MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL AVIATION UNIVERSITY
FACULTY OF AIR NAVIGATION, ELECTRONICS AND TELECOMMUNICATIONS
DEPARTMENT OF AVIONICS

APPROVED
Head of department
________S.V. Pavlova
‘___’ ___________2021

GRADUATION WORK

(EXPLANATORY NOTES)

FOR THE DEGREE OF MASTER

SPECIALITY 173 ‘AVIONICS’

Theme: ‘The on-board system for forecasting for dangerous flight situation’

Done by: AV-209m group, Zeng Xinyu
(student, group, surname, name, patronymic)

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Kyiv 2021

МІНІСТЕРСТВО ОСВІТИ І АУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ АЕРОНАВІГАЦІЇ, ЕЛЕКТРОНІКИ ТА ТЕЛЕКОМУНІКАЦІЙ
КАФЕДРА АВІОНІКИ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_________С.В. Павлова
«___»___________2021

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ МАГІСТРА

ЗА СПЕЦІАЛЬНІСТЮ 173 «АВІОНІКА»

Тема: «Бортова система прогнозування небезпечної польотної ситуації»

Виконав: АВ-209М, Цзен Сіньюй
(студент, група, прізвище, ім'я, по-батьвові)

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Київ 2021

NATIONAL AVIATION UNIVERSITY

Faculty of Air Navigation, Electronics and Telecommunications

Department of avionics

Specialty 173 ‘Avionics’

APPROVED

Head of department
_________S.V. Pavlova
‘___’___________2021

TASK

for execution graduation work

Zeng Xinyu

1. Theme: ‘Reliability Culture in Aircraft Maintenance organization’, approved by order 1945/ст of the Rector of the National Aviation University of 22 September 2021.

2. Duration of which is from 18 October 2021 to 31 December 2021.

3. Input data of graduation work: A safety culture is a collection of beliefs, values and rules - formal or unspoken - about safety that are shared by all people in an organization. It effectively reflects a company's true commitment - from management to employees - to safety in its day-to-day operations and defines how safety is a priority in practice. It includes the following elements: safety management, aircraft reliability, employee responsibilities, management-employee relations, and the structure of a safety management system - or SMS.

4. Content of explanatory notes: List of conditional terms and abbreviations, Introduction, Chapter 1, Chapter 2, Chapter 3, Chapter 4, Chapter 5,References, Conclusions.

5. The list of mandatory graphic material: figures, charts, graphs.

6. Planned schedule

№	Task	Duration	Signature of supervisor
1.	Validate the rationale of graduate work theme	18.10.2021	
2.	Carry out a literature review	19.10.2021 – 25.10.2021	
3.	Develop the first chapter of diploma	26.10.2021 – 01.11.2021	
4.	Develop the second chapter of diploma	02.11.2021 – 10.11.2021	
5.	Develop the third and fourth chapter of diploma	11.11.2021 – 18.11.2021	
6.	Develop the fifth chapter of diploma	19.11.2021 – 11.12.2021	
7.	Tested for anti-plagiarism and obtaining a review of the diploma	12.12.2021	

7. Consultants individual chapters

Chapter	Consultant (Position, surname, name, patronymic)	Date, signature	
		Task issued	Task accepted

Labor protection	Ph.D., Associate Professor V.V. Kovalenko		
Environmental protection	Ph.D., Associate Professor T.I. Дмитруха		

8. Date of assignment: ‘____‘____________2021

Supervisor ______________ O.V. Kozhokhina

The task took to perform ______________ Zeng Xinyu

(signature) (surname, name, patronymic)

ABSTRACT

Explanatory notes to graduation work ‘Violations and their eliminations during aircraft maintenance’ contained 69 pages, 14 figures, 2 graphs, 22 references.

Keywords: AIRCRAFT, HUMAN FACTOR, AVIONICS, AUTOCORRELATION FUNCTIONS, ICAO.

The object of the research - Aircraft Hazard Prediction Device.

The subject of the research - Violation patterns and human factors in aircraft flight.

Purpose of graduation work –Investigation of the human factors of dangerous accidents in aircraft flight.

Research Method –Mathematical theory, probability theory, information theory, statistical theory, and reliability theory were used to solve this problem.

Scientific novelty –Proposed onboard system for prediction of hazardous flight conditions.

CONTENT

LIST OF ABBREVIATIONS

ATS	Air Turbine Starter
CAAC	Aviation Administration of China
DNL	Day Night Sound Level
EFVS	Enhanced Flight Vision System
FAA	Federal Aviation Administration
FTA	Air Traffic Control
HUD	Head Up Display
ICAO	International Civil Aviation Organization
MOPS	Minimum Operating Performance Standard
NNI	Noise and Number Index
OME	Operator Machine Environment
TCAS	Traffic Alert and Collision Avoidance System

INTRODUCTION

Safety of air transportation plays a very important role in air transportation. Once an accident occurs, the damage caused is incalculable. Referring to the past flight accidents, besides the huge economic loss to the airlines, the casualties are the most regrettable. Therefore, the on-board system for forecasting for dangerous flight is very necessary to ensure the safety of civil aviation transportation. It can determine whether the current flight environment is safe or not, provide pilots with countermeasures when they encounter risks, and assist pilots in solving the risks they encounter.

From past experience, human factors play an important role in ensuring the safety of the operating environment. In hazardous conditions, the pilot's psychological state is affected, resulting in a significant reduction in operational accuracy and a loss of the ability to judge the work situation properly. At the same time, this leads to accidents that deviate from the flight plan and may cause incalculable damage.

In this regard, we need to pay attention to human factors and identify the factors in the operating environment that can affect the pilot's operation, which may affect the pilot's psychology to varying degrees, and may occur simultaneously.

In order to provide a stable and safe enough operating environment for operators, this paper analyzes the airline piloting environment by combining human factors and engineering psychology, and proposes improvements to the cabin working environment in aircraft by combining the current civil aviation cabin working standards and the current advanced avionics technology.

Purpose of the work In order to study the hazard accident prediction system in aircraft flight

In order to achieve this, the following tasks should be accomplished:

1. Analyze existing research on human factors and engineering psychology in aircraft flight.

2. Identify common problems of human factors in aircraft flight and common causes of human error.

3. Analyze the existing avionics of hazard prediction systems for aircraft flight.

4. Develop recommendations based on mathematical modeling to complete the assessment of flight hazards and hazard prediction

The object of the research - Aircraft Hazard Prediction Device.

The subject of the research - Violation patterns and human factors in aircraft flight.

Purpose of graduation work –Investigation of the human factors of dangerous accidents in aircraft flight.

Research Method –Mathematical theory, probability theory, information theory, statistical theory, and reliability theory were used to solve this problem.

Scientific novelty –Proposed onboard system for prediction of hazardous flight conditions.

