning
 - navigation
 - precision agriculture
 - autonomous vehicles
- High quality frequency metrology
 - competitions timing
 - fundamental physics research
- Commercial:
 - VCXO, Rb, Cs, H
- State of the art R&D
 - Sr^+ , Al^+ , Hg^+ , Ca^+ , Yb^+
 - Sr, Yb, Mg, Hg

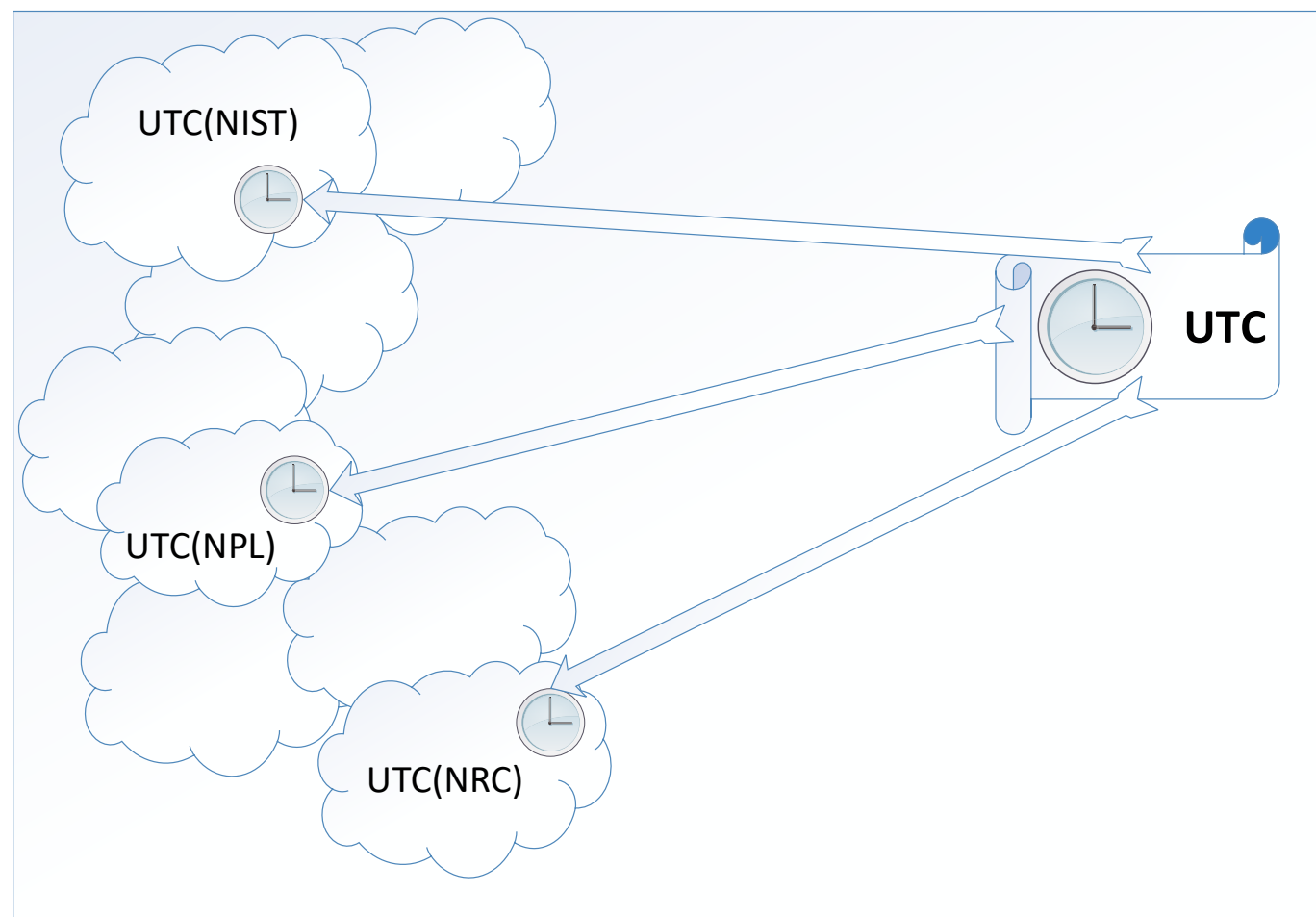
- **Accurate Time**

- Accurate Timestamping
 - smart grids
 - next generation wireless
 - finance
 - network security, cryptography
- Clocks are **synchronized**
 - within one system
 - within one network
 - between networks
 - **Globally**
- **UTC, UTC(k)**

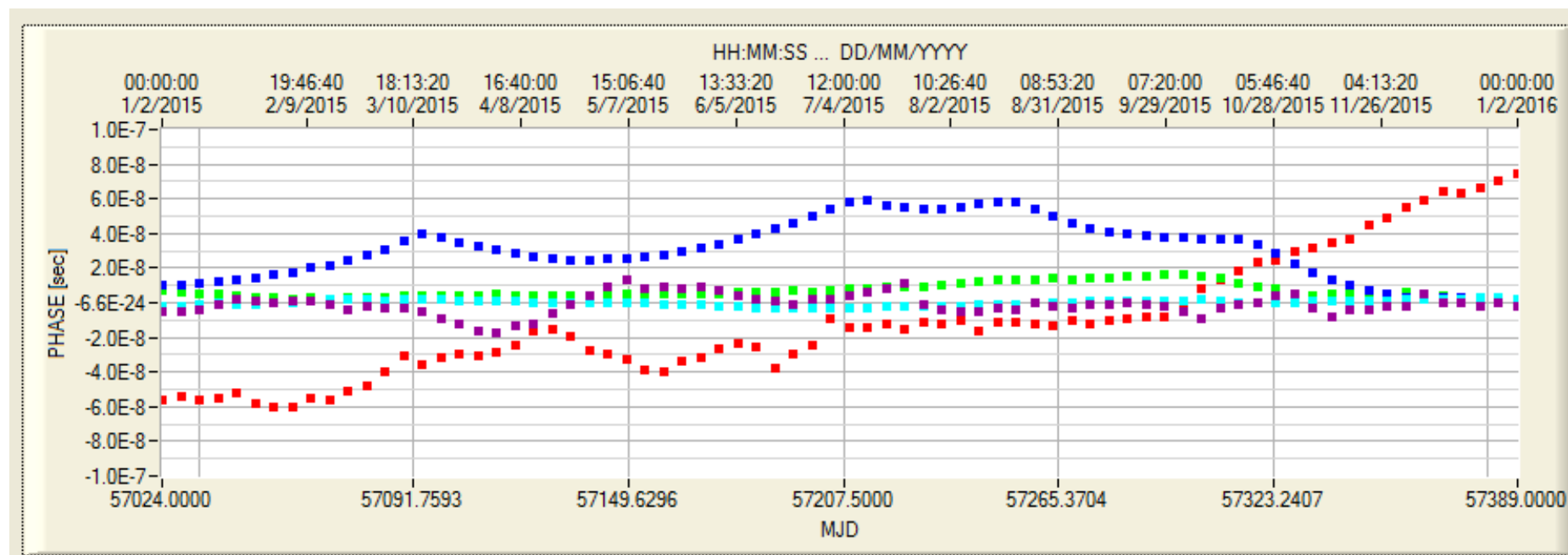
UTC – Coordinated Universal Time (Paper Time Scale)



UTC(k) – Physical Realization of UTC



UTC - UTC(k) Performance Examples



UTC(NRC)

UTC(NIST)

UTC(NPL)

