

GRID EMT

SIMULATION INITIATIVE

Study-driven CIM Architecture

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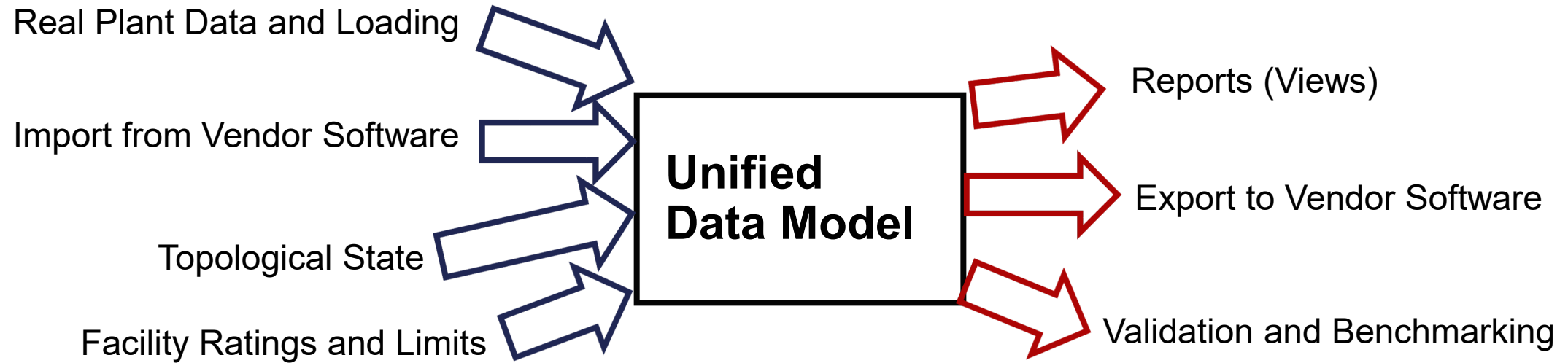
- Matching requirements to existing data
 - Graphical Information Systems <- Asset Management
 - Overhead Electric Line <- LIDAR, Sag, NESC
 - Substation Physical <- Building Infor. Modeling
 - Protection & Control <- OC, Zone, System
- Workflow Analysis
 - Problem Definition: Deep understanding
 - Parameter Sourcing: Locating specific physical data points
 - Process Mapping: Tracking data lineage into CIM



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Unified Data Model



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Actionable EMT Study Outcomes

- **Actionable Results from EMT Studies**
 - **Ride-through validation:** Ensuring plants stay online during voltage/frequency events
 - **Risk mitigation:** Identify negative interactions during real-time operations
 - **Root-cause analysis:** Accelerating post-event diagnostics via data analysis
- **User Study Requirements**
 - **Efficient creation:** Quick and easy to create the CIM context
 - **System observability:** Encoding institutional knowledge into the data model
 - **Strategic cataloging:** List of opportunities for later study



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“Observability” Shadow of the Physical World

- **The Physical Reality** – A cylinder exists in 3D
- **Offline Models** – PSSE, PSCAD, EMTP software (steady-state, dynamic, and EMT)
- **Real-time Measurement** – SCADA, PMU, POW systems (seconds vs. sub-cycle fidelity)
- **Post-event Validation**– hardware in the loop (HIL) systems (closed-loop verification)

Realtime Operations Data

”Built for operators and inherited by engineers!”

The Fragmented Landscape

EMS (Timeseries V/I/P, SOE, logs) | Substations (Fault records, communications) | Generation and RTO Inputs

The Engineering Friction

- The Goal: Unified data access vs. strict storage and bandwidth limits.
- The Paradox: 30,000 samples/sec. forces data pruning while violating pure observability rules against pre-aggregation

