CALENDARIUM SOLARIS

# Scientific Foundations

*The astronomical and metrological basis of the calendar system*

**Scientific Foundations v1.0 — Companion document to Full Specification v3.08.1**
Trial period commences: Equinox 0°, 2026 (UTC)
Official epoch: Equinox 0°, Year 0, 2028 (UTC)

## Introduction

This document sets out the scientific foundations of the Calendarium Solaris. It is intended as a companion to the Full Specification and addresses the questions most likely to arise when the calendar system is presented to official bodies, academic institutions, or the wider public: What is the calendar based on? How accurate is it? How does it compare to existing systems? And what is the source of its key figures?

The Calendarium Solaris is grounded in established astronomical science. All values and definitions referenced in this document are consistent with those maintained by the International Astronomical Union (IAU) and other internationally recognised scientific bodies.

## 1. The Tropical Solar Year

### 1.1 What it is

The Calendarium Solaris is based on the tropical year — the average time it takes the Sun to return to the same position in the sky as seen from Earth, measured from one Equinox 0° to the next. This is the natural cycle that governs the seasons, and it is therefore the scientifically appropriate basis for a solar calendar intended for civil use.

The word “tropical” derives from the Greek tropos, meaning “turn”, referring to the Sun’s apparent turning points at the solstices and equinoxes.

### 1.2 The value used

The International Astronomical Union (IAU) gives the mean tropical year at the J2000.0 reference epoch as:

***365.24219 days ≡ 365 days, 5 hours, 48 minutes, 45 seconds***

This is the value against which the accuracy of the Calendarium Solaris intercalation is measured. It is derived from long-term observations and numerical modelling of the solar system, and is accurate to within a fraction of a second.

The tropical year is not perfectly constant: it shortens very slowly over geological timescales (by approximately half a second per century), and individual years vary by up to about 30 minutes due to the gravitational influence of the Moon and other planets. For practical calendar purposes, the mean value is the appropriate reference.

### 1.3 Comparison of year lengths

| Year type | Length (days) | Basis |
|---|---|---|
| Mean tropical year (IAU, J2000.0) | 365.24219 | Average equinox-to-equinox interval; basis for seasonal calendars |
| Calendarium Solaris (mean) | 365.24225 | Defined by the Solaris intercalation rules |
| Gregorian calendar (mean) | 365.24250 | Defined by the Gregorian leap-year rule |
| Julian calendar (mean) | 365.25000 | One leap day every four years, no exceptions |
| Sidereal year | 365.25636 | Earth’s orbital period relative to background stars |

The Calendarium Solaris mean year of 365.24225 days is closer to the tropical year than the Gregorian calendar by a factor of approximately five, resulting in a substantially lower long-term drift.

## 2. The Structure of the Year: 12 Months of 30 Days

### 2.1 Why 12 months of 30 days, and not 13 months of 28 days

The 13-month structure has genuine appeal and is a recurring proposal in calendar reform. The Calendarium Solaris chooses 12 months of 30 days for reasons that are astronomical, mathematical, and practical.

### The lunar argument for 13

A synodic month (new moon to new moon) averages 29.53059 days. Since there are approximately 12.37 such cycles in a tropical year, neither 12 nor 13 fits the moon exactly. A calendar cannot simultaneously align with both the Sun and the Moon without a separate correction system. The Calendarium Solaris anchors solely to the Sun.

*Source: Encyclopaedia Britannica, “Synodic month”; Chapront-Touzé and Chapront (1988), Astronomy and Astrophysics, 190, pp. 342–352.*

### 12 is a highly composite number; 13 is prime

12 is the smallest positive integer with exactly six divisors: 1, 2, 3, 4, 6, and 12. This makes it straightforward to divide a year into halves, thirds, quarters, and sixths without fractions. 13 is a prime number. A 13-month year cannot be divided into equal quarters, halves, or thirds in whole months, which creates a structural mismatch with virtually every planning cycle used by businesses, governments, and institutions.

*Source: Ramanujan, S. (1915), “Highly Composite Numbers”, Proceedings of the London Mathematical Society, 14, pp. 347–409.*

### The four cardinal points of the solar year

The four moments of Equinox 0°, Solstice 90°, Equinox 180°, and Solstice 270° are precise, calculable astronomical events. A 13-month calendar has no natural structural connection to these four points. The Calendarium Solaris places them explicitly into the year structure as Anchor Days.

### Week stability achieved differently

The main practical attraction of 13×28 days is that every month contains exactly four seven-day weeks, eliminating week drift. The Calendarium Solaris achieves the same result through a five-day week in a 30-day month: every date always falls on the same weekday, without sacrificing the four-point solar structure or the divisibility of 12.

