Satellite & Space Mission Data Analysis

Title: Satellite & Space Mission Data Analysis using SQL

Description: The objective of this project was to design and analyze a relational database that stores information about space agencies, missions, satellites, and telemetry data. Using SQL queries, the system supports mission tracking, orbital analysis, telemetry monitoring, and performance evaluation.

SQL was the primary tool to extract, aggregate, and analyze aerospace datasets for identifying orbital overlaps, mission success rates, fuel efficiency, and telemetry trends.

The project demonstrates how SQL can be applied in the aerospace domain to improve operational efficiency, safety, and decision-making.

Technical Skills Demonstrated

- Advanced SQL querying (JOIN, GROUP BY, HAVING, ORDER BY).
- Use of Window Functions (RANK(), ROW_NUMBER(), LAG(), LEAD(), AVG() OVER).
- Time-based and telemetry trend analysis (battery drop detection, altitude and velocity analysis).
- Data aggregation for mission cost and performance evaluation.
- Relational design for aerospace mission planning (Agencies → Missions → Satellites → Telemetry).

Database Schema

- Agencies: (agency_id, name, country, founded_year)
- Missions: (mission_id, agency_id, name, start_date, end_date, cost, success_status)
- Satellites: (satellite_id, mission_id, name, orbit_type, launch_vehicle, fuel_capacity)
- Telemetry: (telemetry_id, satellite_id, timestamp, altitude_km, velocity_kms, temperature_c, battery_level_percent)

Key SQL Tasks and Solutions

1. **Longest Mission by Duration**

- ○ Find missions with the maximum duration (end_date – start_date) per agency.
- ○ Purpose: Identify agencies with expertise in long-duration missions.

2. **Low Fuel Satellites**
   - ○ Find satellites with fuel capacity < 50% of maximum fuel capacity using a window function.
   - ○ Purpose: Prioritize refueling or decommissioning plans.

3. **Mission Success Rates by Agency**
   - ○ Calculate the percentage of successful missions for each agency.
   - ○ Purpose: Compare agency performance and reliability.

4. **Top Missions by Cost**
   - ○ List the top 5 missions with the highest cost.
   - ○ Purpose: Identify high-investment missions for performance tracking.

5. **Agencies with Highest Mission Expenditure**
   - ○ Calculate total mission cost per agency.
   - ○ Purpose: Monitor financial investment in space programs.

6. **Satellites per Orbit Type**
   - ○ Count the number of satellites operating in each orbit type (LEO, GEO, etc.).
   - ○ Purpose: Monitor orbital distribution and utilization trends.

7. **Maximum Altitude Recorded per Satellite**
   - ○ Find the highest altitude reading for each satellite from telemetry data.
   - ○ Purpose: Monitor performance limits of satellites.

8. **Minimum Temperature Recorded per Satellite**
   - ○ List the lowest temperature reading recorded in telemetry for each satellite.
   - ○ Purpose: Detects extreme environmental exposure.

9. **Missions with Multiple Satellites in LEO**
   - ○ Identify missions that launched more than one satellite into LEO orbit.
   - ○ Purpose: Track clustered launches and constellation deployments.

10. **Satellites by Launch Vehicle Ranking**
    - ○ Rank satellites by fuel capacity within each launch vehicle category.

○ Purpose: Compare performance across different rocket families.

11. Cumulative Mission Cost per Agency

○ Show running total of mission costs ordered by start_date for each agency.

○ Purpose: Track budget spending trends over time.

12. Telemetry Battery Drop Detection

○ Compare consecutive telemetry records using LAG() to identify satellites with decreasing battery levels.

○ Purpose: Detect power degradation and predict satellite end-of-life.

13. Mission Duration per Agency (Average)

○ Calculate average mission duration per agency using AVG() OVER (PARTITION BY agency_id).

○ Purpose: Evaluate consistency of mission lifespans.

14. Satellites in Critical Condition

○ Find telemetry records where altitude > 500 km and battery < 50%.

○ Purpose: Flag satellites in critical conditions for urgent monitoring.

15. Agencies with Most Ongoing Missions

○ Count missions where end_date IS NULL grouped by agency.

○ Purpose: Identify active agencies currently operating missions.

16. Missions Ranked by Cost

○ Rank all missions by cost using RANK().

○ Purpose: Establish investment priorities across space missions.

Impact and Benefits

● Enabled **mission success rate evaluation** per agency.

● Supported **satellite health monitoring** with telemetry analysis.

● Provided insights into **fuel usage and efficiency** across missions.

● Improved **collision risk management** by analyzing orbital overlaps.

● Offered **trend analysis** of mission costs, durations, and satellite utilization.

● Showcased the value of **window functions and advanced SQL** in aerospace analytics.