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# Rapid UTC: a step forward for enhancing GNSS system times

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Eighth Meeting of the International Committee on
Global Navigation Satellite Systems (ICG)
Dubai, United Arab Emirates
9-14 November 2013

# Outline

◆ **Coordinated Universal Time UTC**

◆ **Rapid solution UTCr, features and quality**

◆ **UTC representations used for steering GNSS times**

◆ **Summary**

# **Coordinated Universal Time (UTC)**

◆    UTC is the time-scale maintained by the BIPM, with assistance from the IERS, which forms the basis of a coordinated dissemination of standard frequencies and time signals. It corresponds exactly in rate with TAI but differs from it by an integer number of seconds (Rec. ITU-R TF.460-6);

◆    All standard-frequency and time-signal emissions must conform to UTC (Rec. ITU-R TF.460-6);

◆    The UTC frequency should be used as the ultimate reference for standard-frequency emissions and other electronic systems (Rec. ITU-R TF.486-2);

◆    UTC should be used to designate the time in all international telecommunication activities and in all official documents of the International Telecommunication Union (Rec. ITU-R TF.102-1/7);

◆    UTC is published monthly under the form of values [*UTC-UTC*(*k*)] every five days (*BIPM Circular T*).

# UTC and rapid UTC (UTCr)

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◆ Extrapolation of [*UTC-UTC*(*k*)] over 10-45 days is necessary to many applications;

◆ UTC is not adapted for real and quasi-real time applications;

More frequent publication of UTC impacts on:

◆ UTC contributing laboratories
  ◆ More frequent assessing of the steering of UTC(k),
  ◆ Better stability /accuracy of UTC(k),
  ◆ Enhanced traceability to UTC;

◆ GNSS community and users
  ◆ Better synchronization of GNSS times to UTC via improved UTC(k) predictions.

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# Rapid UTC (UTCr) – General features

◆ Started within a BIPM pilot project in January 2012;

◆ Officially declared a permanent product in July 2013;

◆ 39 participating laboratories (out from 72 in UTC);
  ◆ 60% of the number of clocks in UTC representing 85% of the weight

◆ Daily values of [$UTCr$-$UTC(k)$] are published every Wednesday before 18 h UTC at the BIPM ftp server (ftp://tai.bipm.org/UTCr/);

◆ 1-month instability (over 2012-2013)
  ◆ UTCr is $4.\times10^{-16}$
  ◆ UTC is $3.5\times10^{-16}$

# Rapid UTC (UTCr) – Publication

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```
UTCr_1344
2013 NOVEMBER 06, 12h UTC

                BUREAU INTERNATIONAL DES POIDS ET MESURES
            ORGANISATION INTERGOUVERNEMENTALE DE LA CONVENTION DU METRE
        PAVILLON DE BRETEUIL F-92312 SEVRES CEDEX TEL. +33 1 45 07 70 70   tai@bipm.org

                        Computed values of [UTCr-UTC(k)]

Date 2013        0h UTC      OCT 28   OCT 29   OCT 30   OCT 31   NOV  1   NOV  2   NOV  3
        MJD                  56593    56594    56595    56596    56597    56598    56599
Laboratory k                                    [UTCr-UTC(k)]/ns

