DataSynth

Enterprise Synthetic Data Platform

High-Performance Generation for Accounting, Audit & ML

Rust core • Python wrapper • REST/gRPC API • Desktop UI

Executive Overview

Version 0.2.3

Deterministic, privacy-preserving synthetic data generation
for enterprise finance, compliance testing, and machine learning.

Built with Rust & Python • 16 modular crates • 100 K+ entries/sec

Open-source (Apache-2.0) • Commercial license available

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1 Executive Summary

DataSynth is a high-performance synthetic data platform purpose-built for enterprise accounting, audit analytics, and machine learning. Written in Rust for maximum throughput and memory safety — with a full Python wrapper for data-science workflows — it generates realistic, internally coherent financial data that satisfies the statistical and structural properties of real-world enterprise resource planning (ERP) systems.

Why DataSynth?

- **No real data required** — eliminates privacy, regulatory, and procurement barriers to analytics development.
- **Full auditability** — deterministic, seeded generation means every dataset is perfectly reproducible.
- **ML-ready from day one** — ground-truth labels for fraud, anomalies, and data quality ship alongside every record.
- **Domain depth** — covers the full accounting lifecycle: journal entries, document flows, subledgers, FX, intercompany, period close, and banking/AML.
- **Empirically grounded** — statistical distributions for journal entry line items, amount patterns, and temporal volumes are calibrated against empirical research conducted on real-world enterprise datasets, ensuring synthetic output mirrors the structural properties of production ERP data.

1.1 At a Glance

100 K+
entries/sec (single thread)

20+
labeled fraud typologies

10
industry presets

16
modular Rust crates

14
phases fully completed

4
privacy levels

2 Platform Capabilities

2.1 Enterprise Accounting Simulation

DataSynth generates a complete, internally consistent accounting universe:

Domain	Capabilities
Journal Entries	Balanced debits/credits, Benford-compliant amounts, configurable line-item distributions, SAP ACDOCA format export.
Master Data	Vendors, customers, materials, fixed assets, employees with hierarchies, payment terms, credit ratings, and intercompany flags.
Document Flows	Full Procure-to-Pay (PO → GR → Invoice → Payment) and Order-to-Cash (SO → Delivery → Invoice → Receipt) with three-way match validation.
Intercompany	Matched IC journal entry pairs, transfer pricing (Cost-Plus, Resale-Minus, CUP), and consolidation elimination entries.
Subledgers	AR/AP open items and aging, fixed asset register with depreciation schedules, inventory positions and movements, GL-to-subledger reconciliation.
FX & Translation	Ornstein–Uhlenbeck exchange rate process, multi-currency trial balance translation, currency translation adjustment entries.
Period Close	Month-end accruals, depreciation runs, year-end closing entries, fiscal period status tracking.

2.2 Banking, KYC & AML

A dedicated banking module generates realistic transaction data for anti-money-laundering testing:

- **Customer personas**: Retail, Business, Trust profiles with full KYC envelopes (declared turnover, source of funds, geographic exposure, cash intensity).
- **AML typologies**: Structuring, funnel accounts, layering schemes, money mule networks, round-tripping, and adversarial spoofing for robustness testing.
- **Ground-truth labels**: Entity-level risk classifications, transaction-level labels, and investigation narratives.

2.3 Audit Simulation

Generates ISA-compliant audit artifacts:

- Engagement metadata with materiality thresholds (ISA 320).
- Workpapers per ISA 230, evidence per ISA 500.
- Risk assessments (ISA 315/330), findings (ISA 265), and professional judgment documentation (ISA 200).

2.4 COSO 2013 Internal Control Framework

Full integration with the COSO Internal Control-Integrated Framework:

- **5 Components**: Control Environment, Risk Assessment, Control Activities, Information & Communication, Monitoring Activities.
- **17 Principles**: Complete principle coverage with control mappings.
- **Control Scopes**: Entity-level, transaction-level, IT general, and IT application controls.
- **Maturity Levels**: 6-level model (Non-Existent through Optimized).
- **Export**: `coso_control_mapping.csv` with principle-level granularity.

2.5 Accounting & Audit Standards

Comprehensive standards support via the `datasynth-standards` crate:

Category	Standards Supported
Accounting (US GAAP)	ASC 606 (Revenue), ASC 842 (Leases), ASC 820 (Fair Value), ASC 360 (Impairment)
Accounting (IFRS)	IFRS 15 (Revenue), IFRS 16 (Leases), IFRS 13 (Fair Value), IAS 36 (Impairment)
Audit Standards	34 ISA standards (ISA 200–720), 19+ PCAOB standards with ISA mapping
Regulatory	SOX Section 302 (Certifications), SOX Section 404 (ICFR Assessment), Deficiency Matrix (MW/SD classification)

Supports dual reporting mode (US GAAP + IFRS) with automatic framework difference reconciliation.

2.6 Process Mining (OCEL 2.0)

Object-Centric Event Logs track many-to-many relationships between business objects (orders, invoices, payments) and activities — enabling conformance checking and process variant analysis.