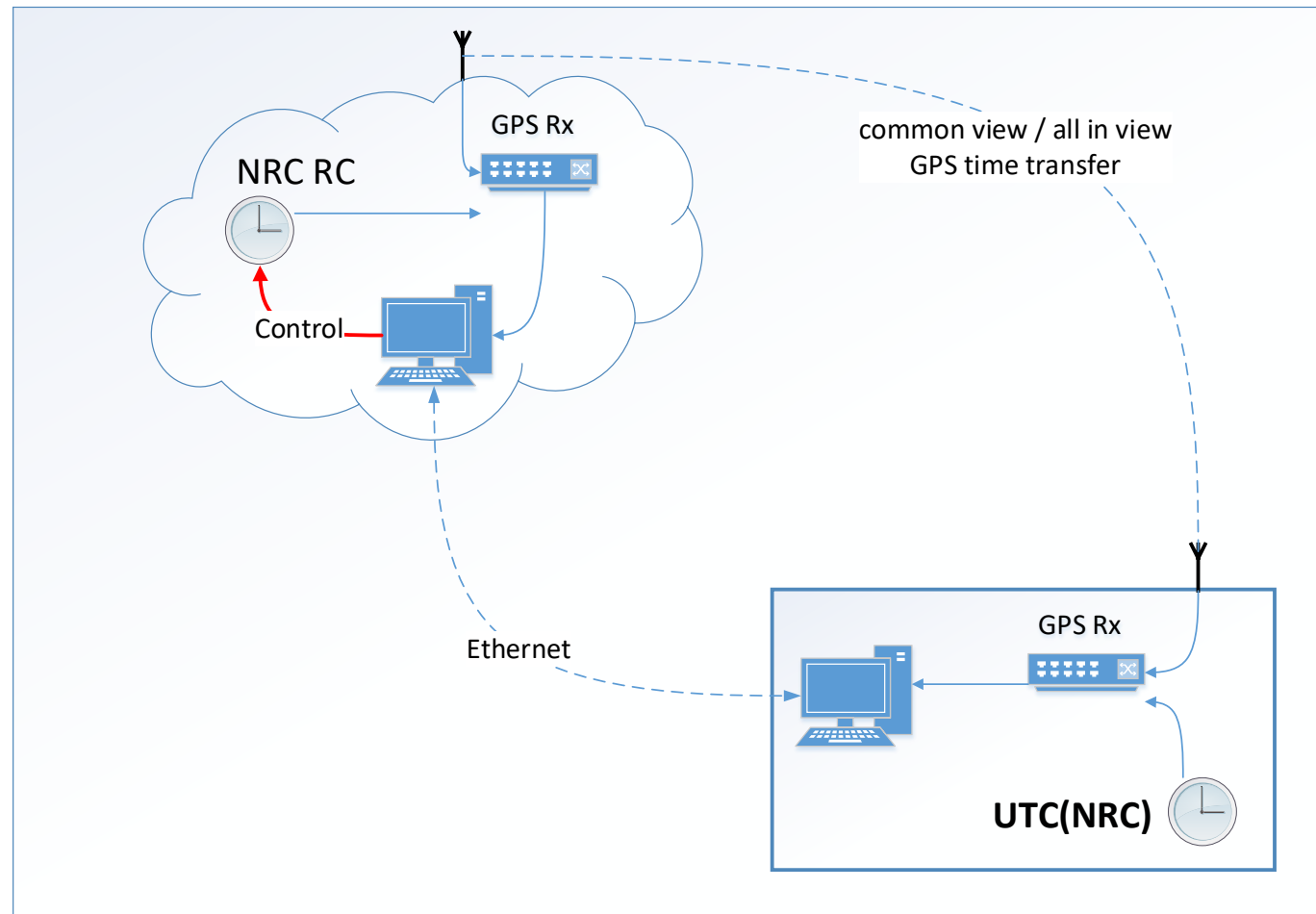
UTC(PTB)

UTC(CNM)

Time Dissemination by NRC

Accuracy Uncertainty	Method	Tools
1 second to 100 millisecond	broadcasting	<ul style="list-style-type: none">• telephone talking clock• short wave radio• web clock
100 millisecond to 10 millisecond	validation	<ul style="list-style-type: none">• NTP• validated GNSS system• validated local system architecture
10 millisecond to 100 microsecond	calibration	<ul style="list-style-type: none">• calibrated GNSS system• calibrated local system architecture• continuous performance monitoring
100 microsecond to 1 microsecond and better	traceability	<ul style="list-style-type: none">• calibrated GNSS system• calibrated local system architecture• continuous performance monitoring• redundant system architecture• continuous local timescale adjustments

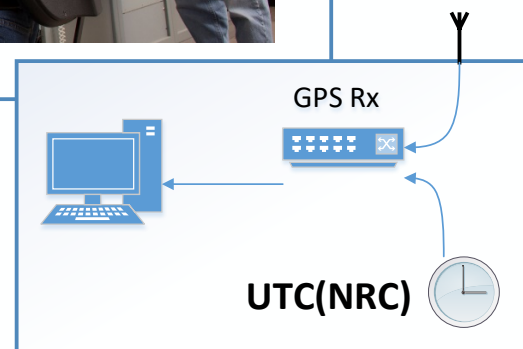
NRC TimeLink - Remote Clock



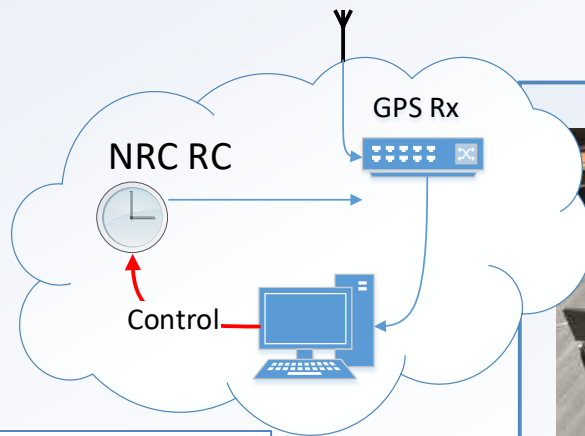
NRC F&T lab



- 2 locations
- 6 Cs standards
- 2 H masers
- 7 GNSS Rx
- multiple backups
- triple redundancy
- continuous monitoring



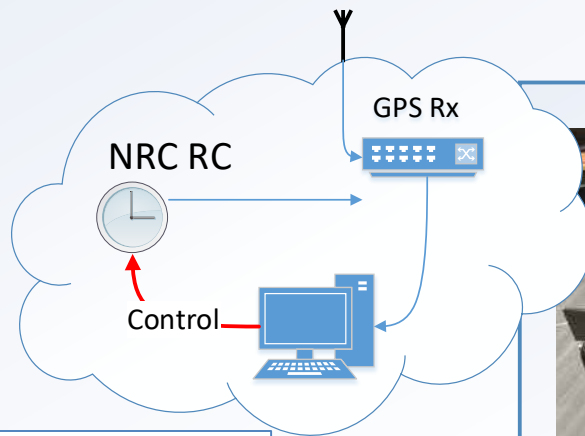
NRC Remote Clock



- Rb standard
- GPS Rx
- Remote control
- Secure connection
- dual power supply
- continuous monitoring



