DESIGN AND IMPLEMENTATION OF A FUZZY LOGIC MODEL FOR AIR TRAFFIC CONTROL SYSTEM

BY

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DECLARATION

I declare that the work in the thesis entitled "Design and Implementation of a Fuzzy Logic Model for Air Traffic Control System" has been performed by me in the Department of Mathematics under the supervision of Dr. O.S. Adewale.

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

_____ _____

Bakare, Kareem Ayeni **Date**

Name of student

CERTIFICATION

This thesis entitled **"**DESIGN AND IMPLEMENTATION OF A FUZZY LOGIC MODEL FOR AIR TRAFFIC CONTROL SYSTEM" by BAKARE, Kareem Ayeni meets the regulations governing the award of the degree of Master of Science in Computer Science of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

Safety of aircraft is a major concern throughout the world. Aircraft accident is caused as a result of mechanical/electrical failure, human error which may be as a result of poor communication between the pilot and air traffic controller or as a result of shortcoming of navigational aids equipment and/or error in radio communication. The air traffic control system is a vast network of people and necessary navigational equipment that ensures the safe operation of commercial and private aircraft throughout the world. Successful taking off, cruising and landing of an aircraft depend on a good and reliable flight data (Strip) which is used by Air Traffic Controller. Flight data is responsible for separation of aircraft, prevention of collisions between aircrafts on the manoeuvring area and maintenance of an orderly flow of air traffic. Every year, many Controllers lost their life because of stress from the use of the existing tedious manual stripping.

Now that the air traffic control system in Aviation industry is moving towards total radar coverage, whereby the modern aircrafts are having their own IP addresses, instrument landing system and the control towers are networked together. With the numerous aircraft accidents, there is a need for Internet based flight data to enhancing the performance of air traffic controller and reduce the rate of aircraft accident. Therefore, in this research project, a fuzzy logic model for air traffic control system is presented that is able to improve safety of aircraft.

The model is developed and implemented using a web based application, apache as a web server with PHP scripting language and MySQL, a relational database.

CHAPTER ONE : INTRODUCTION

1.1 Background of the study

Aviation domain became one of the world's most powerful "team" with millions and millions of dependents and aircraft shortly after the Wright brothers in 1903 made their brief successful flight. Everyone thought that the sky was so vast there was little or no risk for one aircraft to collide with another. However, this belief was short-lived seven years after the Wright's experiment, many countries realized the necessity to regulate the aviation domain by introducing some navigation rules and some ground facilities to guide pilots from their departure to their destination location in a safe and efficient way. This necessity became more urgent after four mid-air collisions in 1910 and six in 1912 (National Air Traffic Service, 2005). As a consequence of all these events and the increasing use of the shared airspace, the International Commission for Air Navigation (ICAN) was created in Paris in 1919. Among the main purposes of ICAN were the establishment of uniform rules and standards for aircraft registration and identification, personnel licensing, maps and charts, and most importantly, for the Air Traffic Control domain, establishing rules and giving solutions for air and flying procedures.

Air traffic system world wide has experienced significant growth during the past twenty years. This growth has resulted in substantial increases in accident and delays at nearly every major airport. However, environmental and geographic constraints limit the opportunities to increase system capacity to embark on building new airports or adding new runways at existing airports. Therefore, the Nigerian Airspace Management Agency (NAMA) and Federal Airport Authority of Nigeria (FAAN) are currently working on introduction of Total Radar Coverage, whereby the modern aircrafts, instrument landing system and the control tower are networked together. Successful taking off, cruising and

landing of an aircraft depend on a good and reliable flight data (Strip) which is being used by Air Traffic Controller (ATC). Strip is used for separation of aircraft, prevention of collisions between aircrafts and maintenance of an orderly flow of air traffic. Many Controllers died while in action as a result of stress from the use of existing manual strip for controlling air traffic, now with the availability of internet, there is a need for Internet based flight data to enhance the performance of air traffic controller and reducing the rate of aircraft accident.

1.2 Research Motivation

In the past, there have been controversies over the cause of many aircraft accidents, in some cases it is difficult to retrieve Black Box that contained the last conversation between the controller and the pilot or even when retrieved, the information might have been tampered with. For instance the controversy surrounding the cause of Boeing 737 ADC Airlines accident on October 29 , 2006 at Tunga Madaki Village near Abuja where ninety six (96) people died including the 19th Sultan of Sokoto Alhaji Ibrahim Muhammad Maccido, Senator Yari Gandi and Senator Maccido could not be ascertained. The accident occurred just after taken off en route Sokoto, the Controller on duty claimed that he informed the pilot about the bad weather condition, but the pilot insisted that he would go. Successful take off, cruising and landing of aircraft depend on a good and reliable Air Traffic Controller's Fuzzy Logic model. This is being used to separate aircrafts, prevent collisions between aircrafts and maintain an orderly flow of air traffic. However, flight progress strip is used for Aerodrome, Approach, Radar and Area Control. Information obtained from flight plan supplied by pilot is used by Air traffic controller to fill strip which presently, is being manually prepared. A strip is manually cut, ruled and filled. Strip represents an aircraft which indicates departure, arrival or en-route. Time in

aviation industries is very crucial, in a busy aerodrome, it is possible that ten or more aircrafts on hold may be requesting for clearance to land while five or more may be requesting for clearance to take off and at the same time one or two en route may be requesting for clearance to over-fly the airway, it is the responsibility of the controller on duty to provide separation between aircrafts by taking appropriate prompt decision to avoid collision, in such a traffic, controller may find it difficult to coordinate the traffic. Failure to take immediate and appropriate decision may jeopardize the life of passengers on board. Many Controllers lost their life as a result of the use of existing tedious manual Flight Progress Strip.

Existing manual system has so many limitations, these include:

(i) manual systems lead to tedious manual works. (ii) a strip represents an aircraft, manually searching for strip of a particular aircraft among numerous ones in the present system is difficult and this can cause delay and consequently can lead to accident (iii) a lot of time is consumed in entering data which is dangerous because time is crucial in aviation. (iv) the volume of strip increases daily so it becomes difficult to manage and generating report is very difficult in the present system.

As a result of these, there is a need to automate Flight Progress Strip in order to ease data entry and retrieval for a particular aircraft departing or arriving. In case of aircraft accident where black box could not be retrieved or some people concerned want to tamper with the information obtained from the box, automatic flight data processor will be readily available to supply useful information.

Therefore, in this thesis, a fuzzy logic model for air traffic control system is developed that will enhance the performance of air traffic controller and reduce the rate of aircraft accident.

1.3 Research Objectives

The objective of this research is to develop a model to automate Air Traffic activities and hence :

(i) expedite and maintain an orderly flow of air traffic.

(ii) prevent collision between aircrafts.

(iii) serve as a legal tender in case of air mishap.

1.4 Methodology

This research applies fuzzy expert systems to control the activities of an air traffic controller. A web programming and database design techniques were used.

Review of related literatures were carried out. Manual methods of flight data processing were examined.

Fuzzy expert systems bring an expert's skill to solving a particular problem, the systems allow parallel operations, and as a result, controllers can take many decisions at the same time. A dynamic relational database keeps track of air traffic operations. A model was developed and implemented using a web based application.

1.5 Contribution to Knowledge

In this research work, fuzzy expert systems is used as a tool to model flight data for air traffic control because of its capability in bringing an expert's skill to solve the problem involved in the process. This allows parallel operations by the controller. Flight data that were done manually before is now being automated to expedite an orderly flow of air traffic. This prevents collision and reduce the consumption of fuel by aircraft and consequently improve safety and reduce the stress of controller.

1.6 Organization of the rest of thesis

The rest of the thesis is organised as follows: Chapter Two focuses on the review of related literature such as the use of a flight progress strips in Aerodrome, Functions of Air traffic controller, Navigational Aids Equipments for Instrument Flight Rules, Rules Guiding aircraft in Flight and on Ground, Separation Standards and Collision Avoidance, Flight Action, Avoidance of Collisions, Fuzzy expert systems, ATC simulators such as Tower Research Simulator (TRS), and Total Airspace and Airport Modeler (TAAM) and existing software such as Tactical Separation Assisted Flight Environment (TSAFE) invented by Heinz Erzberger Chief Scientist for air traffic control at National Aeronautics and Space Administration (NASA) Ames Research Center, CARATS (Configurable Airspace Research and Analysis Tool Sharp) en route air traffic management research software by Menon and his colleagues together with Center - Tracon Automated System (CTAS) designed and implemented at NASA Ames Research Center. Chapter Three presents a Model and System Design for Fuzzy Logic model for Aircraft Control System. Also presented are System Requirement, System design and development, in which requirement specification and design consideration, development, code design, system requirement and testing are specified. Chapter Four discusses results obtained from the model. Finally Chapter Five is Conclusion and Recommendation.

CHAPTER TWO : LITERATURE REVIEW

2.1 Introduction

The Air traffic control service is a generic term which includes flight information service, alerting service, air traffic advisory service and air traffic control service. The air traffic control system is a vast network of people and equipment that ensures the safe operation of commercial and private aircraft. Air traffic controllers coordinate the movement of air traffic to make certain that planes stay a safe distance apart. Their immediate concern is safety, but controllers also must direct planes efficiently to minimize delays. En route and terminal airspace congestion causes queuing delay every day during arrival rushes, Visual Meteorological Conditions (VMC) days will contribute to most of the annual delay benefit (Welch et. al., 2001). According to (Mueller et. al., 2002) delay is categorized into gate delay, taxi-out delay, en route (in flight) delay, terminal delay and taxi-in delay. Each category of delay arises when the aircraft requires more time in that regime than was scheduled. Delay in airport has significant environmental impact – in particular that of noise exposure on the community where the airport is located, (Capozzi et. al., 2002).

Use of a Flight Progress Strips in Aerodrome and Approach Control :

The procedures for the marking of standard flight progress strips as used in Aerodrome and Approach Control. Strips are used as follows:

(a) Departing flights – is labeled as Form AD30A and the colour of cardboard paper used for the form is blue.

(b) Arriving flights - is labeled as Form AD20D and the colour of cardboard paper used for the form is buff.

(c) Local flights - - is labeled as Form DCA30 and the colour of cardboard paper used for the form is pink.

Strip Marking for Departing Flights

The Strip in Figure 2.1 is for Departing Flights.

Instrument Flight Rule (IFR) Plans

<table>
<tr><td colspan="2">A</td><td>B</td><td rowspan="2">F</td><td>G</td><td>H</td><td>I</td><td rowspan="2">K</td><td rowspan="2">L</td><td rowspan="2">M</td></tr>
<tr><td>C</td><td>D</td><td>E</td><td colspan="3">J</td></tr>
</table>

Figure 2.1 : Strip Marking for Departing Flights

Box A. Vacant, or aerodrome abbreviation if the departure is from a subsidiary airfield.

Box B. Planned cruising level.

Box C. Estimated time of departure.

Box D. Actual time of departure.

Box E. May be used to note the time at which an aircraft sets 'course',

Box F. (i) Aircraft identification in large printing in the centre.

(ii) Aircraft type in top right-hand corner.

(iii) Planned cruising true airspeed in bottom right-hand corner.

(iv) Planned initial climbing true airspeed in bottom left-hand corner (if required).

Box G. The time at which action is initiated to contact the Air Traffic Control Centre (ACC) or Zone Control for a clearance.

Box H. Time at which clearance is issued by ACC. If the aircraft is turbine powered, the box is divided into halves by drawing a diagonal line from the top right

to the lower left hand corner and the time at which start-up clearance is issued is written in the upper half of the box, the time at which ATC clearance is issued is written in the lower half.

Box I. The time at which any revised clearance is received.

Box J. Planned route and destination.

Box K. Full details of the clearance written verbatim in abbreviated form omitting aircraft call-sign, type, airfield of departure and general routeing.

Box L. Full details of any revised clearance. A diagonal line being drawn through the cancelled clearance Box K.

Box M. Domestic use (Details of transfer of control, position reports etc)

Note: A check mark will be made against the clearance in Box K or the revision in L when it has been transmitted to the aircraft and acknowledged.

Visual Flight Rule (VFR) Plans

Strip marking as in (Fig. 2.1) above with the following exceptions. Box B. "VFR" inserted, Boxes G, H and I not used. Boxes K and L not used.

Strip Marking for Arriving Flights (Fig. 2.2)

IFR Plans

<table>
<tr><td rowspan="2">A
B</td><td rowspan="2">C</td><td rowspan="2">D</td><td>E</td><td>F</td><td>G</td><td>G</td><td rowspan="2">M</td></tr>
<tr><td>I</td><td>J</td><td>K</td><td>L</td></tr>
</table>

Figure 2.2 : Strip Marking for Arriving Flights

Box A. (i) Clearance limit in top right- hand corner.

(ii) ETA at clearance limit-hours in large numerals and minutes in

Small.

Box B. Time of arrival over the clearance limit. Whenever the aircraft is required to hold over the clearance limit facility the Box is divided into two equal portions by a diagonal line ending in the bottom right-hand corner, the time of arrival over the position is entered in the lower left portion and the time of leaving in the upper right portion.

Box C. (i) Level information in the vertical column stating at the top left corner. The first entry is the release levels, entries below show the levels down to which the aircraft is later cleared. If reports from the aircraft through any of the intervening levels are required, these levels are listed in descending order and cancelled by horizontal lines as reports are made. An arrow indicating descent is drawn and subsequently cancelled after the aircraft reports its arrival at the new level, or passing through the level immediately above.

(ii) If an aircraft cancels its IFR plan "VFR" in large letters is inserted in the box.

Box D. (i) The aircraft's identification or radio call-sign in large outline near the centre of the Box.

(ii) The type of aircraft at the top right-hand corner.

(iii) The aerodrome of departure in the top left-hand corner.

Box E. Flight plan ETA.

Box F. Actual time of landing.

Box G. Vacant.

Box H. Vacant.

Box I. Landing Aerodrome Abbreviation (if subsidiary).

Box J. Release Point.

Box K. Expected approach time.

Box L. The contact point;

(i) If this is a position, the abbreviation is written at the top of the Box and the time over the facility inserted below.

(ii) If it is a level or a time, the Box is check-marked when communication is established.

Box M. Domestic use (Type of approach aid, co-ordination with other aerodromes etc.).

VFR Plans

Strip marking as in (Fig. 2.2) above with the following exceptions:

Box A. ETA aerodrome only.

Box B. Vacant.

Box C. Large "VFR" inserted.

Boxes G,H,I,J,K, and L. Vacant.

Figure 2.3 : Strip Marking for Local Flights

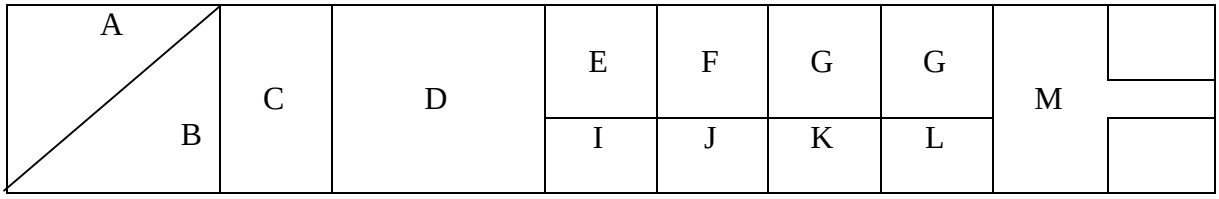


Figure 2. 3 Strip Marking for Local Flights

The pink strip will only be used for local VFR flights, or local IFR flights remaining under the control of Aerodrome or Approach Control. Owing to the

varying requirements at aerodromes, the type of flight etc., as much room as possible is left for domestic use.

Box A. (i) Clearance limit in the top right-hand corner.

(ii) ETA at the clearance limit.

Box B. Actual time of arrival at the clearance limit.

Box C. Level or VFR.

Box D. Aircraft identification.

Box E. Estimated time of departure.

Box F. Actual time of arrival.

Box J. Actual time of departure.

Boxes G, H, J, K, Land M. Flight details/domestic use.

Use of Flight Progress Strips by Airways and Advisory Controllers.

Flight Progress Boards

Flight Progress Boards are laid out so that, taking the top of the board as north, the reporting points (indicated by designators) are in rough geographical relationship. A designator is a permanent flight progress strip bearing the official abbreviation for the reporting point and details of the associated navigational facility where one exists.

Flight Progress Strips

The following flight progress strips are in use:

Buff "en route" strips for eastbound flights.

Blue "en route strips for westbound flights.

Pink "en route" strips for flights crossing airways.

Buff "departure" strips for eastbound departing flights.

Blue "departure" strips for westbound departing flights.

Direction is determined by the overall direction of the flights, not section by section between successive reporting points. Eastbound flights are those following magnetic tracks 000^0 - 179^0 and westbound 180^0 - 359^0

Preparation of Flight Progress Strips

Information on flights reaches an ACC either in the form of:

(a) An estimate for a reporting point in respect of an already active airborne flight, e.g. estimate from an adjacent ACC on an inbound flight, airborne request on en route from an aircraft wishing to join controlled airspace, etc; or

(b) Flight plan details on an aircraft not yet airborne which requires ATC clearance from an ACC before taking off.

For the former, strips are made out for all designated reporting points en route within the area of the ACC giving an ATC estimate for each, the strips are assimilated into the display without delay. For the later, an aerodrome departure strip is made out and also partially completed en route strips for all designated reporting points along the route, an ATC estimate in minutes for the flight time from the previous reporting point being included on each strip. When an ATC clearance is given for the flight, the strips will be annotated as appropriate. As soon as the airborne time is known, the flight becomes active and the flight times in minutes are converted into ATC estimates and the strips incorporated into the display.

Maintenance of the Flight Progress Display

Flight progress strips are only retained in the display whilst they are current and

required for ATC purposes. No hard or fast rule can be laid down, but generally a strip for a reporting point should be discarded when the aircraft checks over the next point or is reported by an approach control to have vacated the lowest stack altitude under the jurisdiction of the ACC.

Preparation of Records of Workload from Flight Progress Strips

Each flight will be allocated a filing number and this number will be marked on each strip connected with the flight. When the flight has terminated, or ten (10) minutes after it has left the area of responsibi1ity of the ACC, all documents relevant to the flight, including strips, will be stapled together and retained for the specified period.

Strip Marking

Flight progress strip marking is done using ball point pens.

Colours

All entries made on flight progress strips by assistant controllers or clerks is made in black.

All entries made on flight strips by air traffic control officers are made in red.

All entries made on flight progress strips by supervisors are made in green.

Block capitals is used for all lettering.

Corrections or revisions to data are made by striking through the original entry and writing the up to date information alongside in the same box.

Strip Marking for En Route Flight Progress Strips

<table>
<tr><td rowspan="2">A

B</td><td rowspan="2">C</td><td rowspan="2">D</td><td>E</td><td>F</td><td>G</td><td>G</td><td rowspan="2">M</td></tr>
<tr><td>I</td><td>J</td><td>K</td><td>L</td></tr>
</table>

Figure 2.4. : Strip Marking for En Route Flight Progress Strips

Box A. (i) ATC estimate of the time an aircraft is expected to reach a reporting point: the hour being written in larger figures than the minutes. All subsequent time entries in other boxes on the same strip need only be the minutes figures unless the hour varies from the hour shown in this box when the full figure group must be entered.

(ii) The abbreviation for the reporting point to which the strip refers is put in the top right hand corner.

Box B. (i) The time of the aircraft's arrival over the reporting point in Box A.

(ii) If the aircraft will hold in flight over this point, the box is divided into halves by drawing a diagonal line into the lower right hand corner. The arrival time being entered in the lower half and the time of leaving the reporting point in the upper half.

Box C. Flight level information in hundreds of feet. If the cleared and actual levels over a point differ, the actual figure is entered and encircled: no marking is required when the values are the same.

When different levels are assigned to successive reporting points, the level at which the first point is crossed is written in the upper right hand corner of this box on the next strip and enclosed in a square.

In assigning a level, this level together with all intermediate levels for which reports are required are entered in sequence and a climb or descent arrow is written between the initial and the final levels. Upon report of leaving or

passing through a level, the figures are cancelled through with a horizontal line. Upon report of reaching the assigned level the climb or descent arrow is cancelled through.

VFR in the large letters across the box to denote that the aircraft has cancelled its IFR plan.

Box D. (i) Aircraft identification in large outline in the centre of the box.

(ii) The standard abbreviation for the type of aircraft in the upper right-hand corner.

(iii) Ground speed of the aircraft and preceded by a "T" the filed true airspeed, in the lower right-hand corner.

(iv) On the final strip for an arriving aircraft the abbreviation for the place of departure in the upper left-hand corner.

Box E. Joining symbol}

Leaving symbol} if appropriate.

Crossing symbol}

Box F. Time of arrival if required.

Box G. Pilot's estimate of arrival over the reporting point.

Box H. (i) Actual time, of arrival over the previous reporting point.

(ii) The abbreviation for the previous reporting point if necessary for clarity.

Boxes I,J,K. (i) The route of flight showing departure and destination aerodrome and the Airways and Advisory Routes to be flown: the Airways abbreviations can be taken to include associated Advisory routes. It

is necessary to write the Advisory Route numbers only when there is no associated Airways.

(ii) On the final strip for an arriving flight Box I is used for the destination aerodrome where more than one aerodrome is fed from a common stack. Box J for the release point to Approach Control and Box K for the Expected Approach Time.

Box L. (i) The time place or level at which the aircraft is instructed to contact the next ACC.

(ii) The frequency to M is used, but only when it is non-standard.

Box M. Control data which has been passed to aircraft such as essential traffic information, holding instructions, time check. etc.

Departure Flight Progress Strips

The strip in Figure 2.5 is used for departure flights by the ACC.

<table>
<tr><td colspan="2">A</td><td>B</td><td rowspan="2">F</td><td>G</td><td>H</td><td>I</td><td rowspan="2">K</td><td rowspan="2">L</td><td rowspan="2">M</td></tr>
<tr><td>C</td><td>D</td><td>E</td><td colspan="3">J</td></tr>
</table>

Figure 2.5 : Strip Marking for Departure Flight Progress Strips

Box A. Aerodrome of departure.

Box B. Cruising level requested by pilot.

Box C. Estimated Time of Departure.

Box D. Actual Time of Departure.

Box E. May be used to note the time at which an aircraft sets course.

Box F. Aircraft identification in large outline in the centre of the box. The type of

aircraft in the upper right hand corner. Filed True Air Speed (TAS) in the bottom right hand corner.

Box G. Time at which clearance is requested.

Box H. Time at which clearance is issued. If the aircraft is turbine powered, the box is divided into halves by drawing a diagonal line from the top right to the lower left hand corner and the time at which start-up clearance is issued is written in the upper half of the box, the time at which ATC clearance is issued is written in the lower half.

Box I. Any delay anticipated by the outbound control officer when clearance is requested.

Box J. Proposed route of aircraft.

Box K. Initial clearance showing details of zone routeing and levels, cruising level, radar climb, restrictions to take-off.

Box L and M. Any revised clearances issued.

Functions of air traffic control system

Air traffic controller performs the functions of air traffic control system, some regulate to airport traffic through designated airspaces; others regulate airport arrivals and departures. The functions of air traffic control system as enumerated by International Civil Aviation Authority (ICAA) are Area control, Approach control and Aerodrome control (Federal Civil Aviation Authority (FCAA), Manual of Air Traffic Control, 1992).

a) **Area Control** is responsible for separation between all IFR flights and between IFR flights and VFR flights. Aircraft shall be equipped with suitable instrument and with

navigation equipment appropriate to the route to be flown. Minimum Level except when necessary for takeoff or landing, or except when specifically authorized by the appropriate authority, an IFR flight shall be flown at a level which is not below the minimum flight altitude established by the State whose territory is over flown, or where no such minimum flight altitude has been established, over high terrain or in mountainous areas, at a level which is at least 600m (2000ft) above the highest obstacle located within 8km of the estimated position of the aircraft. Also elsewhere than as specified above at a level which is at least 300m (1000ft) above the highest obstacle located within 8km of the estimated position of the aircraft .It is possible to change from IFR Flight to VFR Flight.