3 Machine Learning & Analytics

3.1 Anomaly Injection Framework

DataSynth injects labeled anomalies across five categories, each with configurable rates and temporal patterns:

Category	Types	Examples
Fraud	20+	Fictitious transactions, revenue manipulation, ghost employees, kickback schemes
Error	7	Duplicate entries, reversed amounts, wrong period, misclassification
Process	5	Skipped approvals, threshold manipulation, out-of-sequence postings
Statistical	4	Unusual amounts, trend breaks, Benford violations, outlier values
Relational	3	Circular transactions, dormant account activity, unusual counterparties

Every injected anomaly carries a `LabeledAnomaly` record with full metadata, enabling supervised and semi-supervised learning pipelines without manual labeling effort.

3.2 Data Quality Variations

Realistic data imperfections for training data-quality ML models:

- **Missing values**: MCAR, MAR, MNAR, and systematic patterns.
- **Format variations**: Date, amount, and identifier format diversity across regional conventions.
- **Duplicates**: Exact, near, and fuzzy duplicates.
- **Typos**: Keyboard-aware substitution, OCR errors, homophones.
- **Encoding issues**: Mojibake, BOM artifacts, HTML entity corruption.

3.3 Graph & Network Export

Supported Graph Formats

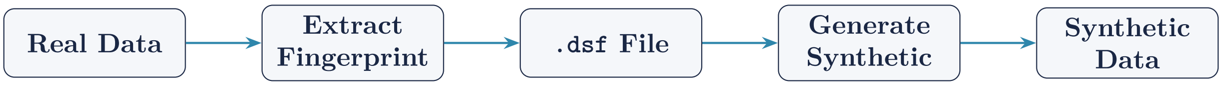
PyTorch Geometric	`.pt` files with node features, edge index, edge attributes, labels, and train/val/test masks.
Neo4j	CSV node/edge files with Cypher import scripts.
DGL	Deep Graph Library format for GNN training.

Computed features include temporal signals (weekday, period-end flags), amount signals (log-amount, Benford probability, round-number flag), structural signals (line count, unique accounts), and one-hot categorical encodings.

4 Privacy & Fingerprinting

4.1 Privacy-Preserving Fingerprint Extraction

DataSynth can extract a statistical *fingerprint* from real data and synthesize new data that matches its properties — without ever copying individual records.



Privacy engine applied here

Fidelity evaluated against fingerprint

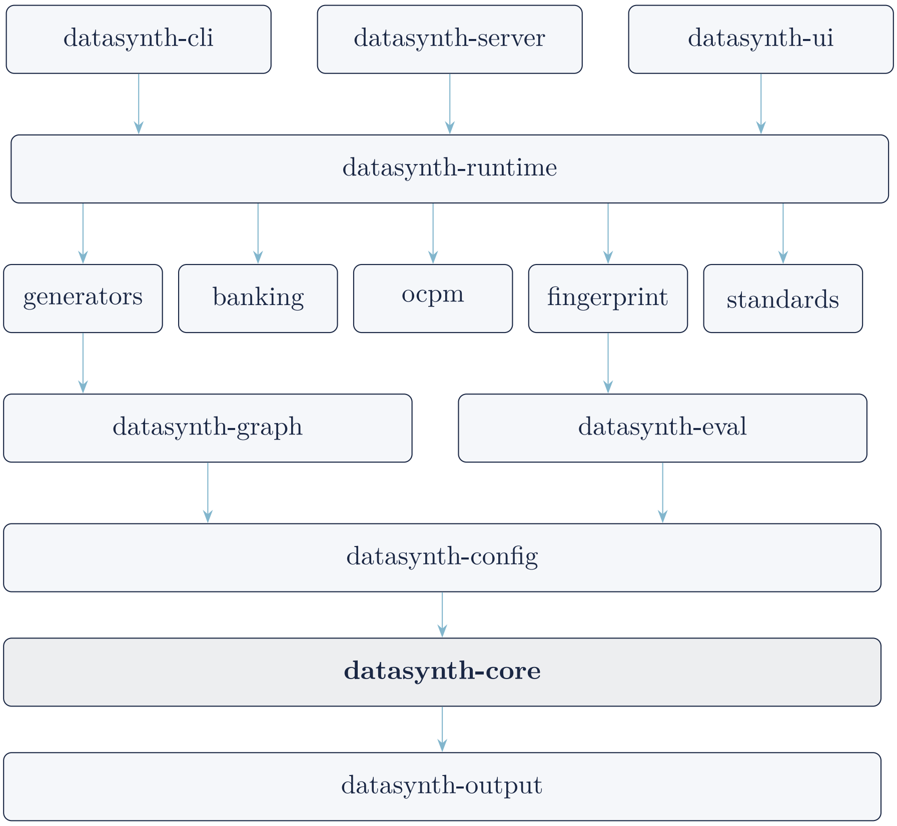
4.2 Privacy Levels

Level	Epsilon (ε)	k-Anon	Outlier %	Use Case
Minimal	5.0	3	99%	Low privacy, high utility
Standard	1.0	5	95%	Balanced (default)
High	0.5	10	90%	Sensitive environments
Maximum	0.1	20	85%	Maximum privacy guarantees

The privacy engine combines differential privacy (Laplace and Gaussian mechanisms), k-anonymity with rare-value suppression, and outlier winsorization. A full privacy audit trail records every decision and the cumulative epsilon budget spent.

