Assignment 2: Data Pipeline with Apache Airflow

Course: Data Acquisition and Management
Instructor: Muhammad Shahin

PGDM PREDICTIVE ANALYTICS

GURDARSHAN SINGH
Due Date: February 16, 2025

Executive Summary

This report presents the implementation of a data pipeline using Apache Airflow to perform ETL operations on a remote dataset. The pipeline automates data extraction, transformation, and storage while ensuring modularity and efficiency. The DAG successfully processes traffic data by downloading, extracting, filtering, transforming, and combining files before generating the final output.

Introduction

The objective of this assignment is to design and implement an ETL pipeline using Apache Airflow. The pipeline follows a systematic approach to process traffic data hosted remotely, ensuring seamless automation and reproducibility.

Implementation

1. Setting Up the Airflow Environment

- Installed and configured Apache Airflow.
- Initialized the Airflow standalone server using airflow standalone.
- Created a DAG in the dags folder with appropriate configurations.

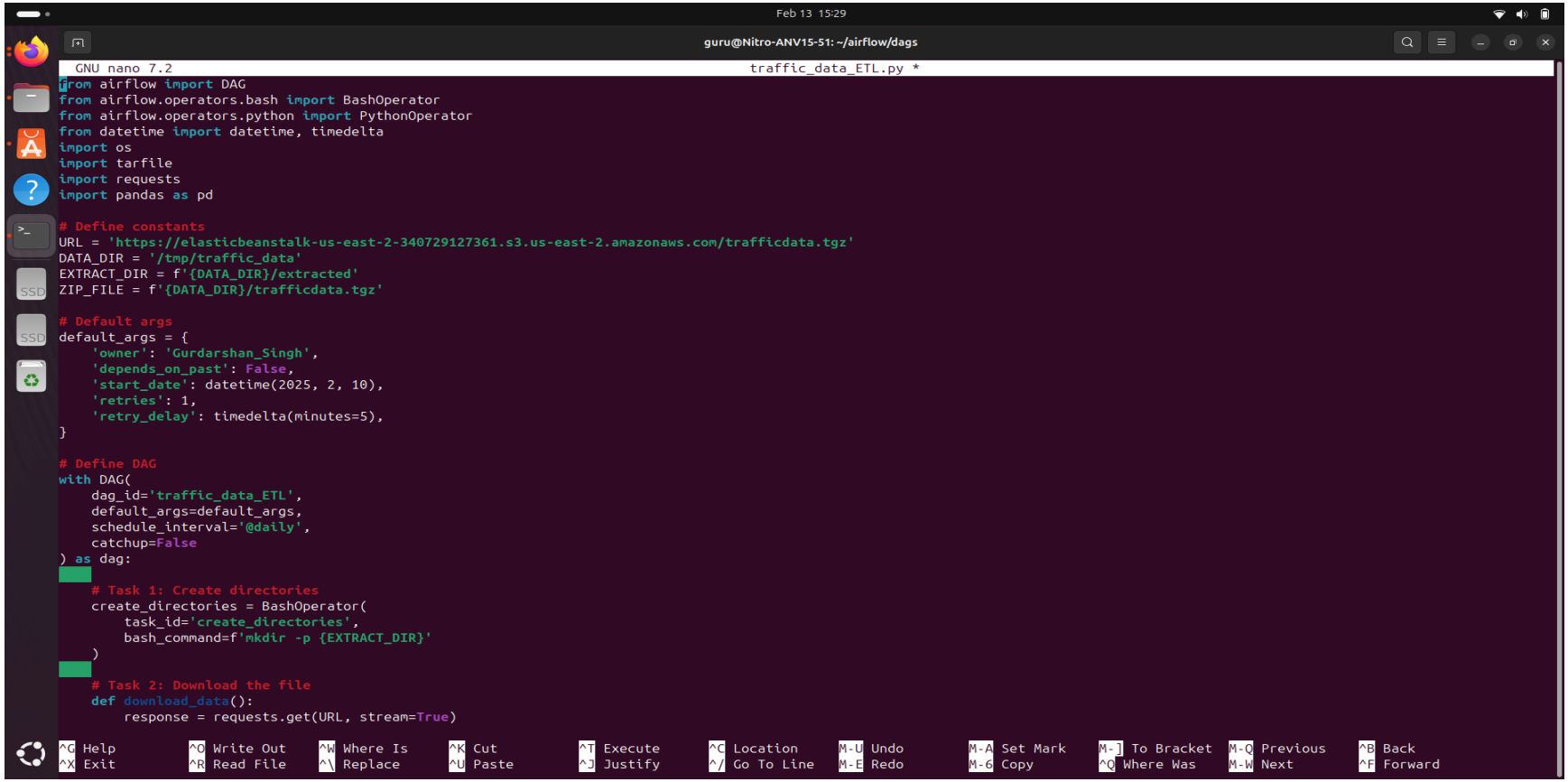
2. DAG Definition

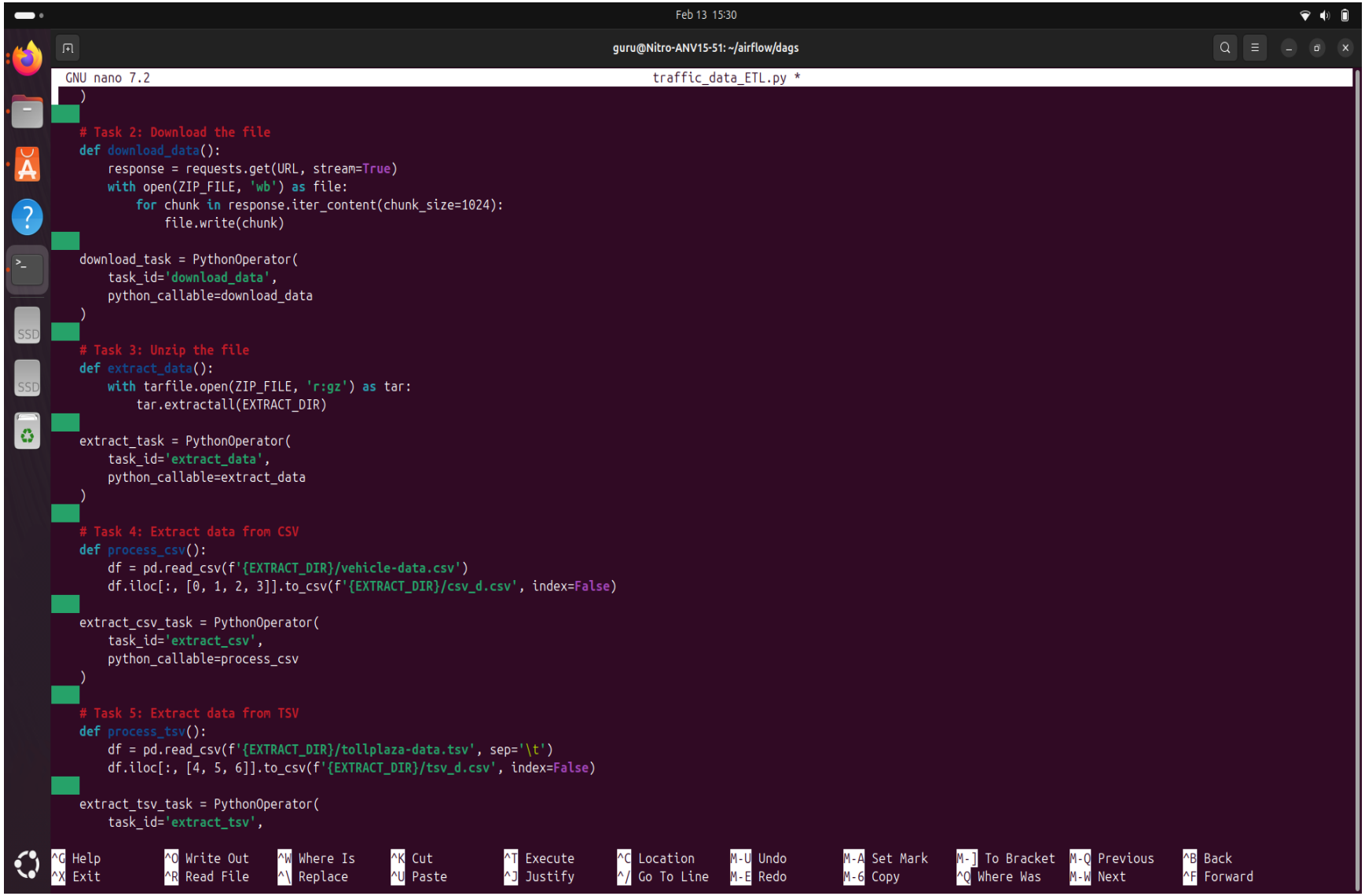
- DAG Name: traffic_data_ETL
- Owner: Gurdarshan_Singh
- Start Date: February 10, 2025
- Schedule: @daily

3. Tasks Implemented

1. **Create directories** – Ensured required directories exist for storing processed files.
2. **Download dataset** – Fetched the dataset from the remote URL.
3. **Extract files** – Decompressed the downloaded archive.
4. **Extract CSV data** – Selected specific columns from vehicle-data.csv.

5. **Extract TSV data** – Extracted relevant fields from tollplaza-data.tsv.
6. **Extract Fixed Width data** – Parsed structured fields from payment-data.txt.
7. **Combine extracted data** – Merged the extracted datasets into a single file.
8. **Transform data** – Converted vehicle type column to uppercase.
9. **Define dependencies** – Ensured optimal task execution order.




