Rolls-Royce Corrosion Tracker

Ana Dalipi, Vaughan Doty, Caleb Feda, Sam Golio, David Hayward, Hannah Hughes, Sheetal Jayasaal, Vladic Keddie, Shashank Kumar, Michael Kusz, Austin Lu, Tom Neafus, Carter Nelson, Michael Pardo, Kush Patel, Zill Patel, Nathan Pfeffer, Karolis Ramanauskas, Sean Richmond, Dakota Robinson, Karthik Subramanian, Haydn Schroader, Vaishnav Swaminathan, Luke Tucker, Abigail Viles, John Wiggins, Josh Wong

Introduction / Background

Problem Statement:
Rolls Royce requires an improvement on last year's algorithm for predicting when AE3007 engines require compressor washes.

The algorithm must be able to accurately predict the interval of washes using the data provided to us by Rolls Royce and outside data sources.

Background:
- Used corrosivity map provided by Rolls-Royce
- Tracked tail numbers to find flights using AE3007
- Created web application that allowed operators to input a date range and tail numbers
  - Shows trajectory of flights during specified date range
  - Indicates which flights flew inside corrosive regions

Subteam Breakdown

Weather
- Identify corrosive factors for the given engine
- Collect appropriate data for chosen corrosion factors
- Map collected data to airports and any other points of interest

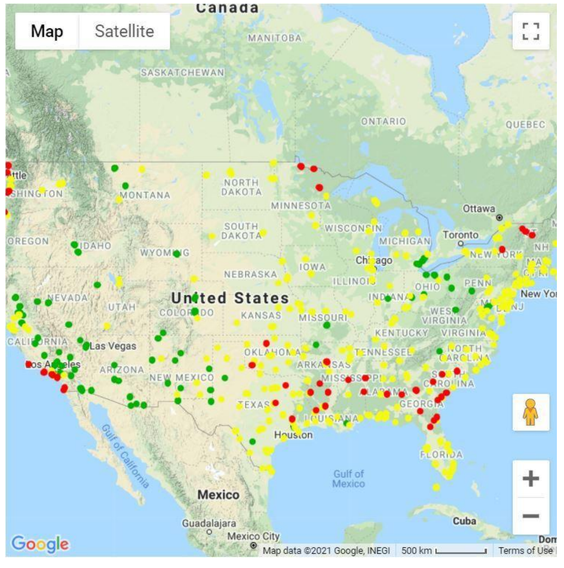
Trajectory
- Determine how to correlate weather data to specific aircraft
- Create a simple, easy-to-use frontend to present our findings
- Integrate our findings/solution with those of the other teams to form a singular product

Corrosion Index
- Researched the corrosion factors of an engine
- Determined how significant of an impact each factor has on corrosion
- Created an algorithm to calculate one corrosivity score for a region on the US map with the given corrosive factors

Data Cleaning
- Match engine operators with correct tail numbers
- Get any relevant data into a usable format
- Organize various datasets and remove outliers

Weather Subsection

Summary:
- Researched corrosive factors for jet engines
- Determined most important factors for hot corrosion in jet engines
  - Salinity
  - Dust/Sulfur Dioxide
  - Humidity
- Found online sources that provided relevant weather data across the country
- Wrote code to automate data downloading and formatting
  - Used batch scheduling to download data at regular intervals
  - Compiled data into CSV files and organized files by date
- Uploaded data to team database
  - Data is available for mapping, graphing, and corrosion index calculations
  - Data is organized by data and location for easy matching with flight history
- Mapped weather data to points of interest (i.e. airports)



Weather Map Output

Compressor Corrosion

Retrieved from:
https://flyjetservices.com/turbine-engine-compressor-wash/

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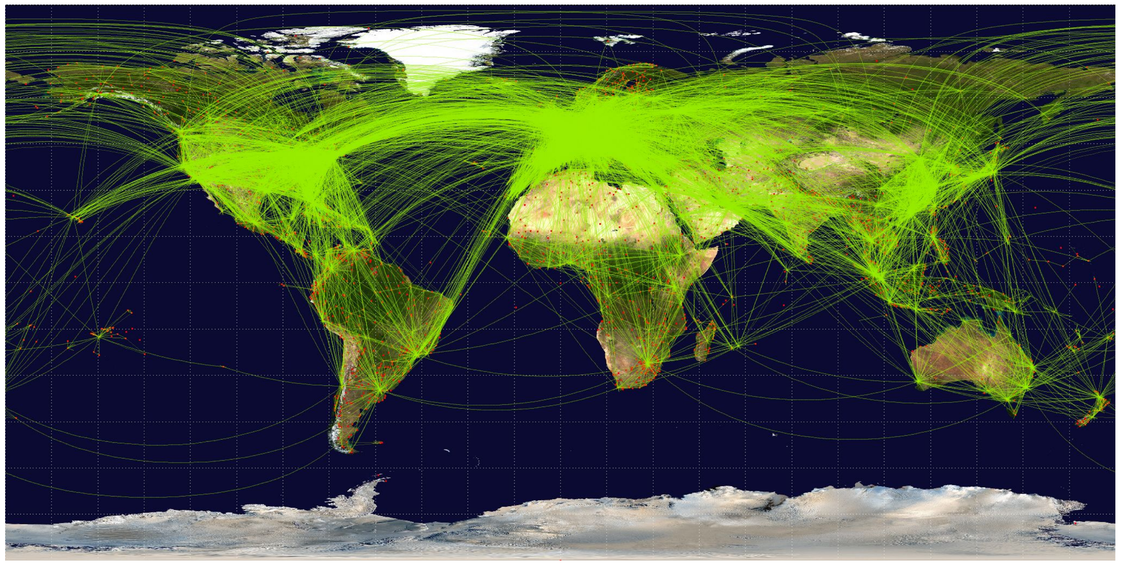
Trajectory Subsection

