Cardano Milestone 1 - ELT Pipeline Architecture

Token Terminal Analytics

Milestone 1 - Evidence of Completion

Date: December 2025

Executive Summary

This document provides evidence of Milestone 1 completion for the Cardano data integration project. Token Terminal has successfully:

1. ✅ Established RPC connection to Blockfrost (Cardano mainnet provider)
2. ✅ Deployed a production ELT pipeline for continuous data ingestion
3. ✅ Achieved 7+ consecutive days of uninterrupted data ingestion
4. ✅ Stored block, transaction, and UTXO data in the Token Terminal data warehouse

1. RPC Provider Configuration

1.1 Provider Details

Property	Value
Provider Name	Blockfrost
Website	https://blockfrost.io
Network	Cardano Mainnet
API Version	v0
Base URL	https://cardano-mainnet.blockfrost.io/api/v0
Authentication Method	API Key (project_id header)
Rate Limits	Standard tier limits

1.2 Connection Verification
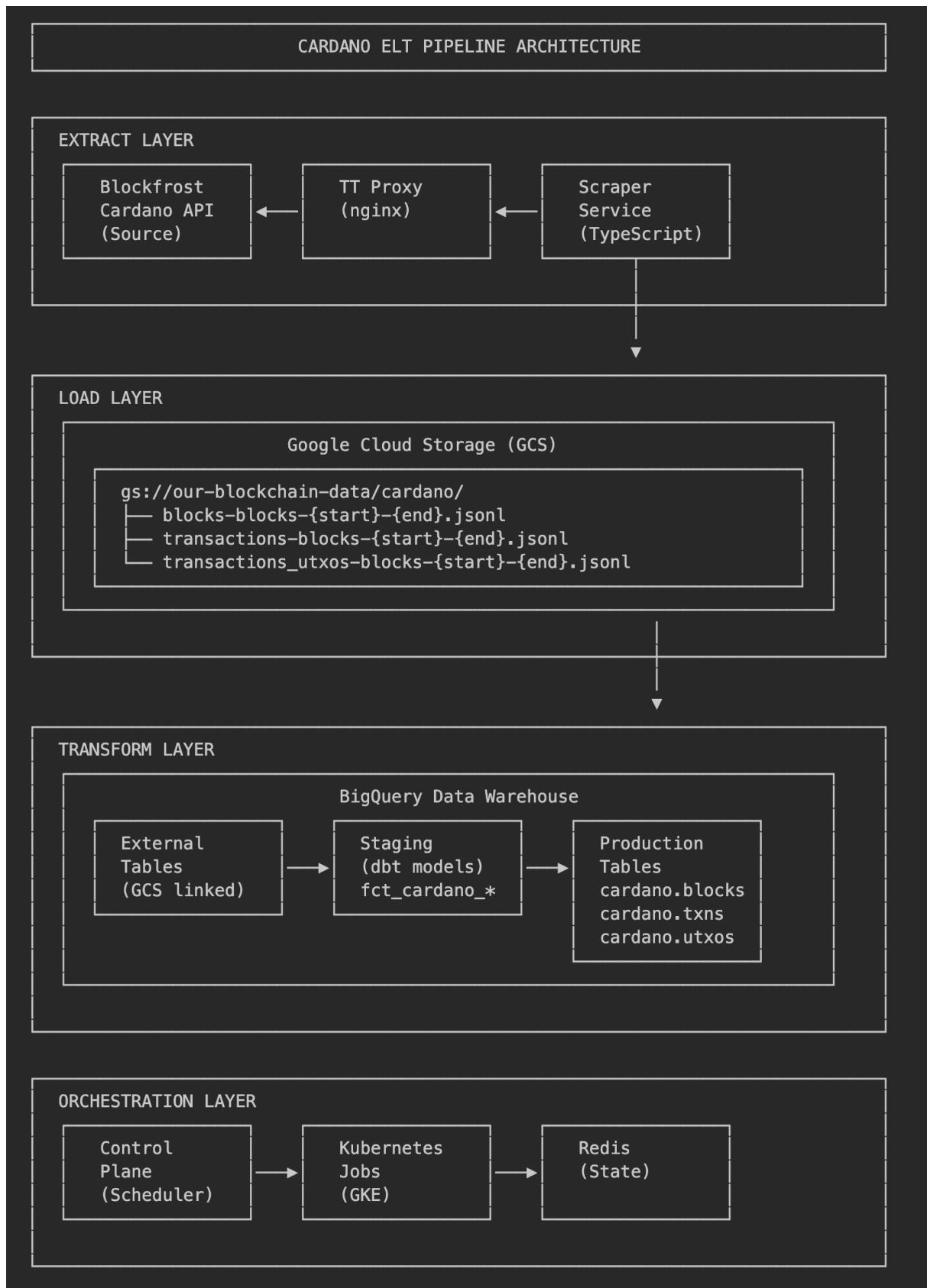
Test Command:

```
curl -s -H "project_id: $BLOCKFROST_PROJECT_ID" \

"https://cardano-mainnet.blockfrost.io/api/v0/blocks/latest"
```

