Impact of a possible redefinition of Coordinated Universal Time on GNSS interoperability

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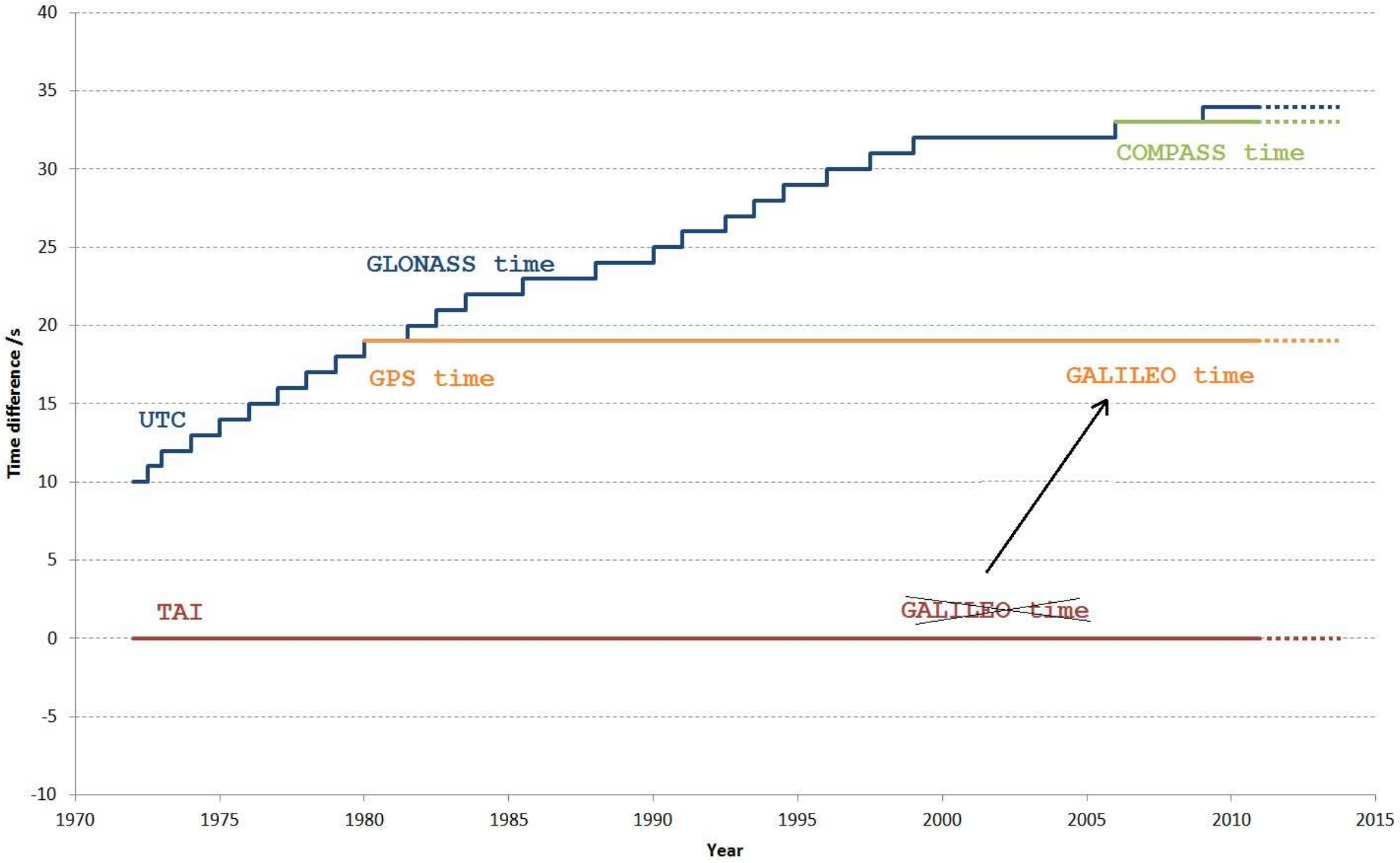
Outline of presentation

- Relation between UTC and GNSS time scales
  - GPS time
  - Glonass time
  - Galileo system time
  - BeiDou system time
- UTC dissemination by GNSS
- Quality of disseminated time scales
- Possible improvement of GNSS interoperability after stopping leap seconds
- Events related to a possible redefinition of UTC