Validation of obtain results was during the following conferences:

Kozhokhina O., Benko V., Violations and Their Elimination During Aircraft Maintenance. Scientific and Technical Conference "Проблеми розвитку глобальної системи зв’язку, навігації, спостереження та організації повітряного руху CMS/ATM": abstracts of reports of the scientific and technical conference 21-23 November 2018, Kyiv, Ukraine, National aviation university / editors: Kredentser S., Herasimenko T. and others. – K.: NAU, 2019 – 84p.

CHAPTER 1

NGINEERING-PSYCHOLOGICAL FEATURES OF ON-BOARD SAFETY SYSTEMS

1.1 Analysis of literature on the problem of human factor

1.1.1 Introduction of human factor

The process of applying psychological and physiological ideas to the engineering and design of goods, processes and systems is known as human factors and ergonomics (often referred to as human factors). Human factors examine how people interact with items of interest to reduce human error, increase productivity, and improve safety and comfort. Human factors and ergonomics are systems for applying psychological and physiological ideas to goods, processes and designs (often referred to as human factors). By focusing on human interaction with things, human factors aims to reduce human error, increase productivity, and improve safety and comfort.

Ergonomics is a branch of industrial engineering that studies the interactions between people, machines and the environment and their rational combinations with a view to designing machine and environmental systems that are suitable for human physiological and psychological characteristics so as to achieve the goals of productivity, safety, health and comfort. As a broad and peripheral subject, it has great potential for research and application. Since it is a broad and peripheral subject with a wide range of research and applications, attempts have been made to define and characterize it from various perspectives.

Psychology, sociology, engineering, biomechanics, industrial design, physiology, anthropometry, interaction design, visual design, user experience and user interface design are all part of this field. Human factors specialists, also known as ergonomics, examine the work (activities) being performed and the demands being placed on the user; the equipment being used (size, shape, and suitability for the task); and the data used to assess the fit between a person and the technology being used (how it is presented, accessed, and changed). Anthropometry, biomechanics, mechanical engineering, industrial engineering, industrial design, information design, kinesiology, physiology, cognitive psychology, industrial and organizational psychology, and spatial psychology are all aspects of ergonomics.

Human factors specialists, also known as ergonomists, are responsible for examining the work being performed (activities) and the demands placed on the user; the equipment being used (size, shape, and suitability for the task); and the data used to assess the fit between a person and the technology being used (how it is presented, accessed, and changed). Anthropometry, biomechanics, mechanical engineering, industrial engineering, industrial design, information design, kinesiology, physiology, cognitive psychology, industrial and organizational psychology, and spatial psychology are all aspects of ergonomics.

Human factors have a significant impact on emergencies. When new threats emerge, the system will not be able to manage them perfectly. Even during an occurrence, the program execution of current instructions can make the danger more severe. Development. At this point, the operator must have sufficiently strong mental characteristics and the ability to calmly examine When a danger occurs, assess it appropriately and calmly, use your experience and expertise to manage the machine, and adjust the current instructions as needed to accomplish risk avoidance.

Sichuan Airlines Flight 8633 (3U8633) is a domestic flight operated by Sichuan Airlines in mainland China. The flight took off from Chongqing Jiang Bei International Airport on May 14, 2018, carrying an aircraft-type Airbus A319-100. About 40 minutes after the plane took off, when cruising at an altitude of 32,100 feet (approximately 9,800 meters), the right windshield of the cockpit broke and fell off, and the aircraft experienced rapid decompression. A series of unfavorable factors such as noise, communication difficulties, machine failures, high altitude flight, emergency descent altitude restrictions, etc., finally landed the aircraft safely at Chengdu Shuang Liu International Airport 35 minutes after the accident. This accident is the first cockpit pressure relief incident in the history of civil aviation in Mainland China. This accident was similar to the British

Airways Flight 5390 accident that occurred on June 10, 1990, and it was also an accident of the windshield in the cockpit of a civil airliner

【https://en.wikipedia.org/wiki/Sichuan_Airlines_Flight_8633】

In this emergency, the captain’s calm handling was particularly important in this emergency evacuation. It can be seen that the operator relied on his proficiency in the equipment and the calm and reasonable handling methods in the emergency. Perfectly dealt with an unknown risk.

The human element of the aviation system is the most adaptive, versatile, and important component. It is, nevertheless, the most susceptible to outside influence, which might have a negative impact on its performance. In the majority of incidents/accidents that are typically attributed to "Human Error," lapses in human performance are listed as primary reasons. Human factors have evolved through time to improve the safety of complex systems, such as aviation, by fostering an awareness of known human limits and their applications in order to effectively control 'human error.' We can only identify and fix the reasons of such a mistake when we look at it from the perspective of a complex system.

Modified SHELL model will be used to better illustrate the concept of Human Factors. The word SHELL is derived from the initial letters of the model's components (Software, Hardware, Environment, and Liveware). The model is constructed one block at a time, with a graphical representation of the necessity for component matching. It makes use of blocks to illustrate the many aspects of Human Factors. In the aviation world, the components will stand for the following:

Table 1.1. SHELL explains

S = Software	<=>	Procedures, manuals checklists, drills, symbology, etc.
H=Hardware	<=>	The File Aircraft and its components (e.g., seats, controls, lay-outs, etc.)
E=Environment	<=>	The situation in which the L-H-S should function (e.g., weather, working conditions, etc.)
L= Liveware	<=>	Human Element (you and other crew members, ground staff, ATC controller, etc.)

Aircrew work involves a continual interplay between those elements, and matching those elements is just as crucial as the qualities of the blocks themselves, as shown in the picture below. Every employee is the middle 'L' who interacts with the other pieces to build a single block on a daily basis. As a result, any misalignment of the blocks might lead to human mistake. The SHELL model is depicted in the diagram.

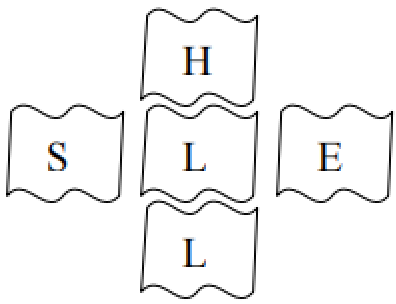


Figure 1.1. SHELL model

The 'Liveware' serves as a hub in the SHELL model of Human Factors, and the remaining components must be altered and matched to this central component. This is especially important in aviation, where mistakes may be fatal.

When creating a new machine and its physical components, manufacturers consider the Liveware-Hardware interaction. Seats are built to meet the human body's sitting features, controls are made to allow for correct movement, instrument layout and information are designed to match human qualities.

The process is made more difficult by the fact that the Liveware, a human being, adapts to mismatches, hiding any mismatch but not erasing it, and therefore constituting a potential hazard. Three-pointer altimeters, a terrible seating layout in cabins that might delay evacuation, and so on are examples of this. In order to address such concerns, manufacturers are increasingly encouraging airlines and professional unions to participate in the design process of aircraft.

The Software, i.e., all non-physical aspects of the system such as procedures, check-list layout, manuals, and all that is introduced whether to regulate the whole or part of the SHELL interaction process or to create defenses to cater for deficiencies in that process, is the other component that continuously interacts with the Liveware. However, faults in this interface are frequently more apparent and, as a result, more difficult to rectify (for example, misinterpretation of a method, symbology confusion, etc...).

