CHAPTER – 1

INTRODUCTION

Aviation comes from the Latin word meaning "bird," an appropriate translation given that aviation deals with travel by air, specifically in a plane. The aviation industry is the business sector dedicated to manufacturing and operating all types of aircraft. Aviation safety means the state of an aviation system or organization in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level. It encompasses the theory, practice, investigation, and categorization of flight failures, and the prevention of such failures through regulation, education, and training. It can also be applied in the context of campaigns that inform the public as to the safety of air travel. Air Traffic Control which is popularly known as "ATC", is a communication-based method through which the pilots in the air are given proper instructions and commands in controlled airspace to safely manoeuvre the aircraft from any dangerous situation and land the aircraft safely in an orderly fashion. Not only on the air but even on the ground it is the Air Traffic Controller's responsibility to guide to the aircraft through the airport to the runway if it's a departing aircraft and to the parking bay if it has just arrived. The ground based controller must accomplish two main tasks. The first task is to ensure all aircrafts are safe. The second task is to provide information to pilots. Air Traffic Controllers, who maintain the flow of aircraft in and out of airports and in flight, are key to aviation safety. So this is well recognized as one of the most stressful jobs, requiring total concentration. Radar controllers, as opposed to tower controllers, also have to work in semi-darkness with an airplane full of passengers in their sight as a mere luminous blip on the screen. The 24/7 staffing of the Air Traffic system sometimes requires more than 40 hour days including nights and weekends. This creates physical as well as mental stress and results in human-errors. So Air Traffic Control ranks' 4^{th} in the

all-time most stressful jobs in the world by Bureau of Labor Statistics. So our goal is to automate a part of Air Traffic Services which is Approach and Clearance Control considering the normal or usual conditions alone.

1.1 INTRODUCTION TO AIR TRAFFIC CONTROL

Air traffic control (ATC) is a service provided by ground-based air traffic controllers who direct aircraft on the ground and through controlled airspace, and can provide advisory services to aircraft in non-controlled airspace. The primary purpose of ATC worldwide is to prevent collisions, organize and expedite the flow of air traffic, and provide information and other support for pilots. In some countries, ATC plays a security or defensive role, or is operated by the military.

Air traffic controllers monitor the location of aircraft in their assigned air space by radar and communicate with the pilots by radio. To prevent collisions, ATC enforces traffic separation rules, which ensure each aircraft maintains a minimum amount of empty space around it at all times. In many countries, ATC provides services to all private, military, and commercial aircraft operating within its airspace. Depending on the type of flight and the class of airspace, ATC may issue instructions that pilots are required to obey, or advisories (known as flight information in some countries) that pilots may, at their discretion, disregard. The pilot in command is the final authority for the safe operation of the aircraft and may, in an emergency, deviate from ATC instructions to the extent required to maintain safe operation of their aircraft.

1.1.1 AIRPORT TRAFFIC CONTROL TOWER

The primary method of controlling the immediate airport environment is visual observation from the airport control tower. The tower is a tall, windowed structure located on the airport grounds. Air traffic controllers are responsible for the separation and efficient movement of aircraft and vehicles operating on the

taxiways and runways of the airport itself, and aircraft in the air near the airport, generally 5 to 10 nautical miles (9 to 18 km) depending on the airport procedures.

Surveillance displays are also available to controllers at larger airports to assist with controlling air traffic. Controllers may use a radar system called secondary surveillance radar for airborne traffic approaching and departing. These displays include a map of the area, the position of various aircraft, and data tags that include aircraft identification, speed, altitude, and other information described in local procedures. In adverse weather conditions the tower controllers may also use surface movement radar (SMR), surface movement guidance and control systems (SMGCS) or advanced SMGCS to control traffic on the maneuvering area (taxiways and runway).

The areas of responsibility for tower controllers fall into three general operational disciplines: local control or air control, ground control, and flight data or clearance delivery—other categories, such as Apron control or ground movement planner, may exist at extremely busy airports. Remote and virtual tower (RVT) is a system based on air traffic controllers being located somewhere other than at the local airport tower and still able to provide air traffic control services. The complex structure comprises an elongated ground building for administration and technology, a 70m tower shaft and a flight station for the controllers – a 16-corner polygon on an elliptical floor plan in the pinnacle of the tower shaft. Two boxes, suspended from the tower shaft, accommodate server rooms, staff rooms and a crisis room. The new ATC Tower at Heathrow is a new prominent feature at the airport. The tower was designed by the Richard Rogers Partnership and engineered by Arup. The tower reached an important stage at the end of 2005 with a topping-out ceremony when its full height of 87m (285ft) was achieved. The topping-out ceremony involved gold bolts being tightened ceremoniously at the base of the tower to mark the completion of the main structure. The new tower is more than twice the height of the old tower and will

offer better unobstructed 360° views of the airport for controllers. Fig 1.1 shows Air Traffic Control tower of London Heathrow Airport and Fig 1.2 shows tower interior.

Fig 1.1 London Heathrow Airport ATC Tower.

Courtesy: pinterest.com

Fig 1.2 ATC tower Interior.

