DOCUMENT
GSM-G-CPL.026

DOCUMENT TITLE

NAVIGATION 1

CHAPTER 8 – TIME

Version 2.0
October 2017

CONTENTS

TIME

8.1 Introduction

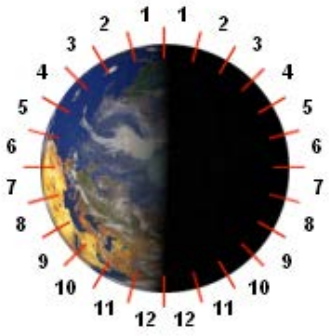
Most human activities involve groups of people acting together in the same place at the same time. People could not do this if they did not all measure time in the same way.

8.2 Measuring Time

For early man, the only changes that were truly regular were the movement of objects in the sky. The most obvious of these changes was the alternating between daylight and night, caused by the rising and setting of the sun.

Each of these cycles of the Sun (daylight and darkness) came to be called a day.

The Babylonians divided the imaginary circular path of the Sun into 12 equal parts.

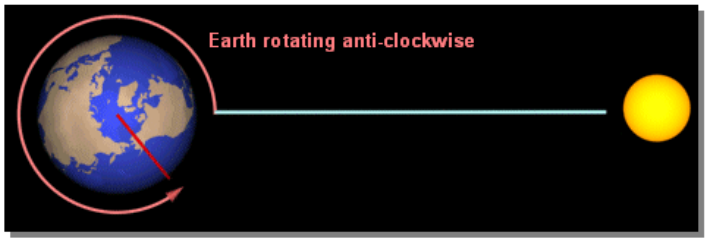


They then divided the periods of daylight and darkness into 12 parts each, resulting in a 24-hour day (also known as a **Mean Solar Day**).

Note:

- **A day consists of 24 hours**
- **An hour consists of 60 minutes**
- **A minute consists of 60 seconds**

It is known that the Earth rotates in an anti-clockwise direction when viewed from above the North Pole, or west to east when viewed from above the equator.



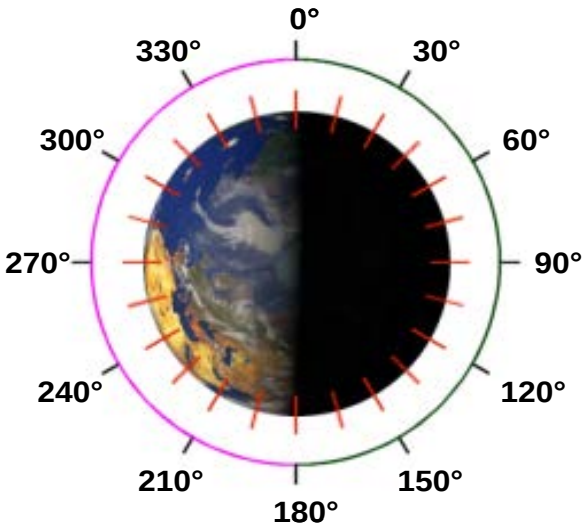
To us on the surface, it appears as though the heavenly objects (sun, stars, etc.) move around the Earth in an east to west direction.

As the Earth rotates on its axis, the sun crosses each meridian once each day. When the sun crosses a specific meridian, the time there is noon (12 o'clock midday).

8.2.1 Arc to Time

The Babylonians also divided the circle into 360 parts called degrees.

Time can also be measured in arc since in one day of mean solar time; the Sun is imagined to travel in a complete circle around the Earth, a motion of 360°.



The measurement of 24 hours is the same measurement as 360° change in longitude.

Over a period of 12 hours the change in arc will be 180°.

Over a period of 24 hours the change in arc will be (**180** + **180**) 360°.

Therefore, the following relationship between time and the change in longitude can be determined:

Change in Longitude	360°	15°	1°	15’	1’	15’’
Time Period	24 H	1 H	4 Min	1 Min	4 Sec	1 Sec

8.2.1.1 Converting Longitude into Time (Relationship Method)

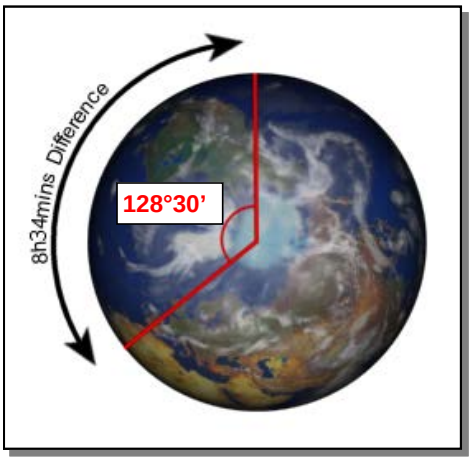
Example: What is the time equivalent of 128°30’ of longitude?