The Liveware Environment element of the SHELL concept is one of the most difficult to duplicate. The aviation system functions within a broad set of social, political, economic, and ecological restrictions that are typically outside the control of the primary Liveware element, yet these parts of the environment will interact in this interface. While part of the environment has been adapted to human needs (pressurization and air conditioning systems, sound-proofing, etc.) and the human element has adapted to natural phenomena (weather avoidance, turbulence, etc.), the incidence of social, political, and economic constraints is central on the interface and should be properly considered and addressed by those in management with enough power to change the outcome and smooth the match.

The interaction between the human elements is represented by the Liveware-Liveware interface. Putting competent and successful people together to create a group or a collection of viewpoints does not guarantee that the group will function efficiently and effectively unless they can work together as a team. We need leadership, strong communication, crew cooperation, collaboration, and personality relationships for them to succeed. CRM (Crew Resource Management) and LOFT (Line Oriented Flight Training) are two programs meant to help you achieve that aim.

CRM evolves into Corporate or Company Resource Management as the breadth of this interface expands to include staff/management interactions, since corporate environment and operating pressures may have a considerable impact on human performance.

In summary, human factors in aviation aims to raise awareness of the human element within the context of the system and give the tools needed to perfect the SHELL concept's fit. It hopes to improve safety and efficiency by doing so.

1.2 Engineering and psychological requirements for the operator machine-environment system

When designing the work environment, the size of the environment must be considered, as well as the size and arrangement of the tools. Seating, work surfaces, tables, equipment, tools and display instruments used in the workplace should all be included. Moving aisles, windows and ambient temperature control systems also play a vital role. It is also important to check that one or more employees share the work area. The goal of ergonomic office design is to increase productivity while maintaining the safety and health of employees. The following three points can be summarized as part of this design:

- Minimizing the physical workload and the associated strain on the working person
- Facilitating task execution, that is, ensuring effortless information exchange with the environment, minimization of the physical constraints, and so on
- Achieving ease of use of the various workplace elements

While achieving all of the above criteria, establishing a work environment that is both ergonomic and task-appropriate is quite difficult. For this reason, it is necessary to consider as many factors as possible and to make trade-offs between competing components. As shown in Figure 1, in any work environment there is a constant mutual adjustment between workplace components, work demands and work individuals.

This mutual adjustment is also influenced by larger environmental factors. Thus, no matter how well designed each component is, changes in the work environment can alter habits and postures in daily work. Take the example of a person working in an aircraft cabin (task requirement: working with an aircraft operator panel). If the panel (workplace component 1) and the seat (workplace component 2) are too low and too high for the anthropometric characteristics of the worker (staff characteristics) The pilot has an uncomfortable posture (leaning forward), which can affect his or her physical workload. In order to see her material on the screen (task requirement), the panel (environmental characteristics) may cause him to turn sideways (awkward posture), thus producing a similar effect. As a result, when creating the workplace, we must take a systematic approach and try to consider the staff's qualities, the activities, and the environment in which the duties are performed.

All aspects of the work system also vary. A variety of different job requirements are possible. For example, when an airliner is in danger, the pilot must communicate with the crew while fixing the aircraft's technical difficulties and reporting the current status in time to maintain passenger morale. At this point, the pilot must remain calm and collected, and the distribution of operator panels and communication panels will help to accomplish the above processes more efficiently. Finally, the office environment may be noisy or quiet, warm or cold, have irritating air currents, be illuminated by natural or artificial light, all of which can change during the day.

Designing the right workplace becomes extremely challenging when you consider the complexity of the work system and the range of ergonomic needs, as well as safety and efficiency considerations. The operator panel should be as simple and visible as possible in order to keep the pilot calm in case of an emergency. As a result, it has been claimed that designing a good workplace is more of an "art" than a "discipline" because there is no one theory or technique that guarantees successful output, and the outcome depends heavily on the designer's "inspiration". While this is true to a certain extent, an in-depth understanding of the workplace's employees, the needs of the activity and the larger environment, and a dedication to discipline in the design process, all contribute significantly to successful design.

Vibration and movement:

During work and relaxation, the human body is motion conscious. Traffic may be arbitrary (e.g., during specific movements) or involuntary (e.g., during certain movements) (e.g., passengers in a vehicle). Six independent directions of motion may coexist: three transmission directions (forward and backward, lateral and vertical) and three rotation directions (rolling, stepping and sprinting). Motion at a constant speed (i.e., no change in speed or direction) is usually imperceptible except to external sensors that sense changes in position relative to other objects (e.g., the eyes or ears). You can also perceive translational motion when the speed of the body changes, resulting in acceleration or deceleration that can be felt by intermediate sensors (e.g., vestibular organs, skin) (kinesthetic or visceral sensory system).

External sensors can detect objects rotating at a constant velocity because it causes translational acceleration of the object, changes the position of the object relative to the Earth's gravity, or causes a change in orientation relative to other objects. Vibration is an oscillatory motion in which the velocity fluctuates, allowing the detection of movement between the molecule and the external sensor.

Body vibration may be beneficial or harmful. It may be perceived as pleasant or unpleasant, and it can cause injury and illness by interfering with various duties. Motion sickness may be caused by low-frequency body vibrations and motion of the visual display. The effects of oscillatory movements on people can be divided into three categories:

1. Motion sickness is the actual or simulated movement of the body or surroundings that causes misjudgment of the body's movement or direction. Motion sickness is always accompanied by low frequency motion sickness, typically less than 1 Hz.

2. Vibration occurs when the entire body is sitting on a vibrating surface (e.g., sitting on a vibrating seat, standing on a vibrating floor, or resting on a vibrating surface). Transportation (e.g., road, cross-country, rail, air, and sea transportation) and adjacent machinery can cause whole-body vibration.

3. Hand-transmitted vibration is generated by various operations in industry, agriculture, mining, construction and transportation, as well as by holding vibrating instruments or workpieces in the hand or fingers.

Vibration and motion may interfere with the acquisition of information (e.g., through the eyes), the output of information (e.g., through hand or foot movements), or complex central processes involving input and output (e.g., learning, memory, decision making). The effects of vibratory motion on human performance can be a safety hazard. The best evidence suggests that whole-body vibration can affect the performance of both input processes (primarily visual) and output processes (primarily continuous hand control). In both cases, there can be disturbances that occur entirely outside the body (e.g., vibrations from viewing a monitor or vibrations from a handheld controller), disturbances in input or output (e.g., eye or hand movements), and disturbances within the body that affect the body. Peripheral nervous system (i.e., afferent or efferent nervous system). Central processes may also be affected by vibrations, but current understanding is too limited to make confident broad statements.

Movement of the injured body part is often a source of vibration exposure for both visual and manual controls (i.e., eyes or hands). Reducing the vibration transmitted to the eyes or hands, or reducing the sensitivity of the work to distractions, reduces these effects (e.g., by increasing the size of the display or reducing the sensitivity of the controller). Rework activities can often greatly reduce the effects of vibration on vision and physical control.

