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Aircraft Aviation System Environment Impact Factors Prediction using Machine Learning

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Abstract: ***Aircraft aviation system modules are considered for eco friendly oriented service estimation by global organizations. The emissions and aerodrome infrastructures effects the environment and citizen areas surrounding to aerodromes. An interest in researching to identify substantial environmental impact factors by authorities to support Eco-systems increased. In this paper Machine-Learning techniques applied over various training data sets related to aircraft aviation systems to generate interesting patterns related to environmental effects by aircrafts. Probabilistic prediction algorithms applied to support decision systems in generating guidelines to enhance the Eco-friendly architectures of aerodromes as well as aircrafts. The factors identification and territorial based environment precautions deviation observed for locating Eco-system regulation needed zones. The classifications performed in this paper over aircraft systems generate interesting measures to classify environmental scalable aircrafts in future with better eco-friendly technology. Rule miners identify the zones attributes associations among various countries. The work projected in this paper supports aircraft organizations to accurately estimate the environmental effect scores for aviation systems.***

Keywords: ARM, Classification, Impact Analysis, Decision Support, Prediction.

I. INTRODUCTION

Aircraft aviation systems are playing a great role in international transportation services. The increased aircraft emissions and aerodromes causing increased impact on environment [1]. The emissions of aircraft causing health impacts over citizen communities surrounded to aerodromes [2]. The EAA (European Environment Agency) proposed models to support LTO cycled aircraft technologies to reduce fuel combustion rates [3]. To increase the safety in transportation, health and industrial environments implementation of cyber security policies with adoptable risk management models is under research [4]. The probabilities distribution of airport performances, air traffic networks and aircraft delays used to select appropriate weather conditions using threshold to perform analysis on environmental impact [7]. Recent technologies keep attention over cylindrical combustion equipment, fan architectures which releases composite materials during flight aviation [5]. Based on incident report databases, service difficulty reports risk analysis oriented models proposed to determine safety classification among aircraft services [8]. Various tools available to assess environmental effects and impacts of aviation systems which calculate the noise, fuel burn, global, regional and local level pollution effects with parametric measurement based procedures [10][13]. The study over alternative fuels to support aircrafts to reduce hazardous gases emission is another key evolutionary step towards research now a day's [11][14]. The CRM strategies using data mining techniques reveal the passenger health and satisfaction over airport services towards constructing environment friendly zones with major environment regulatory authority's policies adoption [9]. International Civil Aviation Organization (ICAO), World Health Organization(WHO), European Environment Council (EEC) and many other world organization reported the increase in civil aviation rate by 10.6% per every year, which increasing the aircraft aviation sector as well as environmental effect factors [6][12].

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II. AIRCRAFT ENVIRONMENT IMPACTS

A. Aircraft Functions

The aircraft systems functional bodies like fuel exhaust, propellers and wing fans emit environment effecting emissions like hot air, $NO2$, $SO2$, $CO2$, soot, volatile and non-volatile particles into atmosphere. Various physics related factors such as Torque, Aero-Dynamics, Inclination Angle, Throttle, Surface Tension, Engine Thrust and atmospheric pressure effects the aircraft emission rates.

$$\int_{i=1}^{n} T_i + \int_{j=1}^{n} ST_j + \int_{k=1}^{n} ADF_k + \int_{x=1}^{n} ET_x + \int_{y=1}^{n} Th_y$$

Where [T_i, ST_j, ADF_k, ET_x and Th_y] are integral sum of factors affect the emission rate of aircraft vehicle. The increasing demand of air transport placing a potential challenge on airport authorities to maintain environmental standards and keeping airport environments echo friendly. The operations that impact environmental issues in airports are

- Aircraft Operations
- Passenger vehicle services
- Airport ground services (Cleaning, maintenance, motor vehicles)

- Fuel filling and storing activities of airports
- Airport facilities and maintenance
- Constructions
- Signaling and guiding of aviation vehicles

The GAO (General Airport Operations) regulated with EPA (Environmental Protection Agency) implementing policies to safeguard environment from aircraft pollutants.

