QZSS Time Management and UTC

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Time management for satellite navigation system

Time management for QZSS

QZSS and UTC

Key technologies for GNSS

by Space Activity Committee, Japan 1997

- On-board atomic clock
- Time management of satellites
  (and the ground segment)

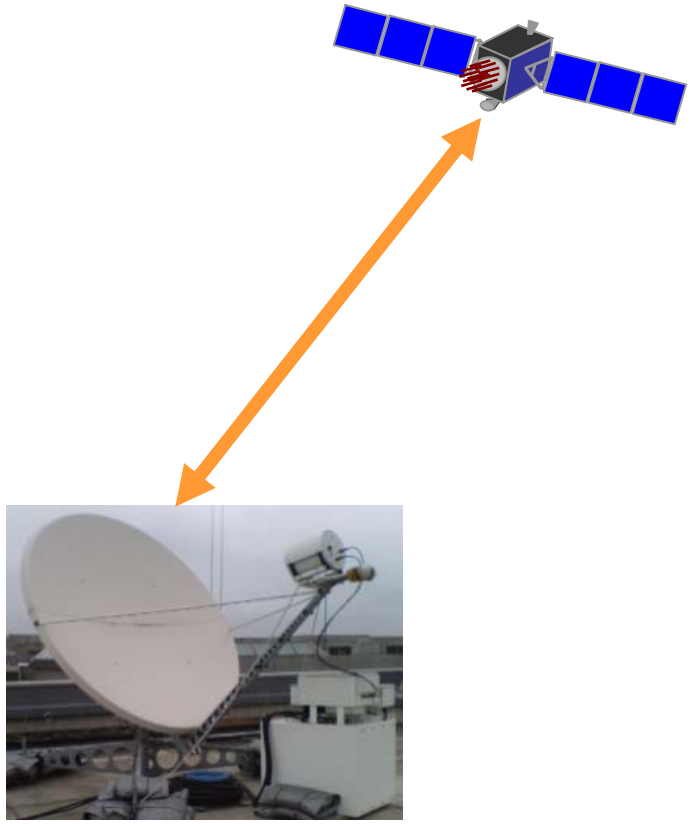
  (measurement of the clock parameter of the satellite)
- Precise orbit determination

today's talk

Measurement of the on-board clock parameter

- estimation from the received signal (one-way)
- adopting two-way method
  (to cancel propagation effect, etc)

method			freq.	
One-way	GPS	USA	L	
	Galileo	EU	L	
	QZSS	Japan	L	
Two-way	ETS-8	Japan	S	2006
	QZSS	Japan	Ku	2010
	ACES	ESA	Ku	2013?

