Universal Times v4.2

Randall Gossett — Creator / Architect, Extropy Engine

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Universal Times

Dual-System Temporal Infrastructure, Entropy Economics, and the Post-Calendar Coordination Problem

A Formal Specification for Hydrogen-Anchored Universal Timekeeping with Entropy-Based Value Minting on Directed Acyclic Graphs

Randall Gossett — Creator / Architect, Extropy Engine With AI co-authors: Comet (Perplexity) and ChatGPT 5.4 July 2026 — **Version 4.2** *Codex-aligned: formula canonical-v3.1.3, protocol v0.1*

Version History

Version 4.2 Change Notes

Version 4.2 incorporates public discussion feedback (Academia.edu, July 2026) and independent technical review. The dual-system architecture, hydrogen frequency anchor, decimal local clock, universal duration vocabulary, planet-profile model, and Extropy Codex v2.0 alignment are preserved. Corrections address claims that exceeded what the physics, topology, or distributed-systems architecture supports.

1. **Epoch redefined.** The Extropy Engine DAG genesis is no longer the origin of Universal Times. The epoch is cosmological: t:0 corresponds to the origin of the observable universe (the Big Bang), calibrated via the cosmic microwave background. The DAG genesis is a ledger-local event with no authority over physical time.

2. **Thermodynamic claims qualified.** A quant is a duration corresponding to one nominal hydrogen-1 hyperfine period. It is not a claim that every counted period is a separate spontaneous decay or entropy-producing event.

3. **Entropy model clarified.** Physical thermodynamic entropy, Shannon information entropy, and governance-defined domain proxies are distinguished. "Entropy reduction" in the XP system is an operational measurement under a versioned domain operator, not a literal thermodynamic claim outside physical domains.

4. **Metrological qualification.** Hydrogen is selected for simplicity, universality, and recognizability. Cesium's long-term stability advantage and optical clocks' superior accuracy are acknowledged. A production ensemble approach is described.

5. **Relativistic qualification.** Universal Position is frame-qualified. The system does not assert a single observer-independent universal present.

6. **DAG role corrected.** The DAG records and validates event order and timestamp claims. It does not create physical time. Absolute security claims are replaced with bounded guarantees under stated assumptions.

7. **Noether's theorem corrected.** Section 19 symmetries are architectural analogues, not claims about conserved quantities from a Lagrangian.

8. **Cultural legitimacy acknowledged.** New subsection distinguishes computational regularity from cultural neutrality.

9. **Seven-day week claim qualified.** Circaseptan biological rhythms acknowledged. The five-day cycle is an optional decimal alternative.

Version 4.1 Change Notes

Version 4.1 reconciled Universal Times with Extropy Codex v2.0 (Comprehensive Edition, July 2026):

1. XP formula retirement and replacement (canonical-v3.1.3)
2. Token economy correction (exactly six tokens; TT retired)
3. Domain alignment (eight canonical domains)
4. Cross-references to Codex v2.0 and Appendix P

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Abstract

This paper presents Universal Times, a temporal representation and coordination architecture that separates three distinct functions: local temporal position, elapsed duration, and frame-qualified event coordinates. The system uses the hydrogen-1 ground-state hyperfine transition frequency (1,420,405,751.768 Hz) as its physical reference and architecturally separates planet-specific clock coordinates from planet-independent duration units.

System 1, the Solar Clock, represents position within a local solar day using a base-10 decimal architecture: 10 loops per day, 100 arcs per loop, 100 ticks per arc, yielding 100,000 ticks per local solar day. Loop, Arc, and Tick are coordinate labels—they tell you WHERE you are in your local day, not how long something takes.

System 2, Universal Duration, represents elapsed intervals using decimal powers of the hydrogen-1 hyperfine period: Pulse (10^11 periods, ~70 seconds), Wave (10^12, ~12 minutes), Tide (10^13, ~2 hours), Spin (10^14, ~20 hours), Current (10^15, ~8 days), Season (10^16, ~81 days), and Epoch (10^17, ~2.2 years). These units retain the same nominal duration everywhere the defining frequency can be realized.

System 3, Universal Position, represents events using frame-qualified quant coordinates anchored to a cosmological epoch (the Big Bang), calibrated via the cosmic microwave background. The system does not assert a single observer-independent universal present.

Beneath both systems lies the **Quant** — one period of the hydrogen-1 ground-state hyperfine transition at the adopted reference value of 1,420,405,751.768 Hz. The quant is a definitional duration anchor corresponding to that transition's period. Time measurement counts periods of this reference frequency. Value measurement (XP) counts verified reductions in domain-specific disorder under governance-defined operators. The Extropy Engine relates both against a shared temporal foundation.

The temporal substrate operates on a directed acyclic graph (DAG) providing causal ordering, attestation, and auditability. Every economic event on the Extropy Engine is

bound to a specific quant range through the DAG's native timestamping. The Extropy Engine operates a six-token economy (XP, CT, CAT, IT, DT, EP) that separates reputation from economic value, specialization from influence, and individual achievement from ecosystem participation. Its entropy-based value model is an operational measurement framework—not a claim that all forms of improvement are literally thermodynamic.

Universal Times runs in parallel with Gregorian calendars, UTC, and SI standards. It does not abolish them. Adoption is voluntary, incremental, and utility-driven, in deliberate contrast to the coercive history of calendar reform.

Section 1: Introduction and Historical Context

1.1 Legacy Timekeeping and Its Limits

Current civil timekeeping is dominated by two intertwined constructs: the Gregorian calendar, which encodes days, months, and years in a heterogeneous base structure with irregular month lengths and leap-year rules; and SI-based clock time, which defines the second via the cesium-133 hyperfine transition but still layers hours, minutes, and time zones in Earth-specific, culturally contingent ways.

This arrangement is functional but not coherent. It mixes astronomical cycles (Earth's rotation and orbit), historical compromises (religious weeks, political calendar reforms), and machine-unfriendly arithmetic (base-60, base-24, irregular months). These choices create persistent friction for distributed systems, formal reasoning, and any attempt to unify time with thermodynamics or information theory.