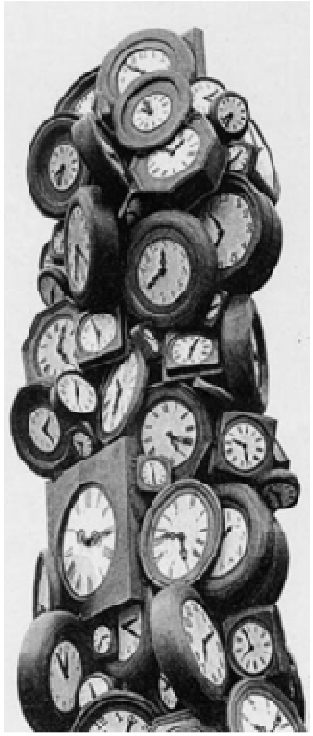
Multiple GNSS use

- **Users need:**
  - **Interoperability**
  - **Interchangability**
- **A number of recommendations related to UTC definition by:**
  - **ICG**
  - **CCTF**
  - **CIPM**
  - **CGPM**


40
35
30
25
20
15
10
5
0
-5
-10
Time difference /s
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
UTC
GLONASS time
GPS time
COMPASS time
GALILEO time
TAI
GALILEO time

System times

- GPS time: steered to UTC(USNO) modulo 1s
  - ✓ [TAI – GPS time] = 19 s + C_0
  - ✓ [UTC -GPS time] = -16 s + C_0
  - ✓ $C_0 \leq 20$ ns
  - ✓ Tolerance is 1 μs
- GLONASS time: steered to UTC(SU) with leap second
  - ✓ [TAI – GLONASS time] = 35 s + C_1
  - ✓ [UTC – GLONASS time] = C_1
  - ✓ C_1 ~ some 100 ns
  - ✓ Tolerance is 1 ms
- Galileo time: steered to a set of EU UTC(k); using GPS time seconds, GGTO
  - ✓ [TAI – Galileo time] = 19 s + C_2
  - ✓ [UTC -Galileo time] = -16 s + C_2
  - ✓ Tolerance is 50 ns
- COMPASS time: will be steered to set of Chinese UTC(k)
  - ✓ [TAI –COMPASS time] = 33 s + C_3
  - ✓ [UTC -COMPASS time] = -2 s + C_3
  - ✓ Tolerance is 100 ns