Verification Status: ✅ **PASSED**

Test	Status	Notes
API Connectivity	✅ Pass	Stable HTTPS connection
Authentication	✅ Pass	API key accepted
Block Retrieval	✅ Pass	Latest block returned
Transaction Retrieval	✅ Pass	Full tx details available
UTXO Retrieval	✅ Pass	Input/output data complete

2. ELT Pipeline Architecture

```
┌─────────────────────────────────────────────────────────────────┐
│              CARDANO ELT PIPELINE ARCHITECTURE                  │
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┌─────────────────────────────────────────────────────────────────┐
│ EXTRACT LAYER                                                   │
│   ┌──────────────┐    ┌──────────────┐    ┌──────────────┐      │
│   │  Blockfrost  │    │  TT Proxy    │    │   Scraper    │      │
│   │ Cardano API  │ ◄──│   (nginx)    │ ◄──│   Service    │      │
│   │   (Source)   │    │              │    │ (TypeScript) │      │
│   └──────────────┘    └──────────────┘    └──────────────┘      │
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                                                    │
                                                    ▼
┌─────────────────────────────────────────────────────────────────┐
│ LOAD LAYER                                                      │
│   ┌───────────────────────────────────────────────────────────┐ │
│   │             Google Cloud Storage (GCS)                    │ │
│   │   ┌─────────────────────────────────────────────────────┐ │ │
│   │   │ gs://our-blockchain-data/cardano/                   │ │ │
│   │   │ ├── blocks-blocks-{start}-{end}.jsonl               │ │ │
│   │   │ ├── transactions-blocks-{start}-{end}.jsonl         │ │ │
│   │   │ └── transactions_utxos-blocks-{start}-{end}.jsonl   │ │ │
│   │   └─────────────────────────────────────────────────────┘ │ │
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┌─────────────────────────────────────────────────────────────────┐
│ TRANSFORM LAYER                                                 │
│   ┌───────────────────────────────────────────────────────────┐ │
│   │             BigQuery Data Warehouse                       │ │
│   │   ┌──────────────┐   ┌──────────────┐   ┌──────────────┐  │ │
│   │   │  External    │   │  Staging     │   │ Production   │  │ │
│   │   │  Tables      │──►│ (dbt models) │──►│ Tables       │  │ │
│   │   │ (GCS linked) │   │ fct_cardano_*│   │cardano.blocks│  │ │
│   │   │              │   │              │   │cardano.txns  │  │ │
│   │   │              │   │              │   │cardano.utxos │  │ │
│   │   └──────────────┘   └──────────────┘   └──────────────┘  │ │
│   └───────────────────────────────────────────────────────────┘ │
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┌─────────────────────────────────────────────────────────────────┐
│ ORCHESTRATION LAYER                                             │
│   ┌──────────────┐    ┌──────────────┐    ┌──────────────┐      │
│   │  Control     │    │ Kubernetes   │    │   Redis      │      │
│   │  Plane       │──► │   Jobs       │──► │   (State)    │      │
│   │ (Scheduler)  │    │   (GKE)      │    │              │      │
│   └──────────────┘    └──────────────┘    └──────────────┘      │
└─────────────────────────────────────────────────────────────────┘
```