The most significant effect of vibration during long periods of manual work is a direct mechanical collision of the hands, resulting in redundant controller action. Fracture error, pitch error, or vibration-related error are terms used to describe this. A vibration error is the accidental movement of a pencil caused by a "bump" while writing on a car. In simple tracking tasks, where the operator must follow the motion of the target, certain errors can be associated with the motion of the target.

The results of studies observing postural effects in control groups seem to support the idea that posture affects hand vibration transmission. According to Thorle, armrests can greatly reduce the effect of vibration on lateral arm controller activity. The shape and position of the control can affect performance by changing the amount of vibration breakthrough or proprioceptive feedback from the operator. Vibration can affect the visual performance of the operator and affect the tracking task. Wilson , Mike Lod and Griffin and others have shown that errors in a given activity can be reduced or even eliminated by bouncing the display through the lens and making it infinitely large. The effects of vibration on manual control and interruptions in vision may have caused performance degradation in previous experimental trials.

Some simple tasks may be little affected by vibration, but some precision or tasks that require a high degree of accuracy can be great dangerous when subjected to uncertain vibration.

Vibration Evaluation:

To evaluate manually transmitted vibration in the frequency range of 8 to 1000 Hz, all current national and international standards use the same frequency weighting (called Wh). This weighing method can be used to measure the vibration acceleration of the three vibration axes at the arm vibration inlet. The most recent standards for estimating the overall intensity of manually transmitted vibration recommend using the sum of the square roots of the frequency-weighted accelerations in the three dimensions. When two instruments vibrate simultaneously, the instrument with the lowest frequency-weighted acceleration will cause less injury or illness, according to the standard. Occupational effects of hand-borne vibration vary depending on the duration of daily exposure and may range from a few seconds to several hours. Irradiation is usually intermittent. The criterion is the equivalent of an 8-hour exposure and simply reports the daily exposure as:

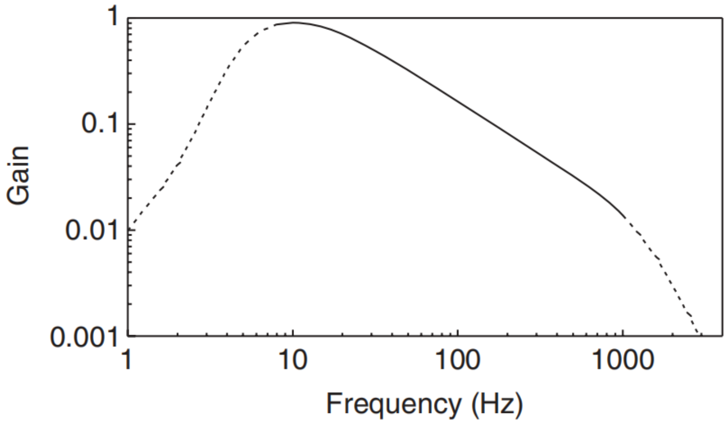


Figure1.2 frequency weighting for hand-transmitted vibration assessment.

$$a_{hw(eq,8h)} = A(8) = a_{hw}\left[\frac{t}{T_{(8)}}\right]^{1/2} \# \ (1.1)$$

T(8) is 8 hours (same units as t) and t is the exposure length in r.m.s. Frequency-weighted acceleration, ahw.

1.3 ICAO requirements for automation of aircraft flight control systems

1.3.1 State and Mode Requirements

- The system must be able to function in either Operational Partition or Simulator Partition mode.

- Operational Mode, Direct Radar Access Mode, Simulator Mode, and Playback Mode should be available on the surveillance and flight display consoles. The servers must be able to run in three modes: active, hot standby, and maintenance.

1.3.2 Human-Computer Interaction

The surveillance sites will be able to give uninterrupted surveillance traces.

Data shall be shown in a clear and understandable manner, preventing confusion and/or misunderstanding, and taking into account the data's contents, meaning, and value.

1.3.3 Functional Controls

- Before the completion or confirmation of the command's execution, the system must be able to cancel or remove any input action that has been begun. A trackball and specialized function keys will be used to control the system.

1.3.4 Color Assignment and Radar Coverage Diagrams

- The supervisor role must be able to choose colors for various display components without degrading or interfering with the performance of operational functions.

- Individual workstations must have the ability to adjust color brightness and intensity as an operational function.

- The main controller position must be able to show coverage diagrams for each surveillance sensor, as well as a combined coverage diagram for all ground-based surveillance sensors in a single color.

- These coverage diagrams will be adjusted to represent theoretical coverage for each azimuth at heights of 5,000 feet, 10,000 feet, and 20,000 feet. A distinctive hue will be applied to areas where there is no surveillance coverage.

1.3.5 Screen Annotation

- The surveillance workstations must be able to save and show up to TBD annotations. Each annotation will have its own color and wording.

- The surveillance workstation must be able to send screen annotations to other surveillance workstations as well as suppress the annotations that are currently shown.

1.3.6 Windows Presentation

- The surveillance workstation must organize all information in windows to provide surveillance data, flight plan data, warnings, status, and instructions, with each window being chosen, resized, or moved by the controller.

- Any vital information displayed in a minimized or inactive window must be notified by the system.

1.3.7 Main Surveillance Window

- The main surveillance window shall present the surveillance data with the capability to zoom and pan.

- The secondary surveillance windows shall provide the same capability than the main surveillance window with independent resize, zoom and pan.

1.3.9 System Status Window

- The System Status Window shall display the following information:

• Time and Date;

• Selected display range;

• Altitude filter bounds;

• SSR block code selections;

• CJS Designation;

• Presentation mode;

• Magnetic Variation;

• Label line selections.

Windows Messages

1.3.10

- The system must be able to display any outstanding coordination messages between centers, sectors, or tracks (via Datalink).

- The system must be able to record all coordinating activities even if the systems' interfaces are down.

- When a response to a coordination message is not received, the system must be able to show an alarm.

- The system must be able to show the received coordination messages until the operator delivers the proper response.

- The system must be able to show the history of coordination messages sent.

1.3.11 Track History Information - In each position, the surveillance workstation must be able to enable or disable track history information.

- Using a specified symbol, the surveillance workstation must be able to pick the number of track history positions.

1.3.12 Maps

- In each surveillance workstation, the system must be able to choose and provide map data.

- The following entities must have specific graphic representations on the map:

FIR/UIR boundaries;

sector lateral limits;

terminal control areas;

control zones;

traffic information zones;

Airways and ATS routes;

Restricted regions

1.3.13Flight Data Displays

- The system must include functioning controls for entering, changing, canceling, and displaying flight data.

- Through graphical point selection, the system should be able to enter a modification in a flight plan path.

• Flight plan data entry;

• Flight plan update data update;

• Display of flight plan data;

• Edition of stored/displayed information;

• Printing of Flight Progress Strips:

• Manual edition of ATS communications;

• Departure clearance for dormant and pre-active flight plans; The system must be able to change a flight plan using a graphic tool while seeing it on a specified themed map.

