DOCUMENT
GSM-AUS-ATP.029

DOCUMENT TITLE
ATPL NAVIGATION (AUS)

CHAPTER 5 – THE SOLAR SYSTEM AND TIME

Version 1.0
January 2013

This is a controlled document. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form, or by any means, electronic, mechanical, photocopying, recording or otherwise, without prior permission, in writing, from the Chief Executive Officer of Flight Training Adelaide.

CONTENTS .... PAGE

CHAPTER 5 – THE SOLAR SYSTEM AND TIME 3

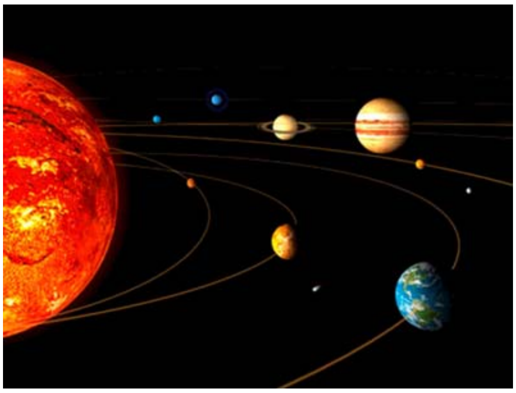
THE SOLAR SYSTEM.. 3
THE SEASONS 3
OBLIQUITY OF THE ECLIPTIC.. 3
WINTER (SOUTHERN HEMISPHERE).. 3
SUMMER (SOUTHERN HEMISPHERE).. 4
SPRING AND AUTUMN (SOUTHERN HEMISPHERE) 4
UNITS OF TIME MEASUREMENT.. 5
THE YEAR 5
THE TROPICAL YEAR 5
THE CIVIL YEAR 5
THE DAY.. 6
THE APPARENT SOLAR DAY 6
THE MEAN SOLAR DAY 7
LOCAL MEAN TIME.. 8
ARC TO TIME... 8
COORDINATED UNIVERSAL TIME 11
ZONE TIME AND STANDARD TIME... 12
STANDARD TIMES 13
AUSTRALIAN STANDARD TIMES.. 18
SUMMER TIME OR DAYLIGHT SAVING TIME 18
TWILIGHT.. 18
THE INTERNATIONAL DATE LINE.. 19
TIME CONVERSIONS 20

© 2005 FTA

CHAPTER 5 – THE SOLAR SYSTEM AND TIME

THE SOLAR SYSTEM

Over many centuries humans have come to regulate their affairs in relation to two phenomena. The first is the rotation of the Earth on its axis, and the corresponding appearance and disappearance of the Sun in a more or less regular cycle. This leads to our definition of the day. Secondly, the revolution of the Earth in its orbit around the Sun provides our concept of the year and the seasons. Since the dynamics of the solar system are fundamental to both these processes, we will commence with a short description of the Earth's daily and annual movements.



THE SEASONS

The annual path traced by the Sun over the celestial sphere is a celestial great circle called 'The Ecliptic'. From a given latitude, the position of individual stars will appear to move westward on successive nights, but their position relative to the elevated celestial pole, and the position of the pole itself, will never vary. Objects within the solar system will, however move relative to the celestial poles. In other words, their declinations (latitude of a body on the celestial sphere) will vary while the declinations of the stars remain constant.

OBLIQUITY OF THE ECLIPTIC

The Earth's spinning axis is not perpendicular to its orbital plane, it is inclined by 66½° to the orbital plane (refer Figure 1). As a result of this inclination the path of the sun over the earth (as represented by the Ecliptic) is no longer aligned with the Equator. As the earth move along its orbital path the latitude over which the sun is located will continually change. These changes are what we experience as seasons.

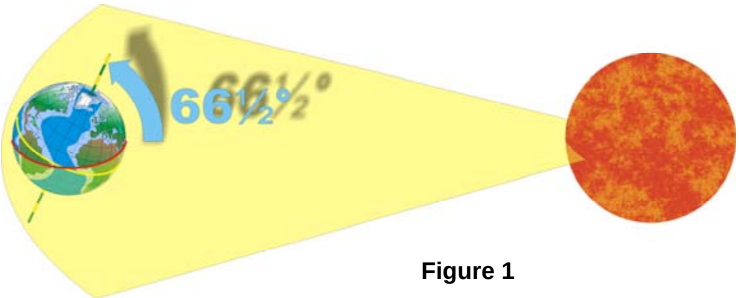


Figure 1

WINTER (SOUTHERN HEMISPHERE)

On about June 21, at noon, the Sun will appear directly overhead the 23°27'N parallel of latitude, i.e. the Sun's sub-point is at latitude 23°27'N, and its declination N23°27'.

© 2005 FTA

This parallel of latitude is called the Tropic of Cancer, and marks the most northerly latitude at which the Sun's altitude reaches 90° above the horizon at noon. This date is referred to as the Summer Solstice.

SUMMER (SOUTHERN HEMISPHERE)

By similar reasoning, on about December 22, the Sun's declination will be S23°27' and its sub-point at 23°27'S latitude at noon. This parallel is called the Tropic of Capricorn, marking the most southerly latitude at which the Sun's altitude reaches 90° at noon. This date is referred to as the Winter Solstice

SPRING AND AUTUMN (SOUTHERN HEMISPHERE)

On March 21 and September 23 the orientation of the radius vector from the Earth to the Sun is at right angles to its orientation at the solstices. It is evident that, in March and September, the Earth's spin axis lies at 90° to the radius vector from the Sun, and that its tilt towards or from the Sun, is zero. The sub-point of the Sun at noon is on the equator, and the Sun's declination is, therefore, zero. This is illustrated in Figure 2.

Viewed from either the South or the North Pole, the Sun does not rise or set, but proceeds around the horizon at zero altitude.

These dates in March and September are called the 'equinoxes', because the length of day and night at all positions on the Earth's surface is equal. March 21 is the Spring or 'Vernal Equinox', and September 23 is the 'Autumnal Equinox', the seasonal definitions again referring to the Northern Hemisphere.

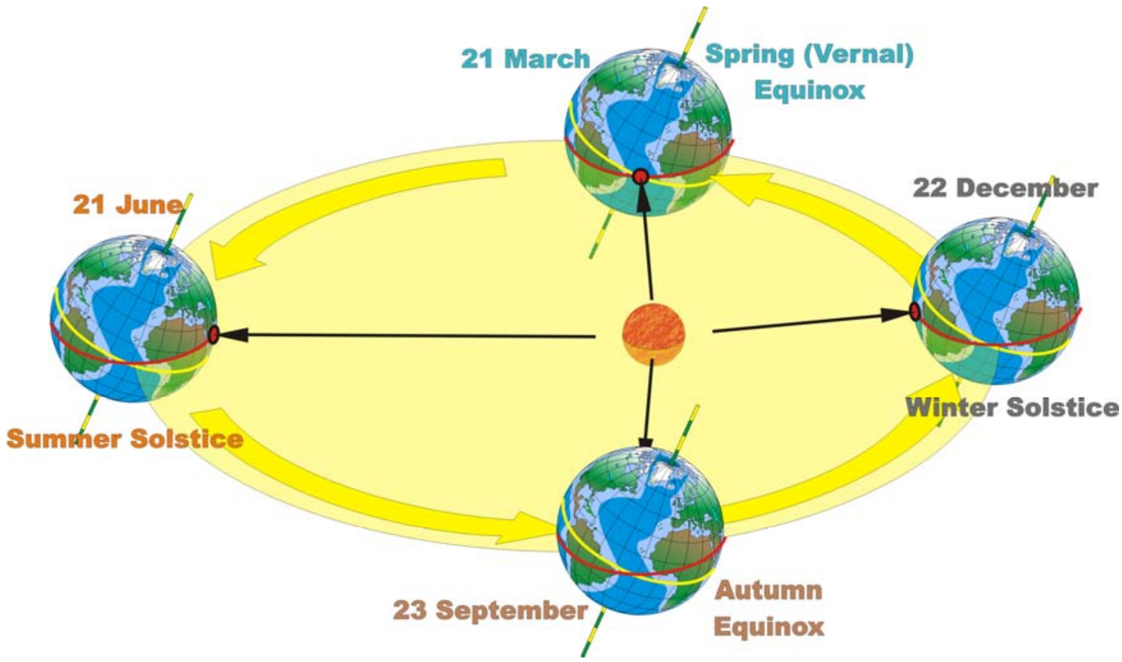


Figure 2

© 2005 FTA

Seasonal references for Solstice and Equinox relates to the Northern Hemisphere

UNITS OF TIME MEASUREMENT

As aviators, we are not concerned with the most profound questions regarding time; what it is, when it started, how and when it might end. Rather, we are interested in the reference it provides in the organisation of our lives and activities, particularly aviation, and in the practical details of its measurement.