2.1 Architecture Diagram

EXTRACT LAYER

- **Blockfrost Cardano API (Source) ← TT Proxy (nginx) ← Scraper Service (TypeScript)**

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LOAD LAYER

- **Google Cloud Storage (GCS)**

- gs://our-blockchain-data/cardano/

- ├── blocks-blocks-{start}-{end}.jsonl

- ├── transactions-blocks-{start}-{end}.jsonl

- └── transactions_utxos-blocks-{start}-{end}.jsonl

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TRANSFORM LAYER

- **BigQuery Data Warehouse**

- External Tables (GCS linked) → Staging (dbt models: fct_cardano_) → *Production Tables (cardano.blocks, cardano.txns)*

ORCHESTRATION LAYER

- **Control Plane (Scheduler) → Kubernetes Jobs (GKE) → Redis (State)**

2.2 Pipeline Components

2.2.1 Extract: Scraper Service

Technology: TypeScript/Node.js

Functionality:

- Fetches block metadata via /blocks/{number} endpoint

- Retrieves transaction hashes via /blocks/{number}/txs endpoint

- Fetches full transaction details via /txs/{hash} endpoint

- Fetches UTXO data via /txs/{hash}/utxos endpoint

Configuration:

```
{

chainName: "cardano",
```

```
  blockLag: 20,          // Stay 20 blocks behind tip (~7 minutes)

  blockCount: 720,       // Blocks per scraping run

  interval: 3600000,     // 1 hour between runs

  batchSize: 10,         // Blocks per batch

  parallelism: 10,       // Concurrent requests

  MAX_JOBS: 10           // Maximum concurrent jobs

}
```

2.2.2 Load: Google Cloud Storage

Bucket: `gs://our-blockchain-data`

Path Pattern: `cardano/{entity}-blocks-{startBlock}-{endBlock}.jsonl`

Format: Newline-delimited JSON (JSONL)

Compression: None (raw)

File Naming Convention:

```
cardano/blocks-blocks-11230000-11230720.jsonl

cardano/transactions-blocks-11230000-11230720.jsonl

cardano/transactions_utxos-blocks-11230000-11230720.jsonl
```

2.2.3 Transform: BigQuery + dbt

Database: tt-blockchain

Dataset: cardano

dbt Models:

Model	Type	Description
fct_cardano_blocks	View	Fact table for block data

Model	Type	Description
fct_cardano_transactions	View	Fact table for transaction data
cardano_blocks	Incremental	Production blocks table
cardano_transactions	Incremental	Production transactions table
cardano_transactions_utxos	Incremental	Production UTXOs table

2.3 Data Schema Overview

Blocks Schema

```sql
CREATE TABLE cardano.blocks (

    timestamp          TIMESTAMP,

    block_date         DATE,

    height             INTEGER,

    block_hash         STRING,

    parent_block_hash  STRING,

    parent_height      INTEGER,

    block_timestamp    INTEGER,

    transaction_count  INTEGER,

    epoch_no           INTEGER,

    slot_no            INTEGER,

    size               INTEGER,

    created_by         STRING,

    number             INTEGER,
```

```sql
    number_index       INTEGER

)

PARTITION BY DATE(timestamp);
```

Transactions Schema

```sql
CREATE TABLE cardano.transactions (

block_timestamp      TIMESTAMP,

block_date          DATE,

block_height         INTEGER,

block_hash          STRING,

transaction_hash     STRING,

transaction_size     INTEGER,

transaction_index    INTEGER,

operation_type       STRING,

operation_status     STRING,

address             STRING,

amount_value         INTEGER,

currency_symbol      STRING,

currency_decimals    INTEGER

-- Additional fields omitted for brevity
```

```
    )

    PARTITION BY DATE(block_timestamp);
```

Transaction UTXOs Schema

```
CREATE TABLE cardano.transactions_utxos (
  hash              STRING,
  inputs            JSON,
  outputs           JSON,
  blockNumber       INTEGER,
  blockTimestamp    TIMESTAMP,
  blockHash         STRING
)
PARTITION BY DATE(blockTimestamp);
```