120° ÷ 15° × 1 h = 8 h (hours)

8° ÷ 1° × 4 min = 32 min (minutes)

30 min ÷ 15 min × 1 min = 2 min

Therefore, 128°30’ of longitude is equivalent to **8h34min** (8h + 32 min + 2 min).



8.2.1.2 Converting Longitude into Time (Alternate Mathematical)

Example: What is the time equivalent of 128°30' of longitude?

- Convert the longitude from degrees, minutes and seconds into degrees and decimals. Divide the minutes of longitude by 60:

  128°30' = 128.5°

- Convert the longitude into hours of time by dividing the degrees and decimals value by 15. Earth rotates 15° in 24 hours:

  128.5° ÷ 15 = 8.566666667h

- Convert the time value (hours and decimals) into hours and minutes format. It is acceptable to round to the nearest minute of time. Disregard the 8 hours and convert the 0.56667 decimal hours into minutes of time by multiplying with 60:

  8.566666667 hours = **8h 34 min**

8.2.1.3 Converting Longitude into Time (Longitude Table)

Refer to the Australian Jeppesen Manual for a table designed specifically for the conversion of longitude into time or the reverse calculation (Jeppesen tables and codes, page AU12):

CONVERSION OF ARC TO TIME

LONGITUDE											
DEGREES						MINUTES					
Long. Deg.	Time		Long. Deg.	Time		Long. Mins.	Time		Long. Mins.	Time	
	Hours	Mins.		Hours	Mins.		Mins.	Secs.		Mins.	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
116	7	44	146	9	44	6	0	24	36	2	24
117	7	48	147	9	48	7	0	28	37	2	28
118	7	52	148	9	52	8	0	32	38	2	32
119	7	56	149	9	56	9	0	36	39	2	36
120	8	00	150	10	00	10	0	40	40	2	40
121	8	04	151	10	04	11	0	44	41	2	44
122	8	08	152	10	08	12	0	48	42	2	48
123	8	12	153	10	12	13	0	52	43	2	52
124	8	16	154	10	16	14	0	56	44	2	56
125	8	20	155	10	20	15	1	00	45	3	00
126	8	24	156	10	24	16	1	04	46	3	04
127	8	28	157	10	28	17	1	08	47	3	08
128	8	32	158	10	32	18	1	12	48	3	12

Example: What is the time equivalent of 128°30' of longitude?

- Locate the degrees of longitude in the left hand column and read the time value in hours and minutes next to it; 128° = 8h 32 min.
- Locate the minutes of longitude in the right hand columns and read the time value in minutes and seconds next to it; 30 min of longitude = 2 min and zero seconds of time.
- Combine the two time values to complete the conversion process:

8h 32 min + 2 min 00 sec = **8h 34 min**

8.3 Date and Time

Time can be expressed as Local Mean Time (LMT), Universal Time Coordinated (UTC) and Local Standard Time (LST).

UTC is the universal time for aviation. LMT is required for daylight and darkness graphs and LST for every day life.

8.3.1 Time in Aviation

In aviation dates and times are organised into a single figure group known as a date/time group. These date/time groups are used in various aviation related publications, e.g. weather forecasts and NOTAMS.

An element of date and time is represented by 2 digits, starting with the longest period (years) to the shortest period (minutes). The 24 hour time format is used.

The amount of digits in the date/time group can vary as required and is typically determined by the length of the time periods.

8.3.1.1 10 Figure Date/Time Groups

YEAR MONTH DAY HOURS MINUTES

NOTAMS often extending over several months, specify the month in the date, and when appropriate the year.

When the year is included, a **ten (10) figure group** is written.

0840 pm on 25 December 2030 would be written as:

3012252040 where 30 (year) 12 (month) 25 (day) 20 (hours) 40 (minutes)

8.3.1.2 8 Figure Date/Time Groups

MONTH DAY HOURS MINUTES

In most cases the year is not needed and an **eight (8) figure group** is used.

1145 am on 23 July 2020 would be written on NOTAMS as:

07231145 where 07 (month) 23 (day) 11 (hours) 45 (minutes)

8.3.1.3 6 Figure Date/Time Groups

For flight planning and navigation purposes it is sufficient to use the day of the month followed by hours and minutes.

For normal operations, date and time are often expressed as a **6 figure date/time group**.

DAY HOURS MINUTES

1140pm on 25 March 2023 would be written on NOTAMS as:

252340 where 25 (day) 23 (hours) 40 (minutes)

8.4 Local Mean Time and Coordinated Universal Time

Due to the size and shape of the Earth, each part of the world will effectively be experiencing a different period of the 24-hour day at any given moment.

8.4.1 Principle of LMT

LMT is measured using the mean sun and the observer's meridian and anti-meridian.