Previously we saw that the Earth's rotation and revolution provided short and longer term timing references - the day and the year - that, in the popular mind, have become synonymous with 'the passage of time'.

THE YEAR

The year is popularly accepted as the time taken for the Earth to complete one orbit of the Sun with respect to a specified datum. We have various datum points to use, from the First Point of Aries to the alignment of celestial bodies. The selection of datum point will determine the length of a year and therefore we have various definitions of the year to consider.

THE TROPICAL YEAR

The Tropical has a mean value of 365 days 5 hours 48 minutes 45 seconds. The tropical year contains exactly one complete cycle of seasons, and is the basis of the modern (Gregorian) calendar devised by Pope Gregory XIII in 1582.

THE CIVIL YEAR

A practical calendar must depict the year as a whole number of days, so we define the 'Civil Year' to be exactly 365 days. The remaining 5 hours 48 minutes 45 seconds to complete one tropical year is very nearly one quarter of a day. We add one full day to the civil year each four years (during years divisible by 4) to keep it synchronised with a tropical year. These extended years of 366 days are called 'Leap Years' with the additional day inserted on 29 February. This insertion of a leap year effectively is an over recovery, so additional measures should be taken to keep the civil year synchronised with the tropical year. This could be corrected by suppressing one leap year in every 128 years, or three leap years in every 384 years but, to keep matters simple, we actually suppress three leap years in every 400 years.

The rule is that centennial years will not be leap years unless they are wholly divisible by 400. Thus 1700, 1800, and 1900 were not leap years, but 2000 was. All years divisible by 4 are leap years, but only centennial years that are also divisible by 400 are also leap years.

© 2005 FTA

THE DAY

The day is defined as the time taken for the Earth to complete one 360° rotation with respect to a specified datum.

THE APPARENT SOLAR DAY

Before the invention of mechanical clocks, a time system based upon the Sun itself was devised. While the times of sunrise and sunset were observed to vary greatly throughout the year due to the large annual change in the Sun's declination, the time at which the Sun crossed the observer's meridian - noon - was seen to provide a stable reference.

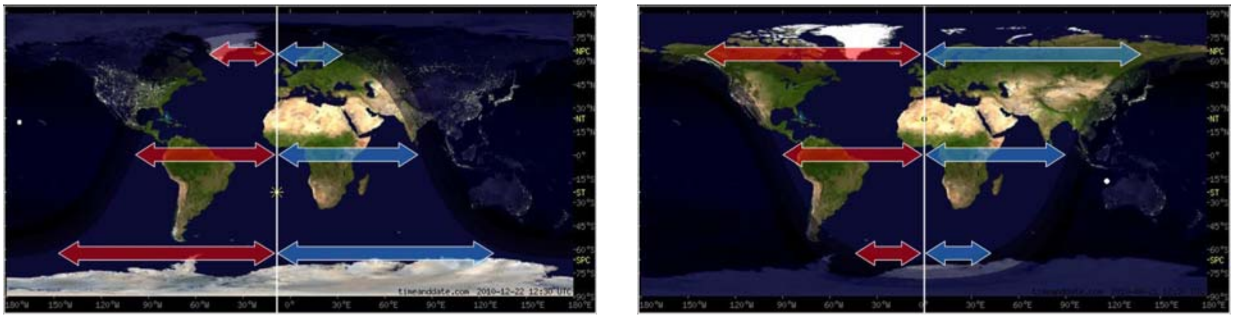


Figure 3: Large changes in sunrise and sunset times during the year

Furthermore, all observers on a particular meridian experience noon at the same instant, i.e. the time of noon is not affected by the Sun's declination or the observer's latitude. This is because the meridian and its associated anti-meridian form a great circle that lies in a flat plane passing through the centre of the Earth. Irrespective of the orientation of the Earth's spin axis, this extended meridianal plane sweeps through the centre of the Sun twice in each daily rotation. In one of these occasions the Sun transits the observer's meridian (the upper transit) and, on the other the observer's anti-meridian (the lower transit). During upper transit, the Sun reaches its highest elevation above every point on the observer's meridian, and its azimuth measured from the observer's position is either 000°(T) or 180°(T).

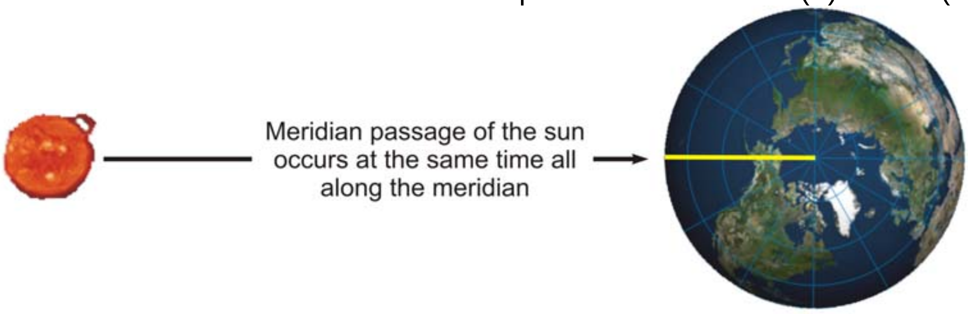


Figure 4

© 2005 FTA

By convention, the day starts at midnight, so solar time actually commences with the lower transit, and date changes occur at midnight.

The time system just described is called Apparent Solar Time, because it is based upon observation of the 'apparent', or 'real' Sun. The 'Apparent Solar Day' that results is defined as the time interval between successive upper transits of the real Sun.

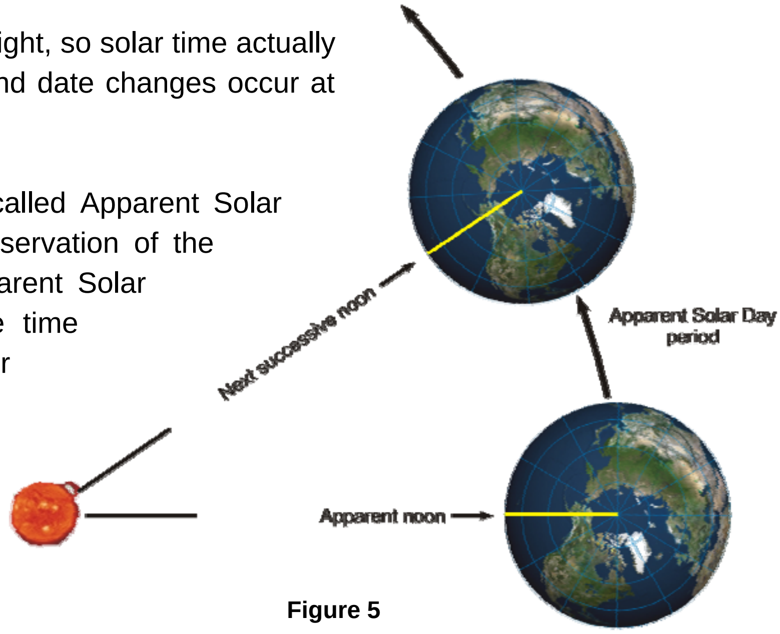


Figure 5

Apparent solar time is the time indicated by a sundial and, in earlier centuries, provided an adequate reference to regulate human activities. It has, however, one serous shortcoming, in that the day so defined is not of fixed duration. The Earth's orbit is elliptical in accordance with Kepler's first law, and to satisfy the second law, the orbital speed must increase near perihelion (Earth's closest to the Sun) and decrease near aphelion (Earth furthest from the Sun).

