

## Section 10. Deliverables

C-6 was designed as the engineering blueprint of CUWF. It does not merely sketch conceptual possibilities; it specifies the dynamical engine of the theory on the entropic manifold  $\mathcal{M}^E$  in a form that can be implemented, simulated, and compared against physical phenomena.

Section 10 summarizes the deliverables of C-6 in four tightly linked outcomes:

- A full formal PDE engine for CUWF collapse dynamics on  $\mathcal{M}^E$  (10.1).
- A specification that is ready for implementation in the C-7 numerical solver (10.2).
- A structured framework for predictive cosmology within CUWF (10.3).
- A concrete algorithm set for collapse evolution, from initialization to event logging (10.4).

Together, these deliverables define the conceptual boundary between C-6 as theory and design, and C-7 as implementation and experimentation.

### 10.1 Full PDE Engine of CUWF Formalized

C-6 formalizes CUWF collapse dynamics as a coupled PDE system defined on the entropic manifold  $\mathcal{M}^E$ . The resulting PDE engine contains the following structural components.

#### Manifold and fields

The entropic manifold  $\mathcal{M}^E$  is equipped with the field objects required for dynamical evolution:

Field / Object	Role in the PDE engine
$g^{lj}(\sigma, \tau)$	Metric field describing local entropic geometry.

Field / Object	Role in the PDE engine
$\mathcal{R}^{IJKL}(\sigma, \tau)$	Curvature tensor field encoding geometric deformation and history.
$T^I{}_J(\sigma, \tau)$	Stability tensor field controlling local stiffness, soft modes, and bifurcation thresholds.
$\Xi^I{}_J(\sigma, \sigma'; \tau)$	Entanglement tensor field controlling nonlocal coupling and wormhole-like transfer.
$\Phi(X, \tau)$	Entropic potential governing collapse descent and attractor structure.
$X^I(\sigma, \tau)$	Configuration field describing collapse trajectories in configuration space.
$\Psi(x, \tau)$	Probability-like or occupancy field used for ensemble-level descriptions.

### Core PDEs

The system includes evolution equations for  $X(\sigma, \tau)$ ,  $\Phi$ ,  $g$ ,  $\mathcal{R}$ ,  $T$ , and  $\Xi$ . Schematically, the full field state can be collected into  $U$ , with evolution written as:

$$dU/d\tau = F[U]$$

Here  $U$  collects all fields and  $F$  encodes entropic gradient flow, diffusion-like smoothing, curvature-driven evolution, and entanglement-induced nonlocal coupling.

### Topology change criteria

C-6 also specifies scalar and tensorial invariants that detect and characterize topology events:

- Curvature sign changes indicating basin birth.

- Soft-mode eigenvalue crossings indicating bifurcation.
- Determinant degeneracy  $\det T \rightarrow 0$  indicating conifold pinch formation.
- Entanglement-strength thresholds  $\bar{\Xi}_{\text{eff}} > \bar{\Xi}_c$  indicating wormhole regimes.

Each event is defined by precise conditions on these invariants and their  $\mathbf{T}$ -derivatives, allowing topology changes to be detected algorithmically rather than inserted manually.

### Multi-scale decomposition

The PDE engine is organized across macro-, meso-, and micro-scale descriptions:

Scale	Description
Macro	Coarse curvature $\bar{R}(\mathbf{T})$ , global geometry, and large-scale entropic regime structure.
Meso	Basin centers, shapes, depths, connectivity, drift, and migration.
Micro	Sub-basin hierarchies, fine-grained collapse spectra, and transition graphs.

Renormalization-flow equations for effective DOFs and parameters connect these scales. In this sense, 10.1 certifies that CUWF now possesses a complete formal PDE description of collapse dynamics at the schematic level required for implementation.

### 10.2 Ready for Implementation in C-7 Solver

The second deliverable is implementability. C-6 is written so that its mathematical output can be translated directly into the architecture of a numerical solver in C-7.

## Discretization targets

C-6 defines clear options for representing  $\mathcal{M}^E$  numerically:

Representation	Best use
Regular grids	Locally flat patches or simplified test regimes.
FEM meshes	Curved but smooth regions requiring adaptive geometric resolution.
Graph manifolds	Basin-dominated and topologically complex regimes.
Hybrid representations	Dynamic switching between local geometry and global basin connectivity.

## Temporal integration requirements

The schematic form  $dU/d\mathbf{T} = F[U]$  supports explicit, implicit, and IMEX integration methods, with adaptive time stepping controlled by local error and stiffness indicators. Integrators must preserve or control monotonic decay of entropic functionals, capture bifurcations and topology events accurately, and handle widely separated time scales.

## Event-detection logic

C-6 specifies the event-detection layer required for implementation:

- Eigenvalue tracking for soft modes.
- $\det T$  and geometric thresholds for conifold detection.
- $\Xi_{\text{eff}}$  thresholds for wormhole mapping.
- Basin birth and bifurcation detection through curvature and Hessian behavior.
- Discrete actions such as mesh surgery, graph updates, basin-registry updates, and connectivity changes.

