

ElectriFly

Team 2 - FDR Presentation

Friday, April 5, 2024



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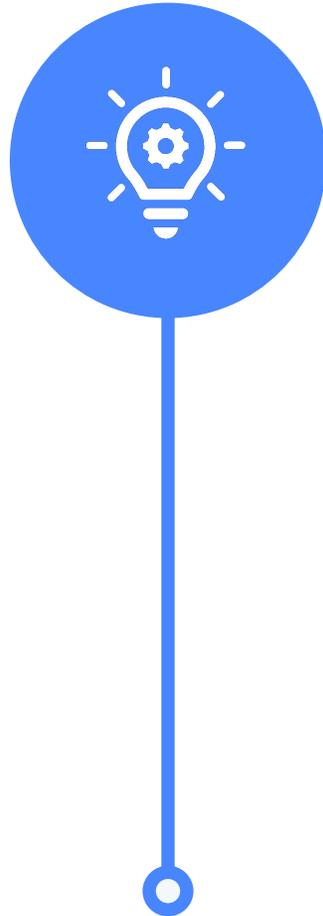
Final Design Review Agenda

- 01 HMW and Project Objectives
- 02 Updated Requirements
- 03 Verification and Validation
- 04 UI Design Alternatives
- 05 Final Designs
- 06 Feasibility and Compatibility
- 07 Design Impact
- 08 Risks and Mitigations
- 09 UI Demo



How Might We Statement

Empowering stronger flight decisions through analytics & ML

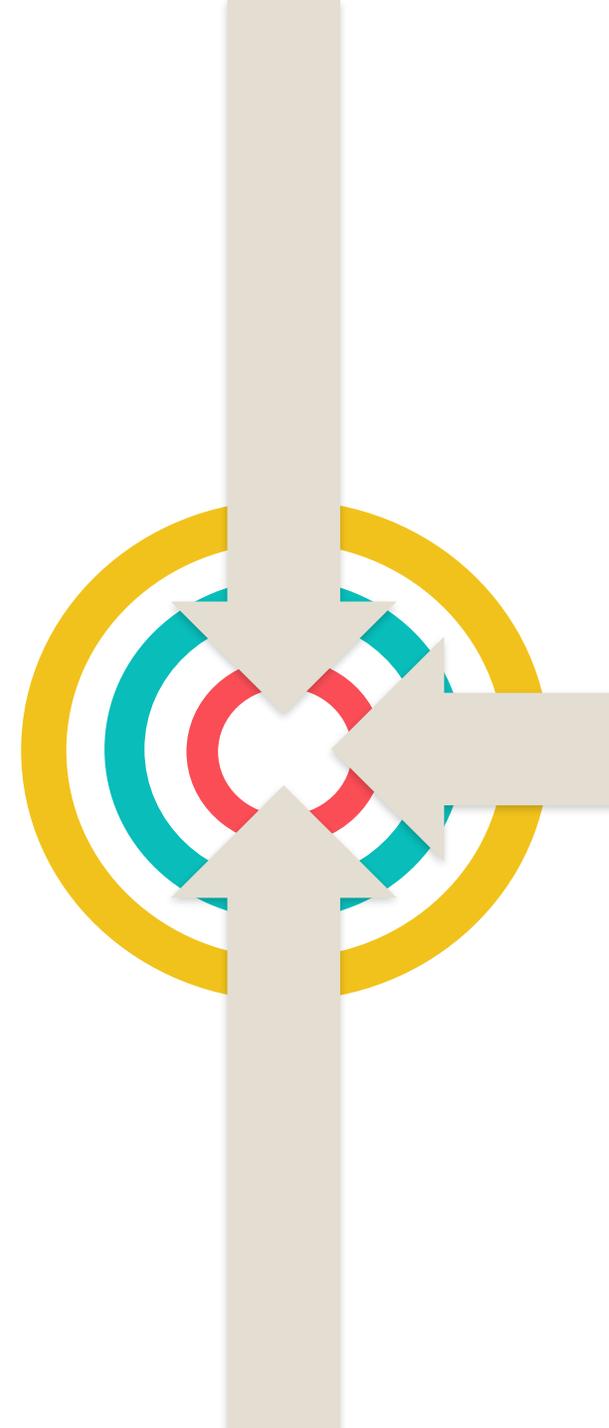
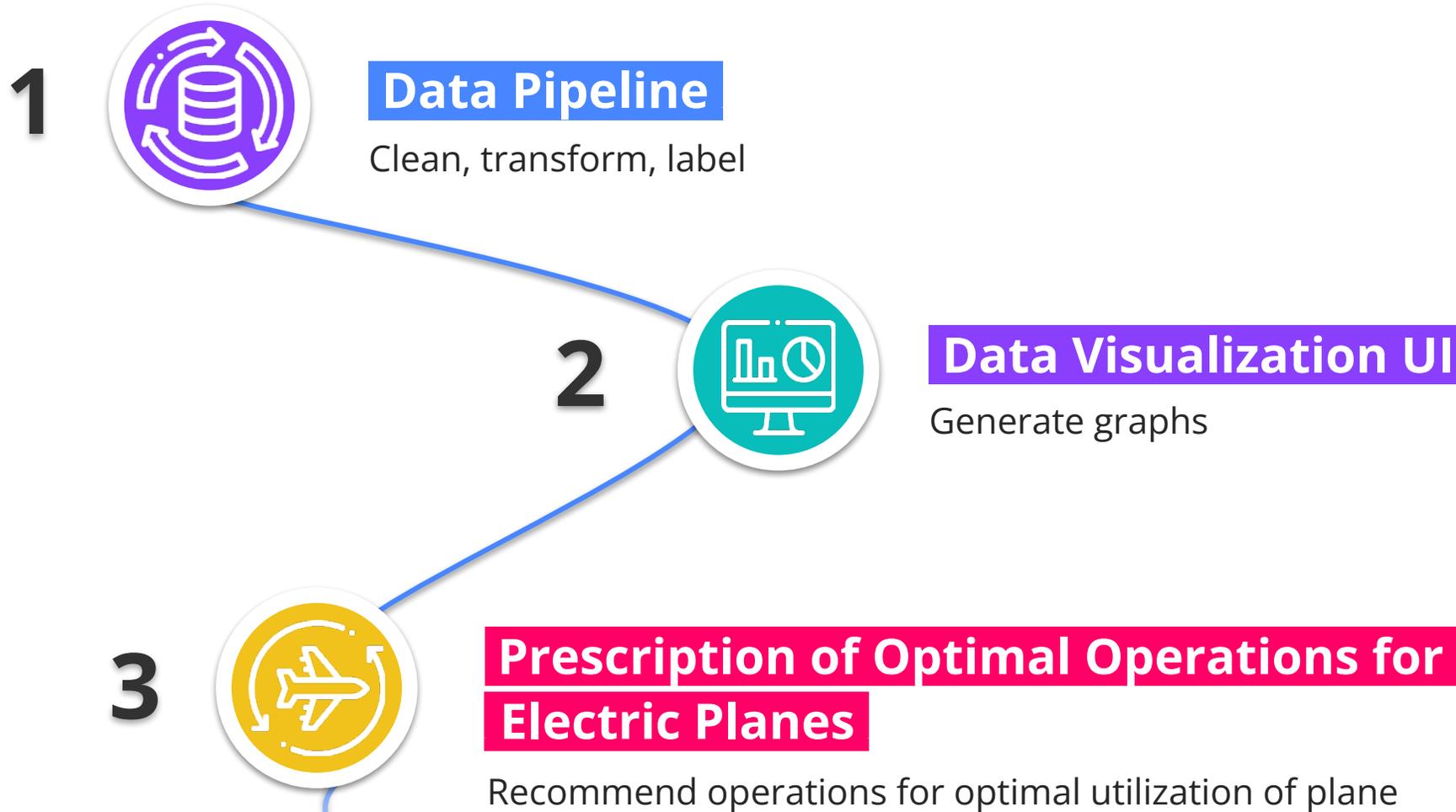