AOS   (Borowiec)               0.3      0.6      0.1     -0.3     -0.4     -1.2     -1.0
BEV   (Wien)                 -36.1    -37.0    -31.8    -25.5    -26.1    -20.5    -20.9
CH    (Bern-Wabern)           -3.7     -6.4     -7.6     -8.3     -8.2     -9.1     -9.5
CNM   (Queretaro)             -5.4     -6.4     -5.0     -5.8     -5.3     -5.9     -6.6
CNMP  (Panama)                 0.0     -1.6     -8.5    -13.2    -23.9    -17.1    -25.4
DMDM  (Belgrade)             -13.1    -16.6    -17.5    -22.3    -30.5    -31.0    -29.4
DTAG  (Frankfurt/M)          240.8    240.5    239.0    239.9    238.4    235.1    233.7
IFAG  (Wettzell)            -863.1   -863.1   -865.7   -871.3   -875.1   -876.9   -875.4
IGNA  (Buenos Aires)        4621.9   4637.8   4654.7   4669.3   4686.0   4705.1   4724.0
INTI  (Buenos Aires)          62.2     61.0     61.3     60.7     67.8     75.9     73.1
IT    (Torino)                -8.8     -9.2     -8.9     -9.0     -9.2    -10.3    -10.0
KRIS  (Daejeon)              -16.0    -16.3    -15.8    -15.7    -15.3    -15.7    -15.0
LT    (Vilnius)              410.7    402.9    393.9    396.9    391.9    389.0    382.2
MSL   (Lower Hutt)           782.4    781.8    791.7    802.6    813.9    828.0    842.6
NAO   (Mizusawa)             -20.3    -23.1    -23.2    -20.5    -23.4    -23.8    -25.4
NICT  (Tokyo)                 10.9     10.6     10.4     10.2     10.0      8.9      8.3
NIM   (Beijing)               -7.8     -7.7     -7.8     -9.1     -8.5     -9.7     -9.9
NIMT  (Pathumthani)            0.1      1.8      2.5     -2.1     -2.3     -1.0      0.0
NIST  (Boulder)               -1.4     -1.9     -2.7     -3.5     -3.5     -4.3     -3.9
NMIJ  (Tsukuba)                0.6      0.3      0.0     -0.4     -0.3     -1.1     -1.2
NMLS  (Sepang)              1119.1   1104.1   1084.3   1072.6   1053.4   1037.7   1018.2
NPLI  (New-Delhi)             -3.7     -3.4     -3.7     -4.2     -4.0     -3.6     -3.3
NRC   (Ottawa)               -22.6    -19.6    -22.1    -20.6    -26.5    -26.6    -22.8
NRL   (Washington DC)         -4.6     -4.4     -4.2     -4.1     -3.4     -2.1     -1.1
NTSC  (Lintong)               -0.1     -0.2     -1.3      0.7     -2.6     -1.9     -3.6
ONRJ  (Rio de Janeiro)       -11.8    -12.1    -13.0    -13.5    -14.8    -14.3    -15.0
OP    (Paris)                 -3.1     -2.8     -3.1     -3.3     -3.2     -3.6     -3.4
ORB   (Bruxelles)            -11.4    -10.6    -10.7    -12.9    -12.4    -15.2    -17.3
PL    (Warszawa)              38.2     38.8     35.7     32.6     29.9     32.5     29.1
PTB   (Braunschweig)          -6.9     -6.6     -7.1     -7.7     -8.1     -8.7     -8.5
ROA   (San Fernando)           0.4      0.6      0.2     -1.1     -1.8     -3.2     -4.0
SCL   (Hong Kong)             33.7     35.6     27.5     34.7     29.3     32.4     28.1
SG    (Singapore)            -17.2    -17.9    -19.2    -20.6    -19.2    -20.2    -19.4
SP    (Boras)                 -6.4     -5.7     -6.3     -6.9     -7.2     -7.6     -7.5
SU    (Moskva)                -2.0     -1.7     -2.1     -2.4     -2.2     -2.6     -1.9
TL    (Chung-Li)              -5.6     -6.2     -6.9     -7.4     -7.8     -8.9     -8.1
UME   (Gebze-Kocaeli)       1363.3   1367.5   1369.9   1370.5   1376.8   1380.7   1379.1
USNO  (Washington DC)         -3.4     -3.8     -4.2     -5.0     -5.1     -5.3     -5.5
VSL   (Delft)                -23.0    -22.2    -22.0    -20.5    -18.3    -18.8    -12.9