More fundamentally, every existing timekeeping system commits a category error that has gone unexamined for millennia: it uses the same units for two fundamentally different purposes. When someone says "it's 3 o'clock," they are stating a position — where they are in the rotation of their planet. When someone says "that takes 3 hours," they are stating a duration — how long something persists. Legacy timekeeping uses "hours" for both, as if the same word should mean both "latitude" and "miles." Universal Times identifies and resolves this conflation.

1.2 Calendar Reform as a Coordination Failure

Multiple attempts at rational calendar and time reform have failed, despite technical merit.

The **French Revolutionary Calendar** (1793–1805) introduced decimal time and rational month structures: 12 months of 30 days each, divided into three 10-day decades, plus 5–6 intercalary days, and decimal time (10 hours/day, 100 minutes/hour, 100 seconds/minute) — identical in structure to the Solar Clock architecture proposed here. It failed because it was imposed by coercion, aimed at cultural obliteration of religious and royalist markers, and provided no individual utility advantage. Napoleon abolished it in 1805.

The **World Calendar** and related League of Nations proposals (1930s) failed at the coordination problem: religious groups objected to breaking the 7-day Sabbath cycle, governments could not agree on a transition date, and the cost-benefit for any individual nation was unfavorable absent universal adoption.

The **Soviet continuous work week** (1929–1940) destroyed social coordination and was abandoned within a decade.

The **Gregorian reform** (1582) succeeded because it solved a concrete, bounded problem (Easter drift). Even so, adoption took over 300 years globally.

The lesson: calendar reforms fail when imposed and succeed when they solve real problems better than the existing system.

1.3 Computational Regularity and Cultural Legitimacy *(new in v4.2)*

Calendar irregularity and calendar legitimacy are different problems.

Gregorian and related civil calendars contain irregular arithmetic, but their social role cannot be evaluated solely as an engineering defect. Calendars encode religious observance, political history, agricultural practice, collective memory, and cultural identity. A mathematically regular calendar is not automatically culturally neutral.

The Gregorian calendar was not imposed globally because it was computationally optimal. It spread through colonial, commercial, and diplomatic power. Its irregularities create genuine engineering friction. But a computationally regular replacement does not automatically inherit cultural neutrality.

Universal Times addresses the engineering problem — providing a coherent, machine-native, physics-grounded coordination layer. It does **not** claim to solve the legitimacy problem. A community's calendar encodes religious observance, agricultural rhythm, collective memory, and political identity. These functions are not served by decimal regularity alone.

The architectural response is **Layer 4 autonomy**: any community may retain Gregorian, Islamic, Hebrew, Hindu, Chinese, Indigenous, or other calendar conventions at the display and governance layer while using Universal Duration and frame-qualified coordinates for technical interoperability. The protocol standardizes conversion interfaces, not cultural meaning.

Universal Times is offered as an optional coordination substrate — not as a claim that one civilization's calendar should displace another's. If it earns adoption, it earns it through utility in technical coordination, not through any assertion of cultural superiority.

1.4 Universal Times as a Parallel Temporal Layer

Universal Times is explicitly designed as a parallel temporal layer. It does not attempt to abolish Gregorian calendars or SI seconds. It runs alongside them, providing:

- A dual-system architecture that separates temporal position from temporal duration
- A hydrogen-anchored physical foundation for a common duration and coordinate scale
- A decimal, machine-native representation of local time
- A universal duration vocabulary that means the same thing on every planet

- A DAG-native model for event ordering and value minting
- A DAG that functions as a distributed temporal attestation layer and structural calendar through native quant timestamping

All implementations MUST support bidirectional conversion between Universal Times formats and legacy time formats (UTC, ISO-8601). During initial adoption, most interfaces SHOULD display both Universal Times and conventional time side by side. The adoption model is voluntary, incremental, and utility-driven.

> **In Plain Terms:** Universal Times is an overlay. You can keep using normal dates and clock times. It adds a new grid underneath that is better for machines, mathematics, and entropy-based value systems. If it wins, it wins because it works better, not because anyone banned the old system.

1.5 What Changed from Previous Versions

This specification (v4.2) carries all architectural advances from v4.0–v4.1 plus the v4.2 corrections above.

- Versions 1–2 treated the "tick" as both clock unit and duration unit. Version 4 separates them completely.
- Versions 1–2 back-solved tick length from Earth's solar day. Version 4+ defines universal duration from powers of 10 of hydrogen hyperfine periods.
- Versions 1–2 used legacy vocabulary with redefined meanings. Version 4+ introduces Loop/Arc/Tick and Pulse/Wave/Tide/Spin/Current/Season/Epoch.
- Version 4.1 retired the pseudo-physics XP formula, corrected tokens from seven to six, and aligned eight domains.
- **Version 4.2** redefines the epoch cosmologically, qualifies thermodynamic and entropy claims, corrects DAG role language, fixes Noether overclaim, and adds cultural legitimacy framing.

Section 2: Philosophical and Physical Foundations

2.1 Time, Entropy, and the Arrow of Time

The deepest question in the philosophy of time is deceptively simple: why does time have a direction? The laws of physics at the quantum and classical levels are almost entirely time-symmetric, yet experience is irreversibly directional.

The answer, developed over 150 years of thermodynamics, is entropy. The second law states that in any closed system, entropy tends to increase or remain constant. The direction of increasing entropy is the arrow of time.

This has an implication for timekeeping: a physically honest clock is one whose tick rate is tied to a reproducible physical process that participates in irreversible dynamics. Universal Times anchors its unit to the hydrogen-1 hyperfine transition frequency — a real physical process — while carefully distinguishing the *definition* of the unit from the claim that every counted cycle is itself a spontaneous entropy event (see Section 3.3).

Landauer's principle (1961) deepens the information–thermodynamics connection: erasing one bit dissipates a minimum of kT ln(2) joules. Shannon's and Boltzmann's entropy formulas are structurally related. The Extropy Engine draws on both insights operationally: it timestamps against a physics-defined frequency scale and mints value against verified reductions in domain-specific disorder.

> **In Plain Terms:** Time moves forward because the universe keeps getting messier at the microscopic level. Universal Times ties its unit to a real atomic process — a hydrogen spin-flip transition — while being honest about what a practical clock actually counts (phase cycles of a coherent oscillator, not individual spontaneous decays).