VFR flight shall be conducted such that aircraft is flown in condition of visibility and distance from cloud equal to or greater than those specified.

It is only when a clearance is obtained from air traffic control unit, VFR flight shall not take off or land at an aerodrome within a control zone, or enter the aerodrome traffic zone or traffic pattern:

a) when the ceiling is less than 450m (1500ft) or

b) when the ground visibility is less than 5km.

VFR flight is between sunset and sunrise, or such other period between sunset and sunrise as may be prescribed by the appropriate Air Traffic Service (ATS) authority shall be operated in accordance with the condition prescribed by such authority. (In Nigeria, no VFR is allowed between sunset and sunrise).

Unless authorized by the appropriate ATS authority, VFR flight shall not be operated:

a) above Flight level (FL) 200

b) at transonic and supersonic speeds.

Except when necessary for take-off or landing, or except by permission from the appropriate authority, a VFR flight shall not be flown:

a) over the congested area of cities, town or settlements or over an open-air assembly of person at height, less than 300m (1000ft) above the highest obstacle within a radius of 600m (2000ft) from the aircraft;

b) elsewhere at a height less than 150m (500ft) above the ground or water.

In Nigerian at a height not less than 300m (1000ft) above the highest obstacle within a radius of 600m (2000ft).

A VFR flight operating within or into areas, or along route designated by the appropriate ATS authority in accordance with requirement to submit a flight plan shall maintain continuous listening watch on the appropriate radio frequency of, and report its positions as necessary to air traffic services unit providing flight information services.

An aircraft operated in accordance with the visual flight rules which wishes to change to compliance with the instrument flight rules shall if a flight plan was submitted communicate the necessary changes to be effected to its current flight plan or when so required to submit a flight plan to the appropriate air traffic services unit and obtain a clearance prior to proceeding IFR when in controlled airspace within its Control Area until released to Approach/Aerodrome Control.

Navigational Aids Equipments for instrument flight rules

Navigational aids equipment use for IFR include Non Directional Beacon (NDB), Very High Omni directional Range/Instrument Landing system (VOR/ILS), Radio detection and Ranging (RADAR) etc.

RADAR is one of the electronic navigation aids but basically unique, in that it

provides the air traffic controller with a comprehensive view of air traffic over a wide area, and hence has assumed a crucial role in ATC procedures, especially in busy airspace and particularly under positive control.

ATC RADAR must therefore be capable of carrying out the functions and roles of:

i approach control

ii extended approach control

iii and/or terminal area control; with the added capability of extended range using Secondary Surveillance RADAR (SSR) techniques.

RADAR systems is capable of integrating with other automated systems used in the provision of Air Traffic Service (ATS), and should provide for an appropriate level of automation with the objectives of improving the accuracy and timeliness of data displayed to the controller and reducing controller workload and the need for verbal coordination between adjacent control positions and ATC units, (Gong et. al., 2004).

RADAR systems is capable to display safety-related alerts and warnings, including conflict alerts, minimum safe altitude warning, conflict prediction and unintentionally duplicated SSR codes. States should, as much as possible, facilitate the sharing of information in order to extend and improve RADAR coverage in adjacent control areas. States should, on the basis of regional air navigation agreements, provide for the automated exchange of coordination data relevant to aircraft being provided with radar services, and establish automated coordination procedures.

Primary Surveillance RADAR (PSR) and SSR may be used either alone or in combination in the provision of ATS, including in the provision of separation between aircraft.

Radar Displays

Radar derived data available for display to the controller shall, as a minimum, include the following:

Radar position indications

Radar map information

SSR Mode A, Mode C and Mode S, when available.

The RADAR system shall provide for a continuously updated presentation of RADAR derived information and RADAR position indications.

RADAR position indications may be displayed as:

a) RADAR position symbols (RPS), including:

   i) PSR symbols;

   ii) SSR symbols; and

   iii) Combined PSR/SSR symbols;

b) PSR blips;

c) SSR responses

RADAR Vectoring

RADAR vectoring is the provision of navigation guidance to aircraft in the form of specific headings, based on the RADAR (Fig. 2.6) in use.

When vectoring an aircraft, a RADAR controller should comply with the following:

a) Vector along routes or tracks on which the pilot can monitor the aircraft position with reference to pilot-interpreted navigation aids. This will minimize the amount of RADAR navigation assistance required and alleviate the consequences resulting from a radar failure.

b) Inform the pilot when his aircraft is given a vector diverting it from a

assigned route, unless it is self-evident, what the vector is to accomplish.

c) Controlled flights should not be vectored into uncontrolled airspace except: in an emergency case to circumnavigate severe weather, in which case the pilot should be so informed at the specific request of the pilot.

d) When vectoring an IFR flight, the radar controller shall issue clearances such that the prescribed obstacle clearance will exist at all times until the aircraft reaches the point where the pilot will resume own navigation.

RADAR System Diagram

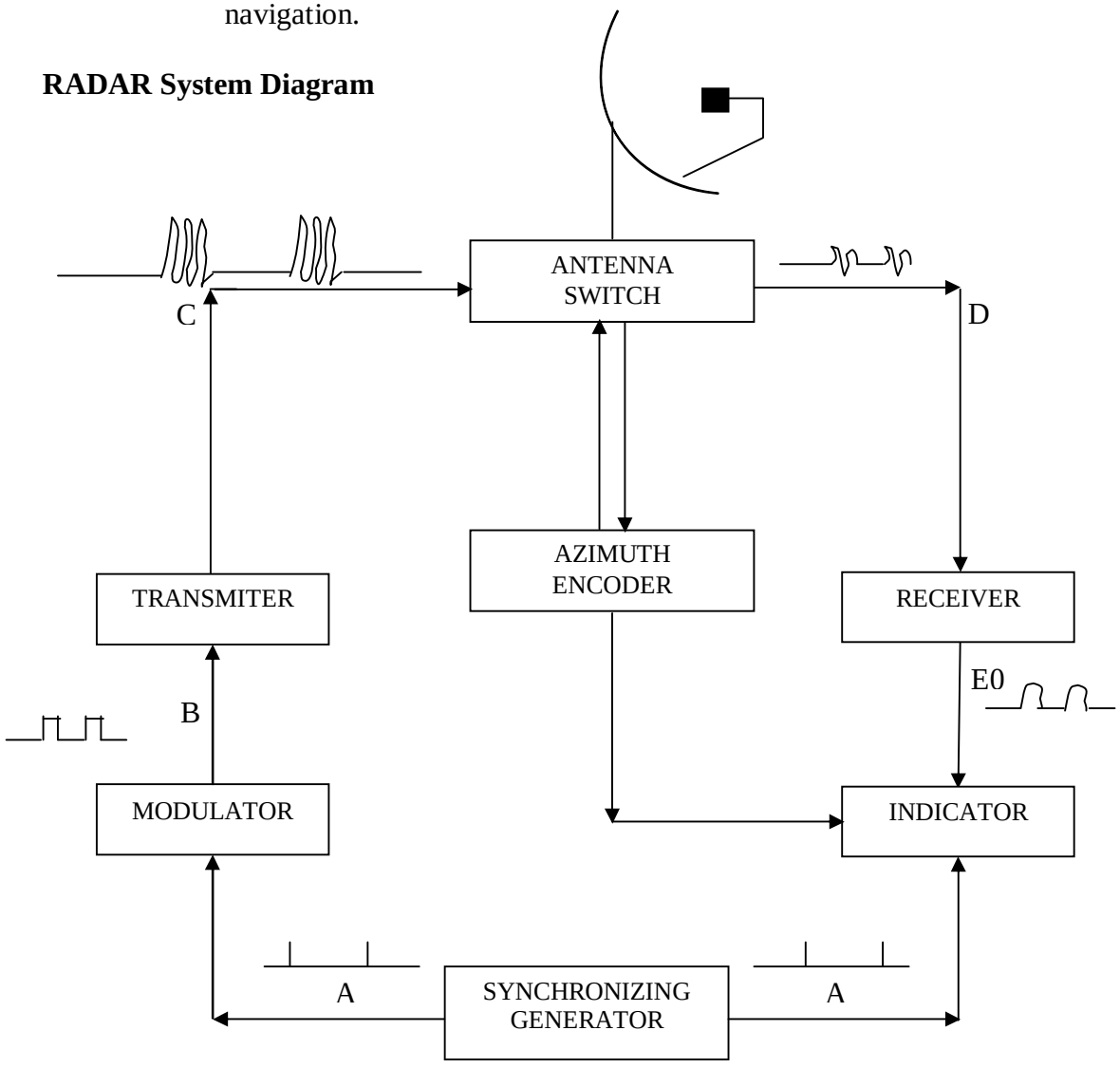


Figure 2.6 : Block Diagram of the Primary Surveillance RADAR System

Synchronizing generation: very short synchronizing pulses are generated with certain intervals.

Modulator: This gives direct current pulses of a certain width to the transmitter.

Transmitter: This, for incoming pulse will start to generate a high frequency carrier pulse to the directional antenna and is then radiated after a while the radio waves hit a reflecting object and a certain part of the wave power is reflected back to the antenna. The antenna receives the echo signal, which is set via the **antenna switch** to the receiver.

Receiver: This amplifies, demodulates and treats the echo signal, and the video signal obtained this way will be fed to the **indicator**. The video signal is presented on the **cathode- ray tube** of the **indicator.**

To be able to present echoes at correct distance, the indicator must know when the pulse is transmitted. This is possible through feeding synchronizing pulses to the indicator. To be able to present echoes in the correct azimuth, the indicator must know in what direction the antenna points and is therefore fed with azimuth signal from the antenna**.** (Manual of Air Traffic Safety Engineering Personnel (ATSEP), 2007).

b) **Approach Control** provides separation between all IFR flights and between IFR flights and VFR flights operated as controlled flights which are:

i arriving, and released by area Control, until they have landed and cleared the runaway.

ii departing, from the time they enter the runaway until they have been released to Area Control.

c) **Aerodrome Control** gives advice and instructions to aircraft taxing, landing, taking-off and flying within the Aerodrome Traffic Zone to achieve an orderly and expeditions flow of air traffic, and to assist in avoiding collision between aircrafts and

between aircraft and obstructions on the ground. Aerodrome Control also assumes control of aircraft, vehicles and personnel on the maneuvering area.

2.2 Rules Guiding Aircraft in Flight and on Ground

In order to ensure safe and efficient movement of flight both in air and on ground, recommended rules have been made to facilitate this. For instance aircraft are made to fly in specified direction called route. This route could either be international route or domestic route. The international routes are those routes that are internationally recognized and endorsed by International Civil Aviation Organisation (ICAO) while the domestic routes are those routes known only within the air space of the country that uses it. An example of such routes are ;

- UR/R 778 extending from Lagos through Kano and exit into Niger at a point called GANLA to North Africa or Asia.
- UR/R 981 extending from Lagos through an exit in Nigeria called TENTU to Europe.

In Nigeria, domestic routes are those routes approved by Nigerian Air Space Management Agency linking towns and states. Such route is used to ease traffic movement in our air space. An example is.

UV 377 extending from Lagos to Kaduna etc.

In moving along this route, aircraft are made to move on certain height above mean sea level called flight level (FL). The flight level is designed in such a way that aircraft moving along a designated route either West-Ward or East-Ward occupy a specified level. In order to avoid collision hazard, aircraft moving east-ward occupy odd level (odd number) and (Even number) for west-ward. Thus by using progress strip for each aircraft, safety can be achieved to certain extent. It is the duty of air traffic controller to assigning this level at the request of the pilot of an aircraft.

2.3 Separation Standards and Collision Avoidance

ATC is responsible for separation between aircraft and collision avoidance.

Provision of separation is between :

i all flights in class A & B airspaces

ii IFR flights in class C,D and E airspaces

iii IFR & VFR in class C airspace

iv IFR and special VFR flights

v special VFR flights, when prescribed by ATS authority

And to increase separation in navigational difficulties, weather avoidance or turbulence and unlawful interference.

Then reduce separation determined by the appropriate ATS authority are as follows:

1) When special electronic or other aids enable pilot to accurately determine aircraft position and communications facility exist for that position to be transmitted without delay to appropriate Air traffic Control Unit (ACCU), or when using rapid and reliable communication facilities RADAR derived information of aircraft position is available to ACCU, or determined by the appropriate ATS authority, or when special electronic or other aids enable ATC to predict rapidly and accurately the flight paths of aircraft and adequate facilities exist to verify frequently the actual aircraft positions with the predicted positions; or when navigational (NAV)-equipped aircraft operate within coverage of electronic aids that provide the necessary updates to maintain navigational accuracy.

2) According to regional air navigation agreements; when special electronic, area navigation or other aids enable the aircraft to closely adhere to their current flight plans and the air traffic situation is such that the conditions as determined by ATS authority regarding communications between pilots and the appropriate ACCU need not necessarily be met to

the degree specified therein Pilot tells ATC that they can not comply as a result of degraded aircraft performance, then ATC will ensure separation of another appropriate type.

2.3.1 Types of Separation

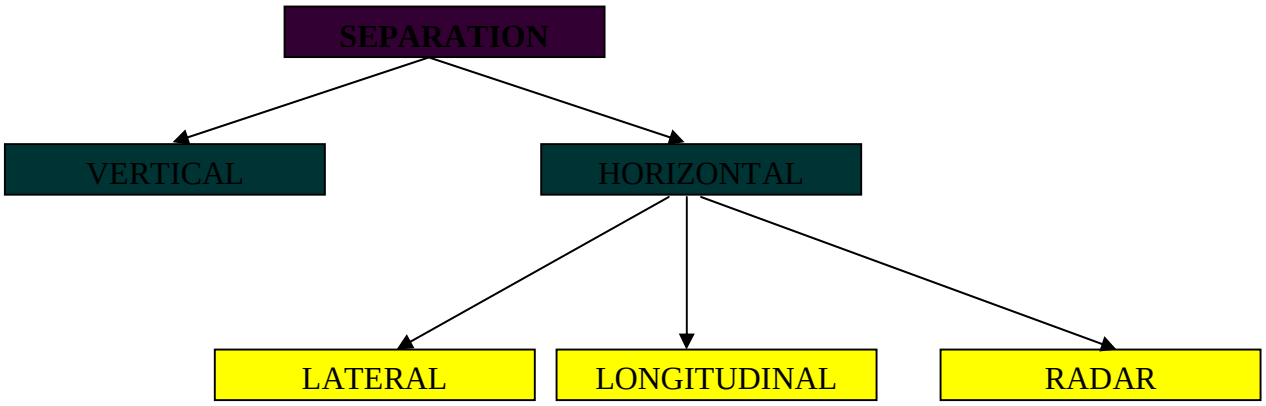


Figure 2.7 : Types of Separation

There are two types of separation, Vertical and Horizontal separation.

Vertical Separation is obtained by requiring aircraft using prescribed altimeter setting procedures to operate at different levels expressed in terms of flight levels or altitudes. It is carried out above or below flight level 29,000 ft.

Horizontal Separation is subdivided into Lateral, Longitudinal and Radar separation.

Lateral separation of aircraft at the same level is obtained by requiring flight on different routes or in different geographical locations as determined by visual observation or by use of radio navigation aids.

Longitudinal separation is applied such that after one aircraft passes over a specified position, the next succeeding aircraft at the same cruising level will not arrive over the same position within less than the prescribed minima.

Radar separation is obtained by requiring aircraft to fly on different tracks which can accurately be determined by reference to a Radar display.

2.4 Flight Action

Before beginning a flight, the pilot-in-command of an aircraft shall become familiar with all available information appropriate to the intended operation (Muhammed, 2006). Pre - Flight action for flights away from the vicinity of an aerodrome, and for all IFR flights, pilot shall fill flight plan after careful study of available current weather reports and forecast, taking into consideration fuel requirements and an alternative course of action if the flight cannot be completed as planned. Based on this, a progress flight strip is manually created by Air Traffic Controller for the aircraft.

Authority of Pilot-in-command of an aircraft.

The pilot-in-command of an aircraft shall have final authority as to the disposition of the aircraft while in command.

Avoidance of Collisions

Although the pilot of an aircraft operates under the instruction of a positive control of an Air traffic controller, never the less, there are certain portion of the rules that requires the pilot to use his discretion where the pilot feels such instructions could cause collision hazard to his flight, notwithstanding that the flight is being made with ATC clearance, it shall remain the duty of the commander (Pilot in command) of an aircraft to take all possible measures to ensure that his aircraft does not collide with any other aircraft.

Right - of - Way

The aircraft that has right of way shall maintain its heading and speed, but nothing in the rules shall relieve the pilot-in-command of an aircraft from the responsibility of taking such action best to avert collision.

An aircraft that is obliged by the following rules to keep out of the way of another shall avoid passing over, under or in front of the other, unless it passes well clear and takes into account the effect of aircraft wake turbulence.

Approaching Head-on

When two aircraft are approaching head - on or approximately so and there is danger of collision, each shall alter/turn its head to the right, (Bach et. al., 2007).

Aircraft Converging

When two aircrafts are converging at approximately the same level, the aircraft that has the other on its right shall give way.

Overtaking Aircraft

An aircraft that is being overtaken has the right-of-way and the overtaking aircraft, whether climbing, descending or in horizontal flight, shall keep out of the way of the other aircraft by altering its heading to the right.

Aircraft Landing:

An aircraft in flight or operating on the ground or water shall give way to aircraft landing or in the final stages of an approach to land.

When two or more aircrafts are approaching an aerodrome for the purpose of landing, aircraft at the higher level shall give way to aircraft at the lower level. However such aircraft should take cognizance of the aircraft that is about landing.

Emergency Landing

An aircraft that is aware that another is compelled to land shall give way to that aircraft.

Air Craft Taking Off

An Aircraft taxing on the maneuvering area of an aerodrome shall give way to aircraft

taking off or about to take off.

2.4.1 Surface Movement of Aircraft

In case of danger of collision between two aircraft taxing on the movement area of an aerodrome the rules shall apply that when two aircraft are approaching head-on, or approximately so, each shall stop or where practicable alter its course to the right so as to keep well clear, if the stipulated rules are adhered to strictly. Analyzing the various accidents critically indicate that most of the accidents that had occurred to date show that the accidents happen either at the point of take – off, after take -off, about landing or after landing on the runway. However that does not mean that accidents don't happen mid-air in flight or even on the surface movement of the aerodrome. An example of such accident on the surface is between two aircrafts, Boeing 747, operated by KLM and Panam, collided on a Foggy runway killing 583 people in March 1977. (The leadership weekend No. 39 Nov. 4th 2006).

Also a mid air accident due to human errors occurred between an Ilyushin (IL - 76) cargo jet from Kazakhstan and with Saudi Air B747 near New Delhi killing 349 in November 1996. (The leadership Weekend No. 39 Nov. 4th 2006).

Investigation shows that the Kazakh crew disobeyed instructions and neither plane was equipped with collision avoidance technology. (McNally et. al., 2006).

When two aircrafts are on a converging course, the one which has the other on its right shall give way by slowing down or stopping.

Thus, having examined the various rules guiding aircraft in flight and on the surface movement, it could appear at this juncture that the human error that is much talked about could be averted because many people have lost their life as a result of inherent limitation of current navigation systems and short coming of controllers, in Nigeria alone thousands have

died as a result of plane crash, (Table 2.1), (Nigerian College of Aviation Technology, Zaria Library Compilation, (2007)).

DATE	AIRCRAFT'S NAME	LOCATION	No. OF DEAD PASSENGERS
1968 July 13	Boeing 707 Reg. OOSJK Sabena Airline	Lagos	7
1983 November	Nigeria Airways F.28	Enugu	53
1984	Airforce Jet Eagle 3	Kano	
1986 August 6	Kabo Airline	Calabar Airport	
1990	Okada Air	Sokoto	4
1991	Hold Trade Airline	Jeddah	237 Nigerian pilgrims
1992	C-130 Military Hercules	Ejigbo	163
1994	Oriental Airlines	Algeria	5 Inwuanyanwu football club players
1994	Nigeria Airways Cargo Plane	Hadeija	5
1994	Shell Petroleum	Abuja	2
1995 June	Harka Air	Lagos	15
1995 November	Nigeria Airways Boeing 737	Kaduna Airport	9
1996 January	Presidential Jet	Kano	14 including Gen. Sani Abacha's son Ibrahim
1996 June 20	Private Jet	Jos	13 including Kano State Governor Col A. Wase
1996 November 7	ADC Airline Boeing 727	Lagos	144 including Professor Cloude Ake
1997 January 31	Sky Power Express private jet	Jos	5
1977 February 24	Air force jet	Kaduna	3
1979 October 27	Air force jet	Mayama village near Birni Kebbi	1
2000 January 7	Sky Power Express EMB 110	Abuja	3
2000 January 30	Kenya Airways KQA-430	Abuja	169
2001 September 15	Air force Trainer Plane	School(NCAT) Zaria	2
2002 May 4	Executive Aviation	Kano	77 including Sports Minister

	Services(EAS)		Mark
2004 January 28	Air force Trainer Jet	Kano	1
2005 June 11	EAS Airline	Jos	
2005 June 12	Boeing 727 Chachangi Airlines	Lagos	
2005 October 22	Boeing 737 Belview Airlines	Lisa Ogun State	117
2005 November 28	Beechcraft 200. Private jet	Kaduna Airport	2
2005 December 10	DC 9 Sosoliso Airlines	Port Harcourt	109 including 62 students of the Cathal Loyola Jesuits College Abuja
2006 September 17	Dornier 288 Military plane	Mbakunu shangev-ya, Benue state	13 top Nigerian military Generals
2006 October 10	Aviation College Zaria Trainer Plane	Zaria	
2006 October 29	Boeing 737 ADC Airlines	Tunga Madaki Village near Abuja	96 including the 19th Sultan of Sokato Alhaji Ibrahim Muhammad Maccido, Senator Yari Gandi, Senator Maccido
2006 November 10	Helicopter	Ovivian in Delta state.	1
2007 April 20	Navy Helicopter	Owerri	3 crew members

Table 2.1 Plane crashes in Nigeria since 1968

2.5 Fuzzy Logic

Two centuries earlier, Buddha saw the world filled with contradictions, that things could be a certain degree true and a certain degree false at the same time. However, it was Plato who laid the foundation for what would become fuzzy logic, indicating that there was a third region (beyond True and False) where these opposites "tumbled about.

In the early 1900s, Lukasiewicz came and proposed a systematic alternative to the bi-valued logic(*bivalence*) of Aristotle. He described a three-valued logic, which can best

be translated as the term `possible', and assigned it a numeric value between True and False. Knuth, a former student of Lukasiewicz proposed a three-valued logic apparently missed by Lukasiewicz, which used an integral range [-1, 0 +1] rather than [0, 1, 2]. Nonetheless, this alternative failed to gain acceptance, and has passed into relative obscurity.

It was not until relatively recently that the theory of fuzzy logic was discovered. Lotfi A. Zadeh, a professor of UC Berkeley in California, soon to be known as the founder of fuzzy logic observed that conventional computer logic was incapable of manipulating data representing subjective or vague human ideas such as "an attractive person" or "pretty hot". Hence, fuzzy logic was designed to allow computers to determine the distinctions among data with shades of grey, similar to the process of human reasoning. In Zadeh (1965) described the mathematics of fuzzy set theory, and by extension fuzzy logic. This theory proposed making the membership function (or the values False and True) operate over the range of real numbers [0.0, 1.0]. Fuzzy logic was now introduced to the world. Although, the technology was introduced in the United States, the scientist and researchers there, ignored it mainly because of its unconventional name.

Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth- truth values between "completely true" and "completely false". As its name suggests, it is the logic underlying modes of reasoning which are approximate rather than exact. The importance of fuzzy logic derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature. One way to represent inexact data and knowledge, closer to humanlike thinking, is to use fuzzy rules instead of exact rules when representing knowledge.

Fuzzy systems are rule-based expert systems based on fuzzy rules and fuzzy inference. Fuzzy rules represent in a straightforward way "commonsense" knowledge and skills, or knowledge that is subjective, ambiguous, vague, or contradictory. This knowledge might have come from many different sources.