   UTC remains available from the monthly Circular T at
   (http://www.bipm.org/jsp/en/TimeFtp.jsp?TypePub=publication).
```
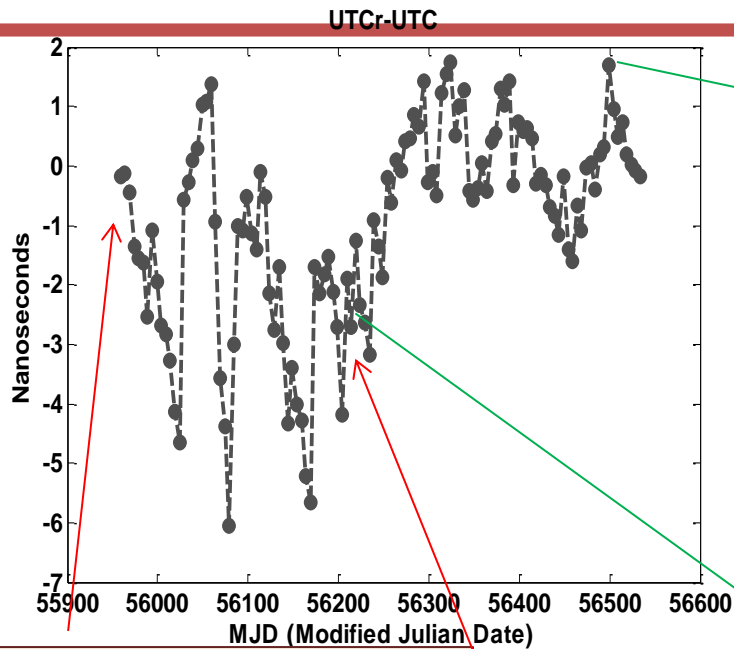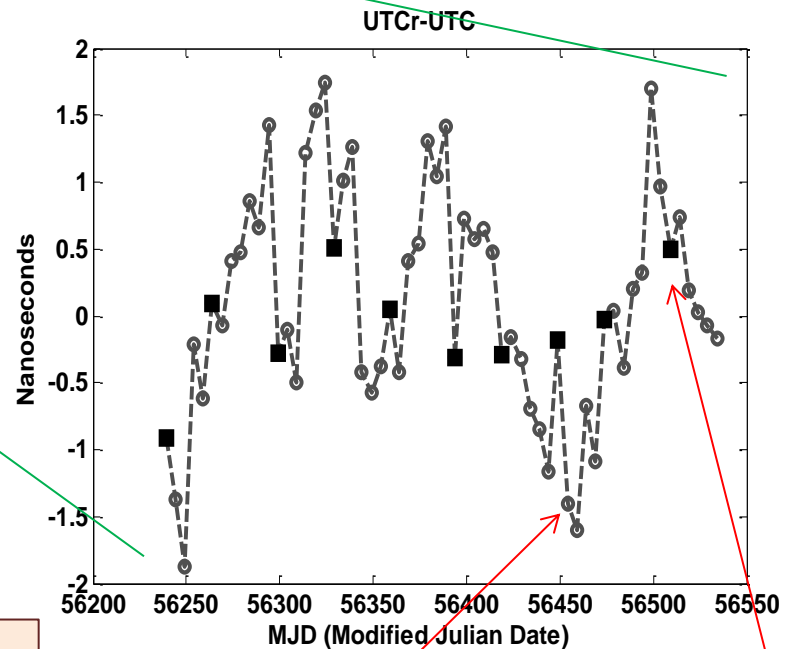
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# Rapid UTC (UTCr) – General features



Start of pilot experiment publication (Feb 2012)
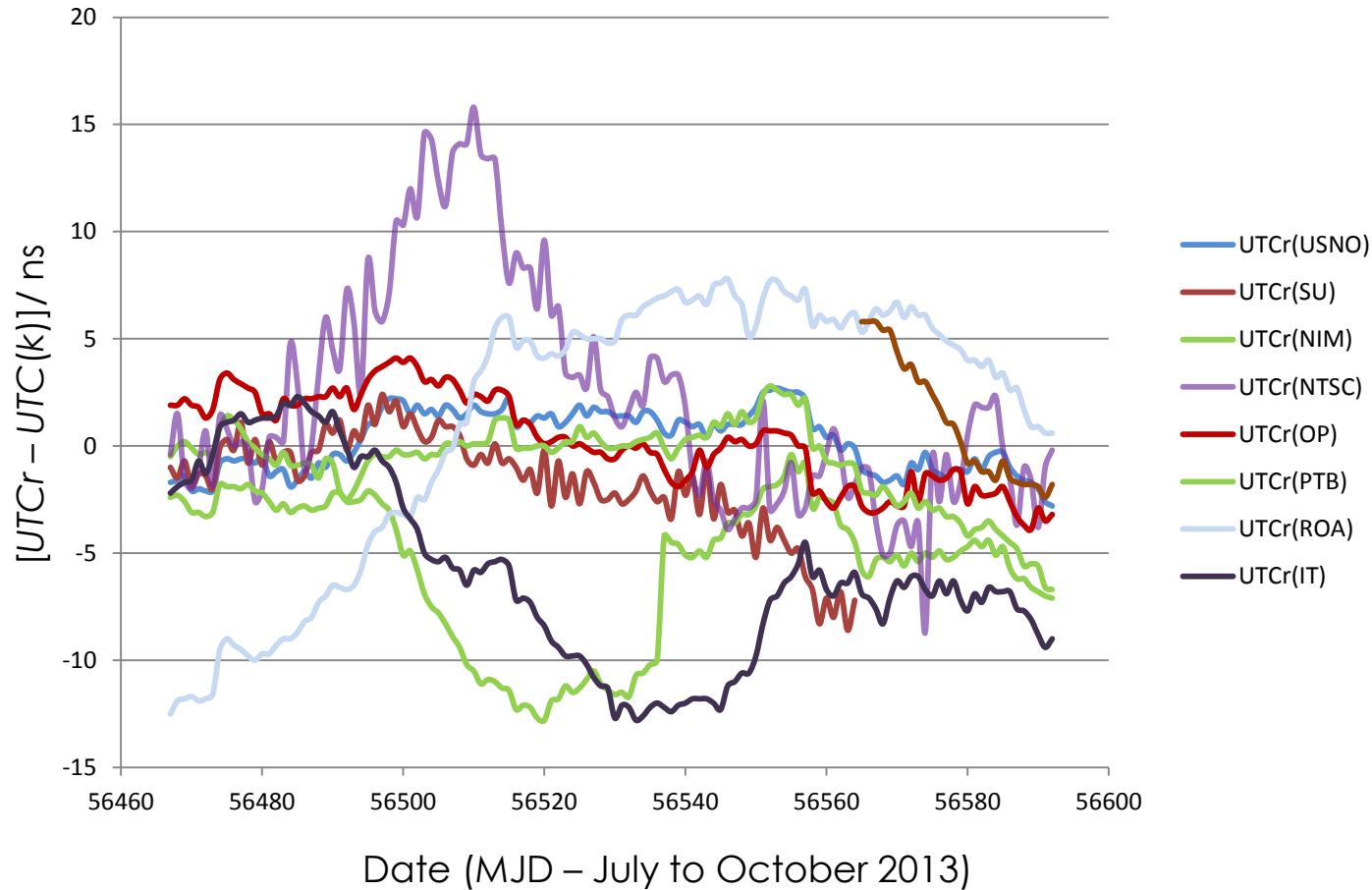
Completed algorithm and procedure (Nov 2012)

Start of official publication (July 2013)

Steering to UTC after publication of *Circular T*■(   )

**UTCr-UTC** [from Nov 2012]
min;max      -1.88 ns;+1.75 ns