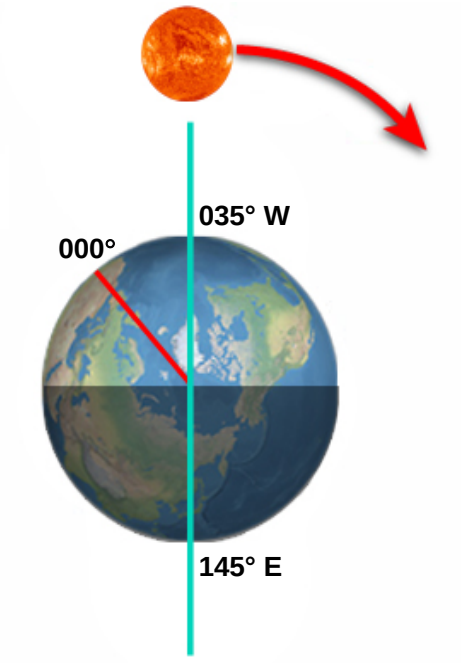
The beginning of a local day is at midnight, or 0000 hours LMT (Local Mean Time) when the sun passes over the observer's anti-meridian.

The anti-meridian is used so that date changes occur during hours of darkness.

Let's consider being in Melbourne (145°E longitude) and the time is 0000 (midnight).

The position of the sun relative to the Earth will be 180° removed from 145°E, at the 035°W meridian (the anti-meridian of 145°E).

As the sun appears to move from east to west relative to the earth, the time in Melbourne will increase, until it reaches 1200 LMT when the sun is directly overhead the 145°E meridian.



It can therefore be said that the local day starts at 0000 hrs when the mean Sun crosses the observer's anti-meridian, and finishes at 2400 hrs when the Sun again crosses the anti-meridian.

As LMT depends on longitude, the LMT around the world will vary by up to 24 hours.

By measuring this change in longitude (chlong) between two observers, the LMT at the second position can be calculated.

Note: As the Earth rotates anti-clockwise as viewed from the North Pole, the Sun moves in a westerly direction. Thus, at any given moment, the time to the West will be less (decrease), and the time to the East will be more (increase).

In aviation, LMT is only used to calculate the time of astronomical events, such as sunrise, sunset, beginning- and end of daylight. LMT is the time that best matches the position of the sun relative to the horizon.

8.4.1.1 LMT to LMT Conversion

Example: The LMT at 078°E is 01h52 on 21 Oct. What is the LMT at 054°W?

Chlong is 132° (78° + 54°)

Time at 054°W is calculated as follows:

Time decreases to the west, therefore the time will be earlier at 054°W, compared to 078°E.

Time difference:

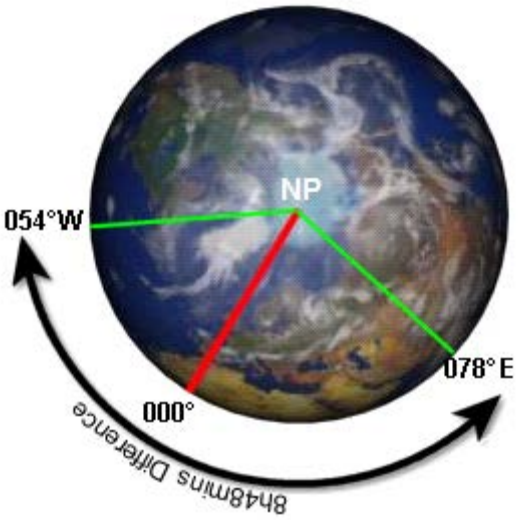
= 01h52 LMT - 08h 48min

= -06h56 LMT on 21 Oct

or rather

= **17h04 LMT on 20 Oct**

(-06h56 + 24h00)



120° ÷ 15 = 8hr
12° ÷ 15 = 0.8 hr or 48min

Therefore the time difference is 8h48min

Note: As the resultant answer after subtracting 08h48 from 01h52 is negative, it is an indication that the local date must change. Adding 24h00 will result in the correct time.

8.4.2 Coordinated Universal Time

UTC is the LMT at the meridian that runs through the observatory at Greenwich. This is the 000° meridian, which is also known as the Prime Meridian.

UTC is the universal time for all aviation related issues, which ensures that watches do not have to be changed as longitude is changed, whilst airborne.

Only at the Greenwich meridian will the time in UTC relate directly to where the sun is in the sky.