HMW Statement

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?**

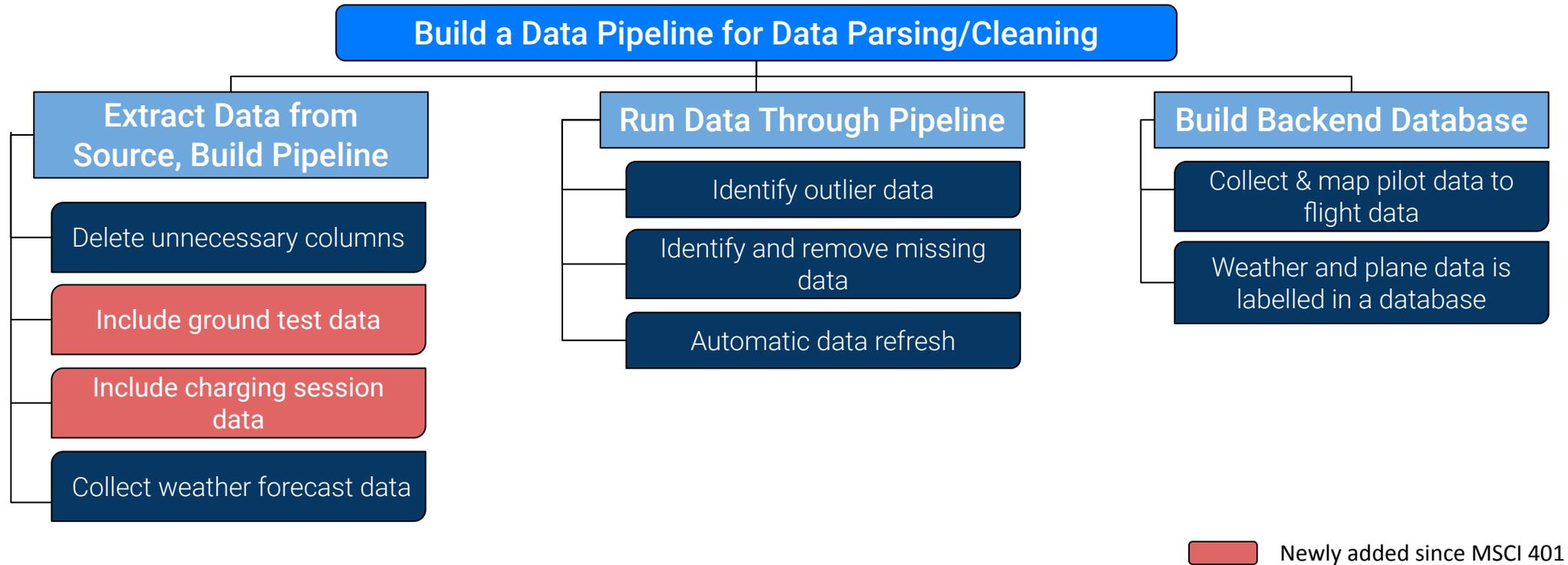
Project Objectives

3 Core Project Objectives



Data Pipeline Requirements

Must-Have Functional Requirements



Success Criteria



KPI

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

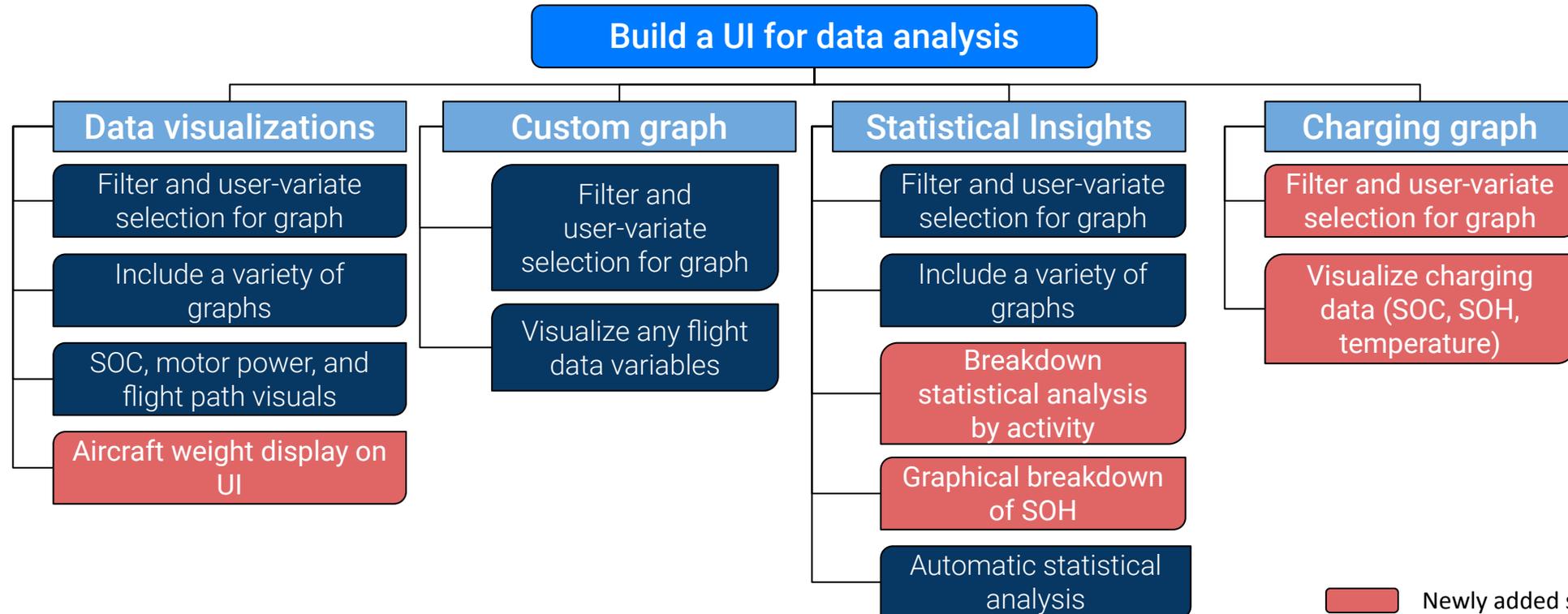


Verification

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

Data Visualization Requirements

Must-Have Functional Requirements



Success Criteria



KPI

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

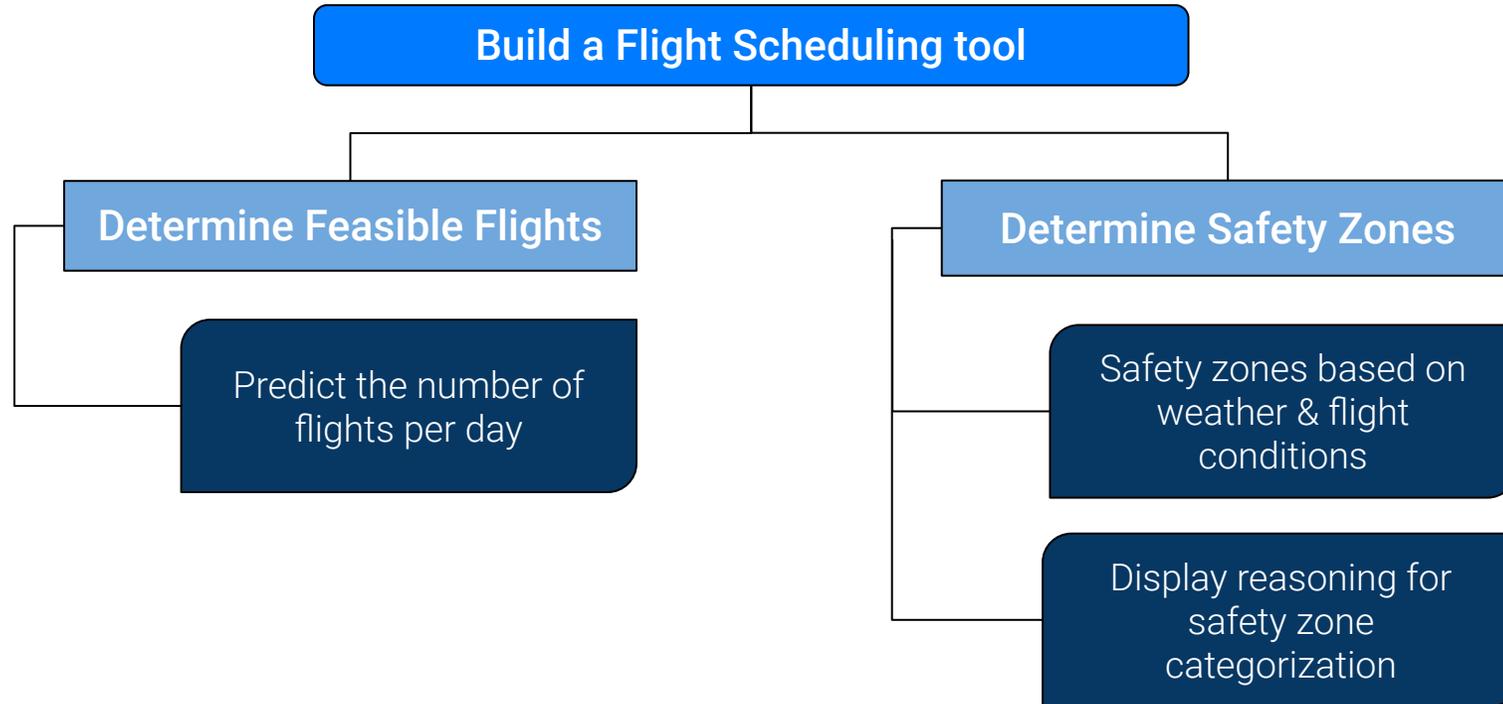


Verification

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

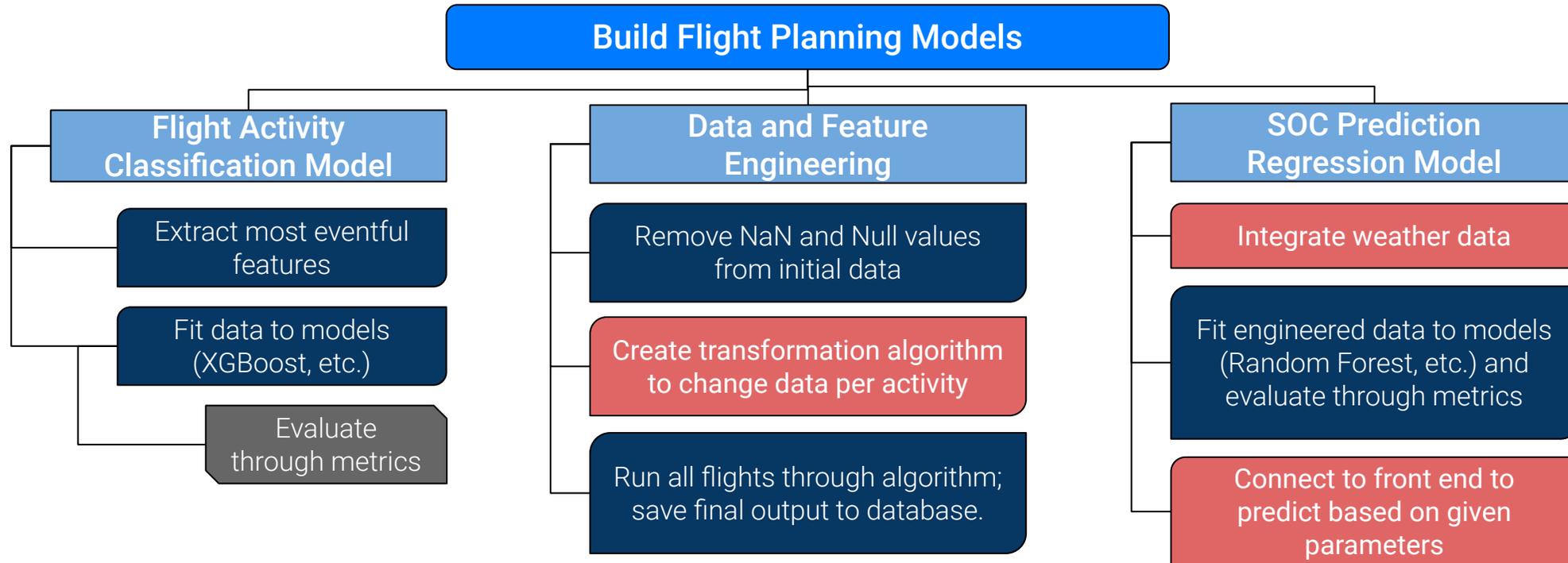


Verification

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



Visibility of System Status

1



Match Between System & Real World

2



User Control And Freedom

3



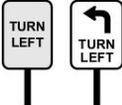
Consistency And Standards

4



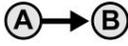
Error Prevention

5



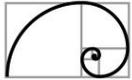
Recognition Rather Than Recall

6



Flexibility And Efficiency of Use

7



Aesthetic And Minimalistic Design

8



Help Users With Errors

9



Help And Documentation

10

49 Potential Improvements

Team Heuristic Evaluation Results						
PM Priority	UI Page	Severity Rating	PM Priority	Description of Problem	Severity Rating	Potential Solution
Urgent		2		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
Urgent		4		H2-4: consistency and standards All graphs titles and legends are cut off	4	Fix the sizing. Make the graphs fit onto Shiny cards.
Must do		2		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
Must do		1		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
Must do		1		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, 2023 10:00

Verification & Validation

UI Validation with Pilot Program

Tangible Feedback & Improvements

1 Most Recent Flight and Weather Data Records

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

2 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

3 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)

State-of-Charge (Percent) vs 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"/>	<input type="radio"/>	<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"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

System Usability Score:
79

Alternative UI Designs

Data Preview

OLD

NEW

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

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)	DEWPOINT (°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

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:

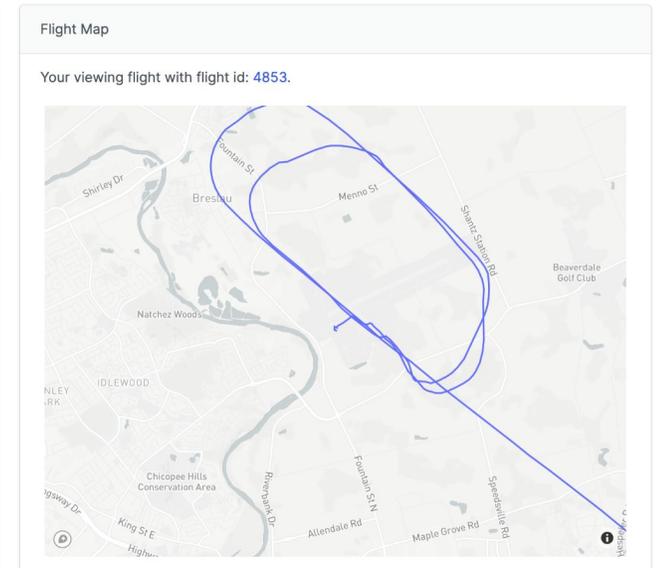
Aug 28, 2023 at 10:45 AM

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

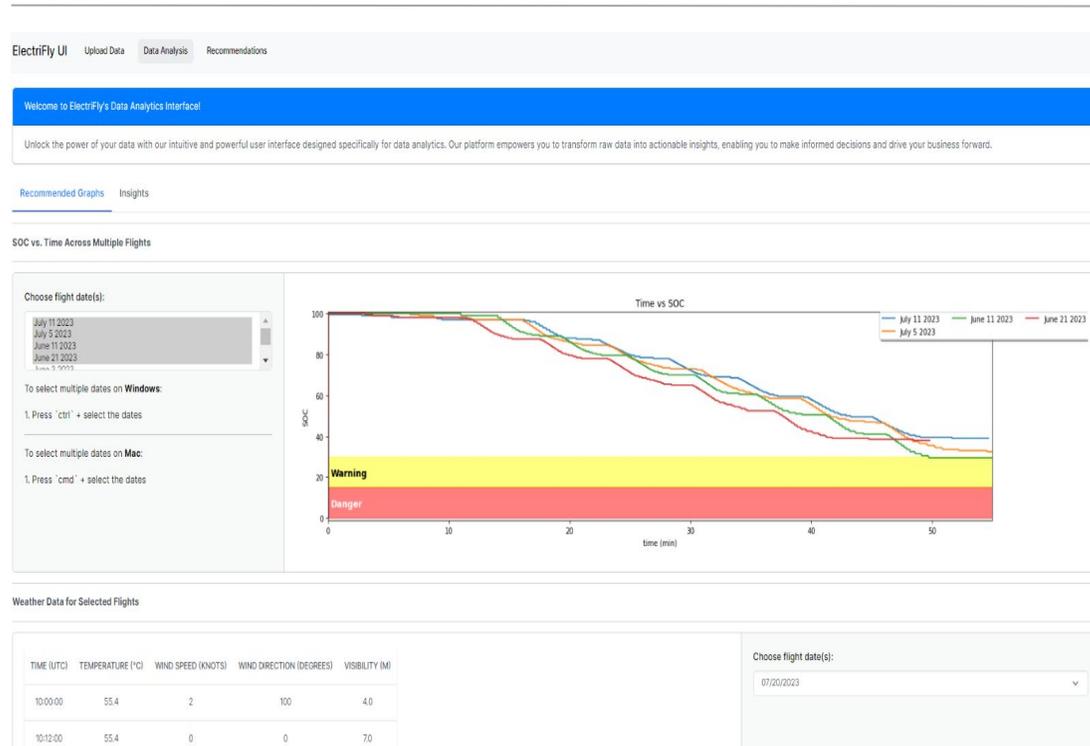


Alternative UI Designs

Data Visualization

OLD

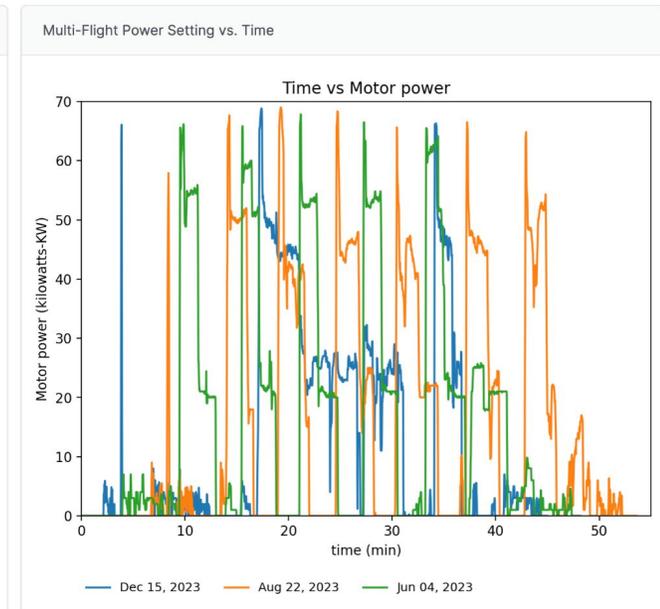
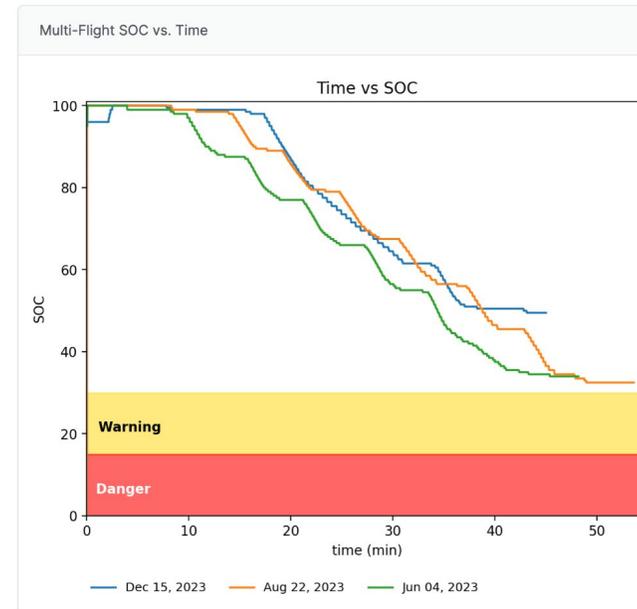
NEW



Time Graphs

Choose Flight Date(s):