Courtesy: boldmethod.com

1.1.2 GROUND CONTROL

Ground control (sometimes known as ground movement control) is responsible for the airport "movement" areas, as well as areas not released to the airlines or other users. This generally includes all taxiways, inactive runways, holding areas, and some transitional aprons or intersections where aircraft arrive, having vacated the runway or departure gate. Exact areas and control responsibilities are clearly defined in local documents and agreements at each airport. Any aircraft, vehicle, or person walking or working in these areas is required to have clearance from ground control. This is normally done via VHF/UHF radio, but there may be special cases where other procedures are used. Aircraft or vehicles without radios must respond to ATC instructions via aviation light signals or else be led by vehicles with radios. People working on the airport surface normally have a communications link through which they can communicate with ground control, commonly either by handheld radio or even cell phone. Ground control is vital to the smooth operation of the airport, because this position impacts the sequencing of departure aircraft, affecting the safety and efficiency of the airport's operation. Fig 1.3 shows ground control staffs.

Fig 1.3 Ground Control staffs

Courtesy: internationalairportereview.com

1.1.3 AIR CONTROL OR LOCAL CONTROL

Air control (known to pilots as "tower" or "tower control") is responsible for the active runway surfaces. Air control clears aircraft for takeoff or landing, ensuring that prescribed runway separation will exist at all times. If the air controller detects any unsafe conditions, a landing aircraft may be instructed to "go-around" and be re-sequenced into the landing pattern. This re-sequencing will depend on the type of flight and may be handled by the air controller, approach or terminal area controller.

Within the tower, a highly disciplined communications process between air control and ground control is an absolute necessity. Air control must ensure that ground control is aware of any operations that will impact the taxiways, and work with the approach radar controllers to create "gaps" in the arrival traffic to allow taxiing traffic to cross runways and to allow departing aircraft to take off. Ground control need to keep the air controllers aware of the traffic flow towards their runways in order to maximize runway utilization through effective approach spacing. Crew resource management (CRM) procedures are often used to ensure this communication process is efficient and clear. Within ATC, it is usually known as TRM (Team Resource Management) and the level of focus on TRM varies within different ATC organizations.

1.1.4 APPROACH AND TERMINAL CONTROL

Many airports have a radar control facility that is associated with the airport. In most countries, this is referred to as terminal control; in the U.S., it is referred to as a TRACON (terminal radar approach control). While every airport varies, terminal controllers usually handle traffic in a 30-to-50-nautical-mile (56 to 93 km) radius from the airport. Where there are many busy airports close together, one consolidated terminal control center may service all the airports. The airspace boundaries and altitudes assigned to a terminal control center, which vary widely from airport to airport, are based on factors such as traffic flows,

neighboring airports and terrain. A large and complex example was the London Terminal Control Centre, which controlled traffic for five main London airports up to 20,000 feet (6,100 m) and out to 100 nautical miles (190 km).

Terminal controllers are responsible for providing all ATC services within their airspace. Traffic flow is broadly divided into departures, arrivals, and overflights. As aircraft move in and out of the terminal airspace, they are handed off to the next appropriate control facility (a control tower, an en-route control facility, or a bordering terminal or approach control). Terminal control is responsible for ensuring that aircraft are at an appropriate altitude when they are handed off, and that aircraft arrive at a suitable rate for landing. Fig 1.4 shows Approach and Terminal control room.

Fig 1.4 Approach and Terminal Control room.

Courtesy: airport-technology.com

1.1.5 AREA OR CENTER CONTROL

ATC provides services to aircraft in flight between airports as well. Pilots fly under one of two sets of rules for separation: visual flight rules (VFR) or instrument flight rules (IFR). Air traffic controllers have different responsibilities to aircraft operating under the different sets of rules. While IFR flights are under positive control, in the US and Canada VFR pilots can request flight following, which provides traffic advisory services on a time permitting basis and may also provide assistance in avoiding areas of weather and flight restrictions, as well as allowing pilots into the ATC system prior to the need to a clearance into certain airspace. Across Europe, pilots may request for a "Flight Information Service", which is similar to flight following. In the UK it is known as a "basic service". En-route air traffic controllers issue clearances and instructions for airborne aircraft, and pilots are required to comply with these instructions. En-route controllers also provide air traffic control services to many smaller airports around the country, including clearance off of the ground and clearance for approach to an airport. Controllers adhere to a set of separation standards that define the minimum distance allowed between aircraft. These distances vary depending on the equipment and procedures used in providing ATC services. Fig 1.5 shows Area Control room.

Fig 1.5 Area Control

Courtesy: Areacontrolcentre.com

1.1.6 RADAR COVERAGE

Since centers control a large airspace area, they will typically use long range radar that has the capability, at higher altitudes, to see aircraft within 200 nautical miles (370 km) of the radar antenna. They may also use TRACON radar data to control when it provides a better "picture" of the traffic or when it can fill in a portion of the area not covered by the long range radar. In the U.S. system, at higher altitudes, over 90% of the U.S. airspace is covered by radar and often by multiple radar systems; however, coverage may be inconsistent at lower altitudes used by unpressurized aircraft due to high terrain or distance from radar facilities. A center may require numerous radar systems to cover the airspace assigned to them, and may also rely on pilot position reports from aircraft flying below the floor of radar coverage. This results in a large amount of data being available to the controller. To address this, automation systems have been designed that consolidate the radar data for the controller. This consolidation includes eliminating duplicate radar returns, ensuring the best radar for each geographical area is providing the data, and displaying the data in an effective format.