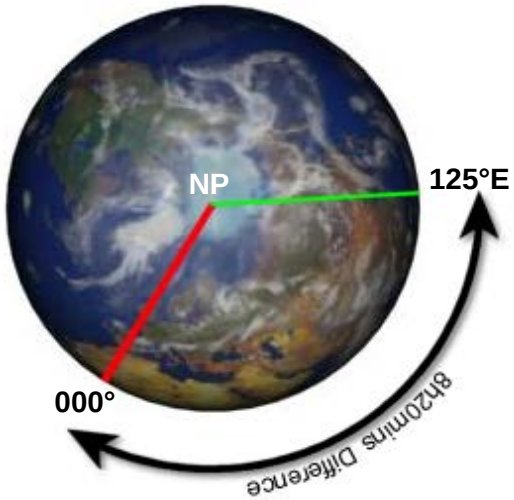
At longitudes relatively far from 000°E/W, such as Adelaide at 138°E, the time in UTC and daylight conditions at this position would not match.

For this reason UTC is not used for day to day life activities.

UTC can be converted to LMT at other meridian by applying change in longitude, as UTC is basically a specific meridian's LMT. (000°E/W meridian in this case).

8.4.2.1 LMT to UTC Conversion

Example 1: The LMT at 125°E is 15h27 on 5 March, what is the time in UTC?



120° ÷ 15 = 8hrs
5° x 4 min = 20 min

Therefore the time difference is 8h20 min

Chlong is 125° (125° - 000°). Time at 000° is calculated as follows:

Time decreases to the west, therefore the time will be earlier at the 000°E/W meridian, compared to 125°E.

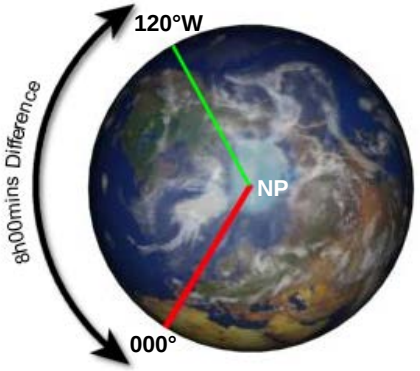
Time difference:

= 15h27 LMT - 08h20min

= **07h07 on 05** March OR **050707** as a six-figure date/time group.

8.4.2.2 UTC to LMT Conversion

Example 2: The UTC at 120°W is 06h00 on 15 September. What is the LMT at this position?



120° ÷ 15 = 8hrs

Therefore the time difference is 8h00 min

Chlong is 120° (120° - 000°). Time at 120W° is calculated as follows:

Time decreases to the west, therefore the time will be earlier at 120°W, compared to the 000°E/W meridian.

Time difference:

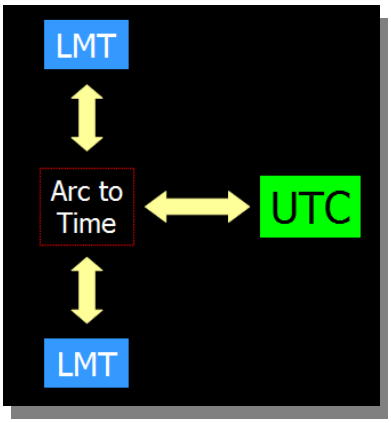
= 06h00 UTC - 08h

= -02h00 on 15 September, or rather

= **22h00 on 14 September (-02h00 + 24h00)**

OR alternatively **09142200** expressed as an eight-figure date time group.

8.4.3 Rules to Remember



The following rules are important when carrying out time calculations:

- To an observer on earth the sun appears to orbit the Earth from east to west.
- LMT East of Greenwich is later (+) and west is earlier (-) than that of Greenwich.
- Convert arc (ch long) into time or vice versa, then using UTC as a reference, start the calculation for conversions between LMT and UTC.
- The calculation is a basic addition or subtraction of time and as midnight (00H00) is passed, the date will change.

8.5 Zone Time and Standard Time

Time zones were created by dividing the Earth's surface into 24 zones, each zone is 15° longitude wide and with the time of the central meridian through the zone.