Commonsense knowledge may have been acquired from long-term experience, from the experience of many people, over many years.

The essential characteristics of fuzzy logic as founded by Zader Lotfi are as follows.

- In fuzzy logic, exact reasoning is viewed as a limiting case of approximate reasoning.
- In fuzzy logic everything is a matter of degree.
- Any logical system can be fuzzified
- In fuzzy logic, knowledge is interpreted as a collection of elastic or, equivalently , fuzzy constraint on a collection of variables
- Inference is viewed as a process of propagation of elastic constraints.

The third statement hence, defines Boolean logic as a subset of Fuzzy logic.

Fuzzy Sets

Fuzzy Set Theory was formalised by Professor Lofti Zadeh at the University of California in 1965. What Zadeh proposed is very much a paradigm shift that first gained acceptance in the Far East and its successful application has ensured its adoption around the world. A paradigm is a set of rules and regulations which defines boundaries and tells us what to do to be successful in solving problems within these boundaries. For example the use of transistors instead of vacuum tubes is a paradigm shift - likewise the development of Fuzzy Set Theory from conventional bivalent set theory is a paradigm shift. A Fuzzy Set is

any set that allows its members to have different grades of membership (membership function) in the interval [0,1].

Bivalent Set Theory can be somewhat limiting if we wish to describe a 'humanistic' problem mathematically. For example, Figure 2.8 below illustrates bivalent sets to characterise the temperature of a room.

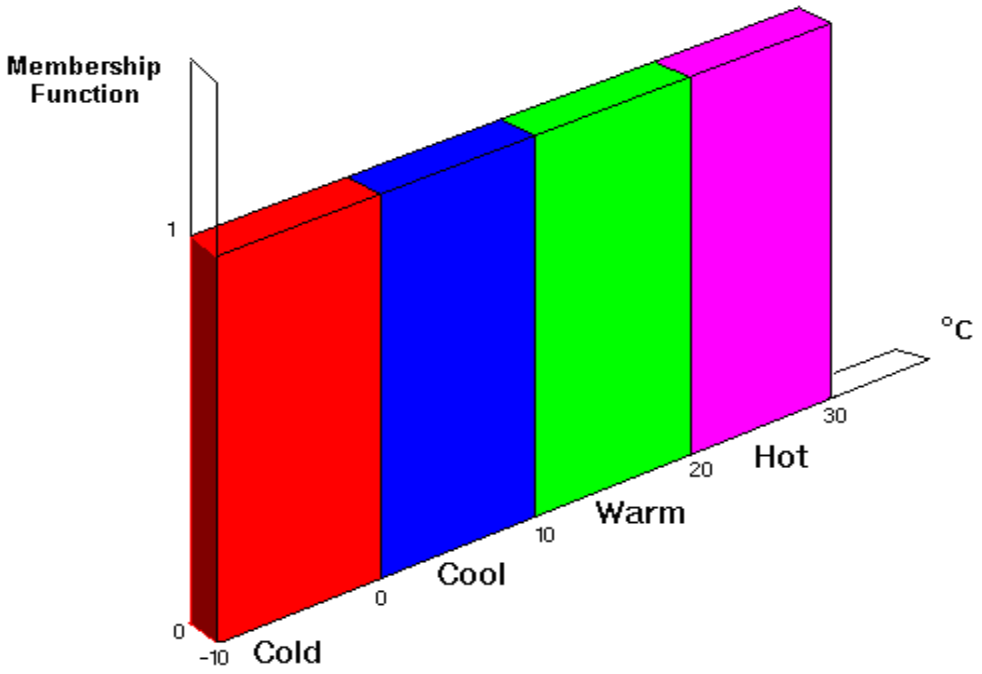


Figure 2.8 : Bivalent sets to characterise the Temperature of a Room

The most obvious limiting feature of bivalent sets that can be seen clearly from the diagram is that they are mutually exclusive - it is not possible to have membership of more than one set (opinion would widely vary as to whether 50 degrees Fahrenheit is 'cold' or 'cool' hence the expert knowledge we need to define our system is mathematically at odds with the humanistic world). Clearly, it is not accurate to define a transition from a quantity such as 'warm' to 'hot' by the application of one degree Fahrenheit of heat. In the real world a smooth (unnoticeable) drift from warm to hot would occur.

This natural phenomenon can be described more accurately by Fuzzy Set Theory. Figure 2.9 below shows how fuzzy sets quantifying the same information can describe this natural drift.

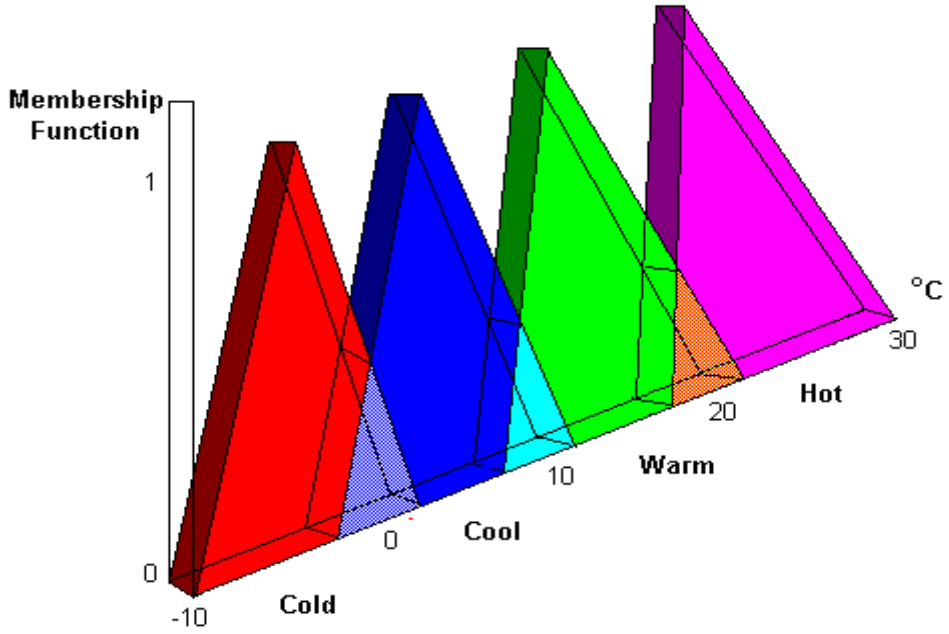


Figure 2.9 : Fuzzy sets to characterise the Temperature of a Room

There are two very special fuzzy sets needed in fuzzy expert systems: (i) discrete fuzzy sets and (ii) fuzzy numbers.

In discrete Fuzzy Sets, conventionally the truth value of a member in a fuzzy set is called its grade of membership. Discrete fuzzy sets for fuzzy expert systems may be numeric or non-numeric, depending on whether their members describe numeric or non-numeric quantities. As an example, consider :

Size = $\frac{\mu}{\text{small}}, \frac{\mu}{\text{medium}}, \frac{\mu}{\text{large}}$

its members describe a numeric quantity. Members of a numeric discrete fuzzy set always describe a numeric quantity. Such discrete fuzzy sets are called linguistic variables, with

members linguistic terms.

Fuzzy numbers represent a number of whose value we are somewhat uncertain. They are a special kind of fuzzy set whose members are numbers from the real line, and hence are infinite in extent. The function relating member number to its grade of membership is called a membership function.

Fuzzy Rules

Human beings make decisions based on rules. Although, we may not be aware of it, all the decisions we make are all based on computer like if - then statements. If the weather is fine, then we may decide to go out. If the forecast says the weather will be bad today, but fine tomorrow, then we make a decision not to go today, and postpone it till tomorrow. Rules associate ideas and relate one event to another. Fuzzy machines, which always tend to mimic the behaviour of man, work the same way. However, the decision and the means of choosing that decision are replaced by fuzzy sets and the rules are replaced by fuzzy rules. Fuzzy rules also operate using a series of if-then statements. For instance, if X then A, if y then b, where A and B are all sets of X and Y. Fuzzy rules define fuzzy *patches*, which is the key idea in fuzzy logic. The "if" part of the rule is the antecedent; the "then" part is the consequent. The main problem in building fuzzy expert systems is that of articulating the heuristic fuzzy rules and membership functions for the fuzzy terms.

Here are some methods for obtaining fuzzy rules:

The first is to interview an expert. Sometimes, communication between expert and interviewer can be difficult owing to a lack of common understanding. The shape of membership functions, the number of labels, and so forth should be defined by the expert. However, sometimes the human expert is unfamiliar with fuzzy sets or fuzzy logic and the knowledge engineer is unfamiliar with the domain area.

The second approach, as formulated by Yamakawa (1993), is to imagine (in the designer's own mind) physical behaviour of the real system and think about the physical meaning in natural and technical languages. The system designer has to be particularly experienced with the system in order to imagine its behaviour. There is no need to explain the behaviour with mathematical equations, typically differential equations. In some cases, the designer has to assign by imagination and intuition, the consequences of the fuzzy rules which usually appear on the grid of the rule map.

Fuzzy Set Operations.

Union

The membership function of the union of two fuzzy sets A and B with membership functions μ_A and μ_B respectively is defined as the maximum of the two individual membership functions. This is called the *maximum* criterion.

$$\mu_{A \cup B} = \max(\mu_A, \mu_B)$$

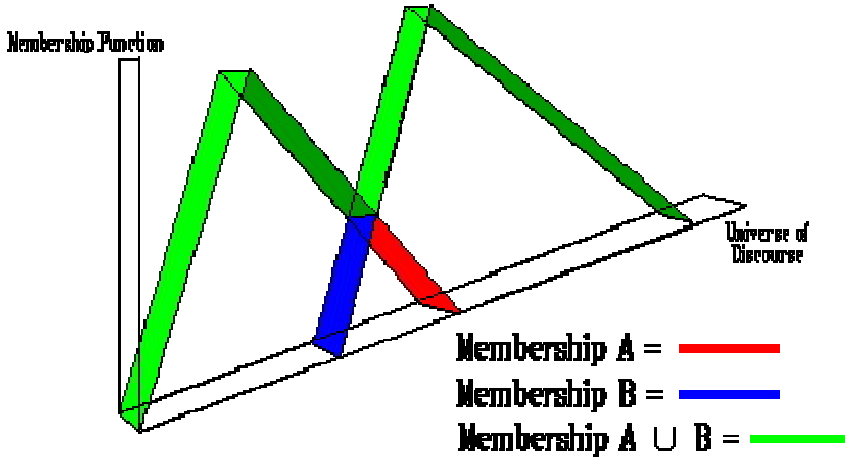


Figure 2.10 : The *maximum* criterion.

The union operation in Fuzzy set theory is the equivalent of the **OR** operation in

Boolean algebra.

Intersection

The membership function of the intersection of two fuzzy sets A and B with membership functions μ_A and μ_B respectively is defined as the minimum of the two individual membership functions. This is called the *minimum* criterion.

$$\mu_{A \cap B} = \min(\mu_A, \mu_B)$$

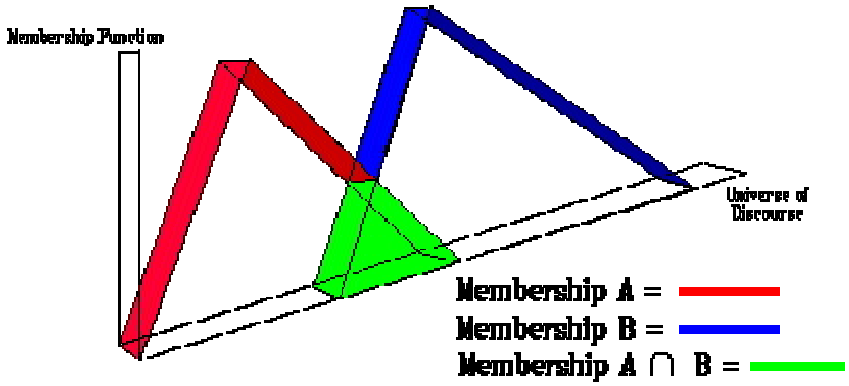


Figure 2.11 : The *minimum* criterion.

The Intersection operation in Fuzzy set theory is the equivalent of the **AND** operation in Boolean algebra.

Fuzzy Control

Fuzzy control, which directly uses fuzzy rules is the most important application in fuzzy theory. Using a procedure originated by Mamdani in the late 70s, three steps are taken to create a fuzzy controlled machine (Zadeh, 1965):

1) Fuzzification : The verb "to fuzzify" has two meanings: (i) to find the fuzzy version of a crisp concept, and (ii) to find grades of membership of linguistic values of a linguistic variable corresponding to an input number, scalar or fuzzy. Usually, the term fuzzification is used in the second sense, and it is that sense that is used in this research work. Suppose

we have a fuzzy number t whose truth values are defined from 0 to 100^{o}C. To fuzzify t means to find grades of membership of linguistic values in a linguistic variable (say Temperature), which are the linguistic equivalent of the number t, over the interval t [0, 100]. The name of the fuzzy set could be Temp with members flow, medium, high, all defined by membership functions in [0, 100]. The fuzzification operation is quite simple. The grade of membership of each linguistic value is the truth value of the fuzzy propositions.

2) Rule evaluation (Application of fuzzy rules as discussed earlier).

3) Defuzzification: At the end of a sequence of rule firings in a fuzzy expert system we may end up with a fuzzy conclusion C that is a linguistic variable, whose values have been assigned grades of membership. Quite often we want to compute a single scalar, which corresponds to these grades of membership. The process of computing a scalar from C is called defuzzification. This is especially needed in fuzzy control because the final conclusion must be communicated to the process, and the defuzzified value is the signal sent to the process.

Defuzzification is a much more complex process than fuzzification; there are several choices to be made, and many different methods have been proposed.

Some of the methods for calculating a single defuzzified number are the average maximum method, the weighted average maxima method, and the method most commonly used, a centroid method, is used in this research work.

A fuzzy control system is a closed-loop system that uses the process of fuzzification to generate fuzzy inputs to an inference engine, which is a knowledge base of actions to take. The inverse process, called defuzzification, is also used in a fuzzy control system to create crisp, real values to apply to the machine or process under control. Fuzzy controllers

have been used to control many machines, including washing machines and camcorders.

The initial work on the automation of air traffic control started with the invention of simulator machines as training tool for both trainees and instructors, among the earlier simulators are Tower Research Simulator (TRS), another one widely used in ATC is the Total Airspace and Airport Modeler (TAAM) (Sood et. al., 2003). TAAM was developed by the Preston Aviation Solutions in Australia. However, Plaettner-Hochwarth et. al., (2000) reported that one of the major drawbacks of this software was the price tag. In 1997 a single site license cost about $350,000. In addition to its high price, TAAM also was reported to lack stochastic options and did not cover all Air Traffic Management (ATM) components.

SIMMOD a brand name was a discrete event based model developed by the Federal Aviation Administration (FAA).

Most of these simulators have so many drawbacks such as : difficult to be adapted to new scenarios, confined to a specific category of ATC, difficult to be used and maintained, not designed initially to support teamwork coordination, portability issues and high prices.

Sidhom (2006) improved on some of these drawbacks. His overall application design was made up of communication module, instructor module, approach module, tower module and pilot module. He used Extensible Markup Language (XML) and Java for the design. The resulted simulator is a flexible training tool for both trainees and instructors.

From simulator machines, researchers started to dwell into real time automation of ATC operations to reduce controller stress and the aircraft accident.

Doitsidis et. al., (2004) in their paper demonstrated fuzzy-logic based autonomous navigation and control of small manned-unmanned aerial vehicles. The implementation framework utilizes MATLAB's standard configuration and the (Aerosim) Aeronautical

Simulation Block Set. The two-module fuzzy logic controller is composed of the *altitude* module, and the *latitude-longitude* module. Another module under development is that of virtual radar.

A fuzzy decision system for helping air-traffic experts in controlling airplane velocities and in keeping an airplane flying within several constraints established to air lane sections, was proposed in a paper titled Airplane Speed Control: A fuzzy logic Approach by Lovato et. al., (2005). The proposed system used Mamdani direct inference method (Zadeh, 1965).

This research addressed the problem of aircraft speed control for landing perimeter system based on a fuzzy decision support system.

Zhengping et. al., (2003) presented a paper on information integration, the Air Traffic Control Command Monitoring System (ATCCMS), which integrates all kinds of fundamental information such as radar information, flight plans, voice communication, and weather conditions into a comprehensive information platform. In this paper, the context of voice communication is analyzed with speech recognition technology and is correlated with radar data and expert knowledge to determine whether any potential danger will emerge from the controller's instructions.

The key components of ATCCMS include: (i) the speech recognition and post-processing of control instructions; (ii) the realization of flight conflict detection and an alerting algorithm; (iii) modeling short-term air traffic flow management; (iv) the development and realization of a global flight status database; (v) the analysis and development of a real time system.

ATCCMS, developed with Visual C++ 6.0, integrates radar information, flight plan information, speech information of control instructions, and weather information into a

common platform. The prototype of ATCCMS is under test run in North China Regional Air Traffic Management Bureau of CAAC.

Dennis G. (2003) worked on Tactical Separation Assisted Flight Environment (TSAFE) invented by Heinz Erzberger Chief Scientist for air traffic control at NASA Ames Research Center. TSAFE a new tool was designed to aid air traffic controllers in detecting and resolving short-term conflicts between aircraft. TSAFE was proposed as a principle component of a larger Automated Airspace Computing System (AACS), whose goal was to shift the burden of maintaining aircraft separation from controllers to computers.

Air traffic control (ATC) software systems are generally highly complex systems of machinery, Dennis G. (2003). TSAFE was developed experimentally, with the goal of emulating controller inference, they typically consist of complex heuristics and intricate algorithms, many of which were added and tweaked in a very ad hoc manner. As a result, ATC systems are notoriously large and messy and intractable in terms of analysis and verification.

In his project, he intended to take TSAFE in the opposite direction, that is, to turn it into a small, trusted, and verifiable component–a Trusted Computing Base. TSAFE Components in the initial proposal was to consist of five main components: (i) a Conformance Monitor, (ii) a Trajectory Synthesizer, (iii) a Conflict Detector, (iv) a Conflict Avoidance Module, and (v) a Controller Interface.

The prototype Gregory built of TSAFE performs two primary functions: conformance monitoring and trajectory synthesis. According to Gregory, "conformance monitoring," means the process of determining the degree to which a flight is conforming, or not conforming, to its instructions. The term "trajectory synthesis" refers to the prediction and construction of the aircraft's future trajectory, or 4-dimensional path.

To perform these functions, TSAFE analyzes flight plan and radar data received from either a live feed or from recorded files. It displays both the observed and computed flight data on an interactive graphical user interface. TSAFE is divided into four main software modules: (i) the database, (ii) the parser, (iii) the engine, and (iv) the client.

CARAT# (Configurable Airspace Research and Analysis Tool Sharp) a rapid – prototyping for en route air traffic management research software by Menon et. al.,(2005) employed FACET (Future ATM Concepts Evaluation Tool) software which was developed at NASA Ames Research Center to provide research capabilities for the en route portion of the air transportation system.

FACET was written in C, with JAVA GUI. CARAT allows the user to access the FACET functionality through scriptable interfaces built in MATLAB and Jython.

If both CARAT# and FACET can be integrated into TSAFE it will form a reliable ATC software.

Center - Tracon Automated System (CTAS) software was designed and implemented at NASA Ames Research Center to assist air Traffic controller in their work, this version is known as the "Concept Development Software". CTAS software is made up of tools such as Final Approach Spacing Tool (FAST), Traffic Management Advisor Tool (TMA), En Route Descent Advisor tool (EDA) etc (NASA Ames Research Center, 2005). CTAS is comprised of multiple executable processes that communicate with each other via messages sent using a TCP/IP socket protocol. The processes typically run on distributed workstations connected by a high-speed network.

The majority of the CTAS software is implemented in the ANSI C language and runs under the Unix operating system. About 20% of the software was implemented in C++. The primary platform for CTAS is the Sun Microsystems Sparcstation, running Sun's Solaris

2.x operating system, which is compliant with the AT&T System V Release 4 (SVR4) version of Unix. The graphical elements of CTAS are implemented using the X11R5 release of X-Windows; all of the CTAS GUI's use the Motif toolkit except for one, which was implemented using the Open-Windows toolkit.

The major concern about some of the worked discussed above is adaptability, especially in Nigeria, some of the navigational aids equipment in use are very old and may not meet the required technical specifications, therefore, there is a need for a model that is suitable for our current situation and adaptable elsewhere.

CHAPTER THREE : SYSTEM ANALYSIS AND DESIGN

3.1 Aerodrome and Approach/Radar Control Modeling

In this section, an aircraft departing or arriving an aerodrome is modeled by using fuzzy expert system, the required parameters are clearly stated. Figure 3.1 shows the fuzzy logic diagram for the model and the required steps are discussed below:

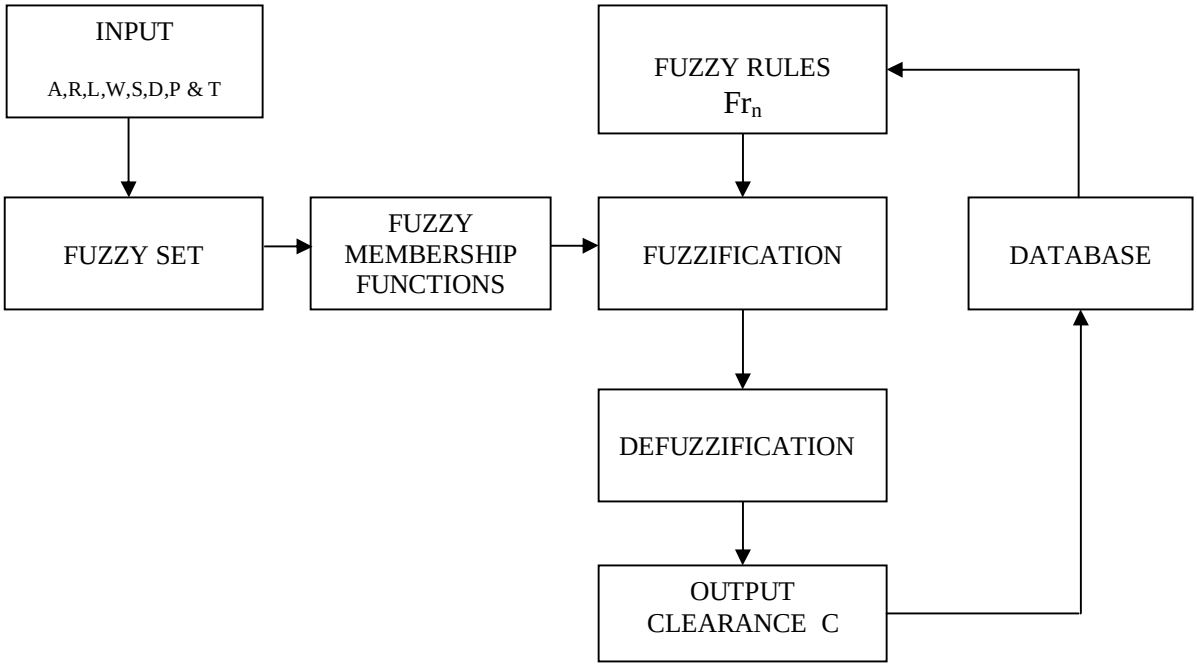


Figure 3.1 Block Diagram of Fuzzy Expert System for Departure and Arrival Model

Input (Required Parameters)

Let R be the route/track, P be the departing airport/airfield, S be the speed of the aircraft.

Let L and W be the level of the aircraft and weather respectively.

Let $T_i = \{ T_1, T_2, \ldots\ldots\ldots T_i \}$, $D_J = \{ D_1, D_2, \ldots\ldots\ldots D_J \}$, $A_k = \{ A_1, A_2, \ldots\ldots\ldots A_k \}$ and $Fr_n = \{ r_1, r_2, \ldots\ldots\ldots r_n \}$ be set of time for departing aircrafts, set of distance covered by departing aircrafts, set of aircrafts departing an airfield and set of rules for departing aircrafts respectively.

