#### The UTC problem and its solution

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(IDATE(I,15),I=1,2),DATS(15)	/	1972,	1,	10D0	/
(IDATE(I,16),I=1,2),DATS(16)	7	1972,	7,	11D0	7
(IDATE(1,17),I=1,2),DATS(17)	7	1973,	1,	12D0	7
(IDATE(I,18),I=1,2),DATS(18)	7	1974,	1,	13D0	7
(IDATE(I,19),I=1,2),DATS(19)	7	1975,	1,	14D0	1
(IDATE(I,20),I=1,2),DATS(20)	7	1976,	1,	15D0	7
(IDATE(1,21),I=1,2),DATS(21)	7	1977,	1,	16D0	1
(IDATE(I,22),I=1,2),DATS(22)	7	1978,	1,	<b>17D0</b>	1
(IDATE(1,23),I=1,2),DATS(23)	/	1979,	1,	18D0	1
(IDATE(I,24),I=1,2),DATS(24)	7	1980,	1,	<b>19</b> D0	1
(IDATE(1,25),I=1,2),DATS(25)	7	1981,	7,	20D0	1
(IDATE(I,26),I=1,2),DATS(26)	7	1982,	7,	21D0	1
(IDATE(1,27),I=1,2),DATS(27)	7	1983,	7,	22D0	1
(IDATE(I,28),I=1,2),DATS(28)	7	1985,	7,	23D0	1
(IDATE(I,29),I=1,2),DATS(29)	7	1988,	1,	24D0	1
(IDATE(I,30),I=1,2),DATS(30)	7	1990,	1,	25D0	1
(IDATE(I,31),I=1,2),DATS(31)	7	1991,	1,	26D0	1
(IDATE(I,32),I=1,2),DATS(32)	7	1992,	7,	27D0	1
(IDATE(1,33),I=1,2),DATS(33)	7	1993,	7,	28D0	1
(IDATE(I,34),I=1,2),DATS(34)	7	1994,	7,	29D0	1
(IDATE(I,35),I=1,2),DATS(35)	1	1996,	1,	30D0	1
(IDATE(I,36),I=1,2),DATS(36)	1	1997,	7,	31D0	1
(IDATE(I,37),I=1,2),DATS(37)	1	1999,	1,	32D0	1
	<pre>(IDATE(I,15),I=1,2),DATS(I5) (IDATE(I,16),I=1,2),DATS(16) (IDATE(I,17),I=1,2),DATS(17) (IDATE(I,18),I=1,2),DATS(18) (IDATE(I,19),I=1,2),DATS(19) (IDATE(I,20),I=1,2),DATS(20) (IDATE(I,21),I=1,2),DATS(21) (IDATE(I,22),I=1,2),DATS(22) (IDATE(I,23),I=1,2),DATS(23) (IDATE(I,24),I=1,2),DATS(23) (IDATE(I,25),I=1,2),DATS(25) (IDATE(I,26),I=1,2),DATS(25) (IDATE(I,26),I=1,2),DATS(26) (IDATE(I,28),I=1,2),DATS(28) (IDATE(I,28),I=1,2),DATS(28) (IDATE(I,29),I=1,2),DATS(28) (IDATE(I,30),I=1,2),DATS(30) (IDATE(I,31),I=1,2),DATS(31) (IDATE(I,33),I=1,2),DATS(33) (IDATE(I,34),I=1,2),DATS(35) (IDATE(I,36),I=1,2),DATS(37)</pre>	<pre>(IDATE(I,IS),I=1,2),DATS(IS) / (IDATE(I,I6),I=1,2),DATS(I6) / (IDATE(I,17),I=1,2),DATS(17) / (IDATE(I,18),I=1,2),DATS(18) / (IDATE(I,20),I=1,2),DATS(19) / (IDATE(I,20),I=1,2),DATS(20) / (IDATE(I,21),I=1,2),DATS(21) / (IDATE(I,22),I=1,2),DATS(22) / (IDATE(I,23),I=1,2),DATS(23) / (IDATE(I,24),I=1,2),DATS(23) / (IDATE(I,25),I=1,2),DATS(24) / (IDATE(I,26),I=1,2),DATS(25) / (IDATE(I,26),I=1,2),DATS(26) / (IDATE(I,27),I=1,2),DATS(27) / (IDATE(I,28),I=1,2),DATS(28) / (IDATE(I,29),I=1,2),DATS(29) / (IDATE(I,30),I=1,2),DATS(30) / (IDATE(I,31),I=1,2),DATS(32) / (IDATE(I,33),I=1,2),DATS(33) / (IDATE(I,34),I=1,2),DATS(35) / (IDATE(I,36),I=1,2),DATS(36) / (IDATE(I,37),I=1,2),DATS(37) /</pre>	<pre>(IDATE(1,15),1=1,2),DATS(15) / 1972, (IDATE(1,16),I=1,2),DATS(16) / 