Some air navigation service providers (e.g., Air services Australia, the U.S. Federal Aviation Administration, NavCanada, etc.) have implemented automatic dependent surveillance – broadcast (ADS-B) as part of their surveillance capability. This new technology reverses the radar concept. Instead of radar "finding" a target by interrogating the transponder, the ADS-equipped aircraft sends a position report as determined by the navigation equipment on board the aircraft. Normally, ADS operates in the "contract" mode where the aircraft reports a position, automatically or initiated by the pilot, based on a predetermined time interval. It is also possible for controllers to request more frequent reports to more quickly establish aircraft position for specific reasons. However, since the cost for each report is charged

by the ADS service providers to the company operating the aircraft, more frequent reports are not commonly requested except in emergency situations. ADS is significant because it can be used where it is not possible to locate the infrastructure for a radar system (e.g., over water). Computerized radar displays are now being designed to accept ADS inputs as part of the display. This technology is currently used in portions of the North Atlantic and the Pacific by a variety of states who share responsibility for the control of this airspace.

1.2 INTRODUCTION TO DATA MINING IN AVIATION (AIR TRANSPORT MANAGEMENT)

Data mining techniques are used to identify patterns and anomalies in Air Traffic Control Operational Errors (OEs). The reduction of Operational Errors plays an important role and remains a challenge in the aviation safety community. Traditional methods focuses on individual aspects of OEs, are limited to operations at a single facility. An attribute focusing technique is applied to study 15 years of operational errors at all FAA Air Route Traffic Control Centers (ARTCCs) 1 in the National Airspace System (NAS) in the U.S. to find 'interesting' patterns of common characteristics, anomalies, and changes in trends of operational errors. NASA has created tools to discover interesting patterns in large data sets in order to ensure its techniques can make a real impact on flight safety and efficiency to make things more accurate or user friendly. Southwest Airlines (fig 1.6) uses reported information to identify and communicate certain issues to Air Traffic Controllers, making them aware, for example, of how certain instructions impacted an airplane’s operations. By collaborating with them, Southwest has since seen a steady improvement in the quality of approaches. Like many airlines, Southwest has traditionally looked for performance issues in its data using exceedances checked against a model. During arrival, for instance, the plane might record an exceedance if it is travelling faster than 250 knots while its altitude is less than 10,000 feet.

Fig 1.6 Southwest Airlines B737

Courtesy: jetphotos.com

NASA's algorithms used by Southwest are the Multivariate Time Series (MTS) search and Virtual Sensors which are used in "letting the data speak for itself by finding unusual flights and candidate anomalies, without having any preconceived notion of what is normal or abnormal. But sometimes you find statistical anomalies that are not safety concerns, but the benefit is that sometimes you'll find anomalies that turns out to be safety concerns or have other operational significance, such as excessive fuel use. These algorithms helped Southwest Airlines to identify areas of concern in certain flight data. By working with its pilots and Air Traffic Control, the company has since seen an increase in the number of stable approaches by its aircraft. Like many airlines, Southwest has traditionally looked for performance issues in its data using exceedances checked against a model. During arrival, for instance, the plane might record an exceedance if it is travelling faster than 250 knots while its altitude is less than 10,000 feet. Each morning, the company looks at a report of all the exceedances that took place the previous day and decides what action to take in the case of

undesirable trends. By making use of data mining tools, Southwest can now query the data itself to figure out what normal operations really look like, thus making an impact on commercial flight safety.

1.2.1 DATA MINING IN AIR TRAFFIC FLOW FORCASTING

The Air Traffic flow prediction plays a key role in the airspace simulation model and Air Traffic flow management system. In China the Air Traffic information in each regional control center has not integrated together by now. Large collection of radar data is stored. But there is no effort made to extract useful information from the database to help in the estimation. Data mining is the process of extracting patterns as well as predicting previously unknown trends from large quantities of data. Neural network and statistics are frequently applied to data mining with various objectives. Here neural networks is combined with the statistical analysis of historical data to forecast the traffic flow. Two models with different types and input data are proposed. The accuracy of two models is tested and compared to each other using flow data at an arrival fix in Beijing control center. The result shows that these models are feasible for practical implementations. The suitable models for different prediction conditions are also suggested.

Many study centers has developed a model for the purpose of Air Traffic forecasting by using off-the-shelf data mining and machine learning techniques. Recent developments use data mining algorithms to predict the likelihood of previously un-connected airport-pairs being connected in the future, and the likelihood of connected airport-pairs becoming un-connected. Despite the innovation of this research, it does not focus on improving the FAA's existing methodology for forecasting future Air Traffic levels on existing routes, which is based on relatively simple regression and growth models. So different approaches are investigated for improving and developing new features within the existing data mining applications in Air Traffic forecasting. As part of future work,

machine learning techniques such as clustering and neural networks are getting applied to improve this model's performance.

