

AIRLINES DATA ANALYTICS FOR AVIATION INDUSTRY

PROJECT REPORT

Submitted by

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**In partial fulfilment for the award of the degree of
BACHELOR OF ENGINEERING**

In

**ELECTRONICS AND COMMUNICATION
ENGINEERING**

**MEENAKSHI SUNDARARAJAN ENGINEERING
COLLEGE
CHENNAI**

INTRODUCTION

1.1 Project Overview

The airline industry processes an enormous amount of data from various sources and operations, such as reservation system, departure system, baggage management, revenue management, flight control, CRM, website, and more. Therefore, compiling all this data and analysing it effectively is very important as it helps airlines to change the way they work and achieve business excellence. The airport codes may refer to either the IATA airport code, a three-letter code that is used in passenger reservation, ticketing and baggage-handling systems, or the ICAO airport code which is a four-letter code used by ATC systems and for airports that do not have an IATA airport code. Our project utilizes IBM Cognos tool and ML models such as KNN, Random Forest etc., along with experience to provide insights and intelligence to airlines for better decision making and improved business outcomes.

1.2 Purpose

To provide better Airline and AirPort services and to avoid delays in Air Travel across different locations at Municipality level. The aim is to provide airports, airlines, and the travelling public with a neutral, third-party view of which airlines are delivering on their promise to get passengers from Point A to Point B on-time. Our project is built to collect data, organize and effectively analyze to deliver vital business intelligence for airline to be more efficient and profitable using EDA, Business Intelligence tools etc.,

LITERATURE SURVEY

2.1 Existing Problem

Airlines and passengers who are expecting efficient use of their funds and minimize the time on travelling by handling large amount of Airlines Data. In the presented context, data coming from various sources in the aviation industry has to be integrated into a common big data repository before being analysed by means of specialized software.

2.2 References

Airline Route profitability analysis and Optimization using BIG DATA analytics on aviation data sets under heuristic techniques by Kasturi E , Prasanna Devi S , Vinu Kiran S, Manivannan S

Big Data Analytics on Aviation data for the prediction of Airline Trends in Seasonal Delay by Dr.M.Sornam, M.Meharunnisa, Parthiban Nagendren

Big Data Analytics in Airlines: Opportunities and Challenges by Hamida Abd El Samie Mohamed, Mahmoud Ramadan Al Azab

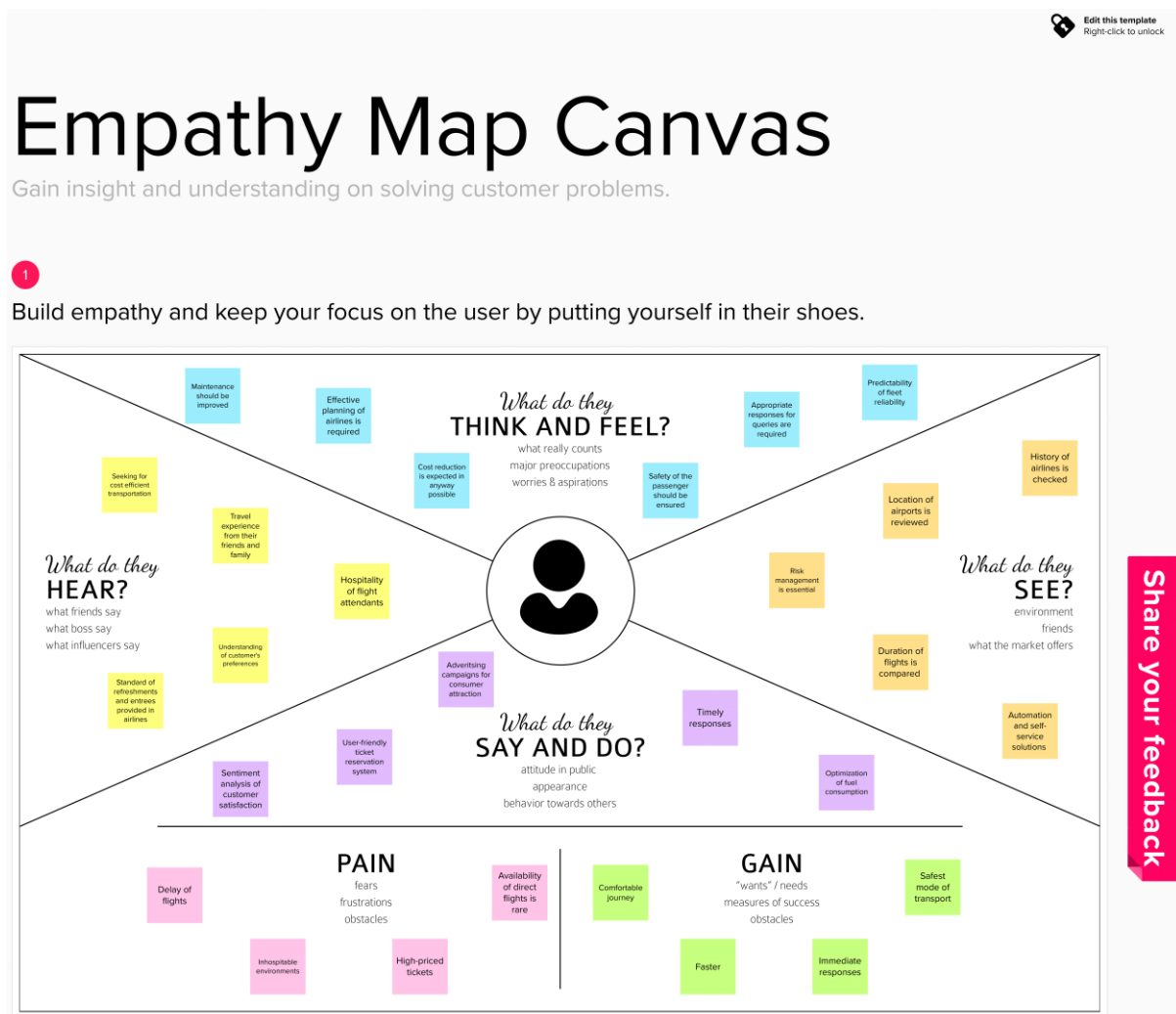
2.3 Problem Statement Definition

Airlines Data is huge that it requires a lot of effort to organize and store it. The fact is that modern airlines have many pending business issues, such as globally uneven playing field, revenue vulnerability, an extremely variable planning horizon, high cyclicity and seasonality, fierce competition, excessive government intervention and high fixed and low marginal cost. With the help of Business Intelligence Tools we can express the data in visualizations for better understanding. Adding to the inconvenience when delay happens due to weather conditions or any other unprecedented situations it affects the timetable. What if a model is made to predict the delayness?

IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

- An empathy map is a simple, easy-to-digest visual that captures knowledge about a user's behaviours and attitudes.
- It is a useful tool to help teams better understand their users.
- Creating an effective solution requires understanding the true problem and the person who is experiencing it.
- This exercise of creating the map helps participants consider things from the user's perspective along with his or her goals and challenges.



3.2 Ideation & Brainstorming

Brainstorming provides a free and open environment that encourages everyone within a team to participate in the creative thinking process that leads to problem solving. Prioritizing volume over value, out-of-the-box ideas are welcome and built upon, and all participants are encouraged to collaborate, helping each other develop a rich amount of creative solutions.

Step-1: Team Gathering, Collaboration and Select the Problem Statement

1

Define your problem statement

What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.

 **5 minutes**

PROBLEM

How might we provide better Airline and Airport services and to avoid delays in Air Travel across different locations at Municipality level. The aim is to provide airports, airlines and the travelling public with a neutral, third-party view of which airlines are delivering on their promise to get passengers from Point A to Point B on-time.

Step-2: Brainstorm

2

Brainstorm

Write down any ideas that come to mind that address your problem statement.

⌚ 10 minutes

TIP

You can select a sticky note and hit the pencil (switch to sketch) icon to start drawing!

Jeban S

Analysis of ticket booking helps the industry to target the customers with personalized offers while optimizing the price in real time using predictive analysis techniques

Descriptive Analysis allows you to pull trends from raw data and succinctly describe what happened or is currently happening. Using Descriptive Analytics the trends and patterns in the traveling data can be derived

Reservation Analytics provides in-depth insights of reservation trends, early alerts and helps our customers in improving reservation systems

With the right information, MROs can minimize the risks associated with overstocking or stock outs by planning their inventory wisely.

