DOI: http://dx.doi.org/10.26483/ijarcs.v9i2.5559

ISSN No. 0976-5697

Volume 9, No. 2, March-April 2018

International Journal of Advanced Research in Computer Science

SURVEY REPORT

Available Online at www.ijarcs.info

NLP TOOLS USED IN CIVIL AVIATION: A SURVEY

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***Abstract*:** In this paper we have a look at the various application tools of NLP applied in the field of Civil Aviation. Civil aviation flights around the world are in huge demand. Order books of major Aircraft manufacturers such as Boeing, Airbus, Embraer etc are overflowing and delivery schedules for the next few years are full. In *WINGS INDIA 2018* held at Hyderabad, Airbus reported that for the next 10 years India will be receiving one Airbus aircraft every week[1][2][3]. More aircrafts leads to more pressure on maintenance teams, ATC (Air Traffic Controller), ground marshals / crew and CNS (Communication Navigation Surveillance) handlers. MRO (Maintenance Repair and Overhaul) units by Boeing, Airbus, ATR apart from simulator Training units are coming up fast in countries like India, China, Srilanka and other countries, which calls for more automation of the day to day technical and maintenance works . NLP (Natural Language Processing) and AI (Artificial Intelligence) tools have been playing just the required role in a remarkable manner in managing incident reports, CNS assistance etc. The supporting role of NLP in maintenance, real time situation awareness and other areas are going to be a necessity in the foreseeable future.

***Keywords*:** *NLP, MT, CNS, ATC, Aviation, AI, ICAO, MRO*

1. INTRODUCTION

AIRBUS has forecasted that in between 2017 and 2036 the Asia-Pacific region will account for 41 percent of passenger aircrafts above 100 seats and freighters over 10 tons that is 14,280 aircrafts, with total demand of 34,900 aircrafts around the world [3] . In addition to it are already in-service crafts and those which are joining the fleets around the world from the long list of older order queues.

Maintenance of such a large number of aircrafts to keep them flying will be a huge challenge and automated tools using NLP can help a lot in such cases. NLP which is supposed to fulfill the dream of translation of languages from one to another through machine translation can also help in Intelligent document search engines for product life cycle management, tapping business policies and procedures, including huge quantity of documents, are now being used heavily by both mechanics and engineer.

Transfer of maintenance manuals from one language to another (using Machine Translation) will help cut across language barriers and engineers around the world speaking different languages can easily understand and adapt to the details of technical maintenance manuals easily.

Incident reports of pilots, controllers, Air Crew and Passengers can be collected and processed (e.g. ASRS Aviation Safety Report System of USA). Such systems can be used for detail analysis thereby avoiding accidents and repetition of such incidents.

NLP tools are widely used in Aviation (maintenance, incident reporting, crew support etc). Research and surveys are continuously being undertaken in order to improve existing systems like moving away from traditional search methodology results, such as binary answer (Is the specific key word present? Yes or No), and which then leads to false positives (the key word is present but in the wrong context) and false negatives (the right context but without the key word), to read and analyze detail flight reports. [4][5]

2. NLP TOOLS USED IN AVIATION

The following are some NLP tools that are being developed or used in the field of Civil Aviation**.**

2.1 TUAM AVIATION :

The TAUM AVIATION project was undertaken in 1976, in Canada by the CETADOL research centre in computational linguistics at University de Montreal (later renamed to TAUM). The aim of the project was to create English to French Machine Translation system which could translate maintenance manuals of aircrafts. In 1979 A Prototypes was developed which performed translation of maintenance and hydraulic manuals. The TAUM AVIATION project was done in the following environment; Hardware: CYBER 173 and Operating System : NOS/BE 1.4

Dedicated dictionaries and grammars were used which in turn were compiled into an object code. This code was then compared and transformed at run time considering the input text.

The source maintenance manuals were in English. The dictionary consisted of core vocabulary and had the following data: 4054 unique entities and the English-French Bilingual dictionary consisted of 3280 unique entities. [6]
The Machine Translation that was used was fully automatic. Input of text was done in a photocomposition format which was ready to be processed. Human intervention in pre-editing was not necessary. whenever unidentified words were encountered, these were entered after lookup in the dictionary. [6] Unfortunately the Project was terminated before reaching a stage where a proper and detail assessment could be made.