Mean            +0.09 ns
RMS              0.83 ns

# UTC(k) serving to steer GNSS times and their [*UTCr-UTC(k)*]

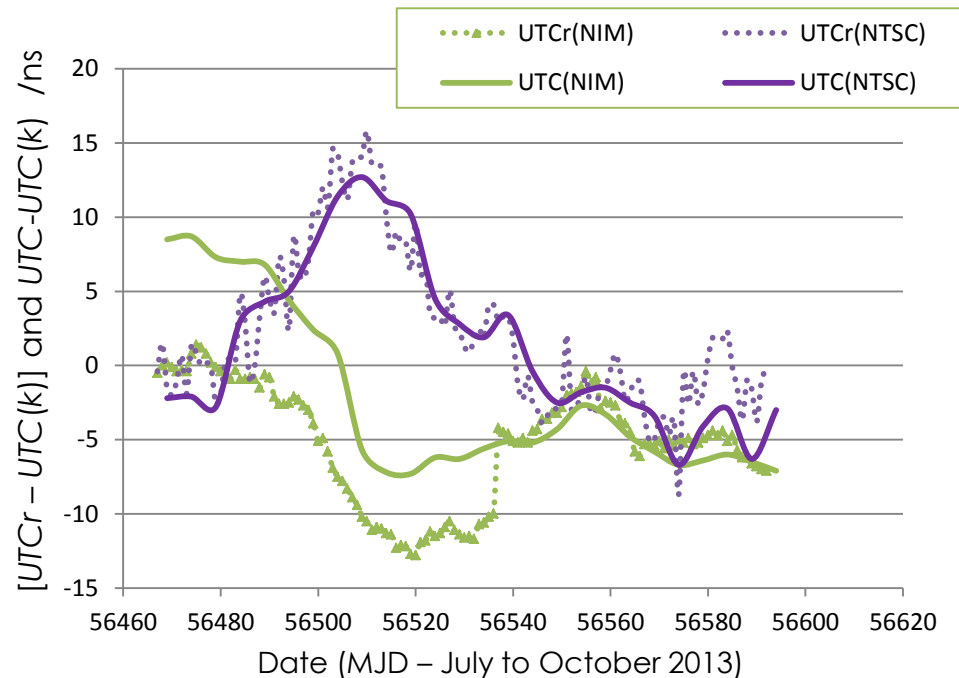**GPS time steered to UTC(USNO)**
**GLONASS time steered to UTC(SU)**   **BeiDou System time steered to**
**UTC(NIM)/UTC(NTSC)**

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♦ of weights
↓ and measures
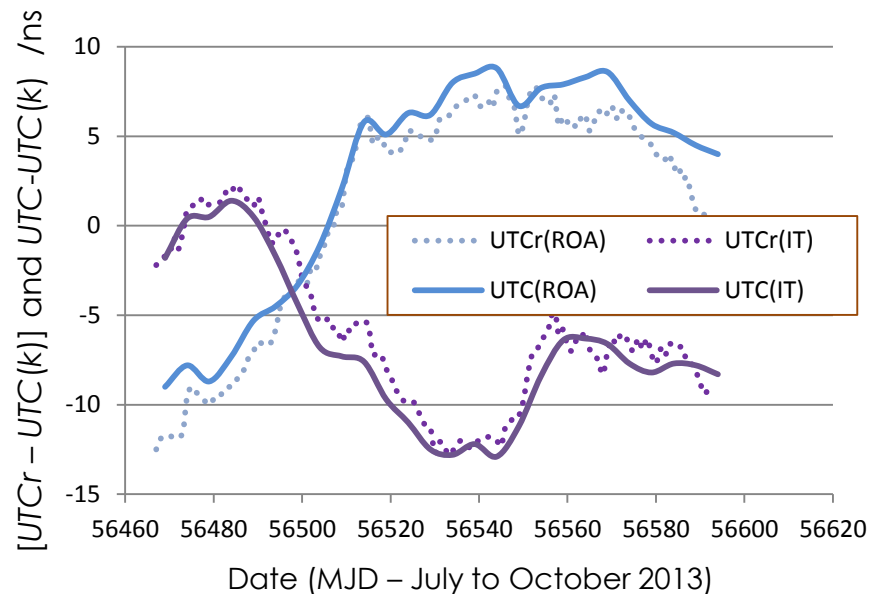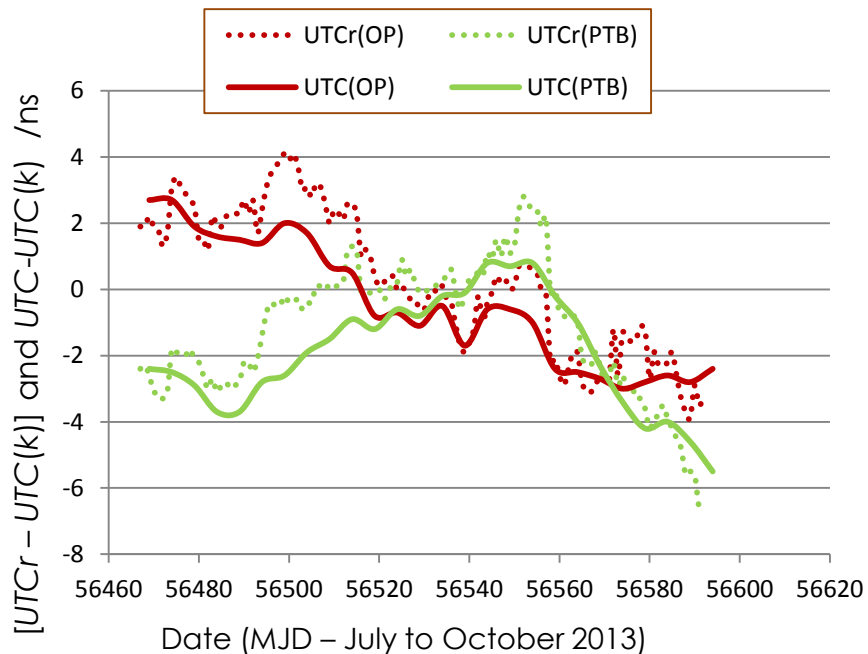
## UTC(k) used for steering GPS/GLONASS times
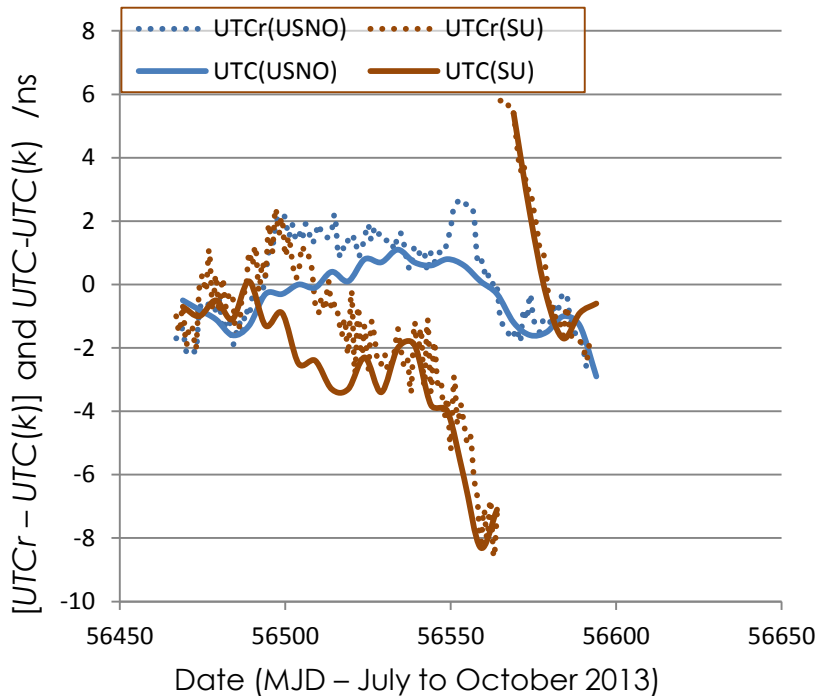
