

# ElectriFly

Team 2 - FDR Presentation

Friday, April 5, 2024



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# How Might We Statement

Empowering stronger flight decisions through analytics & ML



## HMW Statement

How might we **analyze flight, battery, and weather data** for pilots and researchers to optimize plane operations and enable the users to make decisions based on **climate conditions, battery state of charge (SOC), and SOH?**

# Project Objectives

3 Core Project Objectives

1



## Data Pipeline

Clean, transform, label

2



## Data Visualization UI

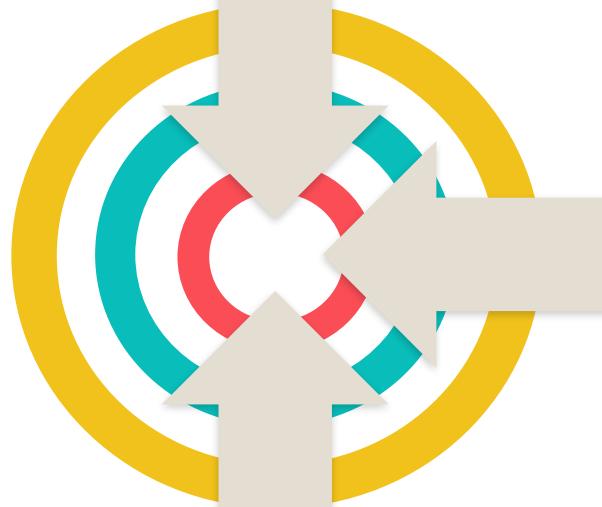
Generate graphs

3



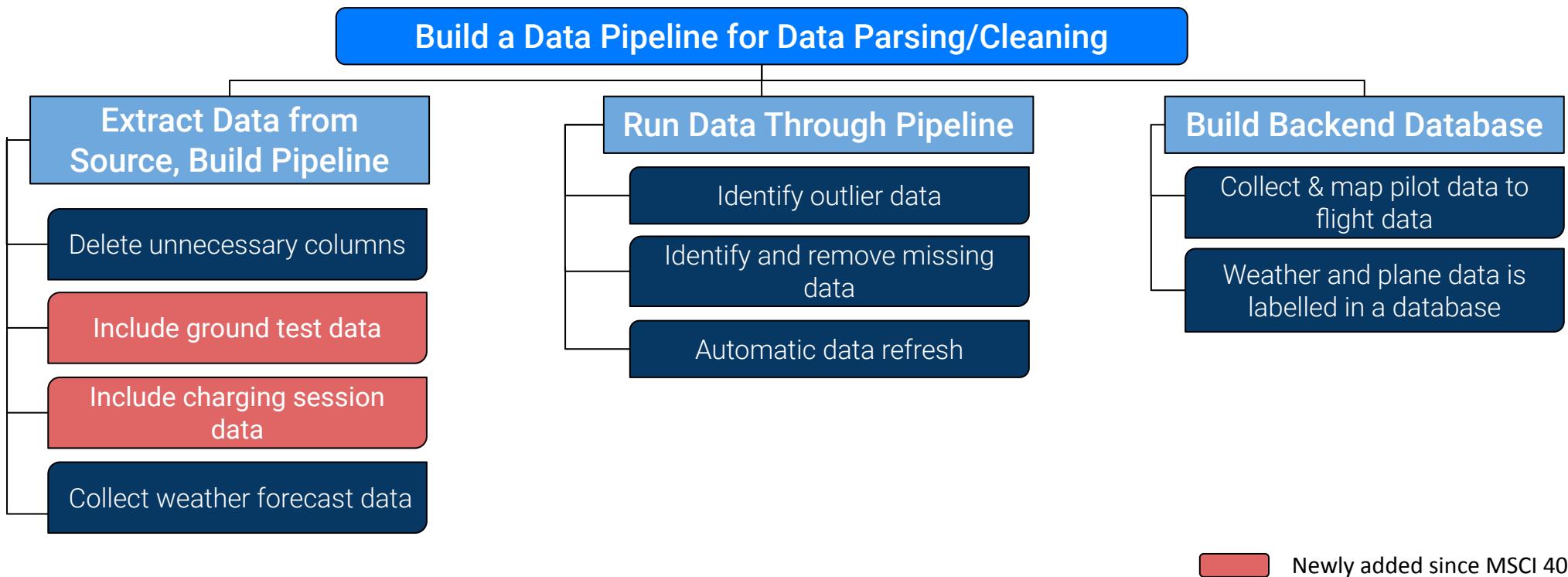
## Prescription of Optimal Operations for Electric Planes

Recommend operations for optimal utilization of plane



# Data Pipeline Requirements

## Must-Have Functional Requirements



## Success Criteria



### KPI

Better metrics compared to previous data parsing (faster and automated process)

