# DATANAUTS FEMME

WiD Datathon 2025

# Meet Datanauts Femme

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# Problem Statement

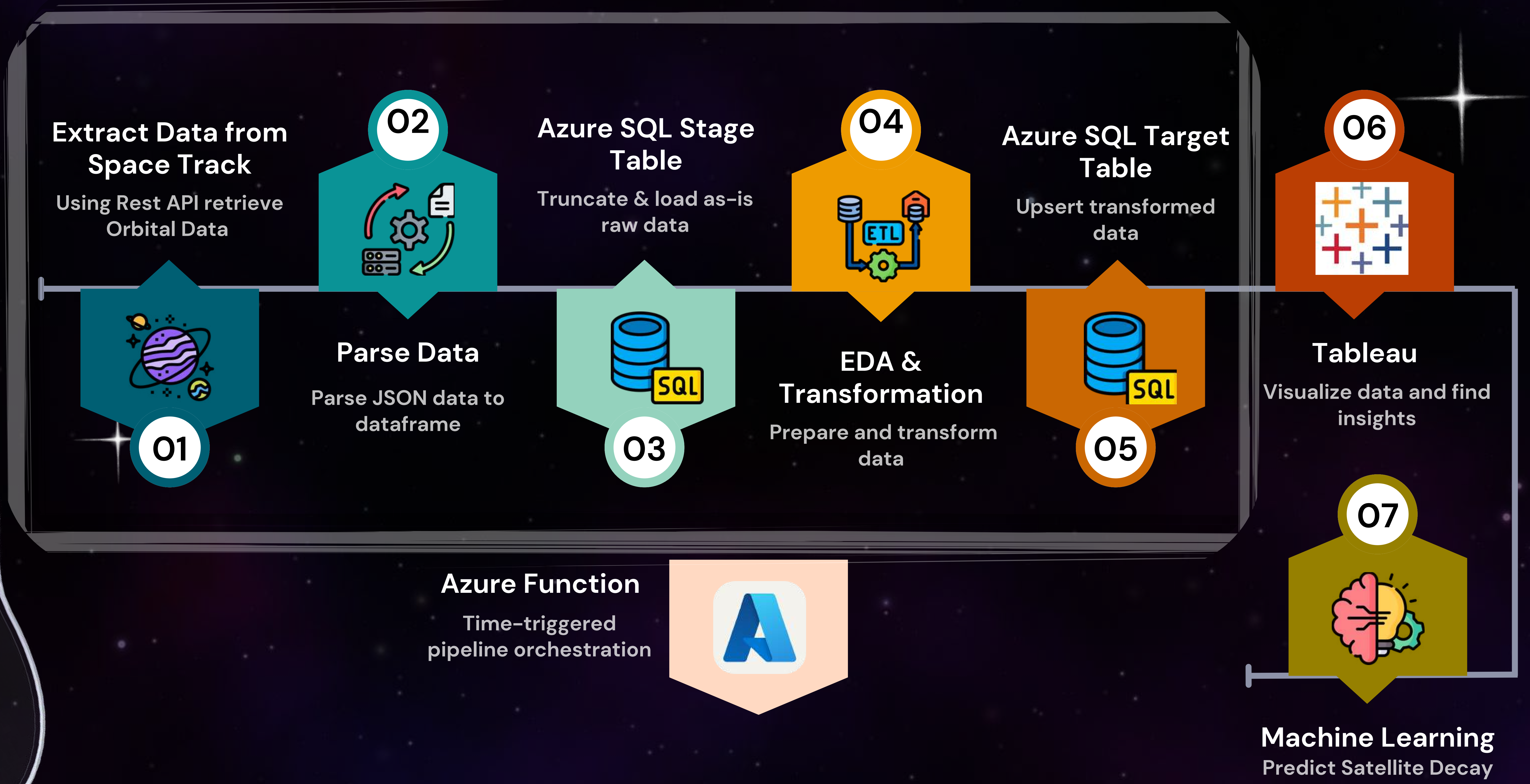
### *Overview*

The growing accumulation of inactive satellites and orbital debris in Earth's orbit poses significant challenges to the long-term sustainability of space operations. This project analyzes the distribution of space objects around Earth, tracks global contributions, and examines their growth over time. By studying orbital characteristics such as mean anomaly and categorizing objects by type and ownership, it provides a comprehensive understanding of orbital congestion and potential risk areas.