2.2 Information as Entropy Reduction

If entropy production defines the forward direction of time, then organized work often involves reducing entropy *relative to a defined description of a system*. When an engineer reduces cyclomatic complexity, a doctor narrows a differential diagnosis, or a community resolves conflict, each is producing a lower-entropy arrangement *under some measurement model*.

This is the theoretical foundation of the Extropy Engine's value metric, XP (Extropy Points). XP is not earned by putting in time — it is earned by demonstrably reducing disorder in a validated, measurable way under domain operators. Time is the denominator context. Measured disorder reduction is the numerator. The canonical formula is specified in Section 11 and Extropy Codex v2.0 Section 5.

> **In Plain Terms:** You earn XP by making things less messy in a provable way — where "provable" means under the measurement rules the system has adopted and can challenge.
>
> **Important Caveat — Entropy as Operational Model (v4.2):**
>
> "Provable entropy reduction" currently means provable *within the measurement operators defined by governance for each domain* (see Sections 17.2 and 17.8). No domain has a fully calibrated, universally accepted entropy metric as of this publication.
>
> Three distinct uses of "entropy" must be distinguished:

1. **Physical thermodynamic entropy** (J/K): Measurable in thermodynamic domains via standard methods.
2. **Shannon/information entropy** (bits): Measurable where probability distributions over states can be defined.
3. **Domain-proxy entropy** (operator scores): Defined by governance-adopted measurement operators for cognitive, social, code, economic, governance, and temporal domains.

> These quantities are related by structural analogy but are **not** naturally commensurable. The weight vector **w·E** in the XP formula constructs a comparison — it does not discover a universal physical exchange rate. Each

domain's claim is only as rigorous as its declared operator, baseline, and falsification conditions.

The system's integrity depends on these operators maturing through adversarial validation over time, not on conflating all forms of improvement into a single thermodynamic quantity.

2.3 Design Goals for a Universal Temporal Substrate

Any system that claims to be a universal temporal substrate must satisfy five properties:

Goal	Requirement
Universality	Same definition everywhere in the observable universe, independent of local astronomy
Measurability	Constructible by any civilization with basic spectroscopic capability
Physical grounding	Unit tied to a genuine, reproducible physical process
Machine-nativeness	Integer arithmetic and causal DAG ordering without floating-point ambiguity
Decoupling from local astronomy	No dependence on any specific planet's rotation or orbit

The architecture — Quant (physical anchor), Protocol Layer (universal duration), Planet Profile (local display) — is the minimal structure that satisfies these constraints.

2.4 Why Previous Specifications Were Incomplete

Previous versions missed the coordinate-versus-distance distinction. Latitude and longitude are coordinates; miles are distances. Legacy timekeeping uses "hours" for both. Across planets this becomes catastrophic: a Martian sol is ~24h 39m 35s Earth time, so "3 hours" means different durations on different worlds.

Universal Times gives each function its own vocabulary: Loop/Arc/Tick (coordinates) and Pulse/Wave/Tide/Spin/Current/Season/Epoch (distances).

Section 3: The Physical Anchor — Hydrogen-1 Hyperfine Transition

3.1 Formal Definition

Definition 3.1 (Quant): A quant is defined as one period of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the hydrogen-1 (protium) atom.

This is the 21-centimeter line, at the adopted reference frequency of **1,420,405,751.768 Hz** (1420.405751768 MHz). The quant is the smallest named unit in Universal Times. It is invisible on any clock face and never spoken in ordinary conversation. It is the physical substrate beneath all other time units.

Period: approximately **7.04 × 10^-10 seconds**.

3.2 Why Hydrogen-1

Criterion	Rationale
Abundance	H-1 ≈ 75% of baryonic matter
Reproducibility	21-cm line is among the most studied spectral features; SETI-relevant
Simplicity	One proton, one electron; cesium-133 has 55 protons and 78 neutrons
Physical significance	Real atomic transition with a well-defined energy gap
Independence from planets	Defined from atomic physics, not solar-day subdivision

3.3 Thermodynamic Interpretation of the Quant *(rewritten v4.2)*

The hydrogen-1 hyperfine transition corresponds to a genuine physical process with thermodynamic consequences when it occurs spontaneously.

The hyperfine structure arises from the magnetic interaction between electron spin and proton spin. Parallel (higher energy) = excited state; anti-parallel (lower energy) = ground state. Energy difference:

ΔE = h · f_H ≈ 9.41 × 10^-25 J

When a hydrogen atom spontaneously decays:

- Energy is released as a photon at 1420.405751768 MHz (21 cm).
- Entropy of the universe increases by ΔS = ΔE / T. At CMB temperature (2.7 K), ≈ 3.5 × 10^-25 J/K per transition.
- The spontaneous process is irreversible without external energy input.

However: the spontaneous emission lifetime of this transition is approximately **1.1 × 10^7 years** per atom. In a hydrogen maser — the practical measurement device — the oscillation is maintained through *stimulated* emission in a resonant cavity, which is a coherent and in-principle reversible process. The maser counts **phase cycles of a coherent oscillation locked to the transition frequency**; it does not count individual spontaneous decays.

The quant's thermodynamic grounding is therefore a **definitional anchor**: each period corresponds to the energy gap of an irreversible transition. It is **not** a claim that every counted oscillation is itself a distinct entropy event. This is analogous to how the SI second is defined by the cesium transition frequency without requiring each counted cycle to be a spontaneous decay.

Real clock operation (state preparation, pumping, cavity maintenance, electronics, environmental coupling) is thermodynamically irreversible in aggregate. The entropy cost depends on the device and operating conditions, not on a universal fixed increment per quant.

3.4 Practical Measurement *(rewritten v4.2)*

Hydrogen masers are among the most precise **short-term** time standards. Short-term stability (1 second to a few hours) exceeds that of cesium clocks.

Long-term stability favors cesium fountain clocks (~10^-16) and optical lattice clocks (~10^-18), compared to the hydrogen maser's typical 10^-15 to 10^-16 per day. Universal Times selects hydrogen for **universality and simplicity**, not for raw metrological precision across all averaging intervals.

In practice, a deployed network would use **hydrogen masers steered by optical or cesium references** — standard practice in precision timing laboratories (GPS, VLBI, pulsar timing).