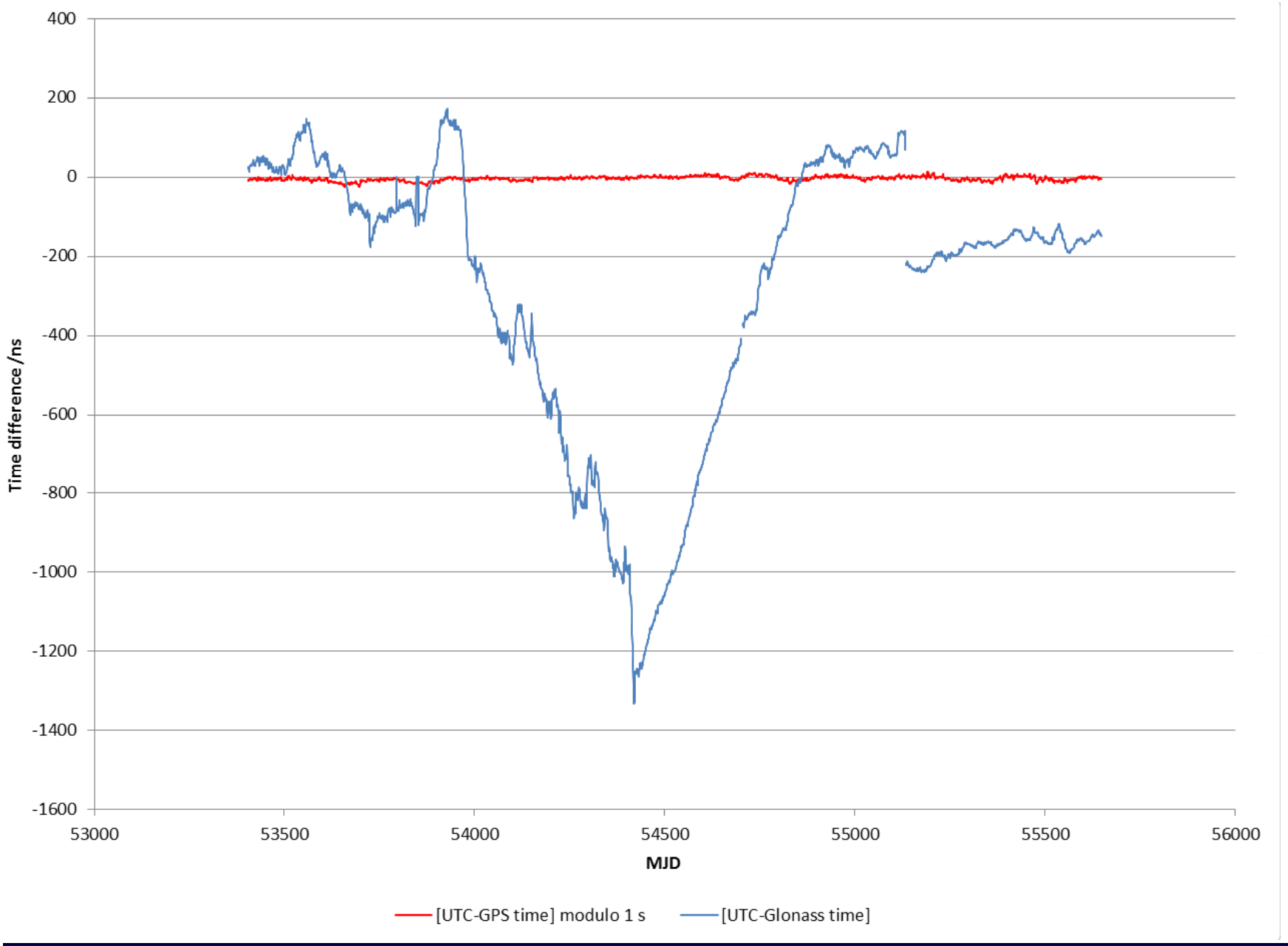


GNSS time dissemination

GNSS broadcast :

- **System time** ***(internal technical parameter)***
- **Prediction of UTC**

2013	GPS time +15 s /ns	*UTC-* **....** **UTC(USNO) by GPS** /ns	GLONASS time /ns	**UTC(SU) by GLONASS** /ns
AUG 1	-0.3	-0.2	-173.4	-362.5
AUG 2	-0.1	-2.3	-171.8	-361.0
AUG 3	-0.2	-2.2	-173.1	-363.0
AUG 4	-0.2	-0.2	-172.1	-362.9
AUG 5	0.0	-2.0	-169.3	-361.2
AUG 6	-0.4	-1.4	-170.2	-362.7
AUG 7	-1.1	-0.6	-169.7	-362.2
AUG 8	-1.2	-2.2	-168.1	-360.7
AUG 9	-2.4	-2.5	-168.4	-360.2
AUG 10	-2.1	-1.6	-170.7	-361.7
AUG 11	-1.8	-0.5	-171.7	-362.3
AUG 12	-2.2	-1.8	-169.7	-359.9
AUG 13	-2.1	-0.5	-168.2	-358.1
AUG 14	-3.8	-3.1	-169.9	-359.1
AUG 15	-3.6	-2.0	-174.1	-362.3
Stand. dev.	**1.1**	**1.2**	**6.3**	**6.3**
Uncert. uB	**10.0**	**10.0**	**500.0**	**500.0**


400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
Time difference /ns
53000
53500
54000
54500
55000
55500
56000
MJD
[UTC-GPS time] modulo 1 s
[UTC-Glonass time]


50
0
-50
-100
-150
-200
-250
-300
-350
-400
450
56150
56200
56250
56300
56350
56400
56450
56500
56550
56600
[UTC - GPS Time]
[UTC - UTC(USNO) by GPS]
[UTC - GLONASS Time]
[UTC - UTC(SU) by GLONASS]

Summary
on quality of broadcast time scales

- **GPS is broadcasting its two time scales with an uncertainty of a few ns, fulfilling needs of most demanding users.**

- **GLONASS is broadcasting its two time scales with an uncertainty of some microceconds, which does not meet requirements of professional users.**

Summary on safety of life issues

- **GNSS providers choose always flat system times to avoid a risk of any disruption**
- **Only GLONASS is taking a risk of stepping its system time**

Summary
on impact of removing leap second

- **Stopping proliferation of alternative time scales**
- **Accomodating needs of modern infrastructure as telecoms**
- **Improving interoperability and interchangeability of GNSS**
- **Improving safety of life**

Related events

- **Sept 2013 - ITU/BIPM Workshop on redefinition of UTC in Geneva**

- **Jan 2015 - World Radio Conference expected change of the definition of UTC**

Possible compromises

- As some administrations are opposing change or are reluctant, compromises are considered
  - Suspending application of leap second
  - Replacing leap second by a leap hour
  - ……..
- Introducing a second official time scale is not acceptable


THANK YOU!