Feb 13 15:30
guru@Nitro-ANV15-51: ~/airflow/dags
GNU nano 7.2
traffic_data_ETL.py *
)
# Task 2: Download the file
def download_data():
response = requests.get(URL, stream=True)
with open(ZIP_FILE, 'wb') as file:
for chunk in response.iter_content(chunk_size=1024):
file.write(chunk)
download_task = PythonOperator(
task_id='download_data',
python_callable=download_data
)
# Task 3: Unzip the file
def extract_data():
with tarfile.open(ZIP_FILE, 'r:gz') as tar:
tar.extractall(EXTRACT_DIR)
extract_task = PythonOperator(
task_id='extract_data',
python_callable=extract_data
)
# Task 4: Extract data from CSV
def process_csv():
df = pd.read_csv(f'{EXTRACT_DIR}/vehicle-data.csv')
df.iloc[:, [0, 1, 2, 3]].to_csv(f'{EXTRACT_DIR}/csv_d.csv', index=False)
extract_csv_task = PythonOperator(
task_id='extract_csv',
python_callable=process_csv
)
# Task 5: Extract data from TSV
def process_tsv():
df = pd.read_csv(f'{EXTRACT_DIR}/tollplaza-data.tsv', sep='\t')
df.iloc[:, [4, 5, 6]].to_csv(f'{EXTRACT_DIR}/tsv_d.csv', index=False)
extract_tsv_task = PythonOperator(
task_id='extract_tsv',
^G Help ^O Write Out ^W Where Is ^K Cut ^T Execute ^C Location M-U Undo M-A Set Mark M-] To Bracket M-Q Previous ^B Back
^X Exit ^R Read File ^\ Replace ^U Paste ^J Justify ^/ Go To Line M-E Redo M-6 Copy ^Q Where Was M-W Next ^F Forward

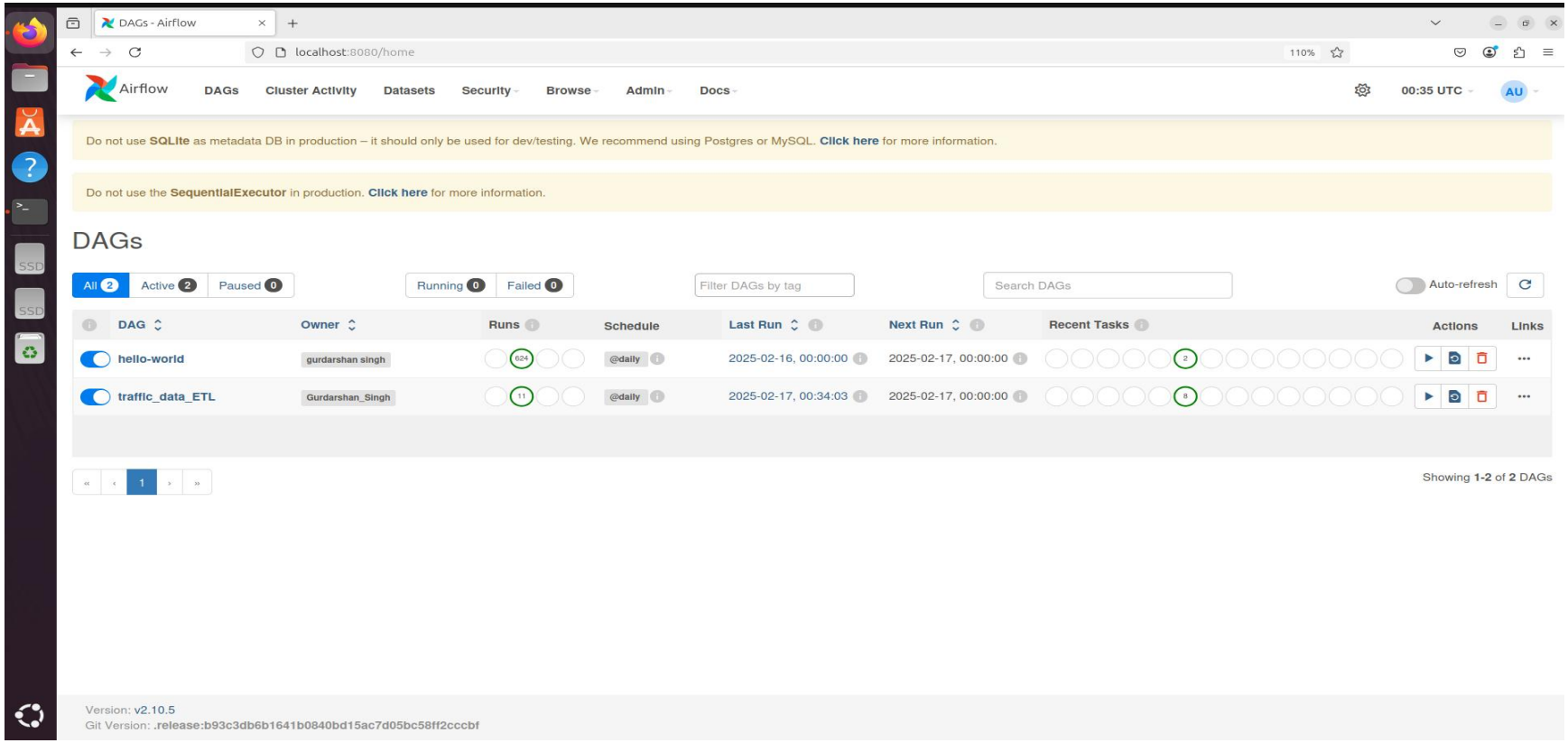

Feb 13 15:30
guru@Nitro-ANV15-51: ~/airflow/dags
GNU nano 7.2
traffic_data_ETL.py *
# Task 5: Extract data from TSV
def process_tsv():
df = pd.read_csv(f'{EXTRACT_DIR}/tollplaza-data.tsv', sep='\t')
df.iloc[:, [4, 5, 6]].to_csv(f'{EXTRACT_DIR}/tsv_d.csv', index=False)
extract_tsv_task = PythonOperator(
task_id='extract_tsv',
python_callable=process_tsv
)
# Task 6: Extract data from fixed-width file
def process_fixed_width():
colspecs = [(0, 2), (3, 5)] # Adjust based on file format
df = pd.read_fwf(f'{EXTRACT_DIR}/payment-data.txt', colspecs=colspecs)
df.to_csv(f'{EXTRACT_DIR}/fixed_width_d.csv', index=False)
extract_fixed_width_task = PythonOperator(
task_id='extract_fixed_width',
python_callable=process_fixed_width
)
# Task 7: Combine extracted files
combine_data = BashOperator(
task_id='combine_data',
bash_command=f'paste -d "," {EXTRACT_DIR}/csv_d.csv {EXTRACT_DIR}/tsv_d.csv {EXTRACT_DIR}/fixed_width_d.csv > {EXTRACT_DIR}/combined_data.csv'
)
# Task 8: Transform data
def transform_data():
df = pd.read_csv(f'{EXTRACT_DIR}/combined_data.csv')
df.iloc[:, 3] = df.iloc[:, 3].str.upper()
df.to_csv(f'{EXTRACT_DIR}/transformed_data.csv', index=False)
transform_task = PythonOperator(
task_id='transform_data',
python_callable=transform_data
)
Set task dependencies
create_directories >> download_task >> extract_task
extract_task >> [extract_csv_task, extract_tsv_task, extract_fixed_width_task] >> combine_data >> transform_task
^G Help ^O Write Out ^W Where Is ^K Cut ^T Execute ^C Location M-U Undo M-A Set Mark M-] To Bracket M-Q Previous ^B Back
^X Exit ^R Read File ^\ Replace ^U Paste ^J Justify ^/ Go To Line M-E Redo M-6 Copy ^Q Where Was M-W Next ^F Forward

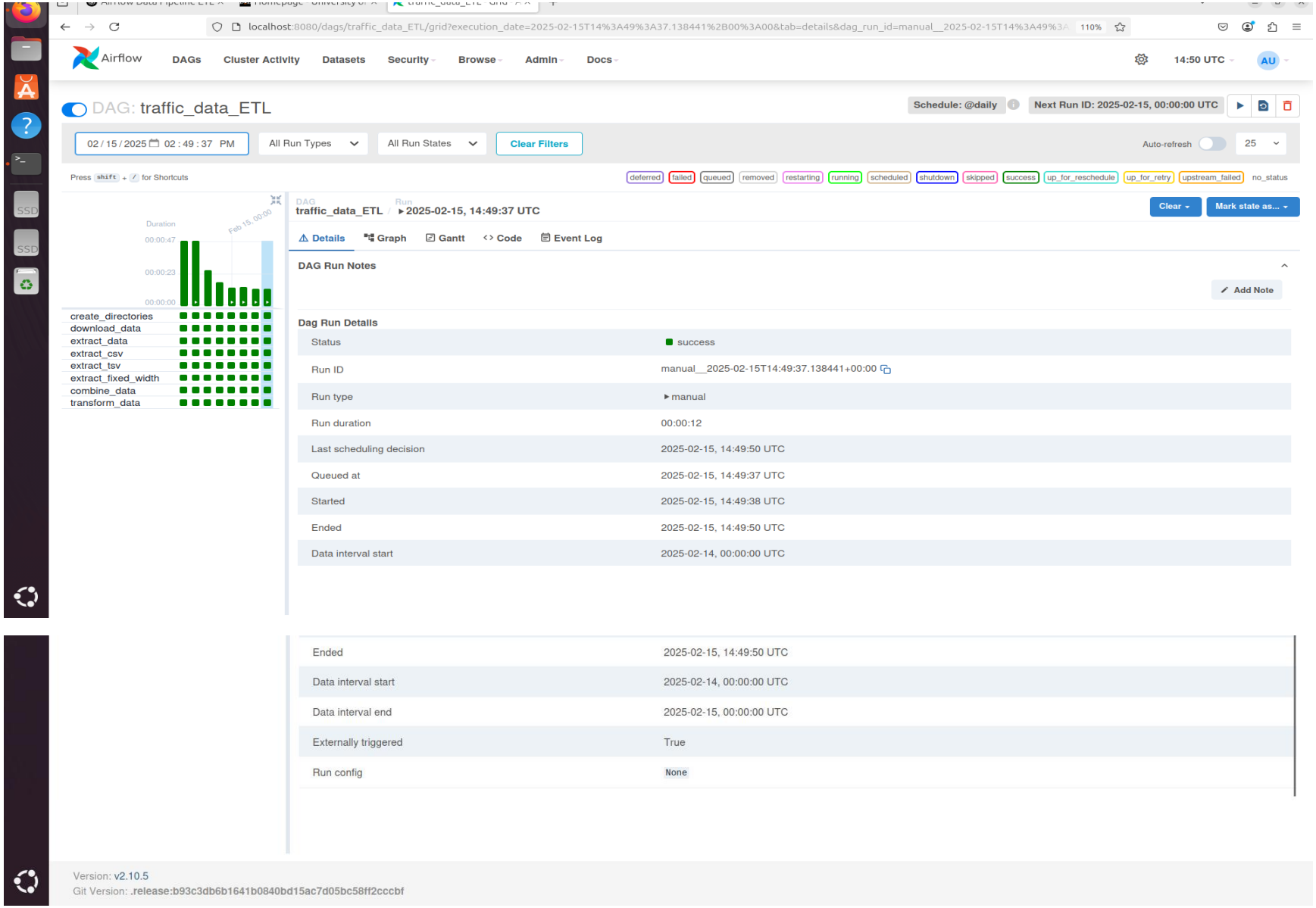
4. Airflow DAG Execution

- DAG successfully appeared in the Airflow UI at http://localhost:8080
- DAG was activated and manually triggered
- Execution logs confirmed successful task completion

