

A DAY WITHOUT SATELLITES in the field of Time & Frequency

W. Lewandowski

Bureau International des Poids et Mesures, Sèvres



Brussels, 27 September 2012

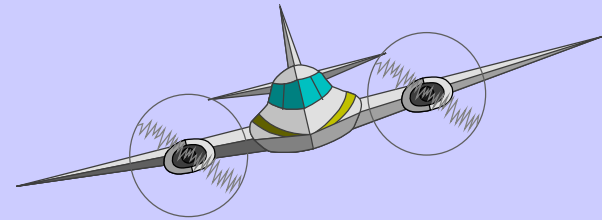
Demanding applications



time keeping

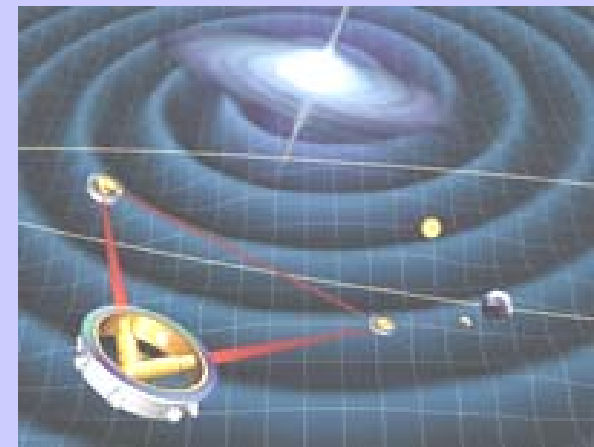


satellite navigation systems



telecommunication systems

fundamental physics

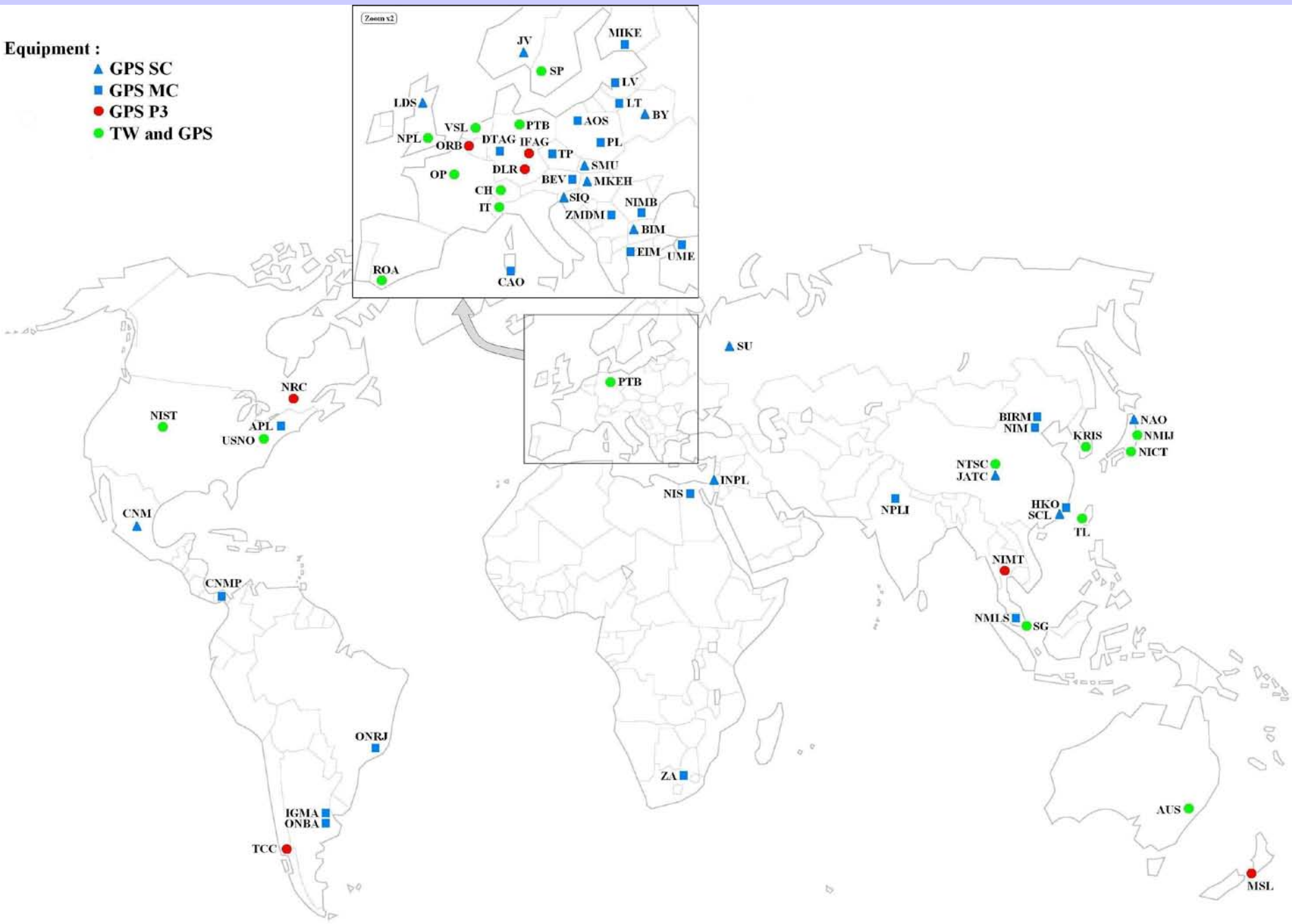


International time scales TAI and UTC

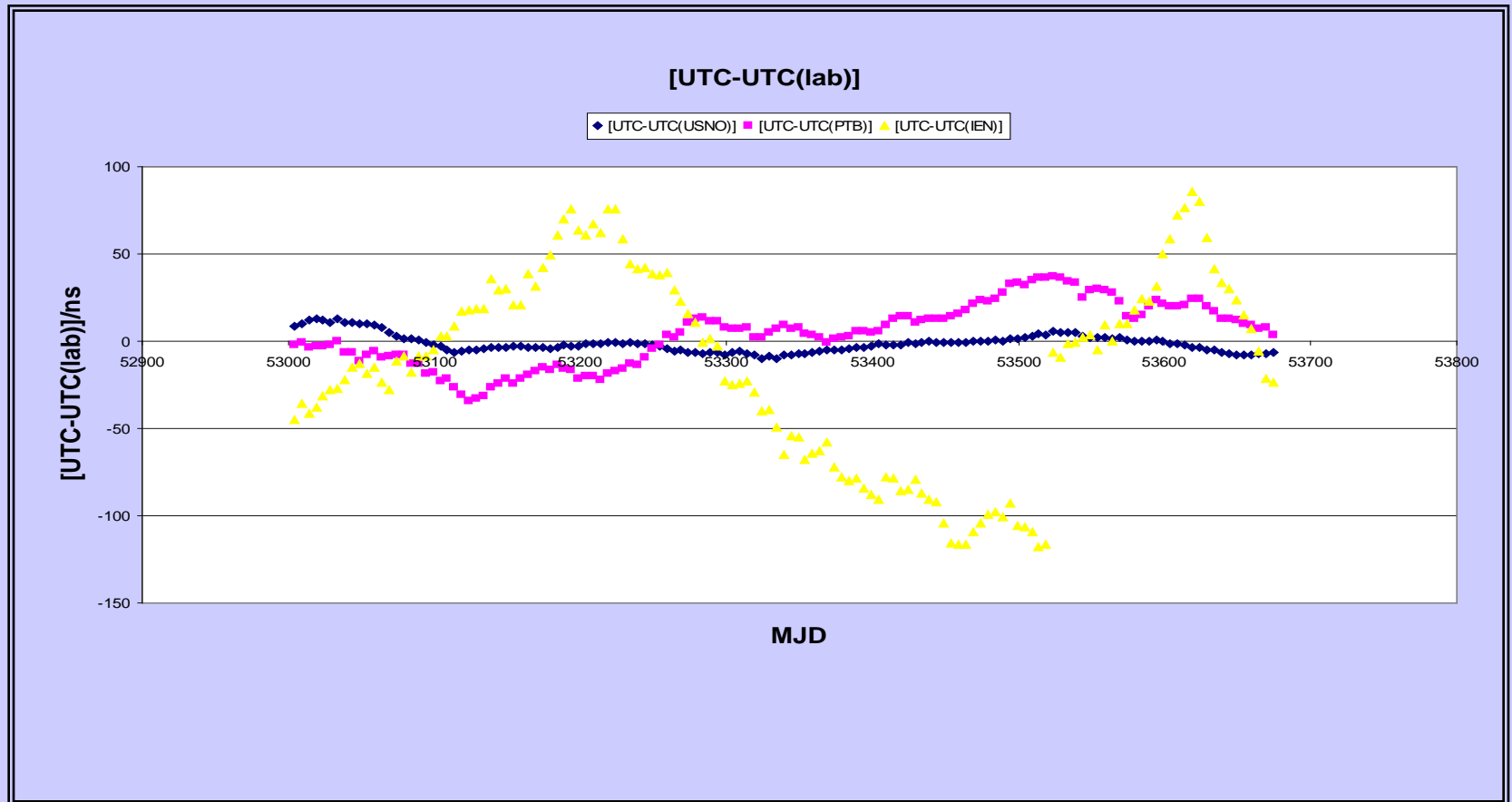
- The BIPM is responsible for realizing, maintaining and disseminating the international reference time scales international atomic time TAI and coordinated universal time UTC;
- International time keeping is the result of the cooperation of many laboratories distributed worldwide;
- The efforts of the community dealing with time metrology are focused towards the construction of time scales adapted to the most demanding applications
 - **Continuity**
 - **Reliability**
 - **Accessibility**
 - **Frequency stability of order 10^{-15}**
 - **Frequency accuracy of order 10^{-15} (traceability to the SI second)**