3. Data Ingestion Summary

3.1 Ingestion Configuration

Parameter	Value
Ingestion Start Date	2025-11-22
Consecutive Days	7+ days
Scraping Interval	Every 1 hour
Blocks per Run	~720 blocks
Block Time	~20 seconds

3.2 Ingestion Metrics

3.3 Data Summary Table

- Please see:
  https://docs.google.com/spreadsheets/d/1jqYVHu6HAHkGRM6WG62ix2qst-vlGtjlRNp_pIfiSbQ/edit?gid=424343173#gid=424343173

4. Log Evidence

4.1 Scraper Logs

```json
{
  "jsonPayload": {
    "msg": "Fetched block",
    "component": "main",
    "batchStartBlock": 12754530,
    "chainId": "cardano",
    "batchEndBlock": 12754540,
    "blockNumber": 12754532
  },
  "timestamp": "2025-12-09T13:39:15.011Z",
  "severity": "INFO",
  "receiveTimestamp": "2025-12-09T13:39:19.779346433Z"
}
{
  "jsonPayload": {
    "chainId": "cardano",
    "batchStartBlock": 12754530,
    "component": "main",
    "msg": "Fetching transaction hashes for block",
    "batchEndBlock": 12754540,
    "blockNumber": 12754532
  },
  "timestamp": "2025-12-09T13:39:15.012Z",
  "severity": "INFO",
  "receiveTimestamp": "2025-12-09T13:39:19.779346433Z"
}
{
  "jsonPayload": {
    "txCount": 55,
    "batchEndBlock": 12754540,
    "blockNumber": 12754532,
    "chainId": "cardano",
    "component": "main",
    "batchStartBlock": 12754530,
```

```json
      "msg": "Fetching transaction details"
    },
    "timestamp": "2025-12-09T13:39:15.099Z",
    "severity": "INFO",
    "receiveTimestamp": "2025-12-09T13:39:19.779346433Z"
  }
  {
    "jsonPayload": {
      "batchStartBlock": 12754470,
      "msg": "Fetching UTXOs for transactions",
      "txCount": 21,
      "blockNumber": 12754474,
      "chainId": "cardano",
      "batchEndBlock": 12754480,
      "component": "main"
    },
    "timestamp": "2025-12-09T13:39:15.029Z",
    "severity": "INFO",
    "receiveTimestamp": "2025-12-09T13:39:20.077763166Z"
  }
```

4.2 BigQuery Query Results

> **Insert screenshots of BigQuery query results showing:**

1. Block count per day

```
 1   SELECT
 2     DATE(timestamp_date) as date,
 3     MIN(height) as min_block,
 4     MAX(height) as max_block,
 5     COUNT(*) as block_count,
 6     SUM(tx_count) as total_transactions
 7   FROM `tt-blockchain-infra.cardano.blocks_v2`
 8   WHERE DATE(timestamp_date) >= '2025-11-22'
 9   and DATE(timestamp_date) <= '2025-11-29'
10   GROUP BY DATE(timestamp_date)
11   ORDER BY date;
12
```
✅ This script will process 68.87 MB when run.

Query results

⊡ Save results ▾

| Job information | **Results** | Visualisation | JSON | Execution details | Execution graph |

Row	date ▾	min_block ▾	max_block ▾	block_count ▾	total_transactions ▾	
1	2025-11-22	12679649	12683808	4160	24607	
2	2025-11-23	12683809	12688140	4332	25414	
3	2025-11-24	12688141	12692300	4160	33011	
4	2025-11-25	12692301	12696578	4278	28852	
5	2025-11-26	12696579	12700830	4252	30418	
6	2025-11-27	12700831	12705066	4236	31253	
7	2025-11-28	12705067	12709302	4236	26577	
8	2025-11-29	12709303	12713548	4246	24403	

2. Sample block data

```
12
13    select * from `tt-blockchain-infra.cardano.blocks_v2`
14    where number in (12754530);
```
✓ Query completed