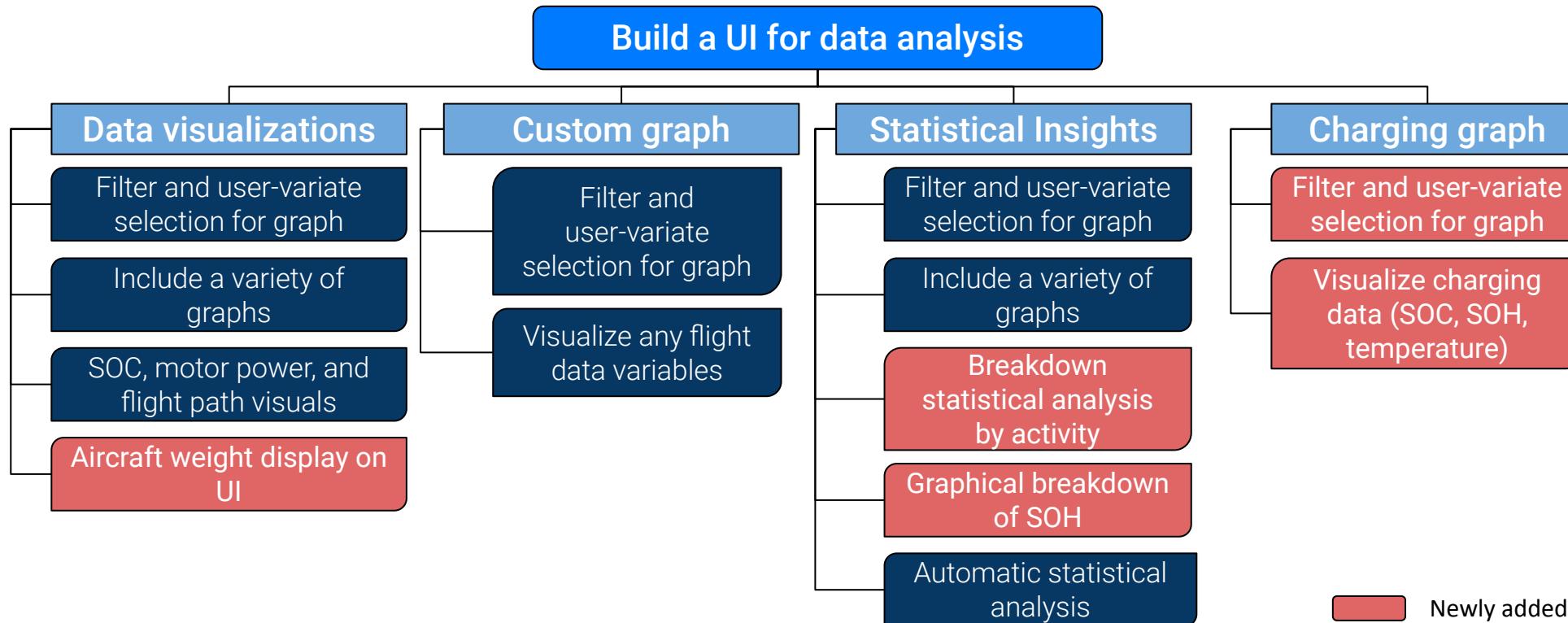


### Verification

Calculations, historical analysis, and qualitative user experience, pilot program

# Data Visualization Requirements

## Must-Have Functional Requirements



Newly added since MSCI 401

## Success Criteria



### KPI

Better metrics compared to previous manual analysis, and qualitative user experience (heuristic evaluation and pilot program)

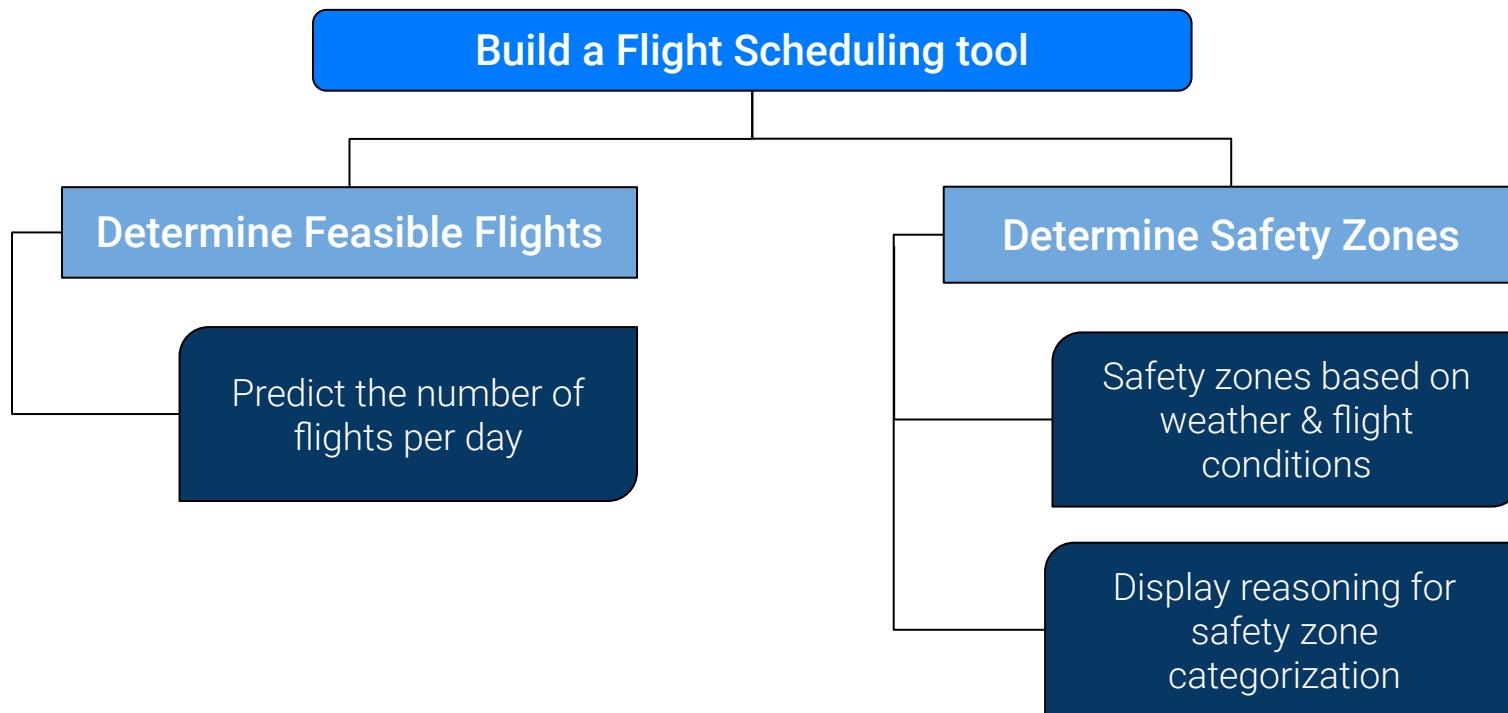


### Verification

Calculations, historical analysis, and qualitative user experience (heuristic evaluation and pilot program)