The angular velocity of the Earth's rotation is constant with respect to fixed space, and the higher orbital speed near perihelion would require the Earth to turn further on its axis between successive transits than would be the case at aphelion (figure 6). In other words, the day at perihelion would be longer than the day at aphelion. This is clearly unacceptable for activities requiring precision, so to overcome the difficulty a new datum, the 'mean Sun', was introduced (as explained earlier).

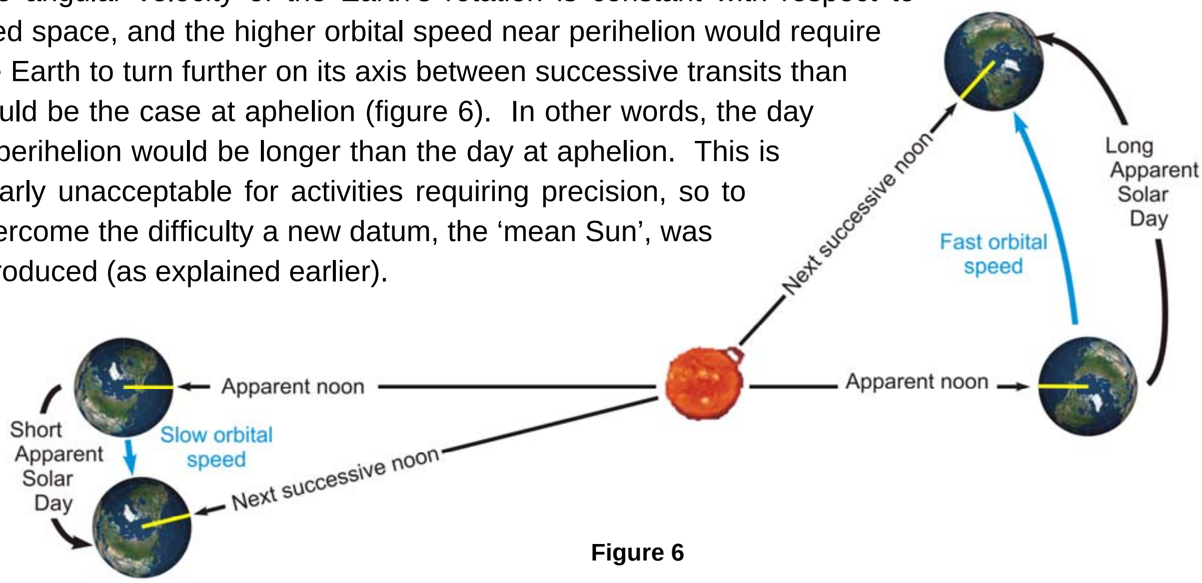


Figure 6

THE MEAN SOLAR DAY

The mean Sun is the basis of all practical systems of timekeeping, and use of the word 'mean' in terms like 'Greenwich Mean Time' and 'Local Mean Time' signifies that the time standard is based upon the mean Sun. The 'Mean Solar Day' is then defined as the time interval between two successive upper transits of the mean Sun.

The mean solar day is arbitrarily divided into 24 hours, each consisting of 60 minutes, each minute consisting of 60 seconds. Hence, the second is defined as $^{1}/_{86,400}$ of a mean solar day.

The difference between the apparent solar day and the mean solar day is always less than one minute, but the differences are cumulative over significant periods of time. For example, at the Greenwich meridian on February 12, mean noon is 14.3 minutes earlier than apparent noon, and on November 3, mean noon is 16.4 minutes later. These discrepancies are barely noticeable, and any minor disadvantage is greatly outweighed by the benefits of a uniform time standard.

LOCAL MEAN TIME

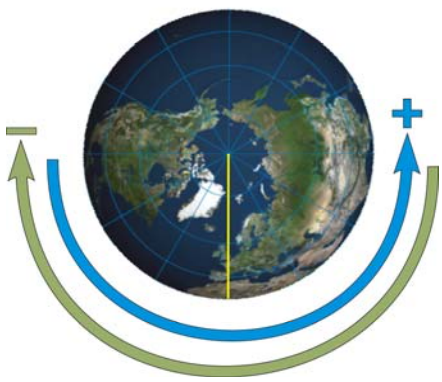
At any given meridian, the mean solar day commences when the mean Sun transits the observer's anti-meridian, and mean noon occurs at the instant of upper transit (overhead the observer's meridian). The time system based upon the observer's meridian is called Local Mean Time (LMT), and it is obvious that every meridian will keep its own LMT. Furthermore, every point along a given meridian will observe the same LMT because all will experience noon at the same instant, and this will be different from the LMT at every other meridian.

ARC TO TIME

From the definition of the mean solar day we observed that one day is equivalent to 360° of Earth rotation, and hence, to 360° change of longitude relative to the mean Sun. We use this relationship to convert 'arc to time' and 'time to arc' as follows:

Time	Arc (Longitude)
1 day	360 degrees
24 hours	360 degrees
1 hour	15 degrees
4 minutes	1 degree
1 minute	15 minutes
4 seconds	1 minute

Hence, if we know the d-long (ch long) between any two points, we can immediately determine the difference between their respective LMTs either by calculation using the above conversions, or by referring to an arc-to-time table. To determine the sense of the difference, we observe that the mean Sun moves from east to west, so the easterly longitude will have the later LMT (be further ahead in time). The key alongside shows that if we change our position in an easterly direction (counter clockwise when



© 2005 FTA

viewed from above the north pole) we have to add the time difference to calculate LMT, and subtract if we go in the opposite direction.

Arc to time conversion is also presented in tabular form in the Air Almanac, Jeppesen Volume 1, and the AIP although the latter two are restricted to the band of longitudes covering a particular region.

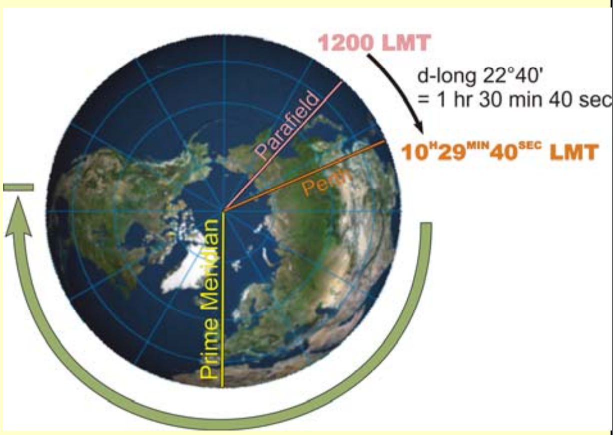
AIP Australia   25 NOV 04   GEN 2.7 - 7

CONVERSION OF ARC TO TIME

DEGREES						MINUTES					
Long Deg	Time Hours	Min	Long Deg	Time Hours	Min	Long Min	Time Min	Sec	Long Min	Time Min	Sec
110	7	20	140	9	20	0	0	00	30	2	00
111	7	24	141	9	24	1	0	04	31	2	04
112	7	28	142	9	28	2	0	08	32	2	08
113	7	32	143	9	32	3	0	12	33	2	12
114	7	36	144	9	36	4	0	16	34	2	16
115	7	40	145	9	40	5	0	20	35	2	20

Example

The LMT at Parafield (34°48'S, 138°38'E) is 1200 (noon). What is the LMT at Perth International (31°56'S, 115°58'E)?



