



Traceability to UTC from GNSS measurements

Michael Wouters

CONSULTATIVE COMMITTEE
FOR TIME AND FREQUENCY

GNSS as a source of time and frequency

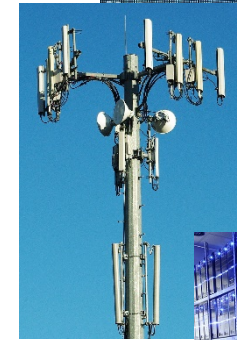


+



time of day accurate to +/- 10 ns
frequency accurate to parts in 10^{12}

finance



telecomms



power



data networks

Regulations

COMMISSION DELEGATED REGULATION (EU) 2017/574

of 7 June 2016

**supplementing Directive 2014/65/EU of the European Parliament and of the Council
with regard to regulatory technical standards for the level of accuracy of business clocks**

Article 1

Reference time

Operators of trading venues and their members or participants shall synchronise the business clocks they use to record the date and time of any reportable event with the Coordinated Universal Time (UTC) issued and maintained by the timing centres listed in the latest Bureau international des poids et mesures Annual Report on Time Activities. Operators of trading venues and their members or participants may also synchronise the business clocks they use to record the date and time of any reportable event with UTC disseminated by a satellite system, provided that any offset from UTC is accounted for and removed from the timestamp.

Traceability

Article 4

Compliance with the maximum divergence requirements

Operators of trading venues and their members or participants shall establish a system of traceability to UTC. They shall be able to demonstrate traceability to UTC by documenting the system design, functioning and specifications. They shall be able to identify the exact point at which a timestamp is applied and demonstrate that the point within the system where the timestamp is applied remains consistent. They shall conduct a review of the compliance of the traceability system with this Regulation at least once a year.

VS

the “... property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.”

International Vocabulary of Metrology (VIM)

Task group on traceability to UTC from GNSS measurements

CCTF



Hot topic: “Mutual benefit of UTC and GNSS”