NRC Remote Clock

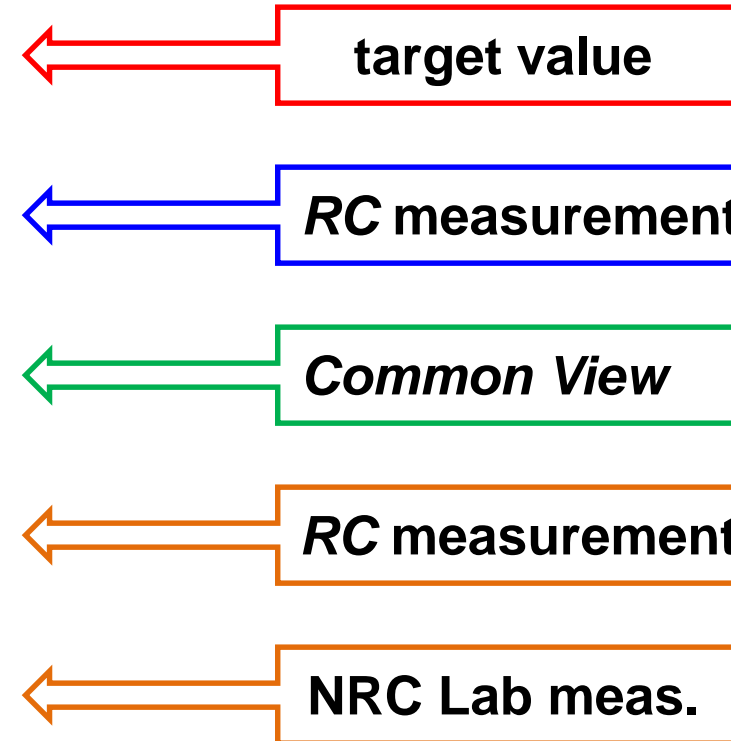


- Rb standard
- GPS Rx
- Remote control
- Secure connection
- dual power supply
- continuous monitoring



Time Transfer

$$\begin{aligned} [RC_R - UTC(NRC)] &= 0 = \\ &= [RC_R - GPS_R] + \\ &+ [GPS_{sd_R} - GPS_{sd_L}] - \\ &- [RC_L - GPS_L] - \\ &- [UTC(NRC) - RC_L] \end{aligned}$$



R – remote location
L – NRC location

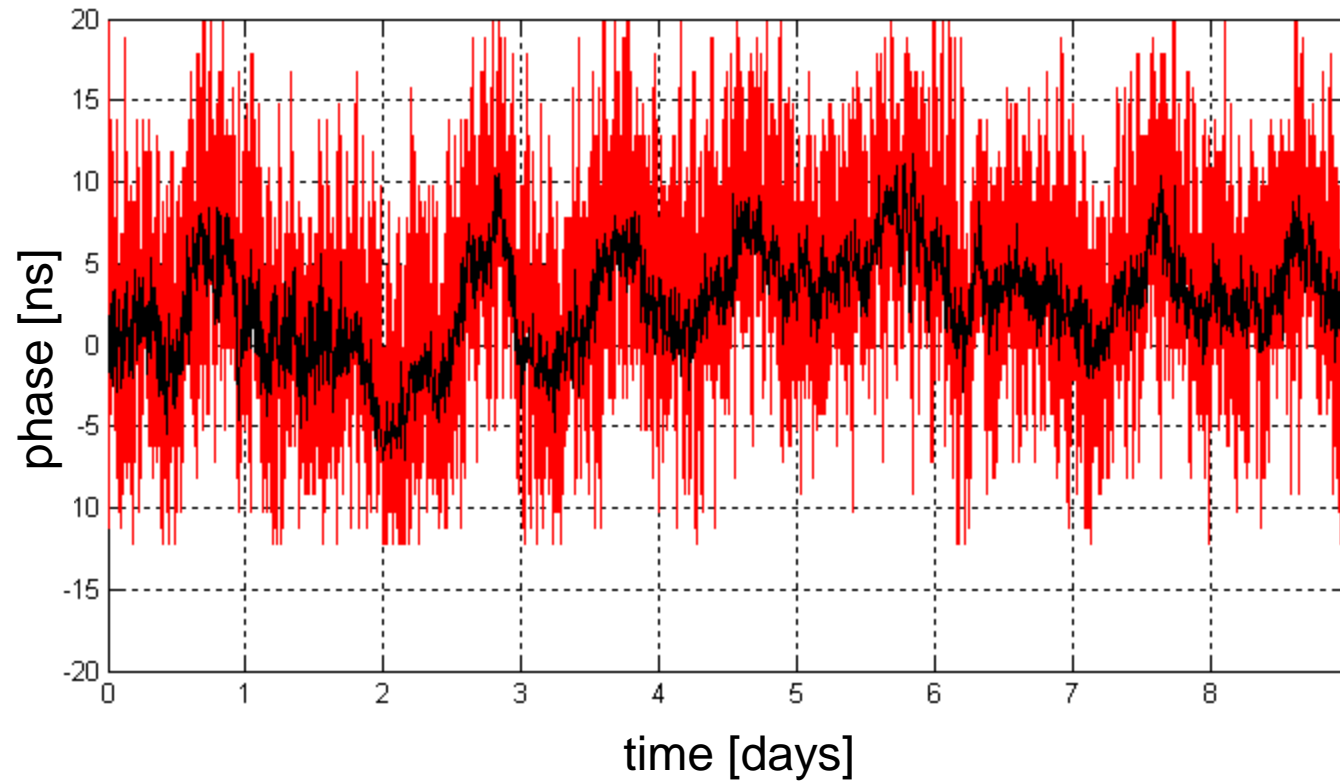
Performance: [RC – UTC]

remote location

- [RC - GPS]

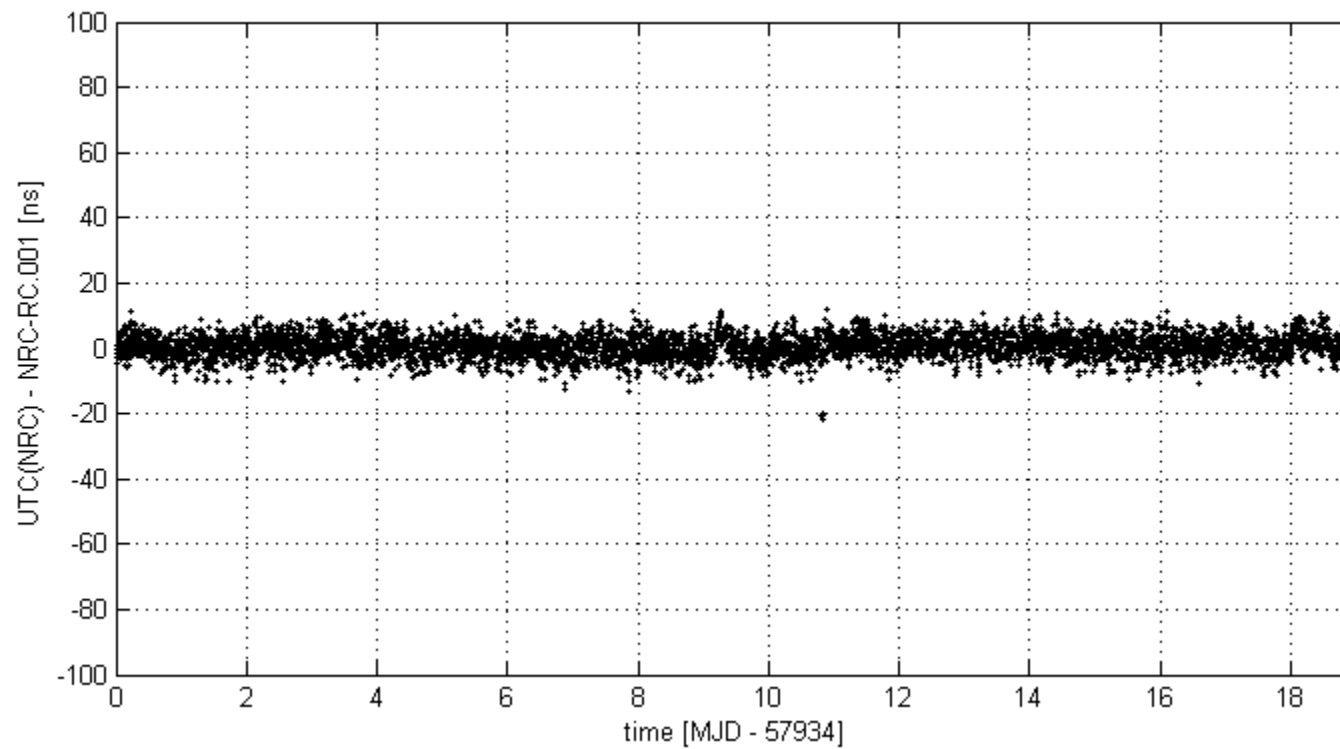
NRC location

- [UTC(NRC) -GPS]



