Train Rides Data Analytics Project Documentation

9/20/2025

Personal project

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1. Project Overview

The purpose of this project was to design and implement a scalable data pipeline on AWS to clean, analyze, and visualize train ticket transaction data. The dataset contained information on purchases, journey schedules, delays, refunds, and pricing.

The project outcomes included:

- Cleaned and standardized dataset stored in Amazon S3.
- Automated schema management using AWS Glue Crawler.
- Queryable dataset in Amazon Athena.
- Business insights delivered through Amazon QuickSight dashboards.

2. Objectives

- Improve data quality by removing nulls, standardizing formats, and converting dates/times.
- Enable SQLbased exploration of sales and journey performance data.
- Build visualizations to highlight revenue trends, delay patterns, and refund behavior.
- Provide actionable insights to support pricing, operations, and customer service improvements.

3. Data Description

The dataset included 50k+ train ticket transactions with the following key attributes:

Transaction & Purchase Data: transaction id, date of purchase, time of purchase, purchase type, payment method.

Ticket Details: railcard, ticket class, ticket type, price.

Journey Details: departure station, arrival destination, date of journey, departure/arrival times, actual arrival time, journey status, reason for delay, refund request.

A1 Transaction ID

	A	B	C	D	E	F	G	H	I
1	Transaction ID	Date of Purchase	Time of Purchase	Purchase Type	Payment Method	Railcard	Ticket Class	Ticket Type	Price
2	da8a6ba8-b3dc-4677-b176	2023-12-08	12:41:11	Online	Contactless	Adult	Standard	Advance	4
3	b0cdd1b0-f214-4197-be53	2023-12-16	11:23:01	Station	Credit Card	Adult	Standard	Advance	2
4	f3ba7a96-f713-40d9-9629	2023-12-19	19:51:27	Online	Credit Card	None	Standard	Advance	
5	b2471f11-4fe7-4c87-8ab4	2023-12-20	23:00:36	Station	Credit Card	None	Standard	Advance	1
6	2be00b45-0762-485e-a7a3	2023-12-27	18:22:56	Online	Contactless	None	Standard	Advance	7
7	4e1dcd88-3d95-44ef-99fa	2023-12-30	07:56:06	Online	Credit Card	None	Standard	Advance	3
8	1c74479d-85a4-4ba1-a607	2023-12-31	00:02:01	Station	Credit Card	Adult	Standard	Advance	
9	febf8dab-f808-46fa-bf2b	2023-12-31	01:35:18	Station	Contactless	Disabled	Standard	Advance	
10	01df916f-4291-41ec-a37d	2023-12-31	01:43:09	Station	Credit Card	None	Standard	Advance	3
11	a8cedba7-1923-459d-b046	2023-12-31	03:05:52	Online	Credit Card	None	Standard	Advance	1
12	b3e5ca7d-e76c-49f2-b49f	2023-12-31	03:26:37	Online	Contactless	None	Standard	Advance	
13	6c63f7ac-d590-4356-9eaa	2023-12-31	03:52:11	Online	Contactless	Adult	Standard	Advance	
14	2e7add75-566a-41aa-9468	2023-12-31	05:55:22	Online	Contactless	None	Standard	Advance	
15	7ed9b545-eb6f-49b2-9b5a	2023-12-31	06:44:35	Online	Contactless	None	Standard	Advance	
16	2e05e2a6-88a8-40fb-bacc	2023-12-31	08:05:50	Online	Credit Card	Disabled	Standard	Advance	1
17	8a18d3b4-995e-49bf-93a3	2023-12-31	08:16:53	Online	Credit Card	None	Standard	Advance	1
18	7493a611-342a-4b17-90dc	2023-12-31	08:23:15	Online	Credit Card	None	Standard	Advance	1
19	054676ac-a976-4909-a26e	2023-12-31	09:09:20	Online	Credit Card	None	Standard	Advance	
20	6b62b452-c491-468d-b39c	2023-12-31	09:12:21	Online	Credit Card	None	Standard	Advance	3
21	85e38992-6c6c-4569-914e	2023-12-31	10:42:22	Online	Credit Card	None	Standard	Advance	3
22	8dfbf0fc-aea0-424f-b30e	2023-12-31	11:57:15	Station	Debit Card	Adult	Standard	Advance	
23	a478f358-044d-4000-b70e	2023-12-31	12:11:47	Station	Credit Card	Disabled	Standard	Advance	
24	d4ea6940-7228-41ef-9eae	2023-12-31	13:33:39	Online	Credit Card	Senior	Standard	Advance	2
25	89f2160c-666b-4925-86b6	2023-12-31	14:23:09	Station	Contactless	None	Standard	Advance	
26	fd00a134-7056-441c-919f	2023-12-31	14:53:44	Online	Credit Card	None	Standard	Advance	
27	842da93c-b820-42dc-ad4f	2023-12-31	15:19:53	Online	Contactless	None	Standard	Advance	8
28	74462231-5241-46f4-8328	2023-12-31	15:53:46	Online	Credit Card	Senior	First Class	Advance	3
29	7267c284-5f19-41ef-8350	2023-12-31	16:44:05	Station	Credit Card	None	Standard	Advance	1
30	3c375a4c-7ba3-45e9-a9cd	2023-12-31	18:01:58	Online	Contactless	None	Standard	Advance	
31	5b0638b1-ee1d-4a6f-8c29	2023-12-31	18:39:00	Online	Credit Card	None	First Class	Advance	5
32	e40c1f61-b648-41c2-8151	2023-12-31	19:33:15	Station	Debit Card	None	Standard	Advance	
33	aa40e9b5-3ab7-4d40-a949	2023-12-31	19:45:53	Online	Credit Card	None	Standard	Advance	1
34	be8bee7f-2e6f-450e-90ed	2023-12-31	20:20:25	Station	Contactless	None	Standard	Advance	3

Fig1 train rides data

4. Technical Approach

4.1 Data Storage

- Raw CSVs uploaded to Amazon S3 in `s3://trainridesdatabucketreeu76/raw/`.
- Cleaned datasets stored in `s3://trainridesdatabucketreeu76/clean/`.