Equipment :

- ▲ GPS SC
- GPS MC
- GPS P3
- TW and GPS

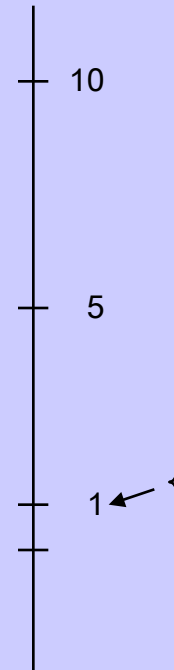
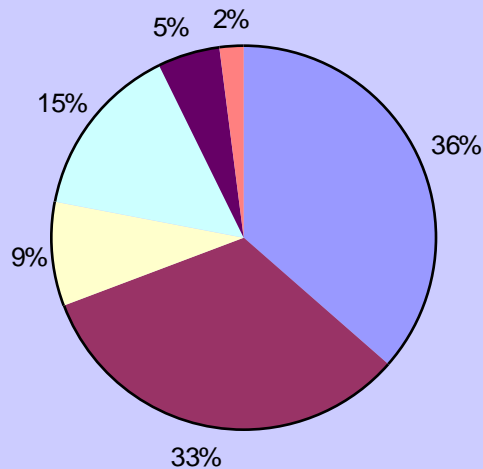


Diferences to UTC of some local realizations



Clock comparison

uncertainty (ns)