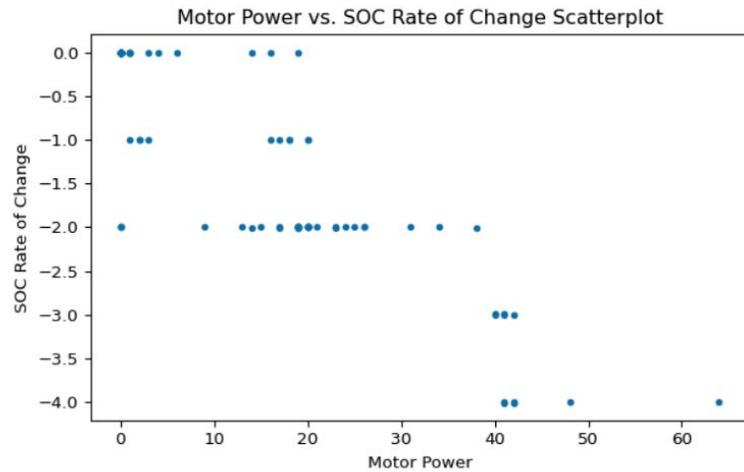
- Dec 15, 2023 at 07:04 PM ×
- Aug 22, 2023 at 10:25 AM ×
- Jun 04, 2023 at 10:25 AM ×



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

NEW

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

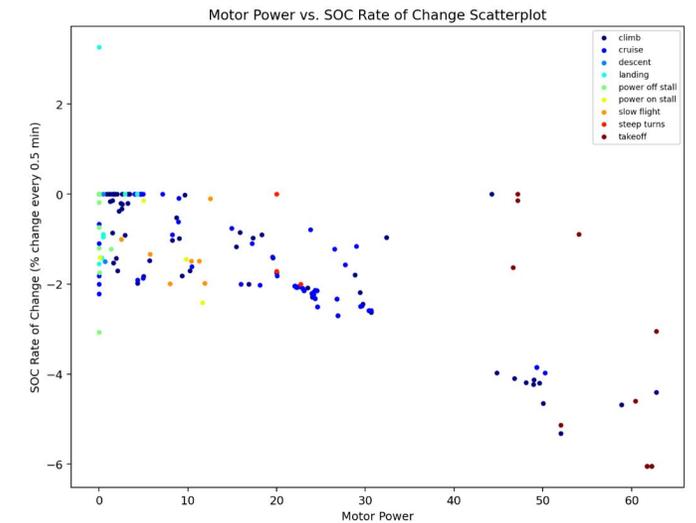
Choose activities:

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

Power vs. SOC Rate of Change By Activity



Alternative UI Designs

Flight Exercise Planning

OLD

NEW

ElectriFly Data Preview Data Analysis **Flight Planning**

Flight Exercise Planning

Choose Flight Date:

Choose start time of flight:

Choose Flight Operation:

Choose number of minutes for landing:

ACTIVITY	TIME (MINUTES)
takeoff	10
cruise	5
landing	15

Flight Date & Time

Choose start time of flight:

Flight Activity Selection

Single attribute selection

Choose Flight Activity:

Time (mins)

Motor power (KW)

Change in Altitude (ft)

Ground speed (knots)

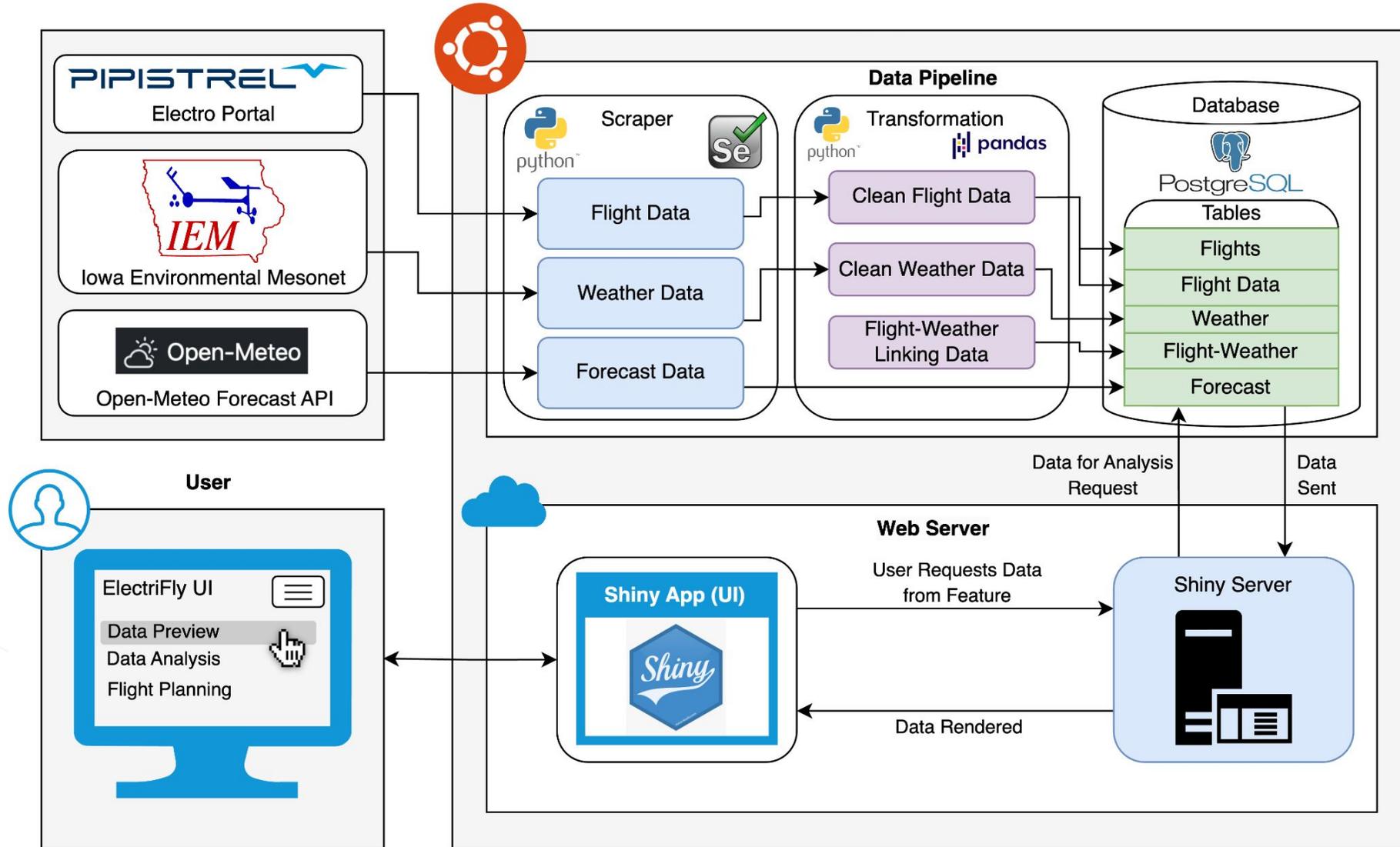
State-of-health (%) from the latest flight will be used.