1972, (IDATE(I,17),I=1,2),DATS(17) / 1973, (IDATE(I,18),I=1,2),DATS(18) / 1974, (IDATE(I,19),I=1,2),DATS(19) / 1975, (IDATE(I,20),I=1,2),DATS(20) / 1976, (IDATE(I,21),I=1,2),DATS(21) / 1977, (IDATE(I,22),I=1,2),DATS(21) / 1977, (IDATE(I,23),I=1,2),DATS(22) / 1978, (IDATE(I,23),I=1,2),DATS(23) / 1979, (IDATE(I,24),I=1,2),DATS(24) / 1980, (IDATE(I,25),I=1,2),DATS(25) / 1981, (IDATE(I,26),I=1,2),DATS(26) / 1982, (IDATE(I,27),I=1,2),DATS(26) / 1983, (IDATE(I,28),I=1,2),DATS(28) / 1985, (IDATE(I,28),I=1,2),DATS(28) / 1988, (IDATE(I,30),I=1,2),DATS(30) / 1990, (IDATE(I,31),I=1,2),DATS(31) / 1991, (IDATE(I,33),I=1,2),DATS(33) / 1993, (IDATE(I,34),I=1,2),DATS(34) / 1994, (IDATE(I,35),I=1,2),DATS(35) / 1996, (IDATE(I,36),I=1,2),DATS(37) / 1999,</pre>	<pre>(IDATE(1,15),1=1,2),DATS(15) / 1972, 1, (IDATE(1,16),I=1,2),DATS(16) / 1972, 7, (IDATE(I,17),I=1,2),DATS(17) / 1973, 1, (IDATE(I,18),I=1,2),DATS(18) / 1974, 1, (IDATE(I,20),I=1,2),DATS(19) / 1975, 1, (IDATE(I,20),I=1,2),DATS(20) / 1976, 1, (IDATE(I,21),I=1,2),DATS(21) / 1977, 1, (IDATE(I,22),I=1,2),DATS(22) / 1978, 1, (IDATE(I,23),I=1,2),DATS(23) / 1979, 1, (IDATE(I,24),I=1,2),DATS(23) / 1979, 1, (IDATE(I,26),I=1,2),DATS(24) / 1980, 1, (IDATE(I,26),I=1,2),DATS(25) / 1981, 7, (IDATE(I,26),I=1,2),DATS(26) / 1982, 7, (IDATE(I,28),I=1,2),DATS(27) / 1983, 7, (IDATE(I,28),I=1,2),DATS(28) / 1985, 7, (IDATE(I,29),I=1,2),DATS(29) / 1988, 1, (IDATE(I,30),I=1,2),DATS(30) / 1990, 1, (IDATE(I,31),I=1,2),DATS(31) / 1991, 1, (IDATE(I,33),I=1,2),DATS(33) / 1993, 7, (IDATE(I,34),I=1,2),DATS(34) / 1994, 7, (IDATE(I,35),I=1,2),DATS(35) / 1996, 1, (IDATE(I,36),I=1,2),DATS(37) / 1999, 1,</pre>	<pre>(IDATE(I,15),I=1,2),DATS(15) / 1972, 1, 10D0 (IDATE(I,16),I=1,2),DATS(16) / 1972, 7, 11D0 (IDATE(I,17),I=1,2),DATS(17) / 1973, 1, 12D0 (IDATE(I,18),I=1,2),DATS(17) / 1973, 1, 12D0 (IDATE(I,19),I=1,2),DATS(19) / 1974, 1, 13D0 (IDATE(I,20),I=1,2),DATS(20) / 1976, 1, 15D0 (IDATE(I,21),I=1,2),DATS(21) / 1977, 1, 16D0 (IDATE(I,22),I=1,2),DATS(22) / 1978, 1, 17D0 (IDATE(I,23),I=1,2),DATS(23) / 1979, 1, 18D0 (IDATE(I,24),I=1,2),DATS(24) / 1980, 1, 19D0 (IDATE(I,26),I=1,2),DATS(25) / 1981, 7, 20D0 (IDATE(I,26),I=1,2),DATS(26) / 1982, 7, 21D0 (IDATE(I,28),I=1,2),DATS(27) / 1983, 7, 22D0 (IDATE(I,28),I=1,2),DATS(28) / 1985, 7, 23D0 (IDATE(I,29),I=1,2),DATS(29) / 1988, 1, 24D0 (IDATE(I,30),I=1,2),DATS(30) / 1990, 1, 25D0 (IDATE(I,31),I=1,2),DATS(31) / 1991, 1, 26D0 (IDATE(I,33),I=1,2),DATS(33) / 1993, 7, 28D0 (IDATE(I,34),I=1,2),DATS(34) / 1994, 7, 29D0 (IDATE(I,36),I=1,2),DATS(35) / 1996, 1, 30D0 (IDATE(I,36),I=1,2),DATS(37) / 1999, 1, 32D0</pre>