1.2.2 DATA MINING IN AIR TRAFFIC FLOW MANAGEMENT AND ANALYSIS FOR INFLIGHT COST OPTIMIZATION

The Air Traffic volume has increased significantly over the world. So the great mass of traffic management data, named as Big Data, have also accumulated day by day. This factor presents more opportunities and also challenges as well in the study and development of Air Traffic Management (ATM). Usually, Decision Support Systems (DSS) are developed to improve the efficiency of ATM. Bayesian network approach is used for the data analysis to reduce the costs of flight delay. The process makes possible to adjust the flight plan such as the schedule of arrival at or departure from an airport and also checks the airspace control measurements considering weather conditions. An experimental study is conducted based on the flight scenarios between Los Angeles International Airport (LAX) and Miami International Airport (MIA).

1.2.3 DATA MINING METHODS TO INCREASE THE SAFETY AND REDUCE THE NEGATIVE ENVIRONMENTAL IMPACTS IN AVIATION

The Single Europe Sky Air Traffic Management Research (SESAR) program developed and implemented innovative technological and operational solutions to modernize European Air Traffic management and to eliminate the negative environmental impacts of aviation activity. This SESAR Solution aims to mitigate the risk of runway excursion, to optimize airport operation management by decreasing the number of runway inspections, to make chemical treatment effective with respect to the environment, and to increase resilience, efficiency and safety in adverse weather situations. This approach is based on the enhancement of runway surface condition awareness by integrating data from various sources. Dangerous windy conditions based on Lidar measurements are

also discussed as another relevant factor in relation to runway excursions. Four different data mining methods are explored to obtain runway conditions from the available input data sources, examines their performance and discusses their pros and cons in comparison with a rule-based algorithm approach. The output of the SESAR Solution is developed in compliance with the new Global Reporting Format of the International Civil Aviation Organization for runway condition description to be valid from 2020. This standard is expected to provide concerned stakeholders with more precise information to enhance flight safety and environmental protection.

1.3 RESPONSIBILITES OF AN AIR TRAFFIC CONTROLLER

- Coordinate the movement of air traffic to ensure that planes stay safe distances apart.
- Coordinate the arrival and departure of airplanes.
- Issue landing and takeoff instructions to pilots.
- Monitor and direct the movement of aircraft, using radar equipment.
- Authorize flight path changes.
- Provide weather updates to pilots.
- Alert airport response staff in the event of an aircraft emergency.
- Direct planes efficiently to minimize delays.
- Manage the flow of airplanes in and out of the airport.
- Guide pilots during takeoff and landing.
- Monitor airplanes as they travel through the skies.
- Check flight plans, give pilots clearance for takeoff or landing
- Direct the movement of planes on the runways and other parts of the airport.

- Sequence the arrival and departure of airplanes, and use radar equipment to monitor flight paths.
- Provide pilots with information on weather conditions.
- Monitor airplanes once they leave an airport's airspace.
- Look for traffic patterns that could create bottlenecks in the system.
- Keep traffic levels manageable for the airport and for en route controllers.
- Move all aircraft safely and efficiently through their assigned sector of airspace.
- Communicate with the pilots of aircraft using a push-to-talk radiotelephony system.
- Control aircraft within the immediate vicinity of the airport and use visual observation from the airport tower.

1.4 PROBLEMS IN AIR TRAFFIC CONTROL

With the rise in the airline industry and construction of new airports and runways, air traffic has increased dramatically in the past few years. It has put additional pressure on air traffic control system that handles thousands of flights per day. To avoid delays and collisions, air traffic management has to work efficiently. Many problems and challenges are faced by them. Some of the major problems faced by controllers are:

- Communication
- Weather
- Frequency Congestion
- Work
- Noise

The above problems are briefly described below.

- **Communication**

Air traffic controllers constantly need to intently listen to every single word said by pilots and other controllers. They need to be aware that what is going on in their space as well as other sectors around them. If a problem arises, they need to act on it at the very moment. It puts a lot of pressure on air traffic controllers.

- **Weather**

Another biggest issue for a controller is the weather. It adversely affects the work and function of air traffic control staffs. The more it is complex; the more workload is laden on them. A bad weather means a bad day for them.

- **Frequency Congestion**

Often simple things may turn complicated when there are too many persons are speaking on one frequency at a time. Each frequency can support only one person talking at a time, means either pilot or controller. A controller needs to master the flow of communication on that frequency.

- **Work**

If an air traffic control is managing 50,000 flights daily; they have to handle many flights at the same time. It means checking the altitude so that they don't collide against. Plus, multiple flights pass in the same route and during such situation if a flight face problem, they need to give special attention. However, the bigger problems occur when a passenger aircraft goes missing the radar range, or the radar of air traffic control goes down.