With nearly 30 % of the total delay time caused by unplanned maintenance, predictive analytics applied to fleet technical support is a reasonable solution.

Dinesh Sundar S

Revenue management is closely monitored by Business Intelligence tools

Taking the analysis a step further, Diagnostic Analysis includes everything concerning financial movement, uncovering correlations, detecting violations, and determining causal relationships where possible. Diagnostic Analytics is indispensable to fleet for root cause of the travelers' trends.

Prioritizing data collection and analysis should be made in all airlines

Business Intelligence tools are utilised appropriately in this vast ocean of data

In-flight sales and food supply during the time of travel can be optimized based on demand and supply predicted earlier

Akshaya S

Predictive analytics lets users know what will happen in the future so that the people at the point of contact can be alerted. It also provides the best next steps to take in order to resolve customer issues. With the help of predictive analytics we can derive the necessary insights up to be taken in the future - before it's too late!

Planning and Schedule Analytics provides in-depth analysis of ticket sales, operational expense and profitability of airline routes. It helps in fleet rebalancing.

By capturing flight incident data, regulators can improve safety across the aviation industry.

Modern analytical solutions help identify potential fraudulent transactions and revenue leakage cases and prevent them

Airlines use real time systems with built in machine learning algorithms to collect and analyze flight data including route, route distance and altitudes, arrival time and weight. Weather data, issued on flight from data, systems enhance the optimal amount of fuel needed for a flight.

Aswinsivaganesh M

Using predictive analytics and modeling, users can study emerging trends to predict where they are headed. The effective use of predictive maintenance is in its ability to leverage the historical data alongside the live operational data to make predictions.

Loyalty Analytics provides in-depth insights into customer behavior and the opportunity to track customer activity and develop strategies to keep the customer loyal to the brand.

Due to the use of smart data analytics, passengers will avoid many issues with baggage tracking.

Marketing Analytics provides an integrated view and to and view to the target customer needs by focusing on what is best for the customers. It provides with targeted and actionable campaign recommendations based on customer grouping and segmentation

Understanding the travelling needs of customers can be done by feedback surveys

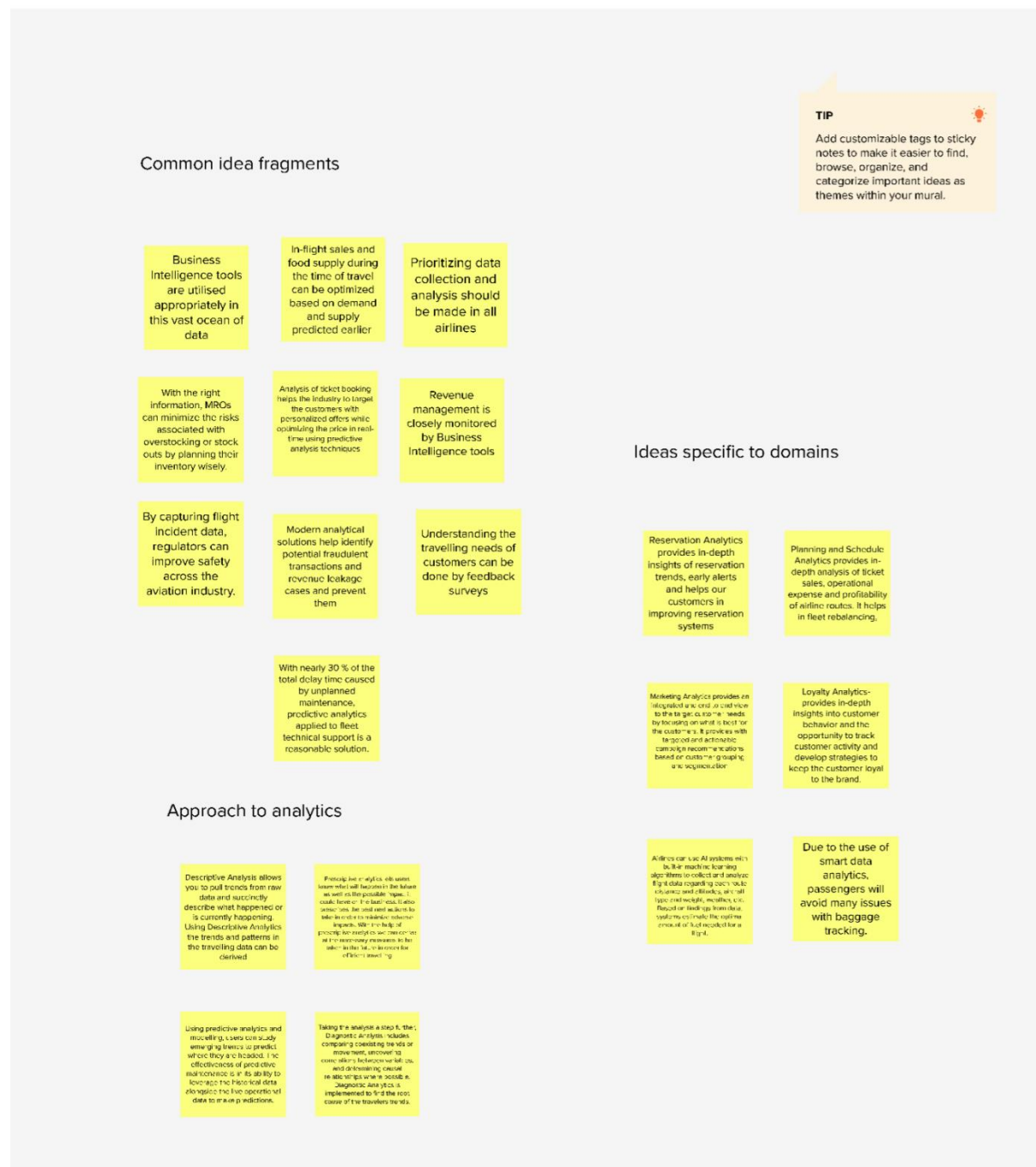
Step-3: Idea Listing and Grouping

3

Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. Once all sticky notes have been grouped, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you can break it up into smaller sub-groups.