Screenshots

(Include screenshots of DAG Graph View, Task Logs, Gantt Chart, and Data Output)




localhost:8080/dags/traffic_data_ETL/grid?execution_date=2025-02-15T14%3A49%3A37.138441%2B00%3A00&tab=details&dag_run_id=manual__2025-02-15T14%3A49%3A
Airflow
DAGs
Cluster Activity
Datasets
Security
Browse
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DAG: traffic_data_ETL
Schedule: @daily
Next Run ID: 2025-02-15, 00:00:00 UTC
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All Run Types
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Press shift + / for Shortcuts
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Graph
Gantt
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Event Log
DAG Run Notes
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Dag Run Details
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manual__2025-02-15T14:49:37.138441+00:00
Run type
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Run duration
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Last scheduling decision
2025-02-15, 14:49:50 UTC
Queued at
2025-02-15, 14:49:37 UTC
Started
2025-02-15, 14:49:38 UTC
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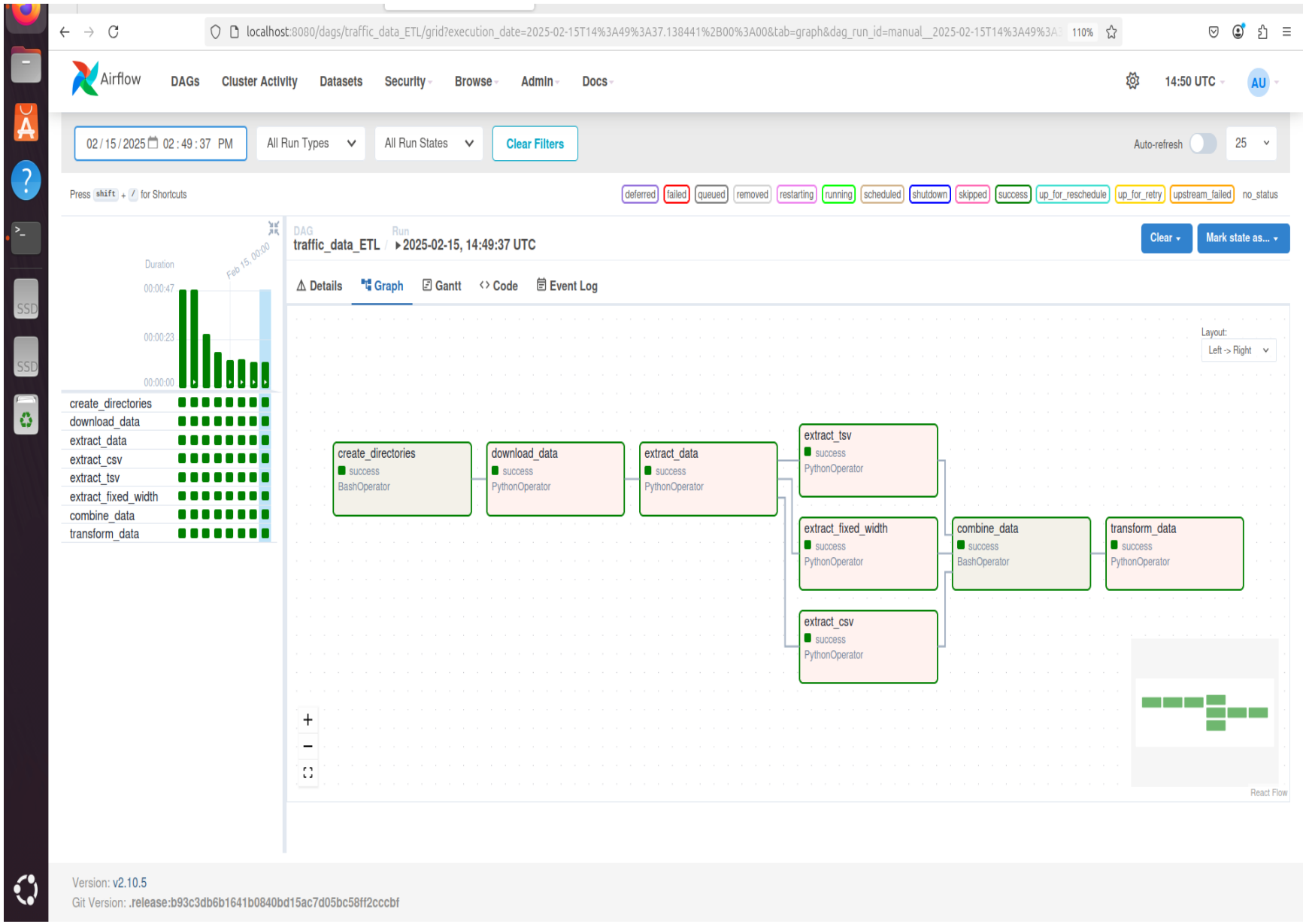
2025-02-15, 14:49:50 UTC
Data interval start
2025-02-14, 00:00:00 UTC
Ended
2025-02-15, 14:49:50 UTC
Data interval start
2025-02-14, 00:00:00 UTC
Data interval end
2025-02-15, 00:00:00 UTC
Externally triggered
True
Run config
None
Version: v2.10.5
Git Version: .release:b93c3db6b1641b0840bd15ac7d05bc58ff2cccbf


localhost:8080/dags/traffic_data_ETL/grid?execution_date=2025-02-15T14%3A49%3A37.138441%2B00%3A00&tab=graph&dag_run_id=manual__2025-02-15T14%3A49%3A
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Gantt
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Event Log
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PythonOperator
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PythonOperator
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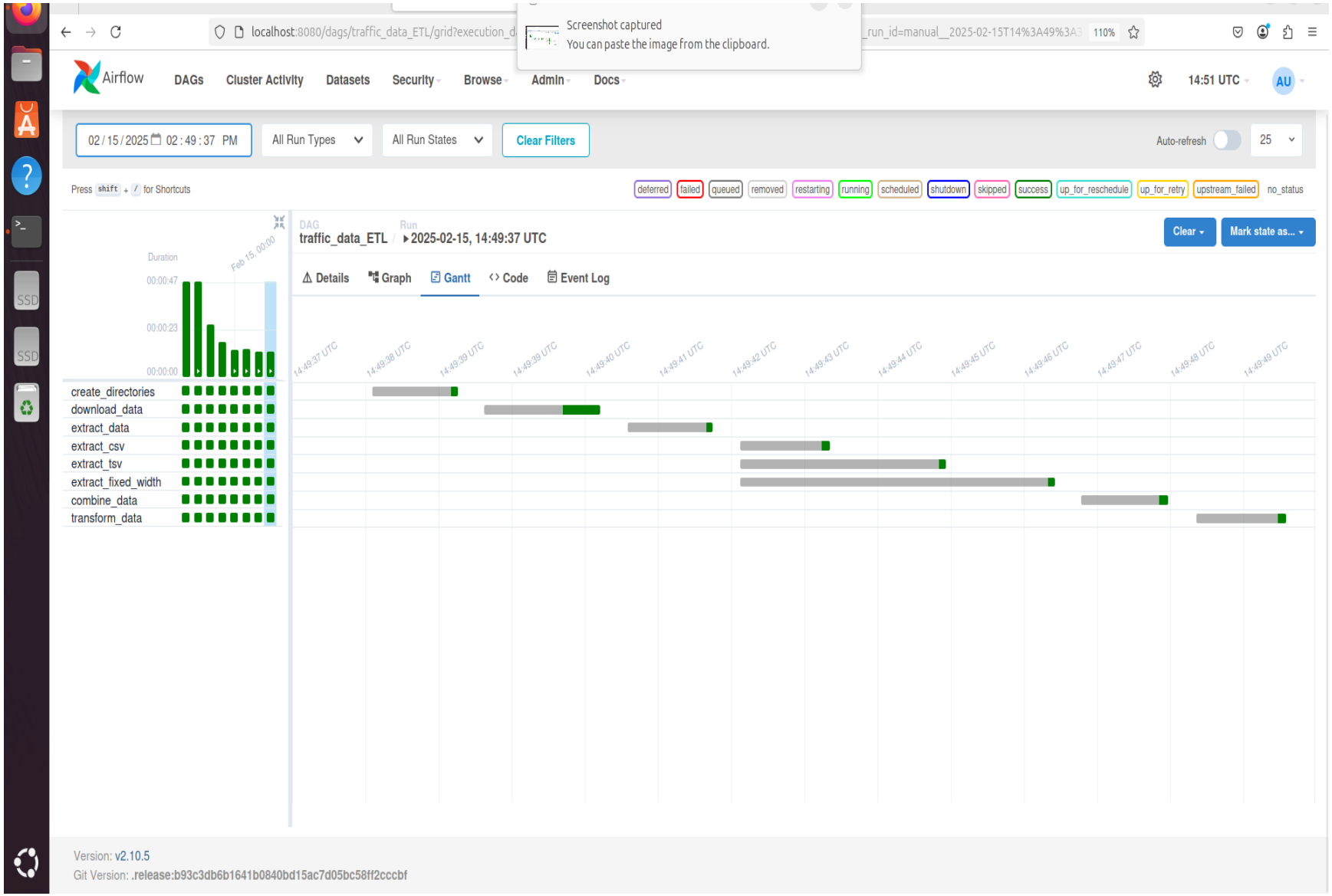
Version: v2.10.5
Git Version: .release:b93c3db6b1641b0840bd15ac7d05bc58ff2cccbf