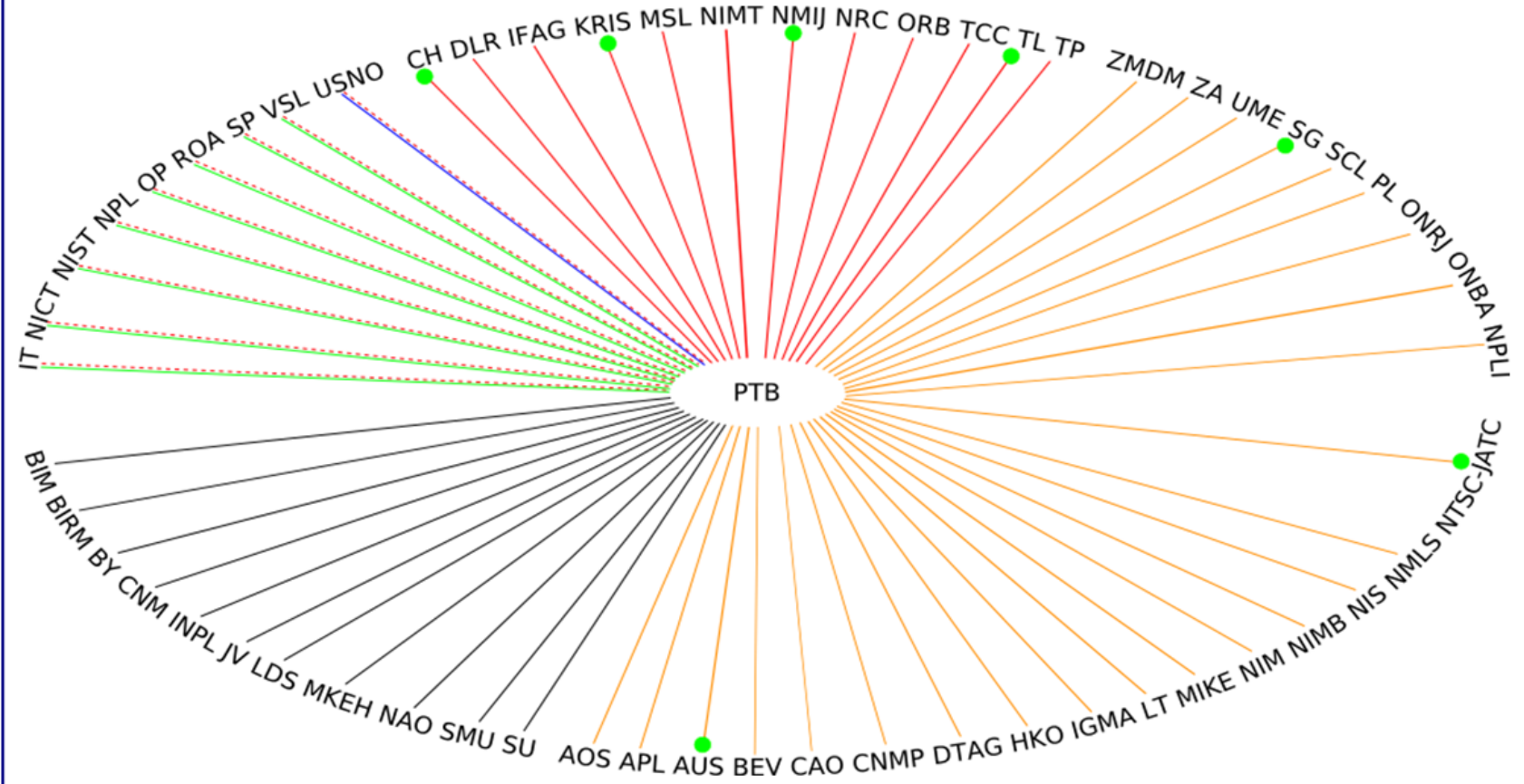


- GPS single-channel
- GPS multi-channel
- GPS P3 (dual-freq)
- TWSTFT

IGS products

- orbits
- ionosphere

- GPS GT
- IL



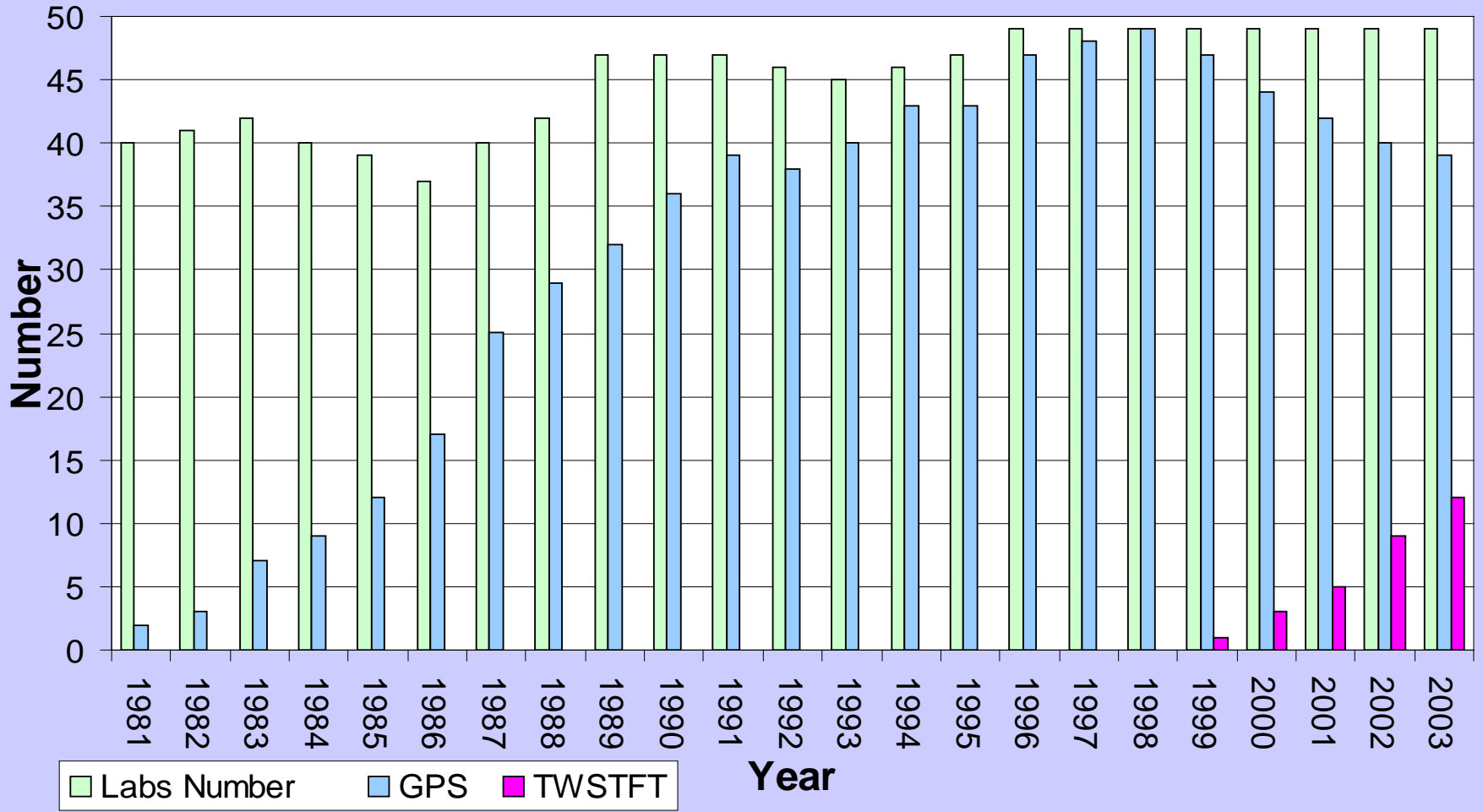
ORGANIZATION OF THE ALL-IN-VIEW INTERNATIONAL TIME LINKS

April 2007

●	Laboratory equipped with TWSTFT (not yet used)		
—	TWSTFT by Ku band with X band back-up	—	GPS AV multi-channel link
—	TWSTFT link	- - -	GPS AV multi-channel back-up link
—	GPS AV single-channel link	—	GPS AV dual frequency link
- - -	GPS AV single-channel back-up link	- - -	GPS AV dual frequency back-up link