- **Noise**

Aircraft noise and its impact on local communities is also a major problem that needs attention. In the upcoming years, with the rise in aircraft

numbers, this issue is only going to trigger. It needs to make a balance between the needs of a country and managing the impact on local communities who are living close to airports.

1.5 ATC ERROR CATEGORIES

Based on many interviews, study, research and surveys of ATC safety experts, the ATC errors are categorized into three major categories. They are communication error, procedure error, and instruction error. The definition of each error category is as follows:

- **Communication Errors**

This refers to errors during radio communication. Communication error in ATC is divided into the two categories of errors that occur between a pilot and an air traffic controller, and the errors that occur between air traffic controllers. For instance, there are errors such as not challenging incorrect read back, using wrong call-signs, using non-standard phraseology, and missing and clipping the call sign.

- **Procedure Errors**

This involves incompliance with ATC procedures; for instance, failure to respond to an unanswered call, not responding to alarm, not identifying aircraft, failure to terminate radar services, not issuing approach clearance, not giving reasons for vectoring information, failure to deliver information to aircraft, etc.

- **Instruction Error**

This occurs while conducting control procedures and communications. Specifically, there are errors such as delivery of incorrect information, issuing descent instruction late, issuing flight phase change instruction late, direction instruction error and clearance instruction error. Table 1.1 describes Structure of

ATC human error elements, category of error, its explanation and operational definition.

CATEGORY	**EXPLANATION**	**OPERATIONAL DEFINITION**
Communication Error	Difficulties in communicative interaction or aeronautical operations	Incorrect Read back Not challenged
		Wrong call sign Used
		Non-standard Phraseology
		Missed call
		Callsign Omission/Truncation
		Clipped call
Procedure Error	Errors such as difficulties in following checklists	Failure to respond to unanswered call
		No/late response to alarm
		No level verification
		No Identification of aircraft
		Late/No Issuance of landing clearance

CATEGORY	EXPLANATION	OPERATIONAL DEFINITION
Instruction Error	Errors such as giving incorrect instructions	Incorrect information passed to aircraft
		Late descent
		Late change
		Altitude Instruction Error
		Heading Instruction Error
		Clearance Instruction Error

Table 1.1 Structure of ATC human error elements.

Courtesy: Air_traffic_control_human_errors.pdf

1.6 PROBLEM DEFINITION

Air traffic has increased dramatically in the past few years, mainly due to its comfortability and speed of travel, and this thereby created a revolution and rise in the airline industry and construction of new airports and runways. It has put additional pressure on air traffic control system that handles thousands of flights per day. To avoid delays and collisions, air traffic management has to work efficiently. The primary responsibility of an Air Traffic Controller is to instruct pilots in the air are given proper instructions and commands in controlled airspace to safely manoeuvre the aircraft from any dangerous situation and land the aircraft safely in an orderly fashion. Not only on the air but even on the ground it is the

Air Traffic Controller's responsibility to guide to the aircraft through the airport to the runway if it's a departing aircraft and to the parking bay if it has just arrived. The ground based controller must accomplish two main tasks. The first task is to ensure all aircrafts are safe. The second task is to provide information to pilots. Air Traffic Controllers, who maintain the flow of aircraft in and out of airports and in flight, are key to aviation safety. So this is well recognized as one of the most stressful jobs, requiring total concentration. Radar controllers, as opposed to tower controllers, also have to work in semi-darkness with an airplane full of passengers in their sight as a mere luminous blip on the screen. The 24/7 staffing of the Air Traffic system sometimes requires more than 40 hour days including nights and weekends. This creates physical as well as mental stress and results in human-errors. So Air Traffic Control ranks' 4th in the all-time most stressful jobs in the world by Bureau of Labor Statistics.

The below table 1.2 shows the major airplane accidents due to air traffic control human factors. It also describes the location, information of the aircraft and the major cause for the air crash.

DATE	**AIRCRAFT AND ACCIDENT OUTLINE**	**MAJOR CAUSE**
1956/6	In the airspace over Grand Canyon, the United States, DC-7 aircraft of UAL and L-1049 aircraft of TWA (both flying under Instrumental Flight Rules (IFR)) had a mid-air collision at 20,000 feet, causing death of all 128 passengers.	Air traffic congestion Shortage of controlling facility Shortage of ATC manpower Insufficient delivery of Traffic information

DATE	AIRCRAFT AND ACCIDENT OUTLINE	MAJOR CAUSE
2002/7	While controlled by the ACC of Zurich, Switzerland, TU-154 aircraft of Russian Bashkirian Airlines and B757 cargo aircraft of the U.S. DHL were flying on a collision course at the same altitude (FL360). Both airplanes descended to avoid each other, then the Bashkirian aircraft collided at a right angle with the Boeing cargo aircraft at FL354, killing all 71 passengers.	ATC instruction error RADAR malfunction (Short Term Conflict Alert) Route congestion Shortage of ATC manpower

Table 1.2 Major airplane accidents related to ATC human factor.