🕒 20 minutes



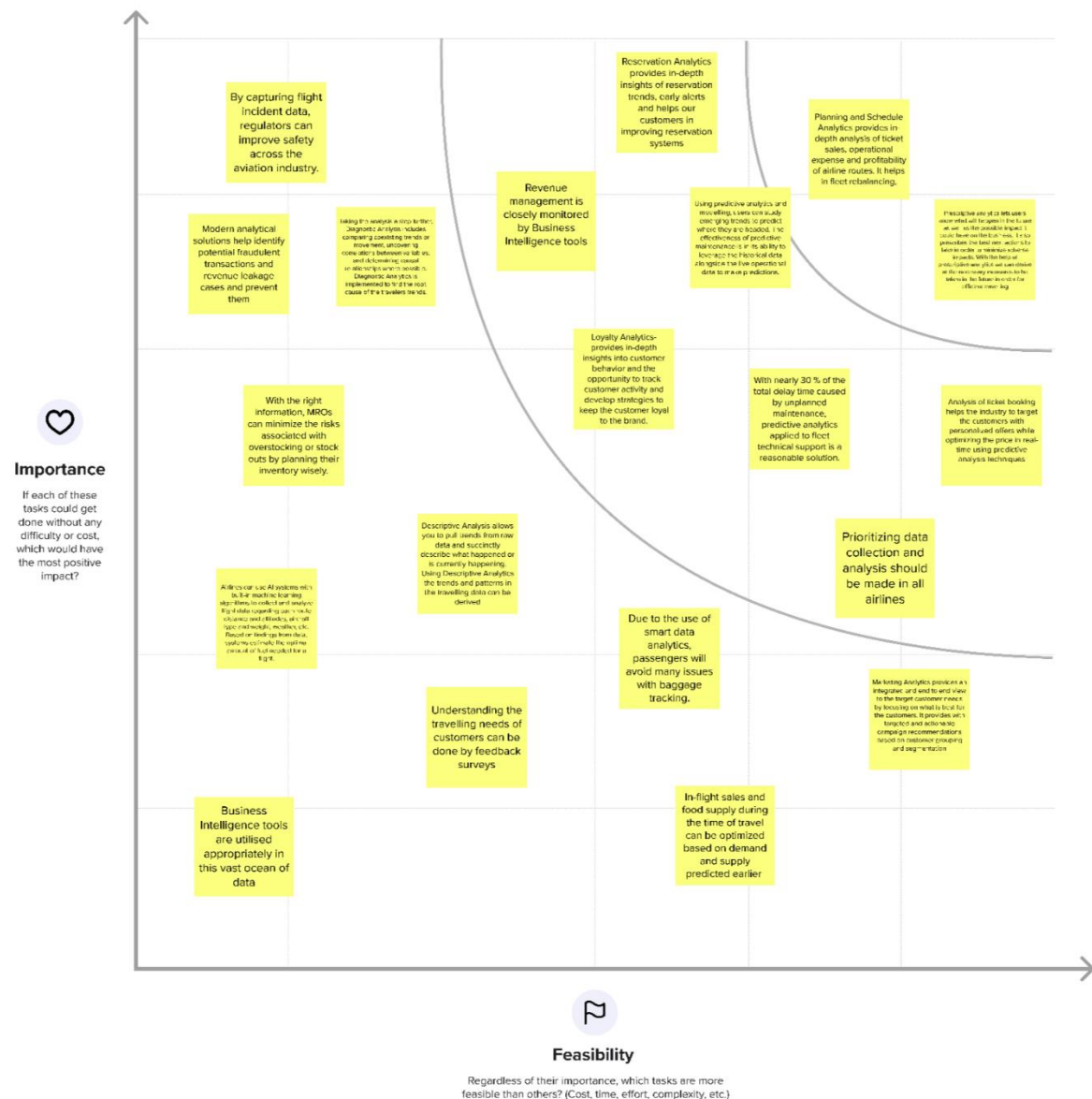
Step-4: Idea Prioritization

4

Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

20 minutes



3.3 Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	How might we provide better Airline and Airport services and to avoid delays in Air Travel across different locations at Municipality level. The aim is to provide airports, airlines and the travelling public with a neutral, thirdparty view of which airlines are delivering on their promise to get passengers from Point A to Point B on time.
2.	Idea / Solution description	<ul style="list-style-type: none"><input type="checkbox"/> Improving sustainability is important to the airlines, their passengers and – most of all – to the planet. That’s why airlines of all sizes are doing everything they can to reduce both fuel burn and carbon emissions.<input type="checkbox"/> Collecting data from hundreds of diverse sources and converting it into actionable information with the help of Business Intelligence Tools.<input type="checkbox"/> To discover trends and suggest the best-operating models, data experts utilize the most up-to-date tools and approaches, such as runway bandwidth, terminal capacity, number of passengers, number of routes, ticket pricing, and so on. Using machine learning models predictive analysis is done.
3.	Novelty / Uniqueness	Dashboards and Reports are generated on Aviation Industry data using IBM Cognos which provides us with the necessary insights for the betterment of travel. ML methods like Regression, Classification are executed to prescribe the actions to be taken in order to increase the efficiency of the airlines.
4.	Social Impact / Customer Satisfaction	Data analytics helps the industry to understand customers’ preferences. For instance, analysis of ticket booking helps the industry to target the customers with personalised offers while optimising the price in real-time using predictive analysis techniques. The model we are proposing is highly customer-oriented.

5.	Business Model (Revenue Model)	Revenue generation is made possible through targeting airlines in need of analytical model for their optimization of airspace use and fuel consumption. By making reliable system of Data Analytics we can draw customers thus creating a source of profits.
6.	Scalability of the Solution	The aviation analytics market is projected to grow from USD 2.5 billion in 2022 to USD 4.7 billion by 2027, at a CAGR of 13.0% from 2022 to 2027. Aviation analytics is an evolving technology, which is increasingly being used to arrive at actionable insights for various business functions. The solution we are providing is based on SaaS model.

3.4 Problem Solution fit

The Problem-Solution Fit simply means that we have found a problem with our customer and that the solution we have realized for it actually solves the customer's problem. It helps entrepreneurs, marketers and corporate innovators identify behavioral patterns and recognize what would work and why.

Purpose:

- Solve complex problems in a way that fits the state of your customers.
- Succeed faster and increase your solution adoption by tapping into existing mediums and channels of behavior.
- Sharpen your communication and marketing strategy with the right triggers and messaging.
- Increase touch-points with your company by finding the right problem-behavior fit and building trust by solving frequent annoyances, or urgent or costly problems.
- Understand the existing situation in order to improve it for your target group.

Problem-Solution fit canvas 2.0



<p>1. CUSTOMER SEGMENT(S) CS</p> <p>Who is your customer? i.e. working parents of 0-5 y.o. kids</p> <p>Airlines and passengers who are expecting efficient use of their funds and minimize the time on travelling by handling large amount of Airlines Data.</p>	<p>6. CUSTOMER CONSTRAINTS CC</p> <p>What constraints prevent your customers from taking action or limit their choices of solutions? i.e. spending power, budget, no cash, network connection, available devices.</p> <p>Storing of Data is a prime challenge, which occurs when data are not collected into one place. Financial and business challenges such as cost concerns return on investment (ROI) and commercial challenge.</p>	<p>5. AVAILABLE SOLUTIONS AS</p> <p>Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros & cons do these solutions have? i.e. pen and paper is an alternative to digital networking</p> <p>Big data analytics is defined as a collection of data and technology that accesses, integrates, and reports all available data by filtering, correlating, and reporting insights</p>
<p>2. JOBS-TO-BE-DONE / PROBLEMS J&P</p> <p>Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one, explore different sides.</p> <p>In the presented context, data coming from various sources in the aviation industry has to be integrated into a common big data repository before being analysed by means of specialized software.</p>	<p>9. PROBLEM ROOT CAUSE RC</p> <p>What is the real reason that this problem exists? What is the back story behind the need to do this job? i.e. customers have to do it because of the change in regulations.</p> <p>Airline industry is characterized by large quantities of complex, unstructured and rapid changing data that can be categorized as big data.</p>	<p>7. BEHAVIOUR BE</p> <p>What does your customer do to address the problem and get the job done? i.e. directly related: find the right solar panel, installer, calculate usage and benefits, indirectly associated: customers spend free time on volunteering work (i.e. Greenpeace)</p> <p>To optimize and streamline aviation operations, industry leaders and decision makers need to effectively manage and leverage big data.</p>
<p>3. TRIGGERS TR</p> <p>What triggers customers to act? i.e. seeing their neighbour installing solar panels, reading about a more efficient solution in the news.</p> <p>Applying vital decisions for new airline routes and aircraft utilization are important factors for airline decision making.</p> <p>4. EMOTIONS: BEFORE / AFTER EM</p> <p>How do customers feel when they face a problem or a job and afterwards? i.e. lost, insecure > confident, in control - use it in your communication strategy & design.</p> <p>Before: Complication in comprehending Airlines Data</p> <p>After: Easier understanding hence increased efficiency.</p>	<p>10. YOUR SOLUTION SL</p> <p>What kind of solution suits Customer scenario the best? Adjust your solution to fit Customer behaviour, use Triggers, Channels & Emotions for marketing and communication.</p> <p>In this context, business intelligence tools are valuable instruments that can optimally process airline related data so that the activities that are conducted can be optimized to maximize profits, while meeting customer requirements.</p> <p><small>If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality. If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behaviour.</small></p>	<p>8.1 ONLINE CHANNELS CH</p> <p>What kind of actions do customers take online? Extract online channels from box #7 Behaviour</p> <p>Cloud can be used to manage terabytes of data. Online services are changed in accordance with customer's preferences.</p> <p>8.2 OFFLINE CHANNELS CH</p> <p>What kind of actions do customers take offline? Extract offline channels from box #7 Behaviour and use them for customer development.</p> <p>Personalized apps can be made for passengers to give feedback, receive data, etc.,</p>



Problem-Solution fit canvas is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International license.