# Flight Scheduling Requirements

## Must-Have Functional Requirements



### Success Criteria



#### KPI

Better metrics compared to human decision given data

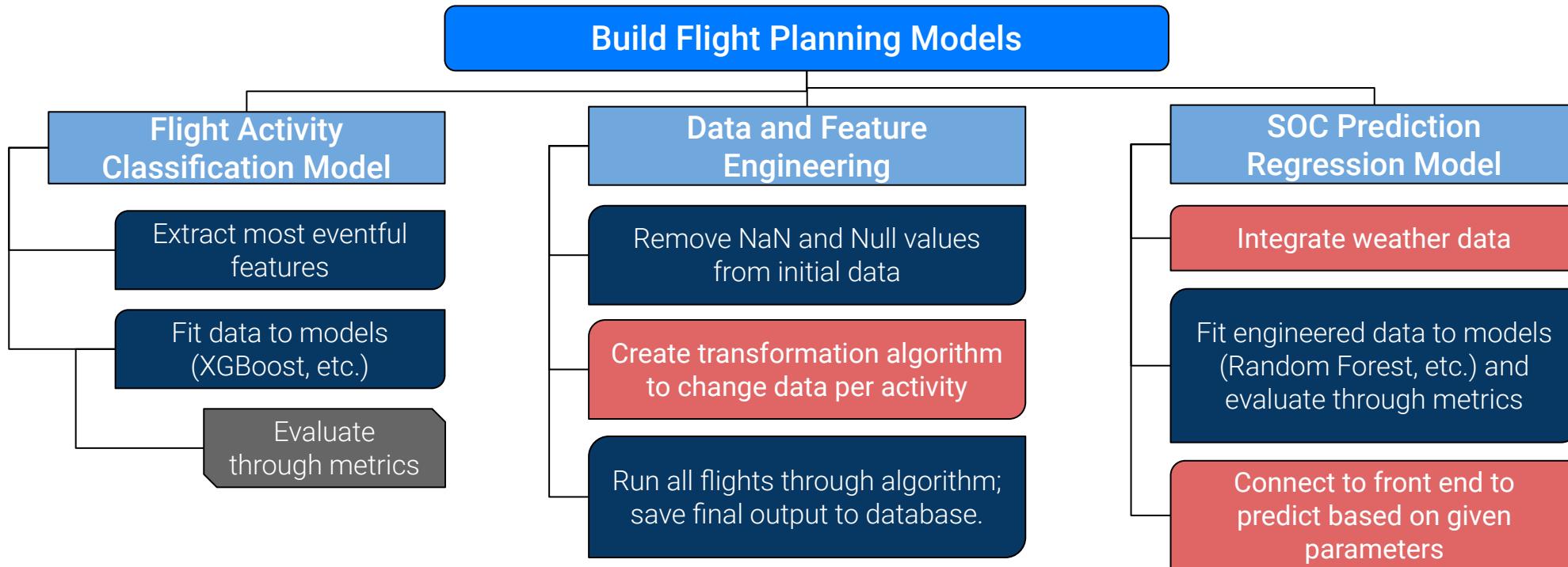


#### Verification

Calculations, historical analysis, and qualitative user experience (heuristic evaluation and pilot program)

# Flight Exercise Planning Requirements

## Must-Have Functional Requirements



Newly added since MSCI 401

## Success Criteria



### KPI

Better metrics compared to human decision given data



### Verification

Calculations and qualitative user experience (heuristic evaluation and pilot program)

# Verification & Validation

## Machine Learning Model

### Verification

	Linear Regression	Ridge Regression	Random Forest	XGBoost
Mean Squared Error (MSE)	3.83	6.44	1.6	2.02
Coefficient of Determination	0.66	0.66	0.91	0.89
K-fold cross validation score	0.64	0.63	0.85	0.88

### Validation



Gabriel, Pilot

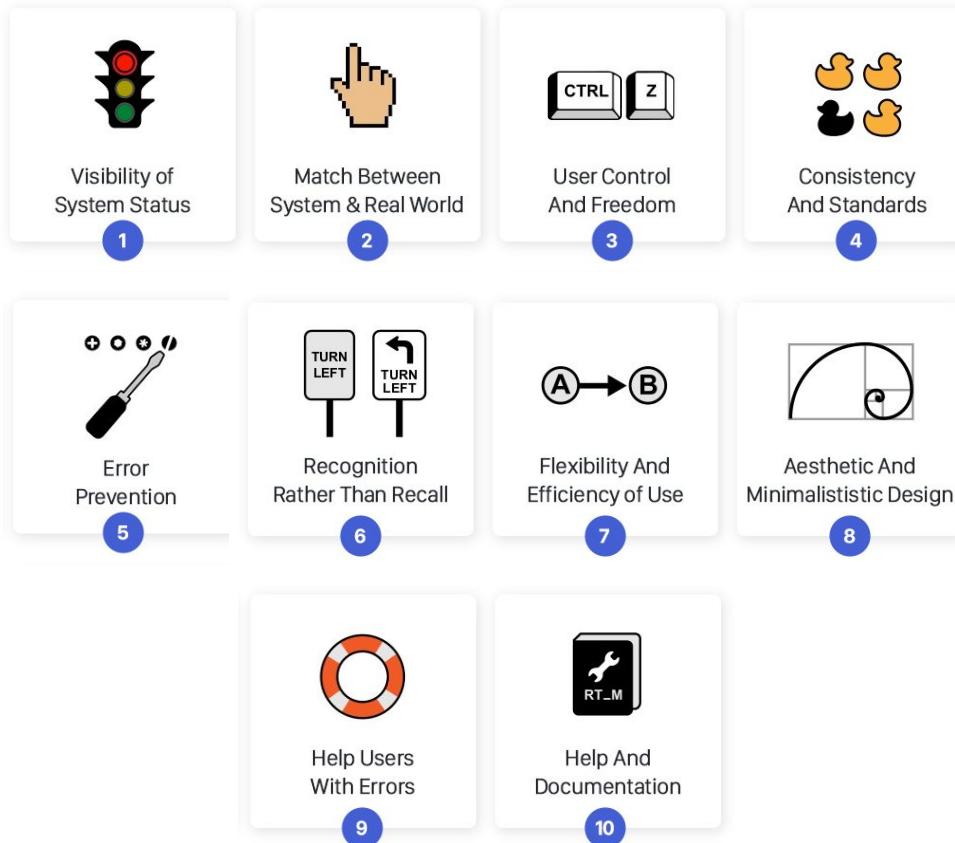


1.5 Week Pilot Program

# Verification & Validation

## UI Verification with Heuristic Evaluations

### Nielsen's 10 Usability Heuristics



### 49 Potential Improvements

Team Heuristic Evaluation Results						
Done	PM Priority	Heuristic	Description of Problem	Severity Rating	Potential Solution	UI Page
<input checked="" type="checkbox"/>	Urgent	H2-1: visibility of system status	Change the menu headers to something more meaningful	2	- Upload Data → "Data Preview" - Data Analysis - Simulation → Flight Planning - Data Analysis > Recommended Graphs → Data Visualization - Simulation > Forecasting → Flight Scheduling - Simulation > Flight Operations Modeling → Flight Exercise Planning	Menu Data Analysis – Recom... Simulation – Forecasting
<input checked="" type="checkbox"/>	Urgent	H2-4: consistency and standards	All graphs titles and legends are cut off	4	Fix the sizing. Make the graphs fit onto shiny cards.	Data Analysis – Recomm... Data Analysis – Custom ...
<input checked="" type="checkbox"/>	Must do	H2-2: match between system an...	Dates are all disorganized to select	2	Make the most recent at the top and less recent at the bottom	Upload Data Page Data Analysis – Recomm... Data Analysis – Custom ... Data Analysis – Statistic... Simulation – Forecasting Simulation – Flight Ops ...
<input checked="" type="checkbox"/>	Must do	H2-7: flexibility and efficiency of...	Be able to edit and delete each exercise	1	For each flight activity chosen, you should be able to edit the mins selected (and potentially the exercise selected), you should be able to delete any row	Simulation – Flight Ops ...
<input checked="" type="checkbox"/>	Must do	H2-4: consistency and standards	Date/time is wrong format	1	• For date: Dec 16, 2023 • For date AND time (if multiple flights): Dec 16,	Upload Data Page Data Analysis – Statistic... Simulation – Forecasting