5 Architecture

5.1 Layered Crate Architecture



5.2 Production-Grade Infrastructure

Capability	Details
Deterministic Output	ChaCha8 PRNG with configurable seed; identical seed ⇒ identical dataset.
Financial Precision	`rust_decimal` throughout; no IEEE 754 floating-point artifacts. Decimals serialized as strings.
Resource Guards	Unified CPU, memory, and disk monitoring with automatic throttling and graceful degradation (Normal → Reduced → Minimal → Emergency).
Collision-Free IDs	FNV-1a hash-based UUID factory with generator-type discriminators prevents document ID collisions across parallel generators.
API Layer	REST + gRPC + WebSocket with API-key authentication, sliding-window rate limiting, and configurable timeouts.
Desktop UI	Tauri + SvelteKit cross-platform application with 15+ configuration pages and real-time streaming viewer.
Python Wrapper	`datasynth-py` package with blueprints, pandas integration, and WebSocket streaming support.

6 Industry Presets

DataSynth ships with ten industry-specific configuration presets, each tuned for realistic business process weightings, chart-of-accounts structures, and regional multi-company setups.

Industry	Key Weight	Characteristics
Manufacturing	40% P2P	Heavy procurement, BOM-driven materials, multi-plant operations.
Retail	50% O2C	High-volume sales, inventory-intensive, multi-currency.
Financial Services	40% R2R	Report-heavy, regulatory compliance, intercompany structures.
Healthcare	15% H2R	Labour-intensive, complex billing, compliance-driven.
Technology	15% H2R	Knowledge workers, SaaS revenue recognition, R&D capitalization.
Professional Svcs.	—	Time-based billing, project accounting.
Energy	—	Capital-intensive, long-lived assets.
Transportation	—	Fleet management, route-based costing.
Real Estate	—	Property portfolios, lease accounting.
Telecommunications	—	Subscription revenue, network assets.

Each preset supports three complexity tiers: **Small** (∼100 GL accounts), **Medium** (∼400 accounts), and **Large** (∼2 500 accounts).

7 Use Cases

Primary Use Cases

- **Fraud Detection ML** — Train and validate models on labeled fraud typologies with realistic base-rate imbalance.
- **Graph Neural Networks** — Export transaction graphs in PyTorch Geometric, Neo4j, or DGL format with pre-computed features and train/val/test splits.
- **AML & KYC Testing** — Generate banking transaction data with structuring, layering, and mule patterns for compliance system validation.
- **Audit Analytics** — Produce ISA-compliant audit artifacts and anomaly-injected financial data for analytics tool development.
- **ERP Integration Testing** — Generate SAP ACDOCA-format data with full document chains for system migration and integration testing.
- **Process Mining** — OCEL 2.0 event logs for process discovery, conformance checking, and variant analysis.
- **SOX & COSO Compliance Testing** — Internal control definitions with COSO 2013 mappings, SOX 302/404 certifications, deficiency classification, and SoD conflict detection.
- **Accounting Standards Testing** — Generate revenue contracts (ASC 606/IFRS 15), lease portfolios (ASC 842/IFRS 16), fair value measurements, and impairment tests with dual-framework reconciliation.
- **Data Quality ML** — Labeled missing values, typos, duplicates, and format variations for training data-cleansing models.

8 Evaluation & Auto-Tuning

DataSynth includes a built-in evaluation framework that measures synthetic data quality across four dimensions:

1. **Statistical Fidelity** — KS statistic, Wasserstein distance, Benford's Law MAD, amount distribution fit.
2. **Coherence** — Balance-sheet validation, intercompany matching, document chain integrity, subledger reconciliation.
3. **Data Quality** — Completeness, consistency, duplicate rates, format correctness, uniqueness.
4. **ML Readiness** — Feature distributions, label quality, graph structure, train/val/test split balance.

An **auto-tuning engine** analyses evaluation results and produces prioritized configuration patches with expected improvement estimates — closing the loop between generation and validation.

9 Getting Started

9.1 Quick Start (CLI)

```
# Generate with demo preset
datasynth-data generate -demo -output ./output

# Create an industry-specific config
datasynth-data init -industry manufacturing -complexity medium -o config.yaml

# Generate from config
datasynth-data generate -config config.yaml -output ./output
```

9.2 Quick Start (Python)

```
from datasynth_py import DataSynth
from datasynth_py.config import blueprints

config = blueprints.retail_small(companies=4, transactions=10000)
synth = DataSynth()
result = synth.generate(config=config)
```

9.3 Server Mode

```
# Start REST/gRPC server with 4 worker threads
cargo run -p datasynth-server - -port 3000 -worker-threads 4
```

Links & Resources

Repository	https://github.com/ey-asu-rnd/SyntheticData
Documentation	https://ey-asu-rnd.github.io/SyntheticData/
Crates.io	https://crates.io/crates/datasynth-core
PyPI	https://pypi.org/project/datasynth-py/

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