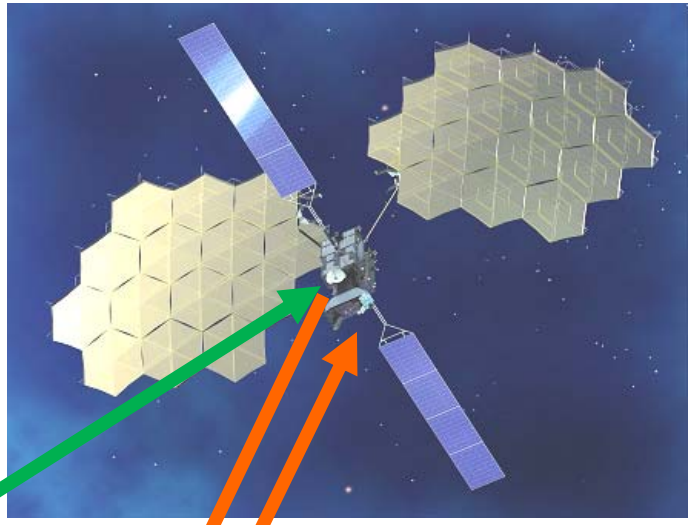


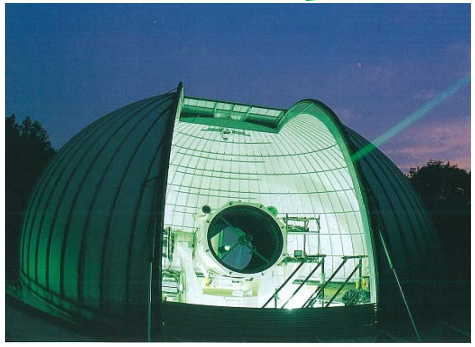
ACES : Atomic Clocks Ensemble in Space

Precise T&F transfer exp. using ETS-8

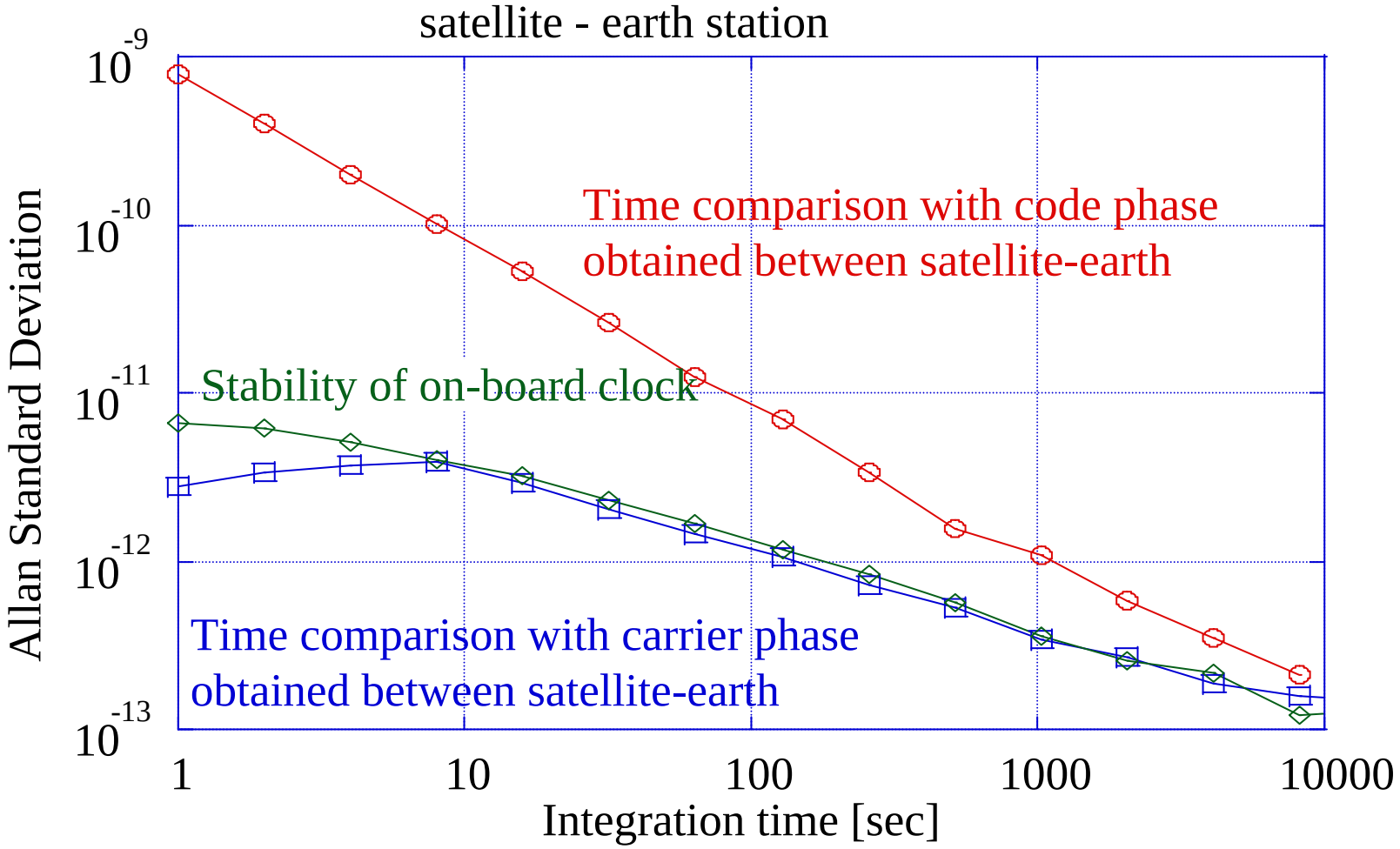
ETS-8
Launched on Dec. 2006 on GSO.
Two on-board Cs clocks.

- Two-way time and frequency comparison between ETS-8 and ground stations.





ETS-8 measurement performance



- 0.7ns@1s for code phase measurement
- 3×10^{-12}@1s for carrier phase measurement