REQUIREMENT ANALYSIS

4.1 Functional Requirement

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	customer Registration	customer can make Registration through Gmail
FR-2	User Confirmation	After the Registration the customer will get confirmation through mail.
FR-3	Visualizing data	User can visualize the Regular trends of delay of flights Using IBM cognos Analytics
FR-4	Generating Report	User can view the flight delay report

4.2 Non- Functional Requirement

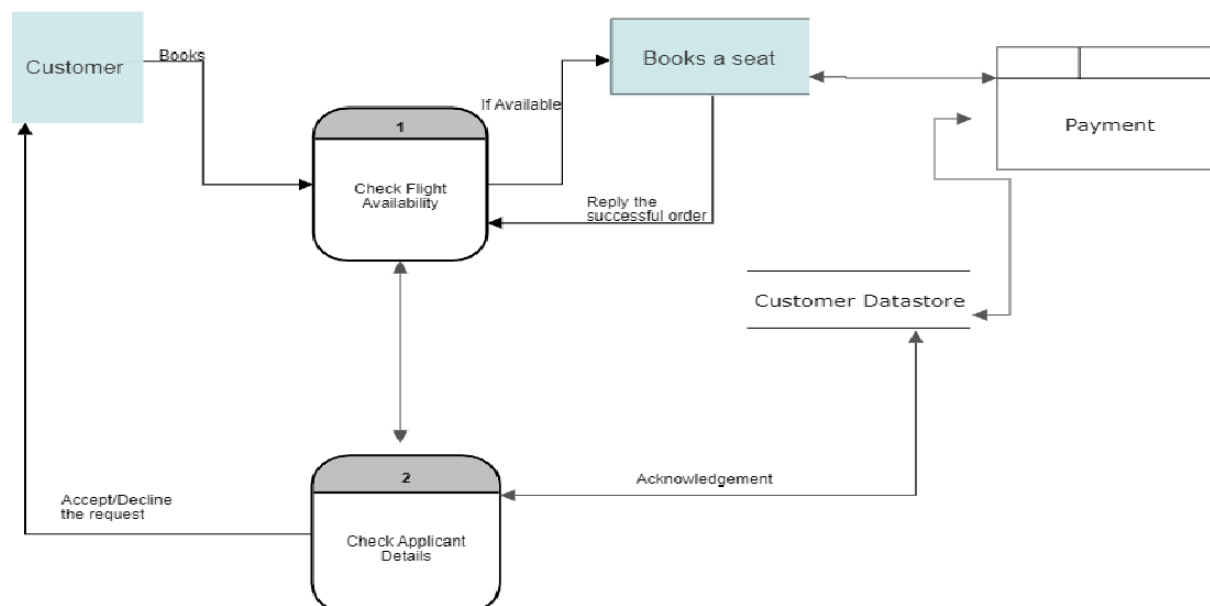
Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	The application will have a simple and user-friendly graphical interface. Users will be able to understand and use all the features of the application easily. Any action has to be performed with just a few clicks
NFR-2	Security	The main security concern is for users account hence proper login mechanism should be used to avoid hacking. The organization system should not disclose personal information of users and other organization details to public.
NFR-3	Reliability	When the system is disconnected or frozen due to over access at the same time, it should save all the process of the users made up to the point of abnormal happenings.
NFR-4	Performance	The system should require a fair amount of speed especially while browsing through the catalogue.
NFR-5	Availability	The system shall be available 24 hours a day 7 days a week. User can access at anytime.
NFR-6	Scalability	Large Number of users can access the website

PROJECT DESIGN

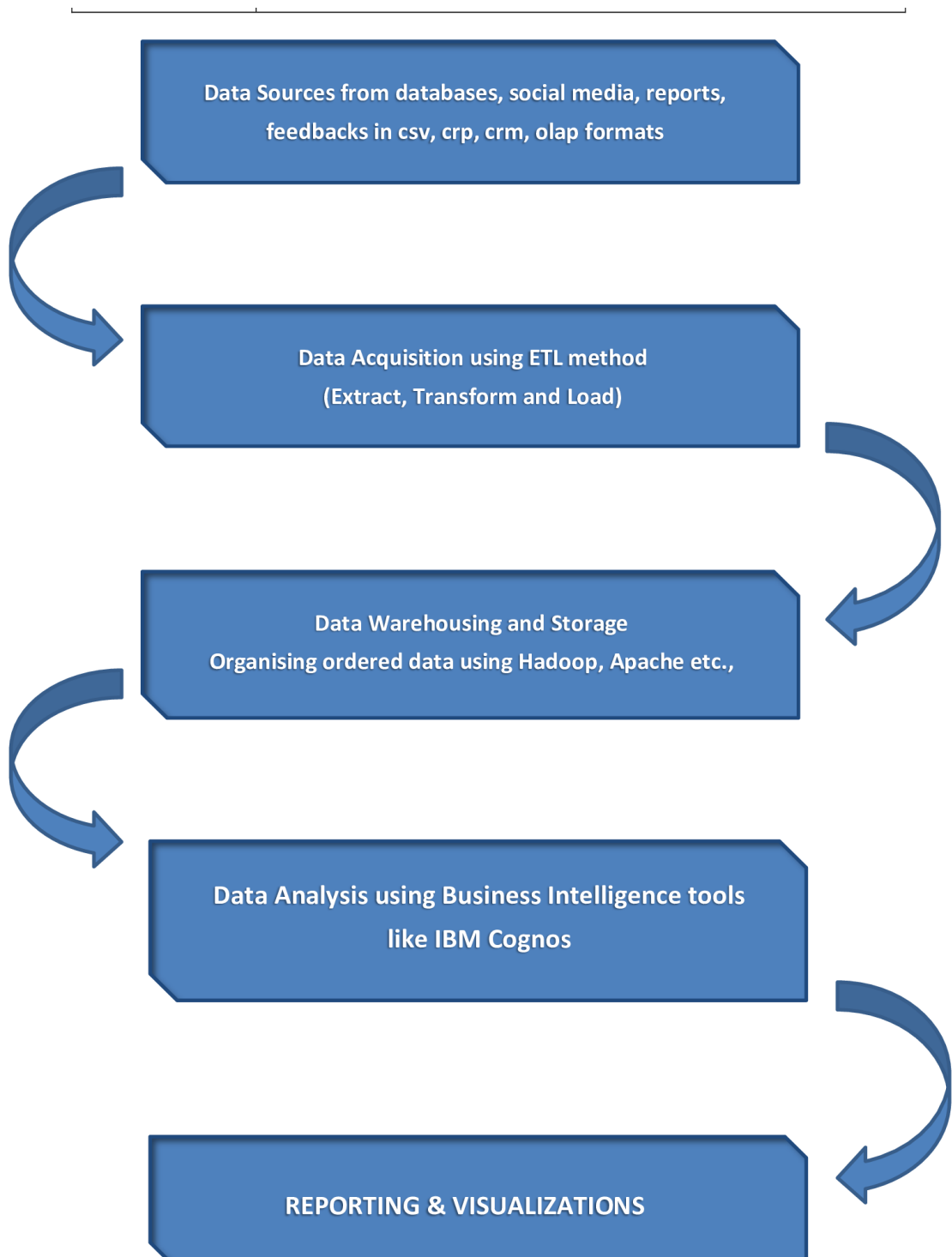
5.1 Data Flow Diagrams

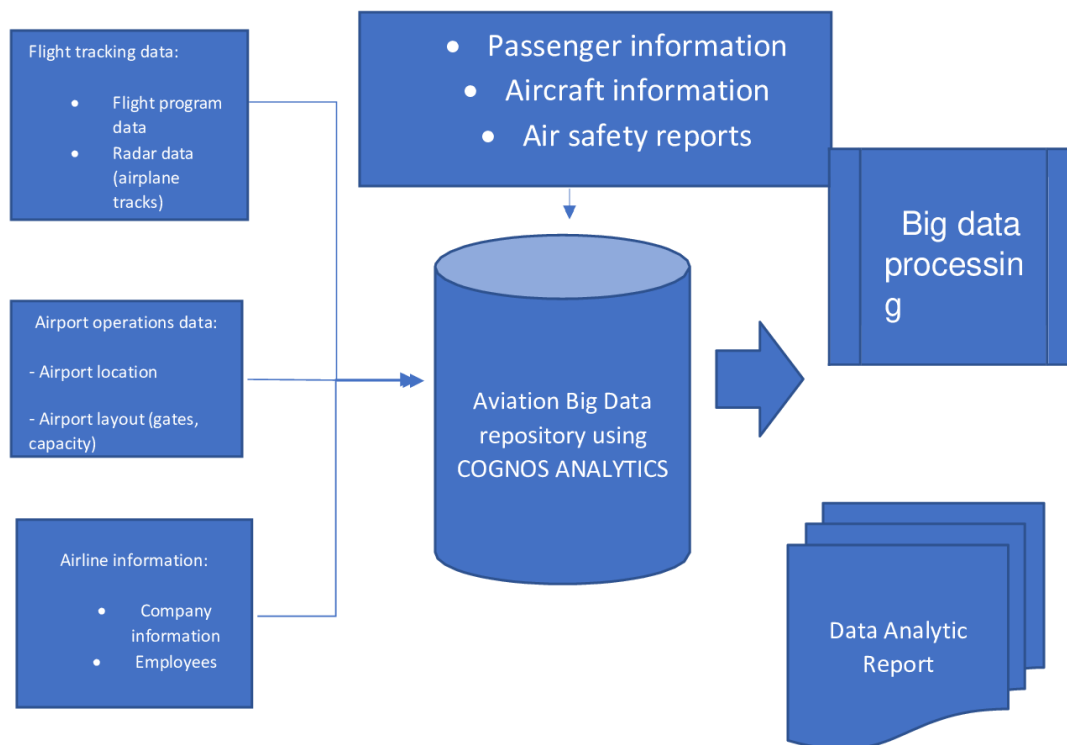
A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enter and leave the system, what changes the information, and where data is stored.