### A note on the menstrual cycle argument

The 13-month calendar has sometimes been promoted on the grounds that the average menstrual cycle is approximately 28 days. Clinical research shows that menstrual cycle length varies considerably between individuals, typically ranging from 23 to 35 days, with a population average closer to 29 days than to 28. The 28-day figure is a statistical approximation, not a biological constant, and it applies to approximately half of the world’s population. It does not constitute a universal human rhythm on which to base a global calendar.

*Sources: Gorrindo et al., American Journal of Obstetrics and Gynecology, 2007; Liang et al. (2023), npj Digital Medicine.*

## 3. The Five-Day Week

### 3.1 The seven-day week has no astronomical basis

The conventional seven-day week originates in ancient Babylonian tradition and was later adopted through Jewish and Roman calendrical practice into the Gregorian system. It does not correspond to any astronomical cycle. Because seven does not divide evenly into 30-day months or into a 365-day year, the seven-day week causes dates to fall on different weekdays each year, generating continuous administrative complexity.

*Source: Zerubavel, E. (1985), The Seven Day Circle, University of Chicago Press.*

### 3.2 The five-day week in the Calendarium Solaris

The Calendarium Solaris replaces the seven-day week with a five-day week: Solcycli, Luxcycli, Maxcycli, Descycli, and Paxcycli. Five divides exactly into 30-day months, producing exactly six complete weeks per month and a calendar in which every date always falls on the same weekday, every year, without exception.

## 4. Equinoxes and Solstices

### 4.1 The Anchor Days

The four cardinal points of the solar year are formally embedded in the Calendarium Solaris as Anchor Days. Each Anchor Day carries the name of the astronomical moment it represents: Equinox 0°, Solstice 90°, Equinox 180°, and Solstice 270°. These are Outside Days: they carry no weekday designation and no month-day status. They are self-contained days whose identity is defined solely by the astronomical event they mark.

- Equinox 0°: the moment at which the Sun’s apparent ecliptic longitude is 0°, crossing the celestial equator moving northward. Day and night are approximately equal in length worldwide.
- Solstice 90°: the moment at which the Sun reaches its maximum northern declination.
- Equinox 180°: the Sun crosses the celestial equator moving southward. Day and night are approximately equal in length worldwide.
- Solstice 270°: the moment at which the Sun reaches its maximum southern declination.

### 4.2 Why equinoxes and solstices vary in Gregorian date

The equinoxes and solstices do not fall on the same Gregorian calendar date each year. The interval between successive Equinox 0° moments approximately equals the tropical year, but the Gregorian calendar advances the equinox by roughly 5 hours and 49 minutes each common year and then pulls it back by roughly 18 hours in a leap year.

| Quarter | From → To | Approx. duration |
|---|---|---|
| Q1 | Equinox 0° → Solstice 90° | ~92.8 days |
| Q2 | Solstice 90° → Equinox 180° | ~93.6 days |
| Q3 | Equinox 180° → Solstice 270° | ~89.8 days |
| Q4 | Solstice 270° → Equinox 0° | ~89.0 days |

The Calendarium Solaris assigns 91 days to each quarter by convention. The Anchor Days are designed to float with the actual astronomical moment rather than being fixed to a rigid day number.

### 4.3 Why Equinox 0° as the annual starting point

- It is the zero-point of the standard ecliptic coordinate system used in astronomy worldwide.
- It is the most precisely determinable of the four cardinal points, as the Sun’s rate of change in declination is greatest at the equinoxes.
- It is hemispherically neutral: the names Equinox 0° and Equinox 180° carry no hemispheric, cultural, or seasonal connotation.

## 5. Intercalation and Long-Term Accuracy

### 5.1 The need for intercalation

A calendar year must consist of a whole number of days. Since the tropical year is approximately 365.24219 days, a fixed 365-day calendar would drift by roughly one full day every four years, and by an entire season every 370 years.

### 5.2 The intercalation rules

- Years divisible by 4 receive an Intercalary Day.
- Years divisible by 100 do not (exception to the above).
- Years divisible by 400 do (exception to the 100-year rule).
- Years divisible by 4,000 do not (long-term correction).

These four rules together produce a mean year of exactly 365.24225 days, calculated as 365 + ¼ – ⅟■■■ + ⅟■■■ – ⅟■■■■.