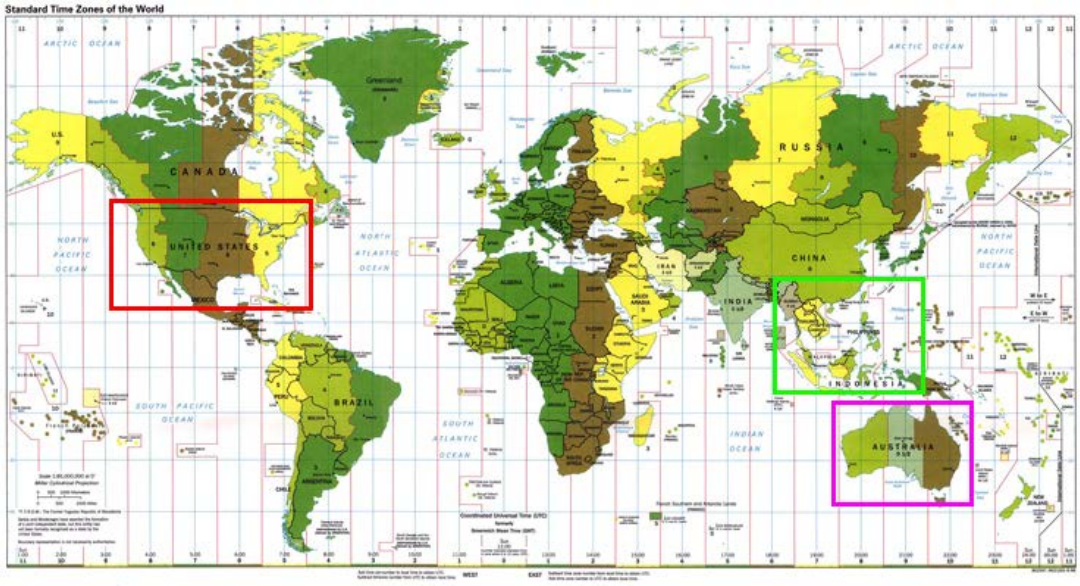
Having an area 15° longitude wide with the same time is advantageous for daily time activities and movements, without the need to reset our watches when a relatively small change in longitude occurs.

8.5.1 Standard Time

Standard time was derived from the concept of zone time. On land, each country or state decides its own time standard, which approximates to zone time but whose boundaries are not confined to specific meridians.

In Australia where the country is divided into three time zones, time in Perth is 2 hours earlier than that of Sydney.

Standard time is used to reduce time zone confusion within countries or territories and is the type of time used for day to day activities.



See below for an explanation of the 3 marked areas.

In the United States, it would be impractical to use one time zone for the whole country.

The country is divided into four time zones, and they are known as Eastern Standard Time (**+5**), Central Standard Time (**+6**), Mountain Standard Time (**+7**) and Pacific Standard Time (**+8**).

At least three different time zones cover south-east Asia.

Singapore observes Western Standard Time which is **+7**.

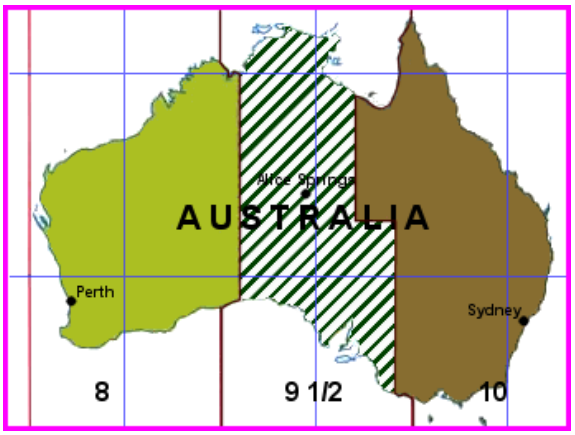
Malaysia observes Central Standard Time which is **+8**

New Guinea observes Eastern Standard Time which is **+9**.

Although the general rule is to keep the standard time zones as rounded hours, there are a few exceptions.

Australia is divided into three time zones, one of which is **9.5 hours**.

Australian Standard Time Zones are listed in Jeppesen, Tables and Codes page AU11.



The UK Air Almanac can be consulted for Standard Times of other parts of the world.

The amount of hours a country or state, is ahead or behind UTC is promulgated in the UK Air Almanac and contains three listings:

- List I – Places ahead of UTC (mainly those East of Greenwich)
- List II – Places keeping UTC (mainly places close to Greenwich)
- List III – Places behind UTC (mainly places West of Greenwich)

An extract of one of these lists:

STANDARD TIMES (Corrected to March 2012)

LIST I — PLACES FAST ON UTC (mainly those EAST OF GREENWICH)

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

	h	m
Admiralty Islands	10	
Afghanistan	04	30
Albania*	01	
Algeria	01	
Amirante Islands	04	
Andaman Islands	05	30
Angola	01	
Armenia	04	
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	
Whitsunday Islands	10	
Austria*†	01	
Azerbaijan*	04	

	h	m
Denmark*†	01	
Djibouti	03	
Egypt, Arab Republic of	02	
Equatorial Guinea, Republic of	01	
Eritrea	03	
Estonia*†	02	
Ethiopia	03	
Fiji*	12	
Finland*†	02	
France*†	01	
Gabon	01	
Georgia	04	
Germany*†	01	
Gibraltar*	01	
Greece*†	02	
Guam	10	
Hong Kong	08	
Hungary*†	01	

* Daylight-saving time may be kept in these places. † For Summer time dates see List II footnotes.
1 Except Broken Hill Area* which keeps $09^h\ 30^m$.
2 Except Pohnpei, Pingelap and Kosrae which keep 11^h and Palau which keeps 09^h.
3 The Line and Phoenix Is. not part of the Kiribati Republic keep 10^h and 11^h, respectively, slow on UTC.