B. Environment Impact

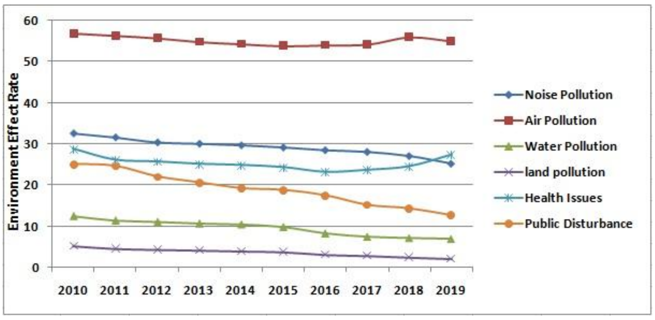


Fig. 1. Survey report on environment impact

The surveys conducted over various aerodromes by national agencies noticed the air pollution effect by aviation systems is high among other consideration factors as shown in figure 1.

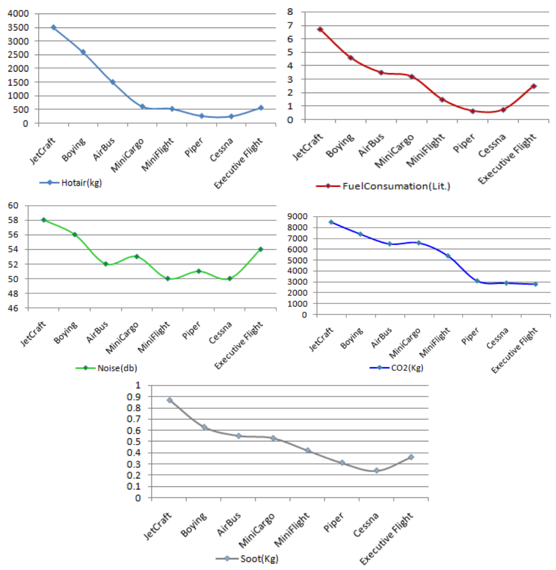


Fig 2. Air craft pollution rate

From above figure utilization of Jet aircrafts increasing the impact on environment more. The operational services also play an important role in aviation systems which affect emissions rate.

C. Operational Improvements

The operational quality improvement in various aviation operational activities reduces the emission rate of environmental hazardous components from aircraft systems. Following are some important areas to improve quality in benefit to eco systems.

- Continuous descent operations
- Arrival Manager System
- Advanced Surface Movement Guidance System
- Navigation Performance Authorization
- Airport Collaborative decision Making System

The modern policies and environmental protection organizations guidelines followed by craft designers and manufacturers to improve the quality of service maintaining the standards to support environment is a necessary adoption needed in recent aviation systems.

III. IMPACT ANALYSIS MODEL

The model proposed in this work accepts the training data sets collected from environment measures databases related to aircraft aviations. Machine Learning techniques applied over training data in a procedural manner to identify various interesting measures and decision support rules. The dependent factors which coupled to effect environment identification using ARM techniques along with factors scoring gives an ability to controlling tasks organization. The clustering mechanisms identify the clusters of aerodromes affected with similar factors with density measures.

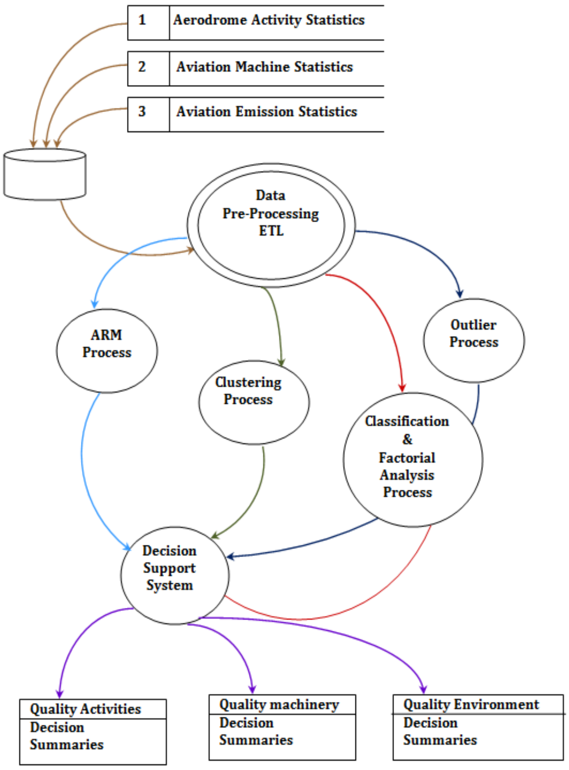


Fig 3. Impact Analysis ML Model

The training data collected from past activities measures from various airports databases. The decision summaries generated from this model helps in assessing the quality of aviation machines, activities and environmental issues. The classification mechanisms applied in this work identifies the emission classes for various aircrafts. The factorial analysis algorithm identifies factor based analysis on aircraft with a comprehensive summarized advises to improve the quality of standards in both services and activities.