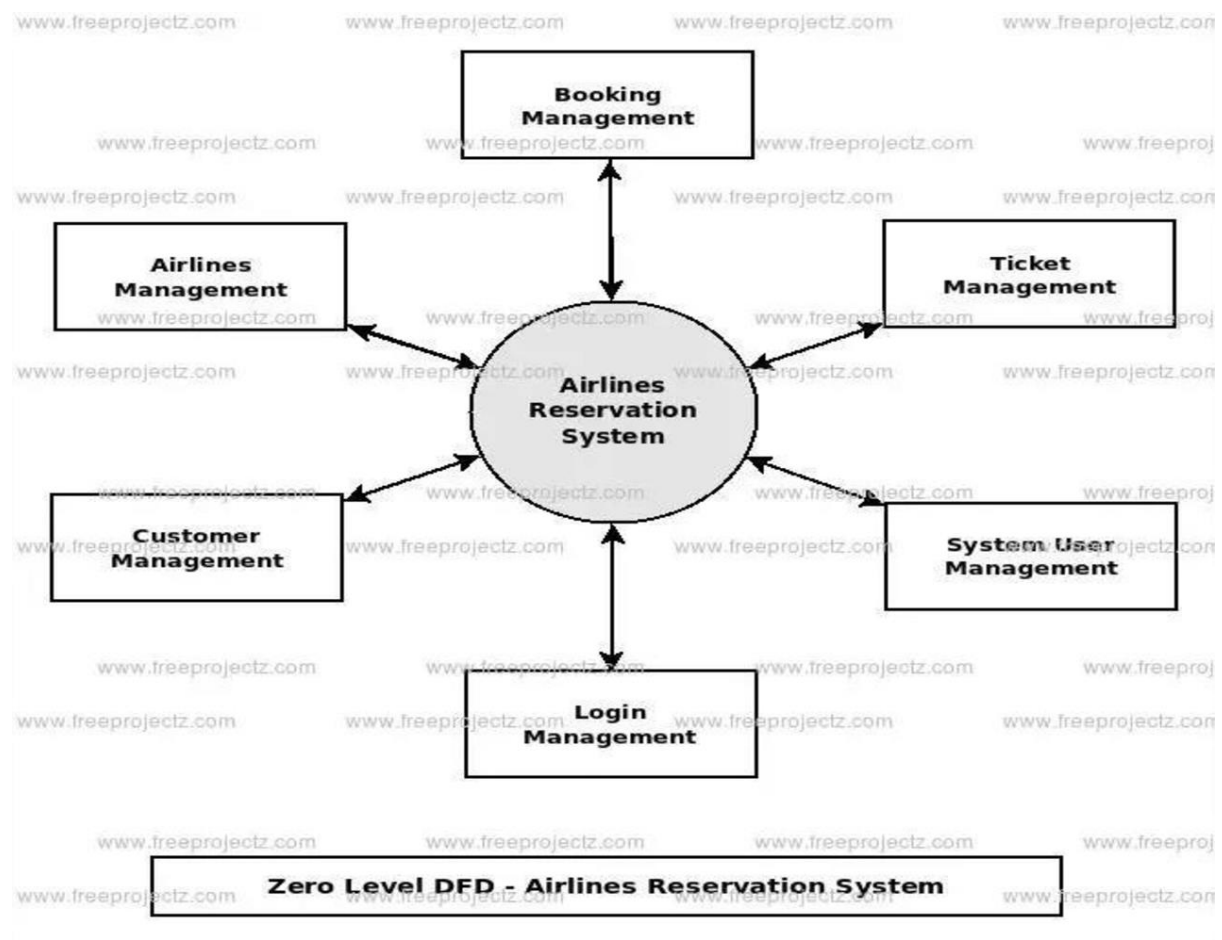
5.2 Solution & Technical Architecture

- Solution architecture is a complex process – with many sub-processes – that bridges the gap between business problems and technology solutions. Its goals are to:
- Find the best tech solution to solve existing business problems.
- Describe the structure, characteristics, behaviour, and other aspects of the software to project stakeholders.
- Define features, development phases, and solution requirements.
- Provide specifications according to which the solution is defined, managed, and delivered.





TECHNICAL ARCHITECTURE:



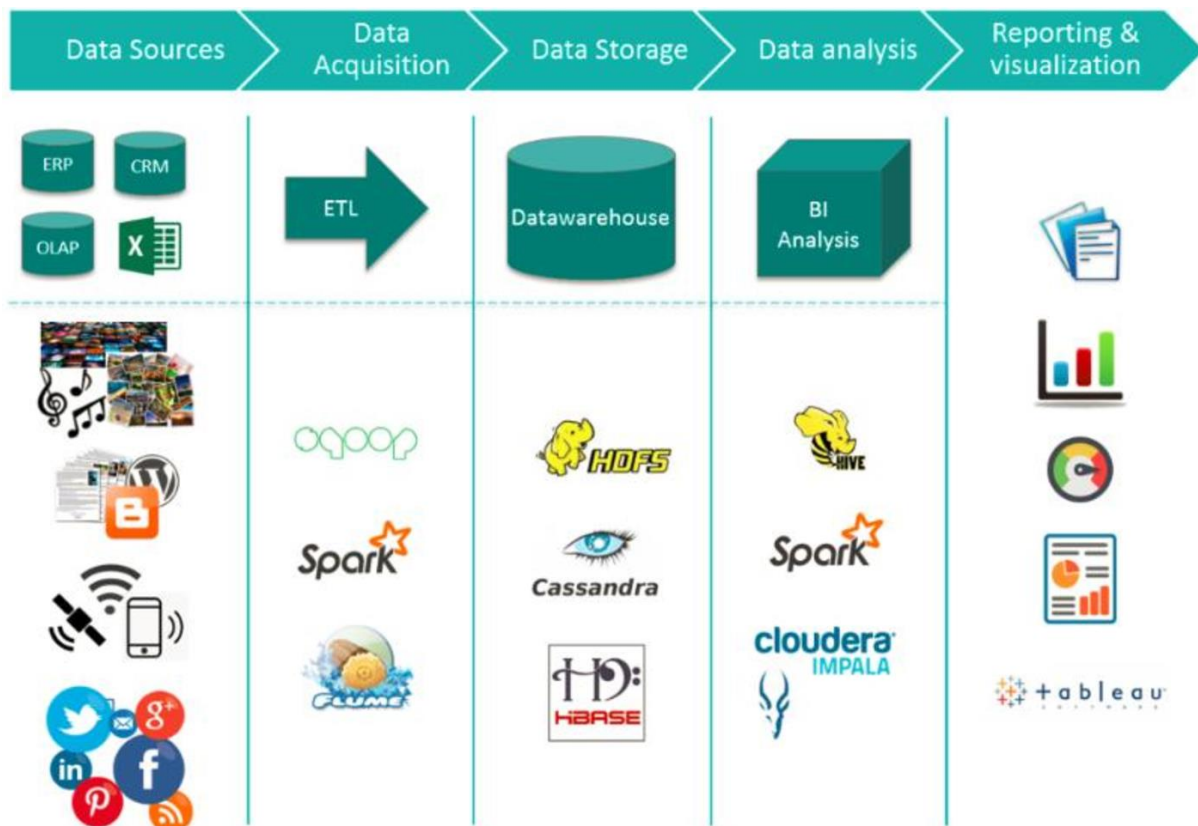


Table-1: Components & Technologies:

S.No	Components	Description	Technology
1.	User Interface	How user interacts with application. Example: Mobile App	HTML, CSS, Java Script, Excel
2.	Application Logic-1	Logic for a process in the application	IBM Watson STT service, Python
3.	Application Logic-2	Logic for a process in the application	IBM Watson Assistant
4.	Database	Data Type, Configurations	MySQL, NSQL
5.	Cloud Database	Database service on cloud	IBM DB2, IBM Cloudant
6.	File Storage	File Storage requirements	IBM Blocks Storage or other storage service or Local File system
7.	External API-1	Purpose of External API used in the application	IBM Weather API

8.	External API-1	Purpose of External API used in the application	Aadhar API
9.	Infrastructure (Server/Cloud)	Application Deployment on Local System/Cloud Local Server Configuration: Cloud Server Configuration	Local, Cloud Foundry

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	List the open-source frameworks used	Technology of open- source framework
2.	Security Implementations	List all the security/access controls implemented, use of firewalls.	Example: SHA-256, Encryption, IAM Controls, OWASP
3.	Scalable Architecture	Justify the scalability of architecture	Cognos Used
4.	Availability	Justify the availability of application (e.g: use of load balancers, distributed servers)	AWS Used
5.	Performance	Design consideration for the performance of the application (number of requests per second, use of Cache, use of CDN's)	Dashboard,Reports,Stories

5.3 User Stories

Use the below template to list all the user stories for the product

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Release
Customer (Web user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application	Sprint-1
		USN-3	As a user, I can register for the application through Gmail.	Sprint-1
	Login	USN-4	As a user, I can log into the application by entering email & password.	Sprint-1
	Dashboard	USN-5	As a user, I can get to know what my dashboard consists of.	Sprint-2
Customer Care Executive	Organization	USN-6	The organization which owns this airplane analysis system will enable the option to customers to reach out the organization if <ul style="list-style-type: none">they have any problem with the organization's system of customer interaction orairplane issues- delay, landing in a different location	Sprint-1
Administrator	Administration	USN-7	The organization takes in-charge of the administrative policies of different departments like: <ul style="list-style-type: none">registrationflight bookingdelay visualizationgeneration of delay report	Sprint-1

PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

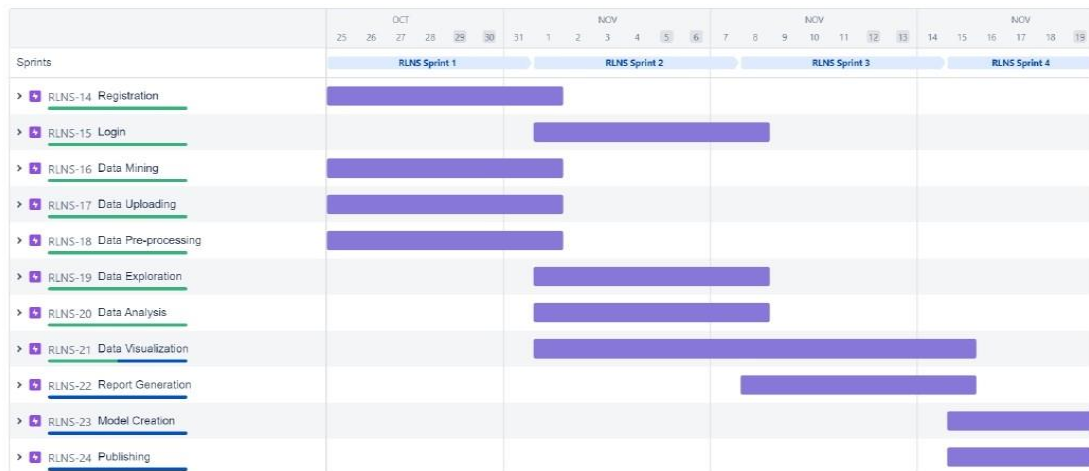
Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	2	High	S.Akshaya S.Jeban
Sprint-1	Registration	USN-2	As a user, I will receive confirmation email once I have registered for the application	1	High	M.Aswinsiv aGanesh S.Dinesh Sundar
Sprint-2	Login	USN-3	As a user, I can login to the application with the email id and password	2	Low	S.Jeban S,Dinesh Sundar
Sprint-1	Data Mining	USN-4	As a user, I will start collecting data from various sources with the help of data mining techniques.	2	Medium	S.Akshaya S,Dinesh Sundar
Sprint-1	Data Uploading	USN-5	As a user, I can upload the collected dataset to the IBM Cloud Account	1	High	S.Jeban M.Aswinsiv aGanesh
Sprint-1	Data Pre-processing	USN-6	After data is uploaded into Cognos, Data pre-processing is done.	2	High	S.Dinesh Sundar
Sprint-2	Data Exploation	USN-7	Exploratory Data Analysis is done in the dataset.	2	High	S.Jeban M.Aswinsiv a Ganesh
Sprint-2	Data Analysis	USN-8	I can study the data under various categories to derive insights.	2	High	S.Akshaya M.Aswinsiv a Ganesh
Sprint-2	Data Visualization	USN-9	Using dashboards in Cognos BI tool for data visualizations with the help of various charts.	2	High	S.Jeban
Sprint-3	Report Generation	USN-10	I will create reports in Cognos based on the requirement of visualizations.	2	High	S.Akshaya
Sprint-3	Data Visualization	USN-11	I can create story in Cognos.	2	Medium	S,Dinesh Sundar
Sprint-4	Model Creation	USN-12	I can generate various ML models for predicting the future requirements based on quantitative analysis.	2	High	S,Dinesh Sundar S.Akshaya
Sprint-4	Publishing	USN-13	I can establish my project in GitHub website	2	High	M.Aswinsiv a Ganesh

6.2 Sprint Delivery Schedule

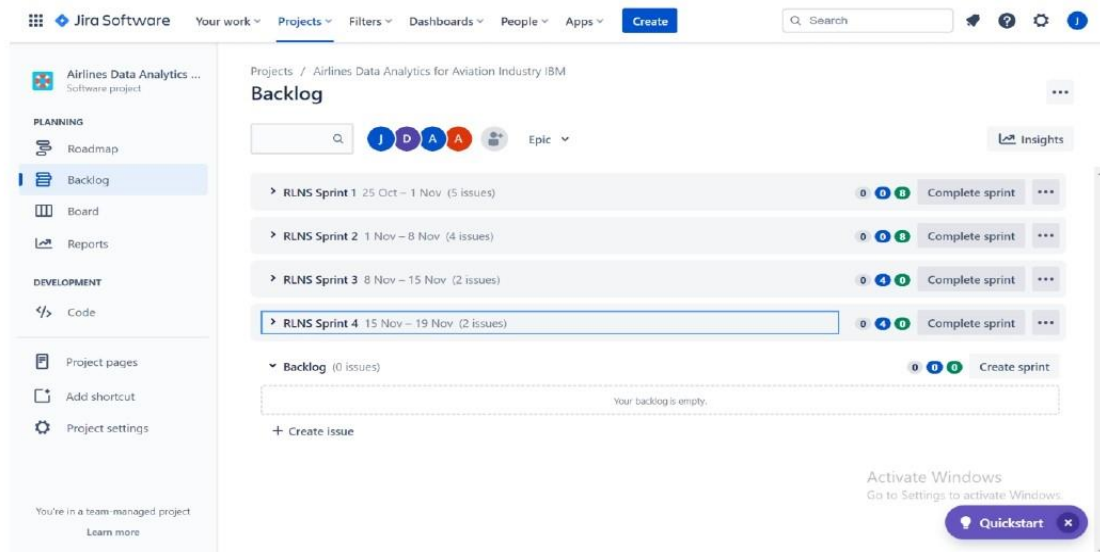
Sprint	Total Story points	Duration	Sprint Start Date	Sprint End Date (Planned)
Sprint-1	20	6 Days	25 Oct 2022	31 Oct 2022
Sprint-2	20	6 Days	1 Nov 2022	7 Nov 2022
Sprint-3	20	6 Days	8 Nov 2022	14 Nov 2022
Sprint-4	20	6 Days	15 Nov 2022	19 Nov 2022