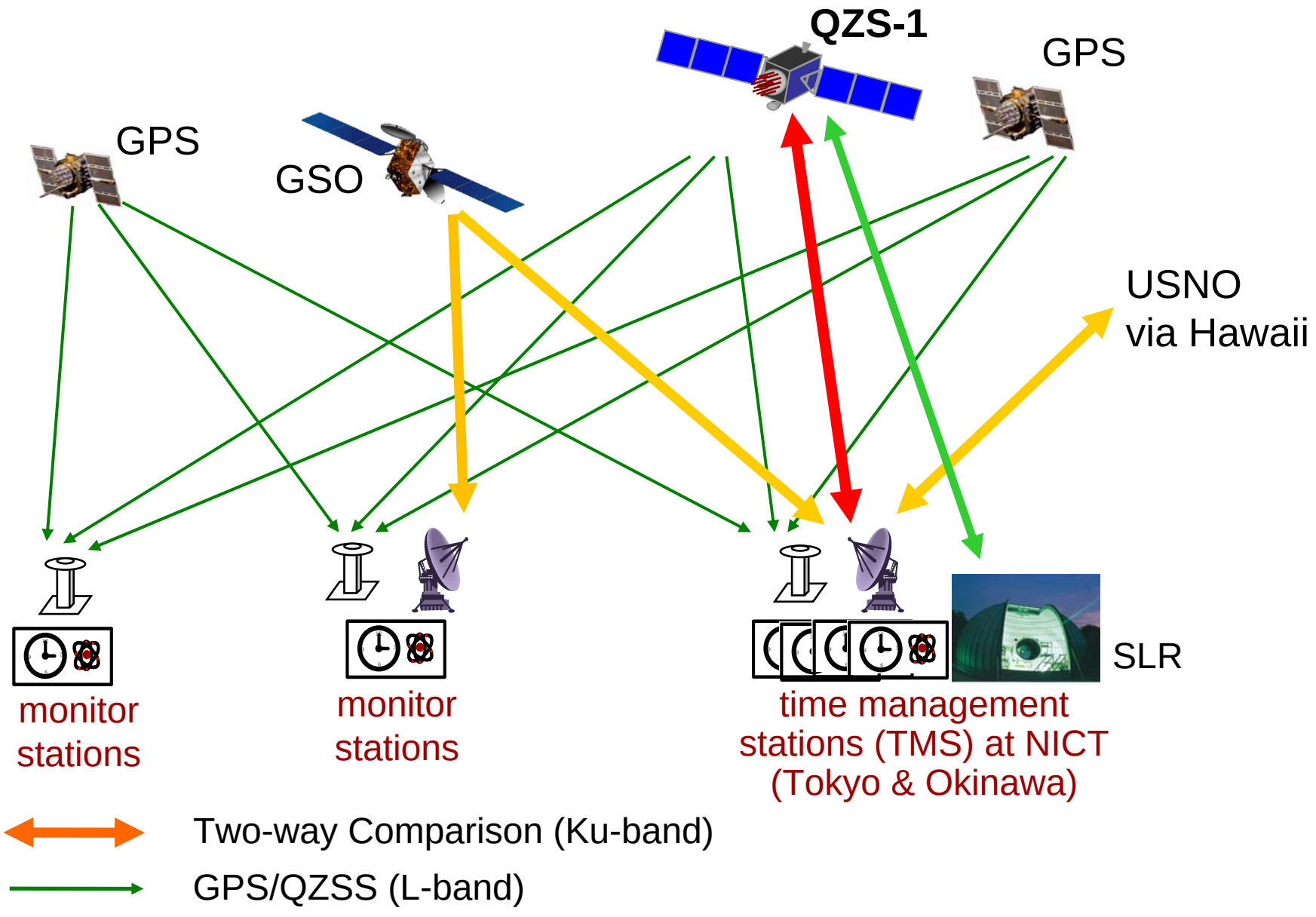
Time Management for QZSS by NICT

- Precise measurement of T&F between the on-board clocks* and the ground clocks (by two-way method)
- Continuous monitoring the on-board clocks*
- Link between UTC(NICT) and UTC(USNO)

(Link between UTC(NICT) and UTC**)

* two Rb frequency standards
** Coordinated Universal Time

Image of time management for QZSS



Function of the space segment of QZSS

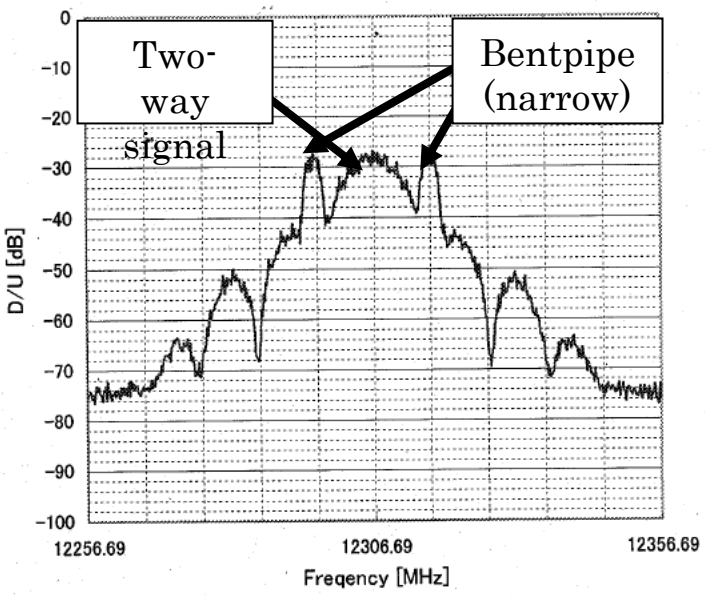
- Precise time & frequency difference measurements
  - between the satellite and the ground staions
    (time management stations; TMS)
  - between the on-board atomic clocks and the system reference
  - between the L-band navigation signals
    (L1 C/A, L1-SAIF, L2C, L5)
  - of the TCU instrumental calibration

- Bent pipe (thru repeater) functions
  for ground-to-ground TWSTFT

Bent pipe Function

- Two types of bent pipe (BP) function for TWSTFT using a non-GSO satellite

	narrow band BP *	wide band BP
Bandwidth (99% power)	6 MHz x 2 (20.46 MHz separated)	50 MHz
Chip rate	2.046 Mcps x 2 BOC(10,2)	10.23 Mcps
spectrum overlap with regular signal	not overlapped	overlapped
comment	equivalent to a wideband	conventional
BPF (@1.4GHz band)	coaxial interdigital	microstrip