Why hydrogen despite cesium's engineering advantages:

Cesium-133 has a single stable isotope, well-understood systematics, decades of infrastructure, and SI traceability. The choice of hydrogen is **not** a claim of superior clock performance. It prioritizes:

1. **Cosmological ubiquity** — H-1 is ~75% of baryonic matter; 21-cm is the most observed radio line.
2. **First-principles simplicity** — one proton, one electron.
3. **SETI-grade recognizability** — any radio-capable civilization encounters this line.
4. **Independence from metrological history** — the SI second was reverse-engineered from the ephemeris second; the quant is defined from atomic structure.

A conforming implementation may realize the quant scale from **any traceable source**: hydrogen maser, cesium standard, optical clock, time-transfer service, or ensemble. The protocol defines the unit and reference value — not a single instrument.

Section 4: The Dual-System Insight — Coordinates vs. Distances

4.1 The Category Error

Every prior timekeeping system uses one vocabulary for two different things:

Concept	Question	Analogy
Temporal position	"What time is it?" → "3 o'clock"	Latitude / longitude

Concept	Question	Analogy
Temporal duration	"How long?" → "3 hours"	Miles / kilometers

On one planet this is merely confusing. Across planets it is catastrophic.

4.2 The Solution: Two Separate Systems

System	Vocabulary	Role
System 1 — Solar Clock	Loop / Arc / Tick	Local coordinates (WHERE in the day)
System 2 — Universal Duration	Pulse / Wave / Tide / Spin / Current / Season / Epoch	Physics-defined distances (HOW LONG)
System 3 — Universal Position	Quant Accumulator Q	Frame-qualified absolute coordinates

4.3 The Three Temporal Questions

1. **"What time is it here?"** → Solar Clock → `t:7:42:85` (planet-local)
2. **"How long will this take?"** → Universal Duration → "About 3 waves" (universal)
3. **"When exactly did/will this happen?"** → Quant Accumulator → `Q: 6.2 × 10^26` (frame-qualified, universal scale)

Section 5: System 1 — The Solar Clock (Loop / Arc / Tick)

5.1 Purpose

Answers: **"What time is it here?"** Planet-specific coordinate system mapping position in the local solar day onto a base-10 display. The day remains the biological/astronomical anchor; everything within the day is base-10.

5.2 Structure

Unit	Count per larger unit	Count per day
1 day	—	1
1 loop	10 per day	10
1 arc	100 per loop	1,000
1 tick	100 per arc	100,000

- **Loop** ≈ 2h 24m on Earth
- **Arc** ≈ 86.4 legacy seconds on Earth
- **Tick** ≈ 0.864 legacy seconds on Earth

5.3 Display Format

```
t:L:AA:TT
```

Examples: `t:0:00:00` (start of day), `t:5:00:00` (midday), `t:9:99:99` (final tick).

Casual speech: “seven forty-two” = `t:7:42:00`.

5.4 Planet Profiles

Same face everywhere (10 loops, 100 arcs, 100 ticks). Hand speed varies with day length.

- Earth tick ≈ 0.864 s
- Mars tick ≈ 0.888 s (sol = 88,775 s)

Loop 5 always means local solar midday regardless of planet.

5.5 Time Zones

View-layer tick offsets only. DAG operates on raw quant counts.

```
offset_ticks = round(utc_offset_hours × 100,000 / 24)
```

5.6 Critical Distinction

Loop, Arc, Tick are **coordinates, not durations**.

Correct	Incorrect
“Meeting at t:7:30:00”	“I’ll be there in 3 arcs”
“Wake at t:3:00:00”	“That took 5 loops”
“I’ll be there in 5 pulses”	—

Section 6: System 2 — Universal Duration

6.1 Purpose

Answers: **“How long will this take?”** Same meaning on every planet, station, or habitat. Defined only by H-1 hyperfine periods.

6.2 The Duration Ladder

Unit	Definition	Legacy Equivalent	Conversational Scale
Pulse	10^11 H-periods	~70.4 s (~1.17 min)	Quick task, short pause
Wave	10^12 H-periods	~704 s (~11.7 min)	Meeting segment, commute
Tide	10^13 H-periods	~7,040 s (~1.96 h)	Work block, movie
Spin	10^14 H-periods	~70,400 s (~19.5 h)	Nearly a full day
Current	10^15 H-periods	~704,000 s (~8.1 d)	Sprint, vacation

Unit	Definition	Legacy Equivalent	Conversational Scale
Season	10^16 H-periods	~7.04×10^6 s (~81.5 d)	Quarter, semester
Epoch	10^17 H-periods	~7.04×10^7 s (~2.23 yr)	Career phase, era

6.3 Speech Examples

- "Give me 3 pulses." (~3.5 min)
- "That meeting ran 3 waves." (~35 min)
- "I need a full tide." (~2 h)
- "Back in a spin." (~20 h)
- "The sprint is 2 currents." (~16 d)
- "That rollout took a season." (~81 d)
- "She spent an epoch in that role." (~2 yr)

6.4 Gap Between Pulse and Wave

No intermediate unit. "4–5 pulses" covers ~5 minutes. The minute–hour gap in legacy time (60×) is larger than this gap (10×).

Section 7: System 3 — Universal Position (The Quant Accumulator)

7.1 The Problem of Absolute Time

Neither System 1 nor 2 answers: "When exactly did this happen?" UTC is Earth-anchored. Universal Times uses the Quant Accumulator: a monotonically increasing count of H-1 hyperfine periods since epoch t:0.

7.2 Defining the Quant

```
1 quant = 1 period of H-1 ground-state hyperfine radiation
Frequency (adopted reference): 1,420,405,751.768 Hz
Period: ≈ 7.04 × 10^-10 s
```

7.3 The Accumulator as Timestamp

```
Q:<integer>
```

Display: `Q: 6.18 × 10^26` (scientific notation).

Values are **consistent across clocks sharing the same reference convention and frame**, within stated uncertainty — not "identical on every clock in the universe" without qualification. Relativistic corrections apply (Sections 15.4, 17.1).

Interplanetary coordination uses Q values, not local loop numbers. Each local system converts Q into local Solar Clock via its planet profile.