Summary:

- Collect flight data on specific airplanes
  - Automated webscraping to obtain airplane specific flight data including attributes such as origin, destination, airport, etc.
  - Flight data sourced from transponder information for each flight
- Create and maintain SQL database for necessary data
  - Database automatically updates for new flights, keeps a log of old flights to track corrosive elements
- Wrote backend code for the website
  - Set up pages and connection to SQL database to retrieve data
- Wrote frontend code for the website
  - Displayed summary information about the aircraft
  - Merged the visuals of the corrosivity index team and weather team
  - Added customizable settings to the corrosivity calculations for graphing



Corrosive Index Subsection

Summary

- Worked with the Weather Team to find research on how significant of an impact each factor has on corrosion.
  - Found that Salinity and Humidity are the main factors that affect corrosion of an engine
  - Discovered that Humidity levels below 40% do not impact corrosion
  - Other factors that affect corrosion are: SO_2, PM 2.5 and PM 10, Air Quality Index
- Created a Weighted Decision Matrix to determine the one engine corrosivity score for a particular region on the US map.
  - Assigned a weight value for each factor depending on how significant of an impact it has on corrosion
  - Created an unweighted benchmarking process for each factor where we ranked the corrosive factor levels in each region that the engine has flown from 1 to 5 (1 being the best case scenario and 5 being worst case scenario)
  - Multiplied the ranks assigned with the associated weight values to get the weighted values
  - Added all of the weighted values to get the total corrosivity scores (the higher the value the more corrosive the region)
- Wrote Python code that calculates final value of corrosion.
  - Pulls in weather data from the database
  - Parses that data into the different factors
  - Loops through the rows and determines the value of corrosion based on the weather and the weight of that factor
  - Adds all of those values to determine a final corrosive value
- Created an overall scale to compare the total corrosivity scores for each region and for mapping
  - Created a scale to determine High, Medium, and Low corrosive regions (represented by red, yellow and green points respectively)
  - Calculated the lowest and highest corrosivity scores possible (all 1s and 5s respectively) and evenly divided the scores in between into 3 ranges to determine the red, yellow and green points on map

	CRITERIA	Weight/Importance
1	Salinity	15
2	AQI	10
3	SO2	10
4	Humidity	15
5	PM 2.5 and PM 10	10

BENCHMARKING (Unweighted)

Region 1	Region 2	Region 3
4	1	1
5	5	2
5	5	5
5	5	5
2	4	5

BENCHMARKING (Weighted)

Region 1	Region 2	Region 3
60	15	15
50	50	20
50	50	50
75	75	75
20	40	50
WEIGHTED TOTAL -->	255	230	210

UNWEIGHTED BENCHMARKING PROCESS (5=Worst, 1=Best)

	Rank	mg/L
Salinity	5	>1.6
	4	1.2-1.6
	3	.8-1.2
	2	.4-.8
	1	0-.4

	Rank	Unitless
AQI	5	5
	4	4
	3	3
	2	2
	1	1

	Rank	micrograms/cubic meter
Sulfur Dioxide	5	80-100
	4	60-80
	3	40-60
	2	20-40
	1	0-20

	Rank	%
Humidity	4	>60
	3	50-60
	2	40-50
	1	<40

	Rank	micrograms/cubic meter
PM 2.5 and PM10	5	201 and higher
	4	151-200
	3	101-150
	2	51-100
	1	0-50