- The system must be able to display the history of a flight plan, including all actions and message updates received or communicated in connection with that flight plan.

CHAPTER 2

Advanced onboard systems for predicting a dangerous flight situation

2.1. Onboard flight safety systems

The Boeing B737-500 is a modern, direct replacement for the 737-200, incorporating improvements in the classic Boeing 737 series. This model allows longer journeys, with fewer passengers, than the Boeing 737-300. The fuselage length of the 500 series is 47 cm longer. This unit is equipped with more modern and economical CFM56-3 engines. The capacity of the aircraft is 140 passengers.

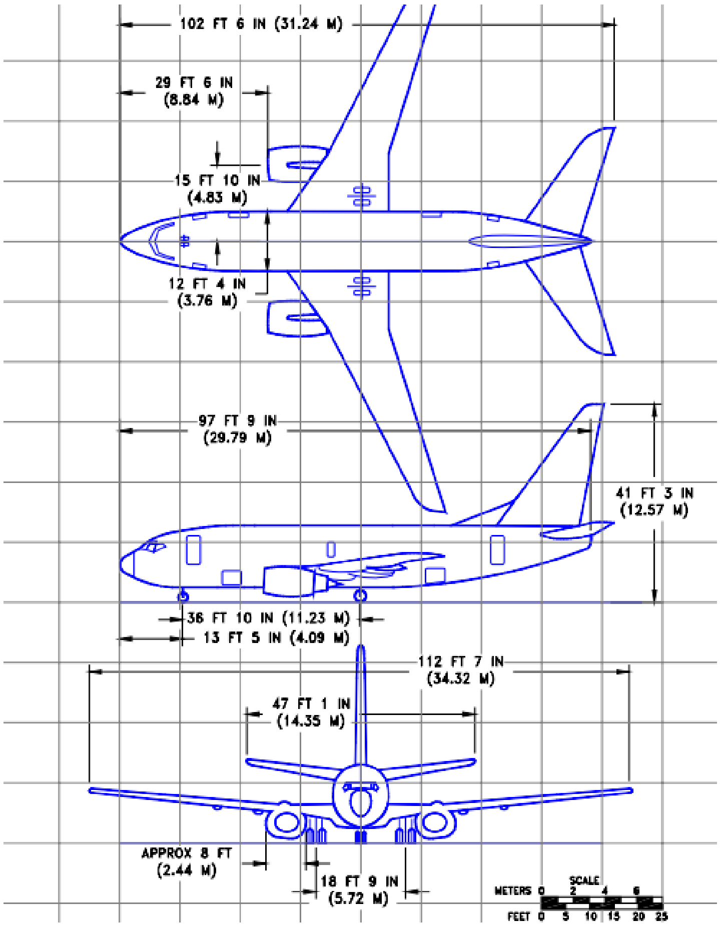


Figure 2.1. Projections of Boeing 737-500

The 737 is a twin-engine airplane designed to operate over short to medium ranges from sea level runways of less than 6,000 ft (1,830 m) in length.

Safety of flight is especially important in aviation, so having a good safety system is a guarantee to reduce the number of safety accidents in aircraft.

The on-board system of safety of Boeing 737 can be classified as follows:

The main purpose-to provide pilots with flight safety related information and short-term predictions of the consequences of operations that exceed the safety factor.

In case of exceeding the safety environment, the risk factor is predicted and the corresponding solution is given to the pilot for reference. The concept of Fault Tree Analysis is invoked to help the system to complete the judgment.

An FTA (Fault Tree Analysis) is a graphical design technique that can be used as an alternative to block diagrams. It is a top-down, deductive approach structured in terms of events. It is used to model faults in terms of failures, anomalies, malfunctions, and human errors

An FTA is a graphical logical representation of a functional system's possible failure occurrences. This logical analysis must be a functional description of the system, and it must contain all possible combinations of system failure events that could cause or contribute to undesirable outcomes. Each important fault event should be investigated further to establish the logical linkages between potential fault events that could lead to it. This fault event tree is grown until all "input" fault events are specified as simple, recognizable faults, which can then be quantified to determine probabilities if required. When the tree is finished, it transforms into a logical gate network with single and multiple fault routes, containing a variety of events and situations, including main, secondary, and upstream inputs that can affect or command a hazardous mode.

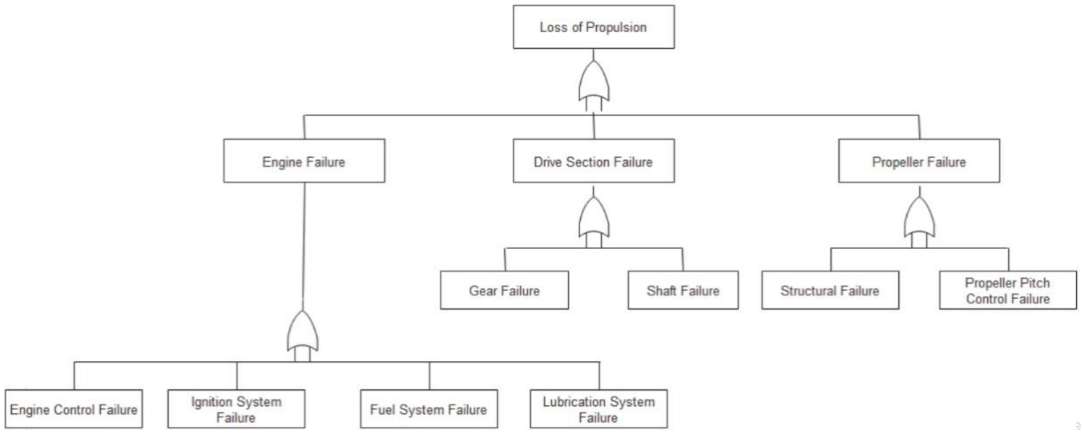


Figure 2.2. Fifita of the propulsion system

The safe on-board system is a system which is made up of sensors, indicators, devices and annunciators.

Also, it can be classified by those categories:

a) According to the type of information provided by the pilot:

-Analogue

-Digital

-Complex character

-Mixed representation

b) By type of system integration of avionics aircraft:

-Integral

-Line replaceable units

c)According to the type of interactions with the pilot:

-Remote

-Collect data on the physiological parameters of the pilot

d)According to the type of interactions onboard system of safety with factors affecting the safety of flight:

-Aircraft security

-Safe surface

- Airplane inside

This classification allows assuming that the onboard system of safety has a lot of prospects, and at the same time has a significant influence on the actions of the pilot, and this in turn determines the level of safety.

The main avionics for safe system of Boeing 737 can be listed as follows:

- Navigation systems
- Radio communication system
- The automatic pilot
- Onboard information system
- Other flight control and navigation systems.