7.4 Epoch t:0 — The Cosmological Anchor *(rewritten v4.2)*

Earlier iterations defined the epoch as the moment the first Temporal Token was minted on the Extropy Engine DAG, or the DAG Genesis Block. **That definition is retired.** It made the universal timeline depend on a local software event — contradicting planet-independence and civilization-independence. A timeline that begins when one project's code is deployed is not universal.

Universal Times now anchors t:0 to the origin of the observable universe: the hot Big Bang. Quant counts are measured forward from that origin.

Because the Big Bang itself is not directly observable, the practical calibration reference is the **cosmic microwave background (CMB)** — relic radiation released at recombination (~380,000 years after the Big Bang, $z \approx 1100$). The CMB is observable from every point in the universe, isotropic to ~1 part in 10^4, and measurable by any civilization with basic radio capability.

Current best estimate of universe age: **13.797 ± 0.023 billion years** (Planck 2018).

$Q_{now} \approx 13.8 \times 10^9 \times 3.156 \times 10^7 \times 1.420 \times 10^9 \approx 6.2 \times 10^{26}$

This value carries ~1% cosmological age uncertainty. For practical intervals, only **differences** between quant values matter; shared epoch uncertainty cancels.

Three consequences:

1. No event in recorded human history carries a negative quant value.
2. The Extropy Engine DAG genesis is a **ledger-local** event — when validated records begin in that system. It receives a quant timestamp like any other event and has **no authority over physical time**.
3. A cosmological quant display is an **estimate**. Hydrogen atoms did not exist in the earliest universe. The display is a retroactive projection ("how many hyperfine periods *would have* elapsed at the current frequency") and carries model-dependent uncertainty.

> **In Plain Terms:** The clock does not start when we turn the system on. It started when the universe did. We calibrate to the oldest light anyone can see — the CMB — because that light reaches every observer. The DAG genesis is one dot on a timeline already 13.8 billion years old.

7.5 Quant Register on the Clock Face

Displayed at 12 o'clock: current estimated quant coordinate since cosmological origin (or elapsed quants since a stated reference event in relative mode). Center: hydrogen symbol (H / 21cm) — the constant. Top: accumulated count — the variable.

Section 8: The 5-Layer Temporal Architecture

8.1 Overview

Layer	Name	Function
0	Epoch	Cosmological origin convention (t:0)
1	Quant	Physical substrate (H-1 hyperfine periods)
2	Universal Duration	Planet-independent elapsed units
3	Solar Clock	Planet-specific day coordinates
4	Display	Culture, calendars, aesthetics, governance labels

Physics (0–2) is not overridden by governance. Culture lives only in Layer 4.

8.2 Layer 0: Epoch *(rewritten v4.2)*

t:0 = cosmological origin (hot Big Bang), calibrated via CMB.

Layer 0 specifies:

- **Reference frame:** Solar system barycentric coordinate time (initial deployment)
- **Epoch convention:** Cosmological origin
- **Calibration source:** CMB-derived universe age (13.797 ± 0.023 Gyr)
- **Uncertainty model:** ~1% on absolute values; negligible on intervals
- **Version:** Protocol-stamped; not casually revised; refinements use explicit conversion maps

DAG genesis of any deployment receives a quant timestamp within this framework. **It does not define Layer 0.**

8.3 Layer 1: Quant

One quant = one H-1 hyperfine period at the adopted reference frequency. Not chosen by committee. Not negotiable as a definition of the unit.

8.4–8.7 Layers 2–4 and Communication

Unchanged in structure from v4.1: Layer 2 = duration packaging; Layer 3 = solar coordinates; Layer 4 = culture. Communication is downward for definition, upward for rendering. No layer modifies the layer below it.

Section 9: Calendar Architecture

9.1 Dual Calendar

System	Answers
Local Orbital Calendar	What season? When is the holiday? How far through the year?
Universal Duration Calendar	How long until shipment? How long has the mission run?

9.2 Local Orbital Structure

- 10 months per orbit
- Months 1–9 equal length; Month 10 absorbs remainder
- 5-day cycles (optional alternative to 7-day week)

Earth: 9 × 40 + Month 10 (5/6) = 365/366 **Mars:** 9 × 74 sols + Month 10 (2–4 sols) ≈ 669 sols

9.3 The 5-Day Cycle *(qualified v4.2)*

The 7-day week has no direct astronomical basis, though **circaseptan (~7-day) biological rhythms** have been documented in human physiology, suggesting the week's persistence may not be entirely arbitrary. Regardless, its non-decimal structure and prime length make it architecturally hostile to a fully decimal system. Universal Times offers the **Cycle** (5-day repeating unit) as an **optional** decimal alternative.

Why 5: divides 40 evenly; historical market-week precedent; base-10 compatible; shorter rest-day distance. Work/rest pattern is Layer 4 governance — not protocol-mandated.

9.4–9.7 Month 10, Naming, Leap Days, Dual Calendar Relationship

Unchanged: leap days only in Month 10; names are Layer 4; Y.M.D numeric protocol format; both calendars connect through Q.

Section 10: The DAG as Temporal Substrate

10.1 Why a DAG

Directed acyclic graph: clear causal ancestry, no loops, parallel branches, convergent merge. Mirrors causal structure better than a linear chain.

10.2 Ordering Without a Central Clock

Topological sort + Lamport timestamps + quant-range bindings. Partial order: ancestor implies before; incomparable implies concurrent.

10.3 The DAG as Clock and Calendar *(corrected v4.2)*

Every event on the DAG carries a quant timestamp. The act of recording an event is a tick of the **system's attestation clock**.

> The DAG does not merely record when things happened — it produces an auditable, causally ordered temporal attestation. Within the system, it functions as both a structural clock and a structural calendar.
>
> **However, the DAG does not create physical time.** Events continue to occur whether or not a vertex is written. The hydrogen frequency does not depend on transaction activity. Transaction density measures recorded system activity, not the rate at which time passes.

10.4–10.5 Causal Consistency and Pruning

Unchanged in substance: ancestor timestamps strictly less; merge greater than all parents; checkpoints never pruned; Quant Accumulator never pruned as the permanent elapsed-time record *within the adopted epoch convention*.