able to share the same bandwidth

* see Amagai, ATF 2008

BOC: Binary Offset Carrier
TWSTFT: Two-Way Satellite Time and Frequency Transfer

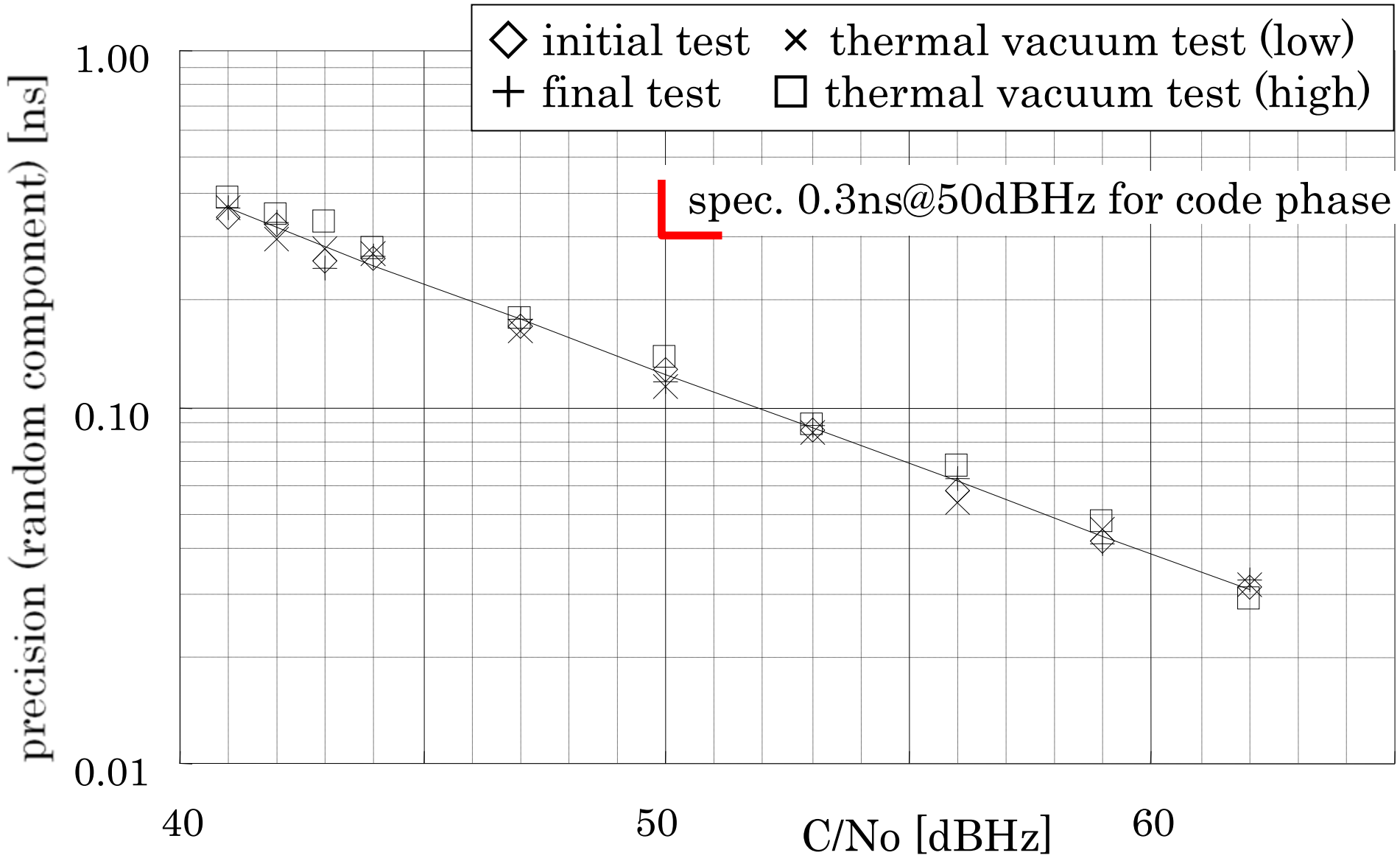
Performance test of the on-board TCU

Error (random component) of the delay measurements (for code phase measurement)