With the development of modern technology and science, flight safety systems are covering more and more levels, but they are also becoming more and more complex as a result, which increases the burden on pilots and increases the likelihood of operational errors in case of danger. Therefore, in aviation development, the level of automation of the system is now also particularly critical. Although the existence of automated systems can not completely replace the pilot's operation, in some critical times can help the pilot to reduce the stress of flight.

Airplane general emergency equipment panels:

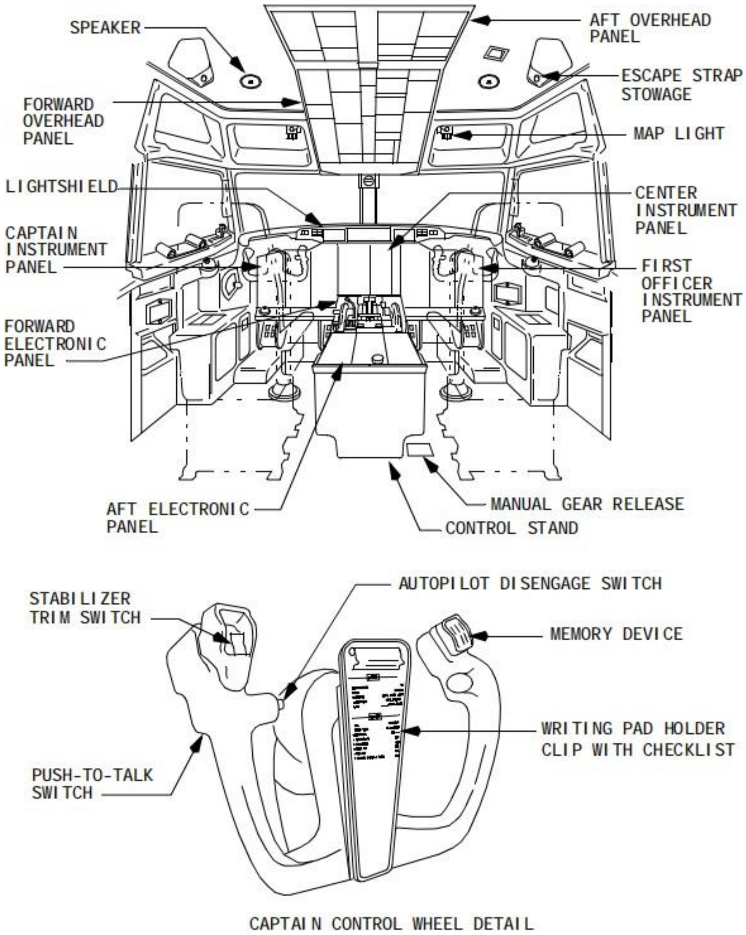


Figure 2.3. The structure of the cockpit

2.2The problem of the influence of avionics failures on the psychophysiological state of the pilot

1. Pressure characteristics of pilots in emergency situations

Under normal circumstances, the state of a well-trained pilot is stable, and the physical and psychological responses of the flight mission change moderately, so the operation at this time is also stable.

During the flight, we generally divide the unfavorable factors encountered during the flight into four different degrees

-Complex flight environment: In this case, the pilot’s psychological load increases slightly, and the flight stability and controllability deteriorate slightly, but it does not affect the completion of the flight mission.

-Difficult flight situation: an emergency situation caused by the change of one or more parameters. At this time, the psychological load of the pilot and crew members increases significantly. At this time, the stability and controllability of the aircraft deteriorate significantly, and one or more flight parameters Broke the normal limit, but did not reach the maximum limit

- Emergency flight situation: In this kind of flight situation, multiple parameters break the limit, and the maximum limit of flight safety is about to be reached. The pilot's psychological burden reaches the maximum value, and the flight stability and controllability are significantly deteriorated.

- Disaster flight situation: In this case, the pilot's control can no longer change the fact that the plane crashed and the casualties, and the pilot's operation can no longer save the fact that the plane crashed, which has nothing to do with the pilot's psychological factors.

The above flight conditions will have different consequences, which depend on the factors that caused them. Special circumstances lead to the final outcome and the flight conditions during the flight are related to the pilot's operations.

Climate factors include：

- flights in areas of icing, thunderstorms and heavy rains, heavy chatter, increased electrical activity of the atmosphere, wind shear, dust storms;

- flights in mountainous and low-lying areas, in deserts and over the water surface;
- flights in the polar regions of the Northern and Southern hemispheres of the Earth;
- flights in difficult ornithological conditions.

Special cases in flight include:

- hit of the aircraft in a dangerous meteorological phenomenon;
- failure of aircraft engines (aircraft engine);
- failures of aircraft systems, which may lead to the need to change the plan, flight profile and forced landing;
- fire on the aircraft;
- loss of stability, controllability, violation of the strength of the aircraft;

attack on the crew (passengers);

- forced landing outside the aerodrome;
- injury or sudden deterioration of the health of crew members (passengers);
- failure of radar means of air traffic control and radio equipment at the aerodrome in the garden;
- failure of radio communication (failure of onboard and terrestrial radio communication systems);
- loss of orientation.

According to the above list of special cases in flight, a "special case in flight" is a circumstance that emerges as a result of an unanticipated failure of the aircraft's functional system or its exposure to conditions that compel the crew to operate differently than usual piloting.

Equipment failures, incomplete and uncertain information incoming from various aircraft devices and measuring systems, a lack of time, the need to perform two or more incompatible actions, and other situations that differ from normal may occur with a significant deterioration of operating conditions.

The operator may experience increased psychophysiological tension, which is accompanied by a significant change in physiological reactions, a violation of the structure of information collection and motor acts, a lack of consistency in results, difficulties and errors in performing the most complex actions. As a result, the operator feels unsafe in the pressures and actions that disrupt the operator's operating characteristics' steadiness.

When a pilot is confronted with events that are not typical of usual driving, he or she will become nervous. The level of tension is determined by the driving situation at the time. One of the main causes of operator stress is that he perceives he cannot resolve the current problem on his own, that it is dangerous, and that he does not know how to resolve it. Other factors that can create stress include the intensity and duration of the event, which can lead to significant physical and psychophysiological stress; and unexpected exceptional conditions that raise the danger of harm. The majority of the time, stress is induced by a combination of variables rather than a single cause. It should be noted that pressure is a common characteristic of flight work. In flight activities, pressure is not a special case.

Nervous emotions might make it difficult for the pilot to analyze the flight situation and make decisions about following operations. Therefore, it is very important to cultivate the flexibility of pilots under pressure, which is usually carried out in two directions:

-Prepare a list of all the possibilities that may arise during the flight, as well as the best options for various crises on the ground.

Second, specific training should be given to flight crews' quick decision-making thinking, i.e., to develop their "unusual way of thinking " when unexpected events arise.

2.0perator- machine - environment (OME)between the different situations

Flight work is one of the most complex types of human activity, and the effectiveness of operator- machine - environment (OME) in aviation depends on a variety of different conditions, which do not often occur on ground equipment. Flight work is characterized by: work in an unusual condition compare with the situation from the ground; forced high speed and mandatory continuity of the crew, which forces to adhere to the required rhythm of flight; fast movement in space; intensive mental work combined with coordinated and accurate motor actions; influence on the body of physical factors (acceleration, noise, vibration, atmospheric pressure drop, temperature fluctuations, etc.), which significantly affect the course of human mental processes.