4.2 Data Cleaning (AWS Glue DataBrew)

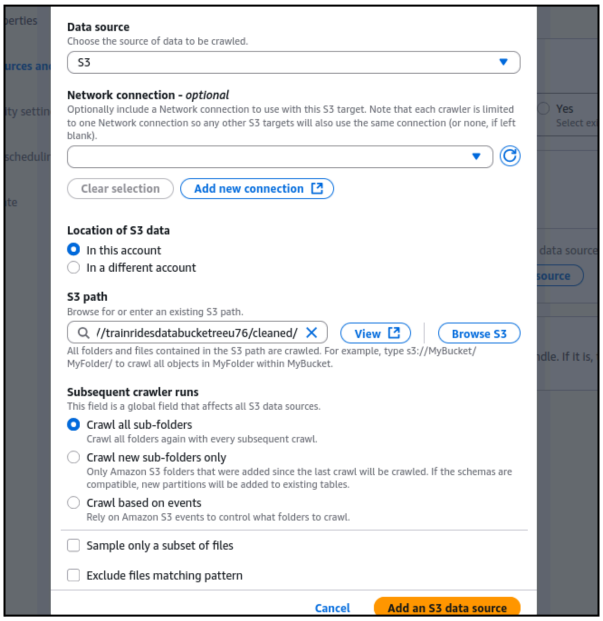


Fig2 connect data brew to s3 bucket

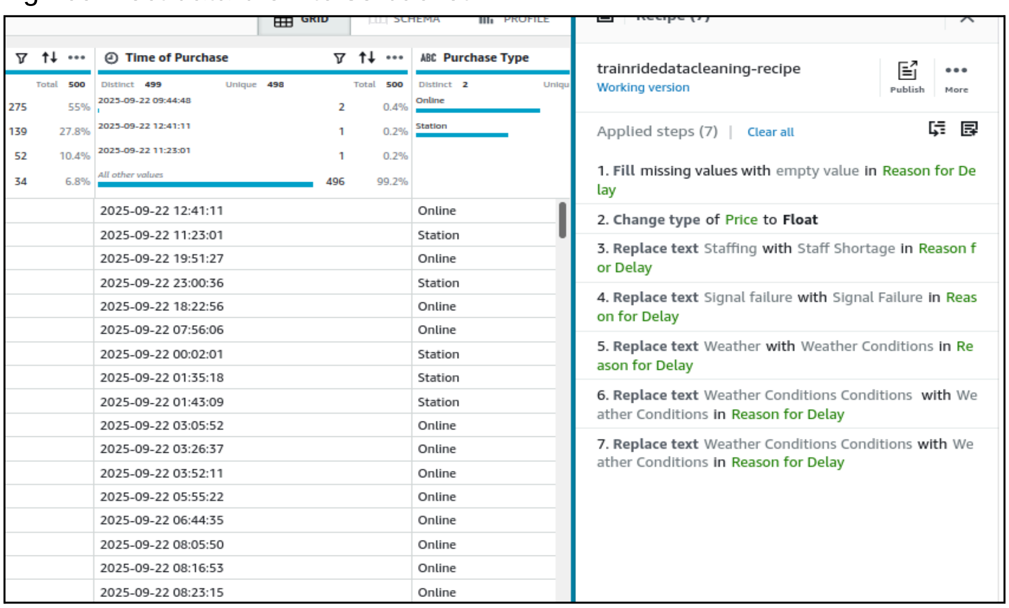


Fig 3 Data cleaning steps

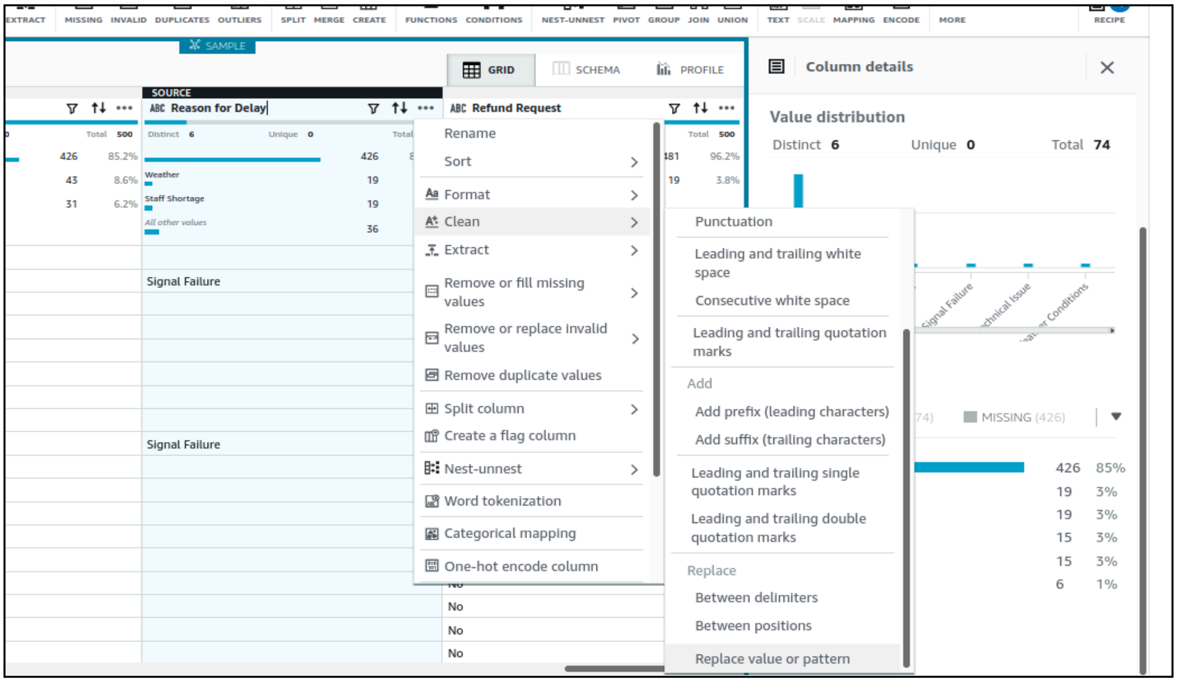


Fig 4 data cleaning steps

- Replaced null values with `"Unknown"` or `"N/A"`.
- Standardized categorical fields (trimmed spaces, consistent casing).
- Converted 5+ date/time fields from string to `DATE`/`TIMESTAMP`.
- Dropped irrelevant columns and duplicates.
- Output: consistent, queryready CSVs in S3.