# Verification & Validation

## UI Validation with Pilot Program

### Tangible Feedback & Improvements

Most Recent Flight and Weather Data Records

Data was last refreshed: Mar 14, 2024 at 11:40 PM

Filters

Select Data Granularity: Granular | Select Data Type: Flight test | Select the Date: Dec 16, 2023 at 03:12 PM | Select Data Preview Limit: 10

Select Flight Data Columns: Flight ID, Time (Min), Bat 1 Current (amp), Bat 2 Current (amp), Bat 1 Voltage (volts)

Select Weather Data Columns: Temperature (°F), Dewpoint (°F), Relative Humidity (%)

Graphs

Flight Date: Jun 03, 2023 at 10:11 AM

Number of circuits: 6 | Aircraft Weight (lbs): 1296.42 | Flight Map

Your viewing flight with flight id: 4620.

CHARGING GRAPH

Welcome to ElectriFly's Charging Graph Interface!

Our charging graph tool enables you to visualize and selectively explore charging data across multiple sessions. Whether you prefer a dynamic line graph or a detailed scatterplot, our tool empowers you to make informed decisions and optimize your charging strategy like never before!

Charging Date and Time: Dec 21, 2023 at 12:15 AM | Independent (X) Variable: Time (min) | Dependent (Y) Variable: State-of-Charge (Percent)

Graph Type: Line Plot

Time (min) vs State-of-Charge (Percent)

Dec 21, 2023

State-of-Charge (Percent)

Time (min)

### Design Validation



ElectriFly UI - System Usability Scale

	Strongly Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I think that I would like to use this system frequently	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the system unnecessarily complex	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought the system was easy to use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I think that I would need the support of a technical person to be able to use this system	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the various functions in this system were well integrated	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought there was too much inconsistency in this system	<input type="radio"/>	<input type="radio"/>			
I would imagine that most people would learn to use this system very quickly	<input type="radio"/>	<input type="radio"/>			

System Usability Score:  
79

# Alternative UI Designs

## Data Preview

OLD

### Most Recent Flight and Weather Data Records

Select Columns to Preview

Flight Date x Flight ID x Time (Min) x Bat 1 SOC x Bat 1 SOH x  
Bat 1 Max Cell Temp x Temperature x Visibility x

FLIGHT DATE	FLIGHT ID	TIME (MIN)	BAT 1 SOC	BAT 1 SOH	BAT 1 MAX CELL TEMP
2023-12-16	5367	0			
2023-12-16	5367	0.02	78.4	65.6	3.6
2023-12-16	5367	0.04	98	82	18
2023-12-16	5367	0.06	98	82	18
2023-12-16	5367	0.08	98	82	18
2023-12-16	5367	0.1	98	82	18
2023-12-16	5367	0.12	98	82	18
2023-12-16	5367	0.14	98	82	18
2023-12-16	5367	0.16	98	82	18
2023-12-16	5367	0.18	98	82	18

Data was last refreshed at: 2024-02-17 15:35:54

NEW

### Most Recent Flight and Weather Data Records

Data was last refreshed: Mar 27, 2024 at 01:50 PM

Filters

Select Data Granularity: Granular | Select Data Type: Flight test | Select the Date: Dec 16, 2023 at 08:12 PM | Select Data Preview Limit: 10

Select Flight Data Columns: Flight ID x Time (Min) x Bat 1 Current (amp) x Bat 2 Current (amp) x Bat 1 Voltage (volts) x

Select Weather Data Columns: Temperature (°F) x Dewpoint (°F) x Relative Humidity (Percent) x Wind Direction (Degrees) x Wind Speed (knots) x

**Apply Filters**

FLIGHT ID	TIME (MIN)	BAT 1 CURRENT (AMP)	BAT 2 CURRENT (AMP)	BAT 1 VOLTAGE (VOLTS)	TEMPERATURE (°F)	DEWPPOINT (°F)	RELATIVE HUMIDITY (PERCENT)	WIND DIRECTION (DEGREES)	W
5367	0.04	0	0	398.1	42.8	37.4	81.07	90	8
5367	0.06	0	0	398.1	42.8	37.4	81.07	90	8
5367	0.08	0	0	398.1	42.8	37.4	81.07	90	8
5367	0.1	0	0	398.1	42.8	37.4	81.07	90	8
5367	0.12	0	0	398.1	42.8	37.4	81.07	90	8
5367	0.14	0	0	398.1	42.8	37.4	81.07	90	8
5367	0.16	0	0	398.1	42.8	37.4	81.07	90	8
5367	0.18	0	0	398.1	42.8	37.4	81.07	90	8
5367	0.2	0	0	398.1	42.8	37.4	81.07	90	8

Select the [Download](#) button to download the data based on the selected granularity, data type, and date.

Download

# Alternative UI Designs

# Data Visualization

**OLD**

NEW

ElectriFly UI   [Upload Data](#)   [Data Analysis](#)   [Recommendations](#)

Welcome to ElectriFly's Data Analytics Interface!

Unlock the power of your data with our intuitive and powerful user interface designed specifically for data analytics. Our platform empowers you to transform raw data into actionable insights, enabling you to make informed decisions and drive your business forward.

[Recommended Graphs](#)   [Insights](#)

SOC vs. Time Across Multiple Flights

Choose flight date(s):

July 11 2023  
July 5 2023  
June 11 2023  
June 21 2023  
June 21 2023

To select multiple dates on Windows:

1. Press 'ctrl' + select the dates

To select multiple dates on Mac:

1. Press 'cmd' + select the dates

Time vs SOC

0 10 20 30 40 50

0 20 40 60 80 100

time (min)

SOC

July 11 2023   June 11 2023   June 21 2023

Warning

Danger

Weather Data for Selected Flights

TIME (UTC)	TEMPERATURE (°C)	WIND SPEED (KNOTS)	WIND DIRECTION (DEGREES)	VISIBILITY (M)
10:00:00	55.4	2	100	4.0
10:12:00	55.4	0	0	7.0

Choose flight date(s):

07/20/2023

# Data Visualization

Welcome to ElectriFly's Data Visualization Interface!

Unlock the power of your data with our intuitive and powerful user interface designed specifically for data analytics. Select the flight dates that you're interested in and our platform will transform raw data into actionable insights, enabling you to visualize trends and patterns.

