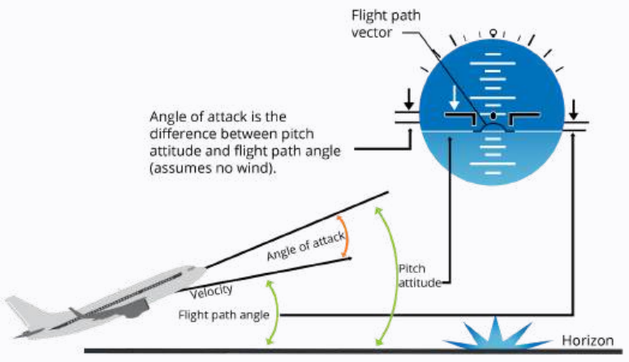
Smart Surrogate Modelling (*Group 3*)

What exactly is a Surrogate Model?

A lightweight approximation of complex physical models

- Built using machine learning or statistical methods.
- Allows fast predictions of system behavior.
- Running time-consuming simulations or flight tests.



Very useful for Aviation in

Real-time decision making, Anomaly detection, Safety analysis

Our Goal

- Develop an **ML surrogate model** for vertical load factor (**VRTG**).
- Achieve high prediction accuracy.
- Ensure robust generalization across flight conditions.
- Validate predictions against sensor data for efficiency.

Our Resources

- NASA Dashlink (flight test data)
- Software: Python, PyTorch, scikit-learn, Pandas, NumPy
- Environment: Google Colab
- Collaboration: Airbus engineers

Building, Training, and Testing

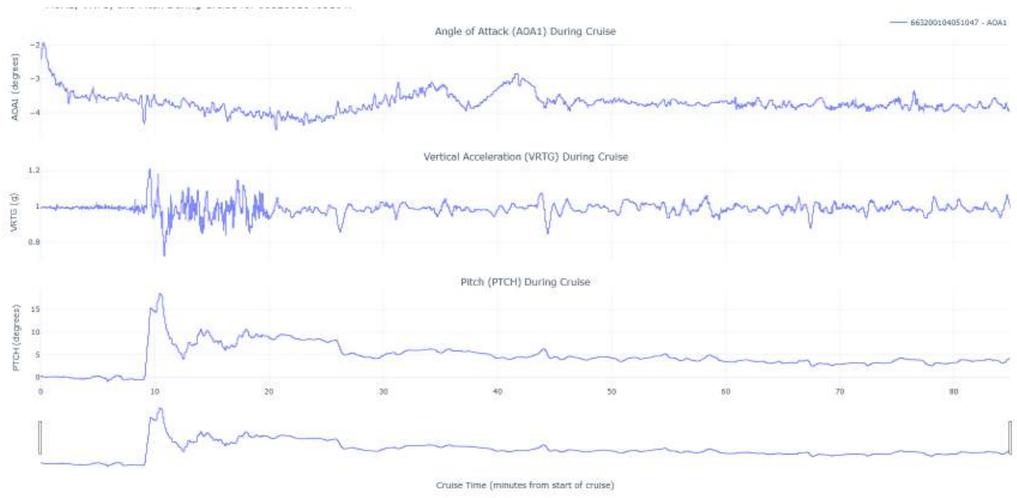
Method: **LSTM-based Surrogate Model**

Reason:

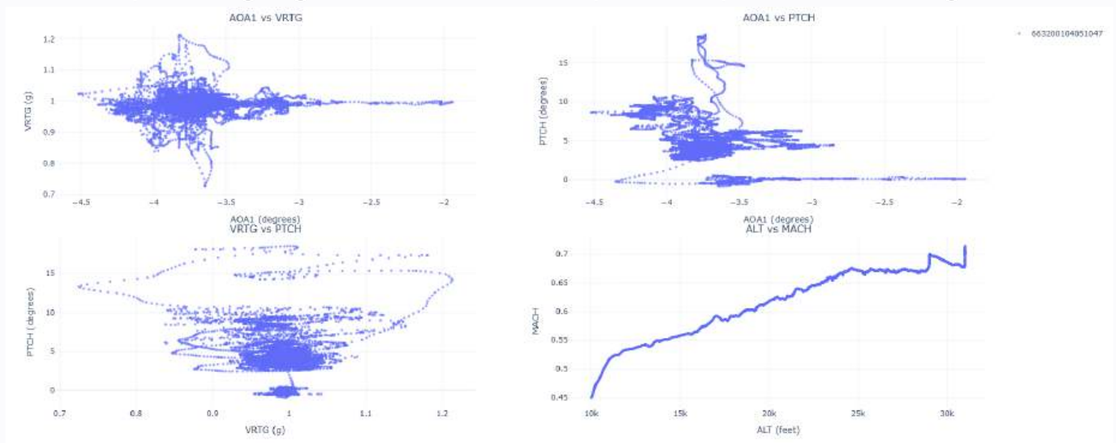
- Flight data is **time-series** based(altitude, pitch, roll, Mach, etc.).
- LSTM (Long Short-Term Memory) can capture temporal dependencies better than standard ML models.
- Helps detect patterns across time, not just isolated points.

