Distant Frequency Comparison with Broadband VLBI System

National Institute of Information and Communications Technology Space Time Standards Laboratory

Comparison with Other T&F Transfer Techniques

| Techniques | RunningCost | Distance | Signal Source | Precision | Advantages | Dis Adv. |
|----------------|------------------|-------------------|-------------------------|------------------|---|--|
| Fiber Link | Depend on Fiber | <3000km ? | Local Laser | \bigcirc | Quite High Precision | Fiber availability Limited Distance |
| TWSTFT (CP) | ~ 200k USD/yr? | Earth Diameter | Satellite R=4.2 e7 m | \bigcirc | High Precision | Operation Cost Satellite Availability |
| GNSS | Low | Earth Diameter | GNSS Satellite | \bigtriangleup | Low Cost | Satellite Orbit dependent, Day Boundary jump |
| VLBI | Relatively Lower | Earth Diameter | Natural Radio source | \bigtriangleup | Independent from satellite condition, Low running cost | Initial cost |

Establishment of independent frequency comparison techniques is important for accuracy assurances.

Frequency link with VLBI Observation between INRiM+INAF - NICT



Broadband VLBI with Small Antenna

Frequency comparison by using Transportable Broadband telescopes

- ■Radio Frequency : 3-14 GHz (VGOS Compatible)
- ■Data Acquisition : 4 band (1024 MHz width)
 - Nominal Freq. Array: Fc=4.0GHz, 5.6GHz, 10.4GHz, 13.6GHz
 - Effective Bandwidth : 3.8GHz (10 times more than Conventional)





NINJA Feed Dual-Pol mounted in July



Data Acquisition System: Simple and Stable without analog frequency conversion



'Small – Small' Baseline

• <u>Closure delay</u> relation used for 'small-small' baseline.

$$\tau_{21}(t_1) = \tau_{23}(t_1) - \tau_{13}(t_1) - \tau_{13}(t_1)\tau_{12}$$

- Advantage of Small Antenna:
 - Quick Slew and Small Distortion
 - Large Diameter's deformation effects are canceled out.
 - Lower Cost
- Disadvantage:
 - Limited Sensitivity, ←Boosted by Large Antenna
 - source structure effect in closure delay.



Sub-pico sec. precision by Broadband Group Delay (3.2-12.6GHz) Kashima34 – Ishioka 13m

Exp. on 14 Aug.2015, Freq. array=(Lower Edge=3.2, 4.8, 8.8, 11.6GHz)





Alan Standard Deviation



VLBI Clock Comparison Testing between NICT-NMIJ



Clock Comparison via VLBI and GPS-ppp 2016Nov25 UTC(NICT) – UTC(NMIJ)



250

200

150

GPS-VLBI

Clock Difference of Long Time Span UTC(NICT)-UTC(NMIJ) By VLBI and GPSppp(BIPM)





Comparison of UTC(NICT)-UTC(NMIJ) via Broadband VLBI and GPSPPP(BPIM): Dec. 2017



Interval [sec]

Summary

- The First frequency transfer experiment with Broadband VLBI over intercontinental baseline is under preparation.
- VLBI can be the alternative choice of long distance frequency transfer.
- Advantage of VLBI technique is free from satellite (orbit info., transponder cost) and lower running cost.
- Measurement error will be order of 1.e-16s/s in 10 days of experiment.
- Subject to be solved are: Data transfer, radio source selection, Broadband signal synthesis on very long baseline.