Screenshot captured
You can paste the image from the clipboard.
localhost:8080/dags/traffic_data_ETL/grid?execution_d
run_id=manual__2025-02-15T14%3A49%3A3
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Airflow
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All Run Types
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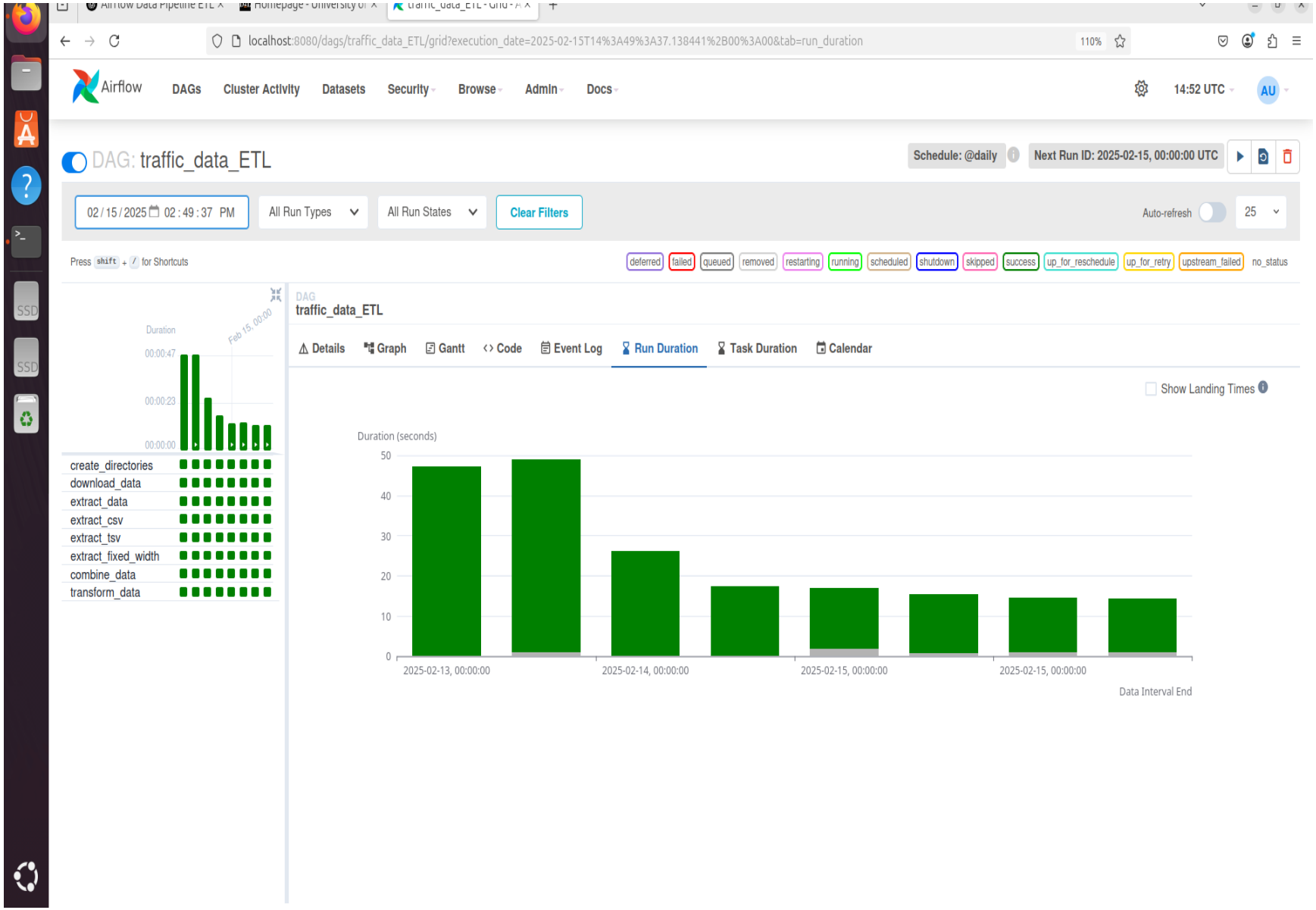
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Airflow
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Code
Event Log
Run Duration
Task Duration
Calendar
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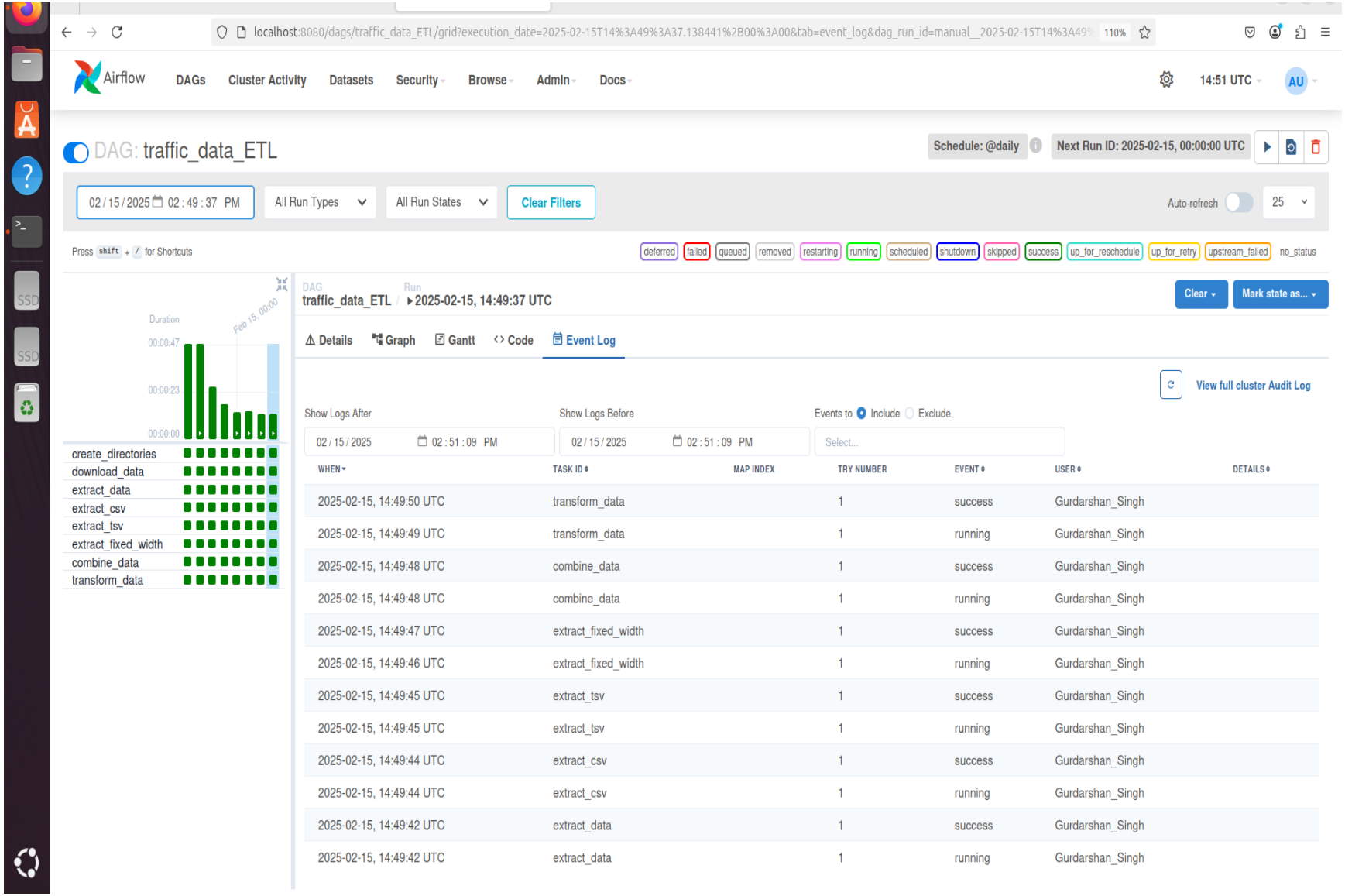
Data Interval End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Airflow
DAGs
Cluster Activity
Datasets
Security
Browse
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Docs
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DAG: traffic_data_ETL
Schedule: @daily
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02 / 15 / 2025 02 : 49 : 37 PM
All Run Types
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combine_data
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Run
2025-02-15, 14:49:37 UTC
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Mark state as...
Details
Graph
Gantt
Code
Event Log
View full cluster Audit Log
Show Logs After
02 / 15 / 2025 02 : 51 : 09 PM
Show Logs Before
02 / 15 / 2025 02 : 51 : 09 PM
Events to Include Exclude
Select...
WHEN
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2025-02-15, 14:49:50 UTC transform_data 1 success Gurdarshan_Singh
2025-02-15, 14:49:49 UTC transform_data 1 running Gurdarshan_Singh
2025-02-15, 14:49:48 UTC combine_data 1 success Gurdarshan_Singh
2025-02-15, 14:49:48 UTC combine_data 1 running Gurdarshan_Singh
2025-02-15, 14:49:47 UTC extract_fixed_width 1 success Gurdarshan_Singh
2025-02-15, 14:49:46 UTC extract_fixed_width 1 running Gurdarshan_Singh
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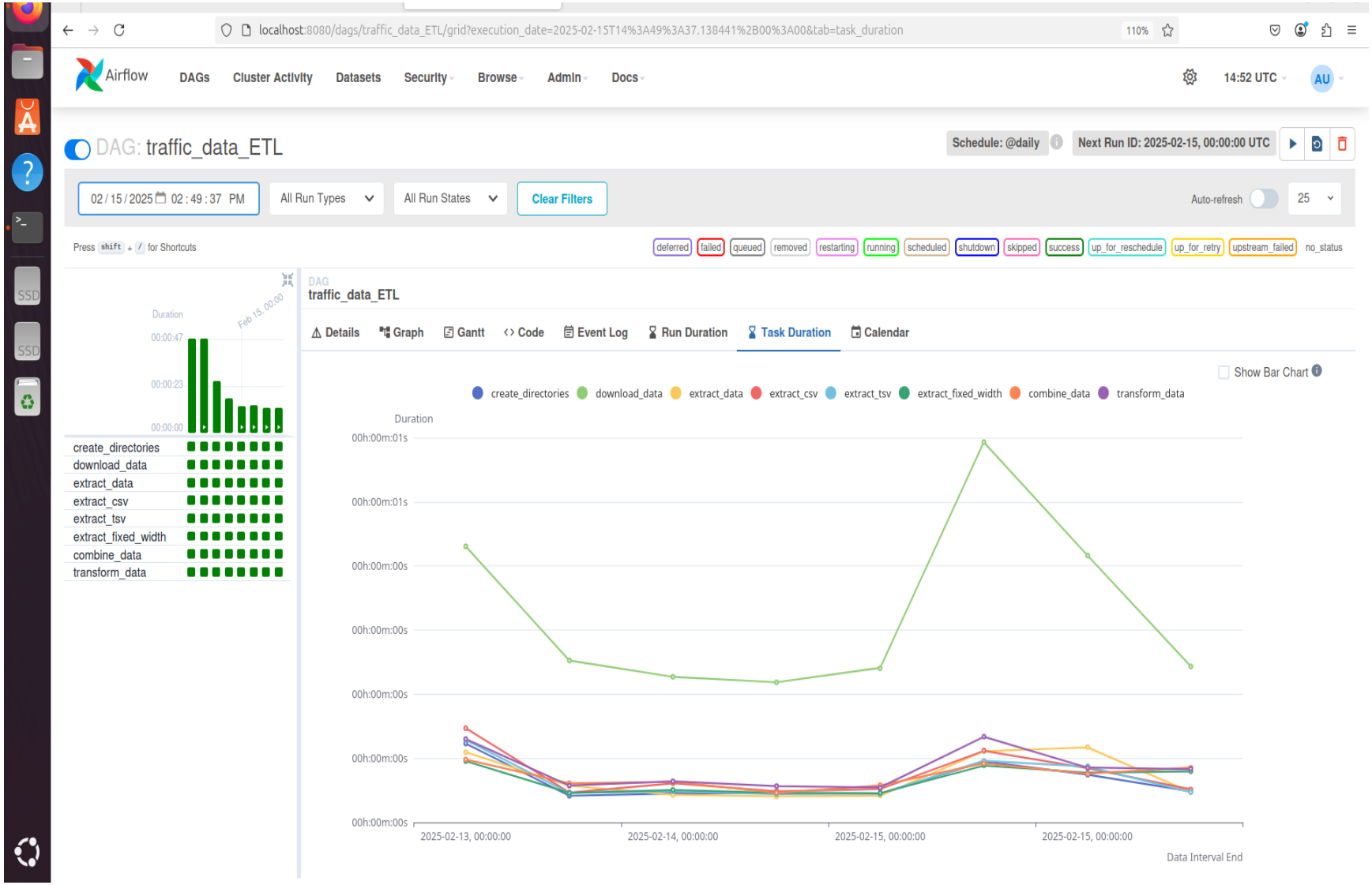
localhost:8080/dags/traffic_data_ETL/grid?execution_date=2025-02-15T14%3A49%3A37.138441%2B00%3A00&tab=task_duration
Airflow
DAGs
Cluster Activity
Datasets
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DAG: traffic_data_ETL
Schedule: @daily
Next Run ID: 2025-02-15, 00:00:00 UTC
02 / 15 / 2025 02 : 49 : 37 PM
All Run Types
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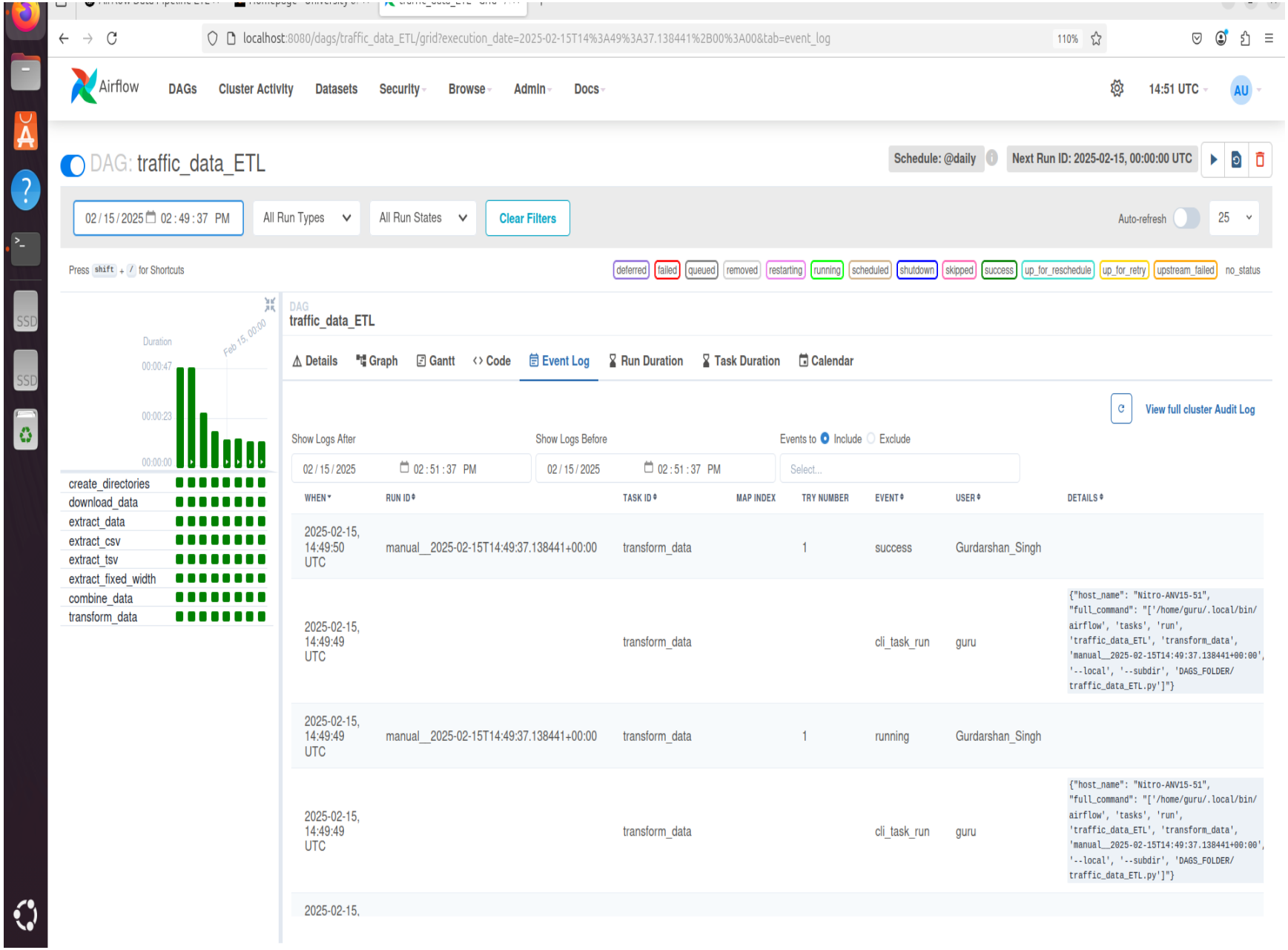
Data Interval End