6.3 JIRA Software

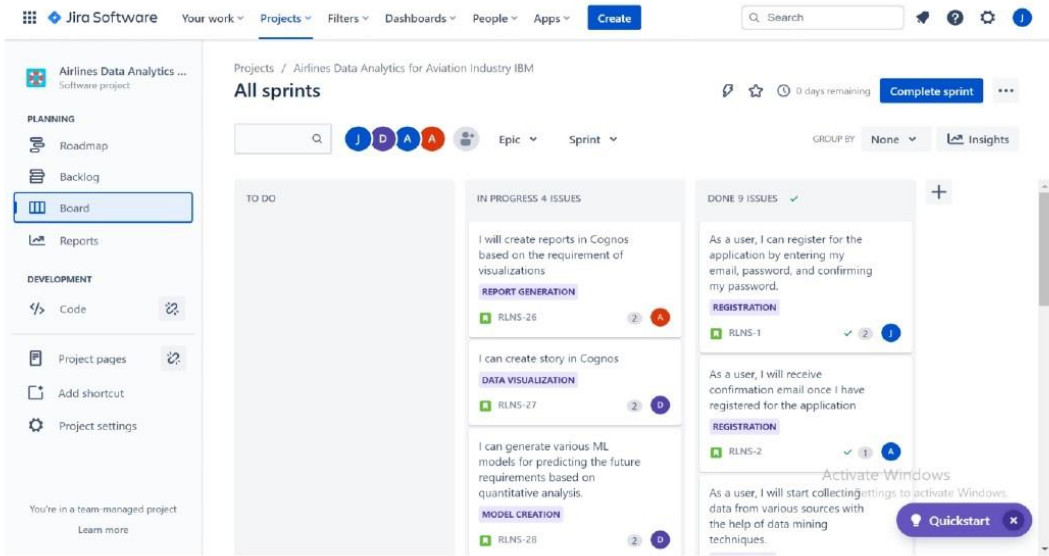
ROADMAP



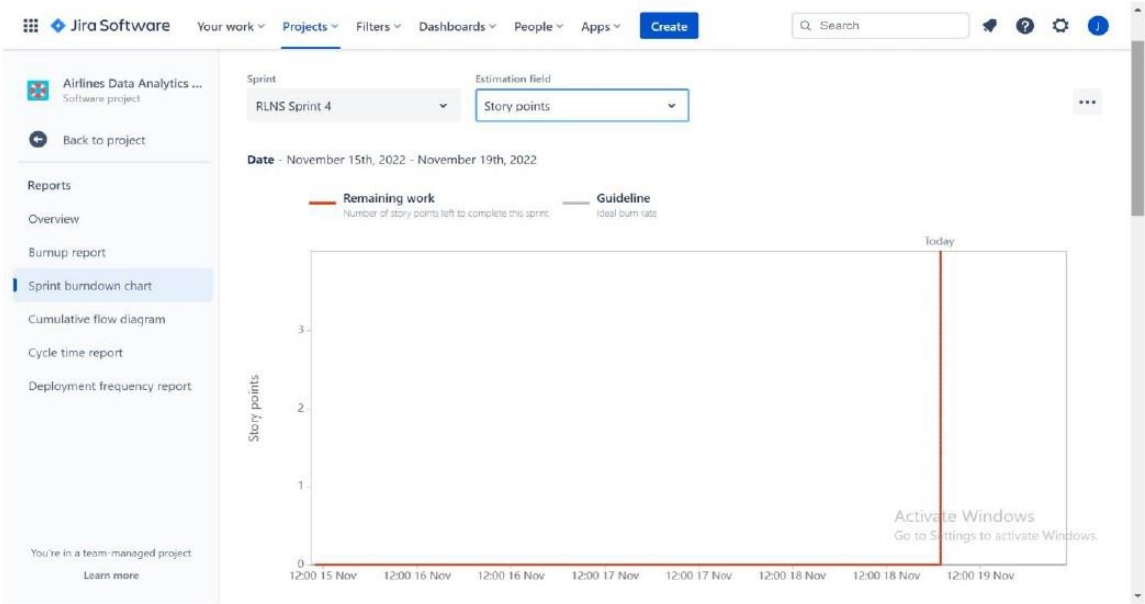
BACKLOG



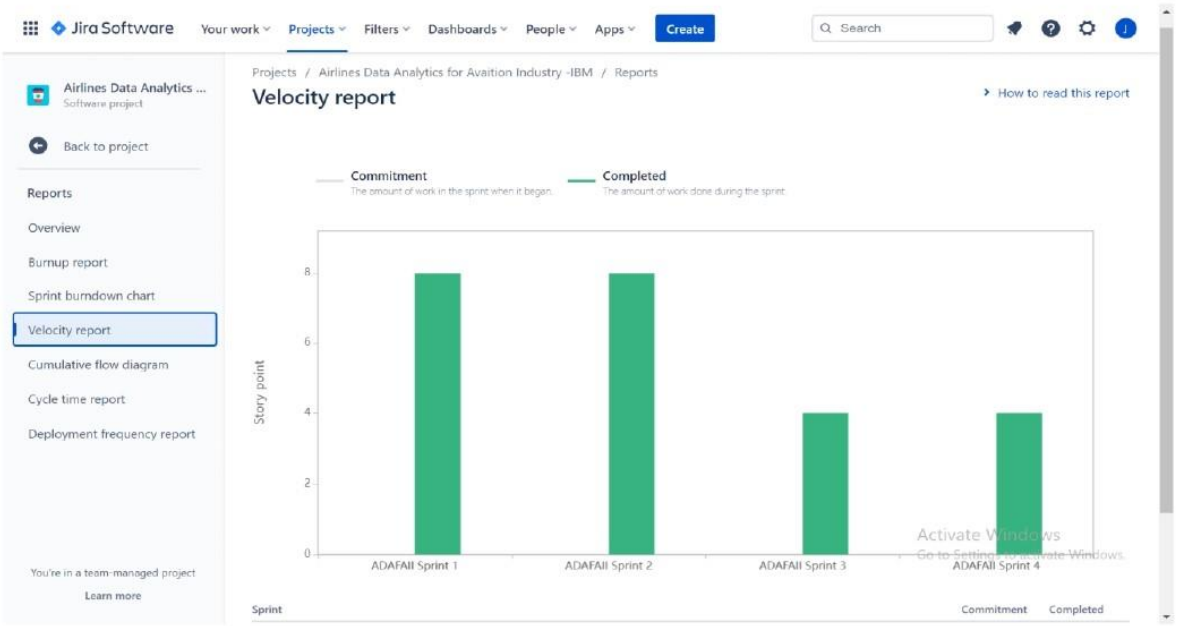
BOARD



SPRINT BURNDOWN CHART



VELOCITY CHART



CODING AND SOLUTIONING

7.1 Data Collection

The process of gathering and analyzing accurate data from various sources to find answers to research problems, trends and probabilities, etc., to evaluate possible outcomes is Known as Data Collection. Data is collected by means of online websites like Kaggle, Driven Data, Data gov etc.,

7.2 Data Preparation

The process of preparing raw data comes in handy for the purpose of analysing. Hence data is pre-processed with the help of python libraries, BI tools etc., Data preprocessing can refer to manipulation or dropping of data before it is used in order to ensure or enhance performance, and is an important step in data mining process.