Section 11: The Canonical XP Formula and Entropy Economics

11.1 Relationship to Extropy Codex v2.0

Universal Times is the temporal substrate. Value minting is Extropy Engine (Codex v2.0). Temporal domain is domain 8 of eight. Implementation: `packages/temporal`, `packages/temporal-service` (Appendix P).

11.2 Canonical XP Formula (canonical-v3.1.3)

$XP = R \times F \times \Delta S(b\_e) \times (w \cdot E) \times \min(\log(1/T\_s), \dots)$

with

$T\_s = \exp(-\lambda\_d \cdot \Delta t)$, $T\_s \in (T\_floor, 1]$

Variable	Range	Meaning
R	[0.1, 10.0]	Rarity coefficient
F	per Codex	Falsifiability score
ΔS_be	[0, cap_d]	Entropy reduction under M_d (bits-equivalent proxy)
w·E	dimensionless	Domain weight dot product
T_s	(T_floor, 1]	Normalized settlement-time factor
T_floor	(0, 1)	Default 0.01
λ_d	> 0	Per-domain settlement decay

Implemented in `packages/xp-formula/src/index.ts`. Formula-version stamped on every mint; mismatch MUST fail closed.

11.3 Retirement of XP = S · c_L²

Retired as pseudo-physics (REJECTED_FRAMINGS R1). Retained only as geometric analogy in Section 19 — not as implemented physics.

11.4 Time as Denominator, Entropy Reduction as Numerator

Architecturally accurate with v4.2 qualifications: quant timeline tracks the reference frequency scale; XP mints against verified disorder reduction under operators. Operationalized via ΔS_be and T_s.

11.5 The Eight Domains

1. Cognitive
2. Code
3. Social
4. Economic
5. Thermodynamic
6. Informational
7. Governance
8. Temporal

No ecological or spiritual domain slots.

11.6 Temporal Decay in Universal Duration

Examples: validation weight half-life 5 Currents; freshness half-life 1 Season; vesting 3 Epochs. Same physical duration on every planet.

11.7 Entropy Accounting

Every XP transaction records input/output disorder proxies, net reduction, energy cost, efficiency — alongside quant timestamp.

11.8 Thermodynamic Consistency Principle *(qualified v4.2)*

Time measurement and value measurement share a philosophical orientation toward irreversibility and order. **Within physical domains**, consistency can be strong. **Across abstract domains**, consistency is only as strong as the operators (see Section 2.2 caveat and Section 17.8). The system must not claim a contribution reduced thermodynamic entropy when only a proxy score moved.

Section 12: The DAG as a Distributed Temporal Attestation Layer *(retitled v4.2)*

12.1 DAG as Clock and Ledger

Every vertex carries Lamport timestamp + quant-range binding. Contribution closed at a Q value is permanently timestamped in physics-defined units, not wall-clock time alone.

Event vocabulary (Codex Section 9.7): LOOP_OPEN, EVIDENCE_SUBMITTED, VALIDATION_RECORDED, LOOP_CONSENSUS, XP_MINT_PROVISIONAL, XP_MINT_CONFIRMED, XP_MINT_BURNED.

12.2 Quant Timestamps

$\Delta Q = 10^{12}$ implies one Wave ≈ 11.7 minutes everywhere. TT is not a token; timestamping is native to the vertex schema.

12.3 Minting as Temporal Attestation *(rewritten v4.2)*

Traditional chains attach weak local-clock timestamps. Extropy makes quant timestamp a primary structural element.

The DAG exists to produce validated, causally ordered temporal records. Value tracking rides on that infrastructure.

> It is not merely a ledger that happens to have timestamps. It is a **temporal attestation layer** that happens to produce a ledger.

12.4 Why This Makes the DAG a Structural Calendar

Properties:

- **Immutability** under cryptographic and consensus assumptions (tamper-**evident**, not magically tamper-proof)
- **Decentralization** — no single calendar authority
- **Universality** — quant-based scale
- **Granularity:** unit resolution is sub-nanosecond (1 quant ≈ 0.7 ns); **accuracy cannot exceed clock-source accuracy**. Sub-nanosecond units do not equal sub-nanosecond accuracy
- **Causality** — ancestry explicit

12.5 Retroactive Entropic Causality

Provisional mint burnable within governance window if Q_d validators accept contrary evidence. Window expressed in Universal Duration (default ~1 Current).

12.6 DFAO-Gated Presentation Layer

Base-10 calendar and Loop/Arc/Tick face are optional presentation (`packages/temporal-service`). DFAO may display Gregorian while substrate remains quant-based.

12.7 Temporal Consensus *(qualified v4.2)*

The network validates not only that a transaction is real, but that its claimed timing is consistent with causal history and consensus windows.

False timestamp claims can be detected and deterred to the extent permitted by clock diversity, attestation independence, network conditions, uncertainty bounds, and consensus assumptions. The system makes temporal fraud **costly and visible** — it does not make it physically impossible.

The **intended equilibrium** is that honest timekeeping accumulates economic rewards (XP) and temporal reputation (consensus weight), while dishonest timekeeping risks slashing and reputation loss. Whether this is a dominant strategy depends on rewards, penalties, collusion costs, validator concentration, clock-source independence, and attack value — requiring formal mechanism analysis, not assertion from DAG structure alone.

Section 13: The Six-Token Economy

13.1 Canonical Six Tokens

Token	Name	Type	Role
XP	Extropy Points	Non-transferable	Minted from verified ΔS_be
CT	Contribution Token	Per-actor coefficient	Access/vote weight
CAT	Capability Token	Portable certification	Domain standing
IT	Influence Token	Non-transferable governance	Decays ~5%/month
DT	Domain Token	Domain-scoped	Token-economy package
EP	Emergence Points	Merchant settlement	XP × loyalty L

TT, GT, RT retired. Six-token invariant is architectural.

13.2 Why TT Is Not Needed

Quant binding is automatic on every vertex. A seventh token would duplicate schema and violate the non-proliferation invariant.

13.3–13.5 EP, Non-Extraction, Temporal Interactions

EP = XP × L. Decay, loop timeouts (default 1 Spin), retroactive windows (default 1 Current) all in Universal Duration. No fiat bridge (NON_EXTRACTION invariant).

Section 14: The Clock Face — Visual Architecture

14.1 Design

Base-10 circular face, 10 divisions, three hands (Loop, Arc, Tick).