Finally let C be the output, clearance to depart.

Fuzzy Set/ Fuzzy Membership Functions/ Fuzzification

Step One: Defining Inputs and Output for the Departure Fuzzy Logic Control Model (DFLCM).

The range of values that inputs and outputs may take is called the universe of discourse. For all of the inputs and outputs of the DFLCM, which are all crisp values. The universe of discourse for inputs and outputs for DFLCM is within the range of (0 – 10). The linguistic input variable names are Route, Speed, Level, Distance, Aircraft and Weather and the output is Clearance.

Step Two: Fuzzify the Inputs

Triangular membership functions as discussed in chapter two is used to fuzzify the inputs (Fig 3.2 – 3.7). Some of the general guidelines used to determine the range of the fuzzy variables as related to the crisp inputs (adapted from Yan, et. al. (1994)) are :

1. Symmetrically distribute the fuzzified values across the universe of discourse.

2. Use an odd number of fuzzy sets for each variable so that some set is assured to be in the middle. The use of 5 to 7 sets is fairly typical.

3. Overlap adjacent sets (by 15% to 25% typically).

The input variables are restricted to positive values and the following fuzzy sets are used to describe them:

Route : Short, Medium, Long, Engaged, NotEngaged.

Speed : XSlow, Slow, Medium, Fast, XFast.

Weather : VHazy Hazy, LittleBright, Bright, VeryBright

Distance : XShort, Short, Medium, Long, XLong.

Aircraft : XSmall, Small, Medium, Big, XBig.

Level : XSmall, Small, Medium, High, XHigh.

Clearance : DontClear, RiskClear SemiClear, Clear, GClear.

Table 3.1 and Figure 3.2, show the assignment of ranges and triangular fuzzy membership functions for Route. Similarly, Table 3.2 and Figure 3.3 assign ranges and triangular fuzzy membership functions for Speed, Table 3.3 and Figure 3.4 for Weather, Table 3.4 and Figure 3.5, Table 3.5 and Figure 3.6 and Table 3.6 and Figure 3.7 for Distance, Aircraft and Level respectively.

Fuzzy Variable Ranges for Route

Crisp Input Range	Fuzzy Variable
0 – 2	Short
1.5 – 4	Medium
3 – 7	Long
6 – 8.5	Engaged
7.5 – 10	NotEngaged

Table 3.1 : Fuzzy Variable Ranges for Route

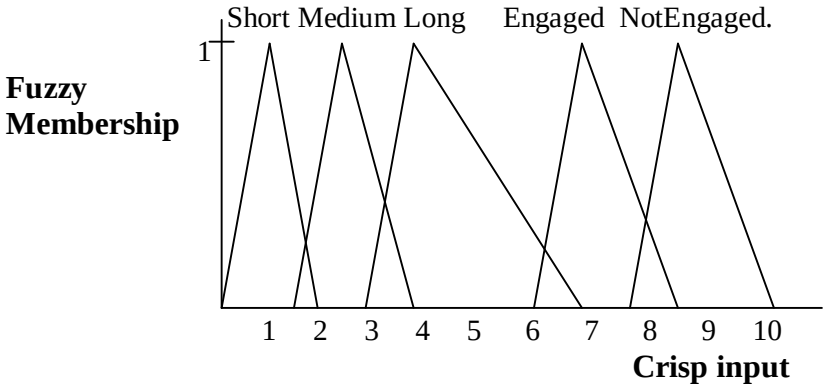


Figure 3.2 : Fuzzy membership functions for Route

Fuzzy Variable Ranges for Speed

Crisp Input Range	Fuzzy Variable
0 – 2	XSlow
1.5 – 4	Slow
3 – 7	Medium
6 – 8.5	Fast
7.5 – 10	XFast

Table 3.2 : Fuzzy Variable Ranges for Speed

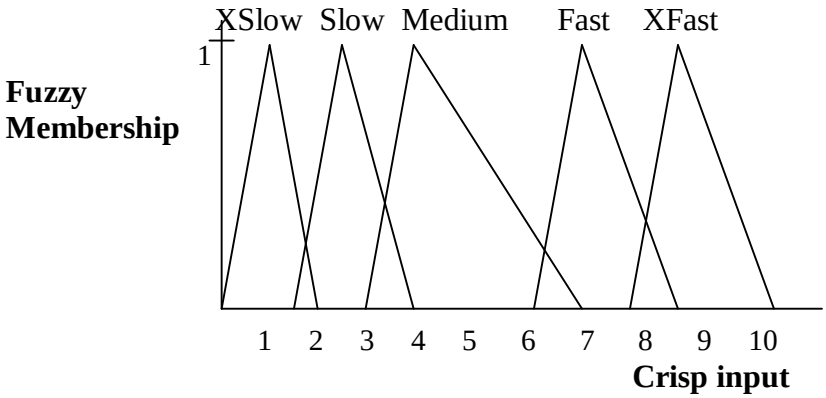


Figure 3.3 : Fuzzy membership functions for Speed

Fuzzy Variable Ranges for Weather

Crisp Input Range	Fuzzy Variable
0 – 2	VHazy
1.5 – 4	Hazy
3 – 7	LittleBright
6 – 8.5	Bright
7.5 – 10	VeryBright

Table 3.3 : Fuzzy Variable Ranges for Weather

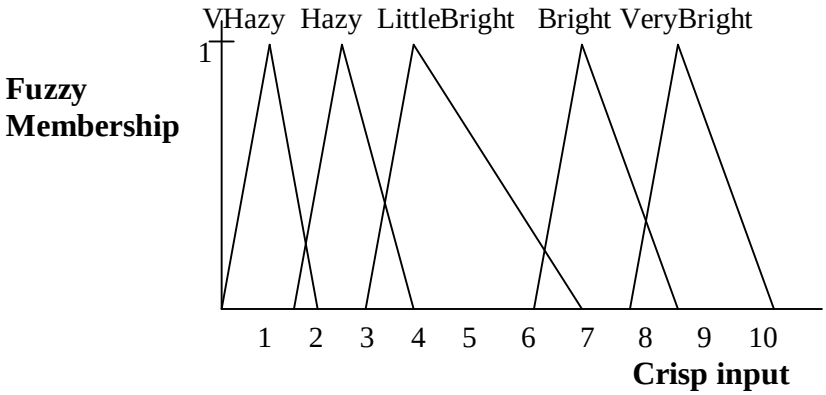


Figure 3.4 : Fuzzy membership functions for Weather

Fuzzy Variable Ranges for Distance

Crisp Input Range	Fuzzy Variable
0 – 2	XShort
1.5 – 4	Short
3 – 7	Medium
6 – 8.5	Long
7.5 – 10	XLong

Table 3.4 : Fuzzy Variable Ranges for Distance

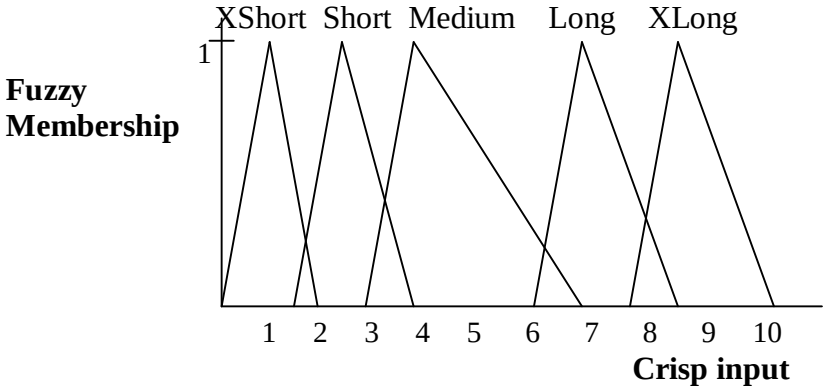


Figure 3.5 : Fuzzy membership functions for Distance

Fuzzy Variable Ranges for Aircraft

Crisp Input Range	Fuzzy Variable
0 – 2	XSmall
1.5 – 4	Small
3 – 7	Medium
6 – 8.5	Big
7.5 – 10	XBig

Table 3.5 : Fuzzy Variable Ranges for Aircraft

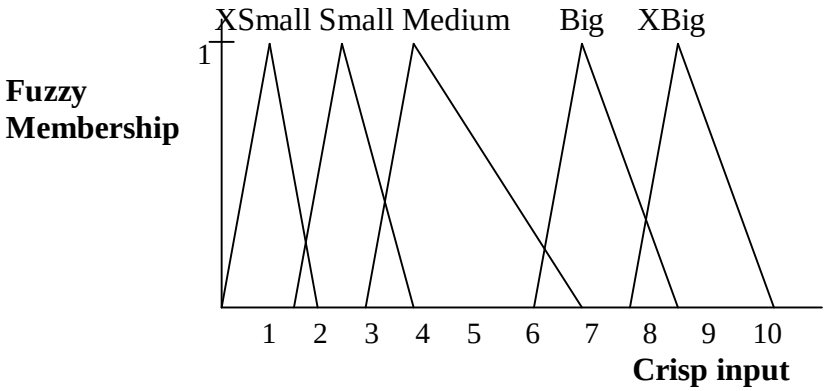


Figure 3.6 : Fuzzy membership functions for Aircraft

Fuzzy Variable Ranges for Level

Crisp Input Range	Fuzzy Variable
0 – 2	XSmall
1.5 – 4	Small
3 – 7	Medium
6 – 8.5	High
7.5 – 10	XHigh

Table 3.6 Fuzzy Variable Ranges for Level

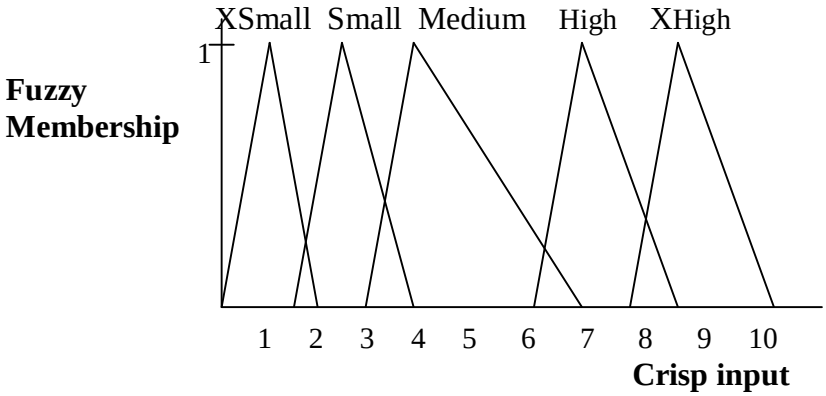


Figure 3.7 : Fuzzy membership functions for Level

Step Three: Set Up Fuzzy Membership Functions for the Output

Fuzzy membership is assigned to the output, Clearance. This is shown in Table 3.7 and Figure 3.8

Fuzzy Variable Ranges for Clearance

Crisp Input Range	Fuzzy Variable
0 – 2	DontClear
1.5 – 3	RiskClear
2.5 – 5	SemiClear
4.5 – 8.5	Clear
7.5 – 10	GClear

Table 3.7 Fuzzy Variable Ranges for Clearance

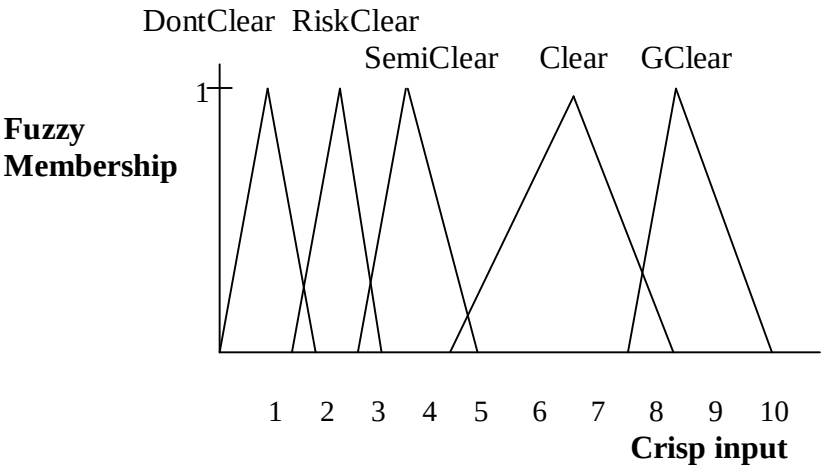


Figure 3.8 : Fuzzy membership functions for Clearance

Step Four: Create a Fuzzy Rule Base

Now that the inputs and the output have been defined in terms of fuzzy variables, then the next step is to specify what actions to take under what conditions; that is, there is a need to construct a set of rules that describe the operation of the DFLCM. These rules usually take the form of IF–THEN rules and are obtained from a human expert, Air traffic Controller and may be stored in the database. Some of the rules are as follows:

1. IF the Aircraft is XSmall AND the Route is Short THEN Clear the Aircraft
2. IF the Aircraft is XSmall AND the Route is Medium THEN Clear the Aircraft
3. IF the Aircraft is XSmall AND the Route is Long THEN DontClear the Aircraft
4. IF the Aircraft is XSmall AND the Route is Engaged THEN DontClear the Aircraft

5. IF the Aircraft is XSmall AND the Route is NotEngaged THEN Clear the Aircraft
6. IF the Aircraft is Small AND the Weather is VHazy THEN DontClear the Aircraft
7. IF the Aircraft is Small AND the Weather is Hazy THEN DontClear the Aircraft
8. IF the Aircraft is Small AND the Weather is LittleBright THEN DontClear the Aircraft
9. IF the Aircraft is Small AND the Weather is Bright THEN Clear the Aircraft
10. IF the Aircraft is Small AND the Weather is VeryBright THEN Clear the Aircraft.

Defuzzification

Step Five: Defuzzify the Output

Each of the fuzzy input variable activations will cause different fuzzy output cells to fire, or be activated, as a result, there is a need for the final step, defuzzification of the output into a crisp value. The center of area (COA) or centroid with the overlap composition method is used.

Assume that at a particular point in time, Aircraft = 7.0 and Weather = 9.0 . These are the crisp inputs entered by the controller. With fuzzification, the following fuzzy memberships is obtained :

crisp input — Aircraft = 7.0

fuzzy outputs with membership values :-

Medium: 0.4

XBig : 0.6

all others: 0.0

crisp input — Weather = 9.0

fuzzy outputs with membership values :-

VeryBright : 0.75

Hazy : 0.25

all others: 0.0

This results in four rules firing:

1. Weather = VeryBright (0.75) AND Aircraft = Medium (0.4)

2. Weather = Hazy (0.25) AND Aircraft = Medium (0.4)

3. Weather = VeryBright (0.75) AND Aircraft = XBig (0.6)

4. Weather = Hazy (0.25) AND Aircraft = XBig (0.6)

To determine what the output should be for each of the AND clauses in the IF–THEN rules, this is done by the conjunction or minimum operator. So for each of these rules the following firing strengths are obtained :

1. (0.75) ¥ (0.4) = 0.4

2. (0.25) ¥ (0.4) = 0.25

3. (0.75) ¥ (0.6) = 0.6

4. (0.25) ¥ (0.6) = 0.25

By using the fuzzy rule base and the strengths assigned previously, we find the rules recommend the following output values with strengths (Fig. 3.9 – 3.12) for Clearance :

1. SemiClear (0.4)

2. DontClear (0.25)

3. Clear (0.6)

4. RiskClear (0.25)

The strength value is used and then the particular triangular membership function to that strength level is filled. For example, for the first rule, the triangular membership function, SemiClear to the 0.4 level. Then the top of the triangle (above 0.4) is cut off. Next the same thing is done for the other rules. Finally the truncated figures are aligned as shown

in Figure 3.10 and combined them according to the overlap composition method (Kosko).

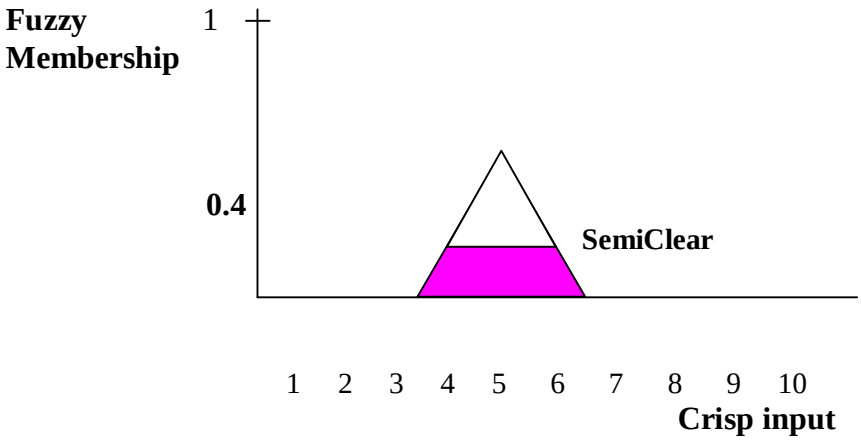


Figure 3.9 : Triangular membership function for SemiClear

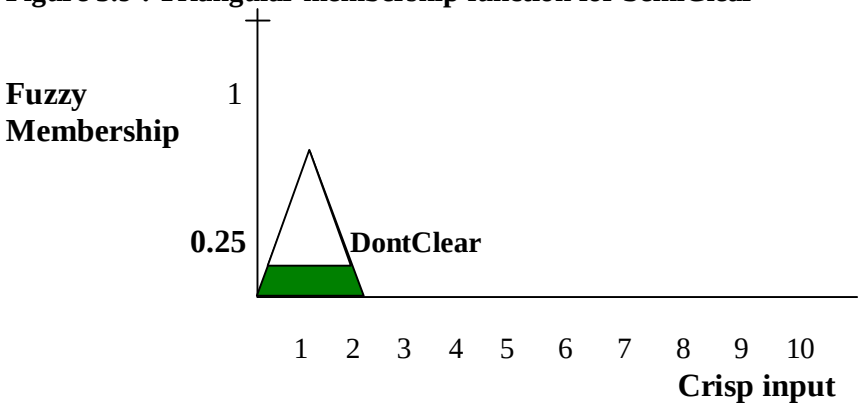


Figure 3.10 : Triangular membership function for DontClear

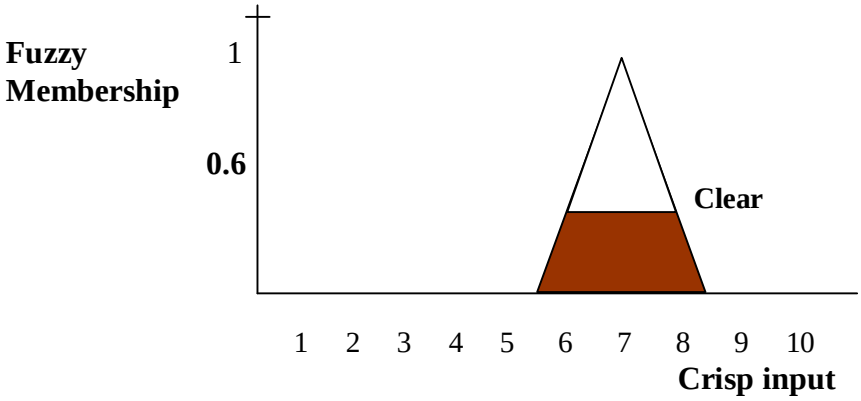


Figure 3.11 : Triangular membership function for Clear

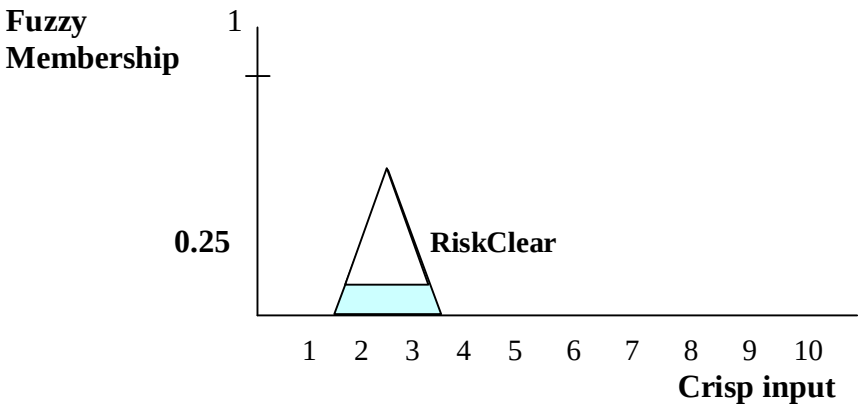


Figure 3.12 : Triangular membership function for RiskClear

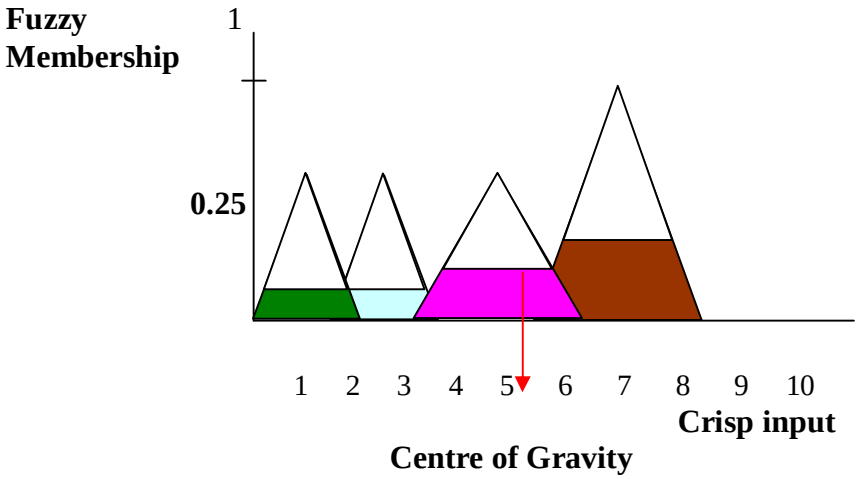


Figure 3.13 : Defuzzification with the Centroid approach

Clearance is between 5.3 – 6.0

The same approach is applicable to arrival model. With Clearance value equals to 5.3, it shows that the aircraft can be allowed to depart or land in the case of arrival. In a situation where the Clearance is SemiClear, it shows that the route is engaged and the Controller needs to perform separation between the departing or arriving aircrafts as the case may be.

If there are two aircrafts departing from the same airfield, if the second aircraft is climbing through the level of the first aircraft and both proceeding on the same track, the second

aircraft has to be delayed for a specific period of time computed by a standard separation equation 3.1 below plus five minutes minimum separation constant.

$X_t = T_2(S_1 - S_2)/ S_1$ ……. 3.1

X_t = Minimum time to be added to 5 Minutes separation constant

S_1 = Speed of first aircraft

S_2 = Speed of second aircraft

T_2 = Time it will take second aircraft to reach the level of first aircraft.

If an aircraft is departing from an airfield and climbing through the level of an incoming aircraft in opposite direction, the departing aircraft has to be delayed for a particular period of time calculated by equation 3.2 to avoid collision.

$X = (T_2+10)(S_1 - S_2)/ S_1$ ……. 3.2

X = Minimum time to be subtracted from the Expected Time of Arrival of the incoming Aircraft.

S_1 = Speed of first aircraft

S_2 = Speed of second aircraft

T_2 = Time it will take second aircraft to reach the level of first aircraft.

Aircraft is not allowed to depart or arrive at DontClear and Riskclear.

3.2 Area Control Model

In this section, an aircraft departing for eastbound or westbound and an aircraft en route eastbound or westbound is modelled by employing the same Block Diagram of Fuzzy Expert System for Departure and Arrival Model.

The clearance value will determine the action to be taken, for example, the clearance will be SemiClear for a faster Big aircraft attempting to overtake a slower smaller aircraft flying in the same direction until the two are separated to avoid collision by using a

separation standard equation in equation 3.3 to find the time to be added to the time of slower aircraft over reporting point before a faster Big aircraft is allowed to overtake.