localhost:8080/dags/traffic_data_ETL/grid?execution_date=2025-02-15T14%3A49%3A37.138441%2B00%3A00&tab=event_log
Airflow
DAGs
Cluster Activity
Datasets
Security
Browse
Admin
Docs
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AU
DAG: traffic_data_ETL
Schedule: @daily
Next Run ID: 2025-02-15, 00:00:00 UTC
02 / 15 / 2025 02 : 49 : 37 PM
All Run Types
All Run States
Clear Filters
Auto-refresh
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upstream_failed
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Feb 15, 00:00
create_directories
download_data
extract_data
extract_csv
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extract_fixed_width
combine_data
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DAG
traffic_data_ETL
Details
Graph
Gantt
Code
Event Log
Run Duration
Task Duration
Calendar
View full cluster Audit Log
Show Logs After
02 / 15 / 2025 02 : 51 : 37 PM
Show Logs Before
02 / 15 / 2025 02 : 51 : 37 PM
Events to Include Exclude
Select...
WHEN
RUN ID
TASK ID
MAP INDEX
TRY NUMBER
EVENT
USER
DETAILS
2025-02-15, 14:49:50 UTC
manual__2025-02-15T14:49:37.138441+00:00
transform_data
1
success
Gurdarshan_Singh
2025-02-15, 14:49:49 UTC
transform_data
cli_task_run
guru
{"host_name": "Nitro-ANV15-51", "full_command": "['/home/guru/.local/bin/airflow', 'tasks', 'run', 'traffic_data_ETL', 'transform_data', 'manual__2025-02-15T14:49:37.138441+00:00', '--local', '--subdir', 'DAGS_FOLDER/traffic_data_ETL.py']"}
2025-02-15, 14:49:49 UTC
manual__2025-02-15T14:49:37.138441+00:00
transform_data
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running
Gurdarshan_Singh
2025-02-15, 14:49:49 UTC
transform_data
cli_task_run
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{"host_name": "Nitro-ANV15-51", "full_command": "['/home/guru/.local/bin/airflow', 'tasks', 'run', 'traffic_data_ETL', 'transform_data', 'manual__2025-02-15T14:49:37.138441+00:00', '--local', '--subdir', 'DAGS_FOLDER/traffic_data_ETL.py']"}
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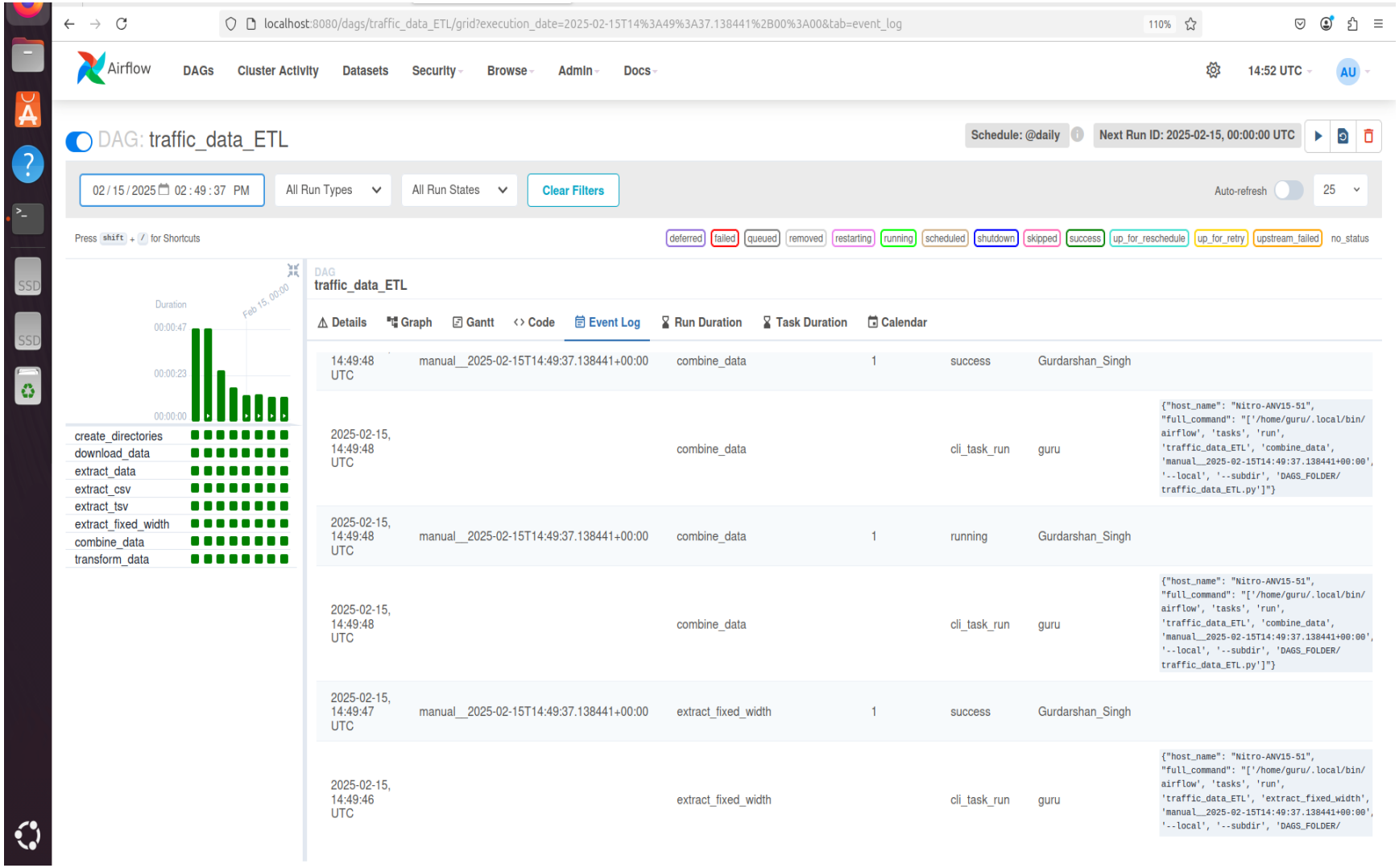
localhost:8080/dags/traffic_data_ETL/grid?execution_date=2025-02-15T14%3A49%3A37.138441%2B00%3A00&tab=event_log
Airflow
DAGs
Cluster Activity
Datasets
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DAG: traffic_data_ETL
Schedule: @daily
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All Run Types
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extract_csv
extract_tsv
extract_fixed_width
combine_data
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traffic_data_ETL
Details
Graph
Gantt
Code
Event Log
Run Duration
Task Duration
Calendar
14:49:48 UTC
manual__2025-02-15T14:49:37.138441+00:00
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1
success
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2025-02-15, 14:49:48 UTC
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cli_task_run
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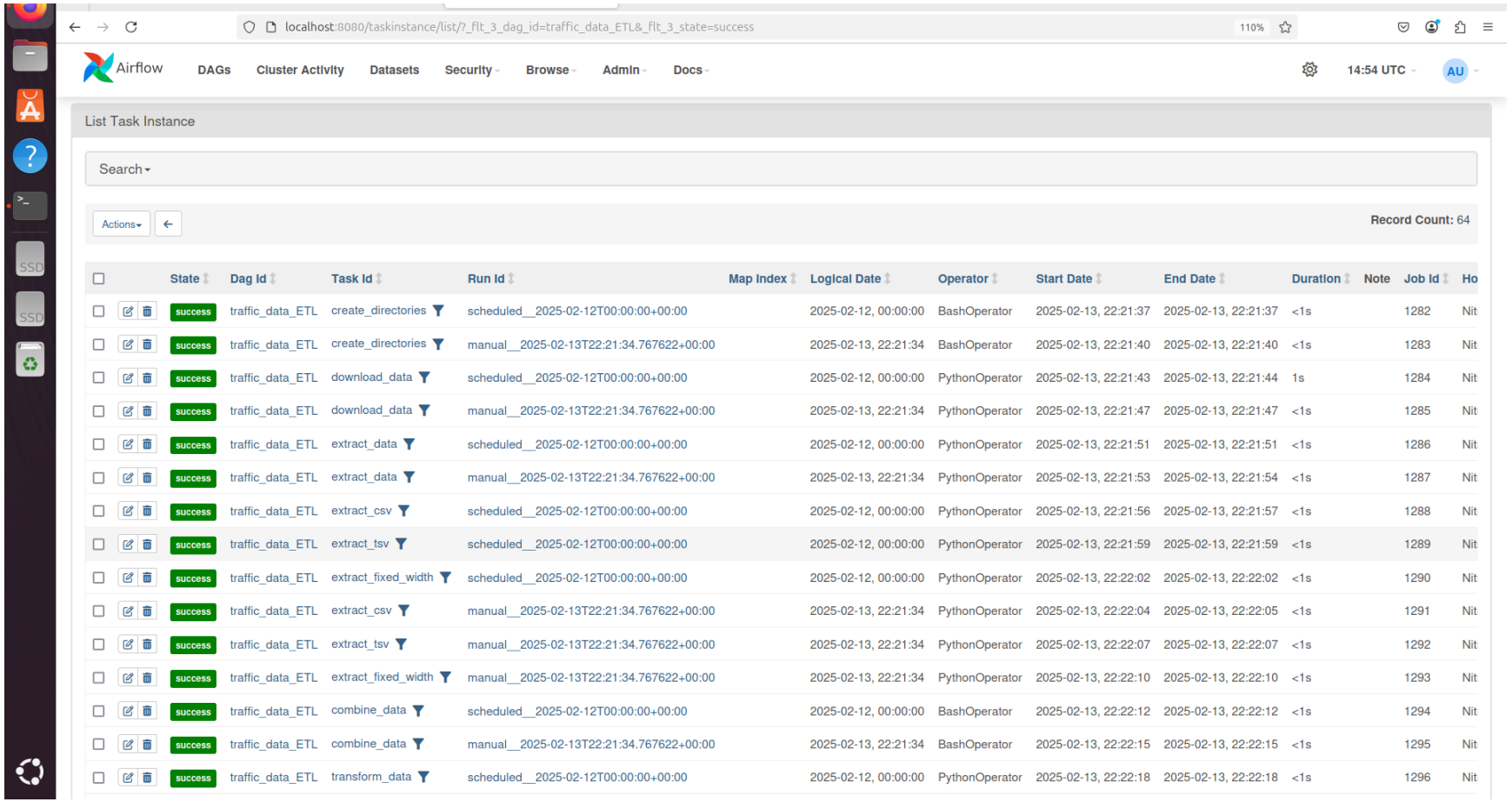