2.2 IBM WATSON

It is a NLP tool that uses NLP-MT and Cognitive computing in aviation. IBM has worked in many aspects of airline information processing. IBM with the wonderful question-answering capacity of Watson and using Machine Translation and Natural Language Processing, helps pilots deal with real time maintenance challenges. IBM has taken help of customer service agents, flight attendants, pilots and technical staff, to provide real time service to the aviation maintenance and support .

Questions put up to Watson in human spoken language are completely intelligible to it. It can recommend suggestions in real time based on earlier occurrences. Neural Machine translation based on RNN helps WATSON in understanding scenarios and consider previous occurrences. Machines such as Watson are real time systems used not only in LAW, Medicine but also in Aviation [7]

Let us take a scenario: if an aircraft suddenly develops a problem with a hydraulic system, The pilot can simply describe / speak the problem, that is in natural human language. The work of Watson is to interpret the problem from a logical viewpoint and then to consider all the concerned technical data pertaining to a solution. It then makes a series of recommendations to the pilot on how to modify operation of the aircraft to mitigate the problem, on how to troubleshoot it, or an alternate or nearest airport to divert to. Using Neural structure Watson will consider all possible options and recommend the optimal one. [7]

Such type of AI systems using NLP and MT are going to form the backbone of incident management and reporting system of the aviation world.
Courses are available at (https://www.watson-academy.info/course/index.php?categoryid=35)
Which introduces state-of-the-art natural language processing methods , with a focus on the technicalities related to IBM Deep Question Answering (Watson) system.

2.3 AMRIT

1Ansah is a company located in Sydney which is trying to help mechanics easily use technical documents while working on helicopters at Airbus Group Australia Pacific using a tool called AMRIT.

AMRIT uses NLP to “READ” 1.2million documents or digital manuals of the following types :

Table 1: Types of manuals for AMRIT

Types of Manuals	Company
maintenance manuals	Airbus
component manuals	Airbus
service bulletins	Airbus
airworthiness directives	Airbus
fault-isolation manuals	Airbus

The Idea is to make an Index related to various tasks by analyzing sentences and grammar in the various above listed manuals. using statistics it learns from previous successes instances of solving problems. once technicians confront similar problems the previously learnt instances are suggested to the technicians

AMRIT, requires proper training to be done depending on the type of aircraft maintenance to be done. It is a fully developed product which is successful in the aviation market. To go through company’s policies and technical procedures amounting millions of documents it uses a search engine that searches document smartly . AIRBUS which manufactures both Fixed wing aircrafts and helicopters has used it on one of its helicopter models to develop fault isolation system. Technicians mechanics, developers MRO engineers now use it. [8] [9]
To deal with huge amount of manuals and queries, help of multiple servers are taken so that parallel processing can be done to achieve the final product.
Hardware configuration is of a Linux server farm consisting of seven servers, which strictly follows Airbus specified infrastructure and configuration. [8][9]
AMRIT in its next stage is being prepared to take in manuals and documents for fixed-wing aircraft and other rotor based models. Then training and testing are to be done in order to field it for real time testing.
1Ansah’s support product of aircraft maintenance and others like it have prospects that are limitless and after Airbus prospective future clients of AMRIT includes Engineering branch of Etihad Airways, Singapore Airlines Engineering Co. ,MRO of Emirates and Lufthansa MRO.

2.4 BLUE

Boeing’s NLP system, BLUE (***Boeing Language Understanding Engine***), consists of the following: 1.Parser , 2.logical form (LF) generator, 3. initial logic generator, and 4. processing modules. [10]

Table 2: Stages of BLUE

1	Parser	has broad coverage and is domain general
2	LF generator	deals with a large subset of linguistic phenomena, including simple sentences, prepositional phrases, compound nouns, ordinal modifiers, proper nouns, some simple types of coordination, adverbs, negation, comparatives, and modals the logical form generator
3	Initial logic Generator	initial logic generator performs a straightforward transformation of the LF to first-order logic syntax
4	Processing	processing modules then perform word

	modules	sense disambiguation, semantic role labeling, co-reference resolution, and some limited metonymic and other transformations