IV. METHODOLOGY

The raw data statistics collected from various aviation systems are pre-processed using ETL. The transformed data collected into .XLS/.ARFF/.CSV format files for machine learning tools adoptability.

As shown in fig 3 Association Rule Mining applied over aircraft services provided to identify the usage patterns of aircrafts globally. These rule generators provide an insight vision into environmental policy adoption levels for various flight combinations.

Based on these rule sets support and confidence factors are evaluated to generate decision supporting summary. Classification algorithm ID3 applied over training data to generate new class labels based on various emission factors of flights. The decisions summaries generated using these classification trees provides a better understanding about need of replacement of technology, policies and flights in environmental protection view. The clustering techniques applied to identify the groups of flights which exhibit similarity in emission rates for various echo hazardous compounds. The decision rules generated by this clustering approach gives an ability to identify low, medium and high pollution flight groups on which we can pay more attention to inherit echo friendly policies.

The K-mean algorithm applied for identifying clusters and to improve accuracy we also used tuning parameters. The CART and ID3 algorithms used for classification with optimal parameters over generalized training data sets. Apriori algorithm applied over training data with assistance of FP-Tree growth logic to identify accurate frequent patterns for analysis. The summaries are generated for each approach to estimate the trend sets with proper guidance to environmental organizations in making policies better to support QoS as well echo friendly zones.

V. RESULT ANALYSIS

The application of Machine Learning techniques over training data sets based on proposed model generated interesting measures. The Scoring analysis conducted over aircrafts available for service at various airports across the globe considering the technical standards and environment policy standards maintaining shown in fig 4. The use of CE equipment in aircraft is 70%, ES-1 policy adoption by aircraft systems is 34%, ES-2 policy adoption is 91.2% and ES-3 policy adoption is 81%. This indicates still aviation uses of an average of 32% aircrafts which are needed to be modified to support certification standards by global authorities of quality & environmental protection.

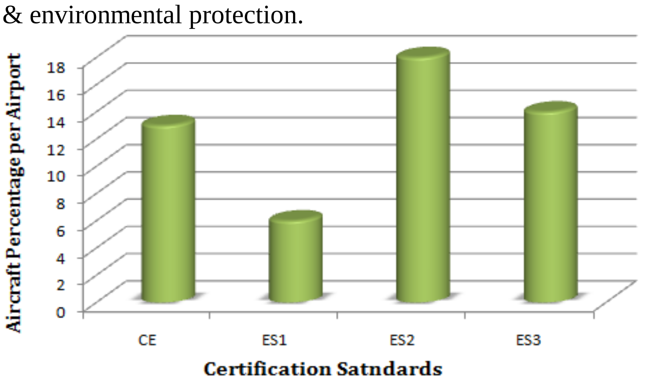
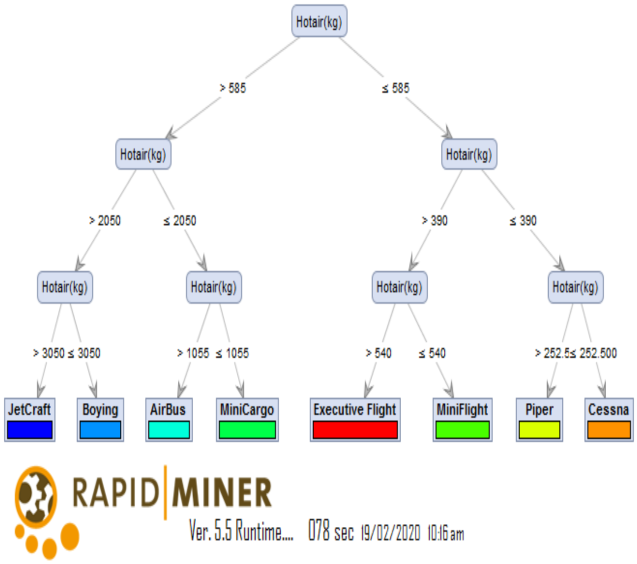
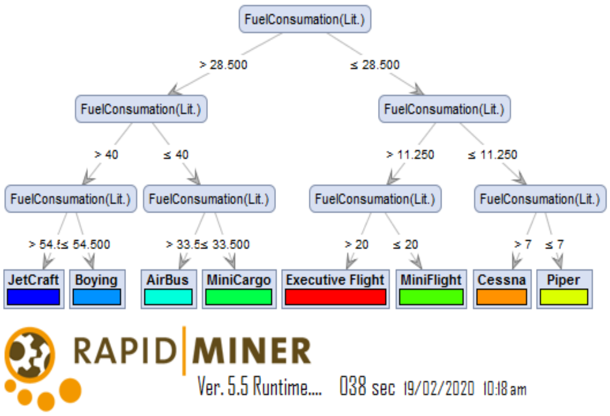