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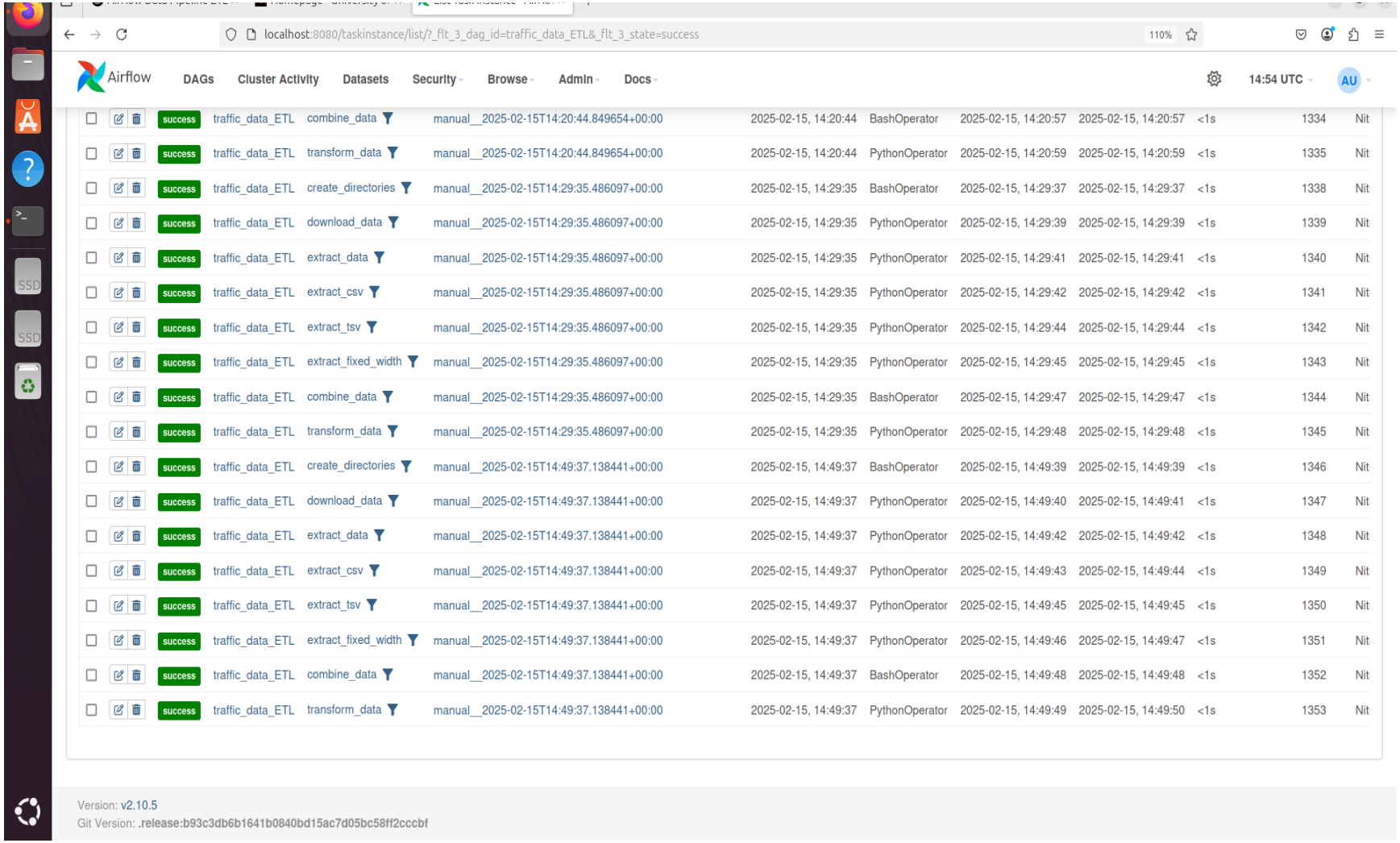
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110%
Airflow
DAGs
Cluster Activity
Datasets
Security
Browse
Admin
Docs
14:54 UTC
AU
success traffic_data_ETL combine_data manual__2025-02-15T14:20:44.849654+00:00 2025-02-15, 14:20:44 BashOperator 2025-02-15, 14:20:57 2025-02-15, 14:20:57 <1s 1334 Nit
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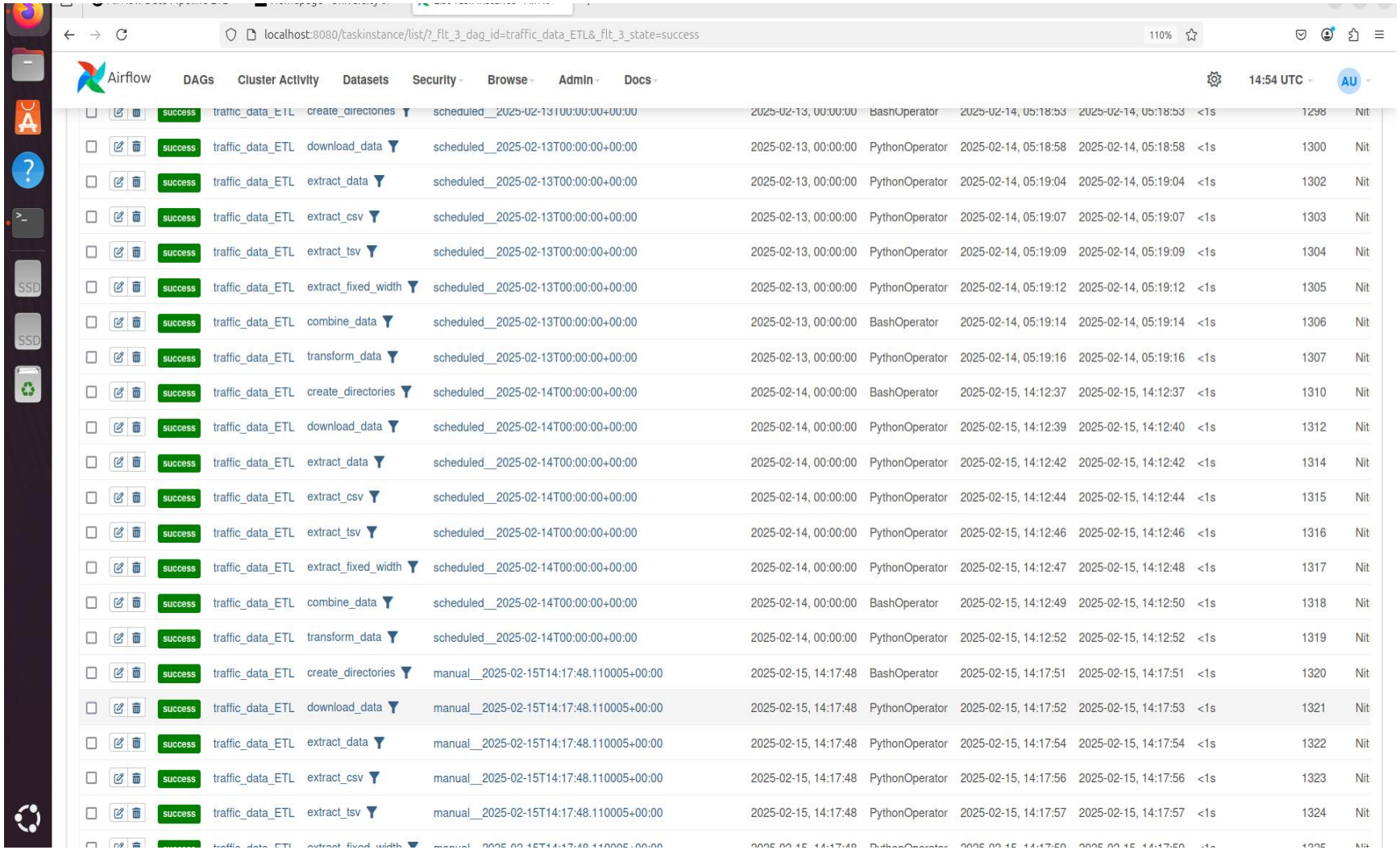

