Centrum für Geodätische Erdsystemforschung

Time Transfer: sideline or geodetic objective?

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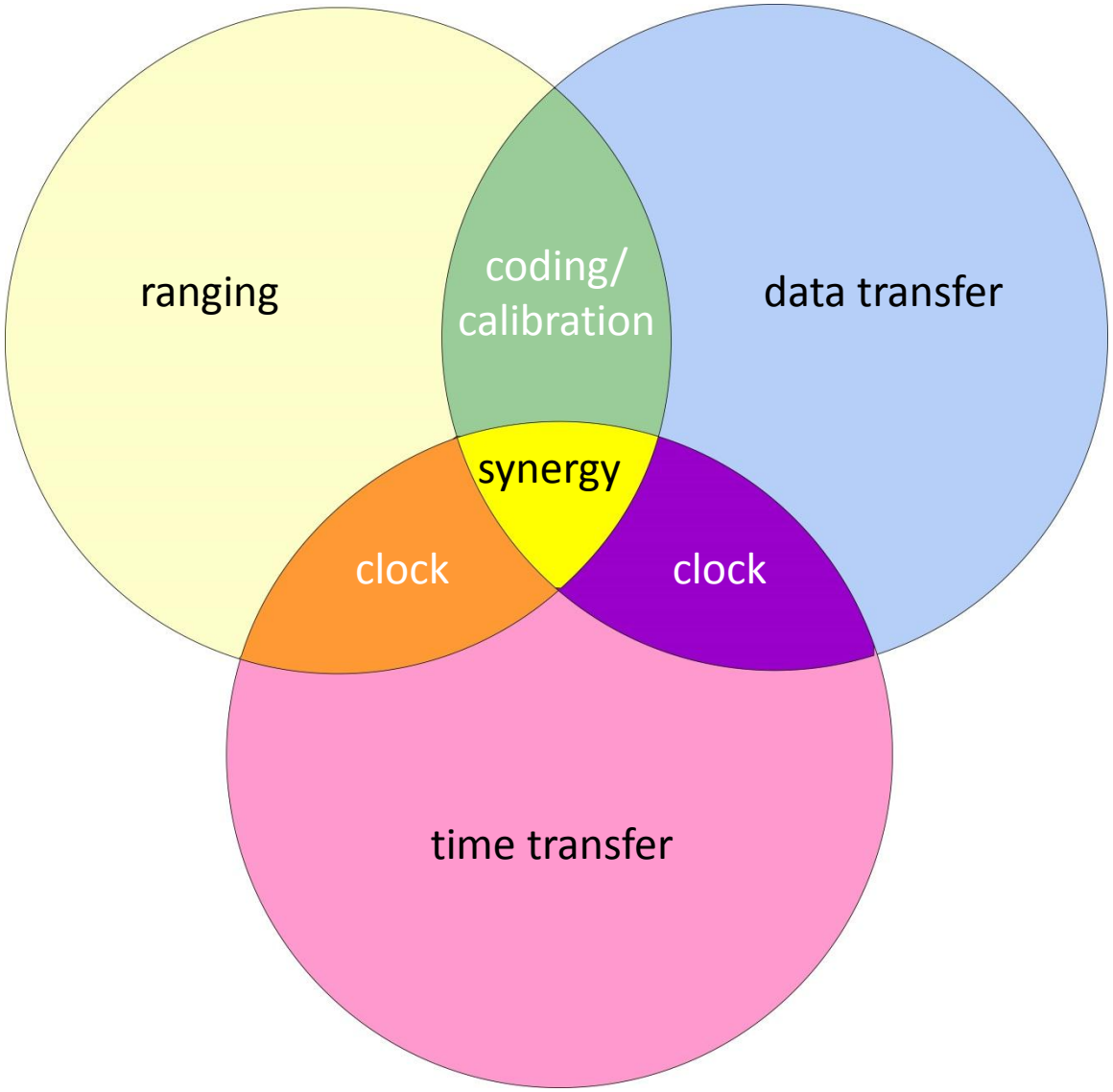
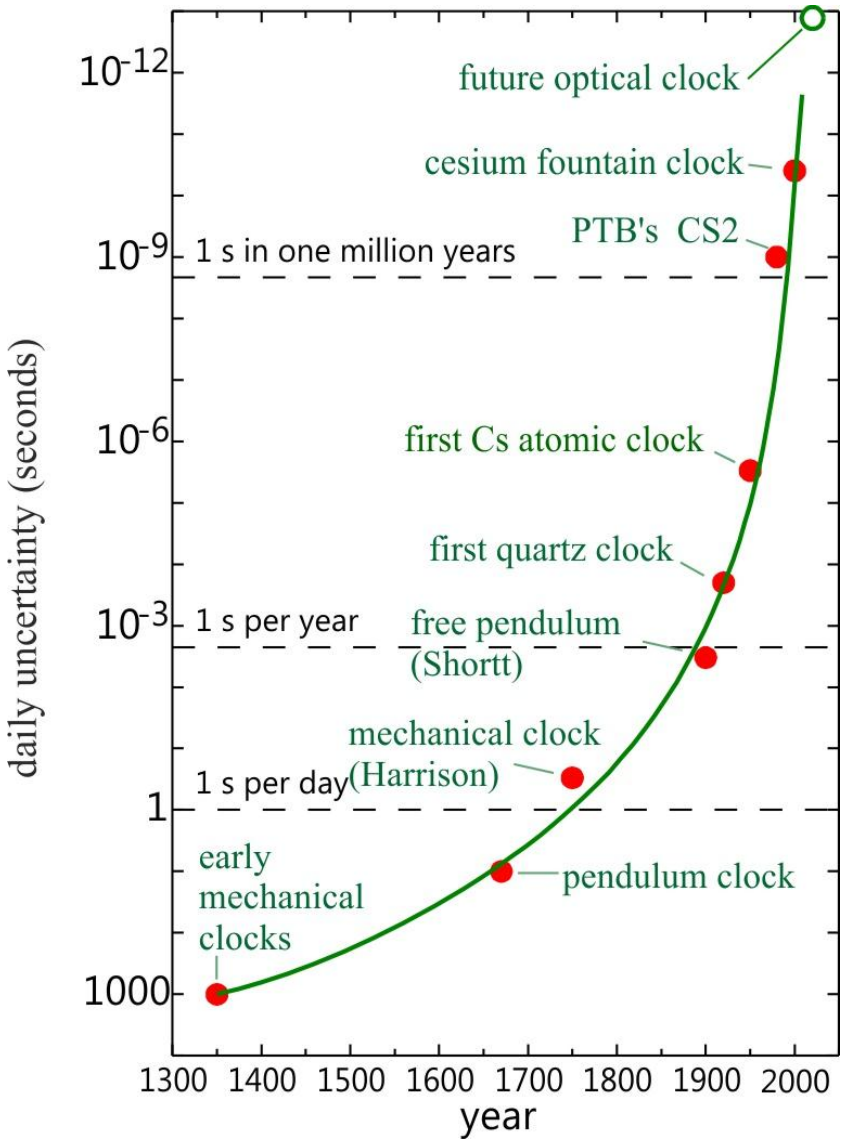
Why time transfer?