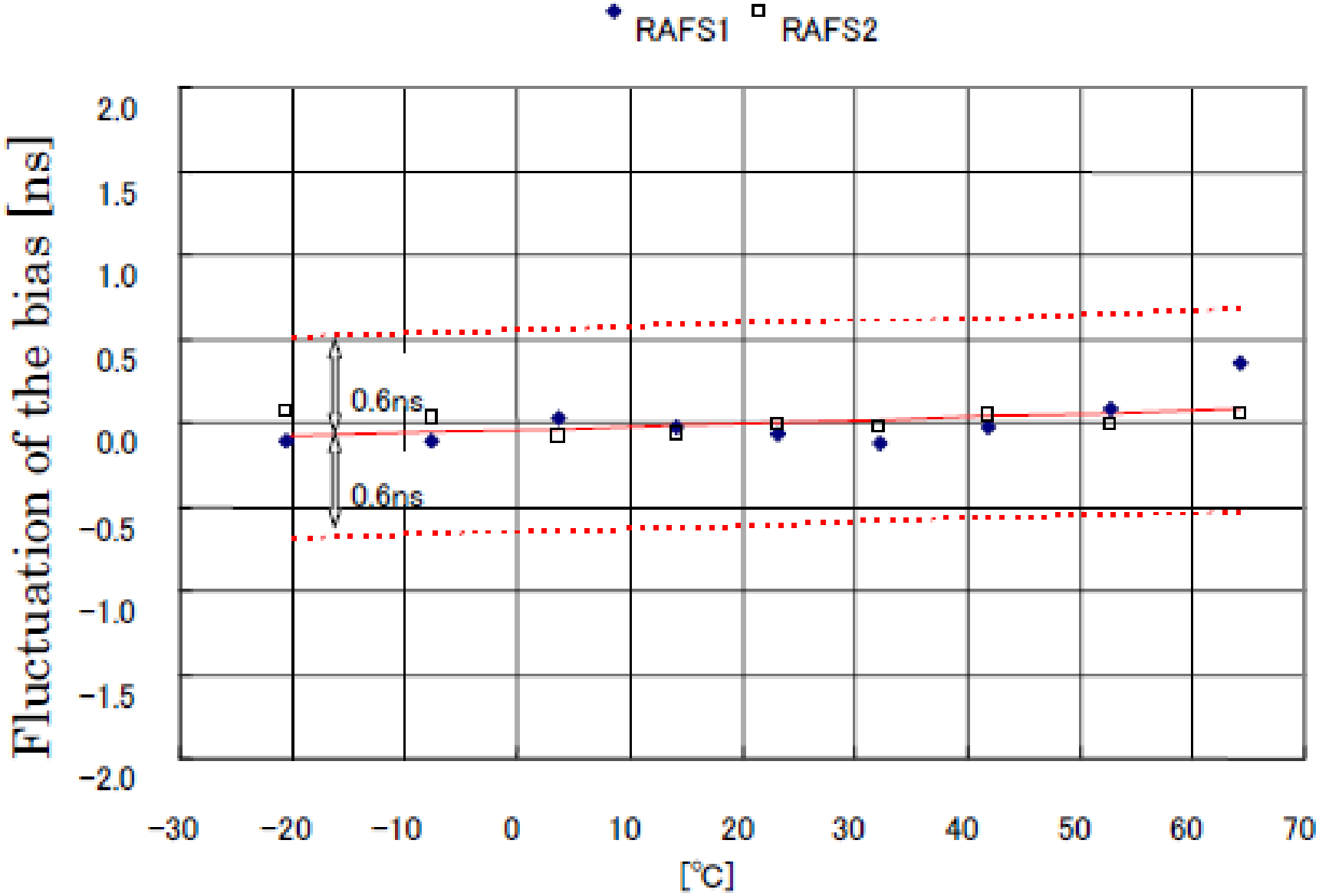
Item	specification	result
QZS-TMS time comparison		
Time comparison error (random)	< 0.3 ns (C/No=50dBHz)	0.14 ns
On-board clock comparison		
Time comparison error (random)	< 0.1 ns	0.04 ns
L-band signal calibration		
Time comparison error (random)	< 0.1 ns for L1 < 0.1 ns for L2 < 0.1 ns for L5	0.01 ns 0.02 ns 0.01 ns
Power consumption	< 41 W	33.9 W
Mass	13.0 kg +/- 1.3 kg	12.9 kg

TCU: Time comparison unit

C/No vs. two-way precision (TCU)



Temperature dependency (TCU) (measurement of on-board clocks)