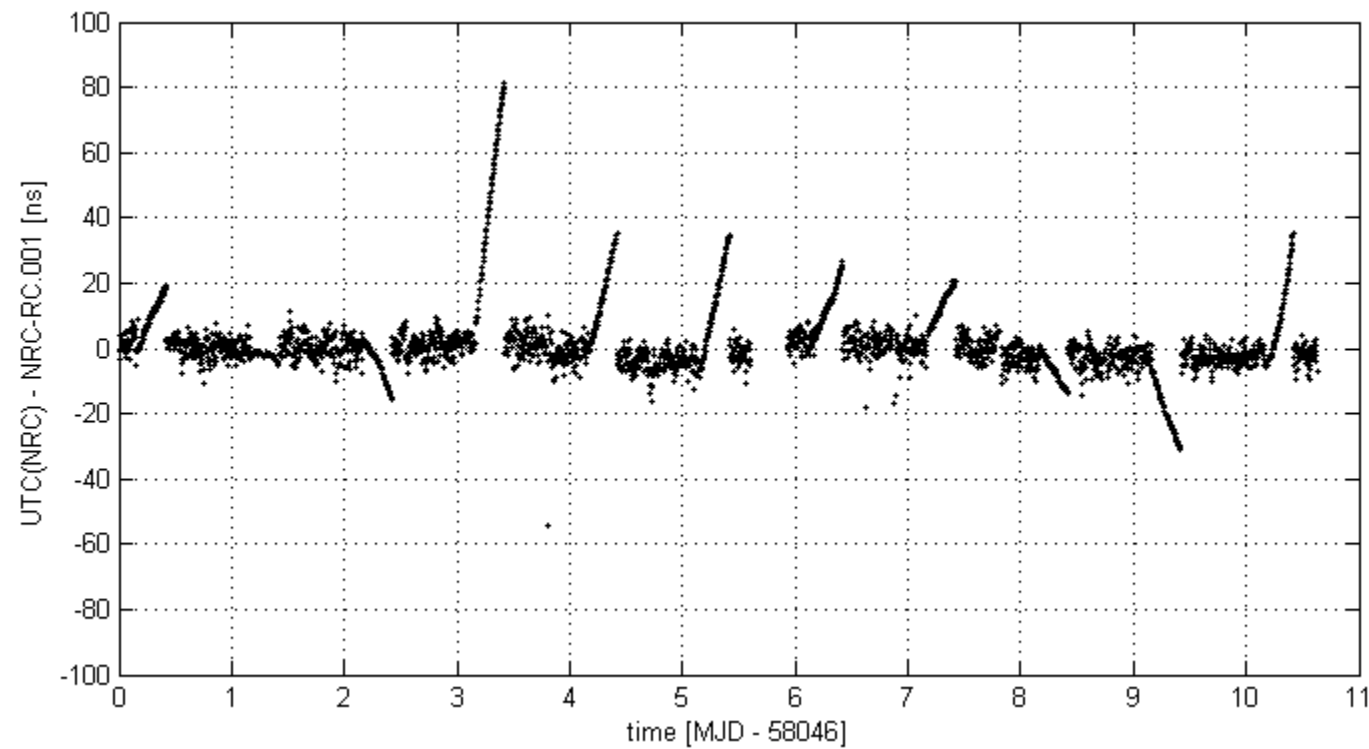
Performance

mean = 0.6 ns STD = 3.6 ns

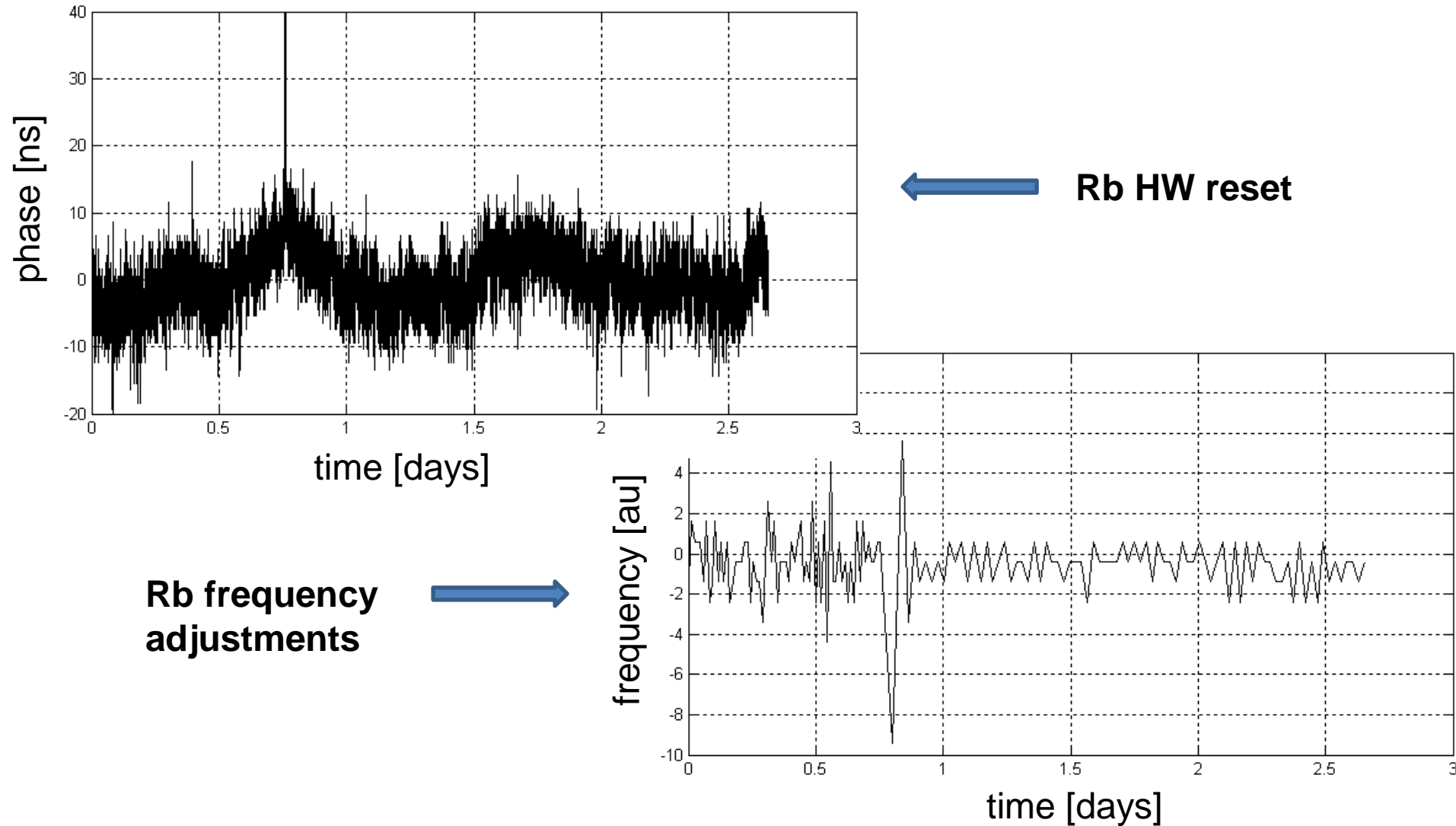


Holdover