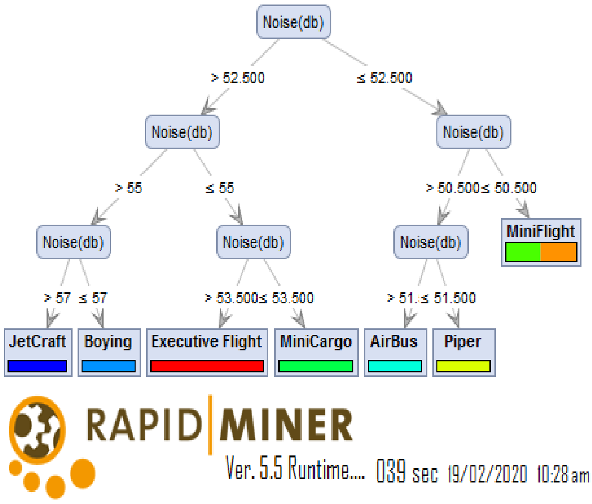
Fig. 4. Certification standard rates

A. Classification based on Aircraft Emissions

The aircrafts emission rates are analyzed using classification techniques to identify classes of emission rates among aircrafts. The Classification tree generated using ID3 is shown in fig 5-9. The ID3 algorithm used to classify the aircrafts based on their emission compounds volume statistics and fuel consummation statistics. The classification identifies the classification rules for future training data sets classification accurately.







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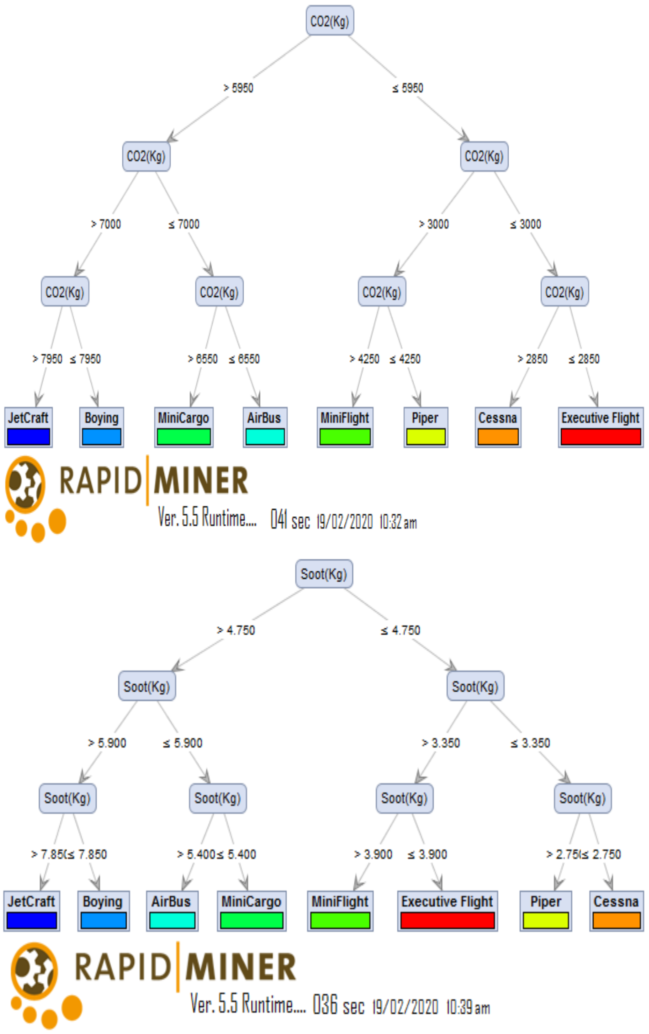
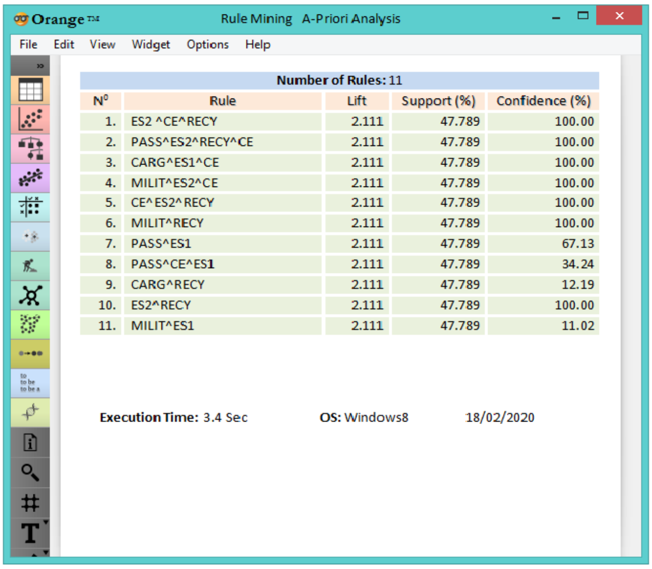