### *Objective*

The goal of this project is to identify factors impacting Satellite decay, quantify the scale of orbital debris, and provide actionable insights that support safer and more responsible management of Earth's orbital environment.

# Data Mission Architecture



# Data Source

**Space-Track.org**

## Source

- Official U.S. Space Command database of satellites & space objects
- Provides orbital elements, launch details, conjunction events, and decay predictions

## Relevance & Applications

- Collision Risk Monitoring
- Launch Activity Analysis
- Space Sustainability
- Orbital Dynamics Insights
- Operational Planning

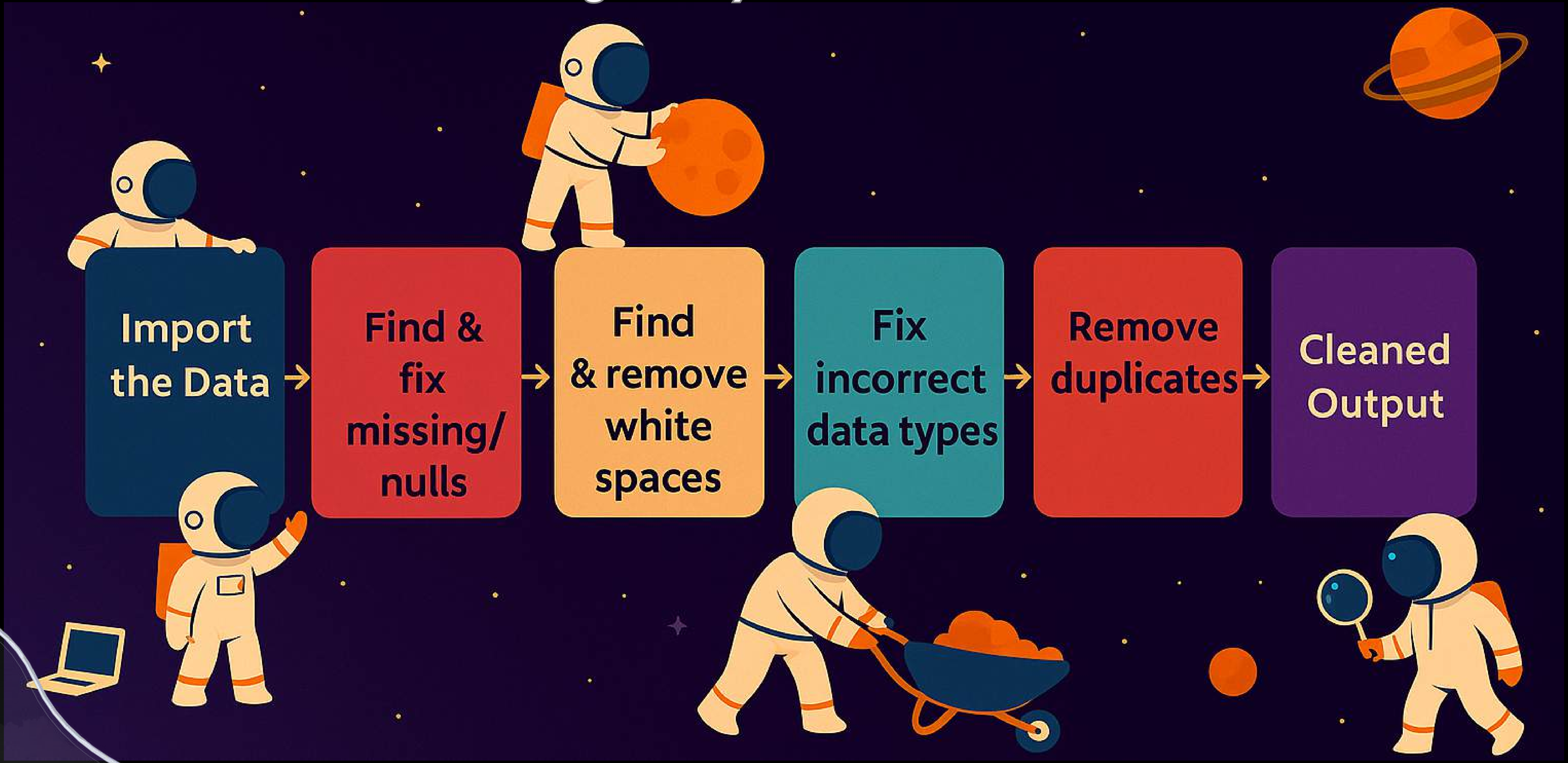
# Data Acquisition

***Getting data from orbit to database***

- **Data Access:** Retrieved 10 years of orbital data (orbits, launches, conjunctions, decay) from Space-Track.org via REST API.
- **Data Processing:** Parsed JSON using Python and transformed into a tabular format with Pandas DataFrame.
- **Data Storage:** Loaded structured data into Azure SQL (stage schema) for further analysis