Planes are a special operating environment, and one of the important points is that orientation in flight is not easy to recognize because separation from the earth's surface. Studies have shown that it is almost impossible to estimate the spatial position in flight without a visual analyzer. However, the importance of other analyzers is not excluded, and each instrument plays an important role in different scenarios. Thus, the pilot reacts to a sharp roll, first of all, at the signal of the vestibular apparatus and only then checks the magnitude of the roll or the accuracy of the display visually. The amplitude and tempo of the rudder movements required for one or another evolution are regulated, first of all, by the motor sensations, and then the new flight mode is specified with the help of a visual analyzer.

2.3. Mathematical analysis of the deterioration of the quality of the piloting technique in terms of flight parameters

Digital avionics systems are standard on modern airplanes. avionics systems. Because of the current element base's increased dependability, we are able to monitor the psychological changes in the pilot as a result of changes in various parameters. Because without ground-side auxiliary monitoring, the workload of pilots and as a result of the increase in crew personnel, various additional factors. Because without ground-side auxiliary monitoring, the workload of pilots and the number of crew members grows as a result of many new aspects and functions. Changes in engine operation patterns, ground communication, visual surveillance of the airspace, and so forth. Monitoring and analyzing several metrics and flying aspects at the same time necessitates a high level of crew focus.

The crew ensures that the aircraft enters a certain location in the airspace during pre-landing maneuvering so that keeping its height on the runway and deviation from the perimeter line within a controlled range. With this premise that the aircraft is in a specific narrow airspace, the position and speed of the aircraft are calculated afterwards. When the current parameter meets the above specified conditions. Conditions for a successful landing are established, and the crew completes the next landing procedure - Glide path entry using signals collected by glide path beacons. If the above requirements are not met, it is up to the driver to decide whether to move to the next stage.

The angle of attack is exactly proportional to the thrust speed of a constant engine. As a result, if we start with the state of ordinariness, we may evaluate if the instrument speed indicators are wrong by adjusting the angle of attack, and the other way around.

Optimal trajectory control system ensures continuous, error-free operator-aircraft processing of aircraft trajectory information. With the help of this system, the flight path described by the system is identical to the actual flight path of the aircraft, and any deviation from the intended flight is recorded by the on-board equipment and the pilot is alerted in time.

comparing to using according the aircraft's angle of attack and speed to control aircraft, we are more willing to using the correlation fields $\Delta\alpha j= (\alpha i\text{-}1)/1and\Delta V j= (Vi–1)/1$, more well as α and γ to get details on coordinated reversal, (α is the angle of attack, γ is the angle of heel).

When reading flight information, *V* is the instrumental speed, and *1* is the minimum error value allowed when reading flight information.

This data is transmitted via sensors via digital-to-analog converters. Various ways of showing flight information, and then the pilot takes steps to rectify the inaccurate data.

The correlation field have those values $x1$, $x2$ ...xn, which correspond to the values $y1$, $y2$ ...yn(Fig. 1). Let a functional relationship φ(x) to put group of points together. Its numerical value is formed based on theoretical considerations or on the location of the points on the correlation field. The technique of approximation must be selected as precisely as $y=\varphi\ (x, a, b, c\ldots)$ numerical parameters a, b, c, ... The well-known least squares approach is used to tackle this problem.

The formula for the sum of the squares of the differences of each value is given below yi and the functions φ ($xi,\ a\ ,b\ ,c,\ldots$)at the correspondence points. The summation function is F (a, b, $c\ldots$).

$$F(a,b,c) = \sum_{i=1}^{n} (y_i - \varphi(x_i, a, b, c))^2 \# \ (2.1)$$

In order to get the smallest values. It is required to choose numerical parameters a, b, c,... for the sum function , that is:

$$F(a,b,c\ \ldots) = \min \# \ (2.2)$$

Use partial derivatives to get the minimum value of the sum function

$$\frac{\partial F}{\partial a} = 0, \frac{\partial F}{\partial b} = 0, \frac{\partial F}{\partial a} = 0\ \ldots \# \ (2.3)$$

The following equations are expressed as a system:

$$\begin{cases} \sum_{i=1}^{n} (y_i - \varphi(x_i, a, b)) \dfrac{\partial \varphi(x_i, a, b, c, \dots)}{\partial a} = 0 \\ \sum_{i=1}^{n} (y_i - \varphi(x_i, a, b)) \dfrac{\partial \varphi(x_i, a, b, c, \dots)}{\partial b} = 0 \\ \sum_{i=1}^{n} (y_i - \varphi(x_i, a, b)) \dfrac{\partial \varphi(x_i, a, b, c, \dots)}{\partial c} = 0 \end{cases} \quad (2.4)$$

Using the minimized by the function of the sum $F(a, b, c, \dots)$ can let such a system of equations with the substitution of the values xi and yi will have numerical parameters a, b, c, ..., get the more great solution

It's necessary to calculate the area of the curvilinear figure, between these curves on a certain interval $x \in [x1, x2]$,if in the correlation field another function $y = f(x)$ is defined in the same way

$$S_{abcd} = \int_{x_1}^{x_2} (\varphi(x) - f(x))dx \quad (2.5)$$

If the correlation field of a function that approximates the supplied values cannot be generated for any reason and the area of the polygon produced by the given points must be determined, then the functional dependency of each link of the polygon must be determined.

Assume that the given is a convex polygon. Equation of straight lines in sections 1-2, 2-3, ...,n-1-n, 1-n:

$$\frac{x - x_1}{x_2 - x_1} = \frac{y - y_1}{y_2 - y_1} \text{ or } y_{1-2} = k_1 x + b_1$$

$$\frac{x - x_2}{x_3 - x_2} = \frac{y - y_2}{y_3 - y_2} \text{ or } y_{2-3} = k_2 x + b_2$$

$$\frac{x - x_{n-1}}{x_n - x_{n-1}} = \frac{y - y_{n-1}}{y_n - y_{n-1}} \text{ or } y_{n-1-n} = k_n x + b_n$$

$$\frac{x - x_1}{x_n - x_1} = \frac{y - y_1}{y_n - y_1} \text{ or } y_{1-n} = kx + b \#(2.6)$$

The formula for calculating the polygon's area is:

$$S_{1-2-3-n} = \int_{x_1}^{x_2}(y_{1-2} - y_{1-n})dx + \int_{x_2}^{x_3}(y_{2-3} - y_{1-n})dx + \dots$$
$$+ \int_{x_{n-1}}^{x_n}(y_{n-1-n} - y_{1-n})dx$$

If the obtained parameter area decreases then it indicates a decrease in the flight quality of the aircraft. This method is applied to every aircraft.