Fig. 5-9 Classification Trees on Emissions

The resultant classification placed {Jet-Crafts, Buoying-XXX, Airbus, Mini-Cargos} into classes that consume more fuel and releases more amount of emissions than classes {Mini Flights, Executive Flights, Pipers, Cesnas} categories which are more fuel efficient with low emissions.

B. ARM Rule generations for Aircraft services

Association Rule mining algorithm Apriori applied over training data of aircraft services provided by airport. This analysis generated interesting measures related to dependency of certifications or services among various types of aircrafts and their demand rates identified through support and confidence measures. A future trend estimation supportive analysis, often helpful to predict the rate of increase in demand of flight services over global airports. From fig-10 it is clear that almost all passenger service flights are CE equipped and ES2 policy satisfied with a benefit of recycling service facilitation. The Military flights supporting ES2 policy and CE certified. Still Cargo flights are ES1 policy supporting which to be enhanced to satisfy ES2 policy. There are 47% of passenger services flights needed to upgrade from ES1 standards to ES2 standards. All the modern flight services are CE certified and maintaining ES2 policy with recycling facility. No cargo service flights are used for passenger service since ┐ Cargo ∧ Passenger= T or ┐ Passenger ∧ Cargo=T.

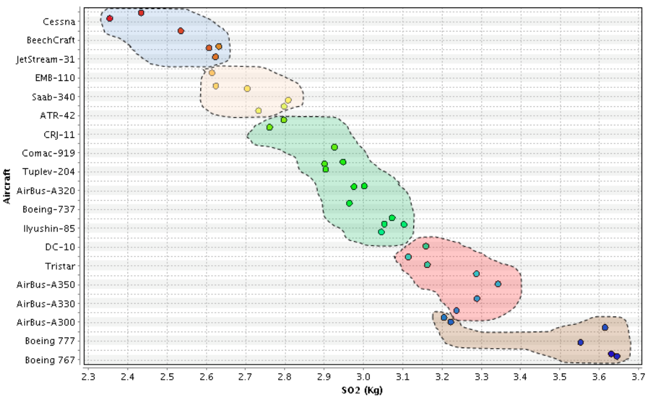


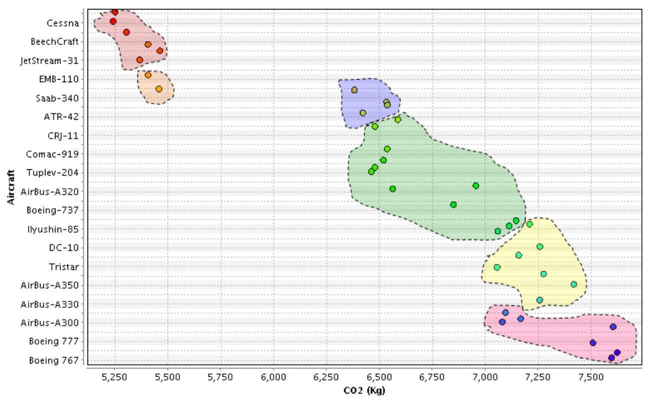
Nº	Rule	Lift	Support (%)	Confidence (%)
1.	ES2 ^CE^RECY	2.111	47.789	100.00
2.	PASS^ES2^RECY^CE	2.111	47.789	100.00
3.	CARG^ES1^CE	2.111	47.789	100.00
4.	MILIT^ES2^CE	2.111	47.789	100.00
5.	CE^ES2^RECY	2.111	47.789	100.00
6.	MILIT^RECY	2.111	47.789	100.00
7.	PASS^ES1	2.111	47.789	67.13
8.	PASS^CE^ES1	2.111	47.789	34.24
9.	CARG^RECY	2.111	47.789	12.19
10.	ES2^RECY	2.111	47.789	100.00
11.	MILIT^ES1	2.111	47.789	11.02

Fig. 10. ARM Rules for aircrafts

C. Clustering of Aircrafts

The clustering algorithm k-Mean applied over training data sets related to aircrafts emission rates. The major categories of emissions that are environmental hazardous considered for analysis. The CO, CO2 and SO2 are highly environmental impact gases released by almost all aircrafts. The universal flights (40) used all over the airports are taken into account for clustering. The results are shown in Fig 11-13 which gives the following summary.