BLUE, is able to generate representational structures for many texts, using numerous linguistic aspects while also missing a variety of others. Each sentence of every paragraph are considered individually, and each sentence is processed . BLUE has a pipelined architecture with multiple transformation steps through which it processes each sentence. Though BLUE produces a output that is good enough for controlled architecture language , such as technical manuals , maintenance manuals etc., but in some cases human assistance may be required to find out the real meaning of the sentence. [10]

2.5 "PLUS" by SAFETY DATA and "Partial Automation of Aircraft Parts" by ATOS

2.5.1 PLUS

Safety Data uses 'PLUS', which uses NLP to read and analyze flight reports. Traditional search methodology generally results in a binary answer (Is the specific key word present? Yes or No), and therefore leads to false positives (the key word is present but in the wrong context) and false negatives (the right context but without the key word). NLP which is a part of AI, Linguistics and Computer Science allows them to weigh a text (here flight reports) depending on its likelihood of addressing the desired topic[4] [5]

The **PLUS** Process can be summarized as follows:

Table 3: Stages of PLUS

STEPS	ROLE
DATA INTEGRATION	PLUS's mediation layer is completely programmable in order to filter and standardize incoming data, which can adapt to any static or dynamic data source.
INVESTIGATE	Queries coupled with logic help in searching for similar occurrences.
NEW KNOWLEDGE	Human assistance and the ability of PLUS to learn allows it to add new knowledge and data related to the concerned work.
GENERATION of WATCH REPORTS	Incoming data is always watched and watch-reports are created in real time. It also helps in making suggestions and decisions in risk handling and prioritization

2.5.2 : Automation of Aircraft Parts by AToS

AToS, is an international information technology services company Serving a global client base, it delivers IT service, based on Machine Learning has undertaken a project which aims to partly automatize the design of aircraft parts and use NLP applications in the process.

These techniques could bring about substantial improvements in the aviation industry, from enhancing safety to minimizing environmental impact. One of the disadvantages of Neural and Statistical Machine Translation and other NLP systems are that many of them suffer from data deficit. They unconditionally depend on access to large and sufficient data to perform complex analyses and get meaningful results. In such cases the quality of the input determines the quality of the output. Fortunately now open source projects and Data sources have been thriving; from 3D printing to the peer-to-peer economy, many of the most revolutionary inventions of the last decade have been the result of open-source collaborations. Indeed, the crowd-sourcing of data collection in aviation has begun, with Automatic Data Surveillance - Broadcast data exchange websites and apps, such as the Flightradar24.com, radarbox24.com, planefinder.com, Open Sky network. The European Union encourages open data exchange and associated projects and has involved sixteen airlines and Air Navigation Service providers who share data with the aim to improve aviation safety.

2.6 ASRS and ECCAIRS:

In 2012 the probability of dying on a single flight on one of the top 39 airlines was one in twenty million. air travel safety is continuously improved. In 2012 ICAO (2013) reported 2012 as have had the least rate of incidents and accidents (3.2 accidents for one million arrivals and departures) [11] In most of the cases, even when something serious occurs, example engine problems or Gear and hydraulics(front and rear) problems, the accident is avoided and the aircraft is able to land safely. Equipments such as ILS, ADS-B, Primary and secondary radar, training in Simulators and safety procedures imposed all throughout has contributed to safety. Air Transportation being a complex procedure requires efforts in all level to make it safe. Procedures incident reporting improves safety of flying.

Now moving on to reporting systems, although several systems exist at different levels for companies, government agencies and NGOs, two of the most widely used are ASRS (a North-American database of incident reports), and ECCAIRS (European Coordination Centre for Accident and Incident Reporting Systems) a software system proposed by Europe for managing incident reports at different levels. [11]

2.6.1 ASRS

The oldest (established in 1976) and most well known incident reporting system is known as ASRS which stands for Aviation Safety Report , which is managed by NASA. It is responsible for collecting reports of aviation events in the United States . [11][12] Its information sources contains data for maintenance, policy development, training. ASRS (https://asrs.arc.nasa.gov/) has processed over a million

incident reports. ASRS receives reports from pilots, air traffic controllers, cabin crew, dispatchers, maintenance technicians, ground personnel and others involved in aviation operations. reporting to ASRS has been remarkable all throughout, with 400 reports per month. In recent years, report intake has grown exponentially which averages to 1,769 reports per week and more than 7,664 reports per month.[12] It has 4 types of forms to report into :

Table 4 : Form types available in ASRS.