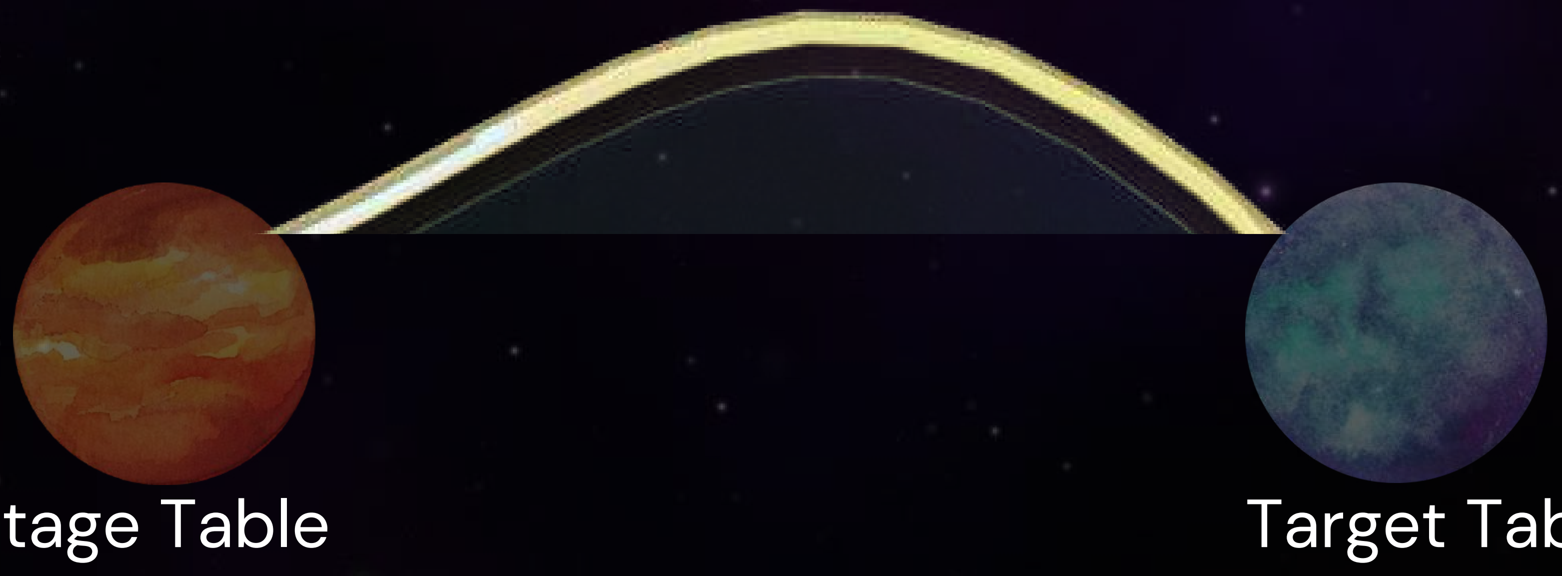
# Data Transformation

*Making messy data usable*



# Data Integration and Automation

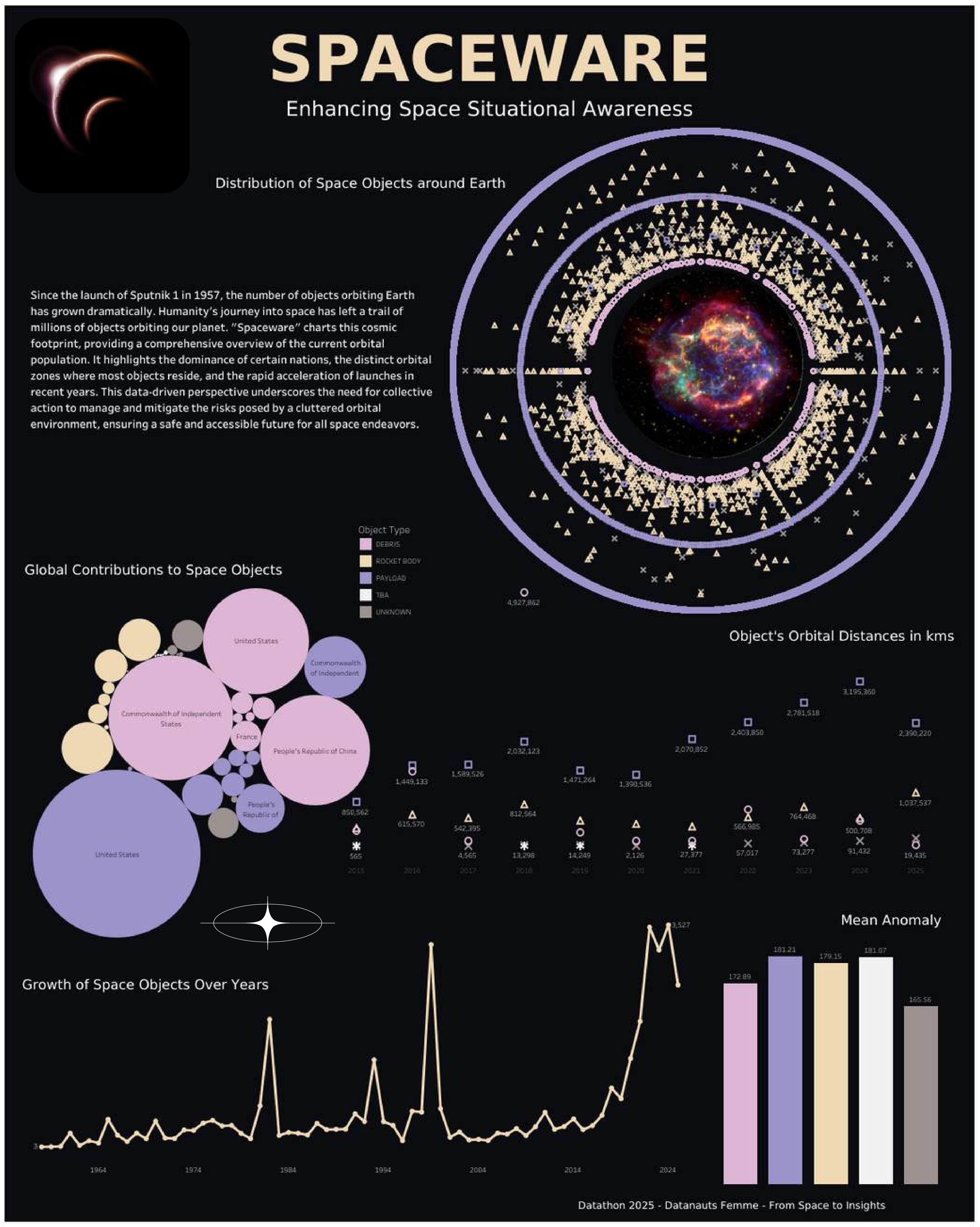
### *From raw to trusted: Single Truth of Analysis*




Transferred transformed data from staging to target tables using an upsert strategy to efficiently handle inserts and updates.

### *Keeping the pipeline alive*

- Real-time data required constant manual work.
- Automated the pipeline after the initial full load.
- Weekly Python and Azure Functions updates load new data into target tables.




# VISUALIZATION

Noticeable Trends:

- Explosive growth in space objects after 2014, with the sharpest spike near 2024.
- High-density orbital bands (especially in low altitudes ~200–600 km) showing the greatest decay/collision risk.
- Concentrated ownership — United States, People's Republic of China, and Commonwealth of Independent States dominate.
- Varying orbital dynamics — mean anomaly and orbital distances fluctuate over time, affecting relative positions and encounter probabilities.
- Unexpected spike in objects was seen in September 1982, June 1993 and May 1999 may be due to Fragmentation of old satellites or rocket stages, accidental collisions and debris cataloging catch-up
- The mean anomaly determines that the objects were closer to Periapsis.