TAI Links

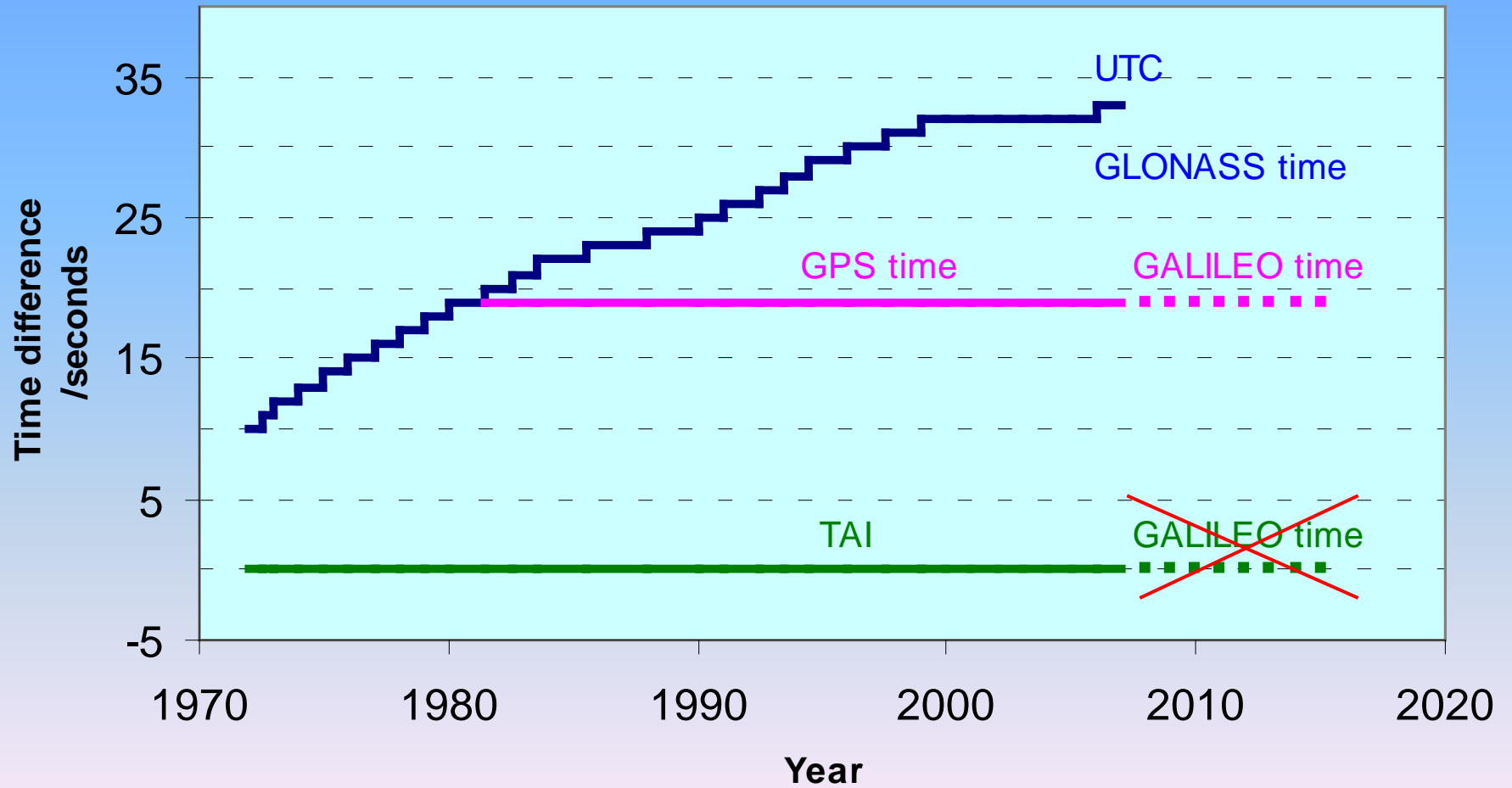


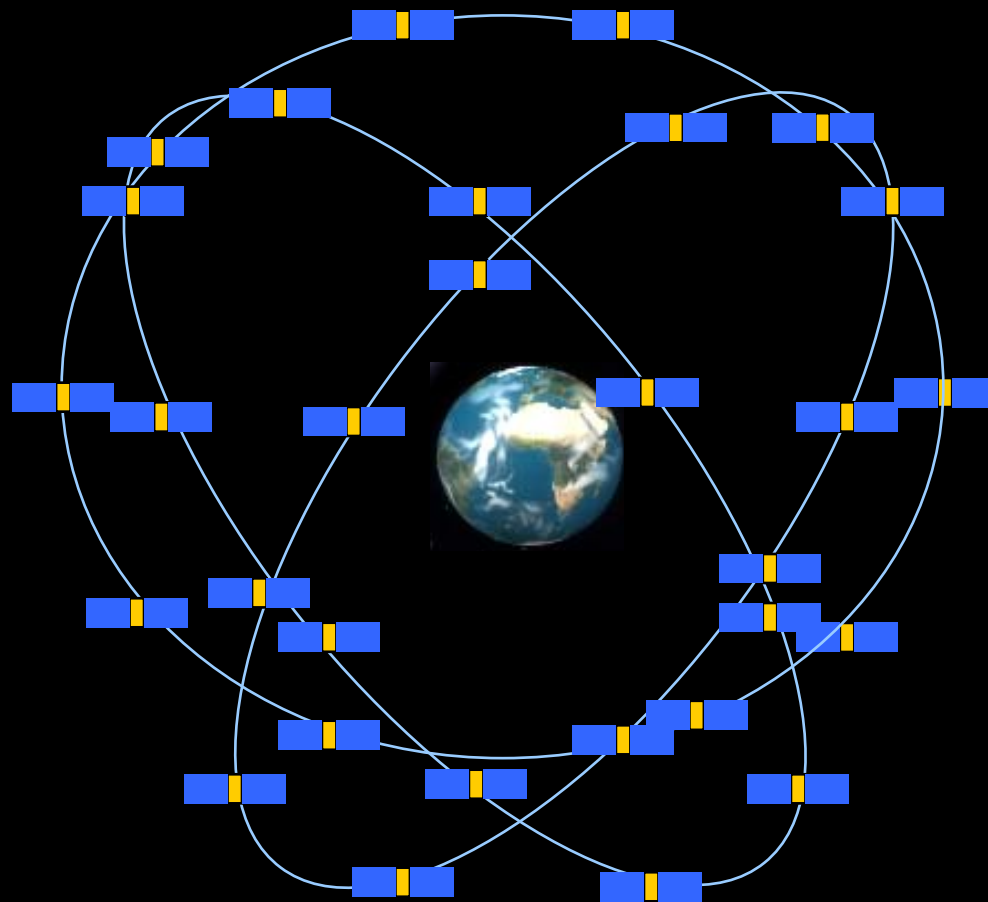
BUREAU INTERNATIONAL DES POIDS ET MESURES

Date 2006 MJD	0h UTC	JUN 28	JUL 3	JUL 8	JUL 13	JUL 18	JUL 23	JUL 28	Uncertainty/ns		
		53914	53919	53924	53929	53934	53939	53944	uA	uB	u
Laboratory k		[UTC-UTC(k)]/ns									
AOS (Borowiec)		5.2	9.3	3.3	6.2	10.6	7.1	9.9	1.6	5.3	5.5
APL (Laurel)		0.8	4.6	-0.7	-3.4	-4.3	3.7	15.4	1.6	5.2	5.4
AUS (Sydney)		-529.0	-498.6	-490.1	-489.2	-475.2	-445.1	-437.4	3.2	6.3	7.1
BIRM (Beijing)		-1874.4	-1893.8	-1898.2	-1913.1	-1930.8	-1946.6	-1964.5	2.8	20.4	20.6
CH (Bern)		30.9	31.3	36.1	32.2	29.9	25.1	21.5	0.8	5.2	5.3
IT (Torino)		-5.0	-5.2	-3.4	-4.6	-3.6	-2.8	-1.1	0.7	2.2	2.3
KRIS (Daejeon)		-14.6	-5.4	-4.0	-8.2	-1.6	2.2	-0.3	1.4	6.3	6.5
LT (Vilnius)		147.0	153.3	145.7	138.2	149.2	161.1	143.2	1.6	5.3	5.5
NIS (Cairo)		-2.4	-3.9	-2.7	-6.4	-7.7	-8.7	-12.4	1.6	7.2	7.4
NIST (Boulder)		9.2	8.3	9.2	8.6	8.1	6.7	6.5	0.7	4.9	5.0
NMIJ (Tsukuba)		-10.3	-11.3	-8.1	-8.3	-7.1	-3.0	0.4	1.4	6.3	6.5