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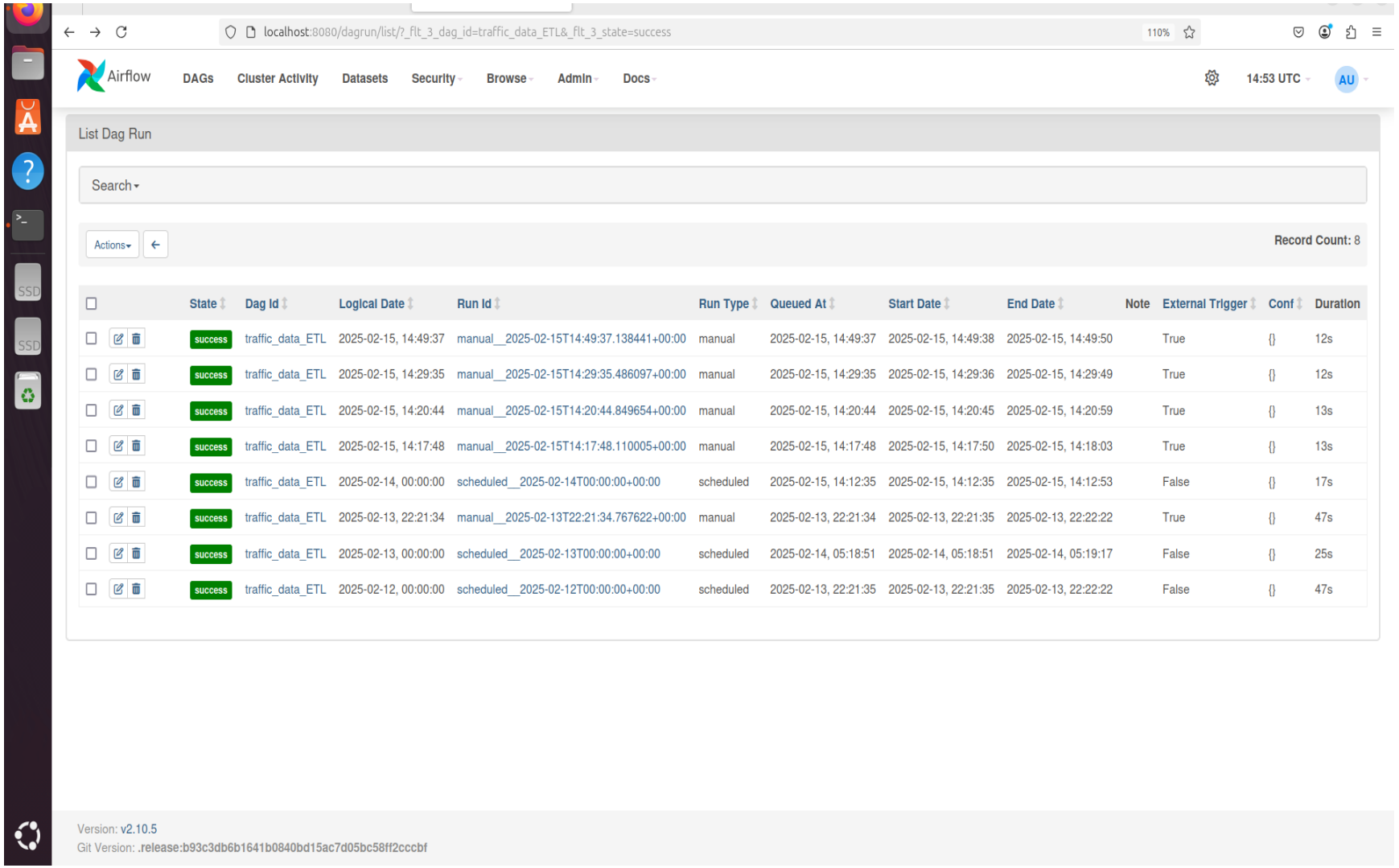
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Airflow
DAGs
Cluster Activity
Datasets
Security
Browse
Admin
Docs
14:53 UTC
AU
List Dag Run
Search
Actions
Record Count: 8
State
Dag Id
Logical Date
Run Id
Run Type
Queued At
Start Date
End Date
Note
External Trigger
Conf
Duration
success traffic_data_ETL 2025-02-15, 14:49:37 manual__2025-02-15T14:49:37.138441+00:00 manual 2025-02-15, 14:49:37 2025-02-15, 14:49:38 2025-02-15, 14:49:50 True {} 12s
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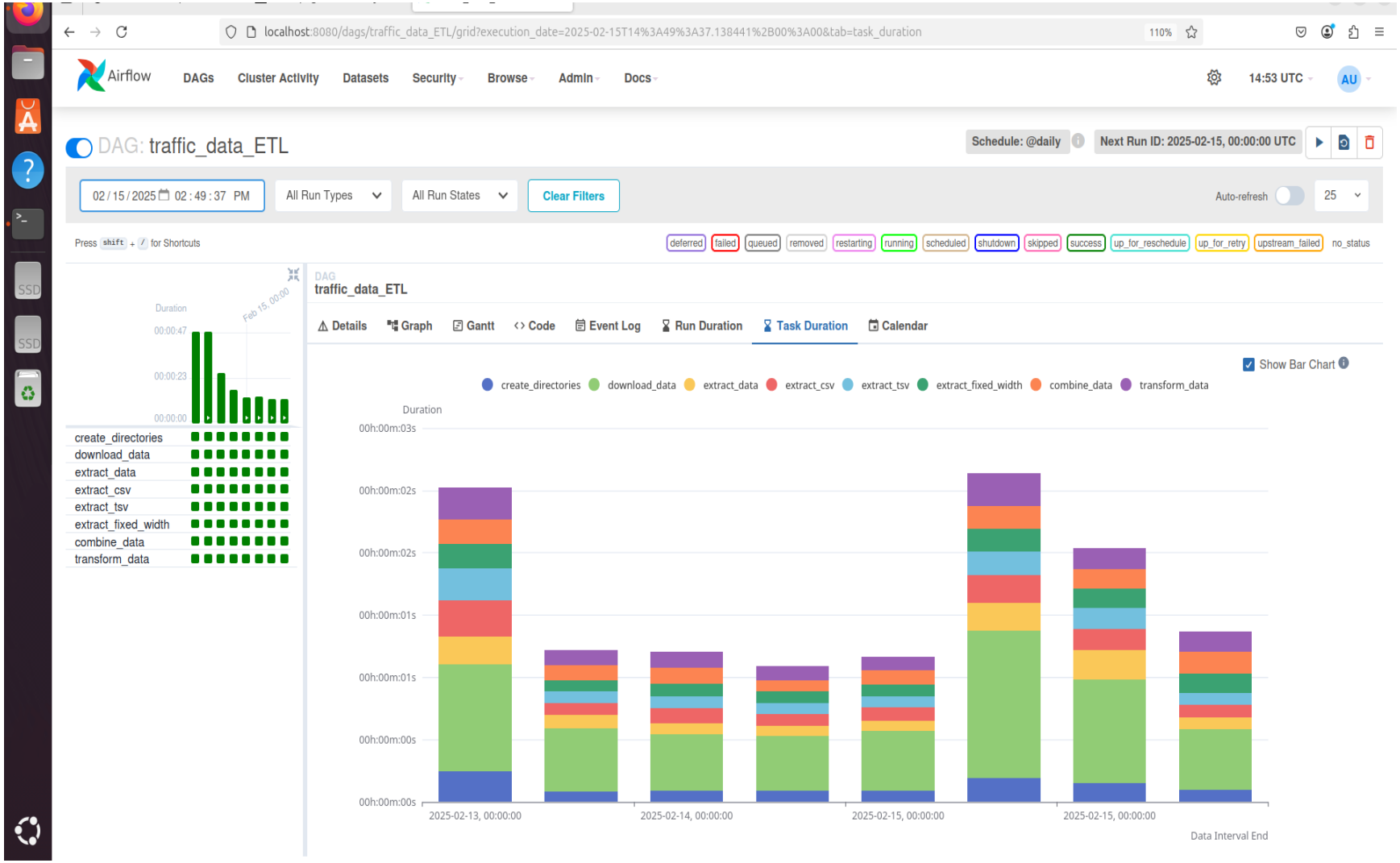
Version: v2.10.5
Git Version: .release:b93c3db6b1641b0840bd15ac7d05bc58ff2cccbf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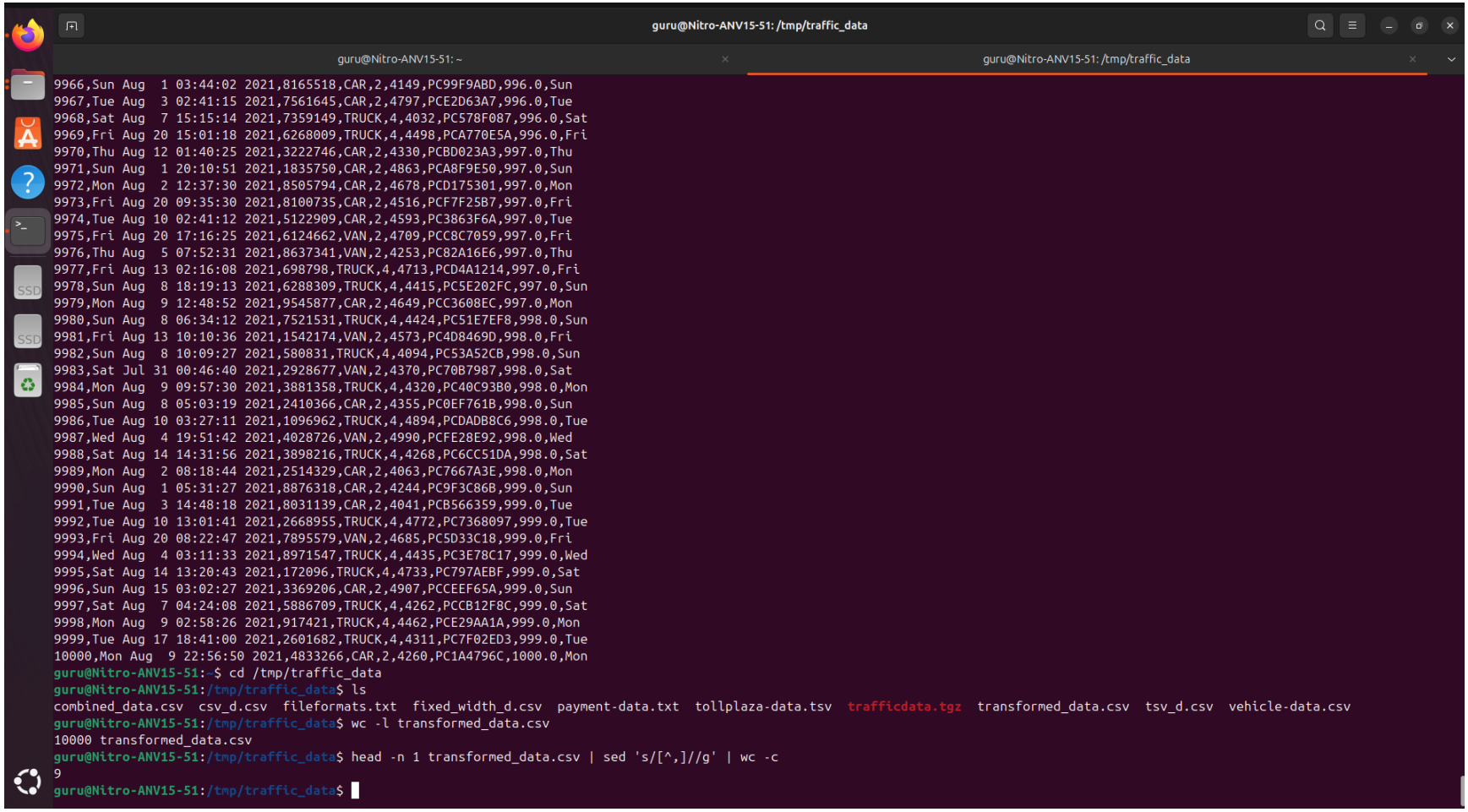
Airflow
DAGs
Cluster Activity
Datasets
Security
Browse
Admin
Docs
14:53 UTC
AU
DAG: traffic_data_ETL
Schedule: @daily
Next Run ID: 2025-02-15, 00:00:00 UTC
02 / 15 / 2025 02 : 49 : 37 PM
All Run Types
All Run States
Clear Filters
Auto-refresh
25
Press shift + / for Shortcuts
deferred
failed
queued
removed
restarting
running
scheduled
shutdown
skipped
success
up_for_reschedule
up_for_retry
upstream_failed
no_status
Duration
00:00:47
00:00:23
00:00:00
Feb 15, 00:00:00
create_directories
download_data
extract_data
extract_csv
extract_tsv
extract_fixed_width
combine_data
transform_data
DAG
traffic_data_ETL
Details
Graph
Gantt
Code
Event Log
Run Duration
Task Duration
Calendar
Show Bar Chart
create_directories
download_data
extract_data
extract_csv
extract_tsv
extract_fixed_width
combine_data
transform_data
Duration
00h:00m:03s
00h:00m:02s
00h:00m:02s
00h:00m:01s
00h:00m:01s
00h:00m:00s
00h:00m:00s
2025-02-13, 00:00:00
2025-02-14, 00:00:00
2025-02-15, 00:00:00
2025-02-15, 00:00:00
Data Interval End