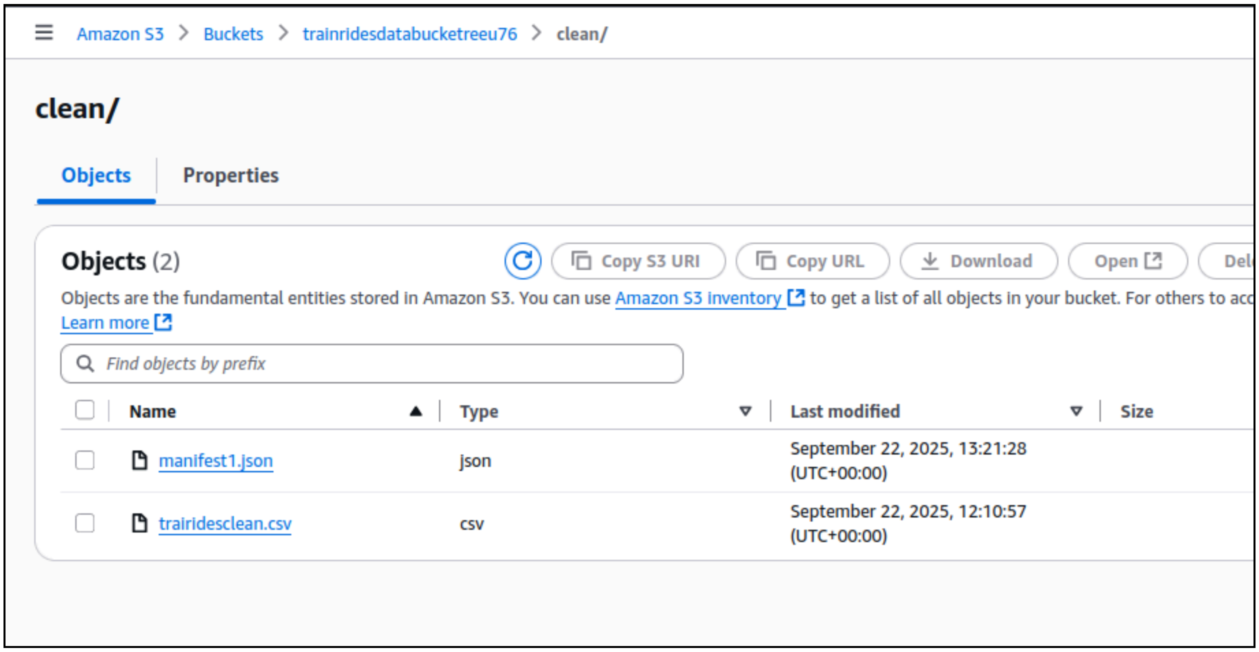


Fig 5 output bucket

4.3 Data Cataloging (AWS Glue Crawler)

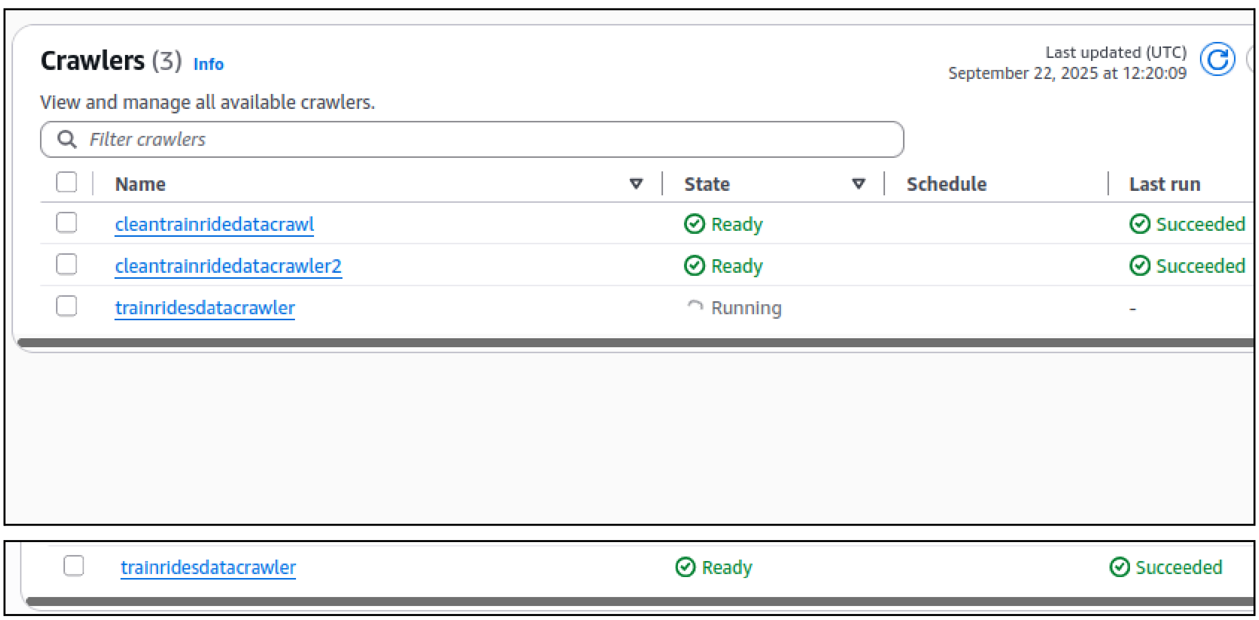


Fig 6 setting up crawlers

- Configured Glue Crawler to scan cleaned S3 bucket.
- Created database: trainridesdb.
- Generated a structured schema automatically available in Athena.

4.4 Querying & Analysis (Amazon Athena)

Create table for the cleaned data in Athena.

```
CREATE EXTERNAL TABLE train_tickets (
  transaction_id       string,
  date_of_purchase     date,
  time_of_purchase     string,
  purchase_type        string,
  payment_method       string,
  railcard             string,
  ticket_class         string,
  ticket_type          string,
  price                double,
  departure_station    string,
  arrival_destination  string,
  date_of_journey      date,
  departure_time       string,
  arrival_time         string,
  actual_arrival_time  string,
  journey_status       string,
  reason_for_delay     string,
  refund_request       string
)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.OpenCSVSerde'
LOCATION 's3://trainridesdatabucketreeu76/cleaned/'
TBLPROPERTIES ("skip.header.line.count"="1");
```