D-long = 138°38' – 115°58'
= 22°40'
22° = 1 hr 28 min
40' = 2 min 40 secs
∴ 22° 40' = 1 hr 30 min 40 sec

Perth is further west than Parafield so the LMT at Perth is earlier (behind Parafield in time).

∴ LMT at Perth = 12:00 - 1:30:40
= 10:29:20

From this we see that LMT is the time reference that most closely synchronises 'the time' with the position of the Sun. This is important for some purposes, e.g. the specification of local sunrise and sunset, but is impractical for everyday use because it would require a different time standard for every meridian.

© 2005 FTA

CONVERSION OF ARC TO TIME

°	h m	°	h m	°	h m	°	h m	°	h m	°	h m	'	m s
0	0 00	60	4 00	120	8 00	180	12 00	240	16 00	300	20 00	0	0 00
1	0 04	61	4 04	121	8 04	181	12 04	241	16 04	301	20 04	1	0 04
2	0 08	62	4 08	122	8 08	182	12 08	242	16 08	302	20 08	2	0 08
3	0 12	63	4 12	123	8 12	183	12 12	243	16 12	303	20 12	3	0 12
4	0 16	64	4 16	124	8 16	184	12 16	244	16 16	304	20 16	4	0 16
5	0 20	65	4 20	125	8 20	185	12 20	245	16 20	305	20 20	5	0 20
6	0 24	66	4 24	126	8 24	186	12 24	246	16 24	306	20 24	6	0 24
7	0 28	67	4 28	127	8 28	187	12 28	247	16 28	307	20 28	7	0 28
8	0 32	68	4 32	128	8 32	188	12 32	248	16 32	308	20 32	8	0 32
9	0 36	69	4 36	129	8 36	189	12 36	249	16 36	309	20 36	9	0 36
10	0 40	70	4 40	130	8 40	190	12 40	250	16 40	310	20 40	10	0 40
11	0 44	71	4 44	131	8 44	191	12 44	251	16 44	311	20 44	11	0 44
12	0 48	72	4 48	132	8 48	192	12 48	252	16 48	312	20 48	12	0 48
13	0 52	73	4 52	133	8 52	193	12 52	253	16 52	313	20 52	13	0 52
14	0 56	74	4 56	134	8 56	194	12 56	254	16 56	314	20 56	14	0 56
15	1 00	75	5 00	135	9 00	195	13 00	255	17 00	315	21 00	15	1 00
16	1 04	76	5 04	136	9 04	196	13 04	256	17 04	316	21 04	16	1 04
17	1 08	77	5 08	137	9 08	197	13 08	257	17 08	317	21 08	17	1 08
18	1 12	78	5 12	138	9 12	198	13 12	258	17 12	318	21 12	18	1 12
19	1 16	79	5 16	139	9 16	199	13 16	259	17 16	319	21 16	19	1 16
20	1 20	80	5 20	140	9 20	200	13 20	260	17 20	320	21 20	20	1 20
21	1 24	81	5 24	141	9 24	201	13 24	261	17 24	321	21 24	21	1 24
22	1 28	82	5 28	142	9 28	202	13 28	262	17 28	322	21 28	22	1 28
23	1 32	83	5 32	143	9 32	203	13 32	263	17 32	323	21 32	23	1 32
24	1 36	84	5 36	144	9 36	204	13 36	264	17 36	324	21 36	24	1 36
25	1 40	85	5 40	145	9 40	205	13 40	265	17 40	325	21 40	25	1 40
26	1 44	86	5 44	146	9 44	206	13 44	266	17 44	326	21 44	26	1 44
27	1 48	87	5 48	147	9 48	207	13 48	267	17 48	327	21 48	27	1 48
28	1 52	88	5 52	148	9 52	208	13 52	268	17 52	328	21 52	28	1 52
29	1 56	89	5 56	149	9 56	209	13 56	269	17 56	329	21 56	29	1 56
30	2 00	90	6 00	150	10 00	210	14 00	270	18 00	330	22 00	30	2 00
31	2 04	91	6 04	151	10 04	211	14 04	271	18 04	331	22 04	31	2 04
32	2 08	92	6 08	152	10 08	212	14 08	272	18 08	332	22 08	32	2 08
33	2 12	93	6 12	153	10 12	213	14 12	273	18 12	333	22 12	33	2 12
34	2 16	94	6 16	154	10 16	214	14 16	274	18 16	334	22 16	34	2 16
35	2 20	95	6 20	155	10 20	215	14 20	275	18 20	335	22 20	35	2 20
36	2 24	96	6 24	156	10 24	216	14 24	276	18 24	336	22 24	36	2 24
37	2 28	97	6 28	157	10 28	217	14 28	277	18 28	337	22 28	37	2 28
38	2 32	98	6 32	158	10 32	218	14 32	278	18 32	338	22 32	38	2 32
39	2 36	99	6 36	159	10 36	219	14 36	279	18 36	339	22 36	39	2 36
40	2 40	100	6 40	160	10 40	220	14 40	280	18 40	340	22 40	40	2 40
41	2 44	101	6 44	161	10 44	221	14 44	281	18 44	341	22 44	41	2 44
42	2 48	102	6 48	162	10 48	222	14 48	282	18 48	342	22 48	42	2 48
43	2 52	103	6 52	163	10 52	223	14 52	283	18 52	343	22 52	43	2 52
44	2 56	104	6 56	164	10 56	224	14 56	284	18 56	344	22 56	44	2 56
45	3 00	105	7 00	165	11 00	225	15 00	285	19 00	345	23 00	45	3 00
46	3 04	106	7 04	166	11 04	226	15 04	286	19 04	346	23 04	46	3 04
47	3 08	107	7 08	167	11 08	227	15 08	287	19 08	347	23 08	47	3 08
48	3 12	108	7 12	168	11 12	228	15 12	288	19 12	348	23 12	48	3 12
49	3 16	109	7 16	169	11 16	229	15 16	289	19 16	349	23 16	49	3 16
50	3 20	110	7 20	170	11 20	230	15 20	290	19 20	350	23 20	50	3 20
51	3 24	111	7 24	171	11 24	231	15 24	291	19 24	351	23 24	51	3 24
52	3 28	112	7 28	172	11 28	232	15 28	292	19 28	352	23 28	52	3 28
53	3 32	113	7 32	173	11 32	233	15 32	293	19 32	353	23 32	53	3 32
54	3 36	114	7 36	174	11 36	234	15 36	294	19 36	354	23 36	54	3 36
55	3 40	115	7 40	175	11 40	235	15 40	295	19 40	355	23 40	55	3 40
56	3 44	116	7 44	176	11 44	236	15 44	296	19 44	356	23 44	56	3 44
57	3 48	117	7 48	177	11 48	237	15 48	297	19 48	357	23 48	57	3 48
58	3 52	118	7 52	178	11 52	238	15 52	298	19 52	358	23 52	58	3 52
59	3 56	119	7 56	179	11 56	239	15 56	299	19 56	359	23 56	59	3 56

The above table is for converting expressions of arc to their equivalent in time; its main use is for the conversion of longitude for application to L.M.T. (added if west, subtracted if east) to give G.M.T., or vice versa, particularly in the case of sunrise, sunset, etc.