## Flight Graphs

Choose Flight Date:

Aug 28, 2023 at 10:45 AM

Number of circuits  3

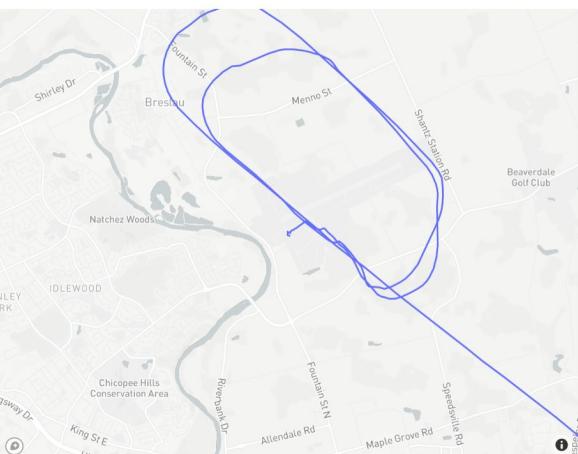
Aircraft Weight (lbs)  1253.42

### Weather Data for Selected Flight

TIME (UTC)	TEMPERATURE (°F)	WIND SPEED (KNOTS)	WIND DIRECTION (DEGREES)	VISIBILITY (MI)
10:44:00	44.600000	2	320	1.750000
11:00:00	46.400000	3	320	1.000000
11:04:00	46.400000	3	320	2.000000
11:07:00	46.400000	3	310	3.000000
11:10:00	48.200000	3	320	6.000000

### Flight Map

Your viewing flight with flight id: 4853.



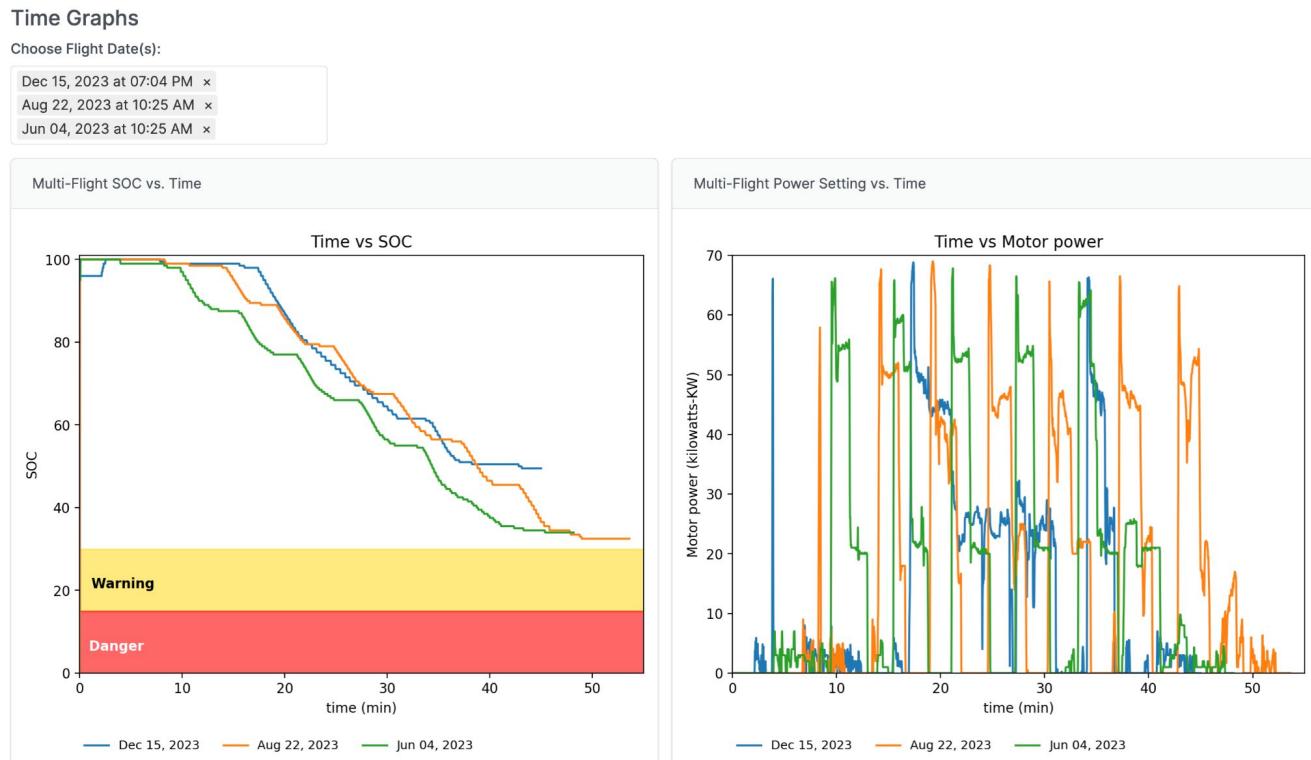
# Alternative UI Designs

## Data Visualization

OLD



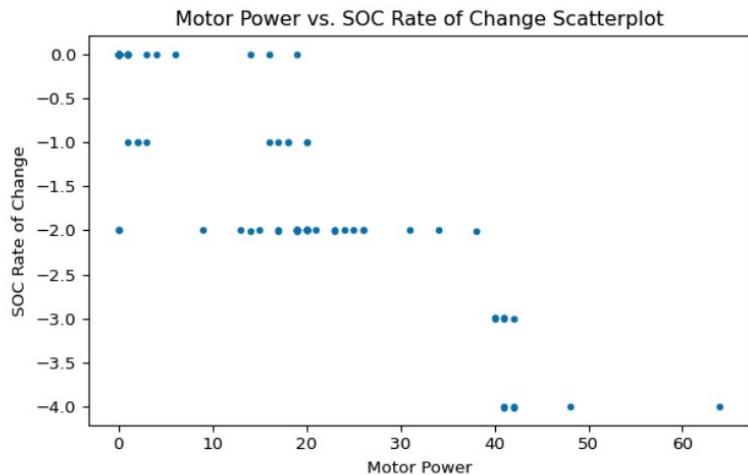
NEW



# Alternative UI Designs

## Statistical Insights

OLD



Choose flight date(s):

- 10/01/2023
- 09/30/2023
- 09/29/2023
- 09/28/2023
- 09/27/2023

## Statistical Insights

Welcome to ElectriFly's Statistical Insights interface!

Discover valuable insights into the heart of the e-plane — the battery. Explore how different aircraft maneuvers affect the battery's state of charge through detailed statistical visualizations. Additionally, monitor the battery's health over time, enabling you to derive actionable insights and enhance your decision-making processes.