How precise are clocks?



ACES clock

E. Peik, U. Sterr, PTB-Mitteilungen, Spec. Iss., vol. 119, no. 2, pp. 25-32, 2009

Why do we put clocks in orbit?

- **Navigation:** GPS, GLONASS, QZSS, BeiDou, Galileo, DORIS

  1-way: „pseudoranges“ -> „biased ranges“
- **Fundamental physics:** ACES, STE-QUEST

  gravity red-shift
- **Transponder:** LRO, Messenger
- **Global time scale:** clock in GEO/Lagrange/GNSS

How can we compare space and ground clocks?

- Microwave links: 100MChips/s Ku Band (ACES)
- T2L2: optical pulsed 10Hz
- LRO

Future:

- ELT: optical pulsed single photon (1kHz)
- LCT: optical modulated 5Gbit/s

SLR contribution:

- Experience with range biases, accuracy
- Distance: Single photon, 1-way transponder

T2L2 – ELT: What‘s the difference?

- Space segment: clock,

  detector (T2L2: multiphoton, ELT: single photon)
- Efforts from the individual stations:

  both: ps resolution of start event crd format

  definition and calibration to clock reference point (integrated GPS)

  ELT specific: single photon mode at ISS (and on ground)

  fit into short timing window on ISS (200ns)

  laser response to trigger < 30ns uncertainty

  synchronisation to UTC < 30ns accuracy

  laser safty

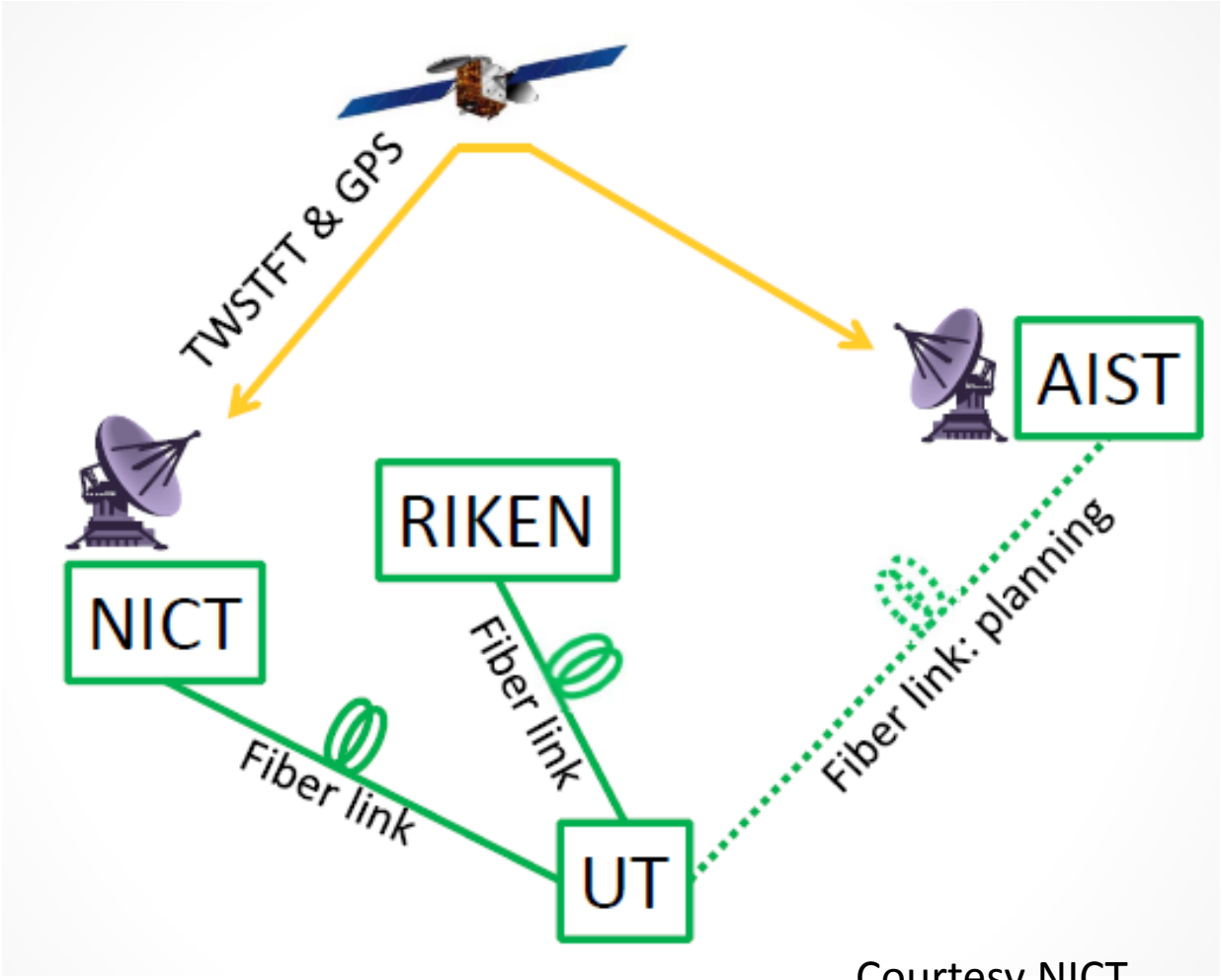
Which „clock“ do we need?