Form type	**Used by**
General	Pilots, Dispatchers, Others
Air Traffic control	Air Traffic Controllers
Maintenance	Mechanics
Cabin Crew	Cabin crew

This system targets several types of events from above mentioned sources. In general a regular ASRS report consists of particular entity or narrative field and attributes set. Each submitted report has multiple narrative fields corresponding to the incident report. The descriptors give detail data about the time, wind speed, cloud cover, location, type of aircraft and other instruments and parties involved. In detail description of the event with controlled values are created and are coded by the ASRS experts . [12]

ASRS products and services are as follows:

Table 5: ASRS products and their corresponding roles [4]

Products and Services	Role played
Alert messages	Safety information issued to organizations and possible corrective actions.
Quick responses	Rapid data analysis by ASRS Staff with immediate operational importance.
ASRS database	Public online database : available in DB report sets and search requests.
Call back	Monthly newsletter available via website and email
ASRS direct line	Safety topics published to meet the needs of operators and flight crew.
Focused study / Research	Studies and research conducted on safety topics in cooperation with aviation organizations

2.6.2 ECCAIRS :

ECCAIRS (European Coordination Centre for Accident and Incident Reporting Systems) standardize accident and incident data collection and exchange within the European Union. ECCAIRS was developed by the European Commission's Joint Research Center. Its aim is to assist entities in Europe to collect, share and analyze safety data and try to improve safety in transportation. Its information are free to be used by researchers and others . it is a software platform using the following taxonomy of ICAOs Accident/incident Data Reporting and covers collection, and knowledge extraction of incident reports. The European Coordination Centre for Accident and Incident Reporting Systems and the Safety Recommendation Information System are based on the (ECF). ECF is a software developed by the Joint Research Centre of European commission responsible to report and share accident and incident reports. It is used by national agencies of several countries, including the French DGAC. The reports collected by DGAC are similar to those of ASRS, with the notable distinction of being written in several languages (French and English).[13] [14]

COMPARATIVE STUDY:

Global Information Sharing Systems (GAIN) a part of FLIGHT SAFETY FOUNDATION has initiated projects and developed products to reduce risk and improve aviation safety worldwide. Some of its projects / studies include:
"Safety Event Descriptor Codes International Standards Development, Lessons Learned and Corrective Actions" [4]
"Sharing Systems for the Aviation Safety Community Automated Airline Safety Information Sharing Systems"[4] .
Of our interest is a survey *"Machine Translation of Language for Safety Information Sharing Systems"*.[4]
The capacity of MT tools relevant for flight safety officers to share data in multiple languages is viewed at. Detail cost comparisons and ICAO language comparisons are done in this study [4].

The Report goes through the various types of translation methods like Direct, Indirect (Interlingua, transfer), controlled language, sublanguage systems etc. and translations demands such as Dissemination, Assimilation, and other methods.
Ultimately the report narrows down to Stand Alone machine and Server based Machine Translation systems and does a comparative study of the MT systems/tools available in between different languages and the cost of each of them. The report also goes through the disadvantage of both the Server based and Stand alone MT S/W's. some of the Stand alone MT S/W's which could be used for ICAO languages as of 2004 are listed in Table 6. we see that there is a coverage gap for six IACO languages (English, French, Chinese, Arabic, Spanish, Russian)

Table 6: Table for stand alone MT systems for ICAO compatible languages

Machine Translation Software	Language pairs/costs
MLTS	English-French (403 Euros) English-Arabic (480 Euros) French-Arabic (480 Euros)
LogoMedia	English-Spanish (163 Euros)
TranSmart	English-Finnish (329 Euros)
HonYaku	English-Japanese (797 Euros)
SysTran	French-Spanish(258 Euros)
LogoVista	French-Japanese(610 Euros) Spanish-Japanese(610Euros)

Table 7:Comparision of Server based and Stand Alone MT tools.