© 2005 FTA

COORDINATED UNIVERSAL TIME

A possible solution would be the adoption of a single time standard for the whole world and this, too, has practical application, e.g. in aviation. For many years the standard internationally accepted was Greenwich Mean Time (GMT), i.e. the LMT at the Greenwich meridian. More recently, advances in the technology of atomic clocks resulted in a new and more precise time standard called Coordinated Universal Time (UTC), accepted by ICAO in 1984. UTC is based upon new definitions and new and more accurate methods of measurement, but for practical purposes there is no discernible difference between UTC and GMT. It is now correct to use UTC rather than GMT, but numerous references to GMT will still be found in older books and publications. In such cases, the two terms can be considered synonymous.

Despite its widespread application in aviation and other fields, UTC is not suitable for everyday use, as except for a narrow band of longitudes about the Greenwich meridian, clocks keeping UTC indicate times that are inconsistent with the observed position of the Sun. Therefore, we need to find a compromise that, on the one hand, keeps local clock times reasonably aligned with the actual position of the Sun, while, on the other, reducing to an acceptable level the number of different time standards. The system of time zones provides the required compromise.

Example

The LMT at Parafield (34°48'S, 138°38'E) is 1200 (noon). What is the UTC time at Parafield?

D-long = 138°38'
138° = 9 hr 12 min
38' = 2 min 32 secs
∴138°38' = 9 hr 15 min

Parafield is East of Greenwich, so the LMT at Parafield is later than UTC (ahead of UTC).

∴UTC at Parafield = 12:00 - 09:15
= 02:45

Longitude East, UTC Least
Longitude West, UTC Best

© 2005 FTA

ZONE TIME AND STANDARD TIME

The world is divided into 24 zones, each 15° of longitude in width, and each keeping the LMT of its central meridian. The system starts at the Greenwich meridian, and every point within the longitude band 07°30'W to 07°30'E, keeps UTC as its zone time (figure 7). UTC is also referred to as Zulu time.

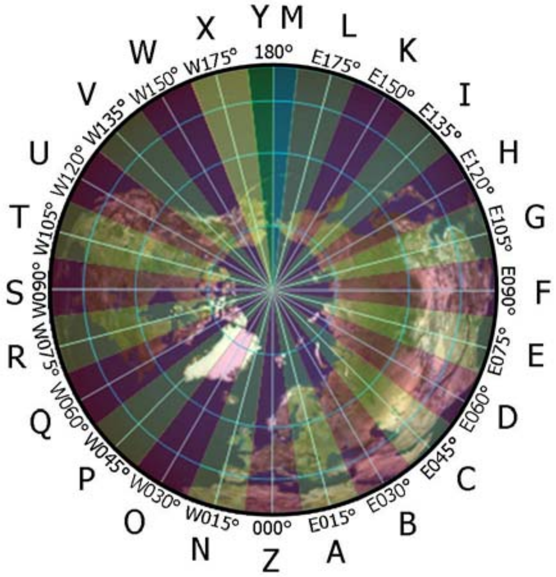


Figure 7

Points on the eastern extremity of the zone therefore keep clock time that is 30 minutes behind LMT, and those on the western extremity keep clock time that is 30 minutes ahead. Thus, the maximum 'error' in the system is 30 minutes, and this is of minor concern when weighed against the convenience of a single time zone within a large longitudinal area. (15° of longitude at the latitude of Adelaide extends some 1,350km).

The time zones adjacent to the Greenwich zone have as their central meridians 15°E and 15°W respectively. The clock time within the eastern zone is UTC+1 hour and in the western zone, UTC-1 hour. Subsequent time zones, each differing by one hour from its predecessor, are established with central meridians at 15° intervals. These zones are numbered according to the number of hours that must be added or subtracted from that particular zone time to obtain UTC. The number of the Greenwich zone is zero, zones west of Greenwich have progressively increasing positive numbers and zones to the east have progressively increasing negative numbers.

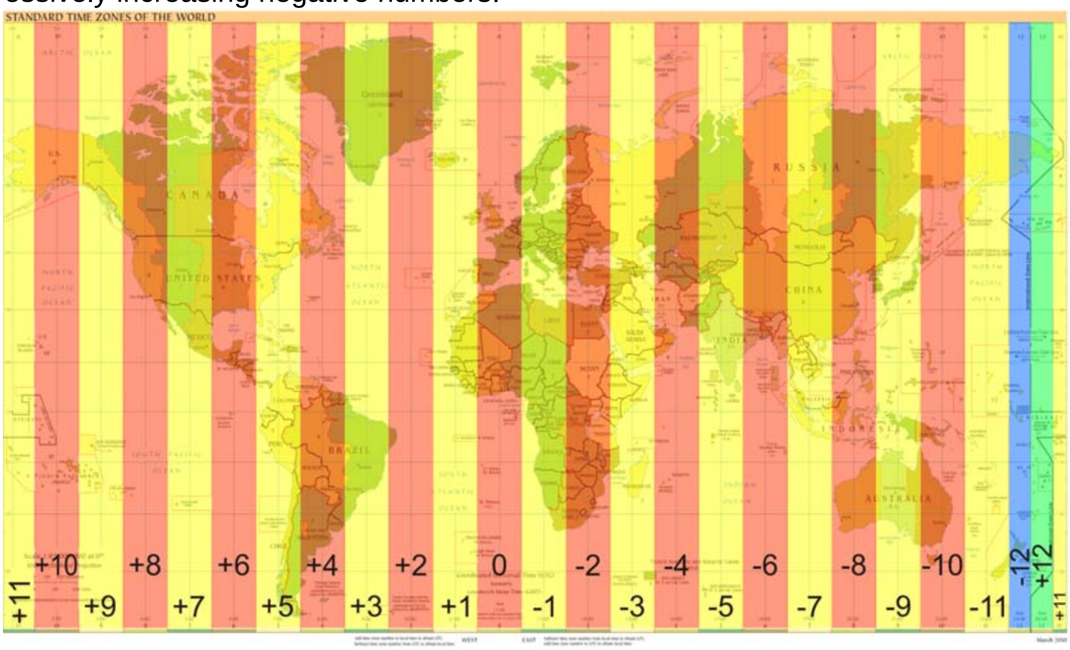


Figure 8

© 2005 FTA

STANDARD TIMES

The system of zone times is a good one, but it is not applied rigidly if a zone boundary is inconveniently located with respect to a state or national boundary. Clearly, it would be undesirable to divide an island, state or nation into two time zones if a small adjustment of the zone boundary would allow the whole area to be included in one zone.

Many such alterations to zone boundaries have been made throughout the world resulting in 'Standard Times' that differ from the local zone time, so it is not advisable to rely on longitude alone when determining the time kept in a particular region. The information is provided in Standard Time tables in the Air Almanac, but for examination purposes the information will be provided as part of the question.

In the examination you could be required to compute the local standard time (LST) date and time of arrival for a flight of stated duration, with a given departure time, to a destination keeping a different LST. You could also be expected to work back towards a required departure time from a stated arrival time due to curfew restrictions or other operational requirements.

Example: Find the date and LST of arrival for a flight of 13 hours duration departing from Sydney, Australia at 7 AM on Wednesday 10 July 2012 for Los Angeles, USA. The difference from Zulu for Sydney is UTC+10 and Los Angeles is UTC-8.

10 Jul	06:00	LST	Depart Sydney, Australia
	-10:00		Time difference from UTC
09 Jul	20:00	UTC	Depart Sydney, Australia
	+13:00		Flight Time
10 Jul	09:00	UTC	Arrival Los Angeles, USA
	-08:00		Time difference from UTC
10 Jul	01:00	LST	Arrival Los Angeles, USA

Example: Sydney (Australia) airport is closed to arrivals until 05:30 AM LST. What is the earliest available LST departure from Narita (Japan) for a flight of 10.5 hours duration to arrive Sydney at 05:30 AM LST on 11 December? Sydney uses UTC+11 and Narita uses UTC+9.