NPL (Teddington)		7.9	4.9	5.2	3.4	1.1	0.6	0.5	0.7	2.2	2.3
NPLI (New-Delhi)		119.6	138.9	154.2	169.9	-119.2	-108.5	-94.9	2.5	7.2	7.6
NRC (Ottawa)		-27.1	-21.3	-26.3	-32.7	-33.7	-28.9	-30.3	3.0	15.1	15.4
NTSC (Lintong)		10.4	7.1	5.1	1.7	-0.8	1.5	7.3	2.6	6.1	6.6
ONRJ (Rio de Janeiro)		7524.1	7568.6	7624.1	7672.2	7726.0	7770.0	7821.6	5.0	20.5	21.1
OP (Paris)		-2.9	-2.8	-2.6	3.8	3.2	5.8	2.4	0.7	2.2	2.3
ORB (Bruxelles)		3.8	2.0	0.1	-3.9	-8.0	-10.0	-7.0	0.8	5.2	5.3
PL (Warszawa)		13.1	11.0	9.0	2.8	12.5	25.5	22.1	1.5	5.0	5.3
PTB (Braunschweig)		25.8	20.8	18.7	17.2	18.2	17.4	13.9	0.5	1.6	1.7
ROA (San Fernando)		63.5	63.4	67.0	61.3	74.6	79.1	69.7	0.8	5.2	5.3
SP (Boras)		25.4	20.1	24.1	25.5	25.6	28.2	25.1	0.8	2.2	2.3
SU (Moskva)		48.1	45.3	45.7	43.6	42.6	43.2	41.1	3.0	5.2	6.0
TL (Chung-Li)		3.1	-0.7	-3.1	-3.8	-7.0	-10.2	-12.1	1.3	6.1	6.3
USNO (Washington DC)		-2.9	-0.3	2.9	3.9	5.3	4.8	5.7	0.5	1.7	1.8
VSL (Delft)		5.6	10.8	5.1	4.3	-3.9	-7.8	-11.6	0.7	3.4	3.4