The clock should be better or comparable to the one on board:

- in our case: MASER with relation to UTC

Preparing the future

Tokyo area



Courtesy NICT

Preparing the future (II)

EURAMET
European Association of National Metrology Institutes

GÉANT

Courtesy PTB

Preparing the future (III)

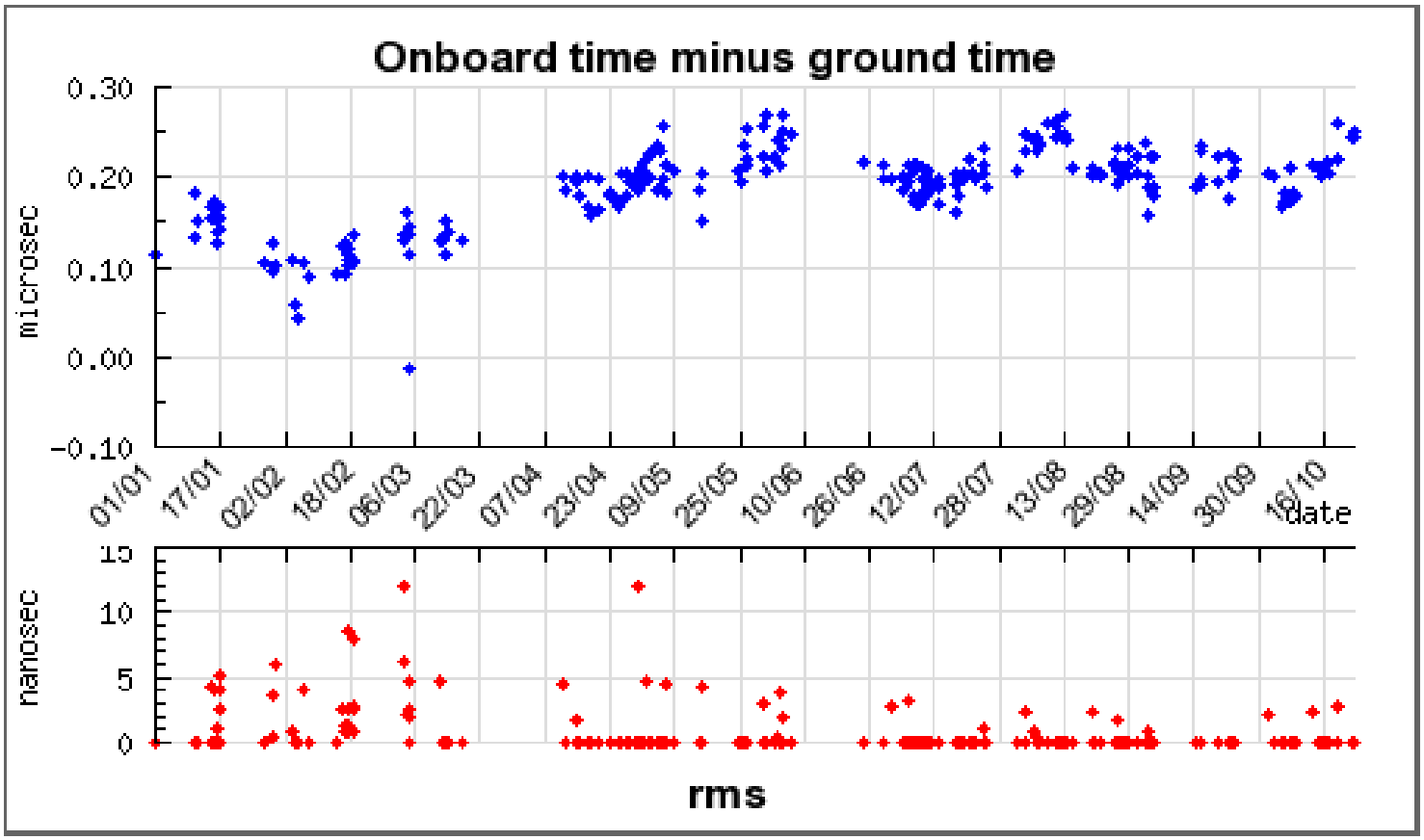
Australia

Courtesy Michael Tobar

Where is our strength?