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

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
takeoff	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

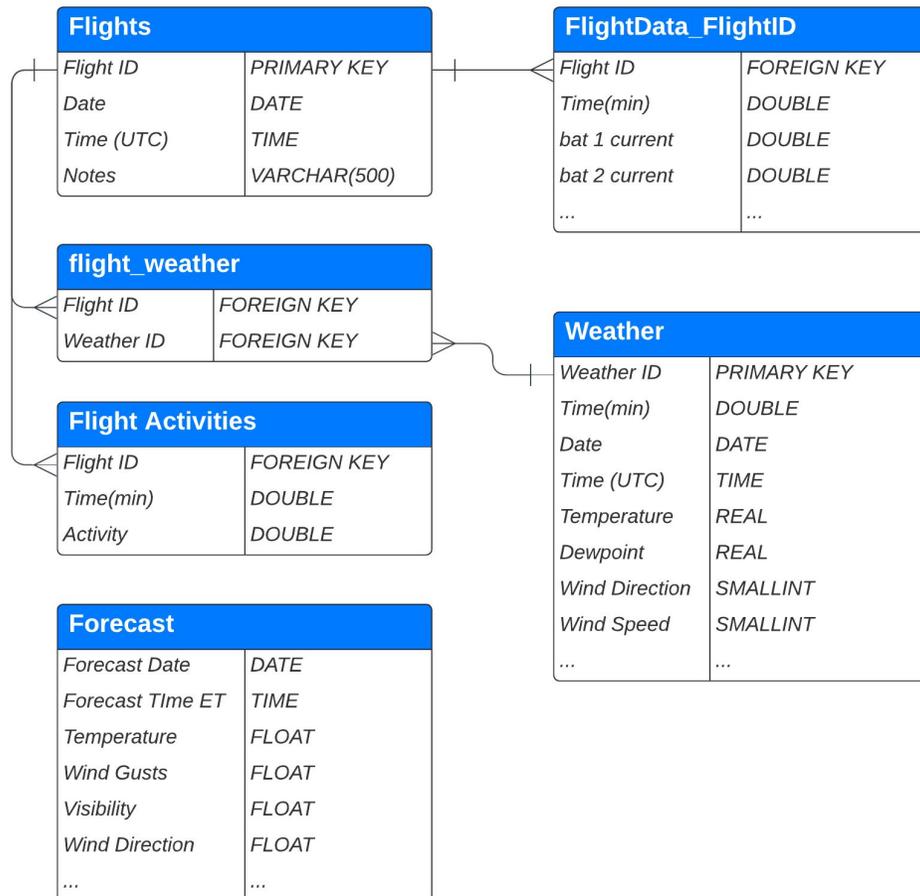
Technology & System



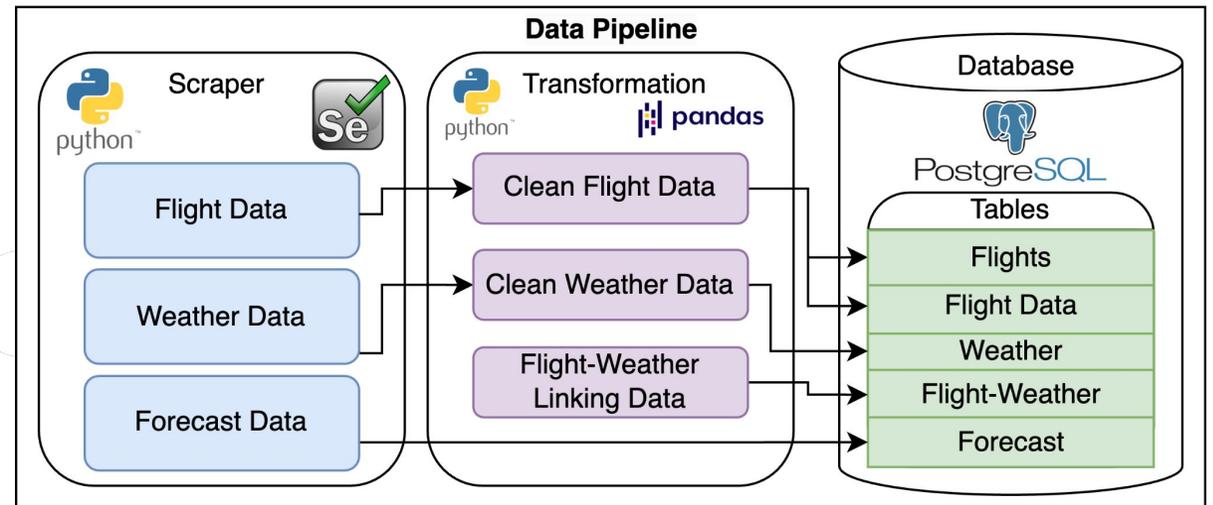
Final Design

Data Pipeline

Database Schema

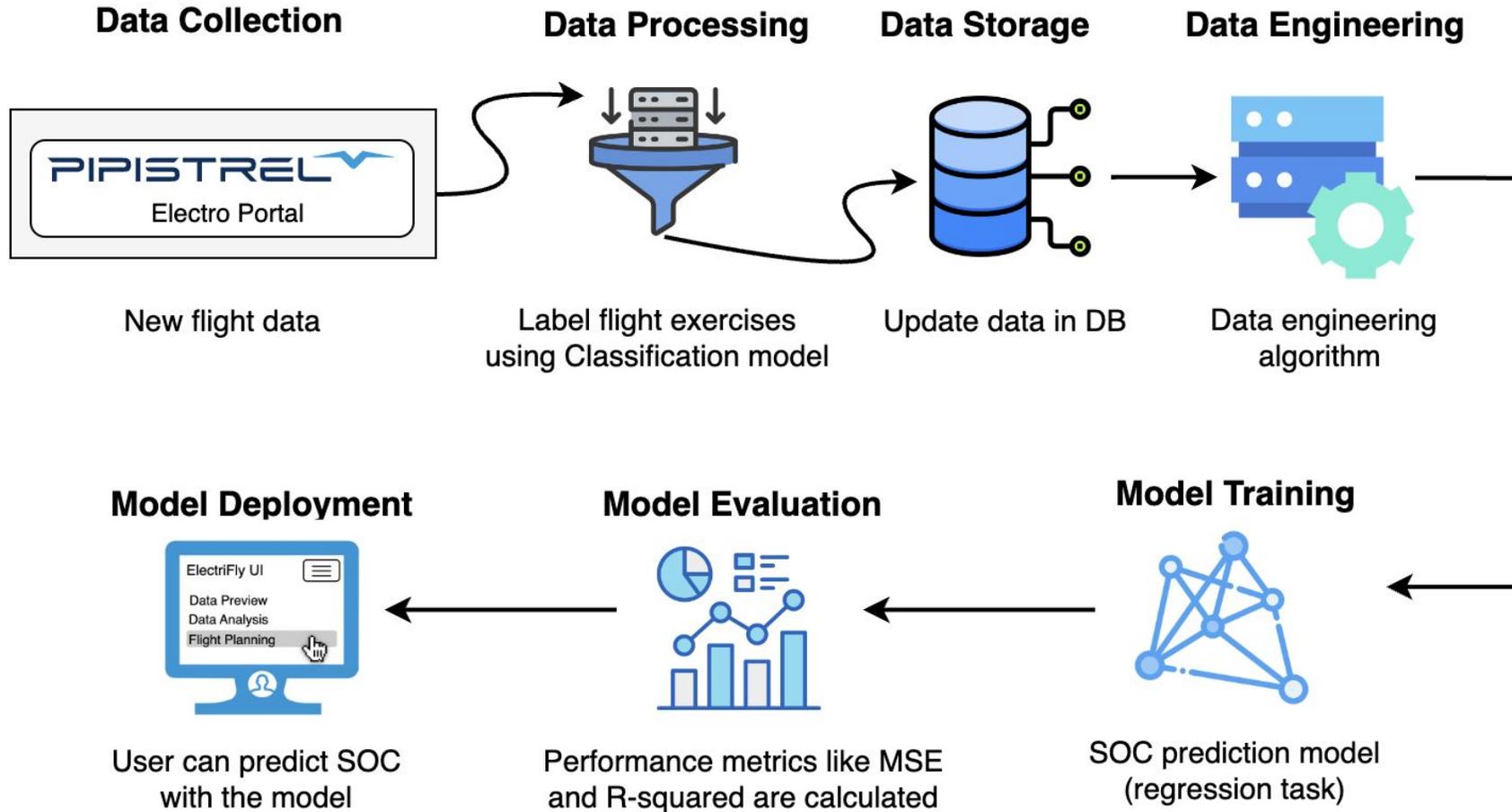


Data Pipeline



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 

Pipistrel - Cloud User Interface

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



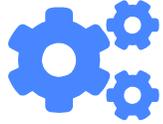
 **Wingman**

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

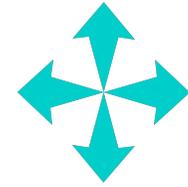
Data is able to be re-uploaded to UI in event of server crash



Social and Economic Impact

Impacts: Researchers

Increase understanding of electric plane usage in Canadian weather



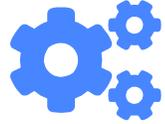
Propagating Impacts

Impacts: WWFC, Pilot trainees

Addresses the pilot shortage and improves utilization rates

Design Impacts

Key Impacts Of Our Design



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Technological Sustainability

Impacts: Stakeholders

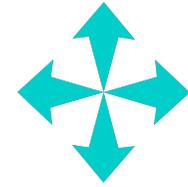
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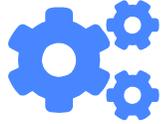
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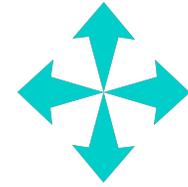
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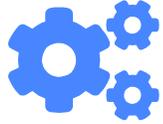
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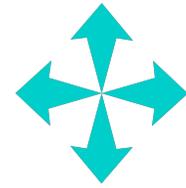
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Social and Economic Impact

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

Risks and Mitigation

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

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?