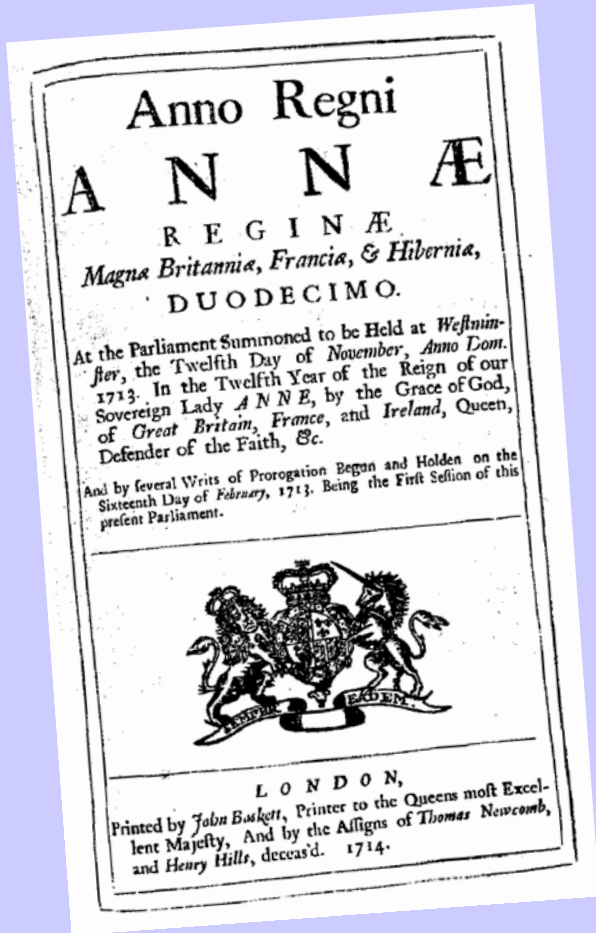


[TAI - Time scale (i)]





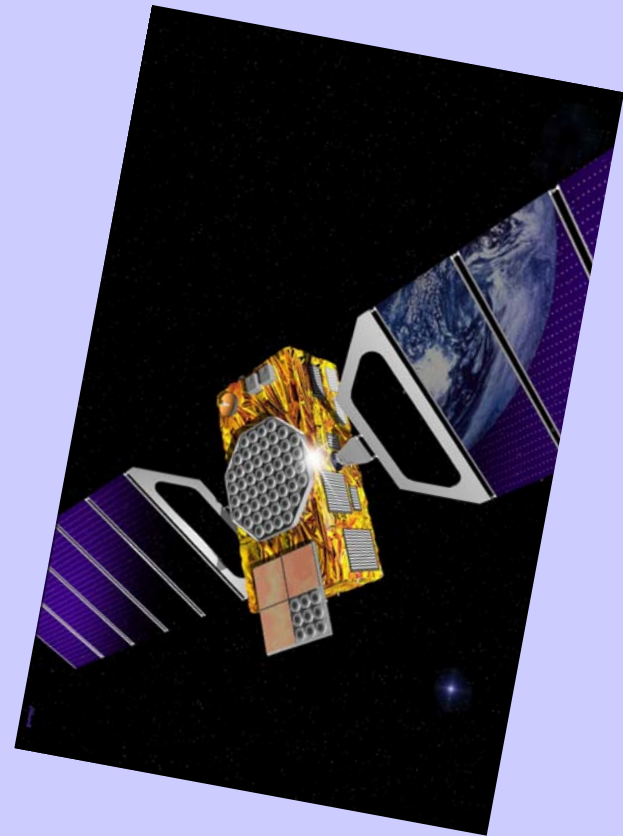
30 GALILEO satellites 23 222 km above Earth