Courtesy: Air_traffic_control_human_errors.pdf

1.7 OBJECTIVE

Since aviation is currently experiencing an enormous increase in aircraft flow and air traffic, it has put additional pressure on air traffic control system that handles thousands of flights per day. To avoid delays and collisions, air traffic management has to work efficiently and it's their responsibility to instruct pilots in controlled airspace to safely manoeuvre the aircraft from any dangerous situation and land the aircraft safely in an orderly fashion. Air Traffic Controllers, who maintain the flow of aircraft in and out of airports and in flight, are key to aviation safety. So this is well recognized as one of the most stressful jobs, requiring total concentration. Radar controllers, as opposed to tower controllers, also have to work in semi-darkness with an airplane full of passengers in their sight as a mere luminous blip on the screen. The continuous staffing of the Air

Traffic system sometimes requires more nights and weekends. This has created an additional responsibility mainly for the controllers and thus this results in physical as well as mental stress and might cause human-errors. So main objective of this project is to implement the concept of LSTM (Long Short Term Memory) in Air Traffic Services. Our goal is to automate a part of Air Traffic Services which is Approach and Clearance Control considering the normal or usual conditions alone.

1.8 KEYWORDS

Air Traffic Services play an important role in aviation. We all fly, but ATC's work, uses and importance are not known by many. In this new concept, the following are some keywords used.

- Aviation
- Air traffic Control
- Approach Control
- Clearance Control
- Voice recognition
- Call Sign
- Flight Plan

1.8.1 AVIATION

Aviation comes from the Latin word meaning "bird," an appropriate translation given that aviation deals with travel by air, specifically in a plane. Aviation refers to flying using an aircraft, like an airplane. It also includes the activities and industries related to flight, such as air traffic control. The biggest of the many uses of aviation are in air travel and military aircraft.

1.8.2 AIR TRAFFIC CONTROL

Air Traffic Control (ATC) is a service provided by ground-based Air Traffic Controllers who direct aircraft on the ground and through

controlled airspace, and can provide advisory services to aircraft in non-controlled airspace. The primary purpose of ATC worldwide is to prevent collisions, organize and expedite the flow of Air Traffic, and provide information and other support for pilots. In some countries, ATC plays a security or defensive role, or is operated by the military.

1.8.3 APPROACH CONTROL

Aircraft control system needs to be incredibly managed and well-prepared to make the propellation of aircraft safe. Approach control is responsible for controlling all instrument flight operating within its area of responsibility. Approach control may serve one or more airfields, and control is exercised primarily by direct pilot and controller communications. It separates all aircraft, including large and small jet aircraft, according to the guidelines set out through the Terminal Radar Approach Control (TRACON) service.

1.8.3.1 Terminal Radar Approach Control (TRACON)

A TRACON is the name in the US for what is also known in other countries as the Terminal Control Center, the control in charge of operations close to one or more large airports (but not on the airports themselves). TRACON manage arrivals and departures, the related transitions to/from cruise, and also aircraft transiting in their area. The following are the services of TRACON:

- Safety alerts
- Traffic Services
- Limited radar vectoring (including assistance for VFR traffic) on a workload permitting basis
- Sequencing at locations where procedures have been established for this purpose and/or when covered in a Letter of Agreement (LoA)
- Will keep the pilot informed of the latest reported weather and actual field conditions such as current ceiling, runway visibility, surface winds, and runway conditions

1.8.4 CLEARANCE CONTROL

A clearance issued by ATC is predicated on known traffic and known physical airport conditions. An ATC clearance means an authorization by ATC, for the purpose of preventing collision between known aircraft, for an aircraft to proceed under specified conditions within controlled airspace i.e. Clearances are issued solely for expediting and separating air traffic and are based on known traffic conditions which affect safety in aircraft operation. The traffic conditions include:

- aircraft in the air;
- aircraft on the manoeuvring area;
- vehicles on the manoeuvring area;
- Obstructions not permanently installed on the manoeuvring area.

ATC clearances do not constitute authority to violate any applicable regulations for promoting the safety of flight operations or for any other purpose; neither do clearances relieve a pilot-in-command of any responsibility whatsoever in connection with a possible violation of applicable rules and regulations. If an air traffic control clearance is not considered suitable by the pilot-in-command of an aircraft, the flight crew may request and, if practicable, obtain an amended clearance.

1.8.5 VOICE RECOGNITION:

Voice recognition is alternatively referred to as speech recognition. Voice recognition is a computer software program or hardware device with the ability to decode the human voice. Voice recognition is commonly used to operate a device, perform commands, or write without having to use a keyboard, mouse, or press any buttons. Today, this is done on a computer with ASR (automatic speech recognition) software programs. In Air Traffic ensuring ATC systems, voice recognition turns speech to text and text to speech.

But introducing higher levels of automation in Air Traffic management (ATM) is the intensive use of voice radio communication to convey ATC instructions to pilots. Automatic speech recognition, which converts human speech into texts, can provide a solution to significantly reduce controllers' workloads and increase ATM efficiency. Automatic speech recognition, which converts human speech into texts, is currently captured through keyboard and mouse devices can provide a solution to significantly reduce Air Traffic Controllers' workloads and increase ATM efficiency. Fig 1.7 represents voice recognition.