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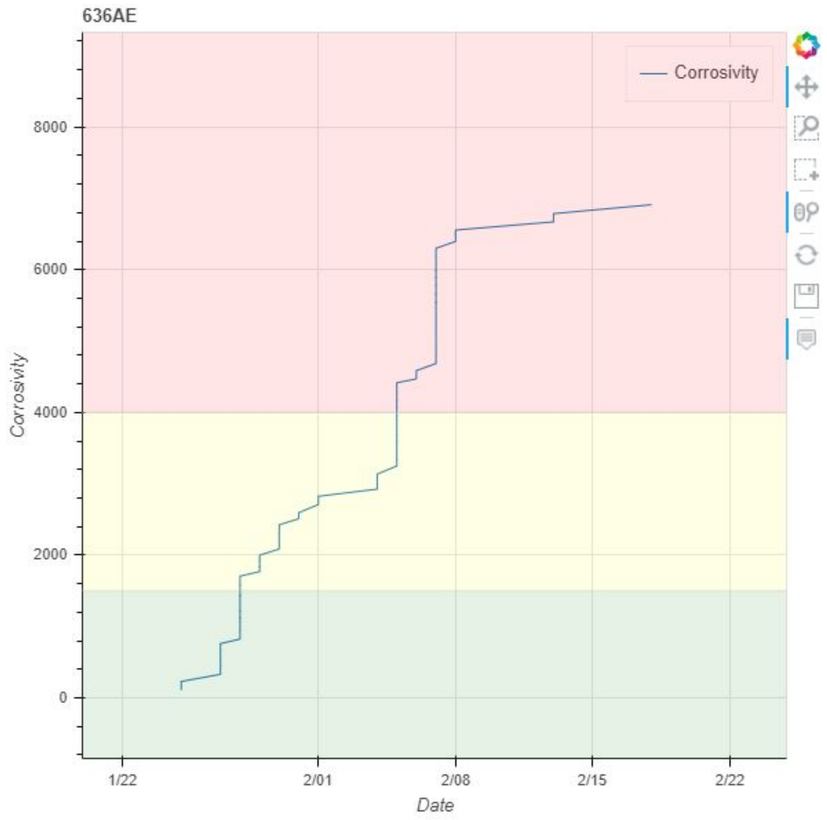
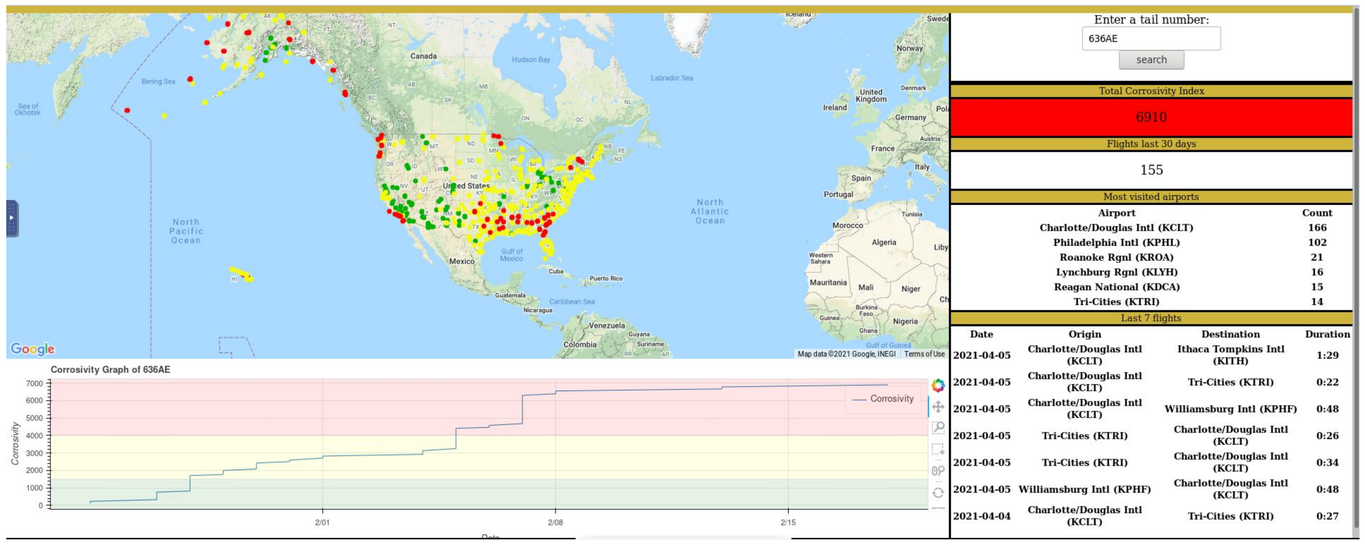
Corrosion of Engine v Time Plot



Future Goals

As more research becomes available on the topic of engine corrosion and engine compressor washes due to environmental factors such as salinity, we will fine tune our product in order to make it more accurate.

Final Website Design



Conclusions

- Integration will provide Rolls-Royce with a way to monitor jet engine corrosion levels
  - Strategic maintenance selection
- Final product takes corrosive factors into account and tracks flight data to determine corrosivity exposure time
  - Corrosivity graph dictates what area of exposure the aircraft has reached
- Improvements
  - Generate our own corrosive region graphs using API data rather than rough guesstimates
  - Flight data timeline plays a key role in our maintenance selection

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