The Balancing Rule

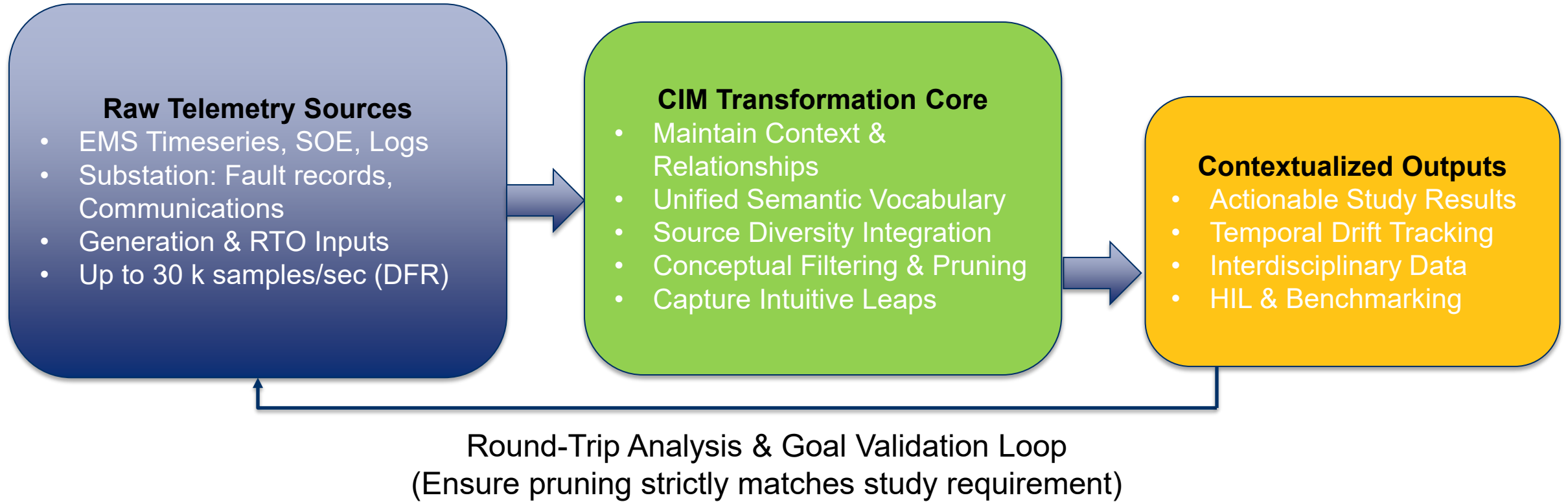
Engineers must weigh observability rules against physical limitations, using the required studies to dictate what data is kept.



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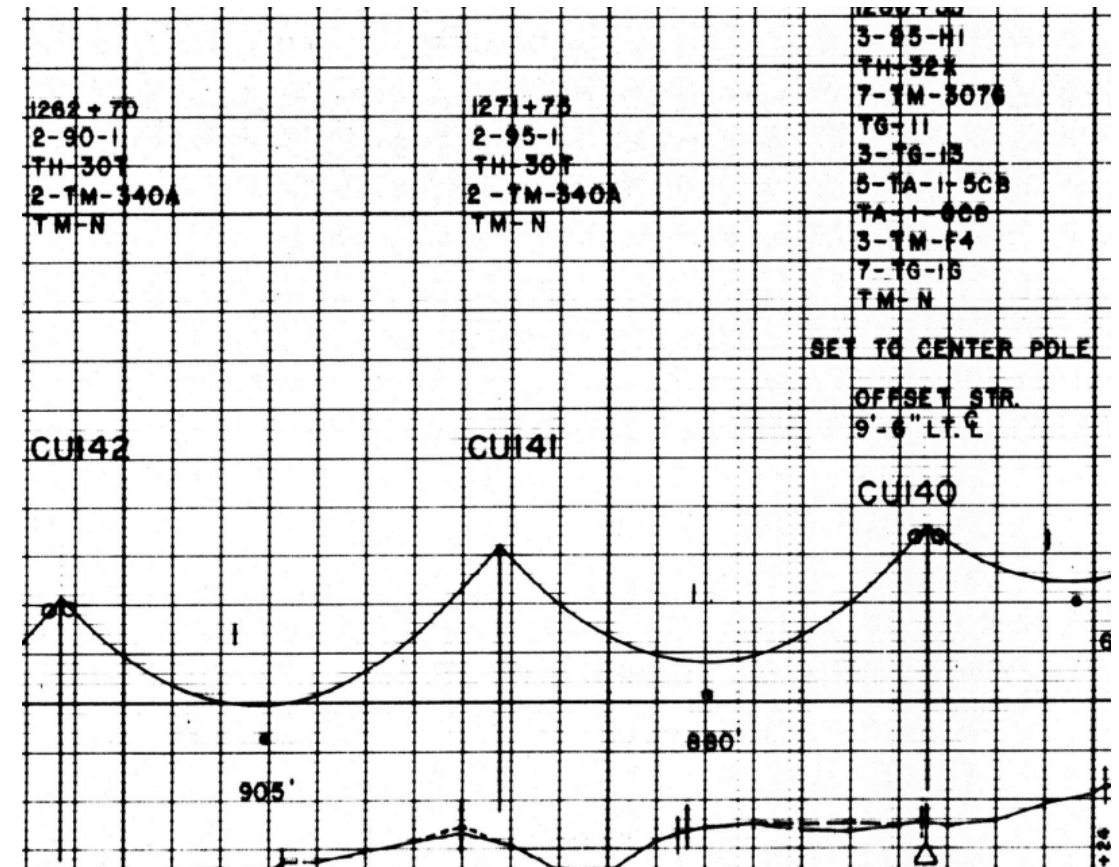
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Usable Telemetry Transformation



Example Workflow: Wideband Transmission Line Model

- **Data Layer Integration**
 - **Line Geometry & Spacing (OpenDSS):** Incorporates physical structures directly utilizing standardized line construction templates.
 - **Mutual Coupling (IEEE P3743):** Formats parallel line configurations sourced straight from short-circuit software.
 - **Earth Boundary Profiles:** Integrates geological borings to parameterize a dynamic, seasonal two-layer soil resistance model.
- **The Cohesive EMT Target**
 - **Unified Execution:** Aggregates physical geometry, standards-based coupling, and soil bounds directly into EMT software.