Note: Many countries in the middle latitudes advance their standard times by 1 hour in the summer months - the actual times are usually also listed in the Air Almanac and other documents.

8.5.2 Summer Time

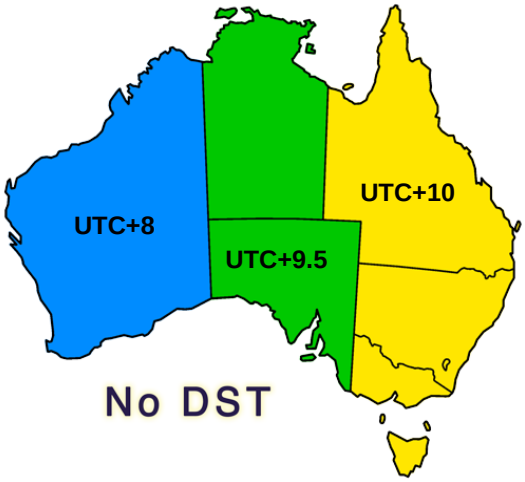
In most parts of Australia the time is advanced by one hour during the summer months and referred to as ''summer time'' or ''daylight savings time''. Daylight Savings Time (DST) is a Standard Time type of time, i.e. an area keeping the time of a certain meridian within that zone.

Parts of Australia observe daylight savings time during the summer months, from October to April the succeeding year.

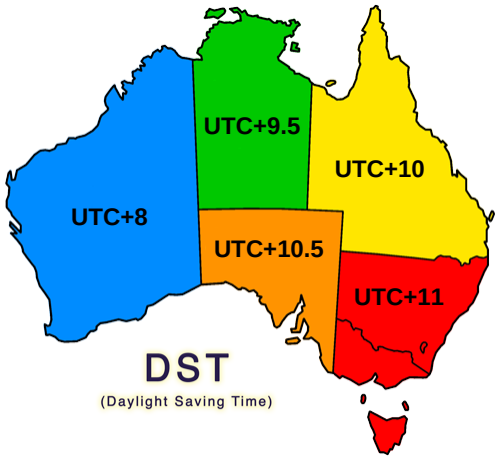
The standard time zones of Australia excluding daylight savings time (i.e. during the winter months) is shown below. Australia has three standard time zones:

- Western Standard Time (WST) eight hours ahead of UTC and kept by the state of Western Australia.
- Central Standard Time (CST) nine and a half hours ahead of UTC and kept by the Northern Territory, South Australia and the Broken Hill area.

- Eastern Standard Time (EST) ten hours ahead of UTC and kept by Queensland, New South Wales (except the Broken Hill area), Victoria, Tasmania and the Australian Capital Territory.



During the summer months, when daylight savings time is introduced, the south eastern states of Australia advance clocks by 1 hour. The five time zones are:



- Western Australia remains on WST as UTC+8.
- The Northern Territory remains on CST as UTC+9.5.
- Queensland remains on EST as UTC+10.
- South Australia (including the Broken Hill area) switches to summertime and now uses Central Summer Time (CSuT) as UTC+10.5.
- New South Wales (excluding the Broken Hill area), Victoria, Tasmania and the Australian Capital Territory all observe summertime and keep Eastern Summer Time (ESuT) as UTC+11.

In Australia all longitudes are east of the Greenwich meridian. So our LMT and LST are ahead of the UTC datum. Therefore, always subtract from LMT or LST to obtain UTC.

NOTAMS advise the start date/time and end date/time for Summertime in Australia for the times of operation of aeronautical facilities.

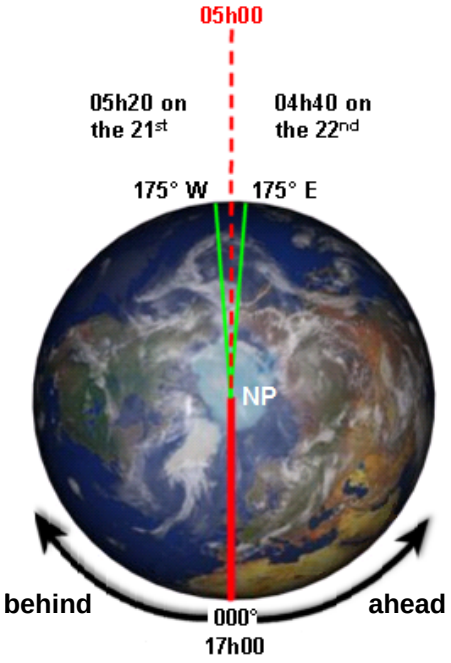
8.5.3 International Date Line

An imaginary line called the **International Date Line (IDL)** separates the 12th zone east and the 12th zone west. The line is halfway around the world from the 000° meridian, and generally follows the 180°E/W meridian.