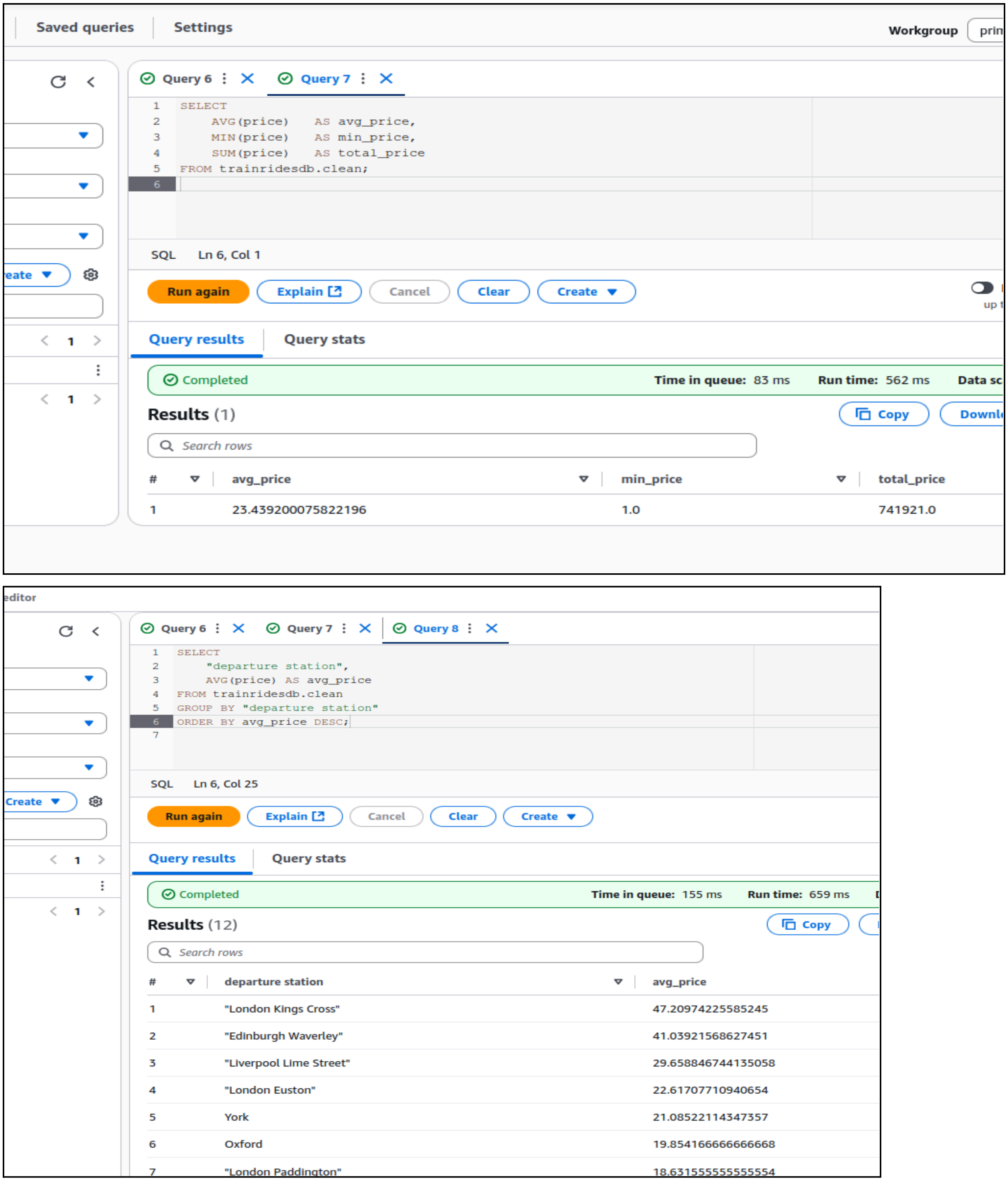


Fig 7&8: Querying data stored by Glue Crawler.

- Casted dates/times using `date_parse` for accurate timeseries analysis.
- Developed 10+ SQL queries for aggregations (AVG, SUM, MIN, MAX).
- Performed joins and groupings to derive routelevel, stationlevel, and ticketlevel insights.

4.5 Visualization (Amazon QuickSight)

- Connected Athena tables to QuickSight.
- Built dashboards highlighting revenue, operational efficiency, and customer behavior.