Choose Flight Date:

Dec 16, 2023 at 08:12 PM

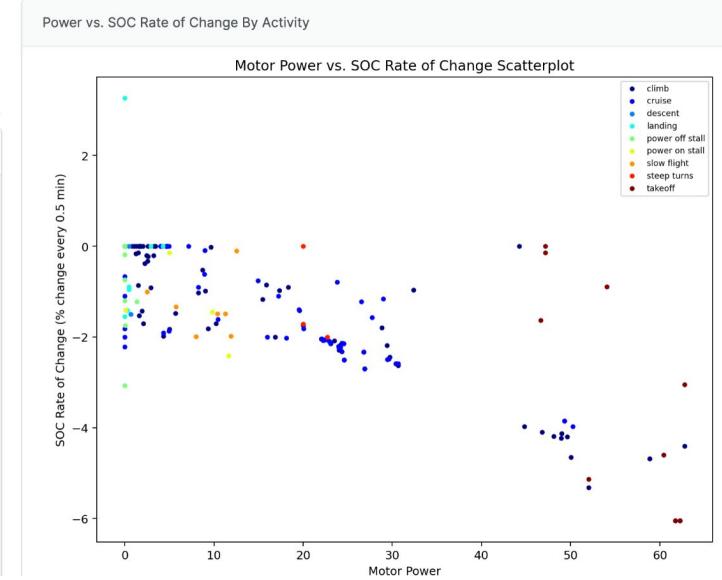
Choose activities:

takeoff x climb x cruise x descent x landing x  
power off stall x slow flight x power on stall x  
steep turns x

### SOC Rate of Change Statistics By Activity

ACTIVITY	MAX	MIN	MEAN	STD	VAR
NA	3.266667	-6.500000	-0.519795	1.197661	1.434393
climb	0.000000	-6.051515	-1.733750	1.570261	2.465720
cruise	0.000000	-3.978772	-1.489917	1.043009	1.087867
descent	0.000000	-1.496078	-0.748039	1.057887	1.119125
landing	3.266667	-1.546457	-0.220243	1.655235	2.739802
power off stall	0.000000	-3.071769	-0.480404	0.869062	0.755269
power on stall	-0.142857	-2.416667	-1.353812	0.932368	0.869310

NEW



# Alternative UI Designs

## Flight Exercise Planning

OLD

ElectriFly Data Preview Data Analysis ▾ Flight Planning ▾

### Flight Exercise Planning

Choose Flight Date:

2024-02-22

Choose start time of flight:

12:00 AM

Choose Flight Operation:

landing

Choose number of minutes for landing:

15

Add activity

ACTIVITY	TIME (MINUTES)
takeoff	10
cruise	5
landing	15

### Flight Date & Time

Choose Flight Date:

Mar 20, 2024

Choose start time of flight:

12:00 AM

### Flight Activity Selection

Single attribute selection

Choose Flight Activity:

landing

Time (mins)

0 - 6

Motor power (kW)

1 - 20

Change in Altitude (ft)

-1,000 - 400 - 500 - 1,000

Ground speed (knots)

0 - 45 - 50 - 100

State-of-health (%) from the latest flight will be used.

NEW

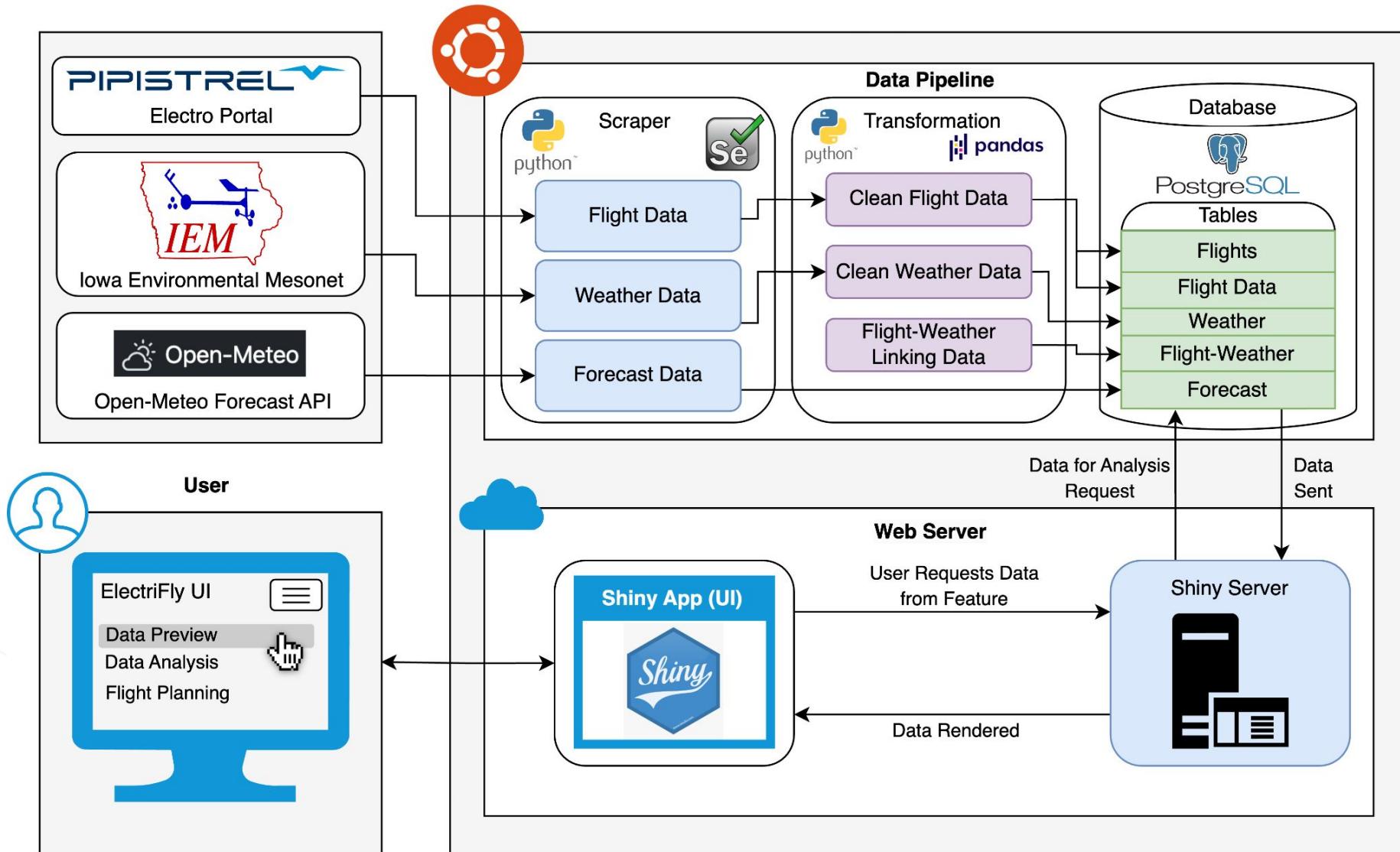
Total Remaining SOC: 54.03. You are free to add more activities in this flight.