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## UTC: the view of users

- If you ask UTC users, overwhelming numbers say "It ain't bust: don't fix it!"
- However, a few influential users say that leap seconds are an unacceptable inconvenience and want them to cease.
- Whose views should prevail?

## Introduction

#### • UTC currently links all of these:

- High-precision time
- civil time
- UT1 (to 0.1s)
- Most discussion has been about weakening or eliminating the link between civil time and UT1.
- This presentation proposes relaxing the link between civil time and high precision.
- But leaving things as they are for the time being remains an attractive option.

## The future of UTC

- In the long term, UTC as presently defined is not sustainable because of the gathering pace of leap seconds. In this sense, UTC is bust.
- And there is no technical fix:
  - Smaller leaps, more often: more inconvenience.
  - Larger leaps, occasionally: mayhem.
  - Change of SI second: unacceptable.
  - Break the link with UT1?...
- So UTC must at some point cease (or be replaced).

# No more leap seconds?

- There are many applications that implicitly assume that UTC is approximately UT1...
  - astro-navigation
  - architects' shadow calculations
  - amateur telescope pointing
  - ...and who knows what else?
- Existing software, some written decades ago, would need to be changed. The cost is unknown and potentially unaffordable.
- The need for software changes will in many cases not come to light until it is too late: the first time UT1-UTC exceeds 0.9s or 1s for instance.

### The dilemma

• UTC can't survive for ever...

 ...but freezing it now will cause trouble, expense and resentment.

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## The problem and its solution

- UTC is an attempt to make one time scale do two rather incompatible jobs:
  - provide access to highly accurate time
  - provide an approximation to UT1
- One answer is to provide two separate time scales for the respective purposes:
  - TAI (e.g. via GPS) for high accuracy applications
  - a new service providing an approximation to UT1

# The proposed UT1 service

- We have new technology: the Internet. With it the IERS can provide an NTP server (and maybe even a clock face on a Web page)
- Such a service would provide a predicted UT1, nominally to 0.1s but in practice better.
- It would be a continuous time scale, arguably a better basis for civil time-of-day than UTC.

### The three time scales

#### • TAI: the one high-accuracy time scale

- Current UTC applications requiring this accuracy migrate to TAI.
- Precise relationship with UT1 (where relevant) managed at the application level.
- New approximate UT1 service
  - Recommended basis for everyday civil timekeeping, consistent with many countries' laws, which still specify "mean time".
- UTC
  - To continue until all users have had time to migrate but then to cease completely.

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# UTC life expectancy

- We need to distinguish UTC the time scale from UTC the name! To many users, a change to the definition means that it isn't UTC any more.
- If UTC is to go, it is reasonable to insist that no new UTC applications be developed from now on.
- Some of the existing ones will last 25-50 years, the lifetime of a major groundbased telescope.
- UTC should be supported until at least 2025: 5 years or even 10 years is **not long enough**.

### Nomenclature

- We already have too many sorts of Universal Time and we should resist the temptation to add "UTC<sub>2000</sub>", "UT1C" etc. because it will confuse people even more.
- For high-accuracy applications, TAI should be used, rather than some new frozen, leap-less UTC, because the jump of 32s will immediately expose any misuse and misunderstanding.
- Calling the new approximate UT1 time scale "Global Mean Time" would be a popular choice.