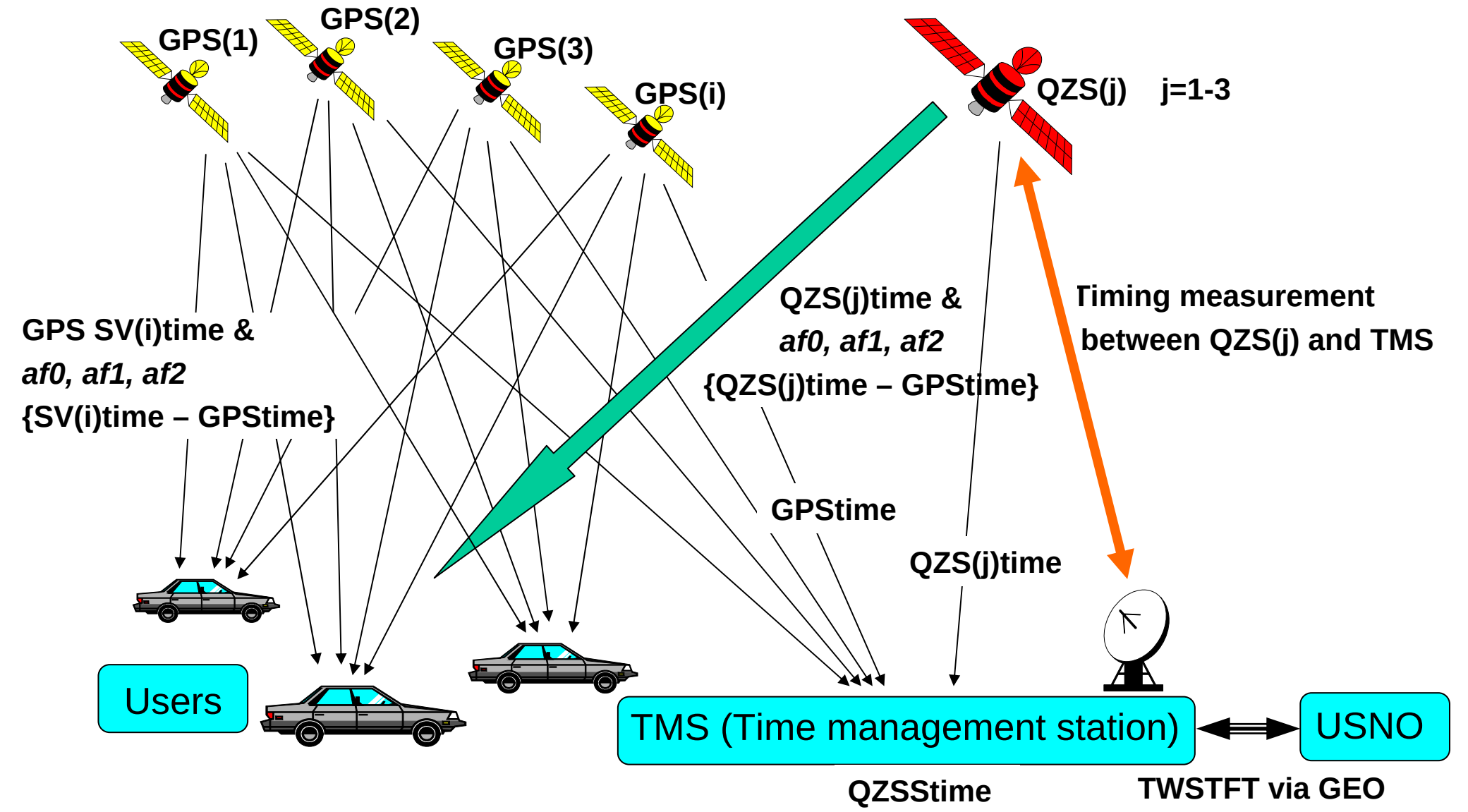


QZSS time and UTC(NICT)

for interoperability between GPS and QZSS,

- QZS broadcasts “SV time - GPST”
- QZS broadcasts “SV time - UTC(NICT)”
- UTC(NICT) tries to meet UTC +/- 10 ns
- UTC(NICT) is to be compared to UTC(USNO) by TWSTFT (via Hawaii)
- QZSST is now defined at a point in TMS Tokyo, and will be defined as an ensemble time in the future

Image of interoperability with GPS



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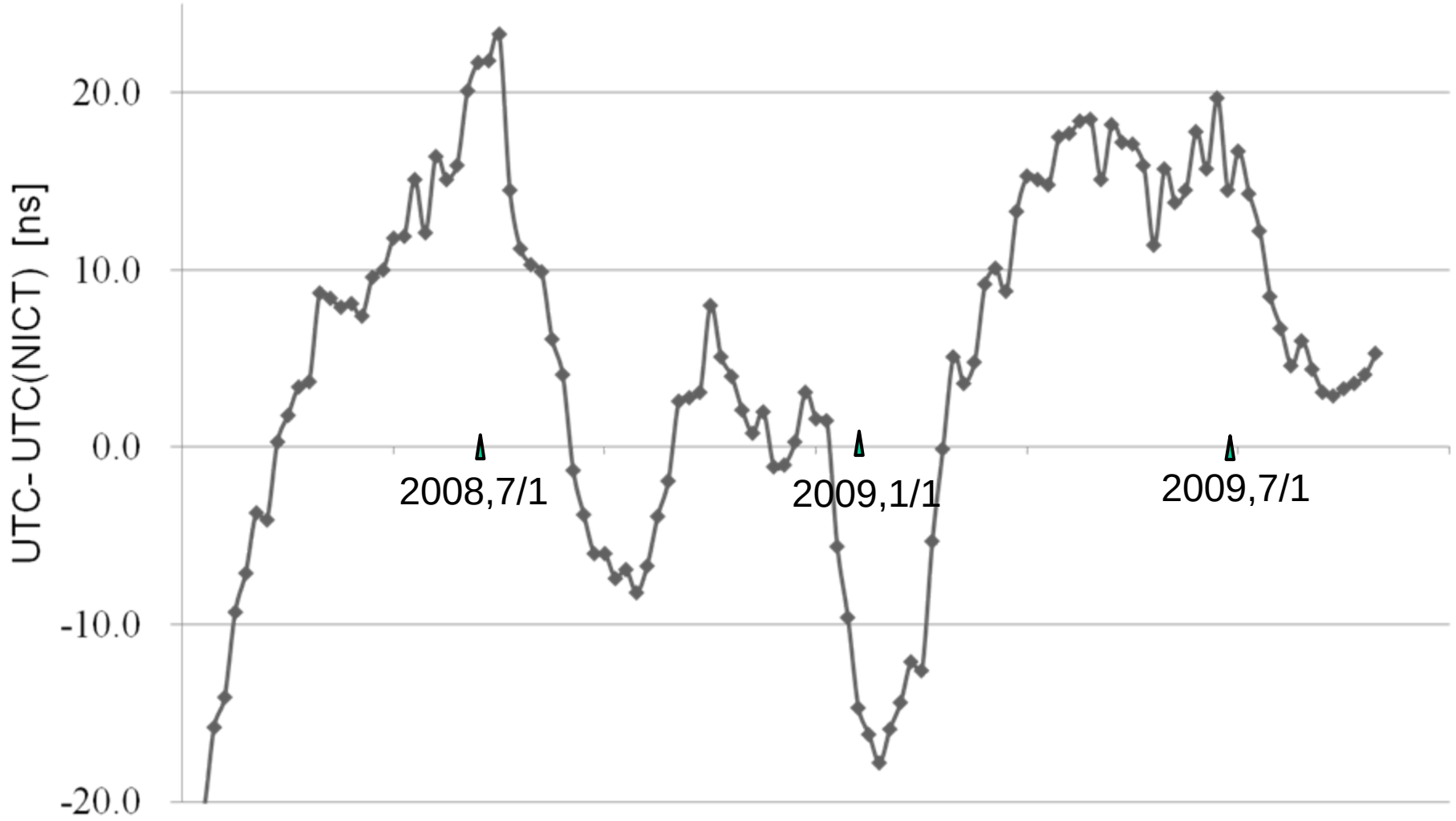
UTC - UTC(NICT)