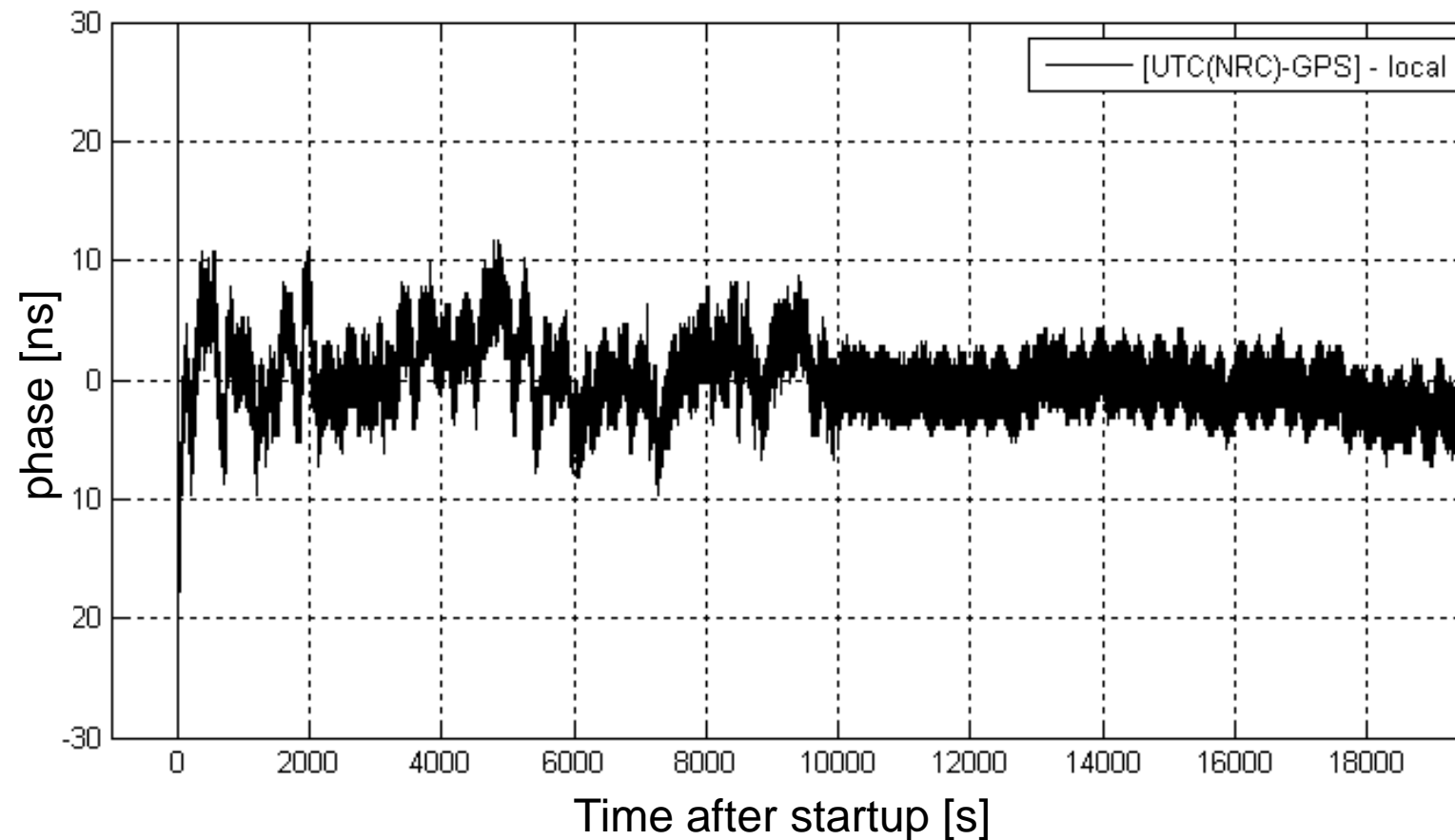
holdover intervals 6 hours



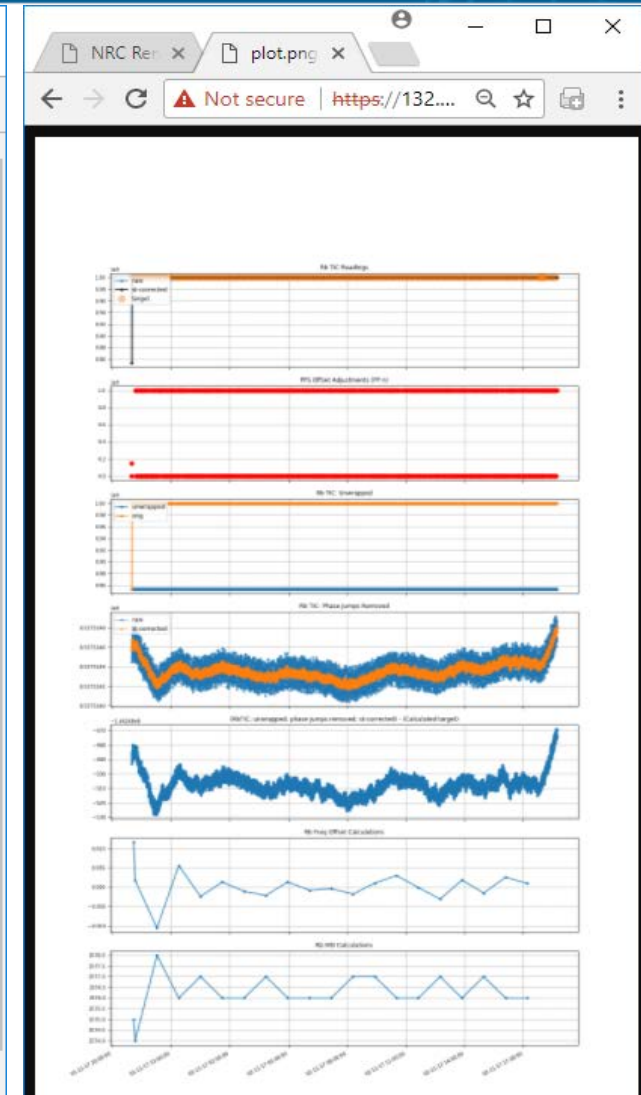
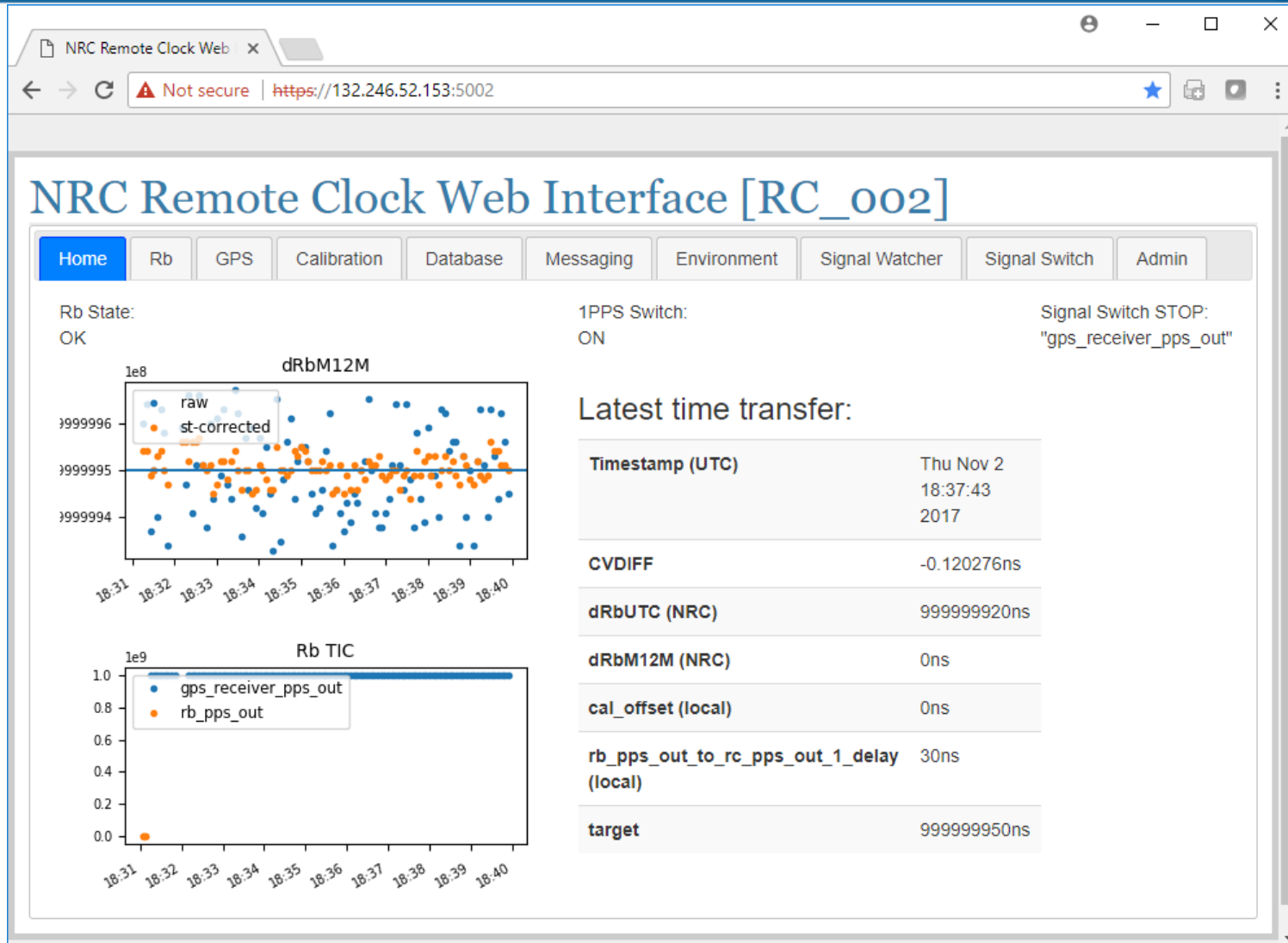
Initialization