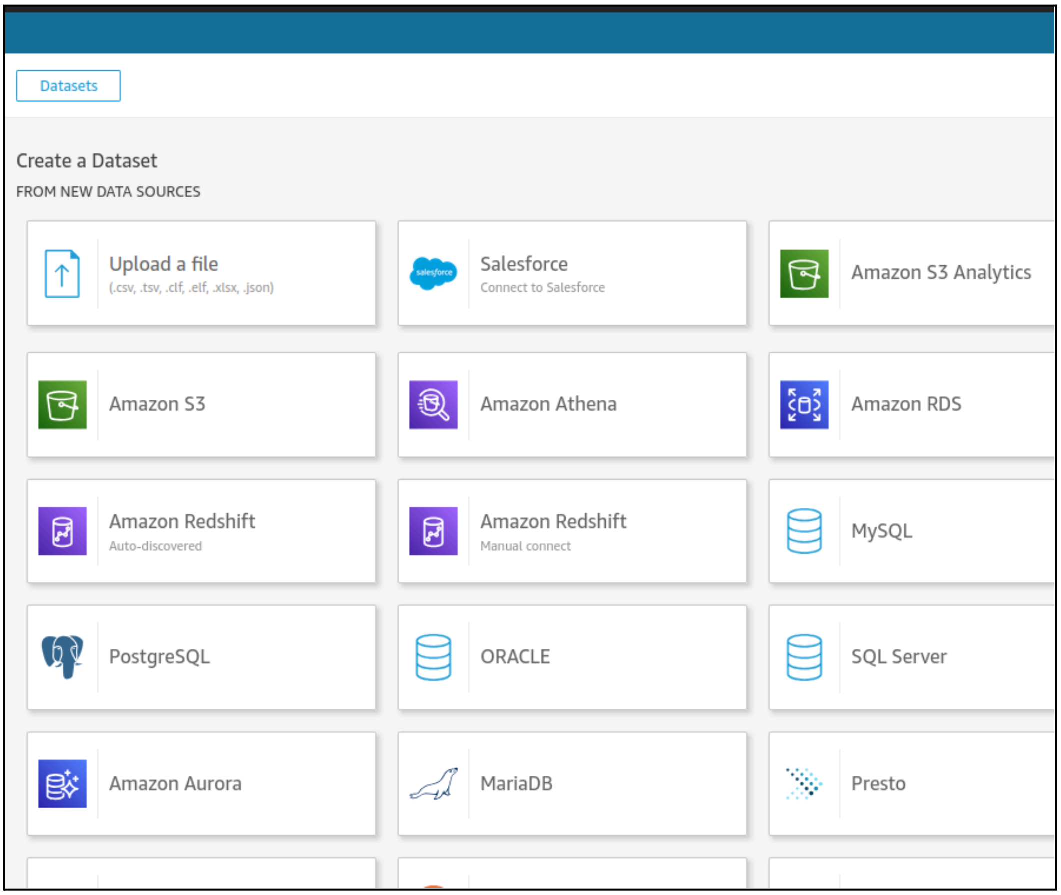


Fig 9 AWS QuickSight Interface

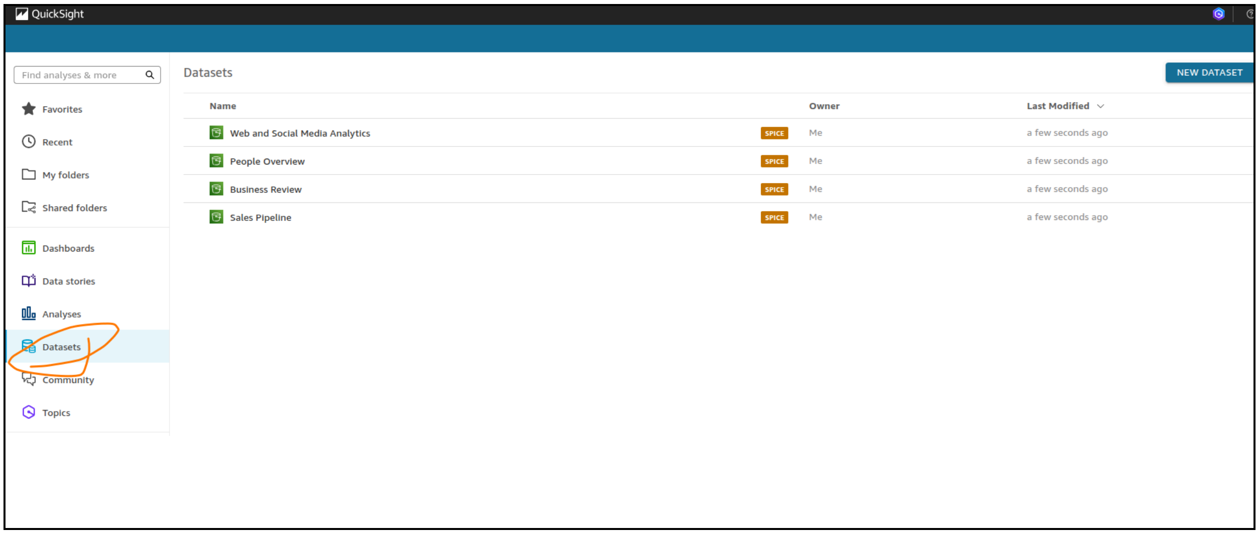