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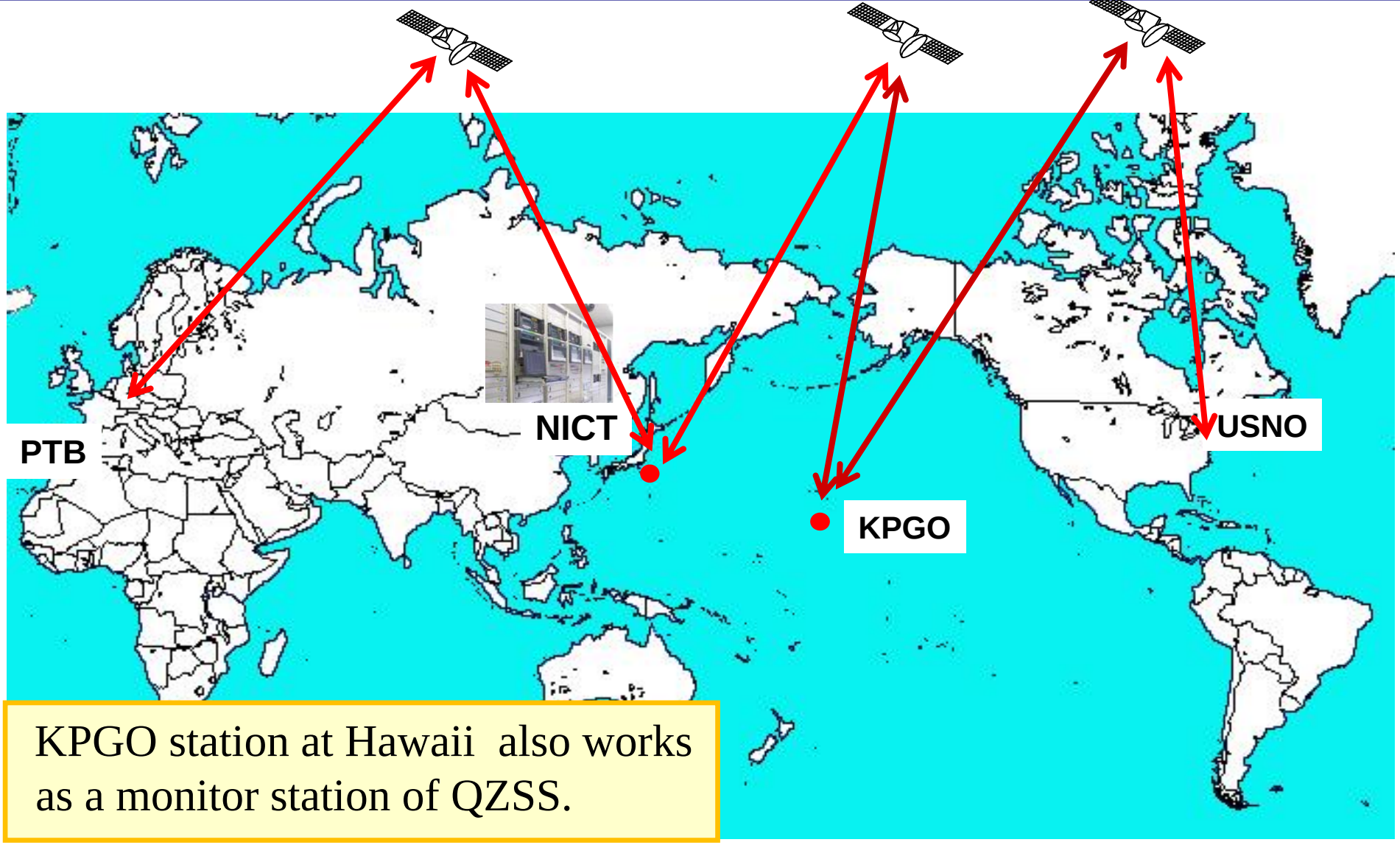
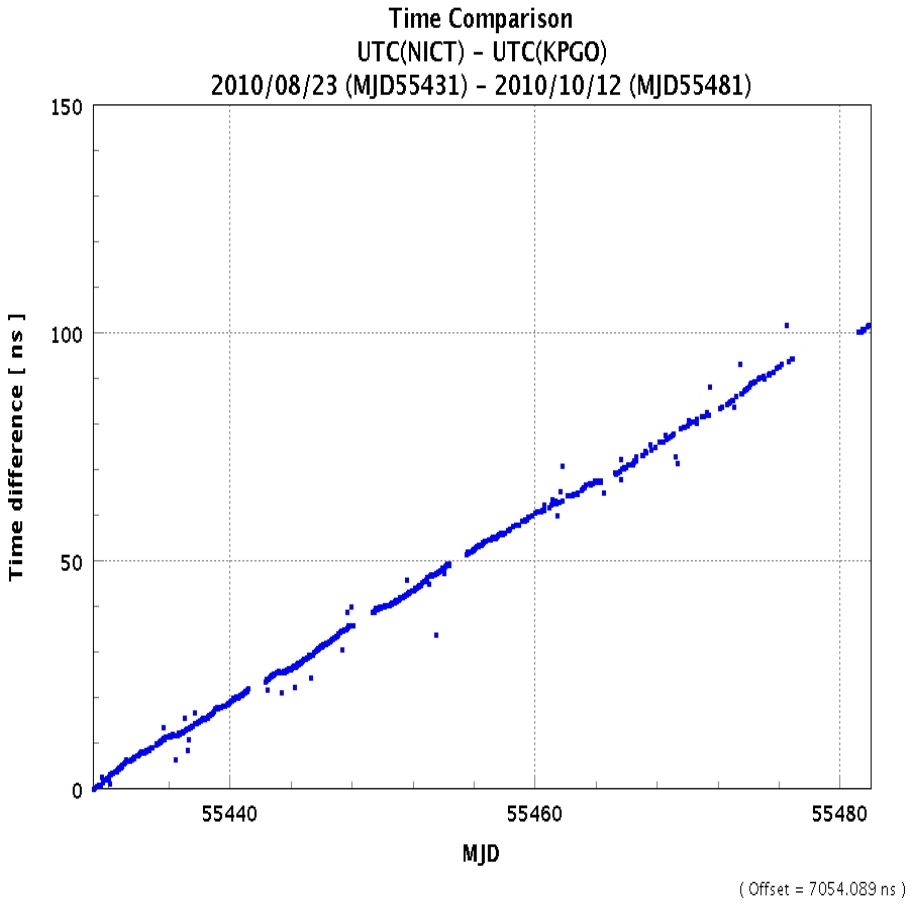
TWSTFT links around Japan wrt QZSS