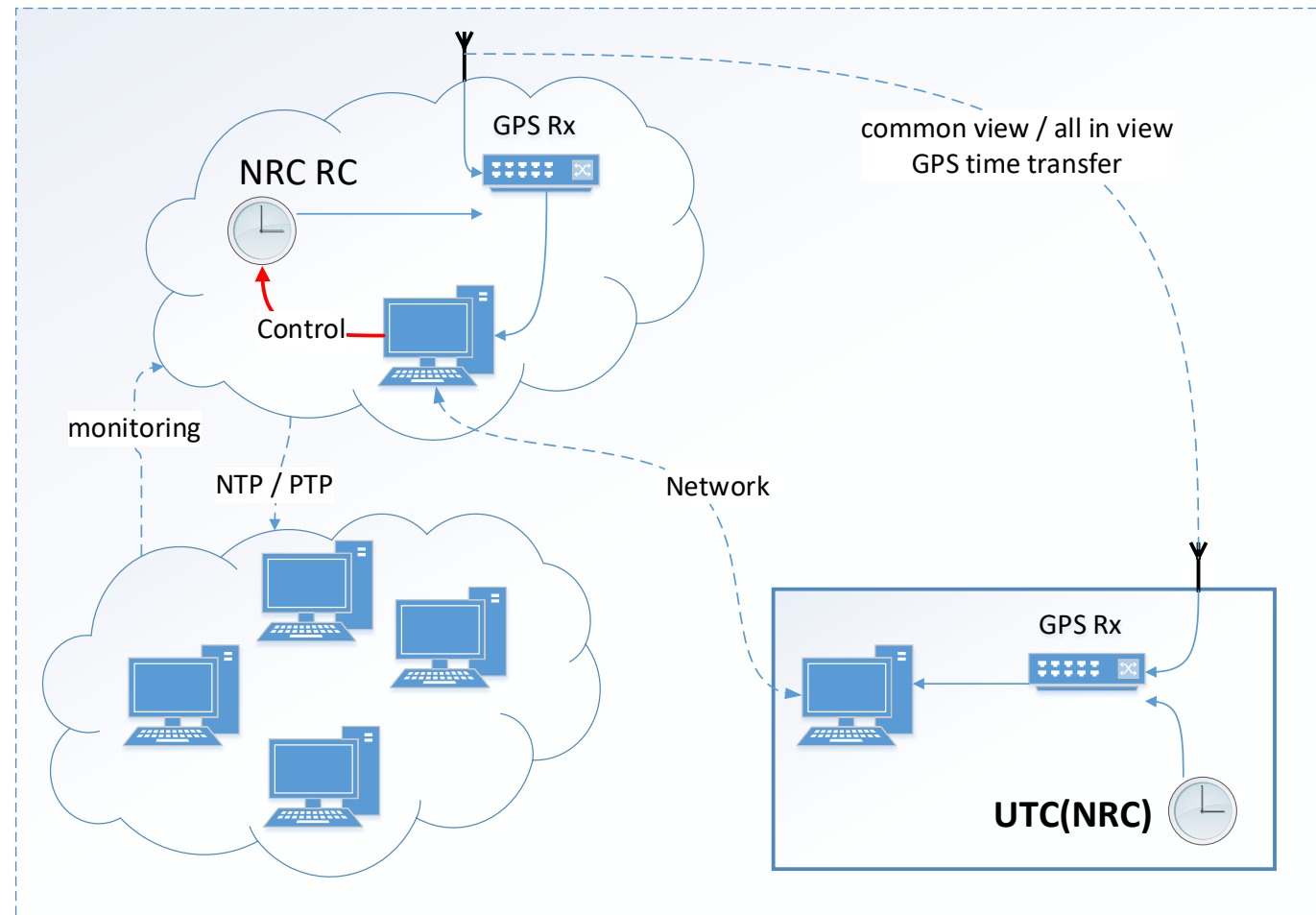
Startup Performance - GPS Site Survey



Interface and Performance monitoring



Traceable time dissemination to sub-networks



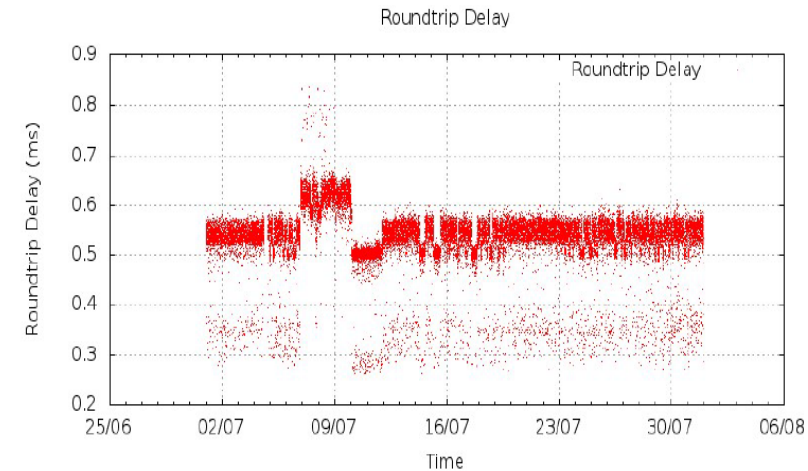
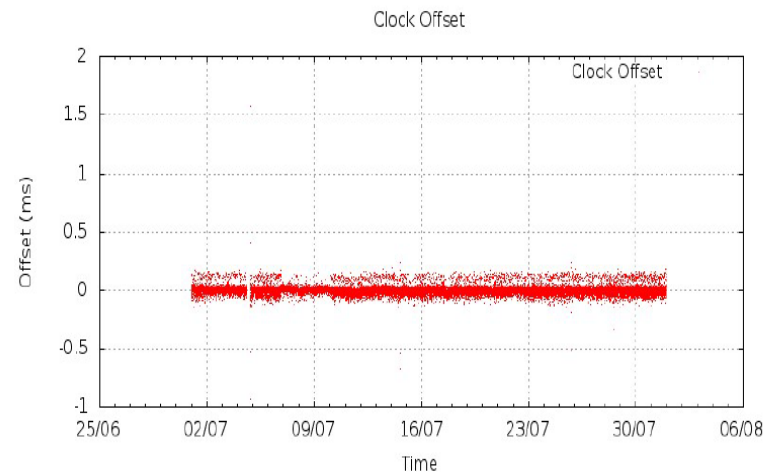
Sub-Networks Traceability Records

NTP Performance Report — 132.246.11.231

Client	Andre Charbonneau, NRC-CNRC
NTP server	132.246.11.231
From	2016-07-01 00:00:00 UTC
To	2016-08-01 00:00:00 UTC
Generated on	2016-08-05 21:00:59 UTC

Graphical Offset and Round Trip Delay Display

The displayed Offset and Round Trip Delay are derived from the NRC operated NTP server.



Statistics

	min	max	mean	sample size