Results

- The extracted and transformed data was saved in the /tmp/traffic_data directory.
- The final processed file, transformed.csv, contained the expected transformed data.



Observations

1. DAG Structure & Task Execution

- The DAG consists of several tasks, each responsible for different stages of the ETL process:
    - **create_directories**: Ensures necessary directories are available before data extraction.
    - **download_data**: Fetches raw traffic data, possibly from an API or external source.
    - **extract_data**: Extracts relevant portions from the downloaded data.
    - **extract_csv, extract_tsv, extract_fixed_width**: Handle extraction from different file formats.
    - **combine_data**: Merges data from multiple sources into a unified dataset.
    - **transform_data**: Applies necessary data cleaning and processing before storage or analysis.
- The execution follows a structured workflow where tasks are executed in a sequence, ensuring data integrity and correctness.

2. Task Execution Status

- All tasks in the DAG have been successfully executed, as indicated by the green status markers.
- No failed or pending tasks were observed, suggesting that the ETL pipeline is functioning without errors.
- The DAG execution timestamps indicate consistent processing, with runs scheduled daily.

3. Task Duration Analysis

- The **Task Duration Chart** highlights the execution time for individual tasks over multiple DAG runs.
- **download_data** consistently records the highest execution time, indicating that fetching raw data is a time-consuming process.
- **combine_data** also takes a relatively longer time compared to other tasks, which is expected as it integrates multiple data sources.

- Other tasks, such as **create_directories** and **extract_data**, execute within milliseconds to seconds, suggesting efficient performance.

4. Execution Trends Over Time

- The **Run Duration Chart** provides insights into total DAG execution time across multiple days (February 13–15, 2025).
- The DAG run on **February 13, 2025**, took the longest time (~50 seconds), while subsequent runs show reduced execution times.
- The decreasing execution time trend indicates potential optimizations in data handling or reduced processing loads.
- Recent DAG executions have stabilized, maintaining a consistent duration across multiple runs.

5. Gantt Chart Observations

- The **Gantt Chart View** provides a timeline representation of task execution.
- Tasks are executed sequentially, with minimal idle time between them, suggesting efficient scheduling.
- Green bars in the chart confirm successful completion, while gray bars indicate queued tasks waiting for execution.
- The **combine_data** task appears to have the longest execution span, aligning with findings from the Task Duration analysis.

6. Airflow Monitoring & Interface Features

- The Airflow UI provides multiple visualization options such as:
    - **Graph View**: Shows task dependencies and execution flow.
    - **Gantt Chart View**: Displays task execution duration and scheduling gaps.
    - **Run Duration View**: Tracks execution time trends over multiple DAG runs.
    - **Task Duration View**: Highlights individual task performance and bottlenecks.
- The system actively monitors DAG runs, ensuring any performance issues or failures are easily identifiable.

Conclusion

The **traffic_data_ETL** pipeline in Apache Airflow executes successfully with structured task dependencies and efficient scheduling. The **download_data** and **combine_data** tasks require the longest execution time, making them key areas to monitor for performance improvements. The DAG's execution time has decreased over multiple runs, suggesting optimizations or variations in data volume. The monitoring capabilities in Airflow allow detailed tracking of task performance, ensuring smooth operation of the ETL workflow.