The LMT of places east of 000° is ahead of UTC, and places west of 000° are behind UTC.

If the time at the 000° meridian is 17h00 on the 21st, the time at 175°E will be 04h40 on the 22nd (175° chlong is 11 hours, 40 minutes), and at 175°W the time will be 05h20 on the 21st.

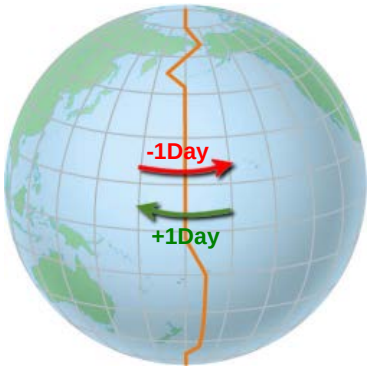
The time at the 180° line will be 05h00 and the date will differ by one day.



On crossing the International Date Line, one day is added on **westerly tracks** and one day is subtracted on **easterly tracks**.

Note:

The date line deviates from the anti-meridian (180 deg E/W) in places to avoid date changes occurring in the middle of populated regions.

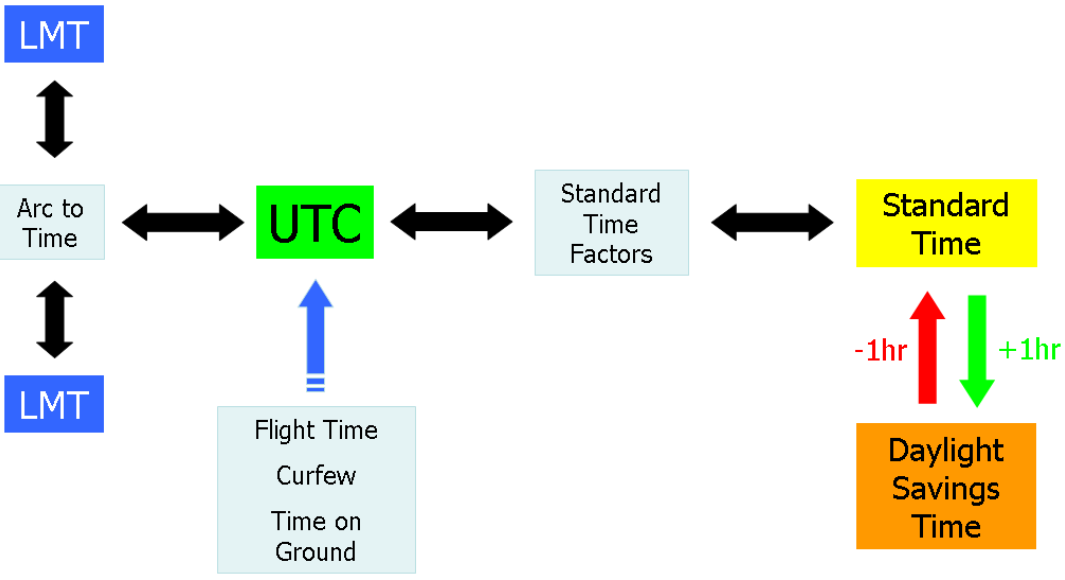


8.5.4 Summary of Time Conversions

The aviator is required to operate in various systems of time:

- LMT is used to define the times of astronomical events.
- UTC is used for all aviation related operations.
- Standard Time and Daylights Savings Time is used for day to day activities.

Methods to covert time:



When converting between LMT and Standard Time always convert to UTC (as a common reference) and then apply flight times, time on the ground, holding periods, etc. before continuing the calculation.

Date changes are calculated with negative time values or hours in excess of 24 hours.

8.6 Factors Affecting the Beginning and End of Daylight

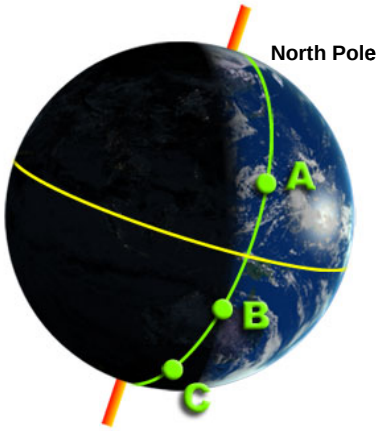
The time of beginning of daylight (first light and sunrise) and end of daylight (last light and sunset) changes throughout the year as the seasons change. In winter the days are shorter and in summer longer.

The time for beginning of daylight (BoD) will be earlier in summer than in winter and the time for end of daylight (EoD) will be later.

The time of beginning of daylight and end of daylight also changes with change in latitude of an observer.

Example: Southern hemisphere in winter (June).

Positions **A**, **B** and **C** all have the same LMT being along the same meridian. The time at the meridian is 06h00 LMT.