$X = S_1(T_2 - 15)/(S_1 - S_2)$ …… 3.3

X = Time to be added to the time of slower aircraft over reporting point.

S_1 = Speed of first aircraft.

S_2 = Speed of second aircraft .

T_2 = Time difference over reporting point.

3.3 System Design

The design and development of a Fuzzy Logic Model for Air Traffic Control System is mostly from the perspective of a user (Air traffic Controller). The technology used is Hypertext Pre-processor (PHP), formally Personal Home Page, a server side scripting language with Apache as the web server and MySQL as the relational database server (Fig. 3.14).

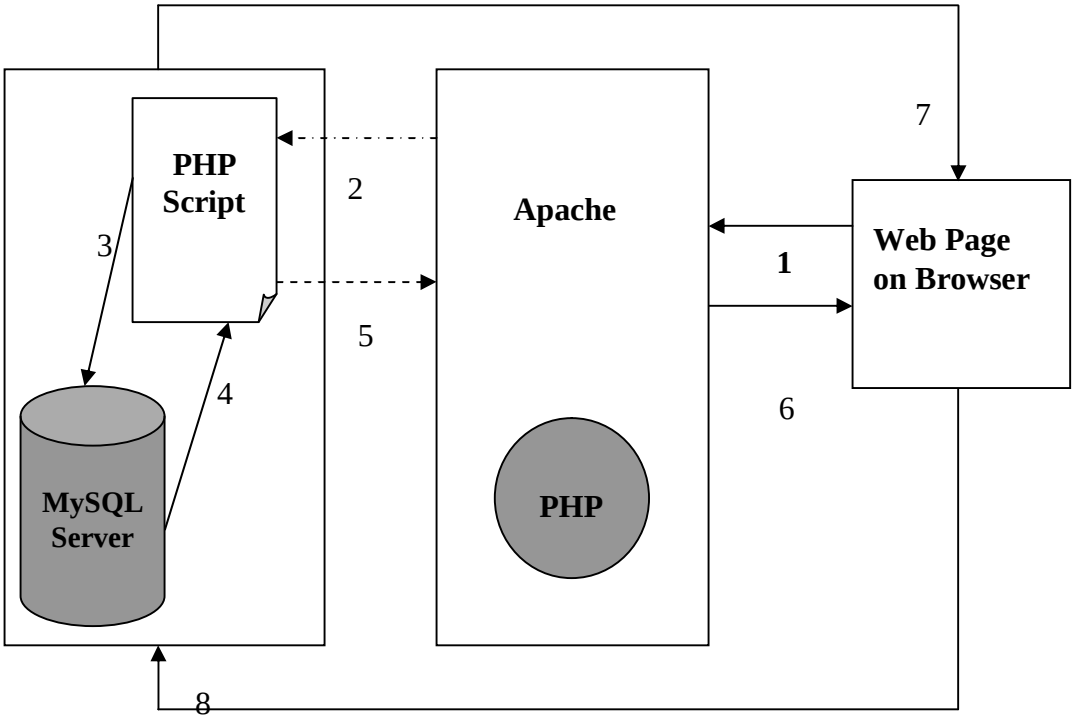


Figure 3.14 : Architecture of Web Application.

A PHP language is used because of the following benefits :

- Easy, powerful and popular
- Server-side scripting language
- Supports many DB's (not only MySQL)
- Platform Independent
- Web Server Independent
- Free and Open Source

A MySQL database is used because of the following benefits :

- MySQL is the largest growing relational database out on the market as it can handle large databases that can be accessed over the Web - Meets the ANSI SQL92 regulations (SQL-Structured Query Language) Mainly runs on UNIX-based environments, but also used on windows
- One of the most used open source databases in the world.
- Capacity to handle 50,000,000+ records.
- Very fast command execution, perhaps the fastest to be found on the market. Flexible and secure password system to protect your data - powerful security system
- Fast, reliable, easy to use, and affordable.
- On-line help facility - (type –help or -?).
- Comes with a source code.
- Multi-User and works on Several Platforms.

The transaction between a web application and a user begins with the user's browser sending a request through the Internet to the web server, since PHP script is used in this work, the web server (Apache) will delegate the processing of the page to

the PHP engine. The PHP script might read or write data to disk. It may send SQL queries to MySQL server and receives response.

3.4 System Requirement

The minimum hardware requirement for the design and implementation of a Fuzzy Logic Model for Air Traffic Control System (FLMATCS) is as follows:

a. A Pentium 4 equivalent CPU 1.8Ghz processor with 512MB memory
b. A hard drive with 40GB capacity
c. A graphic adaptor with screen resolution of 800 x 600 pixels 32 bit quality and a 15.4" monitor
d. A CD/DVD Rewritable drive
e. Internet ready with 56k modem for dial-up access
f. Wireless LAN with 802.11b/g wireless network card
g. 10/100 Mbps Ethernet LAN card
h. Sound Card and Multimedia speakers

The software requirement are as follows :

a. Apache web server version 1.33
b. MySQL database server version 4.1.10
c. PHP server side scripting language version 5.0.4
d. Windows XP Professional with Service Pack 2 as the OS
e. Microsoft Paint as the graphic editor

3.5 Design Considerations

Requirement and analysis is an important stage at the beginning of any project. After consulting with Air traffic Controllers and Pilots in Nigerian College of Aviation Technology (NCAT), the following requirements were identified:

An easy to use and understand interface.

An ability to add, update, search, and browse FLMATCS.

Different access privileges for Air traffic Controllers and Airport Controller.

The ability to categorize FLMATCS forming a hierarchical tree structure.

Given the above points, a web-based FLMATCS is designed and prototype is implemented in NCAT Aerodrome. The FLMATCS has three main features :- Aerodrome Control, Approach/Radar Control and Area Control.

3.6 Login page

Username and Password is required to access FLMATCS. The system will verify the authenticity of the username and password supplied (Fig. 3.15), if correct, the user will be taken directly to the home page.

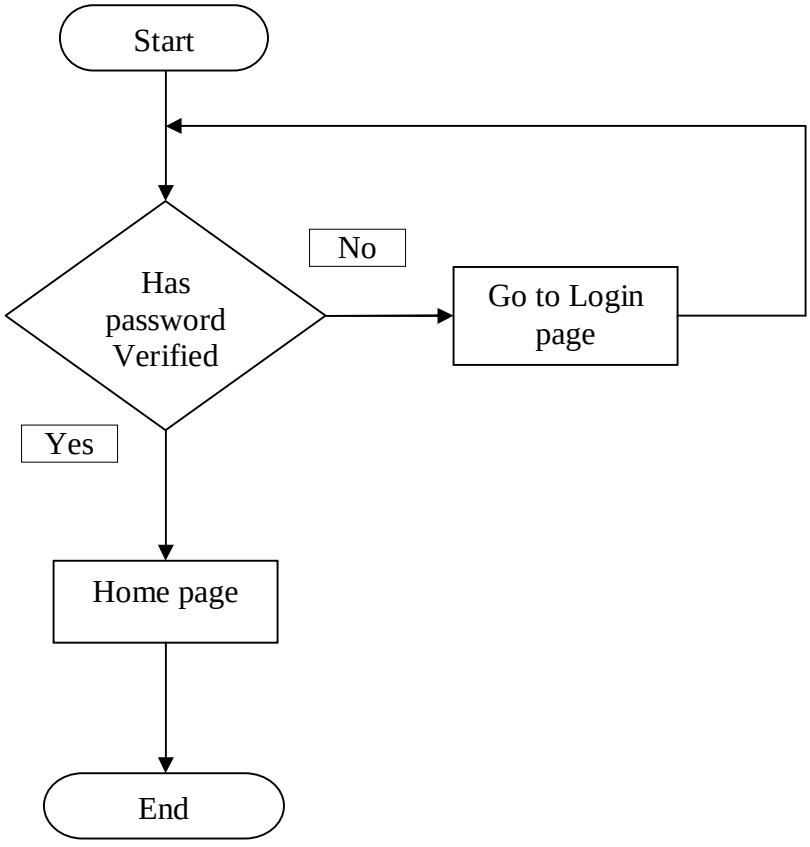


Figure 3.15 : Password Verification

3.7 Aerodrome and Approach/Radar Control

As mentioned earlier in chapter two, section 2.4, pilot shall fill flight plan after careful study of available current weather reports and forecast, taking into consideration fuel requirements and an alternative course of action if the flight cannot be completed as planned. Based on this, a progress flight strip is created by clicking addnew on the Aerodrome page by Air Traffic controller for the air craft departing the aerodrome. Although pilot is in charge of the air craft, but he must get clearance from the controller before taking off. Before the controller can give clearance, he must check the recent clearance issued by clicking on clearance tab to avoid head on collision between departing and arriving aircraft. He may need to change the flight level and the course of departing aircraft if previously assigned value may result in conflict, (Fig 3.16). The same procedure is applicable to arriving aircraft, if the runway is busy, in coming aircraft is kept on holding on the navigational aids equipment till runway is free before being cleared for landing, except it is an emergency landing.

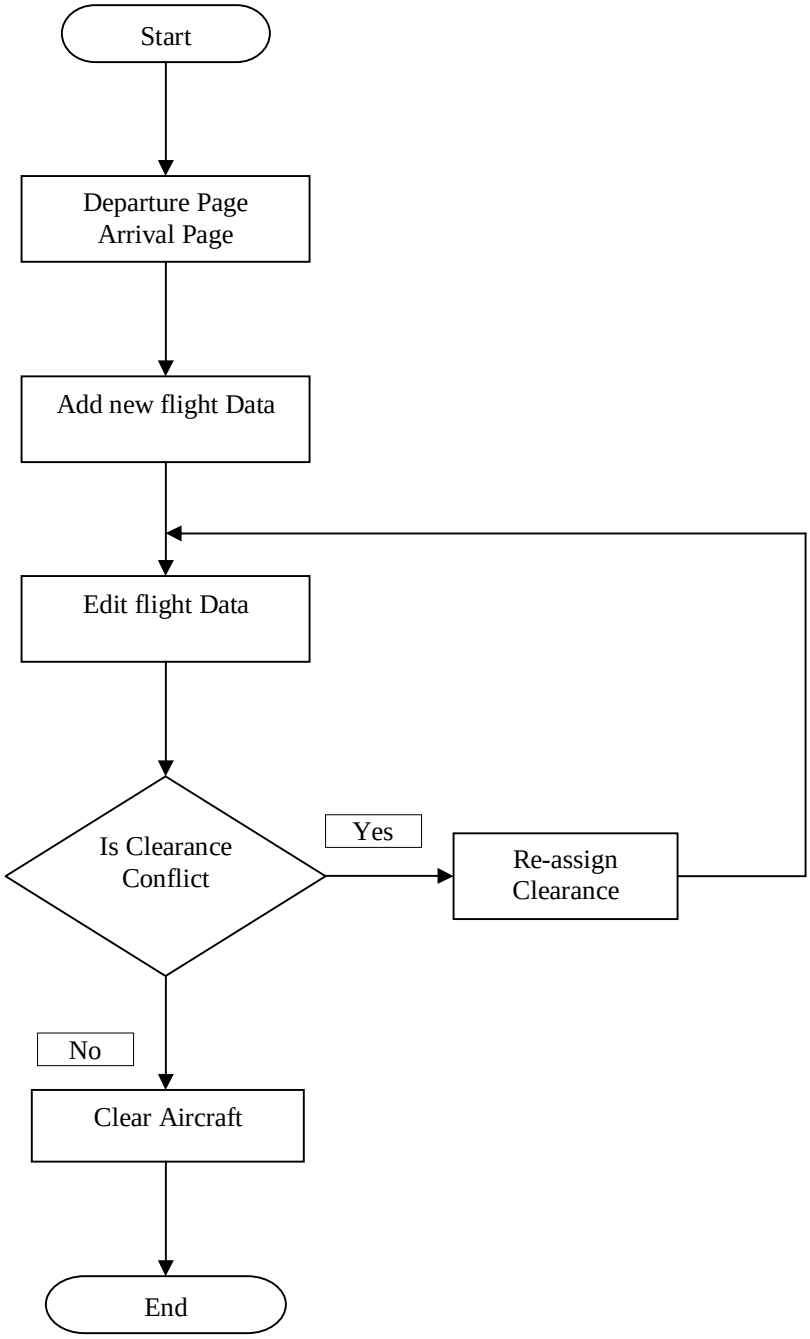


Figure 3.16 : Aerodrome Control.

Approach/Radar Controller takes over the traffic control of the departing aircraft from the aerodrome controller, he provides separation between departing and arriving aircraft based on the flight progress strip entered earlier by aerodrome controller. In a

situation whereby the pilot changes or want to change his course and route because of sudden change of weather he has to check the previous clearance of other aircrafts in the same or opposite direction by using the flight level, true air speed, type of aircraft and course to provide separation before he can approve the pilot's request, Approach/Radar Control hands over to Area controller (Fig. 3.17).

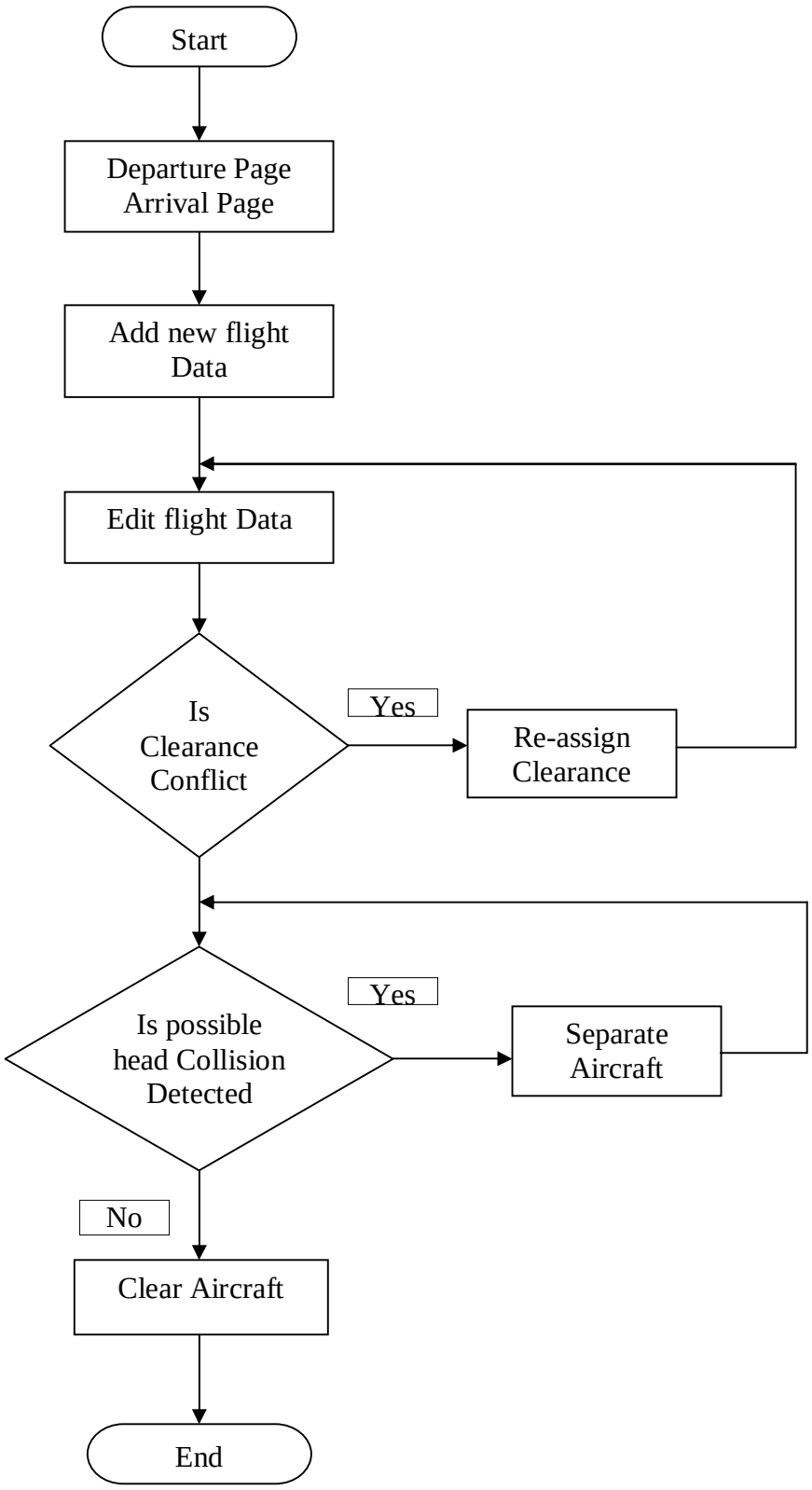


Figure 3.17 : Approach/Radar Control

3.8 Area Control

Area controller separates aircraft based on odd number as flight level for East-Bound aircraft and even number for West-Bound**.** An aircraft on en-route is separated from the one approaching or departing from a destination (Fig. 3.18).

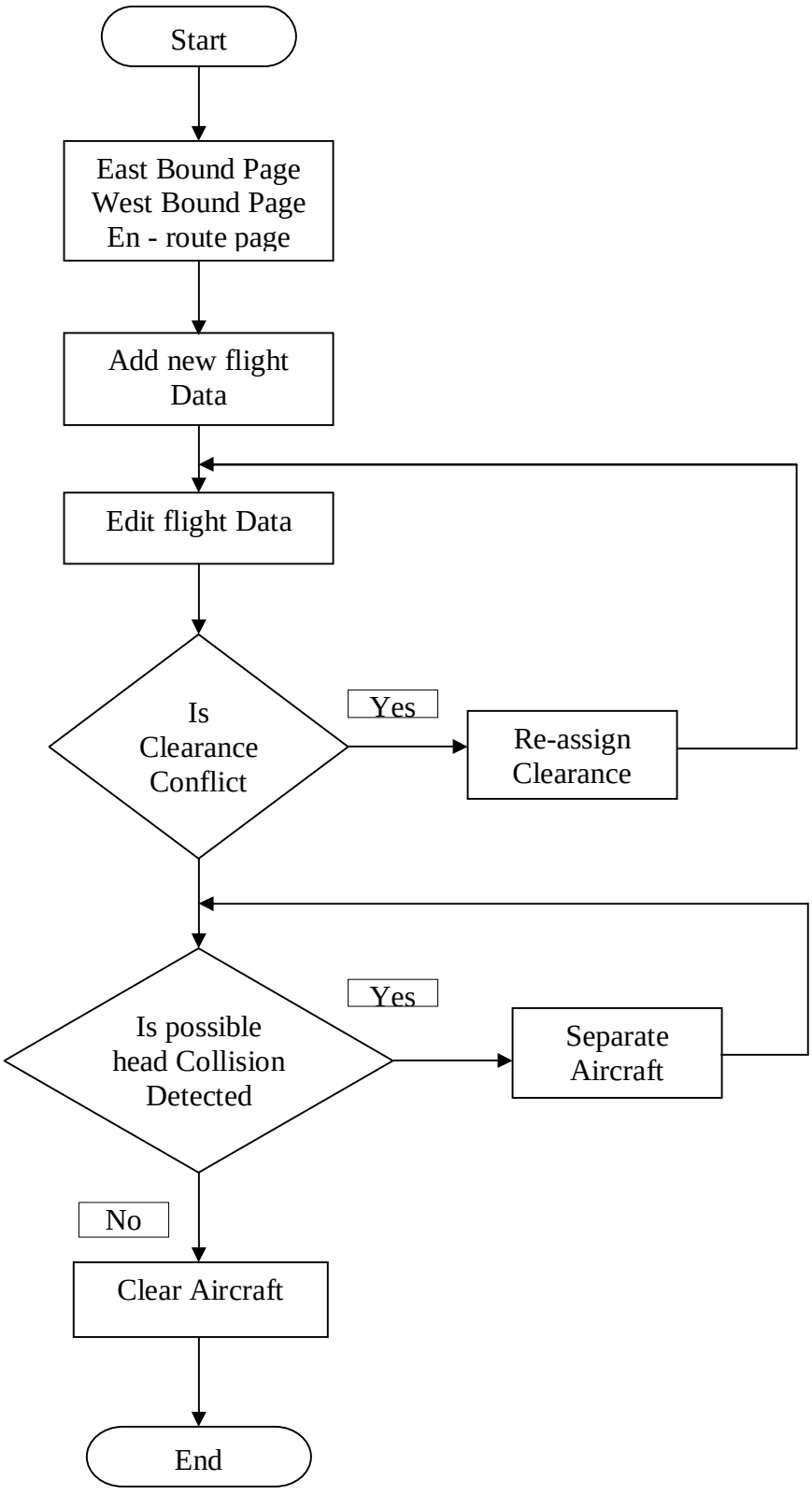


Figure 3.18 : Area Control

CHAPTER FOUR : SYSTEM IMPLEMENTATION, RESULT AND DISCUSSION

The type of site used in this design is the flexible path structure which implies that the user can view the content in any order or sequence, depending on the choice.

The units are available from the home page and other parts of the site through consistent menu design. From any page, it is possible to navigate to other pages with hyperlinks and a well written headline helps the user to understand the current location.

Login page

After successful Username and Password verification, (Fig.4.0), user will be taking directly to home page of FLMATCS (Fig.4.1).

