# Module 13 – LedgerSync & Federation Capsule Binding

Version: 4.1 (Final CTO Edition)

Layer: System Ledger, Replay Chain, Capsule Anchoring, Federation Integration

Status: RELEASE

Dependencies: Modules 00, 06, 14, 17, Federation, Grace Recovery, Capsule Alerts

## 0. Purpose & Capsule Enforcement Scope

This module defines the core capsule ledger structure, trust anchoring logic, federation capsule binding, and replay trace enforcement required for MaxOneOpen v4.1. It manages commit chain integrity, fork detection, frozen capsule flow, alert visibility hooks, and sovereign anchor capsules. LedgerSync is required for runtime validity, certification eligibility, and capsule reentry under degraded execution states.

## 1. Commit Chain Format & Capsule Types

Each execution, governance, or violation capsule is committed via:  
`Commit Capsule (COMMIT)`:  
`{ commit\_id, capsule\_hash, capsule\_class, trust\_scope, anchor\_type, timestamp, prev\_hash, federation\_ref, status\_flag }`  
Supported capsule classes:  
- Execution (EC), Audit (AC), Recovery (RC), Consent (CC), Alert (ALC), Grace (GC), Fork Anchor (FAC), Federation Consent (FCC)

## 2. Replay Defense & Alert Path Hooking

Ledger logic enforces:  
- strict capsule chain integrity (time+hash)  
- cross-trust zone conflict detection  
- `Replay Block Capsule (RBC)` emission on collision  
- `Replay Alert Capsule (RAC)` dispatch via Alert Engine  
Alert overlays hook directly into capsule trace window for audit analysis.

## 3. Federation Capsule Anchoring & Fork State Control

The ledger supports parallel sovereign actors:  
- Federation Consent Capsule (FCC) defines trust zone scope  
- Fork Anchor Capsule (FAC) provides path recovery boundaries  
- Divergence events yield `Fork Alert Capsule (FDAC)`  
- Reconciliation uses capsule timestamp + FAC delta logic

## 4. Grace Recovery Chain & Ledger Suspension Logic

When a trust-critical subsystem fails:  
- ledger emits `Grace Capsule (GC)` with subsystem and TTL  
- execution is downgraded to isolation trust tier  
- ledger path is frozen for replay until `Grace Replay Confirmation (GRCC)`  
Certification and fork propagation are suspended during grace execution.

## 5. Ledger Export Overlays & Observer Access

Ledger states may be exported to overlays:  
- Capsule Audit Trace Export (CATE)  
- Fork Path Snapshot (FPS)  
- Observer Ledger Window (OLW) – public view per role class  
Each export must include full capsule commit lineage and anchor reference hash.

## 6. Certification Binding & Reentry Confirmation

Module 17 must verify:  
- all ledger commits are trace-complete and signed  
- capsule chains with Grace or Fork triggers must include downgrade logic  
- replay window validation and FAC alignment  
- sovereign fork reintegration via `Reentry Capsule (REC)`  
Certification is blocked if replay anomalies or unresolved fork paths remain.