### 5.3 Accuracy and drift

The difference between the Calendarium Solaris mean year (365.24225 days) and the tropical year (365.24219 days) is approximately 0.00006 days per year. This corresponds to a drift of approximately one day every 16,667 years — stated conservatively in the specification as “approximately one day per 16,000 years”.

Both the Solaris figure (16,000 years) and the Gregorian figure below (3,200 years) are stated conservatively. The exact calculated values are 16,667 years and 3,226 years respectively. Both are rounded to reflect the inherent uncertainty introduced by the slow secular shortening of the tropical year over geological timescales.

| Calendar | Mean year | Drift from tropical year |
|---|---|---|
| Julian | 365.25000 days | ~1 day per 128 years |
| Gregorian | 365.24250 days | ~1 day per 3,200 years |

| | | |
|---|---|---|
| Calendarium Solaris | 365.24225 days | ~1 day per 16,000 years |

The Gregorian calendar’s fourth-tier correction (dropping a leap year every 4,000 years) has been proposed by various calendar scholars but was never formally incorporated. The Calendarium Solaris includes this correction as a defined rule from the outset.

### 5.4 The 16,000-year review provision

No fixed intercalation scheme can remain perfectly accurate indefinitely. The Calendarium Solaris therefore includes an explicit provision for a review at year 16,000 P.O. Rather than claiming permanent perfection, the calendar acknowledges the limits of present knowledge and builds in the means to adapt.

## 6. Long-Period Orbital Variations

Several long-period astronomical cycles affect the precision of any solar calendar over very long timescales. They do not affect the calendar’s operation in the near term but are relevant to the 16,000-year review provision.

- Precession of the equinoxes (~26,000 years): Earth’s rotational axis slowly traces a circle in space. A calendar based on the tropical year remains aligned with the seasons regardless of this shift.
- Obliquity cycle (~41,000 years): Earth’s axial tilt oscillates between approximately 22.1° and 24.5° (currently 23.44°). No material impact on the tropical year at calendar-relevant timescales.
- Apsidal precession (~21,000 years): The orientation of Earth’s elliptical orbit slowly rotates, changing the relative lengths of the four solar quarters over very long periods, but averages out over a full cycle.

## 7. Coordinated Universal Time (UTC)

### 7.1 What UTC is

Coordinated Universal Time (UTC) is the primary international time standard, maintained by the Bureau International des Poids et Mesures (BIPM) in Paris under the authority of the General Conference on Weights and Measures (CGPM). It is based on a weighted average of data from approximately 450 atomic clocks in around 85 national laboratories worldwide. UTC belongs to no nation, organisation, or culture.

### 7.2 Why UTC governs the Calendarium Solaris

- Universality: a UTC moment is simultaneous worldwide, independent of geography, time zone, or local civil arrangements.
- Precision: the moment of the equinox can be calculated and published years in advance to a precision far exceeding any practical calendar requirement.
- Neutrality: UTC is governed by an international treaty body with 64 member states. It belongs to no nation, religion, or culture.
- Compatibility: anchoring to UTC ensures full traceability to existing global time infrastructure.

### 7.3 Practical determination of Equinox 0°

The precise UTC moment of each Equinox 0° is calculated using established numerical solar system models, principally the JPL Development Ephemeris series maintained by NASA’s Jet Propulsion Laboratory. The 2026 Equinox 0° occurred on 20 March 2026 at 14:46 UTC. The 2028 Equinox 0° is expected on 20 March 2028 at approximately 02:17 UTC.

## 8. Historical Context

### 8.1 The Julian calendar (46 BC – 1582 AD)

The Julian calendar established a 365-day year with a leap day every four years, giving a mean year of 365.25 days. This overestimated the tropical year by approximately 11 minutes per year. Over thirteen centuries, the error accumulated to ten full days.

### 8.2 The Gregorian reform (1582)

Pope Gregory XIII reformed the calendar in 1582 based on the work of Aloysius Lilius and Christopher Clavius. The reform reduced the annual drift from approximately 11 minutes to approximately 27 seconds. A residual drift of roughly one day per 3,200 years remains. The Calendarium Solaris incorporates the proposed fourth-tier correction as a defined rule from the outset.

### 8.3 Prior calendar reform proposals

Notable proposals include the World Calendar, the International Fixed Calendar, the Hanke-Henry Permanent Calendar, and the Symmetry454 calendar. The Calendarium Solaris differs from all of these: it replaces the Gregorian framework entirely with a system grounded in astronomical science from the outset.

*Sources: Steel, D. (2000), Marking Time, Wiley; Bromberg, I. (2004), “The Symmetry454 Calendar”, University of Toronto.*

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