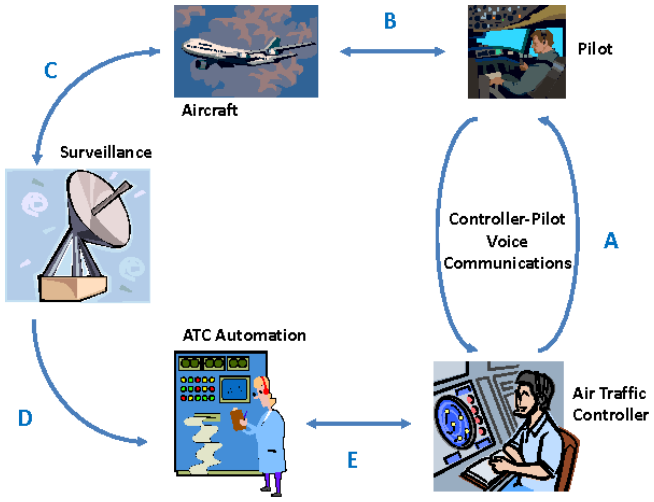

Fig 1.7 Voice recognition

Courtesy: Fsearchcustomerexperience.techtarget.com

1.8.6 CALL SIGNS:

Call signs in aviation are derived from several different policies, depending upon the type of flight operation and whether or not the caller is in an aircraft or at a ground facility. In most countries, unscheduled general aviation flights identify themselves using the call sign corresponding to the aircraft's registration number (also called *N-number* in the U.S., or *tail number*). In this case, the call sign is spoken using the International Civil Aviation Organization (ICAO) phonetic alphabet. Aircraft registration numbers internationally follow the pattern of a country prefix, followed by a unique

identifier made up of letters and numbers. At times, general aviation pilots might omit additional preceding numbers and use only the last three numbers and letters.

1.8.7 FLIGHT PLAN:

An ATC flight plan is a document which provides specified information to Air Traffic service units relative to an intended flight or portion of a flight of an aircraft. (ICAO Annex 2: Rules of the Air) A navigation flight plan is a document prepared in accordance with the instructions of the operator contained in the Operations Manual and used in flight by the pilot to assist in navigation and safe operation of the aircraft. Detailed rules regarding submission, contents, completion, changes to, and closing of a flight plan are contained in ICAO Annex 2 (Rules of the Air) and in national flight information publications. A flight plan may be filed as a written document, an electronic document, or may be filed verbally. A flight plan contains such of the following information as is relevant to the flight:

- Aircraft identification
- Flight rules and type of flight
- Number and type(s) of aircraft and wake turbulence category
- Equipment
- Departure aerodrome
- Estimated off-block time
- Cruising speed
- Cruising level
- Route to be followed
- Destination aerodrome and total estimated elapsed time
- Alternate aerodrome
- Fuel endurance
- Total number of persons on board

- Emergency and survival equipment
- Other information.

All these essential information will be provided by the pilot, which is all about the plane that he is going to operate and submits this flight plan to the Chief controller. Fig 1.8 shows the real time flight plan of Sri Lankan Airlines.