Add activity Delete activity

ACTIVITY	TIME (MINS)	SOH (%)	ALTITUDE GAIN/LOSS (FT)	GROUND SPEED (KNOTS)	MOTOR POWER (KW)	SOC (%)
pre-flight	6.84	80	421	47	16	7.6106681824
take-off	7.66	80	434	45	6	4.1491622925
climb	5.33	80	497	48	14	10.4677171707
cruise	5.17	80	414	46	17	10.5897159576
descent	5.96	80	498	48	15	7.3100547791
landing	7.74	80	436	47	10	5.8398003578

# Final Design

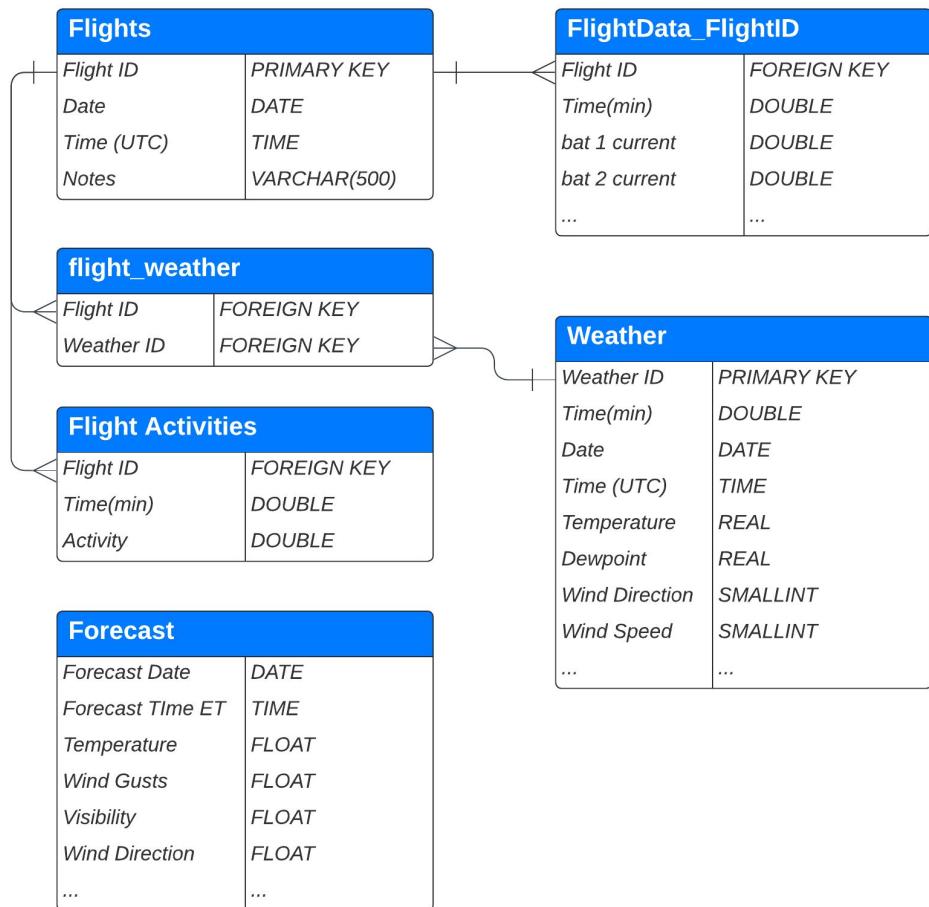
## Technology & System



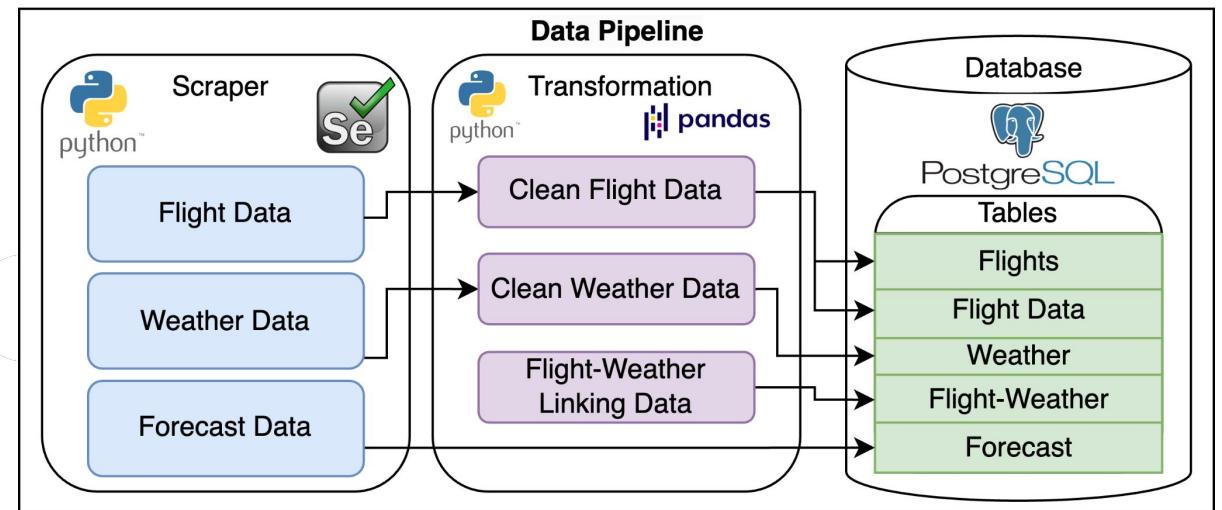
# Final Design

## Data Pipeline

### Database Schema

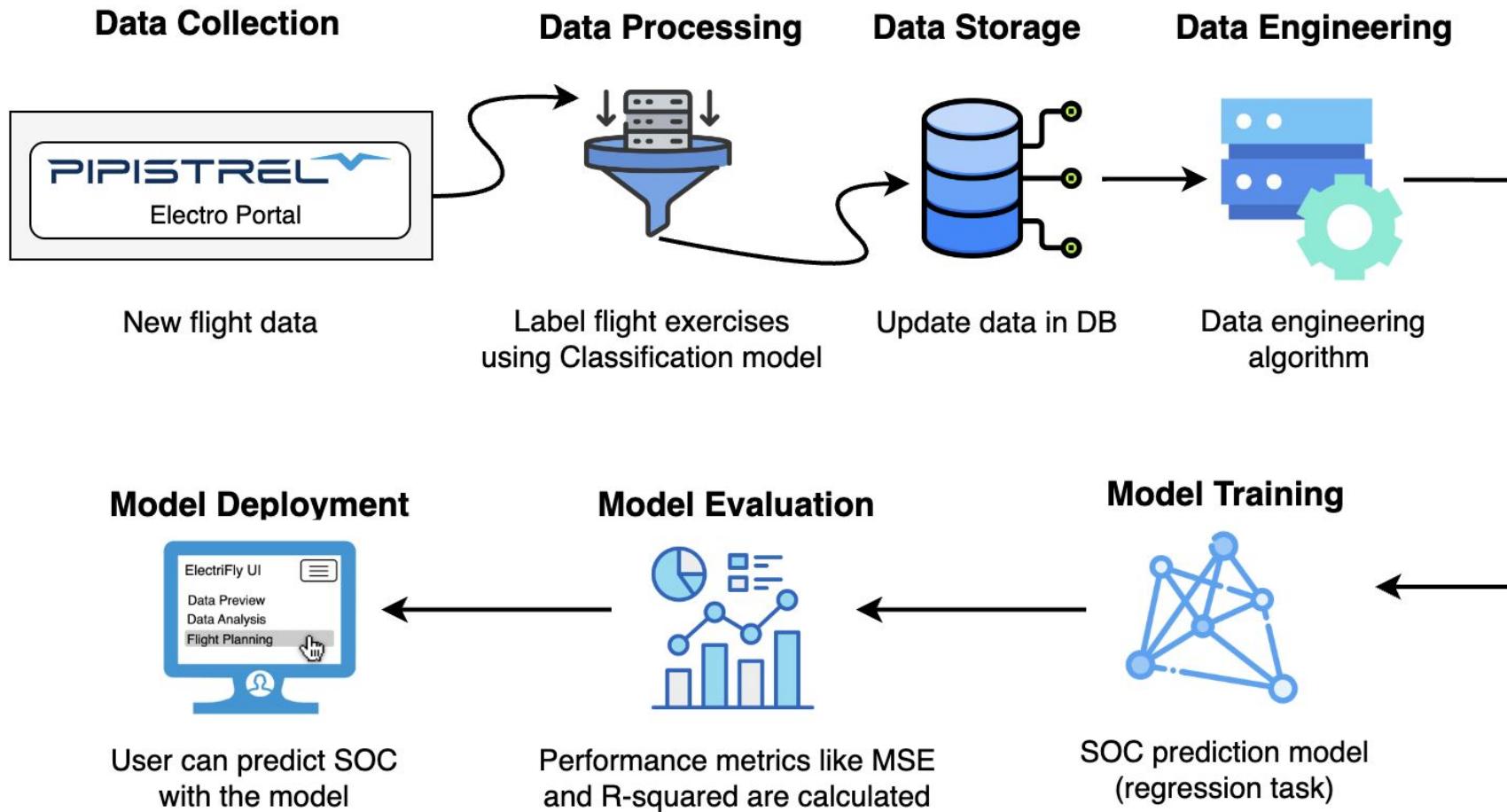


### Data Pipeline



# Final Design

## ML Pipeline



# Feasibility Assessment

## Solution Feasibility



### Verified and Validated Feasibility

Most features determined to be feasible with the workflows of our users



### High Adoption Intentions

75% of pilot program participants plan to use our solution in the future

## Integration with Existing Interfaces



### Pipistrel - Cloud User Interface

- We utilize the Pipistrel UI data
- We enhanced its graphing capabilities
- Ongoing discussions to integrate our application with Pipistrel UI

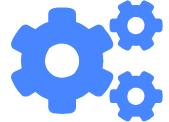


### Wingman - Flight Scheduling

- We provide scheduling decisions that integrate weather data
- WWFC utilizes Wingman to schedule flights
- Not integrated with Wingman, flight decisions at discretion of Flight Centre

# Design Impacts

## Key Impacts Of Our Design



### Safety and Regulations

**Impacts:** Pilots and passengers

Warning and danger zones for SOC in visualizations



### Technological Sustainability

**Impacts:** Stakeholders

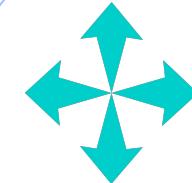
Data is able to be re-uploaded to UI in event of server crash



### Social and Economic Impact

**Impacts:** Researchers

Increase understanding of electric plane usage in Canadian weather



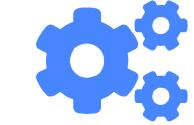