Offset (ms)	-0.941	1.578	0.0027	44293
Roundtrip delay (ms)	0.261	0.836	0.5291	44293

Uncertainties

The Round Trip Delay can be used to estimate the uncertainty of the client NTP timescale. The uncertainty is approximately one-half of the Round Trip Delay; however, operating system delays may degrade the accuracy to some degree. The NRC NTP server timescale is equivalent to UTC(NRC) with the uncertainty of less than 100 micro seconds and can be neglected.

Contact

NRC.Time-Temps.CNRC@nrc-cnrc.gc.ca

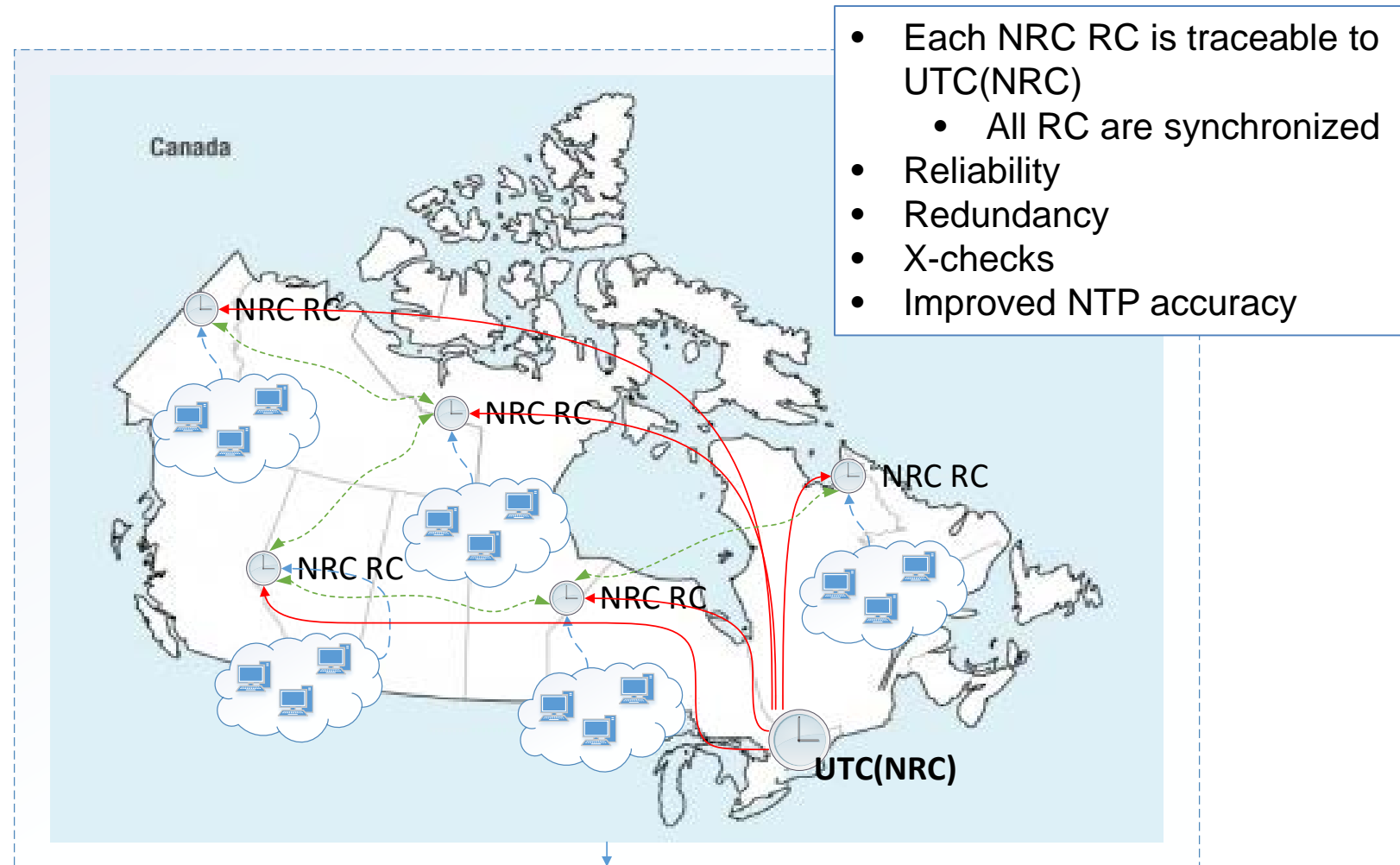
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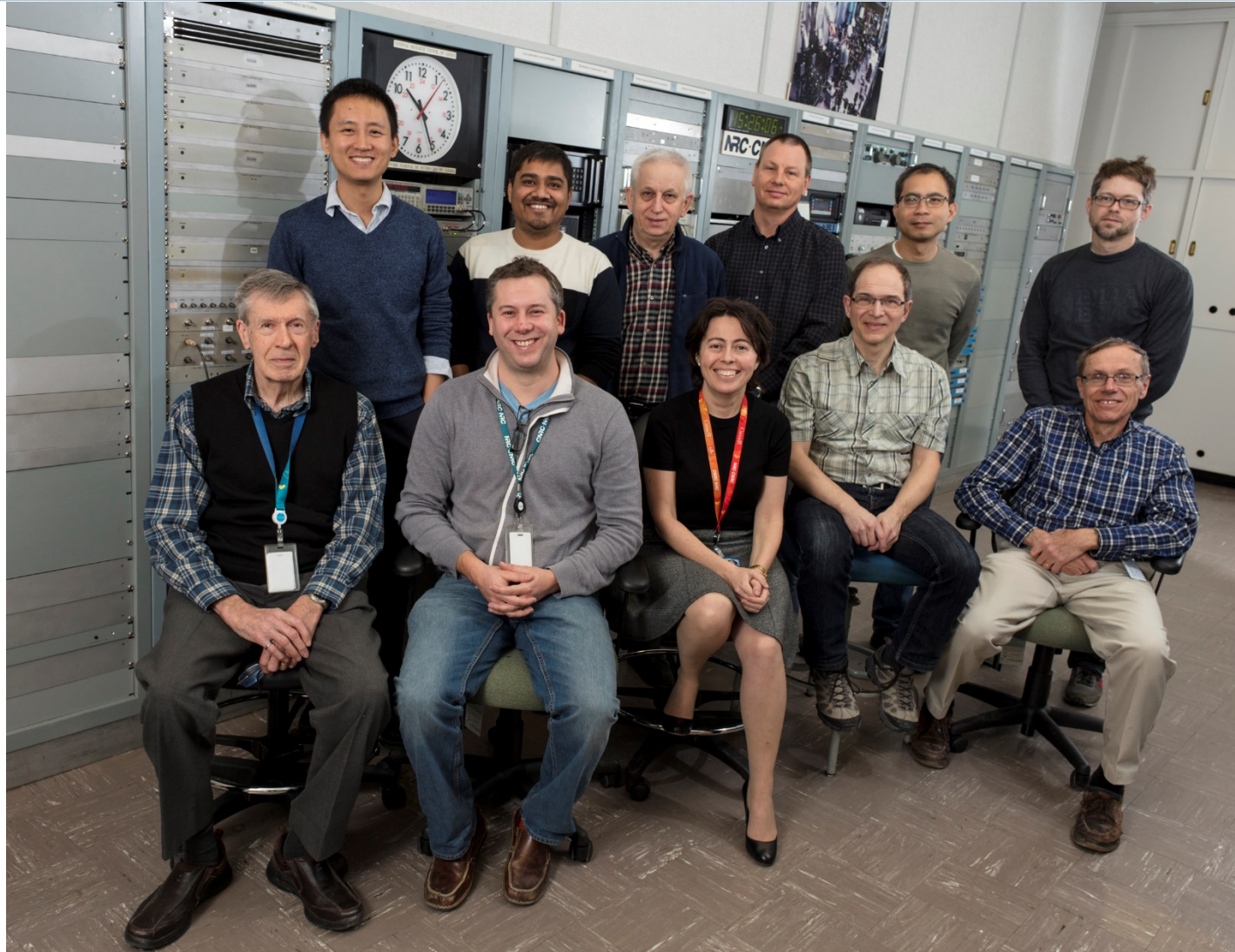
NRC TimeLink Network of Remote Clocks