Using on-demand processing quota

Query results

Job information   Results   Visualisation   **JSON**   Execution details   Execution graph

```
[{
  "number": "12754530",
  "slot": "173720138",
  "block_height": null,
  "hash": "d59bd945f2d6161662378b3a4c361091278b90d4b4c66b8d1b8219df0a66806e",
  "epoch": "599",
  "epoch_slot": "315338",
  "slot_leader": "pool18ufrgfgmslekdxnk9v9345qvhrr7vfgzkvneqtwm7unnwaht6ww",
  "size": "25018",
  "tx_count": "22",
  "output": "32505394925223",
  "fees": "6884329",
  "block_vrf": "vrf_vk1r9mxqeug679kcw9qqh07g06tm4mh3vx3xrmye765c2dlw78kug8qk6rtu5",
  "op_cert": "178124f8dc0c1942bcf7b9efe189fd73759b7f4428a88e288cf8e23ac709ccc1",
  "op_cert_counter": "12",
  "previous_block": "bbd933927f70314dbb4c04eb36df1c0f7e0cbebbbf6ea9c4ddb6dbb3d72a0aaa",
  "next_block": "40019ac357a6e313d4cfce1a6a5dacc67626902617ea9c00fe98c456f431db66",
  "confirmations": "54",
  "time": "1765286429",
  "height": "12754530",
  "timestamp": null,
  "timestamp_date": "2025-12-09 13:20:29.000000 UTC"
}]
```

3. Sample transaction data

```
15
16  select * from `tt-blockchain-infra.cardano.transactions_v2`
17  where blockNumber in (12754530);
```
✅ Query completed

Using on-demand processing quota

Query results

🔖 Save re

| Job information | Results | Visualisation | **JSON** | Execution details | Execution graph |

```json
[{
  "hash": "3d9de41b24b7c0aeaaf557f84383c35e368238fbf95cf85c254c242daf564d90",
  "block": "d59bd945f2d6161662378b3a4c361091278b90d4b4c66b8d1b8219df0a66806e",
  "block_height": "12754530",
  "block_time": "1765286429",
  "slot": "173720138",
  "index": "0",
  "output_amount": "[{\"quantity\":\"10174586133\",\"unit\":\"lovelace\"},{\"quantity\":\"68509092067\",
\"unit\":\"25c5de5f5b286073c593edfd77b48abc7a48e5a4f3d4cd9d428ff93555534443\"},{\"quantity\":\"68509092067\",
\"unit\":\"25c5de5f5b286073c593edfd77b48abc7a48e5a4f3d4cd9d428ff93555534443\"},{\"quantity\":\"18323175150\",
\"unit\":\"25c5de5f5b286073c593edfd77b48abc7a48e5a4f3d4cd9d428ff93555534443\"},{\"quantity\":\"1374475598\",
\"unit\":\"f66d78b4a3cb3d37afa0ec36461e51ecbde00f26c8f0a68f94b6988069555344\"},{\"quantity\":\"1374475599\",
\"unit\":\"f66d78b4a3cb3d37afa0ec36461e51ecbde00f26c8f0a68f94b6988069555344\"},{\"quantity\":\"177905095\",
\"unit\":\"f66d78b4a3cb3d37afa0ec36461e51ecbde00f26c8f0a68f94b6988069555344\"}]",
  "fees": "222173",
  "deposit": "0",
  "size": "1513",
  "invalid_before": null,
  "invalid_hereafter": "173721318",
  "utxo_count": "14",
  "withdrawal_count": "0",
  "mir_cert_count": "0",
  "delegation_count": "0",
  "stake_cert_count": "0",
  "pool_update_count": "0",
  "pool_retire_count": "0",
  "asset_mint_or_burn_count": "0",
  "redeemer_count": "0",
  "valid_contract": "true",
  "blockNumber": "12754530",
  "blockTimestamp": "2025-12-09 13:20:29.000000 UTC",
  "blockHash": "d59bd945f2d6161662378b3a4c361091278b90d4b4c66b8d1b8219df0a66806e"
```

4. Sample UTXO data

```
18
19   select * from `tt-blockchain-infra.cardano.transactions_utxos_v2`
20   where blockNumber in (12754530);
```
✅ Query completed