Benefits:

- Captures nonlinear & time-dependent flight dynamics.
- Provides higher accuracy in sequential prediction tasks.
- Efficient surrogate for real-time monitoring



- Most cruise flight data clusters around **VRTG ≈ 1g**, confirming stable flight
- The altitude–Mach relationship illustrates operational cruise adjustments.
- These plots highlight the need for temporal sequence modeling.



Our Datsets

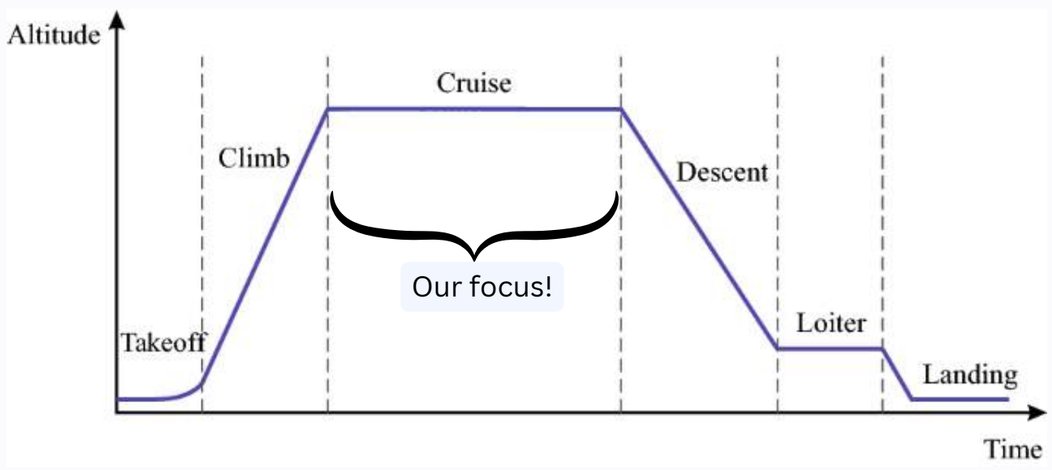
Key parameters we used for training:

AOA1 → *Angle of Attack*
PTCH → *Pitch Angle*
ROLL → *Roll Angle*
TAS → *True Airspeed*
ALT → *Altitude*
LATG → *Lateral Load Factor*
MACH → *Mach Number*

Target parameter: **VRTG** → *Vertical Load Factor (G-force)*

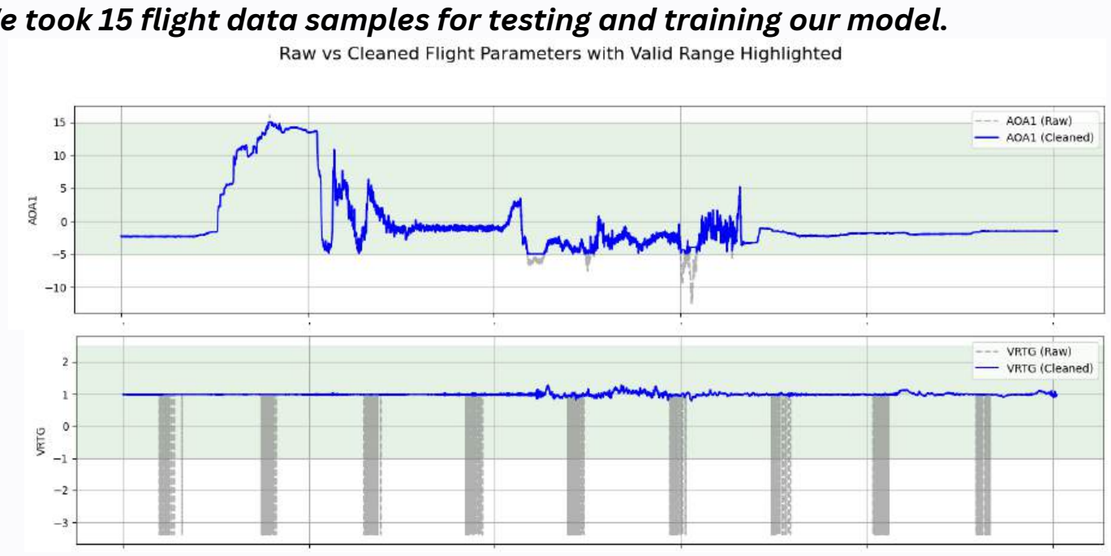
Data pre-processing:

For the best outcome, we focused on the cruise phase of the flights



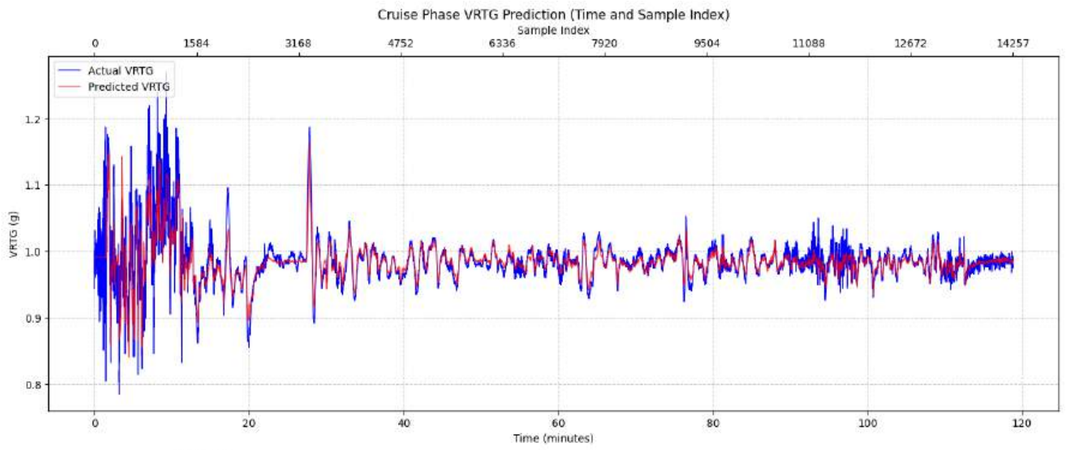
Cleaning the large dataset involved the detection and removal of corrupted and irrelevant data, as well as improving the data quality to make it suitable for the model.

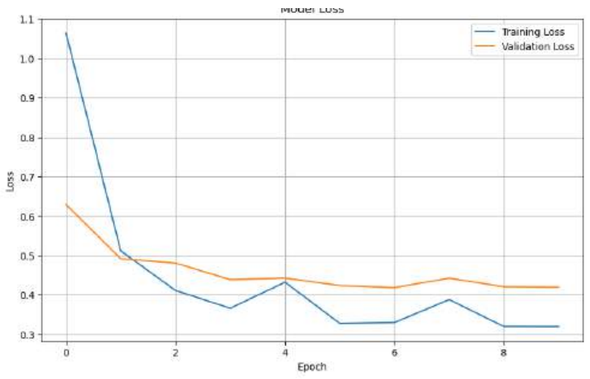
We took 15 flight data samples for testing and training our model.



The Result and Validation

- The LSTM model accurately predicts VRTG during cruise.
- Predictions closely match sensor data, including small fluctuations.
- The model generalizes well across multiple flights.





- LSTM surrogate model predicts VRTG in cruise with high reliability.
- Faster and cheaper than physics-based simulations.
- Extendable to other flight phases for real-time monitoring and safety.

The Team

Name	*Responsibilities*
Radha Rakshe	Data preprocessing, Notion management
Smita Singha Roy	Data cleaning and organization
Mihir Dave	LSTM model development
Sai Parab	Visualization and evaluation
Tawfiq Bashar	Poster design and documentation

With the collaboration of: AIRBUS