11 Dec	05:30	LST	Arrive Sydney, Australia
	-11:00		Time difference from UTC
10 Dec	18:30	UTC	Arrive Sydney, Australia
	-10:30		Flight Time
10 Dec	08:00	UTC	Depart Narita, Japan
	+09:00		Time difference from UTC
10 Dec	17:00	LST	Depart Narita, Japan

© 2005 FTA

STANDARD TIMES (Corrected to June 1985)

LIST I — PLACES FAST ON G.M.T. (mainly those EAST OF GREENWICH)

The times given below should be } added to G.M.T. to give Standard Time. / subtracted from Standard Time to give G.M.T.

Place	h	m
Admiralty Islands	10	
Afghanistan	04	30
Albania *	01	
Algeria	01	
Amirante Islands	04	
Andaman Islands	05	30
Angola	01	
Annobon Island	01	
Australia		
Australian Capital Territory *	10	
New South Wales[1] *	10	
Northern Territory	09	30
Queensland	10	
South Australia *	09	30
Tasmania *	10	
Victoria *	10	
Western Australia *	08	
Austria*.	01	
Bahrain.	03	
Balearic Islands *	01	
Banaba.	11	30
Bangladesh	06	
Belgium *	01	
Benin (Dahomey)	01	
Botswana, Republic of Brunei	02	
Brunei...	08	
Bulgaria *	02	
Burma...	06	30
Burundi.	02	
Cameroon Republic	01	
Caroline Islands, west of long. E. 135 °	09	
long. E. 135 ° to E. 150 ° ...	10	
long. E. 150 ° to E. 160 ° ...	11	
east of long. E. 160 °	12	
Central African Republic	01	
Chad	01	
Chagos Archipelago[2]	05	
Chatham Islands	12	45
China[3]	08	
Christmas Island, Indian Ocean.	07	
Cocos Keeling Islands	06	30
Comoro Islands (Comoros)	03	
Congo Republic	01	
Corsica *	01	
Crete *	02	
Cyprus, Ercan *	02	
Larnaca *	02	
Czechoslovakia *	01	
Denmark *	01	
Djibouti	03	

Place	h	m
Egypt, Arab Republic of.	02	
Equatorial Guinea. Republic of..	01	
Estonia.	03	
Ethiopia	03	
Fernando Póo	01	
Fiji	12	
Finland *	02	
France *	01	
Friendly Islands.	13	
Gabon	01	
Germany, East *	01	
West[4] *	01	
Gibraltar *	01	
Greece *	02	
Guam	10	
Holland (The Netherlands) *	01	
Hong Kong	08	
Hungary *	01	
India	05	30
Indonesia, Republic of		
Bali, Bangka, Billiton, Java,		
Madura, Sumatra	07	
Flores, Kalimantan, Lombok,		
Sulawesi, Sumba, Sumbawa, Timor ..	08	
Aru, Irian Jaya, Kai, Moluccas,		
Tanimbar.	09	
Iran	03	30
Iraq *	03	
Israel *..	02	
Italy *	01	
Japan	09	
Jordan *	02	
Kamchatka Peninsula	12	
Kampuchea, Democratic	07	
Kenya	03	
Kiribati Republic [5]	12	
Korea, North	09	
Republic of (South)	09	
Kuril Islands	11	
Kuwait	03	
Laccadive Islands	05	30
Laos	07	
Latvia	03	
Lebanon *	02	

* Summer time may be kept in these countries.
[1] Except Broken Hill Area which keeps $09^h\ 30^m$.
[2] Except Diego Garcia which keeps 06^h.
[3] All the coast, but some areas may keep summer time.
[4] Including West Berlin.
[5] Except Banaba which keeps $11^h\ 30^m$.

© 2005 FTA

STANDARD TIMES (Corrected to June 1985)

LIST I — *(Continued)*

	h	m
Lesotho	02	
Libya *	01	
Liechtenstein	01	
Lord Howe Island *	10	30
Luxembourg *	01	
Macao	08	
Madagascar, Democratic Republic of	03	
Malawi	02	
Malaysia		
Malaya, Sabah, Sarawak	08	
Maldives, Republic of The	05	
Malta *	01	
Mariana Islands	10	
Marshall Islands [1]	12	
Mauritius	04	
Monaco *	01	
Mongolia, West	07	
Central *	08	
East	09	
Morocco	01	
Mozambique	02	
Namibia (South West Africa)	02	
Nauru	12	
Netherlands. The *	01	
New Caledonia *	11	
New Zealand *	12	
Nicobar Islands	05	30
Niger	01	
Nigeria. Republic of	01	
Norfolk Island	11	30
Norway *	01	
Novaya Zemlya	05	
Okinawa	09	
Oman	04	
Pakistan	05	
Papua New Guinea	10	
Pescadores Islands	08	
Philippine Republic	08	
Poland *	01	
Reunion	04	
Romania *	02	
Rwanda	02	
Ryukyu Islands	09	
Sakhalin	11	
Santa Cruz Islands	11	
Sardinia *	01	
Saudi Arabia	03	
Schouten Islands	09	
Seychelles	04	

	h	m
Sicily *	01	
Singapore	08	
Socotra	03	
Solomon Islands	11	
Somalia Republic	03	
South Africa, Republic of	02	
South West Africa (Namibia)	02	
Spain *	01	
Spanish Possessions in North Africa		
(Ceuta, Melilla) *	01	
Spitsbergen (Svalbard)	01	
Sri Lanka	05	30
Sudan, Republic of	02	
Swaziland	02	
Sweden *	01	
Switzerland *	01	
Syria (Syrian Arab Republic)	03	
Taiwan *	08	
Tanzania	03	
Thailand	07	
Tonga Islands	13	
Truk	10	
Tunisia	01	
Turkey *	02	
Tuvalu Islands	12	
Uganda	03	
Union of Soviet Socialist Republics [2] *		
west of long. E. 40°	03	
long. E. 40° to E. 52* 30'	04	
long. E. 52° 30' to E. 67° 30'	05	
long. E. 67° 30' to E. 82° 30'	06	
long. E. 82° 30' to E. 97° 30'	07	
long. E. 97° 30' to E. 112° 30'	08	
long. E. 112° 30' to E. 127° 30'	09	
long. E. 127° 30' to E. 142° 30'	10	
long. E. 142° 30' to E. 157° 30'	11	
long. E. 157° 30' to E. 172° 30'	12	
east of long. E. 172' 30'	13	
United Arab Emirates	04	
Vanuatu, Republic of *	11	
Vietnam, Socialist Republic of	07	
Wrangell Island	13	
Yemen	03	
Yugoslavia *	01	
Zaire		
Kinshasa. Mbandaka	01	
Haut-Zaire. Kasai. Kivu, Shaba	02	
Zambia, Republic of	02	
Zimbabwe	02	

* Summer time may be kept in these countries.
[1] Except the islands of Kwajalein and Eniwetok which keep a time 24^h slow on that of the rest of the islands.
[2] The boundaries between the zones are irregular; the longitudes given are approximate only.

© 2005 FTA

STANDARD TIMES (Corrected to June 1985)

LIST II — PLACES NORMALLY KEEPING G.M.T.

Ascension Island	Ghana	Ireland, Northern [1]	Mauritania	Sierra Leone
Bourkina-Faso	Great Britain [1]	Irish Republic *	Portugal *	Tangier
Canary Islands *	Guinea Bissau	Ivory Coast	Principe	Togo Republic
Channel Islands [1]	Guinea Republic	Liberia	St. Helena	Tristan da Cunha
Faeroes *, The	Iceland	Madeira *	Sao Tomé	
Gambia	Ifni	Mali	Senegal	

* Summer time may be kept in these countries.
[1] Summer time. one hour in advance of G.M.T., is kept from March 29[1] 01" to October 25° 01" G.M.T., subject to confirmation.