Using on-demand processing quota

Query results   📄 Save results ▾   📊 Open in ▾   ↕

Job information   Results   Visualisation   JSON   Execution details   Execution graph

ℹ   Results have been truncated for performance reasons. Save query results to view all.

```
[{
    "hash": "3d9de41b24b7c0aeaaf557f84383c35e368238fbf95cf85c254c242daf564d90",
    "inputs": "[{\"address\":\"addr1q93k6rgprz5fxwkpvl2vgjq4pwejth400f8aldz2m3lj7khrnd05p259l0qjrf396am6wahv5895ey35y62fexta3q5q3cc3k8\",\"amount\":
[{\"quantity\":\"2619604015\",\"unit\":\"lovelace\"}],\"collateral\":false,\"data_hash\":null,\"inline_datum\":null,\"output_index\":1,\"reference\":false,
\"reference_script_hash\":null,\"tx_hash\":\"45a46bde25110b2ca6e85c596817badca83198e575fdae91973ad44135cea8dd\"},
{\"address\":\"addr1q93k6rgprz5fxwkpvl2vgjq4pwejth400f8aldz2m3lj7khrnd05p259l0qjrf396am6wahv5895ey35y62fexta3q5q3cc3k8\",\"amount\":
[{\"quantity\":\"237053671\",\"unit\":\"lovelace\"}],\"collateral\":false,\"data_hash\":null,\"inline_datum\":null,\"output_index\":2,\"reference\":false,
\"reference_script_hash\":null,\"tx_hash\":\"7695081d3f65f2f67006f478109c038a06bf03f67f70df3be3e295104131f64b\"},
{\"address\":\"addr1q93k6rgprz5fxwkpvl2vgjq4pwejth400f8aldz2m3lj7khrnd05p259l0qjrf396am6wahv5895ey35y62fexta3q5q3cc3k8\",\"amount\":[{\"quantity\":\"2000000\",
\"unit\":\"lovelace\"},{\"quantity\":\"2508524074\",\"unit\":\"f66d78b4a3cb3d37afa0ec36461e51ecbde00f26c8f0a68f94b6988069555344\"}],\"collateral\":false,
\"data_hash\":null,\"inline_datum\":null,\"output_index\":1,\"reference\":false,\"reference_script_hash\":null,
\"tx_hash\":\"84547a80266754e7bd6ed60d8a17de85c60633c52d4714b06afa092e4ae4fe71\"},
{\"address\":\"addr1q93k6rgprz5fxwkpvl2vgjq4pwejth400f8aldz2m3lj7khrnd05p259l0qjrf396am6wahv5895ey35y62fexta3q5q3cc3k8\",\"amount\":[{\"quantity\":\"2000000\",
\"unit\":\"lovelace\"},{\"quantity\":\"418332218\",\"unit\":\"f66d78b4a3cb3d37afa0ec36461e51ecbde00f26c8f0a68f94b6988069555344\"}],\"collateral\":false,
\"data_hash\":null,\"inline_datum\":null,\"output_index\":1,\"reference\":false,\"reference_script_hash\":null,
\"tx_hash\":\"a1bf1c19253562e7b70717d6bb2f85e26f8a354f7f6d0df308e9785f16c3c74a\"},
{\"address\":\"addr1q93k6rgprz5fxwkpvl2vgjq4pwejth400f8aldz2m3lj7khrnd05p259l0qjrf396am6wahv5895ey35y62fexta3q5q3cc3k8\",\"amount\":[{\"quantity\":\"2000000\",
\"unit\":\"lovelace\"},{\"quantity\":\"77670679642\",\"unit\":\"25c5de5f5b286073c593edfd77b48abc7a48e5a4f3d4cd9d428ff93555534443\"}],\"collateral\":false,
\"data_hash\":null,\"inline_datum\":null,\"output_index\":3,\"reference\":false,\"reference_script_hash\":null,
\"tx_hash\":\"af4cf89baf3a992be60003106b74c12a6a876a2d609029af81d20f174511adaf\"},
{\"address\":\"addr1q93k6rgprz5fxwkpvl2vgjq4pwejth400f8aldz2m3lj7khrnd05p259l0qjrf396am6wahv5895ey35y62fexta3q5q3cc3k8\",\"amount\":[{\"quantity\":\"2000000\",