“Longitude Act” 1714



Eiffel Tower 1889



Satelita Galileo 2011



John Harrison

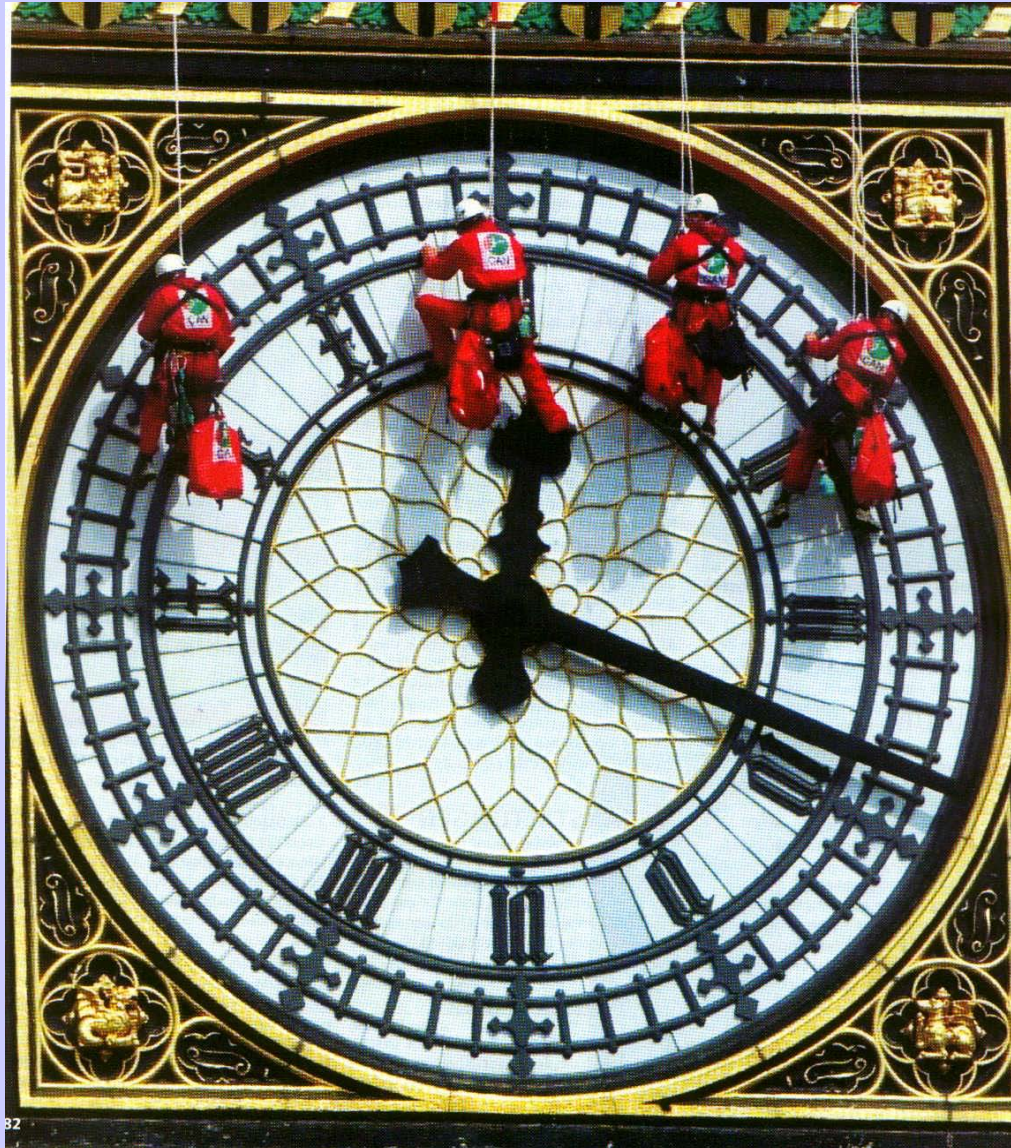


2nd Harrison maritime clock

**4th Harrison
maritime clock**



A day without satellites



Thank you for your attention !!!