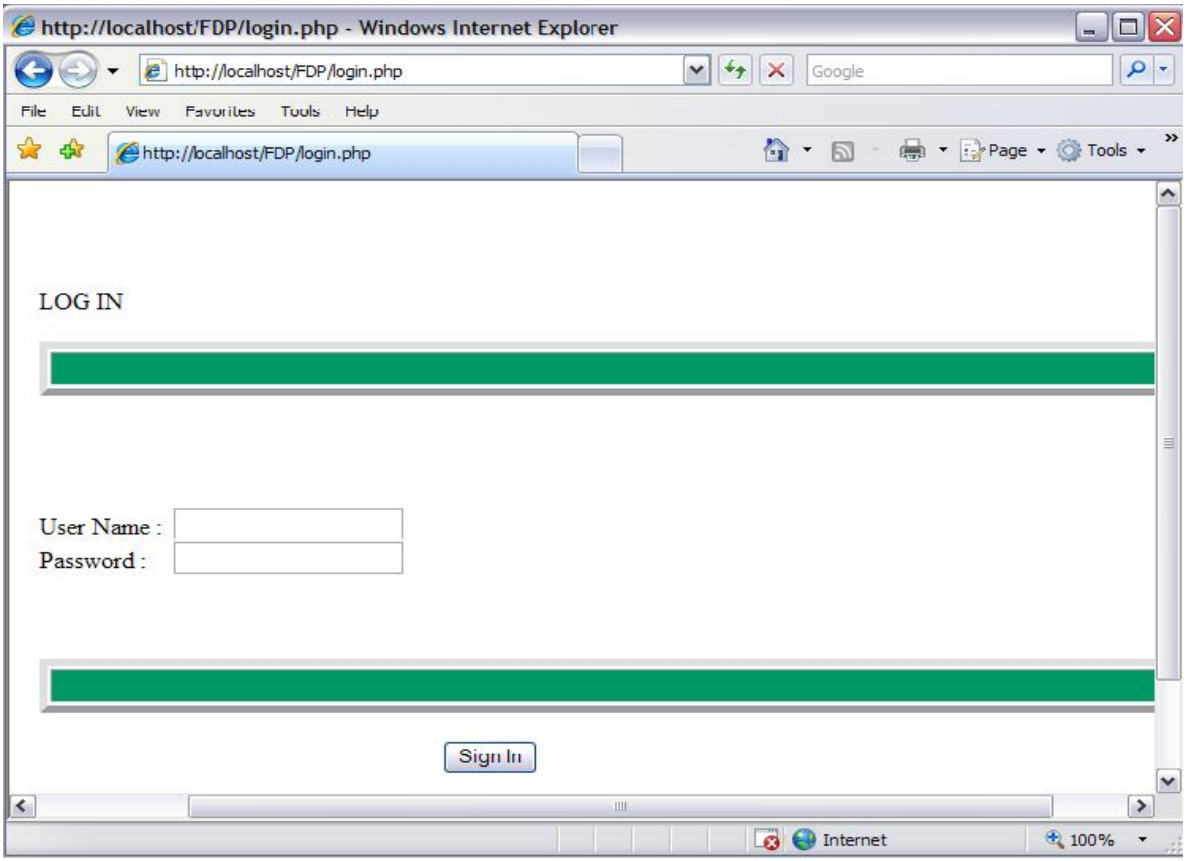


Figure 4.1 : Login Page

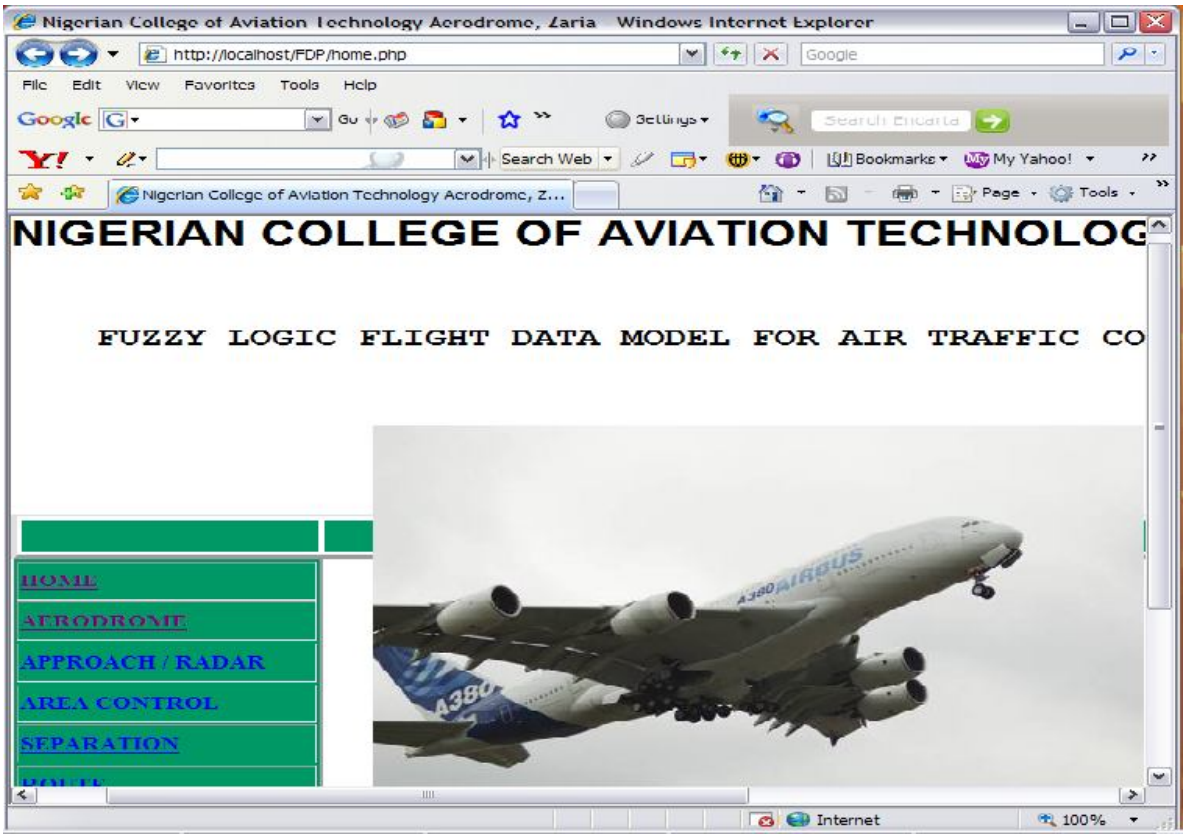


Figure 4.2 : Home Page

Aerodrome and Approach/Radar Control

The design is simulated by an aircraft departing NCAT Zaria aerodrome, a progress flight strip is created by Air Traffic Controller, this is done by clicking addnew on the Aerodrome departure page (Fig. 4.3) for the air craft departing the aerodrome. A Route is selected depending on the traffic and available route to the destination of the aircraft, (Fig. 4.4). Although pilot is in charge of the air craft, but he must get clearance from the controller before taking off. In the Fuzzy Logic Model for Air Traffic Control System, the parameter entered as an input and the rules will determine whether the clearance is DontClear, RiskClear, SemiClear, Clear or GClear. If the clearance is either DontClear or RiskClear, the controller must check the previous but recent clearance issued by clicking on expecting tab to avoid head on collision between departing and arriving aircraft and then

click on clearance tab to confirm if the clearance is GClear or RiskClear. There may be need to change some of the parameters such as flight level and course of departing aircraft if previously assigned value may result in conflict.

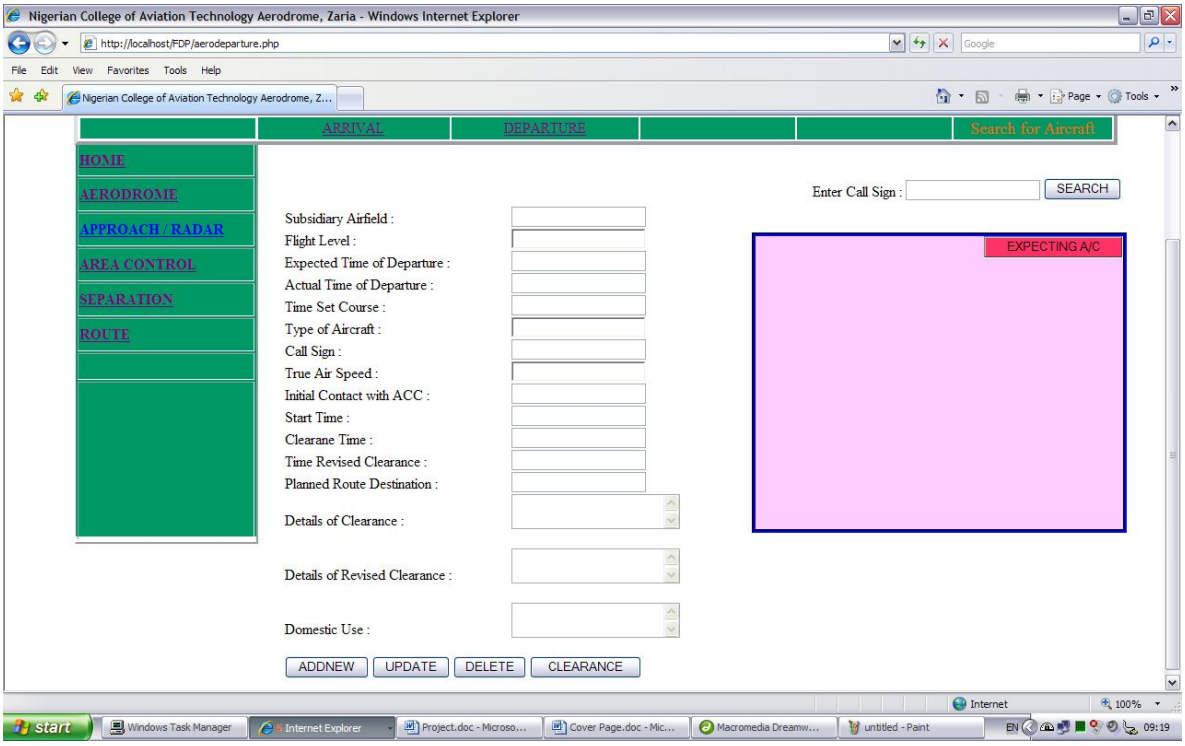


Figure 4.3 : Aerodrome departure Page

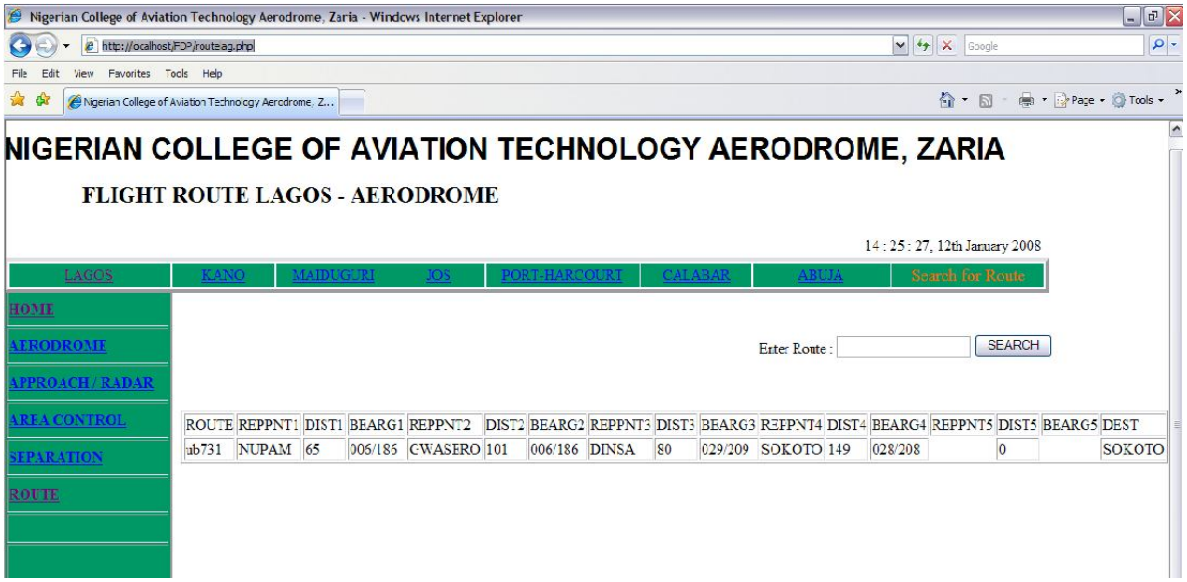


Figure 4.4 : Route Page

If the clearance is SemiClear, Controller has to query the database to confirm if there is any aircraft approaching the aerodrome within the next thirty minutes, or flying over the airfield (en route), if there is any, there is a need to perform separation between the aircrafts to avoid collision, (Fig. 4.5) .

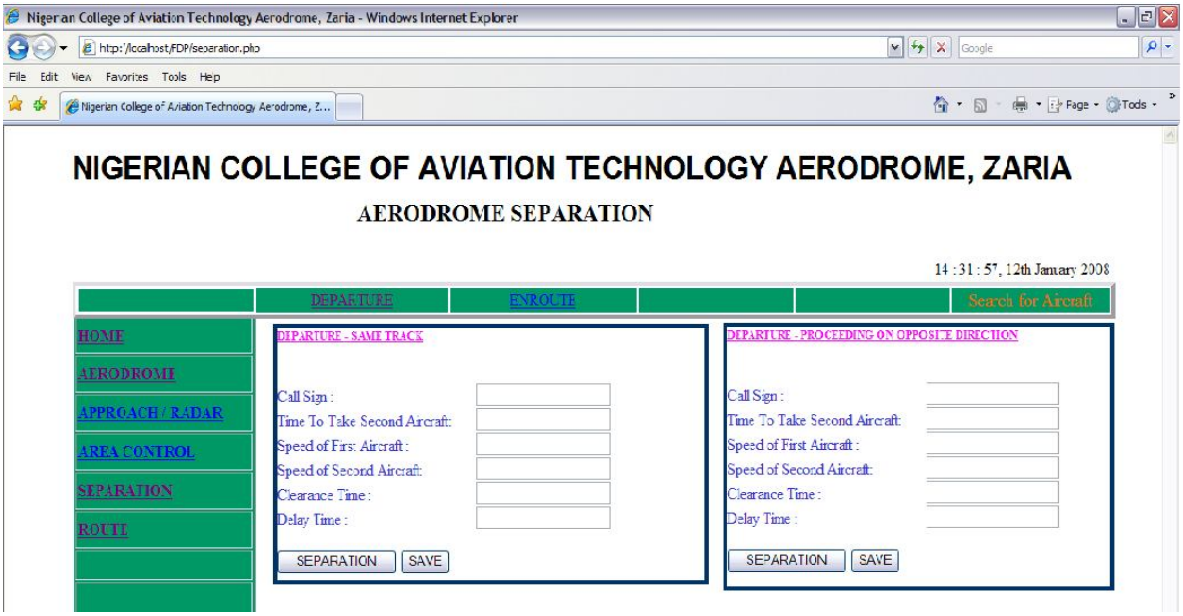


Figure 4.5 : Aerodrome Separation Page

As mentioned in chapter three, Approach/Radar Controller takes over the traffic control of the departing aircraft from the aerodrome controller, he provides separation between departing and arriving aircraft based on the flight progress strip entered earlier by aerodrome controller, (Fig.4.6). In a situation whereby the pilot changes or want to change his course and route because of sudden change of weather or controller wants to change the aircraft course as a result of arriving or en route aircraft, the fuzzy logic rules will fire and the clearance at this point is SemiClear, he has to query the database for the previous clearance of other aircrafts in the same or opposite direction by using the flight level, true air speed, type of aircraft and course to provide separation before he can approve the pilot's request or change the aircraft's course.

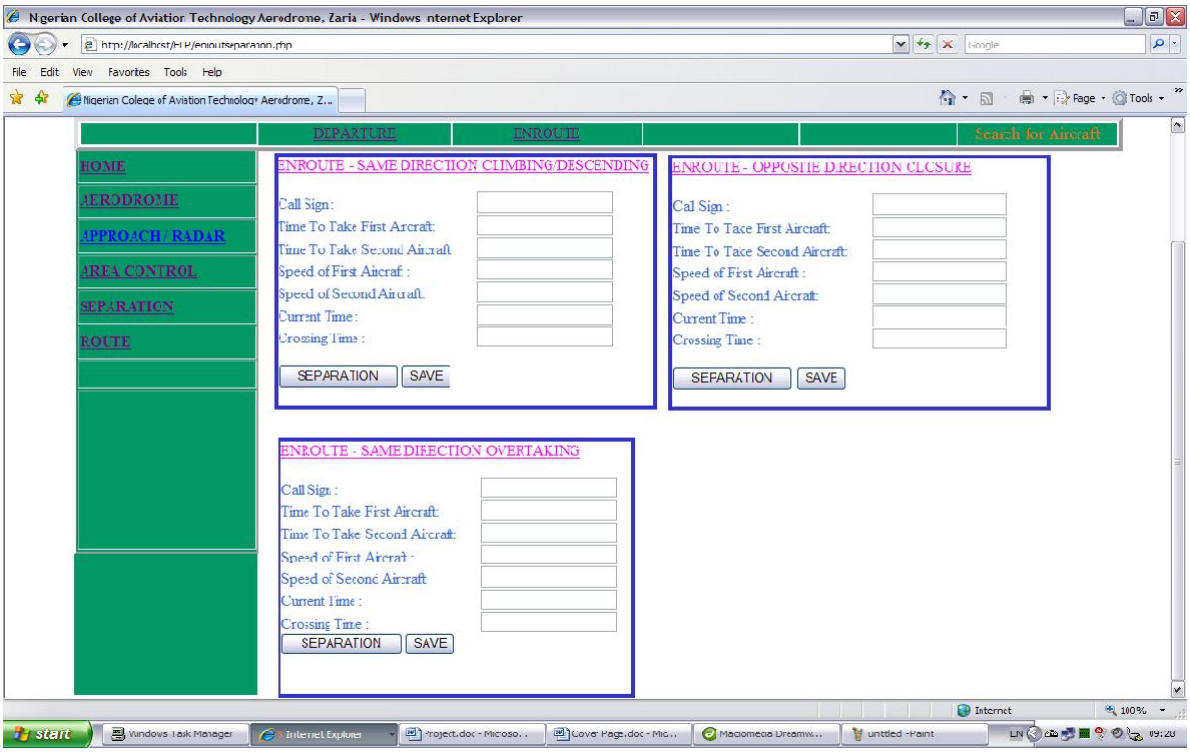


Figure 4.6 : En route Separation Page

Area control

Approach/Radar Controller hands over to Area controller, who separates the aircraft based on flight level, odd number for East-Bound aircraft and even number for West-Bound**.** For an aircraft on en-route westbound, controller has to query the database for west bound departure aircraft, if the clearance is either DontClear or RiskClear, (Fig. 4.7) the pilot is informed to maintain course, but if it is SemiClear, then separation is needed between the aircrafts.

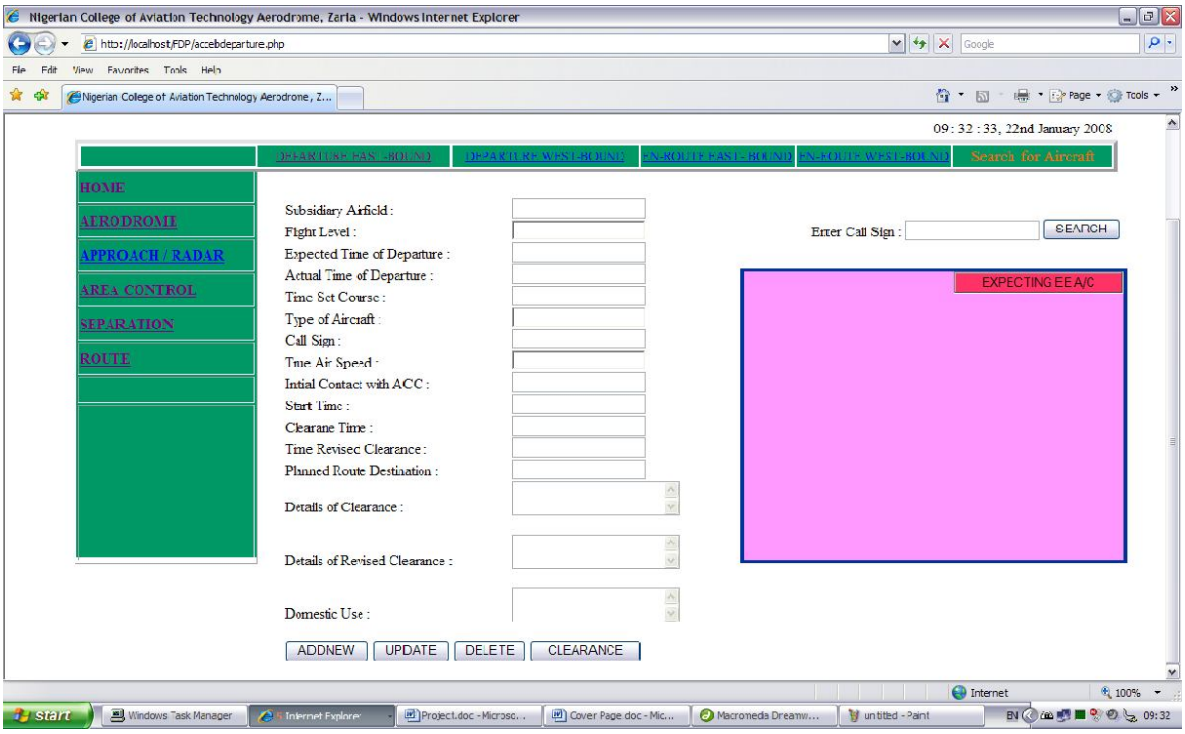


Figure 4.7 : Area Control Page

CHAPTER FIVE : CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION:

Many people all over the world travel by air and major concern of everybody in aviation industry is safety; a great number of human life and material resources has been lost as a result of aircraft accident. On many occasions after the accident, it is difficult to really know the major cause of the accident, whether it is a mechanical fault, electrical failure or human error, at times after the accident, they find it difficult to retrieve the black box that contains information about the conversation between the pilot and controller. With the implementation of internet based FLMATCS, it will facilitate safety and efficient aerodrome, approach and area control of air traffic, aircraft separation and report on any aircraft in case of accident since the database used in FLMATCS is capable to archive online log transaction and also auditing the event, with this level of security, it is impossible for any air traffic controller to deny issuing clearance for any aircraft to land, takeoff or separate. Implementation of FLMATCS will reduce the stress of controllers and the rate of aircraft accident.

5.2 RECOMMENDATION

The global concept of new Communication, Navigation and Surveillance/Air Traffic Management (CNS/ATM) system is a Satellite based communication, using satellite capability, which include Video transmission, Data and Voice communication which is ideal for point-to-multipoint and large distribution and simultaneous delivery of data to unlimited number of stations.

Modern aircraft is expected to have IP address, all the navigational aids equipment, aircraft as well as Air Traffic Controller will be networked and thereby making

communication between pilot and ATC easier not only in voice communication but also in the use of internet based FLMATCS.

Aviation industry all over the world is planning to implement Total Radar coverage, Nigeria also should implement the scheme along with internet based FLMATCS to enhance the performance of air traffic controller and reduce the rate of aircraft accident.

5.3 LIMITATION OF THE STUDY

There is no good work without limitation, among the limitation of fuzzy logic model for air traffic control system is that the users of the FLMATCS system are required to be computer literate and controllers may find it difficult to devote time for training because of their tight schedule.

Despite the fact that controllers know that many of their colleagues have lost their life as a result of the use of existing tedious manual flight progress strip, they may still be reluctant towards the implementation of the new automated system for the fear that the new system may take up their job and reduce drastically the require number of controllers in a particular aerodrome.

Another limitation is the lack of cooperation on the part of other air traffic agency like meteorology in releasing required data or interfacing their existing system with the new FLMATCS system.

5.4 FUTURE RESEARCH

Possible future research includes questions about design improvement. Modern aircraft is expected to have IP address, networking of all the navigational aids equipment, aircraft as well as Air Traffic Controller will be possible, with this, the future work will be the possibility of improving the capability of FLMATCS to take care of the airborne pilot input for separation purpose and integration of FLMATCS into new Trajectory RADAR system.

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APPENDIX A

GLOSSARY AND ABBREVIATIONS

ACC: Area Control Centre.
ACC is an ATC unit that provides ATC service to aircraft operating within a flight information region (FIR).

ACC: Air Traffic Control Centre or Zone Control for a clearance.

ACCU: Air traffic Control Unit.

ATC: Air Traffic Control.

ATS: Air Traffic Service.
ATS is a global term used to denote a set of services that includes ATC services, flight services and alerting service.

ETA: Expected Time of Arrival.

FIR: Flight information region

FAA: Federal Aviation Administration
The FAA is federal authority in the United States of America responsible for civil aviation.

FAAN: Federal Airport Authority of Nigeria, responsible for civil aviation in Nigeria.

FCAA: Federal Civil Aviation Authority.

FL: Flight Level.
The altitude expressed in hundreds of feet indicated on an altimeter set to 29.92 in. of mercury or 1013.2 mb. For example a FL of 300 indicates a flying altitude of 30,000 feet.

ICAA: International Civil Aviation Authority.

ICAN: International Commission for Air Navigation. ICAN was created in Paris in 1919.

ICAO: International Civil Aviation Organisation. ICAO is responsible for civil Aviation all over the world.

IFR : Instrument Flight Rule. When Aircraft flight is based on navigational aids equipment, the flight is instrument flight rule.

NAMA: Nigerian Airspace Management Agency, responsible for airspace management in Nigeria.

NASA: National Aeronautics and Space Administration.

NDB: Non Directional Beacon. A navigational aids equipment.

PSR: Primary Surveillance Radar.

Radar equipment used to determine the position of an aircraft in range (distance between the antenna and the illuminated object) and azimuth (angle between the horizontal antenna plane and the horizontal plane containing the aircraft).

RADAR: Radio detection and Ranging. A navigational aids equipment.

SSR: Secondary Surveillance Radar.

The SSR is an antenna (interrogator) attached to the primary radar emitting special signal called interrogation signal and wait for the "answer" from a particular antenna mounted in the aircraft of other vehicle generally known as transponder. Once receives the interrogation signal, the transponder generates a coded reply signal that includes a lot of information about the aircraft status. This information includes the aircraft identification, speed, cap, and any other anomaly such as communication failure, fire, and aircraft hijacked.

SSR code: A four-digit octal number received from the aircraft transponder when it is interrogated by secondary surveillance radar (SSR). This code could be changed by the pilot or automatically when some abnormal conditions happen in the aircraft such as communication failure, fire, and aircraft hijacked. In such way the SSR code is a valuable piece of information for the controller since it gives additional information about the aircraft status.