\"unit\":\"lovelace\"},{\"quantity\":\"77670679642\",\"unit\":\"25c5de5f5b286073c593edfd77b48abc7a48e5a4f3d4cd9d428ff93555534443\"}],\"collateral\":false,
\"data_hash\":null,\"inline_datum\":null,\"output_index\":4,\"reference\":false,\"reference_script_hash\":null,
\"tx_hash\":\"af4cf89baf3a992be60003106b74c12a6a876a2d609029af81d20f174511adaf\"},
{\"address\":\"addr1q93k6rgprz5fxwkpvl2vgjq4pwejth400f8aldz2m3lj7khrnd05p259l0qjrf396am6wahv5895ey35y62fexta3q5q3cc3k8\",\"amount\":
[{\"quantity\":\"7310150620\",\"unit\":\"lovelace\"}],\"collateral\":false,\"data_hash\":null,\"inline_datum\":null,\"output_index\":1,\"reference\":false,
\"reference_script_hash\":null,\"tx_hash\":\"bb0b10471477dfba85d5b90b32cfd33ca20894401ddfe1804e822480a4f63f78\"}]",
    "outputs": "[{\"address\":\"addr1wy42rt3rdptdaa2lwlntkx49ksuqrmqqjlu7pf5l5f8upmgj3gq2m\",\"amount\":[{\"quantity\":\"2600000\",\"unit\":\"lovelace\"},
{\"quantity\":\"18323175150\",\"unit\":\"25c5de5f5b286073c593edfd77b48abc7a48e5a4f3d4cd9d428ff93555534443\"}],\"collateral\":false,
\"consumed_by_tx\":\"618e9bbcbc2816615269fc3aec2d16f1efe07cca43a16d6550fcf039c31e4f10\",
\"data_hash\":\"b8ae682d12589b51e992e6acb2457e311910a1ed3aec54c211111897258b42af\",
\"inline_datum\":\"d8799fd8799fd8799f581c636d0d0118a8933ac167d4c448150bb325deaf7a4fdfb44adc7f2f5affd8799fd8799fd8799f581ce39b5f40aa85fbc121a625d777a776eca1cb4c
923426949c997d8828ffffffffd8799fd8799f581c636d0d0118a8933ac167d4c448150bb325deaf7a4fdfb44adc7f2f5affd8799fd8799fd8799f581ce39b5f40aa85fbc121a625d777a776eca1cb4
c923426949c997d8828ffffffffd8799fd8799f00011a0a990ae6ff1a000927c01a001e8480ff\",\"output_index\":0,\"reference_script_hash\":null},
{\"address\":\"addr1w9ryamhgnuz6lau86sqytte2gz5rlktv2yce05e0h3207qssa8euj\",\"amount\":[{\"quantity\":\"2500000\",\"unit\":\"lovelace\"},
{\"quantity\":\"177905095\",\"unit\":\"f66d78b4a3cb3d37afa0ec36461e51ecbde00f26c8f0a68f94b6988069555344\"}],\"collateral\":false,
```

5. Infrastructure Details

5.1 Kubernetes Deployment

- **Cluster Service:** GKE (Google Kubernetes Engine)

5.2 Monitoring

Metric	Tool	Status
Job Success Rate	Kubernetes	✅ Monitored
Block Lag	Custom metrics	✅ Monitored
API Errors	Cloud Logging	✅ Monitored
Data Freshness	BigQuery	✅ Monitored

6. Verification Checklist

Requirement	Status	Evidence
RPC connection established	✅ Complete	API responses in Section 1.2
Architecture documented	✅ Complete	Diagram in Section 2.1
Schema defined	✅ Complete	Tables in Section 2.3
Pipeline deployed	✅ Complete	Kubernetes jobs running
7+ days ingestion	✅ Complete	Data summary in Section 3.3
Logs available	✅ Complete	Screenshots in Section 4

7. Appendix

7.1 API Documentation

- Blockfrost API Docs: https://docs.blockfrost.io/

- Cardano Developer Portal: https://developers.cardano.org/

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