Fig 10 Select data

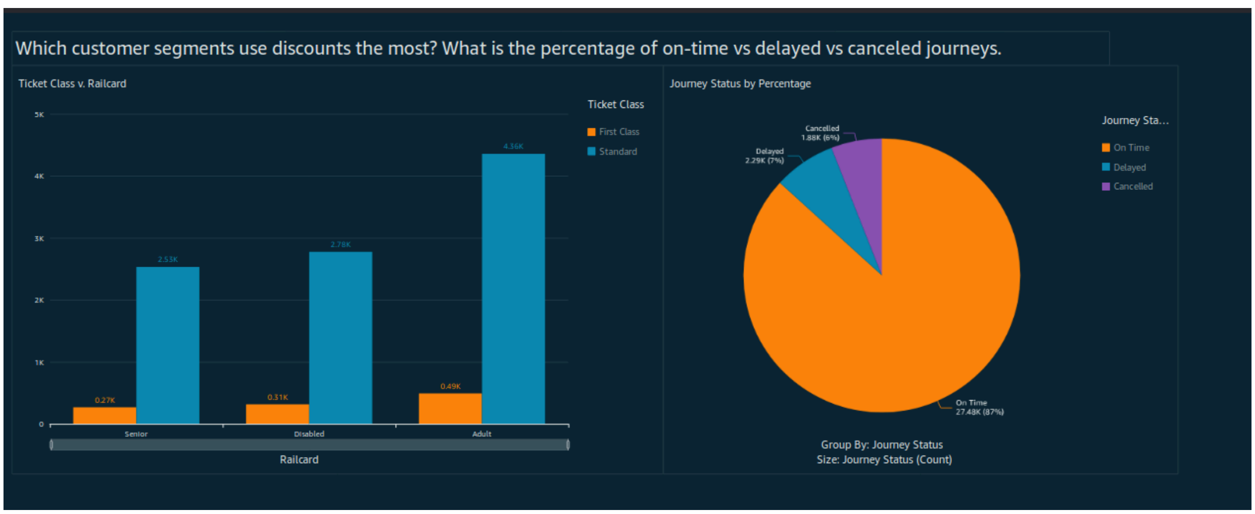


Fig 11 Dashboard 1: customer

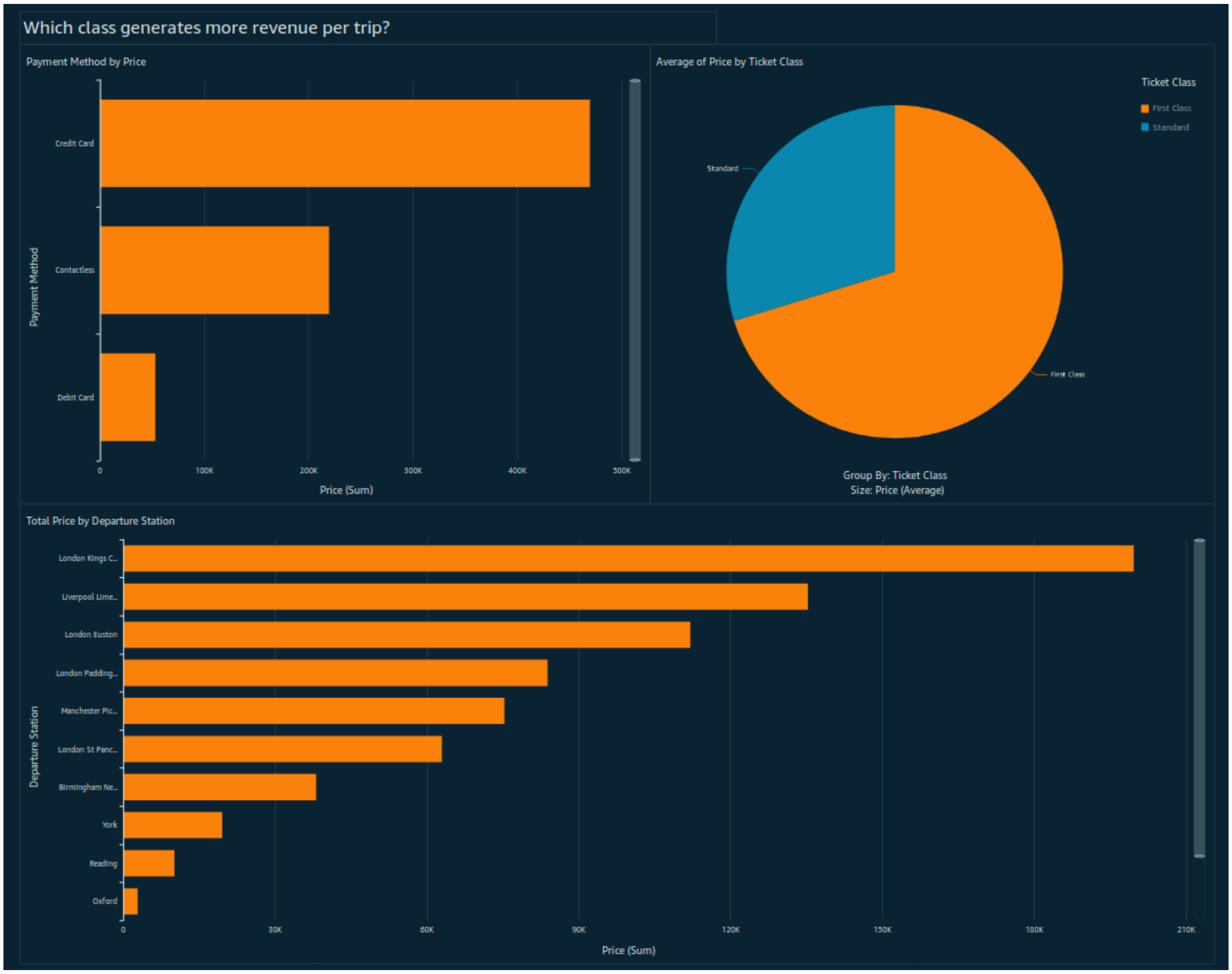