Working Group on GNSS, Working Group on MRA



Task group formed

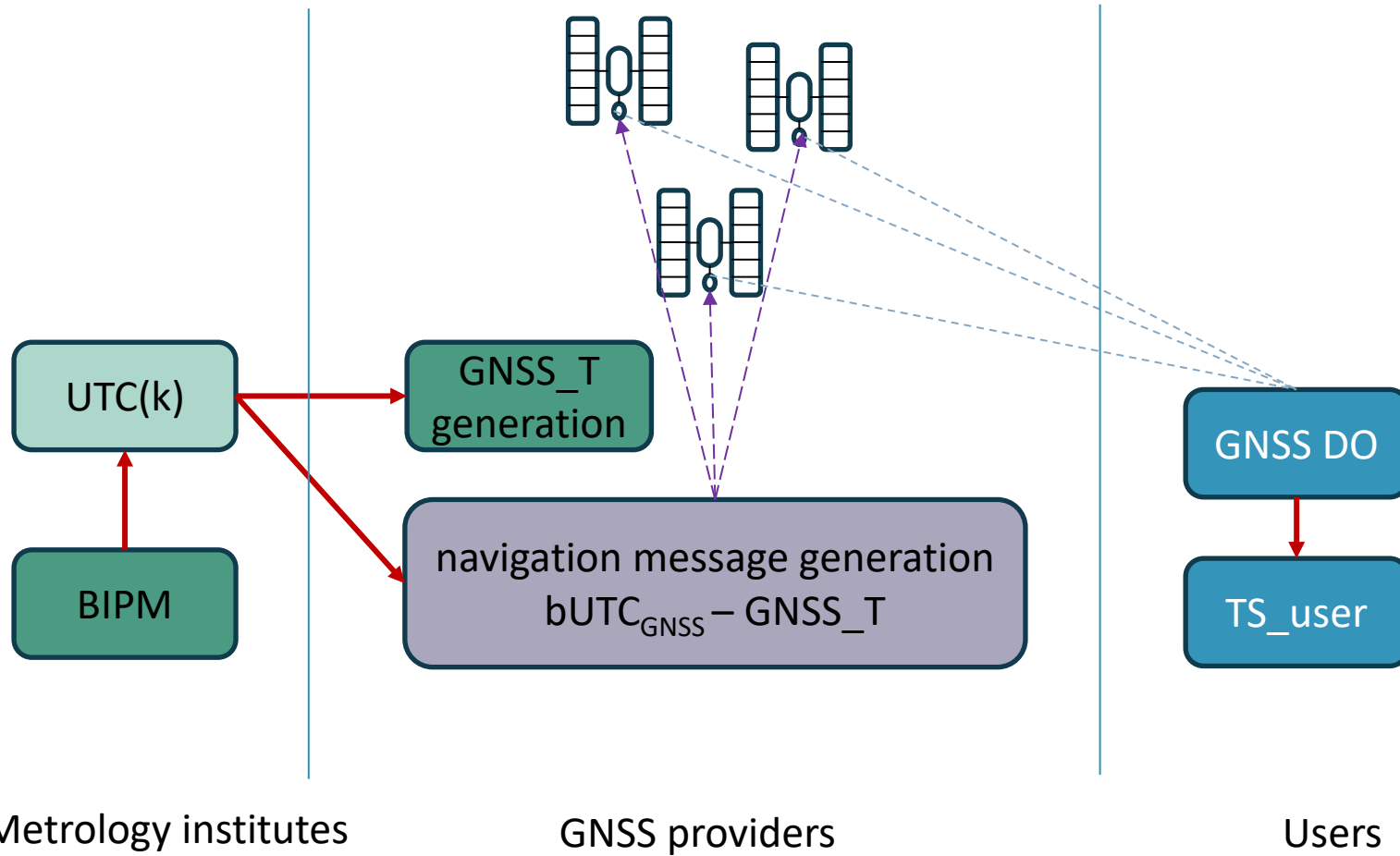


P. Defraigne et al, “Achieving traceability to UTC through GNSS measurements”, Metrologia v59, 2022 (Open Access)



New task group to promote recommendations

Relating the user time scale to UTC via GNSS



$$bUTC_{GNSS} - TS_{user} = [GNSS_T - TS_{user}] + [bUTC_{GNSS} - GNSS_T] \approx 0$$