### Scenario library for testing

The minimum scenario set in Section 8 supplies initial conditions, parameter ranges, and expected qualitative outcomes. These scenarios serve as unit and integration tests for the C-7 solver, ensuring that the implementation reproduces stable basin convergence, bifurcation, conifold pinching, wormhole-enabled collapse, and curvature breathing.

Thus, 10.2 guarantees that C-6 is not merely conceptual. It specifies inputs, outputs, and structural requirements in a form suitable for building and validating C-7.

### 10.3 Framework for Predictive Cosmology

The third deliverable is a framework for cosmological-scale prediction. C-6 does not yet compute detailed cosmological observables, but it provides the mathematical layers needed for such computation once C-7 is operational.

#### Macro-geometry as cosmological driver

Coarse-grained curvature  $\bar{R}(\mathbf{\tau})$  and metric  $\bar{g}(\mathbf{\tau})$  are elevated to primary cosmological variables. Their evolution under macro-PDEs becomes the CUWF analogue of cosmological background dynamics.

#### Connection to structure formation

Basin statistics — including number, depth, size, and connectivity — are tied to the values and history of  $\bar{R}(\mathbf{\tau})$ , as well as to topology transitions such as basin birth, bifurcation, conifold formation, and wormhole transfer. This provides a route from macro entropic geometry to phase content and hierarchical structure.

#### Epoch-based predictions

The curvature-breathing scenario defines distinct entropic epochs characterized by different basin regimes and corresponding changes in effective constants and interaction strengths through

renormalization flow. With C-7, one can simulate candidate  $\bar{R}(\tau)$  trajectories, extract effective law-sets per epoch, and compare them with observational-style cosmological constraints.

### Parameter and scenario space

C-6 defines a parameter space for cosmological studies, including initial macro-curvature states, entropic potential families, entanglement-strength profiles, and topology-event frequencies. C-7 can scan this space to identify regions consistent with observed cosmic history and to search for distinctive CUWF predictions.

Thus, 10.3 positions C-6 as the theoretical backbone for a predictive CUWF cosmology program: once simulations run, the PDE engine can be linked systematically to observable-style quantities.

## 10.4 Collapse Evolution Algorithm Set

The fourth deliverable is an algorithmic decomposition of CUWF collapse dynamics into modules that a C-7 implementation can follow.

### Initialization

- Choose a representation of  $\mathcal{M}^E$ : grid, FEM, graph, or hybrid.
- Initialize fields  $g$ ,  $\mathcal{R}$ ,  $\Phi$ ,  $T$ ,  $\Xi$ , together with  $X(\sigma, 0)$  and/or  $\psi(x, 0)$ .
- Initialize basin and sub-basin registries.
- Optionally set macro-curvature  $\bar{R}(0)$  and entropic epoch parameters.

### Time-stepping loop in $\tau$

For each step, evaluate  $F[U(\tau)]$  and advance the system:

$$U \rightarrow U + \Delta\tau \Phi_{\text{integrator}}(F, U)$$

The chosen scheme may be explicit, implicit, or IMEX, with adaptive  $\Delta\tau$  controlled by local error estimates and stiffness indicators.

### Event detection and handling

- Check soft-mode indicators:  $\lambda_{\min}(T) \approx 0$  triggers bifurcation tracking and attractor snapping.
- Check curvature and Hessian thresholds to detect basin birth.
- Check  $\det T$  and geometric thresholds for conifold pinch candidates.
- Check  $\Xi_{\text{eff}}$  and conifold coincidence to detect wormhole regimes and insert nonlocal edges.
- Update basin registries, sub-basin registries, mesh or graph topology, and DOF renormalization variables.

### Multi-scale management

- Perform coarse-graining or refinement of fields periodically or adaptively.
- Update renormalization flows of effective parameters.
- Recognize self-similar attractor cascades.
- Adjust resolution where needed or replace resolved micro-dynamics with effective models when appropriate.

### Logging and diagnostics

The solver must maintain a history of basin births, bifurcations, conifolds, wormholes, macro-curvature  $\bar{R}(\bar{\mathbf{T}})$ , entropic epoch labels, branching outcomes, and nonlocal correlations. These logs allow C-7 to extract distributions of collapse endpoints, correlation functions, and epoch-dependent statistics.

### Post-processing and interpretation

Numerical histories can then be mapped to classical stability regimes, quantum-like branching statistics, nonlocal correlation patterns, cosmological epoch structure, and law-change sequences. This transforms the static formalism of C-6 into an operational pipeline for C-7.

## Summary of Section 10

Section 10 clarifies what C-6 delivers to the broader CUWF program:

Subsection	Deliverable
10.1	A fully specified PDE engine on $\mathcal{M}^E$ , with necessary fields, equations, invariants, and scale decompositions.
10.2	A solver-ready specification for C-7, including discretization, integration, and event-detection logic.
10.3	A structured framework for predictive cosmology linking macro-curvature dynamics and topology history to observable-style epochal behavior.
10.4	A collapse evolution algorithm set, decomposing the dynamics into implementable modules from initialization to physical interpretation.

With these deliverables, C-6 completes its role: it defines, in a unified way, how CUWF collapse dynamics should be written, computed, and ultimately confronted with phenomena in both quantum and cosmological domains.