14.2 Four Compass Points

Position	Content	Scope
12:00	Quant Register (est. Q since cosmological origin, or relative mode)	Universal
3:00	Season/orbit progress	Planet
6:00	Planet profile symbol	Planet
9:00	Cycle day 1–5	Planet
Center	H / 21cm	Universal

14.3–14.5 Duration Subdials, Color Coding, Digital Format

```
t:L:AA:TT | Q:X.XXX×10^XX | P:EARTH
```

Colors: universal = gold/white; solar = silver/grey; governance = accent colors.

Section 15: Adversarial Modeling and Game-Theoretic Analysis

15.1 Threat Model

Temporal manipulation, consensus attacks, relativity exploits, profile attacks, Sybil attacks.

15.2–15.3 Defenses

Causal structure + temporal consensus window + stake × accuracy hybrid weighting. Attack cost includes capital **and** sustained honest timekeeping history.

15.4 Relativistic Considerations

- Within planet: standard gravitational corrections (as GPS does)
- Between planets: potential differences, computable
- Deep space: solar-system barycenter reference frame for initial deployment
- **No single observer-independent universal "now"** (Section 17.1)

15.5 Economic Attacks

Speed-farming blocked by bounded T_s. Time-dilation arbitrage constrained by frame corrections. Retroactive minting constrained by causal structure + validation window.

Section 16: Implementation Strategy and Adoption Pathways

16.1 Philosophy

Utility-driven, never mandated. Path: niche technical utility to developers to consumers to voluntary mainstream.

16.2 Earth Strategy

Superset, not replacement. Bidirectional conversion. t:5:00:00 ≈ noon. Early adopters: remote teams, crypto, science, logistics.

16.3 Developer Integration

Libraries, REST/WebSocket APIs, RFC-style spec, SDKs. Reference: `packages/temporal-service` at github.com/00ranman/extropy-engine.

16.4 Hardware

Validators: H-maser and/or cesium/optical access, network, compute. End users: any screen.

16.5 Governance

Layers 0–1: physics, nearly immutable. Layer 2: slow. Layer 3: profiles as needed. Layer 4: free culture.

Section 17: Open Questions and Limitations

17.1 Relativistic Time and Reference Frames

Solar-system barycenter works locally. Interstellar / relativistic travelers: each clock keeps proper quant count; conversions use GR; no enforced universal simultaneous "now."

17.2 The Entropy Measurement Problem

Physical entropy is hard; abstract-domain entropy requires proxies. Active research. No domain has fully mature calibration tables as of Codex v2.0.

17.3 Adoption Chicken-and-Egg

Mitigate via use cases valuable without universal adoption: timestamp anchoring, science coordination, interplanetary planning.

17.4 Cultural Resistance

Not French-style coercion. Parallel layer. New capability (interplanetary coordination). Tech-ecosystem emergence.

17.5 Quantum Decoherence / Planck Limits

Universal within classical/semi-classical domain. Does not resolve quantum gravity.

17.6 Long-Term Drift of Constants

If fundamental constants drift, recalibration needed — same problem for SI second.

17.7 Cosmological Epoch Uncertainty *(new v4.2)*

Absolute Q carries ~1% age-of-universe uncertainty and model dependence. Interval timing is unaffected. Implementations SHOULD support relative-Q mode (elapsed since a stated reference event) for high-precision work.

17.8 Entropy Measurement and Cross-Domain Commensurability *(new v4.2)*

There is no demonstrated natural conversion making thermodynamic, informational, code, cognitive, social, economic, governance, and temporal entropy scores mutually commensurable. **w·E** constructs a comparison rule; it does not discover a universal physical exchange rate.

Each domain operator M_d defines "entropy reduction" *within that domain*. Credibility scales with operator rigor under adversarial validation over time.

Section 18: Conclusion

18.1 Summary of Architecture

Innovation	Description
Dual-system design	Coordinates are not distances
Physics-first anchoring	H-1 hyperfine frequency
5-layer stack	Physics insulated from culture
DAG attestation	Auditable causal temporal record
Six-token economy	XP, CT, CAT, IT, DT, EP
Decimal calendar	10 months, 5-day optional cycles, Month 10 remainder
Cosmological epoch	t:0 = Big Bang / CMB calibration (v4.2)

18.2 The Philosophical Claim *(qualified)*

Time and value can be oriented toward the same thermodynamic and informational intuitions: irreversibility and order. A shared temporal foundation enables consistency checks between "when" and "what was claimed." This is strongest in physical domains and only as strong as operators elsewhere.

18.3 What This System Is Not

- Not a mandate to abolish legacy time
- Not a theory of quantum gravity
- Not "just a cryptocurrency whitepaper" — temporal infrastructure is independently useful
- Not a claim of cultural superiority over inherited calendars
- Not a claim that the DAG creates physical time

18.4 Final Word *(rewritten v4.2)*

Humanity has measured time by the sun, by candles, by pendulums, by quartz crystals, and by cesium atoms. Each advance made timekeeping more precise, more portable, and more universal. Universal Times proposes the next step: a timekeeping architecture anchored not to any planet or star, but to the hydrogen atom — the simplest and most abundant building block in the cosmos — and calibrated against the oldest observable light in the universe.

The architecture is specified. The calendar is coherent. The physics is grounded. What remains is implementation, testing, independent review, and the slow accumulation of utility that earns adoption rather than demands it.

Section 19: Geometric Topology of the Temporal Architecture

19.1 Purpose

Complementary geometric representation. Does not alter physics or protocol.

Two orthogonal axes: **vertical** (physics to culture via 5 layers) and **horizontal** (past to future via DAG causal flow). Quant substrate anchors both.

19.2 Fiber Bundle

- **Base B:** quant timeline $Q \in Z+$
- **Fiber:** Layers 2–4 at each Q
- Projection $\pi: E \to B$; fibers homeomorphic across planets (same structure, different parameters)

Layer 0 (v4.2): cosmological origin — not DAG genesis.

19.3 Dual-System Topology

- System 1: coordinate space $\varphi\_P : Z\_Q \to S^1\_P$ (circle per planet day)
- System 2: metric $d(Q1,Q2) = |Q2 - Q1|$ on the line

S^1 coordinates are not comparable to R distances — geometric form of the category error.