$$UTC - bUTC_{GNSS} = [UTC - UTC(k)]$$

Circular T

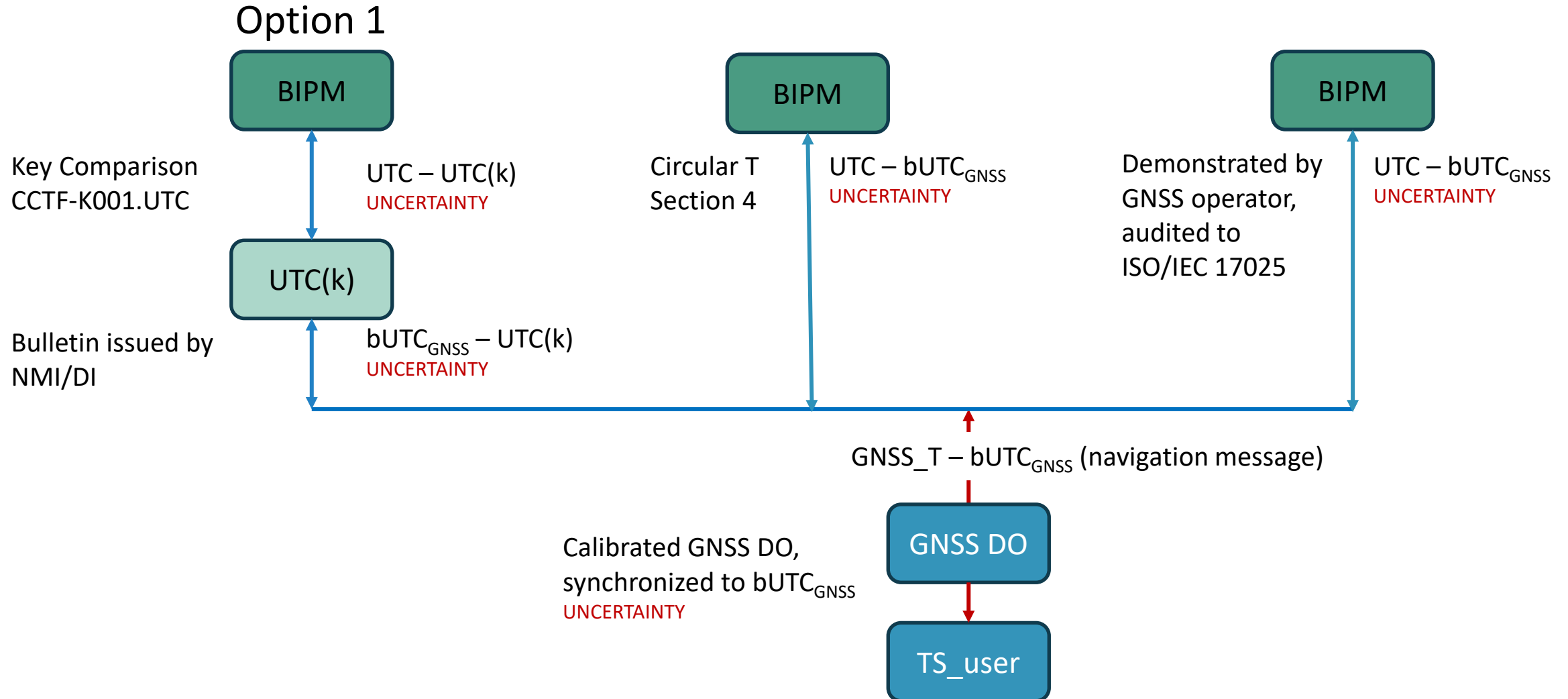
$$+ [UTC(k) - GNSS_T]$$

measured at UTC(k) lab

$$- [bUTC_{GNSS} - GNSS_T]$$

navigation message

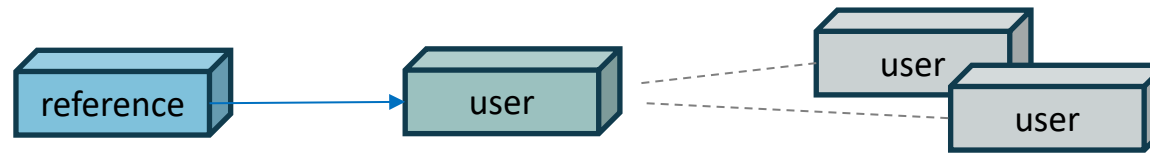
Traceability paths for time (users)



Recommendation on calibration for time (manufacturers)

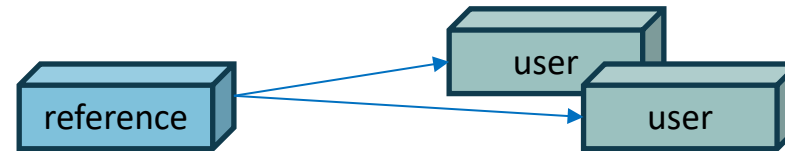
$U > 1 \mu s$

- One unit calibrated by an accredited lab
- One unit of each model calibrated by manufacturer; certificate of conformity for all units of the same model



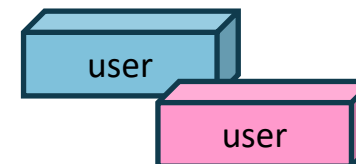
$1 \mu s > U > 100 ns$

- One unit calibrated by an accredited lab
- All other units of each model calibrated by manufacturer; certificate of conformity for each unit

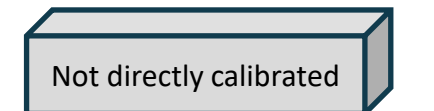
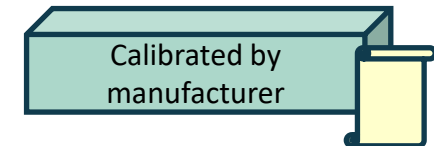
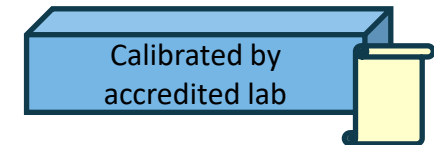
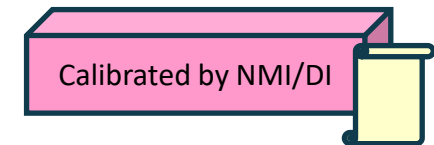


$U < 100 ns$

- All units regularly calibrated by an accredited lab or an NMI /DI
- Optional comparison via GNSS time-transfer