LIST III — PLACES SLOW ON G.M.T. (WEST OF GREENWICH)

The times given below should be } *subtracted* from G.M.T. to give Standard Time. *added* to Standard Time to give G.M.T.

	h	m
Argentina	03	
Austral Islands [1]	10	
Azores *	01	
Bahamas *	05	
Barbados	04	
Belize	06	
Bermuda *	04	
Bolivia	04	
Brazil, eastern [2]	03	
Territory of Acre	05	
western	04	
British Antarctic Territory [3]	03	
Canada.		
Alberta *	07	
British Columbia *	08	
Labrador *	04	
Manitoba *	06	
New Brunswick *	04	
Newfoundland *	03	30
Northwest Territories *		
east of long. W. 68°	04	
long. W. 68° to W. 85°	05	
long. W. 85° to W. 102°	06	
west of long. W. 102°	07	
Nova Scotia *	04	
Ontario *, east of long. W. 90°	05	
west of long. W. 90°	06	
Prince Edward Island *	04	
Quebec *, east of long. W. 63°	04	
west of long. W. 63°	05	
Saskatchewan *		
east of long. W. 106°	06	
west of long. W. 106°	07	
Yukon *	08	

	h	m
Cape Verde Islands	01	
Cayman Islands	05	
Chile *	04	
Christmas Island, Pacific Ocean	10	
Colombia	05	
Cook Islands *, except Niue	10	
Costa Rica	06	
Cuba *	05	
Curacao Island	04	
Dominican Republic	04	
Easter Island (I. de Pascua) *	06	
Ecuador	05	
Falkland Islands [4]	04	
Fanning Island	10	
Fernando de Noronha Island	02	
French Guiana	03	
Galapagos Islands	06	
Greenland [3], Scoresby Sound *	01	
Angmagssalik and west coast'	03	
Thule area	04	
Grenada	04	
Guadeloupe	04	
Guatemala *	06	
Guyana, Republic of	03	
Haiti *	05	
Honduras	06	
Jamaica.	05	
Jan Mayen Island	01	
Johnston Island.	10	
Juan Fernandez Islands	04	

* Summer time may be kept in these countries.
[1] This is the legal standard time, but local mean time is generally used.
[2] Including all the coast and Brasilia.
[3] Except South Georgia which keeps 02^h.
[4] Except Port Stanley which may keep summer time.
[5] Danmarkshavn keeps G.M.T.

© 2005 FTA

STANDARD TIMES (Corrected to June 1985)
LIST III — *(Continued)*

	h	m
Leeward Islands	04	
Low Archipelago	10	
Marquesas Islands [1]	09	30
Martinique	04	
Mexico [2]	06	
Midway Islands.	11	
Miquelon	03	
Nicaragua	06	
Niue Island	11	
Panama Canal Zone	05	
Panama. Republic of	05	
Paraguay *	04	
Peru *	05	
Puerto Rico	04	
Rarotonga	10	
St. Pierre and Miquelon.	03	
Salvador, El	06	
Samoa	11	
Society Islands [1]	10	
South Georgia	02	
Surinam	03	
Tobago	04	
Trindade Island, South Atlantic	02	
Trinidad	04	
Tuamotu Archipelago [1]	10	
Tubuai Islands [1]	10	
Turks and Caicos Islands *	05	
United States of America		
Alabama [3]	06	
Alaska [3], east of long. W. 169° 30'	09	
Aleutian Islands, west of W. 169° 31'	10	
Arizona	07	
Arkansas [3]	06	
California [3]	08	
Colorado [3]	07	
Connecticut [3]	05	
Delaware [3]	05	
District of Columbia [3]	05	
Florida [3,4]	05	
Georgia [3]	05	
Hawaii	10	

	h	m
United States of America (continued)		
Idaho [3,4]	07	
Illinois [3]	06	
Indiana [4]	05	
Iowa [3]	06	
Kansas [3,4]	06	
Kentucky [3], eastern part	05	
western part	06	
Louisiana [3]	06	
Maine [3]	05	
Marylan [3]	05	
Massachusetts [3]	05	
Michigan [3,4]	05	
Minnesota [3]	06	
Mississippi [3]	06	
Missouri [3]	06	
Montana [3]	07	
Nebraska [3,4]	06	
Nevada [3]	08	
New Hampshire [3]	05	
New Jersey [3]	05	
New Mexico [3]	07	
New York [3]	05	
North Carolina [3]	05	
North Dakota [3,4]	06	
Ohio [3]	05	
Oklahoma [3]	06	
Oregon [3,4]	08	
Pennsylvania [3]	05	
Rhode Island [3]	05	
South Carolina [3]	05	
South Dakota [3], eastern part	06	
western part	07	
Tennessee [3,4]	06	
Texas [3,4]	06	
Utah [3]	07	
Vermont [3]	05	
Virginia [3]	05	
Washington, D.C. [3]	05	
Washington [3]	08	
West Virginia [3]	05	
Wisconsin [3]	06	
Wyoming [3]	07	
Uruguay *	03	
Venezuela	04	
Virgin Islands	04	
Windward Islands	04	

* Summer time may be kept in these countries.
[1] This is the legal standard time, but local mean time is generally used.
[2] Except the states of Sonora, Sinaloa. Nayarit and the Southern District of Lower California which keep 07^h, and the Northern District of Lower California which keeps 08^h.
[3] Summer (daylight-saving) time, one hour fast on the time given, is kept in these states from the last Sunday in April to the last Sunday in October, changing at 02^h 00^m local clock time.
[4] This applies to the greater portion of the state.

In the CASA ATPL Navigation Examination (ANAV), you will be given the time difference from UTC for the locations in question. In real life these can be obtained from various documents, the UK Air Almanac being one such document.

© 2005 FTA

AUSTRALIAN STANDARD TIMES

The Australian continent fits neatly into three time zones: UTC+8, centred on 120°E, UTC+9, centred on 135°E, and UTC+10, centred on 150°E. Zone UTC+8 is observed in Western Australia with a minor modification to accommodate the state boundary, and 'Western Standard Time' is UTC +8 hours. Zone UTC+10 with similar minor modifications is used by the eastern states, 'Eastern Standard Time' being UTC +10 hours. For reasons that are somewhat obscure, South Australia and the Northern Territory do not keep Central Standard Time (UTC+9 hours), but rather, UTC+9½ hours. It is noteworthy that the central meridian of the UTC+9½ hours zone is 142°30'E, and this meridian does not even lie within the borders of the states concerned.

SUMMER TIME OR DAYLIGHT SAVING TIME

During the local summer months, many regions throughout the world observe 'Summer Time' or 'Daylight Saving Time'. Summer time is obtained by moving the clock one hour ahead of the local standard time. For example in South Australia 'Central Summer Time' is observed from October to March each year, and is UTC+10½ hours. Summer time is only of practical benefit when the length of daylight considerably exceeds the length of darkness, i.e. during the summer months in non-tropical latitudes. In that situation, it is deemed to provide an additional hour of 'useful daylight' by utilising daylight from the otherwise unused period in the early morning, but the claimed 'benefit' is by no means generally accepted.

Regions that regularly adopt daylight saving are identified in the previously mentioned lists in the Air Almanac, while the dates on which the change to/from summer time occur, are promulgated in NOTAMS.

TWILIGHT

Because the Earth's atmosphere refracts and scatters light, considerable useful daylight is available before sunrise and after sunset. This period is called 'twilight' and is defined arbitrarily as follows:

Morning Civil Twilight (MCT) is that period that begins before sunrise, and Evening Civil Twilight (ECT) is that period that ends after sunset, in both cases when the centre of the Sun is 6° below the horizon.

Modern day aviators are concerned mainly with civil twilight. In particular, in Australia daylight is defined as that period between the beginning of MCT and the end of ECT, and day-VFR flight is permitted only within that period.