19.4 DAG as Directed Topological Space

Alexandrov topology on the reachability poset. Past cones closed; future cones open; concurrent nodes incomparable. Locally Minkowskian causal structure. Q is monotone along causal paths.

19.5 Quant Manifold

Discrete 1-D manifold: orientable (entropy arrow), complete (no gaps in the unit definition), universal. DAG is a section sampling the stream into events.

19.6 Full Spatial Representation *(Noether corrected v4.2)*

- Z: 5-layer stack
- X: quant timeline

- Y: Solar Clock helix per planet

Translational symmetry along X and rotational periodicity in each Solar Clock fiber are **structural analogues** of Noether symmetries:

> These symmetries are **architectural invariants of a data representation**, not dynamical symmetries of a physical Lagrangian. Noether's theorem applies to continuous symmetries of an action functional. The analogy is illuminating — it shows why the architecture feels physically natural — but it is **not** a derivation of energy or angular-momentum conservation from the system's design.

19.7 Topological Invariants

Invariant	Meaning
Quant frequency	Fixed by H-1 physics definition
Layer ordering	Upper cannot modify lower
DAG acyclicity	Time cannot loop
S^1 Solar Clock	Day wraps at local midnight
Q monotonicity	Causal order preserved

19.8 XP as Geometric Ratio

ΔS_be as scalar field on quant base; T_s as local metric coefficient; R, F dimensionless scalings. Product equals XP contribution weighted by temporal and epistemic geometry.

Appendix A: Canonical Earth Planet Profile

Profile: EARTH **Star:** Sol **Orbital period:** 365.2422 solar days **Rotational period:** 86,400.002 legacy seconds

Solar Clock

Parameter	Value
Loops/day	10
Arcs/loop	100
Ticks/arc	100
Ticks/day	100,000
Quants/tick	~1.228 × 10^9
Quants/day	~1.228 × 10^14

- Loop 0 = local solar midnight
- Loop 5 (`t:5:00:00`) ≈ local solar noon

Legacy Conversion

UT	Legacy
1 tick	0.864 s
1 arc	86.4 s = 1.44 min

UT	Legacy
1 loop	8,640 s = 2h 24m
t:2:50:00	~7:00 AM
t:5:00:00	~12:00 PM
t:7:50:00	~7:00 PM

Calendar

Parameter	Value
Months/orbit	10
Days months 1–9	40
Month 10	5 (6 leap)
Cycles/month	8
Days/cycle	5
Year	365/366

Leap rule: Gregorian or governance-redefined; leap day only in Month 10.

Time Zone Offsets

```
offset_ticks = round(utc_offset_hours × 100000 / 24)
```

UTC	Zone ID	offset_ticks
+12	UT-E-P12	+50,000
+9	UT-E-P09	+37,500
+8	UT-E-P08	+33,333
+5:30	UT-E-P0530	+22,917
+1	UT-E-P01	+4,167
0	UT-E-000	0
−1	UT-E-N01	−4,167
−5	UT-E-N05	−20,833
−6	UT-E-N06	−25,000
−7	UT-E-N07	−29,167
−8	UT-E-N08	−33,333
−12	UT-E-N12	−50,000

Duration Conversions (Earth-relative)

Unit	Legacy
Pulse	70.4 s = 1.17 min
Wave	704 s = 11.7 min
Tide	7,040 s = 1.96 h

Unit	Legacy
Spin	70,400 s = 19.6 h
Current	704,000 s = 8.15 d
Season	7.04×10^6 s = 81.5 d
Epoch	7.04×10^7 s = 2.23 yr

Appendix B: Canonical Mars Planet Profile

Profile: MARS **Star:** Sol **Orbital period:** 686.97 Earth days = 668.6 sols **Rotational period:** 88,775.244 s (1 sol)

Solar Clock

Parameter	Value
Loops/sol	10
Arcs/loop	100
Ticks/arc	100
Ticks/sol	100,000
Quants/tick	~1.261 × 10^9
Quants/sol	~1.261 × 10^14

Martian tick ≈ 0.888 s (≈2.75% longer than Earth tick). Tick is LOCAL (solar position), not universal duration.

Calendar

Parameter	Value
Months/orbit	10
Months 1–9	74 sols
Month 10	2–4 sols (remainder)
Cycles	5-sol cycles
Year	~669 sols

Duration Units

Identical on Mars and Earth (physics-defined). Only local tick/arc/loop spanning differs:

Unit	Duration	Martian ticks	Earth ticks
Pulse	70.4 s	~79.3	~81.5
Wave	11.7 min	~793	~815
Tide	1.96 h	~0.79 loops	~0.82 loops
Spin	19.6 h	~7.95 loops	~8.15 loops

Appendix C: Global Terminology Map (v4.1 to v4.2)

v4.1 / earlier	v4.2
"most fundamental atomic process"	"one of the most fundamental and universal atomic processes"
Genesis Block / first TT mint = t:0	Cosmological origin (Big Bang / CMB); DAG genesis is ledger-local
Temporal Token (TT)	Retired; quant native to DAG
"blockchain IS time"	"DAG produces auditable temporal attestation"
"You cannot lie about time"	Temporal fraud costly/detectable under stated assumptions
"identical on every clock"	Consistent under shared reference convention + uncertainty
"tamper-proof"	Tamper-evident under consensus/crypto assumptions
"dominant strategy"	Intended equilibrium (needs formal mechanism analysis)
"precisely 1,420,405,751.768 Hz"	"adopted reference value of 1,420,405,751.768 Hz"
Noether implies conservation laws	Structural analogues only
Entropy reduction (unqualified)	Operator-relative; three entropy types distinguished
7-day week "arbitrary"	No astronomical basis; circaseptan rhythms noted; 5-day optional
Sub-ns resolution implied accuracy	Unit resolution does not equal accuracy

References

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2. Universal Times prior versions (v4.0–v4.1) — dual-system architecture, planet profiles, duration ladder.
3. Hydrogen line (21 cm): f = 1 420 405 751.768(2) Hz.
4. Spontaneous 21-cm lifetime ≈ 1.1 × 10^7 yr.
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7. Landauer, R. (1961). Irreversibility and Heat Generation in the Computing Process.

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