'A' is in daylight, i.e. beginning of daylight has occurred.

'B' is experiencing the BoD at 06h00 LMT.

'C' is still in darkness and BoD will occur after 06h00 LMT.

Due to the latitude difference between the three positions there are differences in the time that BoD and EoD will occur.

Therefore, only the latitude of the observer and day of the year affect the LMT of BoD and EoD (see daylight and darkness graphs in the Jeppesen Manual).

The graphs assume a perfect horizon in terms of LMT. Terrain features and environmental conditions can cause a difference in daylight start and end times as shown in the graphs.

Significant Cloud Cover

Poor Visibility

High Ground to the West

VFR flights (unless night VFR rated) shall not depart from an airport:

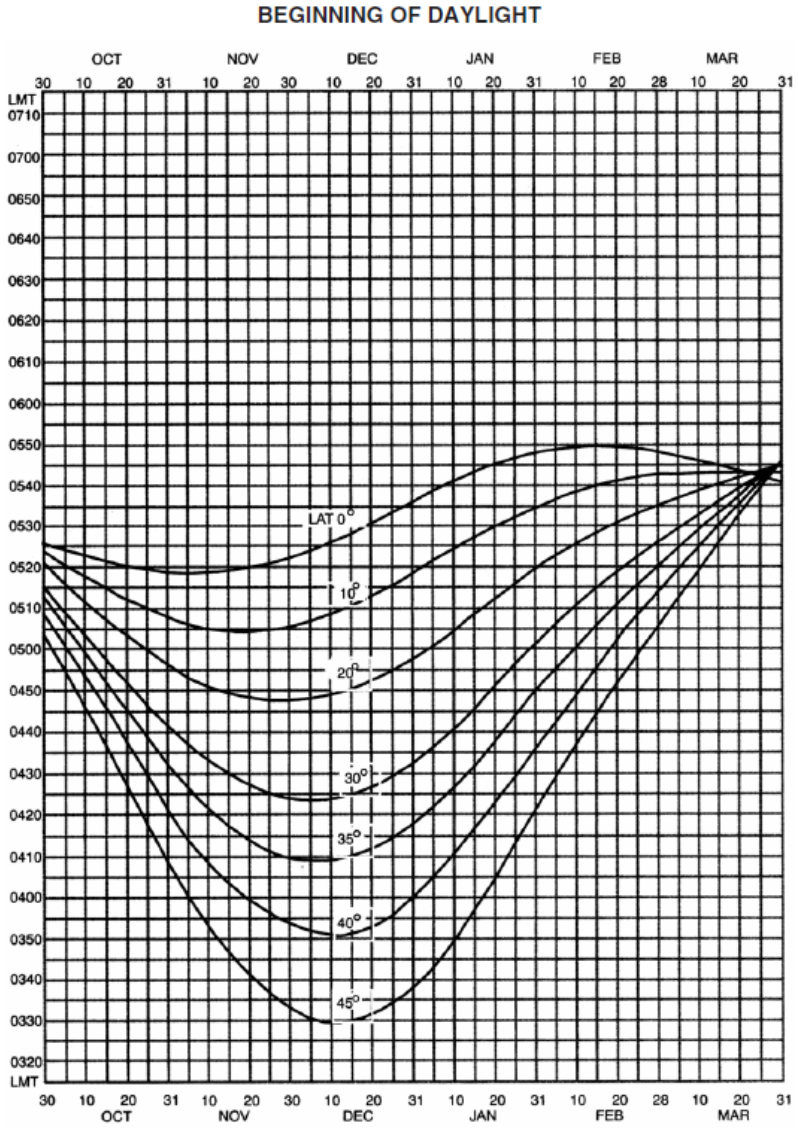
- Before first or after last light.
- Unless the **planned ETA** at the destination (or alternate) is **at least 10 minutes** before last light, after allowing for any required holding. (CASA requirement – Refer Jeppesen Air Traffic Control Section page AU506.)
- Solo VFR navigation flights the **ETA at destination must be no later than 1 hour** before the EoD (refer to the Operations Manual).

8.6.1 Daylight and Darkness Graphs

The LMT for both BoD and EoD can be extracted from the daylight and darkness graphs in the AIP or Jeppesen. Refer to Jeppesen Volume 1 - Tables and Codes - AU13 to AU16 and the instructions on page AU11.

If the time for BoD or EoD is required in any other format than LMT, the time should first be converted to UTC. Flight times, holding periods or curfews should be applied to the UTC time when doing time conversion calculations.

An example of the beginning of daylight graph for the time period October to March can be found below. The daylight and darkness graphs method of use is the same.



- Enter the graph with date and latitude to nearest degree
- Extract the LMT for BoD to the nearest 5 minutes.