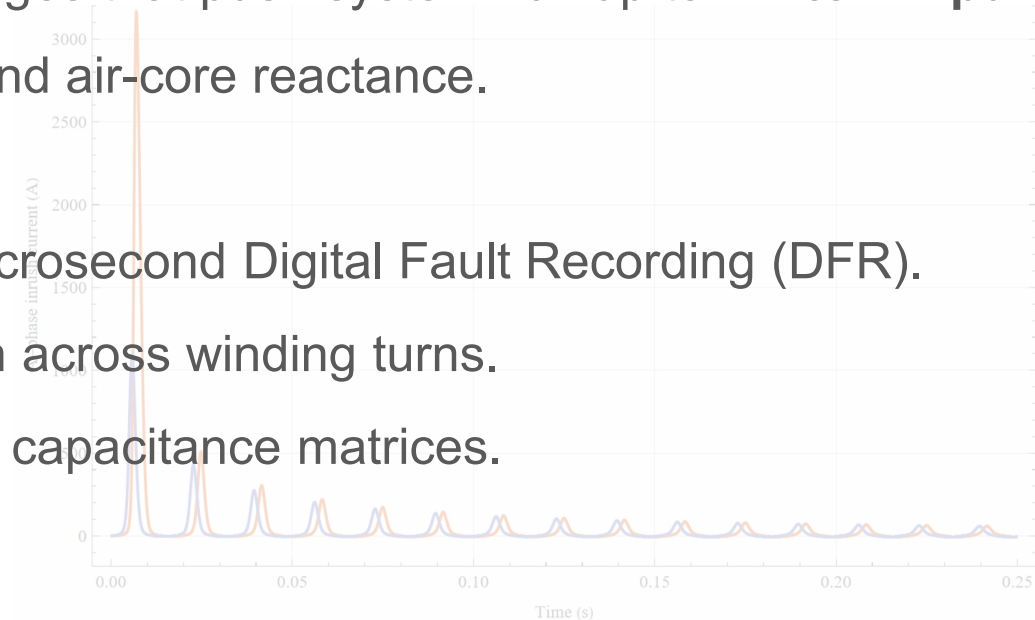
Example Workflow: Transformer Saturation & Transients

Low-frequency Dynamics (Switching)

- **In-rush Capture:** Analyzes high-side open-circuit tests using sub-cycle Point-on-Wave (POW) recording.
- **Deep Core Saturation:** Tracks extreme transient overvoltages that push system flux up to **1.2 to 2.2 pu**.
- **Parametric Focus:** Maps non-linear magnetizing curves and air-core reactance.

High-frequency Dynamics (Lightning)

- **Fast-Front Impulses:** Records lightning strikes via sub-microsecond Digital Fault Recording (DFR).
- **Winding Stress:** Captures non-uniform voltage distribution across winding turns.
- **Parametric Focus:** Identifies inter-disk and disk-to-ground capacitance matrices.



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Why Utilities Must Own the Data Model

The Vendor Lock-In Trap

- **Engine-centric schemas:** Vendors design data structures to optimize their calculation engines, not your multi-domain utility workflows.
- **The abandoned study crisis:** Critical transient simulations fail to happen purely because vendor software schemas make importing multi-source parameters too difficult.
- **Data volume $\neq$ engineering work:** Raw vendor file imports lack the operational context need to turn massive telemetry into usable simulation inputs.

The Solution: Independent Cohesion

- **The true cylinder:** A utility-owned data structure must decouple from vendor code to natively unify EMT, RMS, and Compliance frameworks under a single baseline.



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Conclusions: Bridging Data to Actionable Physics

The Interoperability Ecosystem

- **Vendor-neutral translation:** A separate Unified Data Model forces software vendors to adapt to utility needs, unlocking frictionless data transfers across CGMES CIM, OpenDSS, and the proposed IEEE P3743.

Strategic Takeaways

- **Dynamic physical bounds:** Real studies require high-fidelity telemetry integration to capture dynamic realities – like sweeping from dry to wet earth extremes or tracking 2.2 pu saturation.
- **Intelligent loop:** Telemetry features must maintain relationship topologies and manage the 30 k sample/sec pruning paradox via a Round-Trip Validation Loop.
- **Securing institutional assets:** Standardizing ingestion permanently encodes senior engineering ‘intuitive leaps’ as digital breadcrumbs inside the utility’s ecosystem.



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