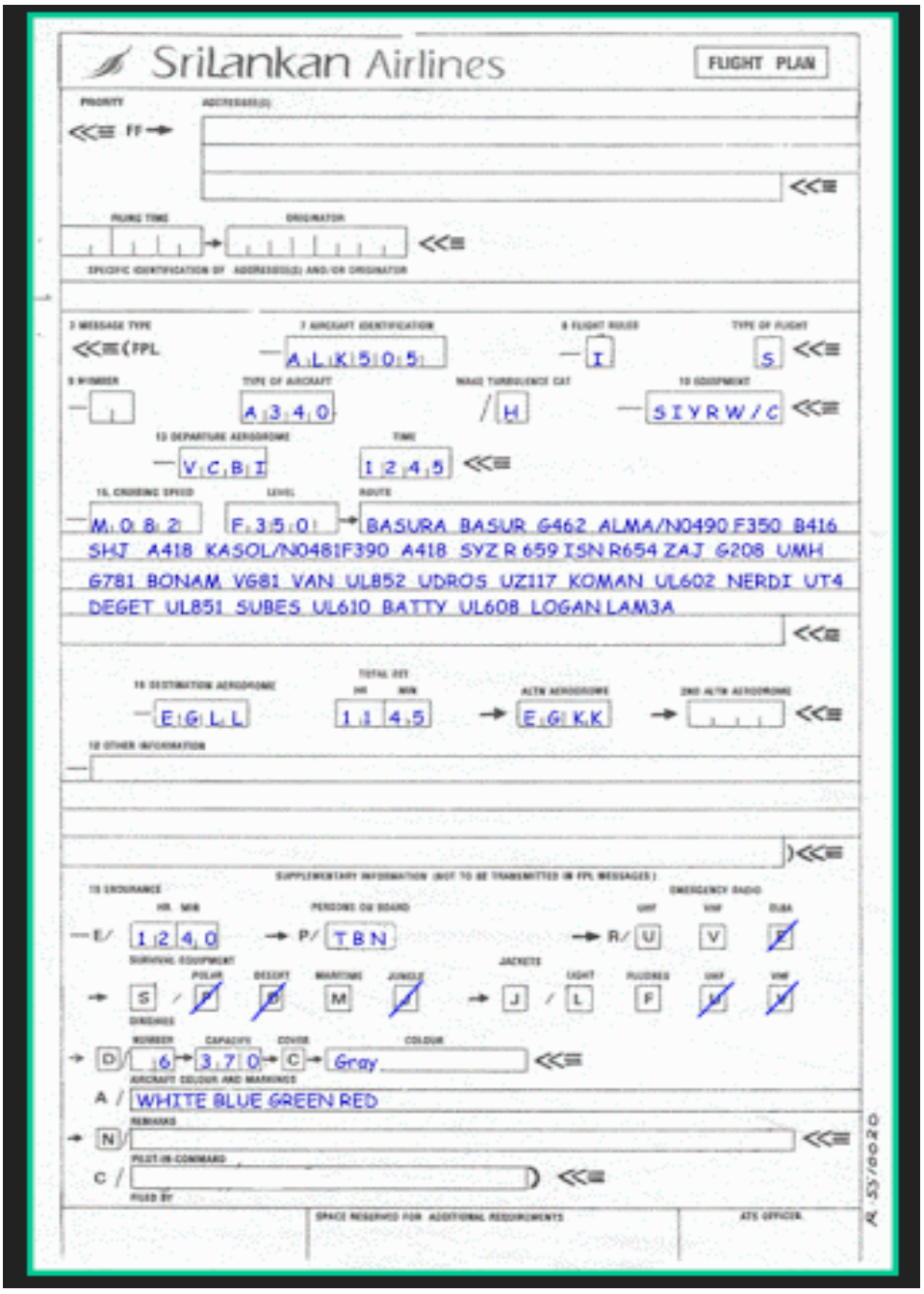

Fig 1.8 Flight Plan of Sri Lankan Airlines

Courtesy: atcsl.tripod.com

1.9 AN OUTLINE OF EXISTING SYSTEM

Air traffic control (ATC) is a service provided by ground-based air traffic controllers who direct aircraft on the ground and through controlled airspace, and can provide advisory services to aircraft in non-controlled airspace. Not only on the air but even on the ground it is the Air Traffic Controller's responsibility to guide to the aircraft through the airport to the runway if it's a departing aircraft and to the parking bay if it has just arrived. The ground based controller must accomplish two main tasks. The first task is to ensure all aircrafts are safe. The second task is to provide information to pilots. This information is related to the traffic and weather. Automatic Dependence Surveillance-Broadcast (ADS-B) radar technologies and given guidance and information that is requested or required by the pilot for the safe passage of flight through that region. To prevent collisions, ATC enforces traffic separation rules, which ensure each aircraft maintains a minimum amount of empty space around it at all times. In many countries, ATC provides services to all private, military, and commercial aircraft operating within its airspace. Depending on the type of flight and the class of airspace, ATC may issue instructions that pilots are required to obey, or advisories (known as flight information in some countries) that pilots may, at their discretion, disregard. The pilot in command is the final authority for the safe operation of the aircraft and may, in an emergency, deviate from ATC instructions to the extent required to maintain safe operation of their aircraft. Radar controllers, as opposed to tower controllers, also have to work in semi-darkness with an airplane full of passengers in their sight as a mere luminous blip on the screen. The 24/7 staffing of the Air Traffic system sometimes requires more than 40 hour days including nights and weekends. Moreover Air Traffic Control ranks' 4^{th} in the all-time most stressful jobs in the world by Bureau of Labor Statistics. So existing system has a high impact in creating stress and burden to the controllers.

1.9.1 DISADVANTAGES OF EXISTING SYSTEM

- Only Ideal Conditions were considered for evaluating and simulating the correctness of the systems, which are not applicable in real-time.
- High chances of incorrect read back, using wrong call-signs, using non-standard phraseology, and missing and clipping the call sign.
- Errors such as delivery of incorrect information, issuing descent instruction late, issuing flight phase change instruction late, direction instruction error and clearance instruction error might happen.
- No recovery in case of an internal system failure.
- Noisy channels can lead to misinformation.
- Human Stress is not focused which might lead to human error.

1.10 SUMMARY

Air Traffic Controllers, who maintain the flow of aircraft in and out of airports and in flight, are key to aviation safety. So this is well recognized as one of the most stressful jobs, requiring total concentration. The 24/7 staffing of the Air Traffic system sometimes requires more than 40 hour days including nights and weekends. This creates physical as well as mental stress and results in human-errors. So Air Traffic Control ranks' 4^{th} in the all-time most stressful jobs in the world by Bureau of Labor Statistics. Air Traffic Control is a tedious task and automating such task is a challenging one just because it deals with crores of money and precious human lives. By implementing this work in real time, we cannot replace an Air Traffic Controller as a whole. Practically considering, this system will reduce human intervention up to some extent. Because of this, the stress faced by the controllers will be considerably reduced. We thereby incorporate a new concept called RNN-LSTM in a totally different domain, Air Traffic Control.