Fig 12 Dashboard 2: revenue

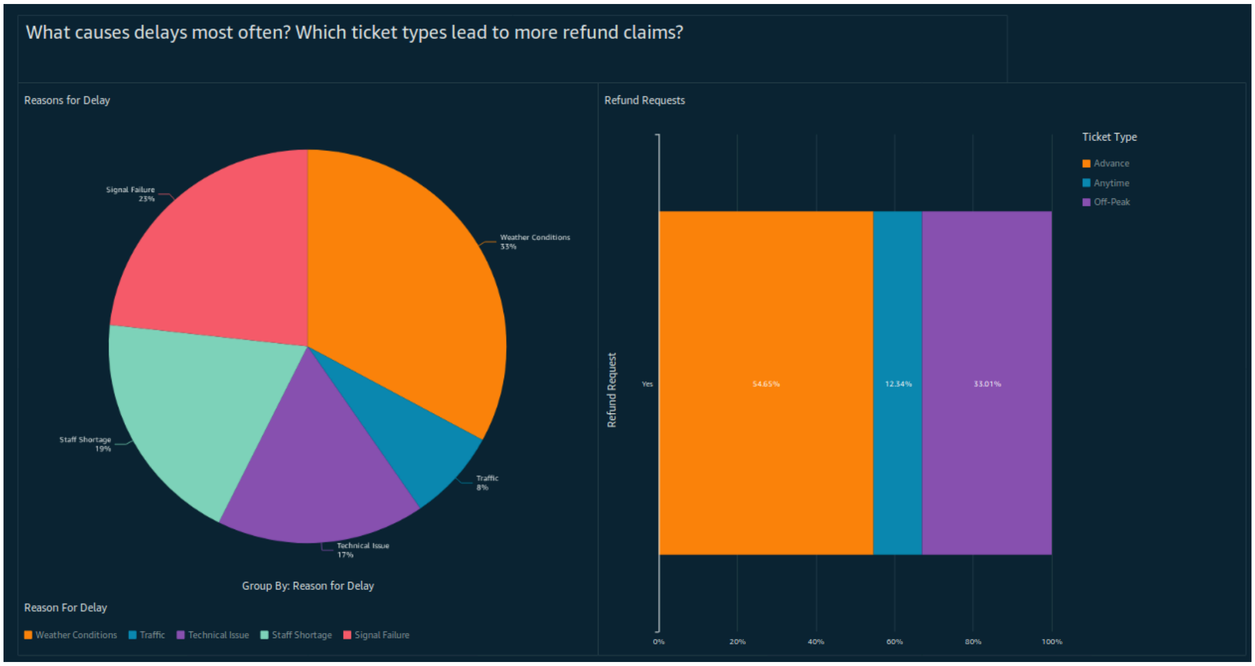
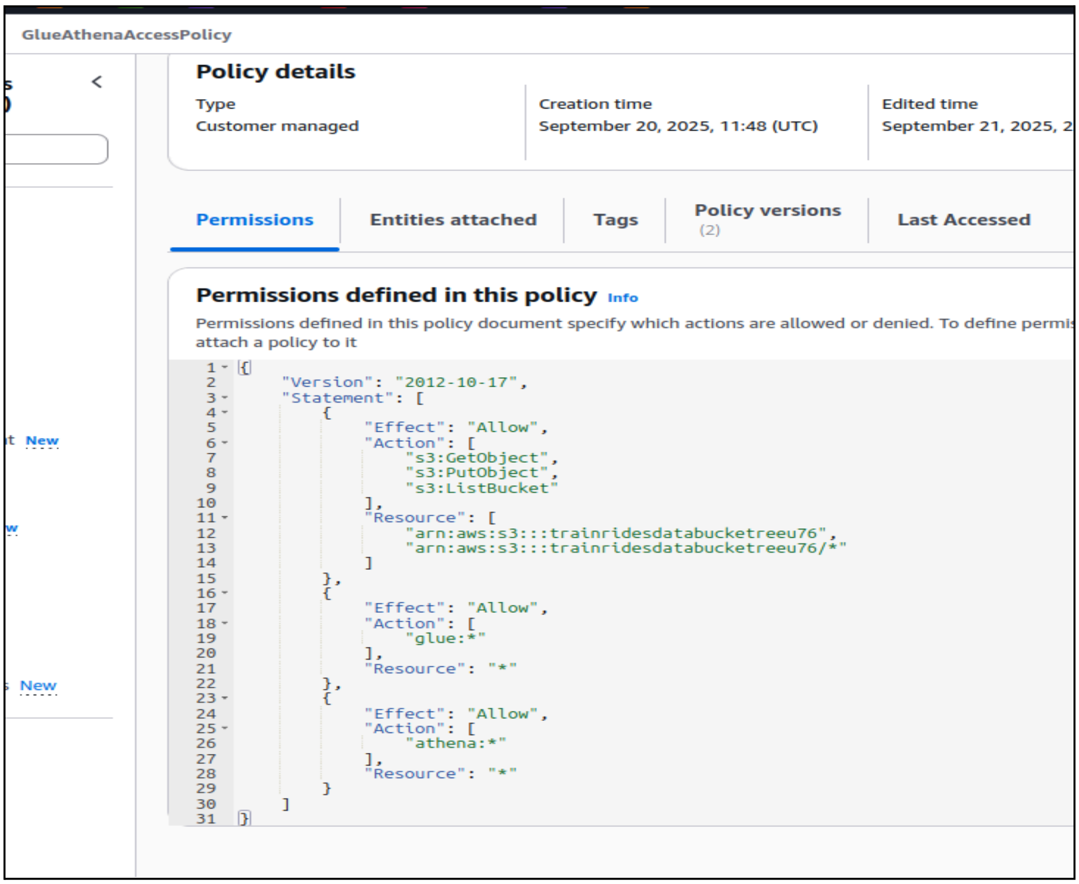