## UTC(k) used for steering BeiDou time



| UTCr-UTC | USNO | SU | NIM | NTSC |
|----------|------|-----|-------|------|
| mean/ns | +0.67 | +0.90 | -3.22 | +0.48 |
| RMS/ns | 0.70 | 0.64 | 5.86 | 3.35 |
| $u_{CirT}$/ns | 3.8 | 2.0 | 5.2 | 4.9 |

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# GALILEO time steered to a set of European realizations of UTC (OP, PTB, ROA, IT, NPL)

## UTC(k) used for steering GALILEO time



| UTCr-UTC | OP | PTB | ROA | IT |
|---|---|---|---|---|
| mean/ns | +0.73 | +0.73 | -1.40 | +0.88 |
| RMS/ns | 0.85 | 0.65 | 3.22 | 0.22 |
| $u_{CirT}$/ns | 1.9 | 1.6 | 5.1 | 2.0 |

# Summary

◆ UTCr is a BIPM official product that provides frequent access to UTC; traceability to UTC remains only through monthly *BIPM Circular T*;

◆ A well designed algorithm allows the provision of a rapid UTC solution with excellent metrological quality,

  ◆ the instability of UTCr is comparable to that of UTC,

  ◆ on average, the absolute value UTCr-UTC < 2 ns since Nov 2012,

◆ UTCr helps in enhancing the quality of the UTC(k);

◆ All UTC contributing laboratories are expected to contribute in the near future;

◆ UTCr is a step forward to a more frequent publication of UTC.