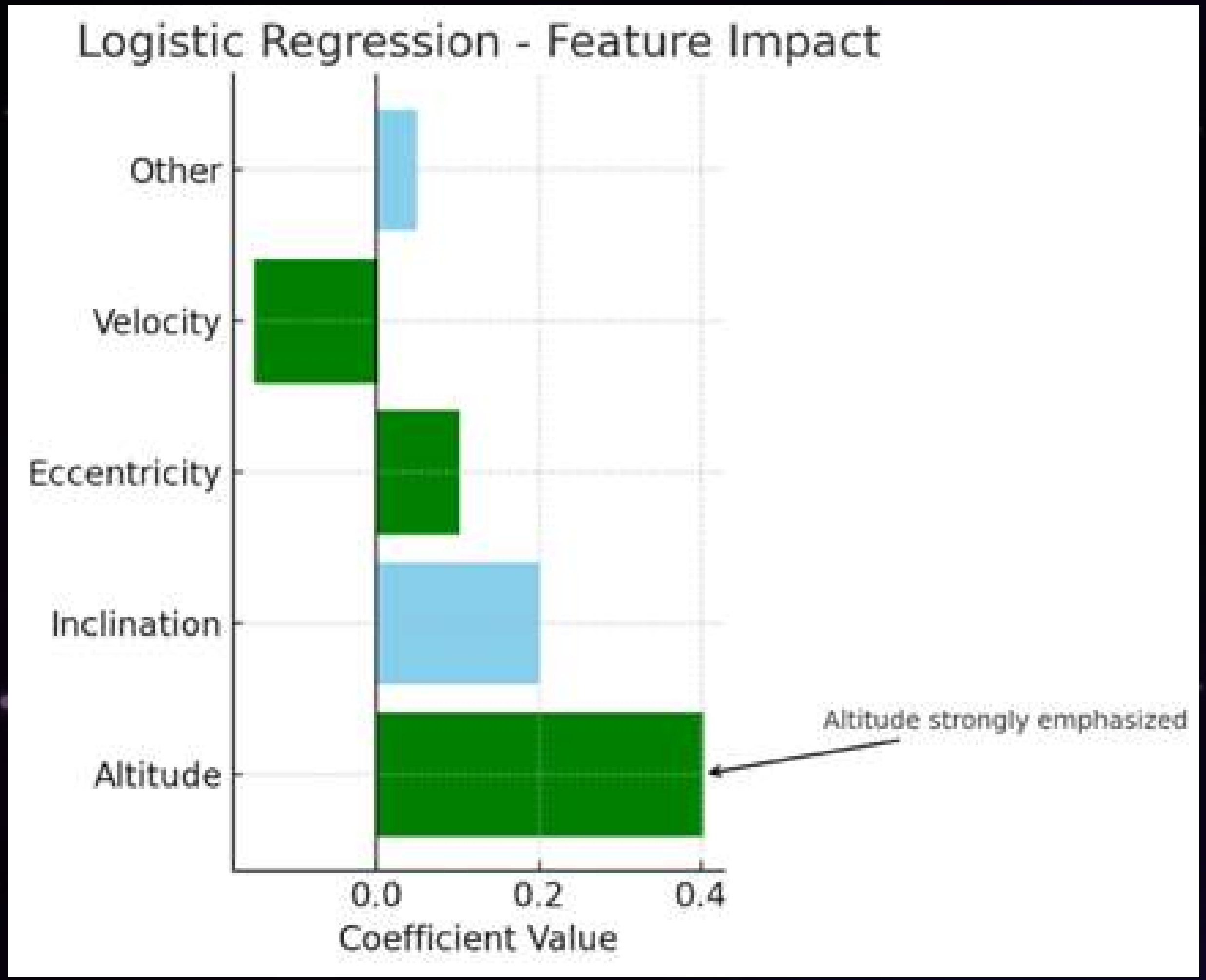
Click here to view the Interactive Visual