7.3 IBM Cognos

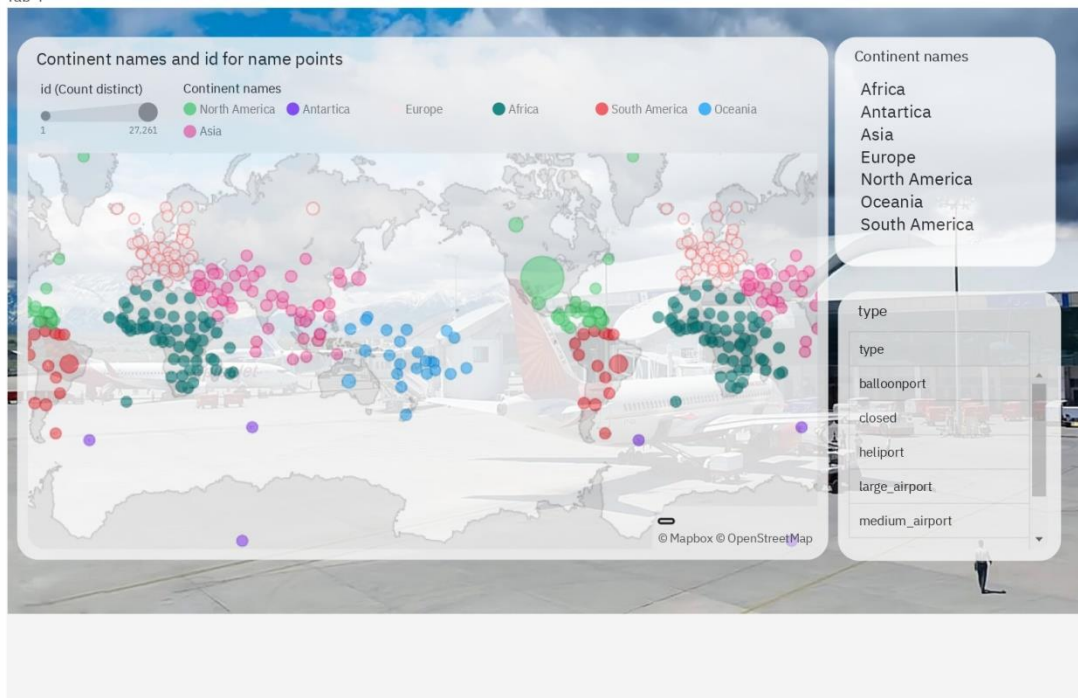
IBM Cognos Business Intelligence is a web-based integrated business intelligence suite by IBM. It provides a toolset for reporting, analytics, scorecarding, and monitoring of events and metrics. The software consists of several components designed to meet the different information requirements in a company. It contains various visualizations for representation. Airlines data is represented through dashboards, reports and stories.

7.4 Dashboard Generation



Tab 2





<https://us3.ca.analytics.ibm.com/bi/?perspective=dashboard&id=FA8661D01A9B46D78F20BCCEF3BA2B06&objRef=FA8661D01A9B46D78F20BCCEF3BA2B06&options%5BdisableGlassPrefetch%5D=true&option...> 5/5

Dashboard link:

https://us3.ca.analytics.ibm.com/bi/?perspective=dashboard&pathRef=.my_folders%2FAirStats%2BDashboard&action=view&mode=dashboard&subView=model0000018481c75a92_00000000

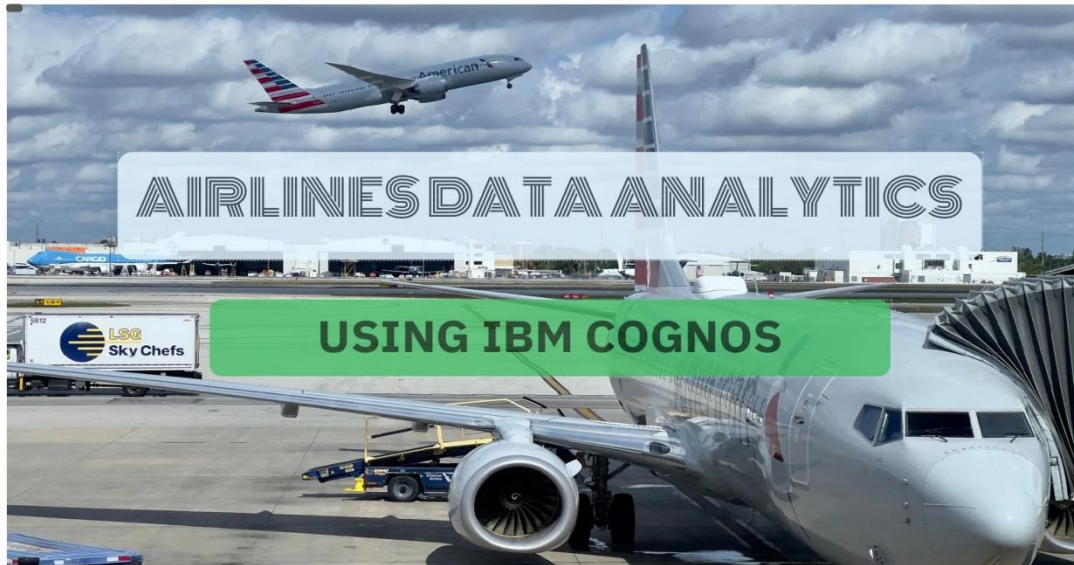
Dataset link:

https://us3.ca.analytics.ibm.com/bi/?perspective=ca-modeller&pathRef=.my_folders%2FAir%2BStats%2BData%2BPrep%2Bnew

7.5 Story Generation

11/19/22, 5:29 AM

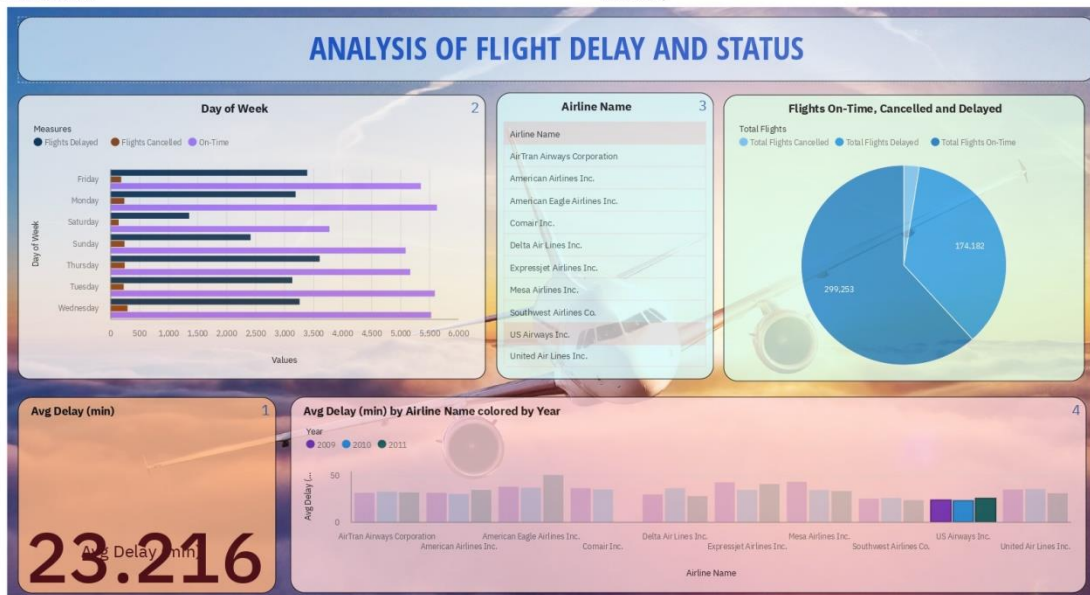
Airlines story



<https://us3.ca.analytics.ibm.com/bi/?perspective=story&id=i84DDEF368A33478D9987B63661486838&options%5BdisableGlassPrefetch%5D=true&options%5Bcollections%5D%5BcanvasExtension%5D%5Bid%5D=...> 1/4

11/19/22, 5:29 AM

Airlines story



<https://us3.ca.analytics.ibm.com/bi/?perspective=story&id=i84DDEF368A33478D9987B63661486838&options%5BdisableGlassPrefetch%5D=true&options%5Bcollections%5D%5BcanvasExtension%5D%5Bid%5D=...> 2/4



https://us3.ca.analytics.ibm.com/bi/?perspective=story&pathRef=.my_folders%2FAirlines%2Bstory&action=view&sceneId=model000001848af3f0eb_00000000&sceneTime=5000

<https://us3.ca.analytics.ibm.com/bi/?perspective=home&folder=i7900D6013CEA4004A5FD E946E950E32E>

Exploratory Data Analysis is done on the acquired dataset to get a clear observation on the data in Google Colab. Machine Learning models such as KNN, Logistic Regression, Random Forest etc., are trained and tested for the dataset. From our observation Random Forest Classifier providing with good results with high accuracy.

CONCLUSION

With the help of data analysis and machine learning to evaluate passenger demand across different routes, delay prediction, count of airports, types of airports and use data insights to optimize airline handling is done. Initially we dealt with visualizations and exploration of the acquired data and we proceeded to create model which is suitable for our data to predict the future values. We used tools such as IBM Cognos Analytics, Google Colab and languages like python which has a large collection of libraries such as pandas, matplotlib, seaborn which helped a lot in the visualizations. In the future this project can be developed further with the help of advanced ML models like XGBoost by predicting more accurate values. BI tools help us with the estimation of fuel consumption, cost and much more important KPIs.