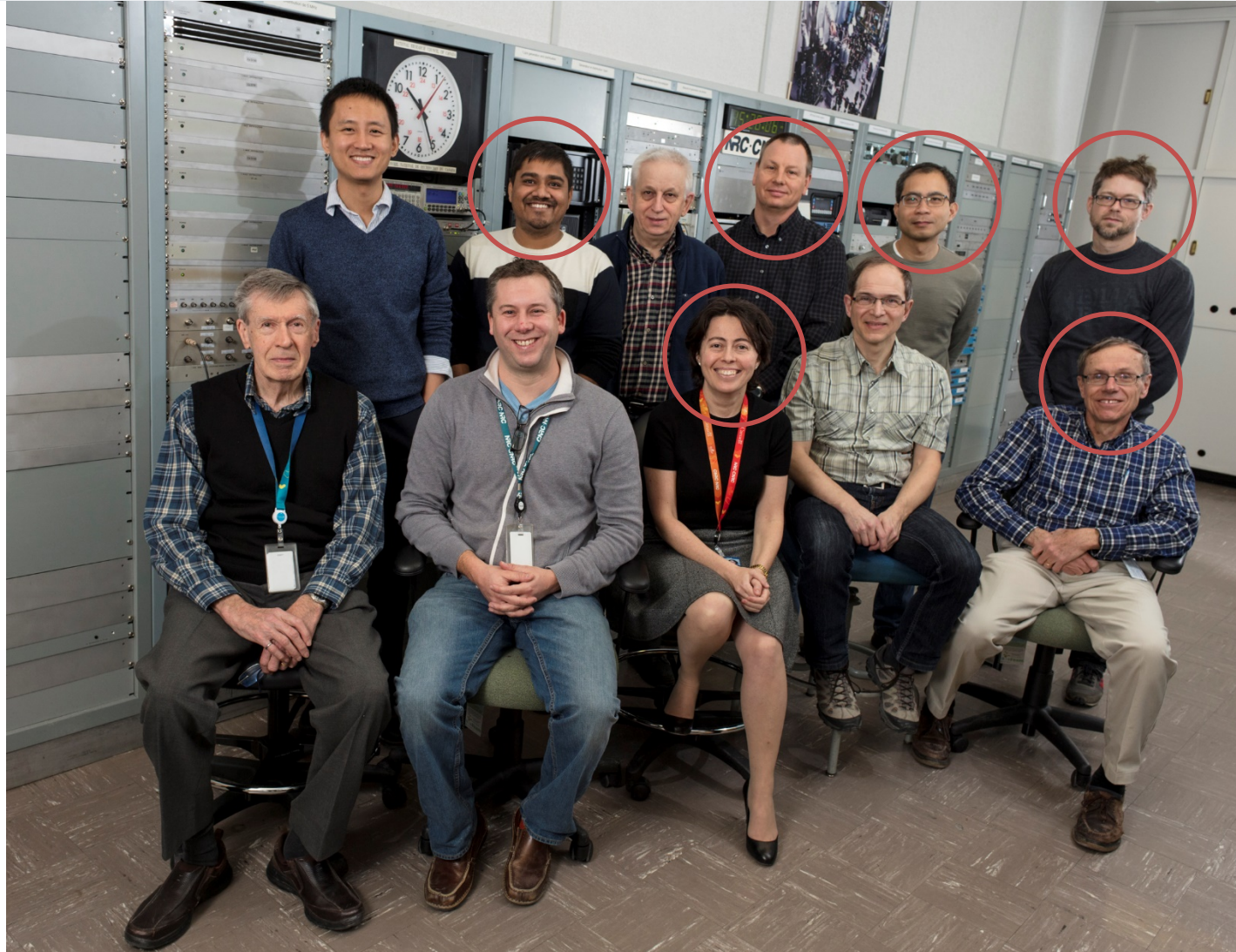
Conclusion

- Traceable Remote Time Dissemination
- Secure, Reliable, Redundant
- Very High Accuracy, Low Uncertainty
- Affordable, Easy to Use

NRC MSS F&T



NRC MSS F&T NRC-RC



Thank you

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Team Leader, Frequency & Time

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www.nrc-cnrc.gc.ca