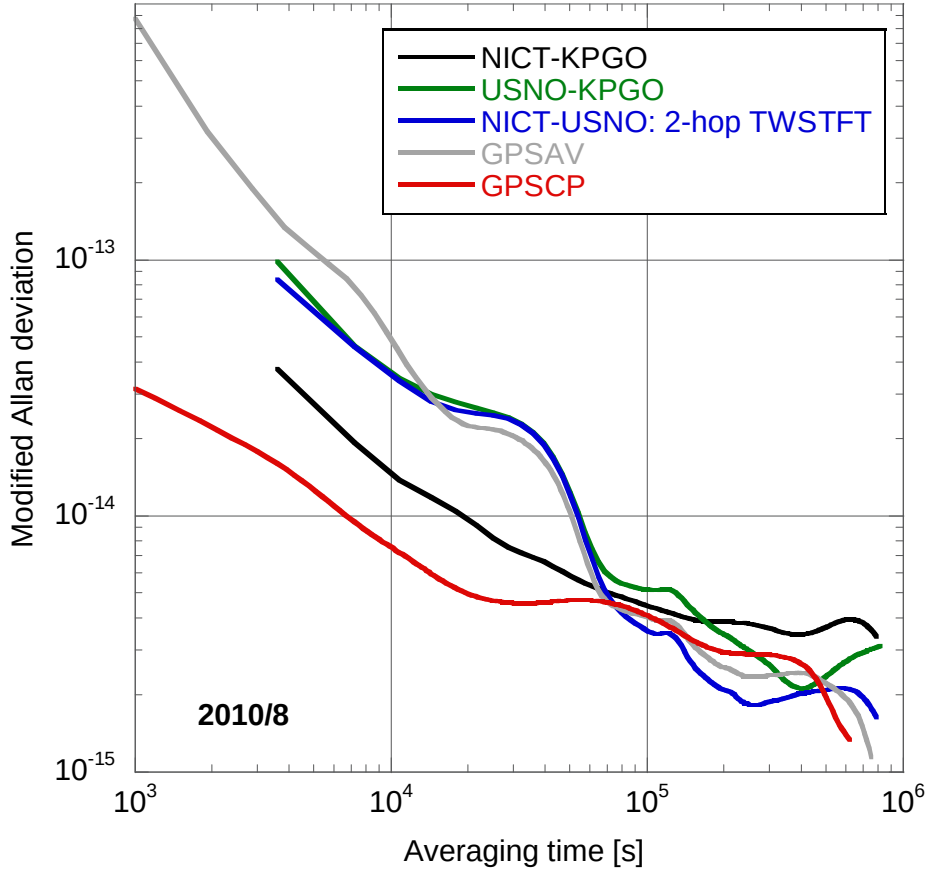
KPGO station at Hawaii also works as a monitor station of QZSS.

(NICT contributes to UTC with 18 Cs and 4 H-masers)

NICT-KPGO-USNO link by TWSTFT



NICT-KPGO by TWSTFT



NICT-KPGO and NICT-USNO
(by TWSTFT and GPS)

Current Status of QZS-1

- QZS-1 was successfully launched on Sep.11.
  Mission Check Out will start soon
- Experiments on time management
- 2nd & 3rd satellite policy will be determined

Establish technologies

of satellite navigation system in Japan

QZS-1 launch on Sep.11, 2010

Thank you
for your attention.

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courtesy
of JAXA