Morning and Evening Civil Twilight are the times corresponding to Beginning and End of Daylight.

© 2005 FTA

THE INTERNATIONAL DATE LINE

Proceeding west from Greenwich, we reach time zone number 11, bounded by 157°30'W and 172°30'W, with central meridian at 165°W. Similarly, if we proceed east from Greenwich, we reach time zone number -11. The next zone, centred on 180E/W and bounded by 172°30'W and 172°30'E would, apparently, be numbered 12 if we approach westward from Greenwich, or -12 if we approach eastward from Greenwich. Thus, at the 180° meridian itself, we experience a time difference of

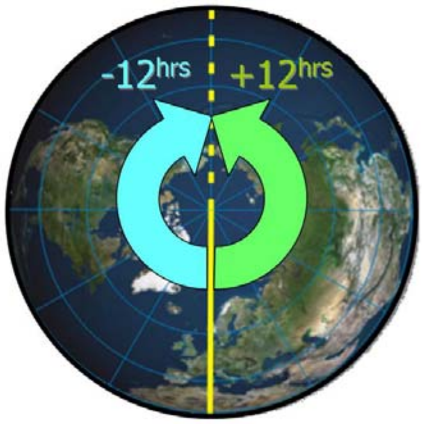


Figure 9

(UTC + 12) - (UTC - 12) = 24 hours

In other words the day changes at that point, the region to the west of the 180° meridian being in Monday, and the region to the east in Sunday. For this reason, the 180° meridian is also referred to as the International Date Line (IDL).

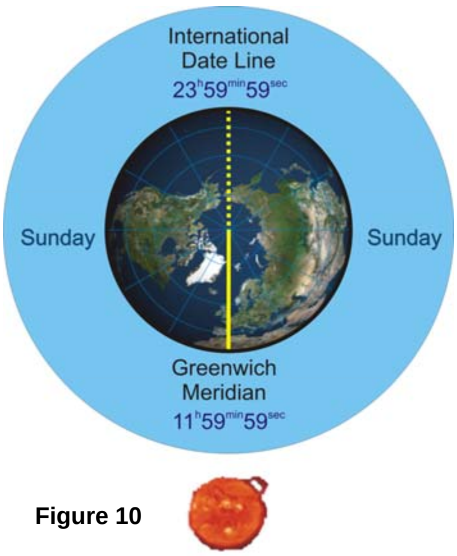


Figure 10

To understand how this happens, consider Figure 10 in which the mean Sun is just about to cross the Greenwich meridian. The LMT at Greenwich is $11^h59^{min}59^{sec}$, and the LMT at the IDL is $23^h59^{min}59^{sec}$. In that instant, the day over the whole world is Sunday.

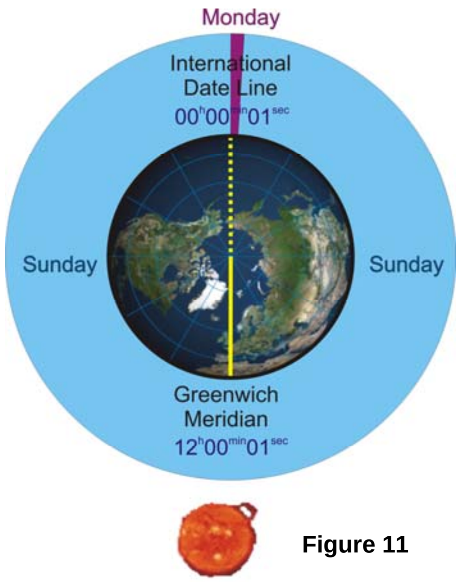


Figure 11

Two seconds later (figure 11), the time at Greenwich is $12^h00^{min}01^{sec}$ and at the IDL, $00^h00^{min}01^{sec}$ on Monday. As the mean Sun moves from east to west around the Earth the LMT at the Sun's anti-meridian is always 0000 or 2400, and always marks the point of local change of day from Sunday to Monday.

© 2005 FTA

In Figure 12 the Sun is over the IDL; it is midnight at Greenwich and the Greenwich day is changing from Sunday to Monday. At this point, the hemisphere to the west of the IDL is in Monday, and the hemisphere to the east is still in Sunday.

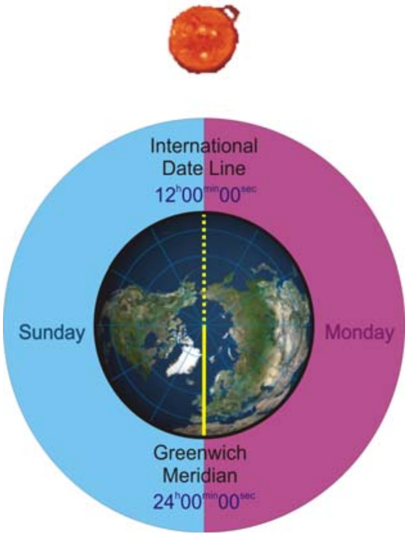


Figure 12

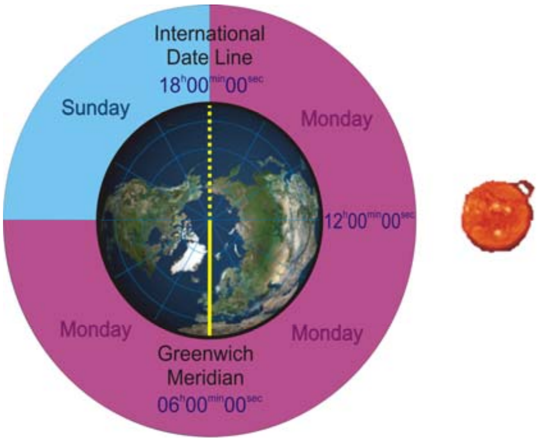
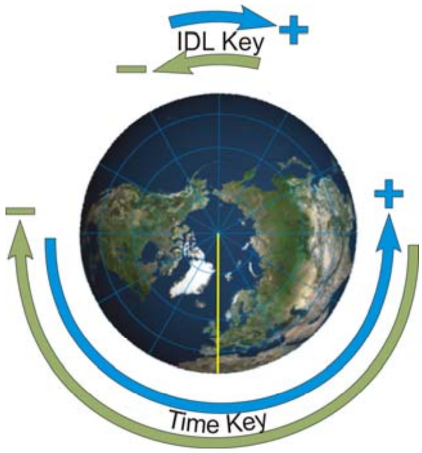


Figure 13

As shown in Figure 13 continued progression of the mean Sun further increases the sector of the Earth in Monday, and reduces the sector still in Sunday. Finally, as the mean Sun approaches the Greenwich meridian again, its anti-meridian obliterates the last remaining sector still in Sunday, and the process commences again with a new day at the IDL.

From this we observe that, if we cross the IDL from east to west, e.g. from Australia to the US, we move from Monday back to Sunday. Crossing from west to east, we move from Sunday on to Monday.



Figure

It is not generally recognised that a discontinuity will occur somewhere, irrespective of the system of longitude or zone time that we might adopt. The existing system is optimal, because it places the discontinuity in the middle of a large expanse of ocean where it causes the least possible inconvenience. However, like the standard time boundaries, the IDL is not rigidly aligned with the 180° meridian, deviations occurring as necessary to avoid populated areas.

TIME CONVERSIONS

Aviation and associated activities are conducted with reference to UTC, although some phenomena of importance, e.g. sunrise, twilight, etc. are presented in terms of LMT. Meanwhile, the general population regulates all its activities in local standard time or daylight saving time as applicable. The airline pilot operates in all these environments, and so must be proficient in changing from one time reference to another, both quickly and accurately. This requires sound knowledge of the underlying theory, and extensive practice in applying arc-to-time, time-to-arc and standard time conversions.

© 2005 FTA