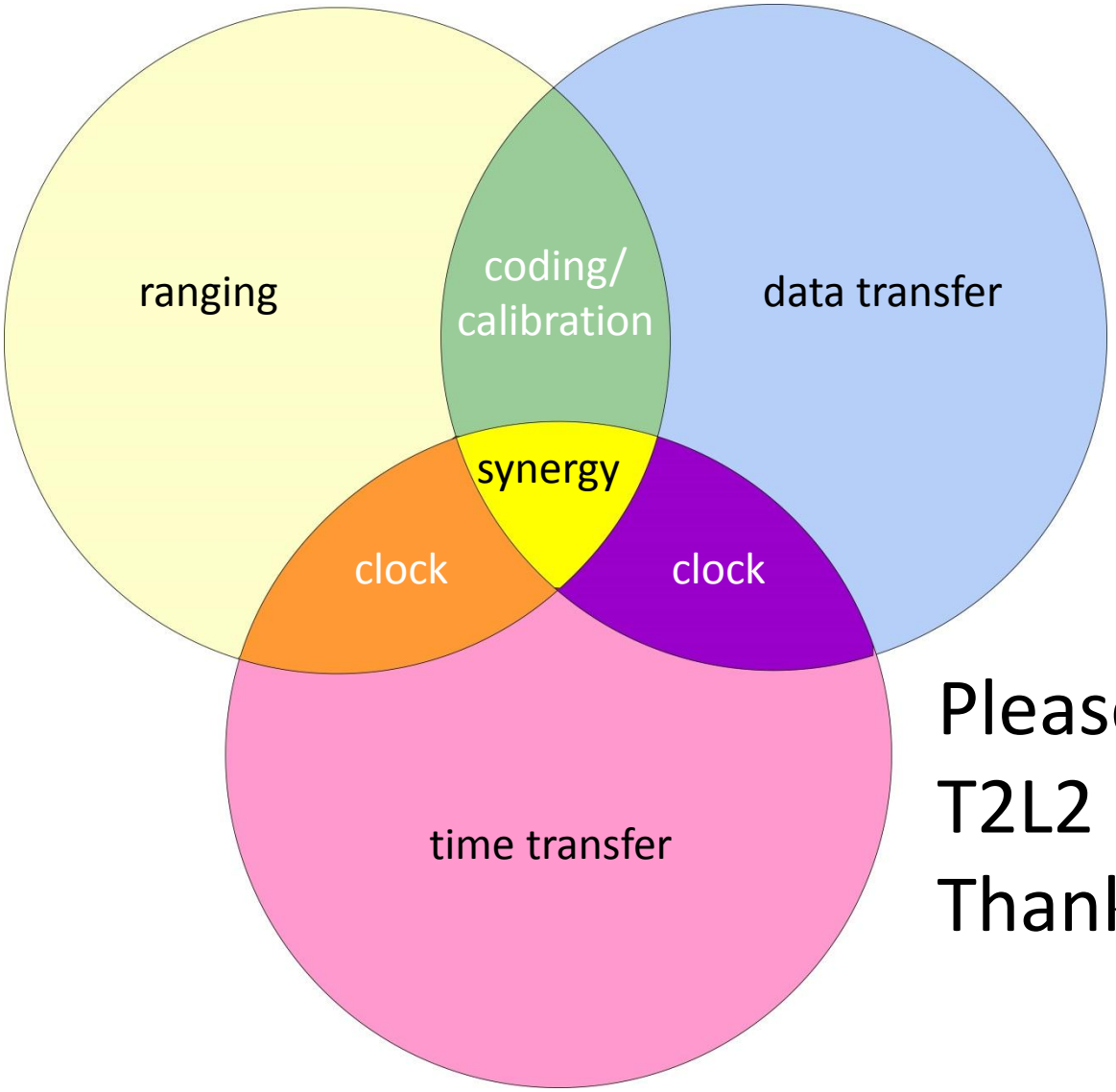
	SLR	Data transfer
Limitation of precision	10 kHz but low dispersion	100MChip/s (5Gbit/s) higher dispersion Influence of atmospheric fluctuations
accuracy	T2L2: 50ps (repeatability) ELT: 50ps ground-space ELT: 25ps ground-ground LRO: combination of MWL and optical	MWL ACES : 100ps
distance	LRO, Messenger	Optical TT limited
infrastructure	ILRS	

What can a station gain?



http://www.geoazur.fr/t2l2/en/data

Let‘s find our place in this synergy diagram!



Please contribute to
T2L2 and ELT!
Thank you very much!