Server based MT tools	**Stand alone MT tools**
Price is significantly higher (8000 Euros including after-sales service) compared to Stand alone MT systems	Prices range from 100 to 800 Euros
Generally Licensed for specific language pairs	Sometimes licensed for multiple language pairs
Contract for one to several years (depending on package)	Tools once bought can be used throughout.
Software updates, Translation-Engine updates, vocabulary updates available	No such facility available
Customer can call for technical support	No technical support available (In most cases)
Multiple CPU support available	No such support available.

In this paper we have come across some NLP tools that is helping various Aircraft manufacturers produce crafts faster and better and also some NLP tools that help us in storingincident reports and help us to have a safer future for aircrafts by helping to identify the problems and how to avoid the incidents and in turn accidents. Let's compare the tools covered in this paper in the table below:

Table 8 : comparison table of tools covered in the paper.

Name of the Tool	Used by (Company, Country, Area)	Purpose
TUAM AVIATION	CANADA	Transfer of Maintenance Manuals from French to English
IBM WATSON	USA	Question-Answering capacity, pilots deal with maintenance challenges in flight
AMRIT	AIRBUS HELICOPTERS	To provide guidance with use of digital maintenance manuals, component manuals, service bulletins, airworthiness directives and fault-isolation manuals to help maintenance of aircrafts
BLUE	BOEING, USA	Language Understanding Capability
PLUS	ATR, Air France, EASA, France	Generates one consolidated reliable information source from sets of unstructured data in incident reporting of Aviation.
Automation of Aircraft Parts by ATOS	Bezons, France	Partial automation of design of Aircraft parts by using Speech based NLP
ASRS	NASA, North America	Interpretative descriptors are used to describe the event with controlled values (categories) using incident reporting databases
ECCAIRS	European Union	Assistance to European and other transport entities to collect, share and analyze safety data for improving public safety

CONCLUSION:

The demand and need for NLP based maintenance tools are increasing with each passing day with more and more aircrafts coming in the market. As of 2017 the market for Artificial Intelligence, NLP and Machine Translation together in aviation market was USD 112.3 Million and by 2015 it may go up to USD 2,222.5 Million.[15] The NLP tools discussed in this paper and their likes are most likely going to form the backbone of NLP applications in Aviation (both Civil and Military). While tools related to Maintenance and operational manuals has evolved from translating from French to English (*Tuam Aviation*) to giving real time maintenance guidance (*AMRIT*), achieving reduced time frame, still further research can be conducted not only to increase the number of documents, business policies and procedures for various companies in the Tool's Databases but also translation from English / French to regional languages.

Tools like IBM WATSON are not only restricted to aviation and space but are also being used in Health and Law. The development of such NLP tools can also be extended to other sectors like tourism, medical tourism etc.

Research thrust may be given on Automatic Classification of reports which is now increasing day by day. Such tools can improve the usability of large databases of maintenance, policies and incident reports.

Other research areas involve developing tools that will be able to display not only real time aircraft position but also local and global weather conditions and thus predict flight paths and expected turbulence.

Airports, Aviation organizations issues NOTAM (Notice To Airmen) and Airlines issues information over social media such as Twitter / Facebook and alike on the condition of local weather and subsequent delay/rescheduling of flights which are readily available but not in a centralized manner. These information are generally not cross referenced which may lead to misinformation. Such news feeds can be brought together by NLP applications and predictions based on facts can be displayed by future NLP based tools benefiting travelers, ATC controllers and others.

With multiple MRO (Maintenance Repair and Overhaul) units coming up in countries like India, Srilanka , China , Engineers and technicians speaking local and diverse

languages are being employed. NLP based Speech to Speech, Speech to Text translation systems based on Machine Translation specifically designed for aviation domain are a must.

ACKNOWLEDGMENT

I would like to express my gratitude to Prof. Bipul Syam Purkayastha , Department of CS, Assam University Silchar, Mr. Arnab Kumar Das, manager CNS, AAI Silchar Airport, and Mr. Dipalay Dey Assistant Manager , Centrum Defense Systems Ltd for their constant guidance and support. I am very indebted to my parents B.B. Paul and Gouri Paul, wife Arpita dey, Son Shreyansh paul and Daughter Aishani Paul for their love and support in all respect.

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