Key

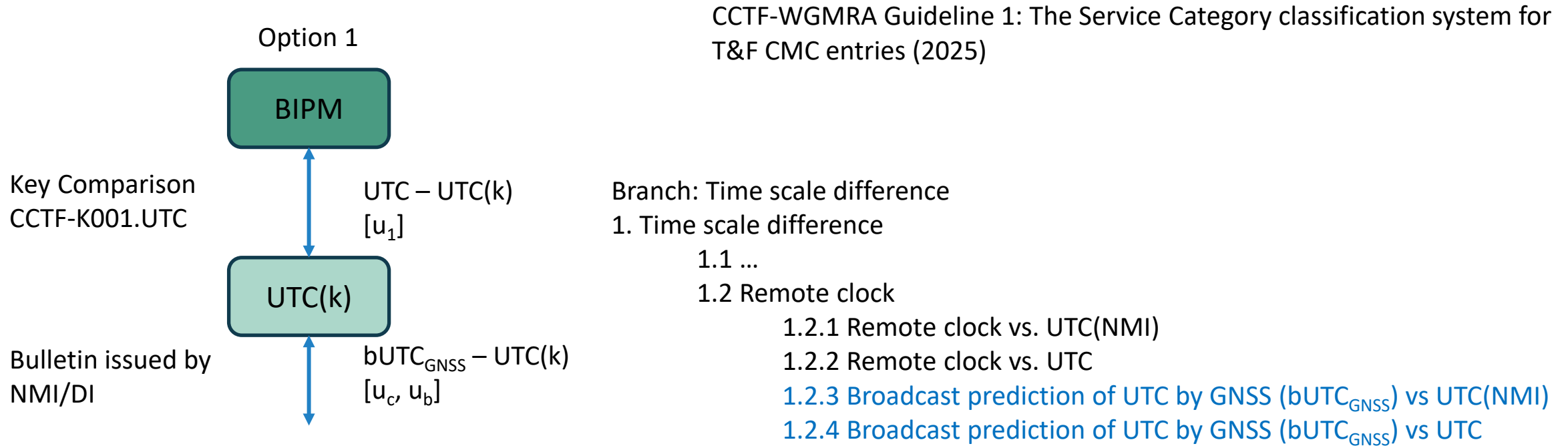


CCTF Recommendation 4 (2022)

NMIs/DIs are recommended to:

- Offer calibration services for GNSS equipment
- Publish results on the performance of received GNSS signals, with an uncertainty estimate.
- Publish GNSS time-transfer data (CGGTTS/RINEX); provide information to users about how these data can be used; and an uncertainty estimate.
- Intensify their efforts to educate users and equipment manufacturers about the proper use of GNSS to access UTC
- Provide feedback to the WGGNSS and WGMRA on their experience in regard to user needs and the requirements of their accreditation bodies

Supporting traceability with a new CMC (NMIs)



... currently (Sep 2025) no published CMCs in KCDB

How might you do this?

CGGTTS file: UTC(k) – GNSS_T

SAT	CL	MJD	STTIME	TRKL	ELV	AZTH	REFSV	SRSV	REFSYS	SRSYS	DSG	IOE	MDTR	SMDT	MDIO	SMDI	MSIO	SMSI	ISG	FR	HC	FRC	CK
			hhmmss	s	.1dg	.1dg	.1ns	.1ps/s	.1ns	.1ps/s	.1ns		.1ns	.1ps/s	.1ns	.1ps/s	.1ns	.1ps/s	.1ns				
G01	FF	60919	001400	780	162	1314	-3410240	-23	-145	+21	37	105	288	+53	393	+19	393	19	26	0	0	L3P	5E
G06	FF	60919	001400	780	282	222	+5067732	+98	-109	-26	21	42	172	-40	366	-44	366	-44	17	0	0	L3P	5C
G13	FF	60919	001400	780	395	3063	-6992056	-22	-127	-28	12	51	127	+15	299	+46	299	46	10	0	0	L3P	6D
G14	FF	60919	001400	780	468	1197	-6907504	-30	-147	+11	32	125	111	+8	215	+10	215	10	19	0	0	L3P	44

RINEX navigation file: GNSS_T - bUTC_{GNSS}

```

3.04          N: GNSS NAV DATA      M: MIXED          RINEX VERSION / TYPE
sbf2rin-13.8.0          20250902 004501 UTC PGM / RUN BY / DATE
GPSA   2.5146E-08   2.2352E-08 -1.1921E-07 -1.1921E-07          IONOSPHERIC CORR
GPSB   1.3312E+05   3.2768E+04 -2.6214E+05  4.5875E+05          IONOSPHERIC CORR
GPUT   1.8626451492E-09 6.217248938E-15 319488 2382          TIME SYSTEM CORR

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IS-GPS-200 tells you how to use these parameters

TASK GROUP on Traceability to UTC from GNSS Measurements

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The background of the slide is a dark blue space scene. It features a network of satellites, each with two large solar panel wings, connected by thin, light blue lines representing communication or data links. These satellites are positioned along several intersecting orbital paths. In the lower-left corner, a portion of the Earth is visible, showing the continents of Europe and Africa. The overall theme is space-based technology and global communication.

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 CCTF

www.bipm.org