# Machine Learning

***Model Selection and Comparison to Predict Satellite Decay***

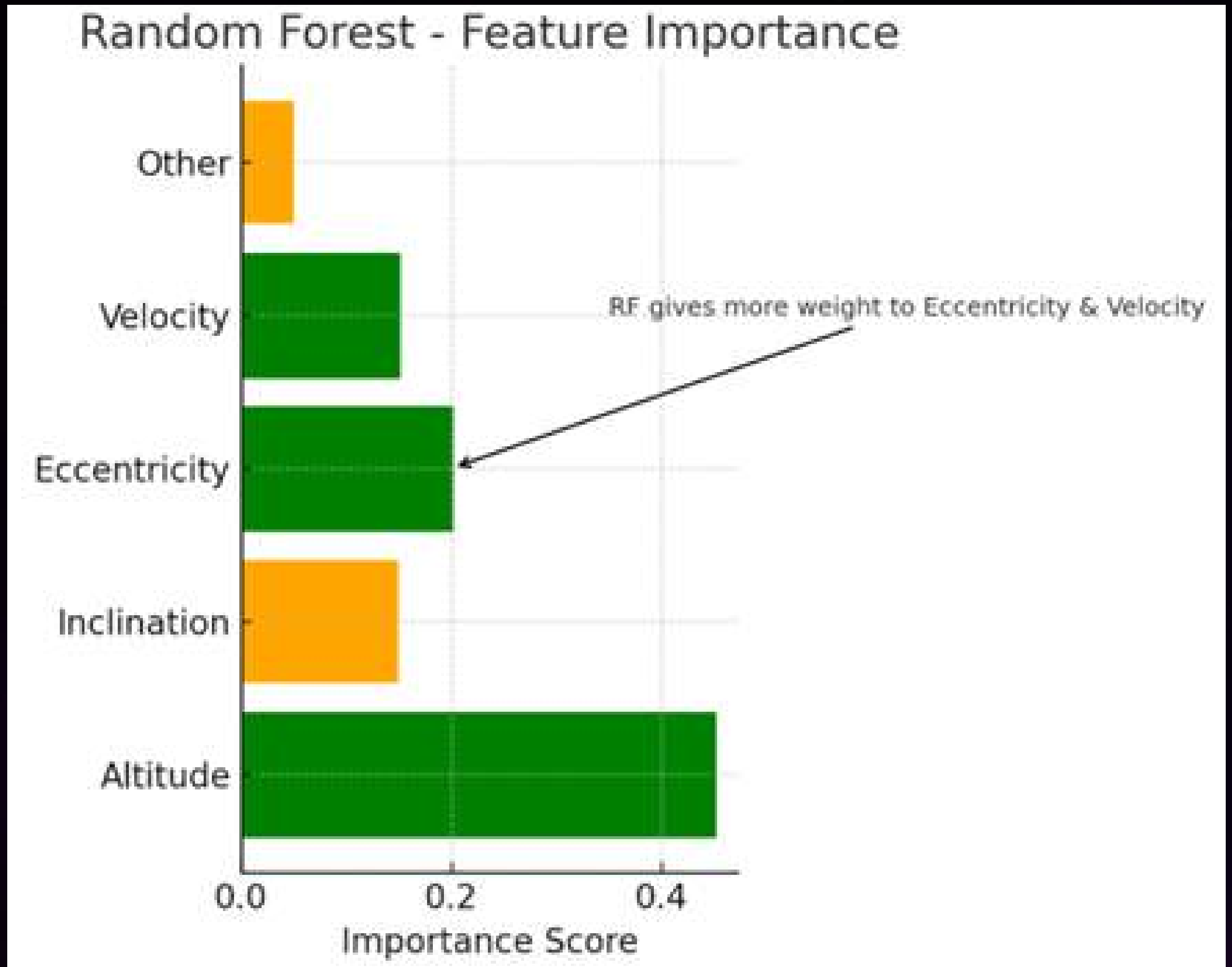
## Logistic Regression

- Simple & Interpretable
- Provides probabilities
- Easy to Explain




## Random Forest

- Stronger accuracy
- Handles complex pattern
- Shows feature importance



# Key findings for Stakeholders

- “Altitude + Eccentricity + Inclination” together are predictive of satellite decay/collision risk.
- **Altitudes:** Satellite at lower altitudes ( ~200km to 600 km above Earth’s surface level) faced significantly higher decay risk.
- **Inclinations:** Orbits tilted away from the equator → some angles (e.g., ~50–60° or >120°) cause more drift and instability.
- **Eccentricity:** ‘Eccentric Orbits’ (i.e. orbits that are more elliptical than circular) experience atmospheric drag at it’s low point making it unstable over time.
- Consideration: Some satellites will be in the risk zones mentioned above based on their mission. Example: International Space Station and Earth observing satellites remain at lower altitudes.

# Recommendations

1. Launch & Mission Planning
   - Overlay density heatmaps to find low-risk altitude–inclination corridors.
   - Model decay vs. altitude/eccentricity to estimate orbital lifetimes.

2. Active Fleet Operations
   - Align maneuvers with low-congestion windows from distance–density trends.
   - Track anomaly divergence to predict conjunctions and plan attitude control.

3. End-of-Life Strategy
   - Use low-use altitude bands as parking orbits before deorbit.
   - Time deorbits during low launch activity to reduce collision risk.

4. Analytics & Risk Modeling
   - Model risk using altitude, eccentricity, and inclination.
   - Weight collision models by ownership density.

# Thanks for orbiting with Datanauts Femme