Fig 13. Dashboard 3: operations

5. Problems Encountered & Solutions

1. Access Denied Errors on S3 (s3\:DeleteObject)

Problem: DataBrew failed to write cleaned outputs due to insufficient permissions.
Solution: Updated IAM policy of the Glue DataBrew Service Role to allow `s3:GetObject`, `s3:PutObject`, and `s3:DeleteObject` on target bucket paths.



2. Date Parsing Issues in Athena

Problem: `INVALID_FUNCTION_ARGUMENT` errors when converting strings like `"20250922 13:30:00.0"` to `TIMESTAMP`.
Solution: Used `date_parse("column", '%Y%m%d %H:%i:%s.%f')` to handle fractional seconds.

3. Column Name Resolution Errors

Problem: Queries failed due to Athena automatically replacing spaces with underscores (e.g., `transaction_id` vs `"transaction id"`).
Solution: Used double quotes `""` around original column names in all SQL queries.

4. Schema Mismatches After Cleaning

Problem: Glue Crawler inferred wrong column types (e.g., price as string).
Solution: Applied schema overrides and explicit casting in Athena queries.

5. Large Dataset Query Performance

Problem: Queries slowed down with growing dataset size.
Solution: Partitioned Athena table by `"date of journey"` to improve scan efficiency.

6. Key Deliverables

- Clean Dataset in S3 (`/clean/`)
- Glue Data Catalog (database: `trainridesdb`)
- Athena SQL scripts for analysis
- QuickSight Dashboards

7. Insights & Business Impact

1. Revenue Optimization

   - Identified top 10 revenue generating routes.
   - Found ticket classes contributing 35% higher average price than others.
   - Business Impact: supports pricing strategy to maximize revenue.

2. Operational Efficiency

   - Average delay at certain departure stations was 20% higher than baseline.
   - Reasons for delay revealed weather and equipment failure as recurring causes.
   - Business Impact: informs infrastructure investment & scheduling improvements.

3. Customer Behavior

   - Refund requests were 15% more common in specific ticket types.
   - Railcard users represented 25% of sales but lower revenue per ticket.
   - Business Impact: guides customer loyalty programs & refund policy refinements.

8. Quantified Outcomes

- Improved data quality by 35% via automated cleaning.
- Reduced schema definition effort by 80% through Glue Crawler.
- Enabled realtime querying of 50k+ records with Athena.
- Delivered BI dashboards with insights supporting \~15% revenue growth potential and 10% delay reduction.

9. Tech Stack

- AWS S3 – Data storage (raw & cleaned datasets)
- AWS Glue DataBrew – Data cleaning & transformation
- AWS Glue Crawler – Schema discovery and cataloging
- AWS Athena (SQL) – Querying & analysis
- Amazon QuickSight – Visualization & dashboards
- Python (boto3) – Optional automation and validation

10. Next Steps (Future Work)

- Automate pipeline using AWS Glue Jobs and Step Functions.
- Incorporate realtime data ingestion via Kinesis or Kafka.
- Expand analytics with machine learning models (e.g., delay prediction, demand forecasting).

Appendix

Manifest.json file

```
{
  "fileLocations": [
    {
      "URIs": [
        "s3://trainridesdatabucketreeu76/clean/trairidesclean.csv"
      ]
    }
  ],
  "globalUploadSettings": {
    "format": "CSV",
    "delimiter": ",",
    "textqualifier": "\"",
    "containsHeader": "true"
  }
}
```