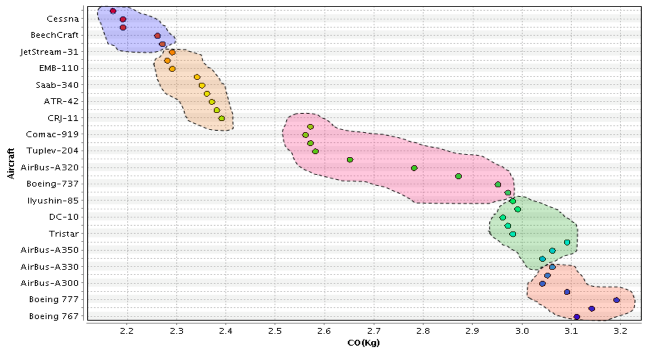


Fig. 11-13 Clustering Aircrafts

An average of 12 aircrafts maintaining low emissions and echo friendly to surroundings and 8 aircrafts are releasing high emissions to affect environment. There is a need to adopt good environment policies and improve aircraft machinery to reduce Bio-Hazardous emission rates.

Table- 1: Rate of Emissions

Gas	Low Emission rate Flights	High Emission rate Flights
SO_2	4	12
CO_2	8	12
CO	8	10
HC	13	10
VS	8	3
NVS	4	8
HV	4	8
NO_x	8	4

The flights represent the percentage of usage by airports in this work per 140 flights of various types used in a famous airport with heterogeneous services. There are 40.7% aircrafts are with low emission rate under service and 59.2% flights are with high emission rate under service. It is clear that by above summary there is a need of more improvement in technology, policies and maintenance of aviation systems globally needed in current situations. The major factors influencing aircraft emissions are listed in Table 2.

Table- 2: Factors Influencing Aviation Systems

Factor	Influencing Rate
Aircraft Technology	64.5%
Environment Policy	21.8%
Maintenance	16.9%
Utilization Scenarios	5.0%
Operational Services	45.6%
Airport Infrastructure	26.3%

VI. CONCLUSION

From the work carried in this paper we applied Machine Learning model to generate summaries of decisions among various aircraft emission characteristics. This analysis improves to estimate the future trend rates of emissions and the factors which influence the environmental impact emissions release at higher rates. Identification of airports which require environment policies and improvements in aircraft machineries with guidelines can be generated with this approach effectively. We can also identify the consequences of aircraft usages in contrast to echo friendly environments. The scalability of aircrafts with current passenger and other services estimated with reference to their environmental impact factors using learning tools effectively. This approach can be also applied for Land transportation systems to improve their quality of service with a perspective of Eco protection view.

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