TAS: True Air Speed.

VFR: Visual Flight Rule. When Aircraft flight is visual, the flight is Visual Flight Rule.

VMC: Visual Meteorological Conditions

VOR/ILS: Very High Omni directional Range/Instrument Landing system. A navigational aids equipment.

APPENDIX B

INTERFACES CODES

/*******Login Page*********/**

```
<?php
 session_start();
$db = mysql_connect("localhost","****","******") or die(mysql_error());
mysql_select_db("fdp",$db) or die(mysql_error());

if(isset($_POST['userid']) && isset($_POST['passwd']))
$userid = $_POST['userid'];
$passwd = $_POST['passwd'];
/* checking the user name */
if(isset($_POST['fdplog']))

{

	$sql = "SELECT * FROM fdp_luser WHERE userid = '$userid' and passwd =
'$passwd'";
	$result = mysql_query($sql);
	mysql_query($sql) or die('<hr />MySQL Error: ' .mysql_error(). '<hr />');
	$myrow = mysql_fetch_array($result);
	if($myrow) {
	$_SESSION['valid_user'] = $userid;
	//echo 'You are logged in as : '.$_SESSION['valid_user'].' <br>';
	header("Location: home.php");
}
else{
header("Location: error.php");

}
}
?>
<html>
<style type="text/css">
<!--
.passwdtg {
	margin-left: 0.1cm;
}
.passwdtga {
	margin-left: 0.36cm;
}
-->
</style>
<body>
```

```
<style type="text/css">
<!--
body {
        margin-left: 20%;
        margin-top: 10%;

}

-->
</style>
<form name="form1" method="post" action="">
  <p>
    <label>LOG  IN <br>
    </label>
  </p>
  <table width="760" height="27" border="5">
    <tr>
      <td width="714" bgcolor="#009966" scope="row"> </td>
    </tr>
  </table>
    <label for="textfield"><br>
    <br>
    <br>

     <br>
   User Name :
  <input name="userid" type="Text" class="passwdtg" value="<?php echo $userid ?>">
  <br>
   Password :
  <input name="passwd" type="password" class="passwdtga" value="<?php echo $passwd
?>">

  <p> </p>
  <table width="760" height="27" border="5">
    <tr>
      <td width="714" bgcolor="#009966" scope="row"> </td>
    </tr>
  </table>
  <p align="center">
    <label for="Submit"></label>
    <input type="Submit" name="fdplog" value="Sign In" id="Submit">
  </p>
  <p> </p>
  <p> </p>
</form>
</body>
```

```
</html>
/*******Aerodeparture Page*******/

<?php require('sesuser.php');?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<title>Nigerian College of Aviation Technology Aerodrome, Zaria</title>
<style type="text/css">
<!--
#Layer1 {
	position:absolute;
	width:199px;
	height:430px;
	z-index:1;
	left: 75px;
	top: 183px;
	background-color: #009966;
}
#Layer2 {
	position:absolute;
	width:456px;
	height:84px;
	z-index:2;
	left: 750px;
	top: 180px;
	border-color: #FFFFFF;
	border-top-style: solid;
	border-right-style: solid;
	border-bottom-style: solid;
	border-left-style: solid;
	border-top-width: thick;
	border-right-width: thick;
	border-bottom-width: thick;
	border-left-width: thick;
	background-color: #FFFFFF;
}
body {
	margin-left: 5%;
	margin-top: 10%;
	background-color: #FFFFFF;
}
.aerocss {
	padding-right: 40px;
	padding-left: 0px;
```

```
        font-size: 14px;
        font-weight: bold;
}
#Layer3 {
        position:absolute;
        width:431px;
        height:383px;
        z-index:3;
        left: 302px;
        top: 210px;
        background-color: #FFFFFF;
        border-right-color: #FFFFFF;
        border-width: 10;
        outline: 10;
        border-top-style: solid;
        border-right-style: solid;
        border-bottom-style: solid;
        border-left-style: solid;
        border-top-width: thick;
        border-right-width: thick;
        border-bottom-width: medium;
        border-left-width: thin;
        border-top-color: #FFFFFF;
        border-bottom-color: #FFFFFF;
        border-left-color: #FFFFFF;
        outline-width: thick;
}
.style2 {font-family: Arial, Helvetica, sans-serif}
.style3 {
        font-size: 24px;
        font-weight: bold;
        outline-color: #9999FF;
}
#Layer4 {
        position:absolute;
        width:542px;
        height:43px;
        z-index:4;
        left: 909px;
        top: 161px;
}
#Layer5 {
        position:absolute;
        width:399px;
        height:318px;
        z-index:5;
        left: 811px;
```

```
        top: 283px;
        visibility: visible;
        overflow: auto;
        outline-color: #FFFFFF;
        outline-style: groove;
        outline-width: thick;
        outline: 20;
        background-color: #FFCCFF;
        border: medium groove #0000FF;
        color: #FF6633;
}
#Layer6 {
        position:absolute;
        width:1143px;
        height:187px;
        z-index:6;
        left: 75px;
        top: 22px;
}
.anytg18 {
        margin-left: 3.28cm;
}
.anytg15 {
        margin-left: 2.13cm;
}
.ANYTG {
        margin-left: 1.66cm;
}
.anyTSC {
        margin-left: 3.52cm;
}
.any14 {
        margin-left: 4.36cm;
        background-color: #FFFFFF;
        font-size: 14px;
        color: #FF6600;
}
.any36 {
        margin-left: 4.8cm;
}
.any42 {
        margin-left: 3.72cm;
        background-color: #FFFFFF;
        font-size: 14px;
        color: #FF6600;
}
.any366 {
```

```
        margin-left: 3.65cm;
        background-color: #FFFFFF;
        font-size: 14px;
        color: #FF6600;
}
.anytg32 {
        margin-left: 2.25cm;
}
.anytg38 {
        margin-left: 4.55cm;
}
.anytg41 {
        margin-left: 3.89cm;
}
.anytg27 {
        margin-left: 2.34cm;
}
.anyPRD {
        margin-left: 2cm;
}
.anytg34 {
        margin-left: 3cm;
}
.anyDRC {
        margin-left: 1.62cm;
}
.anytg4 {
        margin-left: 3.98cm;
}
.anytg388 {
        margin-left: 3.83cm;
}
.style4 {color: #FF6600}
.style6 {
        color: #FF6600;
        font-family: "Times New Roman", Times, serif;
        font-size: large;
}
.LY2 {
        border-top-color: #0000FF;
        border-right-color: #0000FF;
        border-bottom-color: #0000FF;
        border-left-color: #0000FF;
        border-top-width: thick;
        color: #0000CC;
        border-top-style: solid;
        border-right-style: solid;
```

```
        border-bottom-style: solid;
        border-left-style: solid;
}
.LY3 {
        border: medium solid #0000CC;
}
#Layer7 {       position:absolute;
        width:219px;
        height:37px;
        z-index:7;
        left: 1008px;
        top: 130px;
}
-->
</style>
<script type="text/JavaScript">
<!--
function MM_timelinePlay(tmLnName, myID) { //v1.2
  //Copyright 1998, 1999, 2000, 2001, 2002, 2003, 2004 Macromedia, Inc. All rights
reserved.
  var i,j,tmLn,props,keyFrm,sprite,numKeyFr,firstKeyFr,propNum,theObj,firstTime=false;
  if (document.MM_Time == null) MM_initTimelines(); //if *very* 1st time
  tmLn = document.MM_Time[tmLnName];
  if (myID == null) { myID = ++tmLn.ID; firstTime=true;}//if new call, incr ID
  if (myID == tmLn.ID) { //if Im newest
    setTimeout('MM_timelinePlay("'+tmLnName+'",'+myID+')',tmLn.delay);
    fNew = ++tmLn.curFrame;
    for (i=0; i<tmLn.length; i++) {
      sprite = tmLn[i];
      if (sprite.charAt(0) == 's') {
        if (sprite.obj) {
          numKeyFr = sprite.keyFrames.length; firstKeyFr = sprite.keyFrames[0];
          if (fNew >= firstKeyFr && fNew <= sprite.keyFrames[numKeyFr-1]) {//in range
            keyFrm=1;
            for (j=0; j<sprite.values.length; j++) {
              props = sprite.values[j];
              if (numKeyFr != props.length) {
                if (props.prop2 == null) sprite.obj[props.prop] = props[fNew-firstKeyFr];
                else        sprite.obj[props.prop2][props.prop] = props[fNew-firstKeyFr];
              } else {
                while (keyFrm<numKeyFr && fNew>=sprite.keyFrames[keyFrm]) keyFrm++;
                if (firstTime || fNew==sprite.keyFrames[keyFrm-1]) {
                  if (props.prop2 == null) sprite.obj[props.prop] = props[keyFrm-1];
                  else        sprite.obj[props.prop2][props.prop] = props[keyFrm-1];
        } } } } }
      } else if (sprite.charAt(0)=='b' && fNew == sprite.frame) eval(sprite.value);
      if (fNew > tmLn.lastFrame) tmLn.ID = 0;
```

```
  } }
}

function MM_timelineGoto(tmLnName, fNew, numGotos) { //v2.0
  //Copyright 1998, 1999, 2000, 2001, 2002, 2003, 2004 Macromedia, Inc. All rights
reserved.
  var i,j,tmLn,props,keyFrm,sprite,numKeyFr,firstKeyFr,lastKeyFr,propNum,theObj;
  if (document.MM_Time == null) MM_initTimelines(); //if *very* 1st time
  tmLn = document.MM_Time[tmLnName];
  if (numGotos != null)
    if (tmLn.gotoCount == null) tmLn.gotoCount = 1;
    else if (tmLn.gotoCount++ >= numGotos) {tmLn.gotoCount=0; return}
  jmpFwd = (fNew > tmLn.curFrame);
  for (i = 0; i < tmLn.length; i++) {
    sprite = (jmpFwd)? tmLn[i] : tmLn[(tmLn.length-1)-i]; //count bkwds if jumping back
    if (sprite.charAt(0) == "s") {
      numKeyFr = sprite.keyFrames.length;
      firstKeyFr = sprite.keyFrames[0];
      lastKeyFr = sprite.keyFrames[numKeyFr - 1];
      if ((jmpFwd && fNew<firstKeyFr) || (!jmpFwd && lastKeyFr<fNew)) continue; //skip
if untouchd
      for (keyFrm=1; keyFrm<numKeyFr && fNew>=sprite.keyFrames[keyFrm];
keyFrm++);
      for (j=0; j<sprite.values.length; j++) {
        props = sprite.values[j];
        if (numKeyFr == props.length) propNum = keyFrm-1 //keyframes only
        else propNum = Math.min(Math.max(0,fNew-firstKeyFr),props.length-1); //or keep in
legal range
        if (sprite.obj != null) {
          if (props.prop2 == null) sprite.obj[props.prop] = props[propNum];
          else       sprite.obj[props.prop2][props.prop] = props[propNum];
      } }
    } else if (sprite.charAt(0)=='b' && fNew == sprite.frame) eval(sprite.value);
  }
  tmLn.curFrame = fNew;
  if (tmLn.ID == 0) eval('MM_timelinePlay(tmLnName)');
}

function MM_initTimelines() { //v4.0
    //MM_initTimelines() Copyright 1997 Macromedia, Inc. All rights reserved.
    var ns = navigator.appName == "Netscape";
    var ns4 = (ns && parseInt(navigator.appVersion) == 4);
    var ns5 = (ns && parseInt(navigator.appVersion) > 4);
    var macIE5 = (navigator.platform ? (navigator.platform == "MacPPC") : false) &&
(navigator.appName == "Microsoft Internet Explorer") &&
(parseInt(navigator.appVersion) >= 4);
    document.MM_Time = new Array(1);
```

```
    document.MM_Time[0] = new Array(2);
    document.MM_Time["Timeline1"] = document.MM_Time[0];
    document.MM_Time[0].MM_Name = "Timeline1";
    document.MM_Time[0].fps = 2;
    document.MM_Time[0][0] = new String("behavior");
    document.MM_Time[0][0].frame = 16;
    document.MM_Time[0][0].value = "MM_timelineGoto('Timeline1','1')";
    document.MM_Time[0][1] = new String("sprite");
    document.MM_Time[0][1].slot = 1;
    if (ns4)
        document.MM_Time[0][1].obj = document["Layer4"];
    else if (ns5)
        document.MM_Time[0][1].obj = document.getElementById("Layer4");
    else
        document.MM_Time[0][1].obj = document.all ? document.all["Layer4"] : null;
    document.MM_Time[0][1].keyFrames = new Array(1, 15);
    document.MM_Time[0][1].values = new Array(2);
    if (ns5 || macIE5)
        document.MM_Time[0][1].values[0] = new Array("115px", "160px", "205px",
"249px", "294px", "339px", "384px", "429px", "473px", "518px", "563px", "608px",
"652px", "697px", "742px");
    else
        document.MM_Time[0][1].values[0] = new
Array(115,160,205,249,294,339,384,429,473,518,563,608,652,697,742);
    document.MM_Time[0][1].values[0].prop = "left";
    if (ns5 || macIE5)
        document.MM_Time[0][1].values[1] = new Array("76px", "75px", "75px", "74px",
"73px", "72px", "72px", "71px", "70px", "70px", "69px", "68px", "67px", "67px", "66px");
    else
        document.MM_Time[0][1].values[1] = new
Array(76,75,75,74,73,72,72,71,70,70,69,68,67,67,66);
    document.MM_Time[0][1].values[1].prop = "top";
    if (!ns4) {
        document.MM_Time[0][1].values[0].prop2 = "style";
        document.MM_Time[0][1].values[1].prop2 = "style";
    }
    document.MM_Time[0].lastFrame = 16;
    for (i=0; i<document.MM_Time.length; i++) {
        document.MM_Time[i].ID = null;
        document.MM_Time[i].curFrame = 0;
        document.MM_Time[i].delay = 1000/document.MM_Time[i].fps;
    }
}
//-->
</script>
<link href="Confirm.css" rel="stylesheet" type="text/css">
</head>
```

```
<body onLoad="MM_timelinePlay('Timeline1')">
<div id="Layer1">
  <table width="200" height="438" border="2">
    <tr>
      <th height="30" scope="col"><div align="left"><a
href="home.php">HOME</a></div></th>
    </tr>
    <tr>
      <th height="30" scope="row"><div align="left"><a
href="aeroarrival.php">AERODROME</a></div></th>
    </tr>
    <tr>
      <th height="30" scope="row"><div align="left"><a
href="approarrivala.php">APPROACH / RADAR</a></div></th>
    </tr>
    <tr>
      <th height="30" scope="row"><div align="left"><a href="accebdeparture.php">AREA
CONTROL</a></div></th>
    </tr>
    <tr>
      <th height="30" scope="row"><div align="left"><a
href="separation.php">SEPARATION</a></div></th>
    </tr>
    <tr>
      <th height="30" scope="row"><div align="left"><a
href="routelag.php">ROUTE</a></div></th>
    </tr>
    <tr>
      <th height="23" scope="row"> </th>
    </tr>
    <tr>
      <th height="159" scope="row"> </th>
    </tr>
  </table>
</div>
<div id="Layer4" style="left: 115px; top: 76px; width: 498px;"><span
class="style3">AERODROME  CONTROL</span> <span class="style3">-
DEPARTURE</span> </div>
<div id="Layer6">
  <h1 class="style2">NIGERIAN COLLEGE OF AVIATION TECHNOLOGY
AERODROME, ZARIA</h1>
  <p class="style2"> </p>
  <p class="style2"> </p>
  <table width="1133" height="27" border="4">
    <tr>
      <td width="188" height="10" bordercolor="#009966" bgcolor="#009966"
```

```
scope="col"><div align="right"></div></td>
    <td width="204" bordercolor="#009966" bgcolor="#009966" scope="col"><div
align="center"><a href="aeroarrival.php">ARRIVAL</a></div></td>
    <td width="199" bordercolor="#009966" bgcolor="#009966" scope="col"><div
align="center"><a href="aerodeparture.php">DEPARTURE</a></div></td>
    <td width="164" bordercolor="#009966" bgcolor="#009966"
scope="col"> </td>
    <td width="164" bordercolor="#009966" bgcolor="#009966"
scope="col"> </td>
    <td width="168" bordercolor="#009966" bgcolor="#009966" scope="col"><div
align="center"><span class="style6">Search for Aircraft</span></div></td>
   </tr>
  </table>
  <p class="style2"> </p>
</div>
<div id="Layer7">
  <p>
   <?PHP
/* Date function */
echo DATE('H : i : s,  jS F Y');
?>
  </p>
  <p>  </p>
</div>
<p> </p>

<div id="Layer2">

<form action="aerodeparture.php" method="POST">
  <p align="left" class="style4"> </p>
  <p align="right">
     Enter Call Sign :
   <input type="Text" name="CS"/>
    <input type="Submit"  value="SEARCH"> <br>
   </p>
</form>
</div>

<div id="Layer5">
  <form name="formc" method="post" action="">
 <p align="RIGHT"> <input name="confirm" type="Submit" class="CONFIRM"
value="EXPECTING A/C">
 </p>
  </form>

   <p align="center">
  <?php
```

```
/* Connection to Database */
$db = mysql_connect("localhost", "*****", "********");
mysql_select_db("FDP",$db);
if (isset($_POST['confirm']))
   {
$result = mysql_query("SELECT cs, tac, eta, eat, fl, du FROM aeroarrival WHERE DATE
= current_date and TIMEDIFF( eta, current_time ) <= '00:30:00'
ORDER BY ETA",$db);
if($myrow = mysql_fetch_array($result)) {
echo "<table border=1>\n";
echo
"<tr><td>CALLSIGN</td><td>TAC</td><td>ETA</td><td>EAT</td><td>FL</td><td>
DU</td></tr>\n";
do {
printf("<tr><td>%s</td><td>%s</td><td>%s</td><td>%s</td><td>%s</td><td>%s</td>
</tr>\n",$myrow[0], $myrow[1],
/* Print out  of search */
$myrow[2],$myrow[3],$myrow[4],$myrow[5]);
} while ($myrow = mysql_fetch_array($result));
echo "</table>\n";
}
 else {
echo "Sorry, no records were found!";
}
}
?>
  </p>
  <p>     </p>
</div>
<div id="Layer3">
<?php
$db = mysql_connect("localhost", "*****", "********");
mysql_select_db("FDP",$db) or die('<hr />MySQL Error: ' .mysql_error(). '<hr />');

/* Posting Callsign */
if(isset($_POST["CS"])) $CS = $_POST["CS"];
if (isset($_POST['update']))
   {
   $SUBAF = $_POST['SUBAF'];
   $FL = $_POST['FL'];
   $ETD  = $_POST['ETD'];
   $ATD = $_POST['ATD'];
         $TSC = $_POST['TSC'];
   $TAC = $_POST['TAC'];
   $CS = $_POST['CS'];
   $TAS = $_POST['TAS'];
         $ICA = $_POST['ICA'];
```

```
   $ST = $_POST['ST'];
   $CT = $_POST['CT'];
         $TRC = $_POST['TRC'];
   $PRD = $_POST['PRD'];
         $DC = $_POST['DC'];
   $DRC = $_POST['DRC'];
   $DU = $_POST['DU'];
            $sql = "UPDATE aerodeparture SET SUBAF ='$SUBAF', FL ='$FL', ETD
='$ETD', ATD ='$ATD', TSC ='$TSC', TAC ='$TAC', CS ='$CS', TAS ='$TAS', ICA
='$ICA',ST ='$ST', CT ='$CT',TRC ='$TRC',PRD ='$PRD', DC ='$DC',DRC ='$DRC', DU
='$DU' WHERE CS ='$CS'";
   $result = mysql_query($sql);
         mysql_query($sql) or die('<hr />MySQL Error: ' .mysql_error(). '<hr />');

   echo "Thank you! Information updated.\n";
   }

         if (isset($_POST['addnew']))
{
         $SUBAF = $_POST['SUBAF'];
   $FL = $_POST['FL'];
   $ETD  = $_POST['ETD'];
   $ATD = $_POST['ATD'];
         $TSC = $_POST['TSC'];
   $TAC = $_POST['TAC'];
   $CS = $_POST['CS'];
   $TAS = $_POST['TAS'];
         $ICA = $_POST['ICA'];
   $ST = $_POST['ST'];
   $CT = $_POST['CT'];
         $TRC = $_POST['TRC'];
   $PRD = $_POST['PRD'];
         $DC = $_POST['DC'];
   $DRC = $_POST['DRC'];
   $DU = $_POST['DU'];

         $sql = "INSERT INTO aerodeparture (SUBAF,FL,ETD
,ATD,TSC,TAC,CS,TAS,ICA,ST,CT,TRC,PRD,DC,DRC,DU) VALUES
         ('$SUBAF','$FL','$ETD','$ATD','$TSC','$TAC','$CS','$TAS','$ICA','$ST','$CT','$T
RC','$PRD','$DC','$DRC','$DU')";
         $result = mysql_query($sql) or die('<hr />MySQL Error: ' .mysql_error(). '<hr />');

         echo "Thank you! Information entered.\n";
}

if (isset($_POST['delete']))
{
```

```
        $sql = "DELETE FROM ----- WHERE CS='$CS'";
        $result = mysql_query($sql);
/*delete Selected record */
        echo " Record deleted!<p>";
}

if (isset($CS))
   {
        $sql = "SELECT * FROM aerodeparture WHERE CS='$CS'";
   $result = mysql_query($sql);
        mysql_query($sql) or die('<hr />MySQL Error: ' .mysql_error(). '<hr />');
   $myrow = mysql_fetch_array($result);
        $SUBAF = $myrow['0'];
   $FL = $myrow['1'];
   $ETD  = $myrow['2'];
   $ATD = $myrow['3'];
        $TSC = $myrow['4'];
   $TAC = $myrow['5'];
   $CS = $myrow['6'];
   $TAS = $myrow['7'];
        $ICA = $myrow['8'];
   $ST = $myrow['9'];
   $CT = $myrow['10'];
        $TRC = $myrow['11'];
   $PRD = $myrow['12'];
        $DC = $myrow['13'];
   $DRC = $myrow['14'];
   $DU = $myrow['15'];
        }
        ?>

  <form name="form1" method="post" action="">
      <p align="left"> </p>
   <p align= "left">
        Subsidiary Airfield :
     <input name="SUBAF" type="Text" class="anytg18" id="SUBAF" value="<?php echo
$SUBAF ?>">
  <br>
  Flight Level :
  <input name="FL" type="Text" class="any14" value="<?php echo $FL ?>">
  <br>
  Expected Time of Departure :
  <input name="ETD" type="Text" class="ANYTG" id="ETD" value="<?php echo
$ETD?>">
<br>
Actual  Time of Departure :
  <input name="ATD" type="Text" class="anytg15" id="ATD" value="<?php echo $ATD
```

```
?>">
<br>
Time Set Course :
    <input name="TSC" type="Text" class="anyTSC" id="TSC" value="<?php echo $TSC
?>">
     <br>
          Type of Aircraft :
      <input name="TAC" type="Text" class="any366" value="<?php echo $TAC ?>">
  <br>
   Call Sign :
     <input name="CS" type="Text" class="any36" value="<?php echo $CS ?>">
     <br>
   True Air Speed :
   <input name="TAS" type="Text" class="any42" value="<?php echo $TAS ?>">
         <br>
Initial Contact with ACC :
         <input name="ICA" type="Text" class="anytg32" id="ICA" value="<?php echo
$ICA ?>">
         <br>
         Start Time :
    <input name="ST" type="Text" class="anytg38" id="ST" value="<?php echo $ST ?>">
         <br>
         Clearane Time :
    <input name="CT" type="Text" class="anytg41" id="CT" value="<?php echo $CT
?>">
         <br>
Time Revised Clearance :
    <input name="TRC" type="Text" class="anytg27" id="TRC" value="<?php echo $TRC
?>">
         <br>
Planned Route Destination :
    <input name="PRD" type="Text" class="anyPRD" id="PRD" value="<?php echo
$PRD ?>">
<br>
     Details of Clearance :