### Propagating Impacts

**Impacts:** WWFC, Pilot trainees

Addresses the pilot shortage and improves utilization rates

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### Technological Sustainability

**Impacts:** Stakeholders

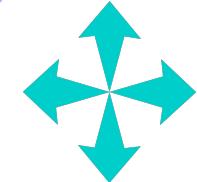
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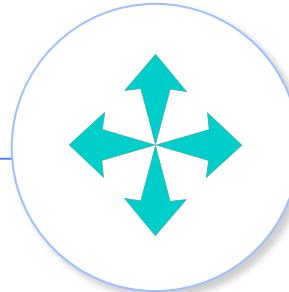
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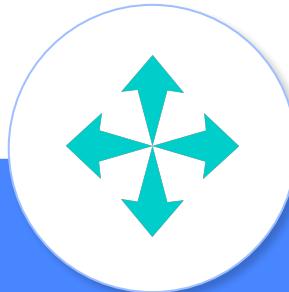
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### Propagating Impacts

**Impacts:** WWFC, Pilot Trainees

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# Risks and Mitigation

Component	Risk	Mitigation
Data Pipeline 	<b>Web scraping may fail if changes occur to source data format</b>	Communicate to stakeholders and provided user manual
User Interface 	<b>Faulty sensors could lead to inaccurate data collection</b>	Stakeholder communication and cleaned inconsistent data
ML Prediction 	<b>Inadequate predictions could lead to unintended outcomes</b>	System monitored and improved upon with pilot feedback

# ElectriFly Demo

ElectriFly Data Preview Data Analysis Flight Planning

## Empowering Flight, Electrifying Tomorrow!



**What is ElectriFly?**



Electric planes offer a promising alternative to traditional gas-powered aircraft. However, e-planes bring on new challenges including limited battery capacity and scarce knowledge of their performance in Canadian weather.

Our team is using data from the Pipistrel Velis Electro, the world's first type certified electric plane. Our platform enables researchers to analyze flight data and create a battery management strategy for the optimal operation of the electric plane. Leveraging machine learning, ElectriFly optimizes flight schedules based on weather forecasts and improves flight planning by predicting battery consumption.



# Questions?