      <textarea name="DC" class="anytg34" id="DC"><?php echo $DC ?></textarea>
           <br>
   Details of Revised Clearance :
     <textarea name="DRC" class="anyDRC" id="DRC"><?php echo $DRC ?></textarea>
   <br>
   Domestic Use :
     <textarea name="DU" class="anytg4"><?php echo $DU ?></textarea>
     <br>
   </p>
   <p align= "left">
     <input type="Submit" name="addnew" value="ADDNEW">
     <input type="Submit" name="update" value="UPDATE">
```

```
    <input type="Submit" name="delete" value="DELETE">
          <input type="Submit" name="clearance" value="CLEARANCE">


     </p>
  </form>
</div>
</body>
</html>

/*******Enroute Separation Page*******/
/* Check the session for the authentic user*/
<?php require('sesuser.php');?>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<title>Nigerian College of Aviation Technology Aerodrome, Zaria</title>
<style type="text/css">
<!--
#Layer1 {
          position:absolute;
          width:199px;
          height:590px;
          z-index:1;
          left: 75px;
          top: 183px;
          background-color: #009966;
}
#Layer2 {
          position:absolute;
          width:456px;
          height:84px;
          z-index:2;
          left: 484px;
          top: -148px;
          border-color: #FFFFFF;
          border-top-style: solid;
          border-right-style: solid;
          border-bottom-style: solid;
          border-left-style: solid;
          border-top-width: thick;
          border-right-width: thick;
          border-bottom-width: thick;
          border-left-width: thick;
          background-color: #FFFFFF;
```

```
}
body {
	margin-left: 5%;
	margin-top: 10%;
	background-color: #FFFFFF;
}
.aerocss {
	padding-right: 40px;
	padding-left: 0px;
	font-size: 14px;
	font-weight: bold;
}
/* Format the container */
#Layer3 {
	position:absolute;
	width:431px;
	height:301px;
	z-index:3;
	left: 773px;
	top: 583px;
	background-color: #FFFFFF;
	border-right-color: #FFFFFF;
	border-width: 10;
	outline: 10;
	border-top-style: solid;
	border-right-style: solid;
	border-bottom-style: solid;
	border-left-style: solid;
	border-top-width: thick;
	border-right-width: thick;
	border-bottom-width: medium;
	border-left-width: thin;
	border-top-color: #FFFFFF;
	border-bottom-color: #FFFFFF;
	border-left-color: #FFFFFF;
	outline-width: thick;
}
.style2 {font-family: Arial, Helvetica, sans-serif}
.style3 {
	font-size: 24px;
	font-weight: bold;
	outline-color: #9999FF;
}
#Layer4 {
	position:absolute;
	width:542px;
	height:43px;
```

```
        z-index:4;
        left: 909px;
        top: 161px;
}
#Layer5 {
        position:absolute;
        width:327px;
        height:318px;
        z-index:5;
        left: 883px;
        top: 283px;
        visibility: visible;
        overflow: auto;
        border-right-style: solid;
        border-bottom-style: solid;
        border-left-style: solid;
        border-top-width: thick;
        border-right-width: thick;
        border-bottom-width: thick;
        border-left-width: thick;
        border-color: #FFFFFF;
        border-width: 20;
        border-top-color: #FFFFFF;
        border-top-style: solid;
        border-top: 10;
        border-right: 10;
        border-bottom: 10;
        border-left: 10;
        outline-color: #FFFFFF;
        outline-style: groove;
        outline-width: thick;
        outline: 20;
        background-color: #FF3366;
}
#Layer6 {
        position:absolute;
        width:1143px;
        height:158px;
        z-index:6;
        left: 75px;
        top: 22px;
}
.anytg18 {
        margin-left: 2.23cm;
}
.anytg15 {
        margin-left: 1.3cm;
```

```
}
.any14 {
	margin-left: 4.4cm;
	background-color: #FFFFFF;
	font-size: 14px;
	color: #FF6600;
}
.sep1 {
	margin-left: 4cm;
}
.sep2 {
	margin-left: 1.1cm;
}
.sep3 {
	margin-left: 0.62cm;
}
.sep4 {
	margin-left: 1.83cm;
}
.sep5 {
	margin-left: 1.42cm;
}
.sep6 {
	margin-left: 3.3cm;
}
.sep7 {
	margin-left: 3.13cm;
}
.l1 {
	border: medium solid #3333CC;
	color: #3366CC;
}
.st1 {
	font-family: "Times New Roman", Times, serif;
	font-size: 12pt;
	color: #FF00FF;
	text-decoration: underline blink;
}
.any36 {
	margin-left: 4.82cm;
}
.any42 {
	margin-left: 3.77cm;
	background-color: #FFFFFF;
	font-size: 14px;
	color: #FF6600;}
.any366 {
```

```
        margin-left: 3.67cm;
        background-color: #FFFFFF;
        font-size: 14px;
        color: #FF6600;
}
.anytg32 {
        margin-left: 4.07cm;
}
.anytg38 {
        margin-left: 3.8cm;
}
.anytg41 {
        margin-left: 4.08cm;
}
.anytg27 {
        margin-left: 2.3cm;
}
.anytg34 {
        margin-left: 3.16cm;
}
.anytg4 {
        margin-left: 4cm;
}
.anytg388 {
        margin-left: 3.83cm;
}
.style6 {
        color: #FF6600;
        font-family: "Times New Roman", Times, serif;
        font-size: large;
}
#Layer7 {
        position:absolute;
        width:406px;
        height:268px;
        z-index:7;
        left: 291px;
        top: 190px;
        visibility: visible;
}
#Layer8 {
        position:absolute;
        width:390px;
        height:269px;
        z-index:8;
        left: 697px;
        top: 191px;
```

```
}
#Layer9 {
	position:absolute;
	width:458px;
	height:115px;
	z-index:9;
	left: 301px;
	top: 633px;
}
#Layer10 {
	position:absolute;
	width:384px;
	height:269px;
	z-index:1;
	left: 302px;
	top: 525px;
}
sep1 {
	padding-right: 5%;
	margin-right: 5%;
}
.style9 {font-family: "Times New Roman", Times, serif; font-size: 12pt; color: #330066;
text-decoration: blink; }
#Layer11 {
	position:absolute;
	width:404px;
	height:267px;
	z-index:9;
	left: 718px;
	top: 192px;
}
#Layer12 {
	position:absolute;
	width:200px;
	height:115px;
	z-index:10;
	left: -424px;
	top: 297px;
}
#Layer13 {
	position:absolute;
	width:378px;
	height:271px;
	z-index:10;
	left: 295px;
	top: 497px;
}
```

```
#Layer14 {
	position:absolute;
	width:218px;
	height:43px;
	z-index:11;
	left: 1011px;
	top: 130px;
}
-->
</style>
<script type="text/JavaScript">
<!--
function MM_timelinePlay(tmLnName, myID) { //v1.2
  //Copyright 1998, 1999, 2000, 2001, 2002, 2003, 2004 Macromedia, Inc. All rights
reserved.
  var i,j,tmLn,props,keyFrm,sprite,numKeyFr,firstKeyFr,propNum,theObj,firstTime=false;
  if (document.MM_Time == null) MM_initTimelines(); //if *very* 1st time
  tmLn = document.MM_Time[tmLnName];
  if (myID == null) { myID = ++tmLn.ID; firstTime=true;}//if new call, incr ID
  if (myID == tmLn.ID) { //if Im newest
    setTimeout('MM_timelinePlay("'+tmLnName+'",'+myID+')',tmLn.delay);
    fNew = ++tmLn.curFrame;
    for (i=0; i<tmLn.length; i++) {
      sprite = tmLn[i];
      if (sprite.charAt(0) == 's') {
        if (sprite.obj) {
          numKeyFr = sprite.keyFrames.length; firstKeyFr = sprite.keyFrames[0];
          if (fNew >= firstKeyFr && fNew <= sprite.keyFrames[numKeyFr-1]) {//in range
            keyFrm=1;
            for (j=0; j<sprite.values.length; j++) {
              props = sprite.values[j];
              if (numKeyFr != props.length) {
                if (props.prop2 == null) sprite.obj[props.prop] = props[fNew-firstKeyFr];
                else       sprite.obj[props.prop2][props.prop] = props[fNew-firstKeyFr];
              } else {
                while (keyFrm<numKeyFr && fNew>=sprite.keyFrames[keyFrm]) keyFrm++;
                if (firstTime || fNew==sprite.keyFrames[keyFrm-1]) {
                  if (props.prop2 == null) sprite.obj[props.prop] = props[keyFrm-1];
                  else       sprite.obj[props.prop2][props.prop] = props[keyFrm-1];
        } } } } }
      } else if (sprite.charAt(0)=='b' && fNew == sprite.frame) eval(sprite.value);
      if (fNew > tmLn.lastFrame) tmLn.ID = 0;
  } }
}

function MM_timelineGoto(tmLnName, fNew, numGotos) { //v2.0
  //Copyright 1998, 1999, 2000, 2001, 2002, 2003, 2004 Macromedia, Inc. All rights
```

```
reserved.
  var i,j,tmLn,props,keyFrm,sprite,numKeyFr,firstKeyFr,lastKeyFr,propNum,theObj;
  if (document.MM_Time == null) MM_initTimelines(); //if *very* 1st time
  tmLn = document.MM_Time[tmLnName];
  if (numGotos != null)
    if (tmLn.gotoCount == null) tmLn.gotoCount = 1;
    else if (tmLn.gotoCount++ >= numGotos) {tmLn.gotoCount=0; return}
  jmpFwd = (fNew > tmLn.curFrame);
  for (i = 0; i < tmLn.length; i++) {
    sprite = (jmpFwd)? tmLn[i] : tmLn[(tmLn.length-1)-i]; //count bkwds if jumping back
    if (sprite.charAt(0) == "s") {
      numKeyFr = sprite.keyFrames.length;
      firstKeyFr = sprite.keyFrames[0];
      lastKeyFr = sprite.keyFrames[numKeyFr - 1];
      if ((jmpFwd && fNew<firstKeyFr) || (!jmpFwd && lastKeyFr<fNew)) continue; //skip
if untouchd
      for (keyFrm=1; keyFrm<numKeyFr && fNew>=sprite.keyFrames[keyFrm];
keyFrm++);
      for (j=0; j<sprite.values.length; j++) {
        props = sprite.values[j];
        if (numKeyFr == props.length) propNum = keyFrm-1 //keyframes only
        else propNum = Math.min(Math.max(0,fNew-firstKeyFr),props.length-1); //or keep in
legal range
        if (sprite.obj != null) {
          if (props.prop2 == null) sprite.obj[props.prop] = props[propNum];
          else       sprite.obj[props.prop2][props.prop] = props[propNum];
      } }
    } else if (sprite.charAt(0)=='b' && fNew == sprite.frame) eval(sprite.value);
  }
  tmLn.curFrame = fNew;
  if (tmLn.ID == 0) eval('MM_timelinePlay(tmLnName)');
}

function MM_initTimelines() { //v4.0
    //MM_initTimelines() Copyright 1997 Macromedia, Inc. All rights reserved.
    var ns = navigator.appName == "Netscape";
    var ns4 = (ns && parseInt(navigator.appVersion) == 4);
    var ns5 = (ns && parseInt(navigator.appVersion) > 4);
    var macIE5 = (navigator.platform ? (navigator.platform == "MacPPC") : false) &&
(navigator.appName == "Microsoft Internet Explorer") &&
(parseInt(navigator.appVersion) >= 4);
    document.MM_Time = new Array(1);
    document.MM_Time[0] = new Array(2);
    document.MM_Time["Timeline1"] = document.MM_Time[0];
    document.MM_Time[0].MM_Name = "Timeline1";
    document.MM_Time[0].fps = 2;
    document.MM_Time[0][0] = new String("behavior");
```

```
    document.MM_Time[0][0].frame = 16;
    document.MM_Time[0][0].value = "MM_timelineGoto('Timeline1','1')";
    document.MM_Time[0][1] = new String("sprite");
    document.MM_Time[0][1].slot = 1;
    if (ns4)
        document.MM_Time[0][1].obj = document["Layer4"];
    else if (ns5)
        document.MM_Time[0][1].obj = document.getElementById("Layer4");
    else
        document.MM_Time[0][1].obj = document.all ? document.all["Layer4"] : null;
    document.MM_Time[0][1].keyFrames = new Array(1, 15);
    document.MM_Time[0][1].values = new Array(2);
    if (ns5 || macIE5)
        document.MM_Time[0][1].values[0] = new Array("115px", "160px", "205px",
"249px", "294px", "339px", "384px", "429px", "473px", "518px", "563px", "608px",
"652px", "697px", "742px");
    else
        document.MM_Time[0][1].values[0] = new
Array(115,160,205,249,294,339,384,429,473,518,563,608,652,697,742);
    document.MM_Time[0][1].values[0].prop = "left";
    if (ns5 || macIE5)
        document.MM_Time[0][1].values[1] = new Array("76px", "75px", "75px", "74px",
"73px", "72px", "72px", "71px", "70px", "70px", "69px", "68px", "67px", "67px", "66px");
    else
        document.MM_Time[0][1].values[1] = new
Array(76,75,75,74,73,72,72,71,70,70,69,68,67,67,66);
    document.MM_Time[0][1].values[1].prop = "top";
    if (!ns4) {
        document.MM_Time[0][1].values[0].prop2 = "style";
        document.MM_Time[0][1].values[1].prop2 = "style";
    }
    document.MM_Time[0].lastFrame = 16;
    for (i=0; i<document.MM_Time.length; i++) {
        document.MM_Time[i].ID = null;
        document.MM_Time[i].curFrame = 0;
        document.MM_Time[i].delay = 1000/document.MM_Time[i].fps;
    }
}
//-->
</script>
</head>

<body onLoad="MM_timelinePlay('Timeline1')">
<div id="Layer1">
  <table width="200" height="438" border="2">
    <tr>
      <th height="30" scope="col"><div align="left"><a
```

```
href="home.php">HOME</a></div></th>
    </tr>
    <tr>
      <th height="30" scope="row"><div align="left"><a
href="aeroarrival.php">AERODROME</a></div></th>
    </tr>
    <tr>
      <th height="30" scope="row"><div align="left"><a
href="approarrivala.php">APPROACH / RADAR</a></div></th>
    </tr>
    <tr>
      <th height="30" scope="row"><div align="left"><a href="accebdeparture.php">AREA
CONTROL</a></div></th>
    </tr>
    <tr>
      <th height="30" scope="row"><div align="left"><a
href="separation.php">SEPARATION</a></div></th>
    </tr>
    <tr>
      <th height="30" scope="row"><div align="left"><a
href="routelag.php">ROUTE</a></div></th>
    </tr>
    <tr>
      <th height="23" scope="row"> </th>
    </tr>
    <tr>
      <th height="159" scope="row"> </th>
    </tr>
  </table>
</div>
<div id="Layer4" style="left: 115px; top: 76px; width: 498px;"><span
class="style3">ENROUTE SEPARATION</span><span class="style3"> </span></div>
<div id="Layer6">
  <h1 class="style2">NIGERIAN COLLEGE OF AVIATION TECHNOLOGY
AERODROME, ZARIA</h1>
  <p class="style2"> </p>
  <p class="style2"> </p>
  <table width="1133" height="27" border="4">
    <tr>
      <td width="188" height="10" bordercolor="#009966" bgcolor="#009966"
scope="col"><div align="right"></div></td>
      <td width="204" bordercolor="#009966" bgcolor="#009966" scope="col"><div
align="center"><a href="separation.php">DEPARTURE</a><a
href="aeroarrival.php"></a></div></td>
      <td width="199" bordercolor="#009966" bgcolor="#009966" scope="col"><div
align="center"><a href="enroutseparation.php">ENROUTE</a></div></td>
      <td width="164" bordercolor="#009966" bgcolor="#009966"
```

```
scope="col"> </td>
     <td width="164" bordercolor="#009966" bgcolor="#009966"
scope="col"> </td>
     <td width="168" bordercolor="#009966" bgcolor="#009966" scope="col"><div
align="center"><span class="style6">Search for Aircraft</span></div></td>
   </tr>
  </table>
  <p class="style2"> </p>
</div>
<div id="Layer14">
<?PHP
echo DATE('H : i : s,  jS F Y');
?>
</div>
<p> </p>
<div class="l1" id="Layer7">
  <p class="st1">ENROUTE - SAME DIRECTION CLIMBING/DESCENDING</p>
  <p>
   <?php
$db = mysql_connect("localhost", "*****", "*******");
mysql_select_db("FDP",$db) or die('<hr />MySQL Error: ' .mysql_error(). '<hr />');

          if (isset($_POST['SEPARATION'])) {

   $CS = $_POST['CS'];
          $T1 = $_POST['T1'];
          $T2 = $_POST['T2'];
   $S1  = $_POST['S1'];
   $S2 = $_POST['S2'];
          $Curt = $_POST['Curt'];
          $CT = $_POST['CT'];
          $X1 = $S2 + $S1;
          $Xt = @((($T2-$T1)*$S2)/$X1);
          $CT = $Xt + $Curt;
          echo " $Curt <p>";
          echo " $Xt <p>";
    }

          if (isset($_POST['SAVE']))
{
          $CS = $_POST['CS'];
          $T1 = $_POST['T1'];
          $T2 = $_POST['T2'];
   $S1  = $_POST['S1'];
   $S2 = $_POST['S2'];
          $Curt = $_POST['Curt'];
          $CT = $_POST['CT'];
```

```
        $sql = "INSERT INTO enroutsep (CS ,T1, T2, S1, S2, Curt, CT) VALUES
        ('$CS', '$T1','$T2','$S1','$S2','$Curt','$CT')";
        $result = mysql_query($sql);

        echo "Thank you! Information entered.\n";
        }
?>
</p>
  <form name="forms" method="post" action="">

   Call Sign :
  <input name="CS" type="Text" class="sep1" value="<?php echo $CS ?>">
  <br>
  Time To Take First Aircraft:
  <input name="T1" type="Text" class="sep2" value="<?php echo $T1 ?>">
  <br>
    Time To Take Second Aircraft:
  <input name="T2" type="Text" class="sep3" value="<?php echo $T2 ?>">
  <br>
   Speed of First Aircraft :
  <input name="S1" type="Text" class="sep4" value="<?php echo $S1 ?>">
  <br>
    Speed of Second Aircraft:
  <input name="S2" type="Text" class="sep5" value="<?php echo $S2 ?>">
  <br>
   Current Time :
  <input name="Curt" type="Text" class="sep6" value="<?php echo $Curt ?>">
  <br>
   Crossing Time :
  <input name="CT" type="Text" class="sep7" value="<?php echo $CT ?>">
  <br>
  <br>

   <input name="SEPARATION" type="Submit" value="SEPARATION">
   <input name="SAVE" type="Submit"  align="right" value="SAVE">
</form>
</div>

<div class="l1" id="Layer11">
<p class="st1">ENROUTE - OPPOSITE DIRECTION CLOSURE</p>
  <p>
    <?php
$db = mysql_connect("localhost", "*****", "*******");
mysql_select_db("FDP",$db) or die('<hr />MySQL Error: ' .mysql_error(). '<hr />');
```

```
        if (isset($_POST['SEPARATION1'])) {

   $CS = $_POST['CS'];
        $T1 = $_POST['T1'];
        $T2 = $_POST['T2'];
   $S1  = $_POST['S1'];
   $S2 = $_POST['S2'];
        $Curt = $_POST['Curt'];
        $CT = $_POST['CT'];
        $X1 = $S1s - $S2s;
        $Xt = @((($T2s-$T1s)*$S1s)/$X1);
        $CTs = $Xt + $Curts;
        echo " $Curt <p>";
        echo " $Xt <p>";
    }

        if (isset($_POST['SAVE1']))
{
        $CS = $_POST['CS'];
        $T1 = $_POST['T1'];
        $T2 = $_POST['T2'];
   $S1  = $_POST['S1'];
   $S2 = $_POST['S2'];
        $Curt = $_POST['Curt'];
        $CT = $_POST['CT'];


        $sql = "INSERT INTO enroutsepa (CS ,T1, T2, S1, S2, Curt, CT) VALUES
        ('$CS', '$T1','$T2','$S1','$S2','$Curt','$CT')";
        $result = mysql_query($sql);

        echo "Thank you! Information entered.\n";
        }
?>
</p>
  <form name="forms" method="post" action="">

   Call Sign :
  <input name="CS" type="Text" class="sep1" value="<?php echo $CS ?>">
  <br>
  Time To Take First Aircraft:
  <input name="T1" type="Text" class="sep2" value="<?php echo $T1 ?>">
  <br>
    Time To Take Second Aircraft:
  <input name="T2" type="Text" class="sep3" value="<?php echo $T2 ?>">
  <br>
   Speed of First Aircraft :
```

```
  <input name="S1" type="Text" class="sep4" value="<?php echo $S1 ?>">
  <br>
   Speed of Second Aircraft:
  <input name="S2" type="Text" class="sep5" value="<?php echo $S2 ?>">
  <br>
   Current Time :
  <input name="Curt" type="Text" class="sep6" value="<?php echo $Curt ?>">
  <br>
   Crossing Time :
  <input name="CT" type="Text" class="sep7" value="<?php echo $CT ?>">
  <br>
  <br>

   <input name="SEPARATION1" type="Submit" value="SEPARATION">
   <input name="SAVE1" type="Submit"  align="right" value="SAVE">
</form>
</div>
<div class="l1" id="Layer13">
<p class="st1">ENROUTE - SAME DIRECTION OVERTAKING</p>
  <p>
    <?php
$db = mysql_connect("localhost", "*****", "********");
mysql_select_db("FDP",$db) or die('<hr />MySQL Error: ' .mysql_error(). '<hr />');

          if (isset($_POST['SEPARATION2'])) {

    $CS = $_POST['CS'];
          $T1 = $_POST['T1'];
          $T2 = $_POST['T2'];
    $S1  = $_POST['S1'];
    $S2 = $_POST['S2'];
          $Curt = $_POST['Curt'];
          $CT = $_POST['CT'];
          $X1 = $S2 - $S1;
          $Xt = @(($T2-15)*$S1/$X1);
          $CT = $Xt + $Curt;
          echo " $Curt <p>";
          echo " $Xt <p>";
     }

          if (isset($_POST['SAVE2']))
{
          $CS = $_POST['CS'];
          $T1 = $_POST['T1'];
          $T2 = $_POST['T2'];
    $S1  = $_POST['S1'];
    $S2 = $_POST['S2'];
```

```
        $Curt = $_POST['Curt'];
        $CT = $_POST['CT'];


        $sql = "INSERT INTO enroutsepb (CS ,T1, T2, S1, S2, Curt, CT) VALUES
        ('$CS', '$T1','$T2','$S1','$S2','$Curt','$CT')";
        $result = mysql_query($sql);

        echo "Thank you! Information entered.\n";
        }
?>
</p>
  <form name="forms" method="post" action="">

   Call Sign :
  <input name="CS" type="Text" class="sep1" value="<?php echo $CS ?>">
  <br>
  Time To Take First Aircraft:
  <input name="T1" type="Text" class="sep2" value="<?php echo $T1 ?>">
  <br>
    Time To Take Second Aircraft:
  <input name="T2" type="Text" class="sep3" value="<?php echo $T2 ?>">
  <br>
   Speed of First Aircraft :
  <input name="S1" type="Text" class="sep4" value="<?php echo $S1 ?>">
  <br>
    Speed of Second Aircraft:
  <input name="S2" type="Text" class="sep5" value="<?php echo $S2 ?>">
  <br>
   Current Time :
  <input name="Curt" type="Text" class="sep6" value="<?php echo $Curt ?>">
  <br>
   Crossing Time :
  <input name="CT" type="Text" class="sep7" value="<?php echo $CT ?>">
  <br>
  <input name="SEPARATION2" type="Submit" value="SEPARATION">
   <input name="SAVE2" type="Submit"  align="right" value="SAVE">
  </form>
</div>
</body>
</html>
```