The aircraft rating index given varies depending on the area. For example: flight quality–[0.43-1]This range represents relatively good flight quality; average flight quality–[0.29-0,43]; and the bad flight quality– [0-0.29]. Most values of the range of relative areas [0,43-1] are found in the range [0,43-0,62]. However, it is theoretically possible to exceed the extreme values, exceeding the value 1.Pilot’s Stress During the Glissade Entry by the Crew:

When the aircraft lands into the glide phase, the aerodynamic configuration of the aircraft changes due to the release of the flaps and landing gear. And when flying in steering mode it adds some extra maneuvers to the pilot. If a system failure occurs at this time, the pilot's psychological stress will increase. The way the pilot operates in this situation may then deteriorate. We have made relevant statistics for this situation: since the parameters of the aircraft vary smoothly in the area.

We can combine the autocorrelation function to make the relevant calculations. The formula is used to do calculations:

$$R_i^{(j)} = \frac{1}{n-j+1}\sum_{i=1}^{n-j+1}\left(A_i - \frac{1}{n}\sum_{i=1}^{n} A_i\right)\left(A_{i+j-1} - \frac{1}{n}\sum_{i=1}^{n} A_i\right) \quad \# \ (2.8)$$

L signifies a delay in the argument 0, 1, 2 ... ($L - 1$). The number of observations in the time series A_i is denoted by n.,$j = 1, 2, 3, \dots$

It is very important to note that this flight condition occurs when two to three pieces of equipment fail at the same time. At this point the mental state of the crew is noted in this complex aviation simulation equipment. These failure conditions should be included without affecting the aerodynamics and the degree of controllability of the aircraft. Experimental data show that in 70-80% of cases, extreme flight conditions and uncertainty of accident occurrence lead to increased pilot tension, resulting in larger amplitudes of flight parameters, so the re-simulation equipment should be applied not only for the learning of specific maneuvers, but also for the pilot's stress resistance.

For the investigation of the counteraction of pilots overlay factors, one version of the application order of trend algorithms is explored. Given numerical data or graphs representing headend change (ψ), roll(γ),pitch (ϑ) and vertical velocity (V_y) from the end of the fourth turn through landing.

It is necessary to 1) determine the distance between the extreme values of these functions and zero 2) calculate the difference between each extreme value and determine the maximum and minimum values of each parameter. 3) calculate the half-life (T) corresponding to the maximum and minimum values of each parameter. The calculation is performed for each parameter according to the following equation.

$$\Delta A = \frac{A_{\max} - A_{\min}}{A_{\min}} \# \text{ (2.9)}$$

Following that, the following multichannel image of parameter change is obtained:

$$\Delta\Delta A_{\gamma,\Psi,\theta,V_y} = \sqrt{\Delta A_{\gamma}^2 + \Delta A_{\Psi}^2 + \Delta A_{\vartheta}^2 + \Delta A_{Vy}^2} \# \text{ (2.10)}$$

When working with numbers in degrees, amplitude may be measured and applied to the axis of coordinates. When dealing with graphs, remember to work with relative units and periods, which are measured in seconds and conditional relative units, respectively.

Wrong and illogical actions taken by pilots during flight in case of danger are associated first of all with the effect of changes in uncertainties on them leading to changes in mental processes (reflected in differences in polar values). In such conditions may lead to operational deformation of pilots (chaotic use of levers, switches, buttons and other functions on the aircraft). In order to avoid this phenomenon, it is very important to train the whole crew and to master the technique of motion space delay while operating the aircraft.

In addition, one should pay attention to another key element of this approach - flight training logic. It is an important basis of training and the only correct solution to choose against unexpected stimuli.

In the ideal scenario we have the difference in magnitude between the absence of obstacles in flight and the occurrence of obstacles, and by comparing this difference we are able to derive the degree of danger posed in adverse conditions.

(Hryshchenko & Romanenko & Daria Pipa: Methods for Assessing the Glissade Entrance Quality by the Crew)

CHAPTER 3

Development of an on-board flight safety system

3.1 Weather radar

Regardless of the size and lifespan of the aircraft, the threat posed by extreme weather to the aircraft is fatal. Severe weather such as lightning, hail, and storms will make it difficult for pilots to operate the aircraft. And cause damage to the aircraft to varying degrees.

Not only that, the inaccuracy of weather forecasts can lead to pilots making wrong judgments and decisions. According to relevant statistics, flight schedule delays related to bad weather cost airlines millions of dollars each year and also reduce the productivity of countries. Therefore, accurate weather radar monitoring equipment is very important in air transportation.

Traditional 2D or tilt-based radars, whether manual or automatic tilt control, can only offer a restricted slice of the weather.As a result, in severe weather, the pilot cannot completely comprehend the weather circumstances and must rely on manual tilt control to estimate and assess the flying height. Radar operations based on the tilt technology type are complex, requiring pilots to perform geometric calculations in conjunction with the curvature of the earth and the current tilt angle to predict the potential danger of the current weather. And it is worth noting that misinterpretation of data and calculation errors by pilots using this type of radar can easily occur when the workload is excessive

Compared to 2D radar, IntuVue's RDR-4000 3D weather radar largely reduces pilot workload. Adequate perception of weather patterns allows for greater anticipation of hazardous routes providing greater safety.

Table 3.1 The limitations of conventional 2D radar compare with RDR-4000

THE LIMITATIONS OF 2D RADAR	**THE INTUVUE/ RDR-4000 SOLUTION**
To identify cell tops in tilt-based manual mode, pilot calculations are required.	Manual mode with continual flight slices is simplified with IntuVue 3D buffer and elimination of the earth's curvature for rapid and easy pilot examination of cell tops.
Using one or two tilt angles, radar scans only a part of the airspace in front of the aircraft.	The 3D radar has a range of -80 to +80 degrees from the aircraft fuselage and is capable of scanning all weather in the range of 0 to 60,000 feet. This allows AUTO weather mode to display weather conditions affecting the current path and changes affecting the flight plan, thus providing complete situational awareness.
The use of radar is limited to one view at a time.	The RDR-4000 offers three modes of operation, AUTO, MAN and MAP mode, allowing two pilots to operate the radar independently or in tandem. In this condition, one pilot can be allowed to perform manual analysis calculations while the other pilot remains in AUTO mode.
Does not provide vertical weather judgment	Only the RDR-4000, with its 3D volumetric scanner, can identify and analyze the vertical growth of a storm cell in MAN mode or with a vertical situation display using flight level slices in 1000 ft increments
Does not account for the curvature of the earth	The curvature of the earth will be corrected with the weather information in the 3D buffer automatically.And in analysis mode, the display panel will show the weather parameters at the specified altitude, as opposed to traditional 2D radar, which requires the pilot to perform geometric calculations based on the curvature and tilt angle of the Earth
The range of hazard detection offered is limited.	RDR-4000 was the first radar to offer predictive hail and lightning displays with the Hazard V1.0 Upgrade.Hazard V2.0 now adds the ability to separate convective weather from stratus, further enhancing hazard detection capabilities.
Because of the waveguide, there are signal losses.	Waveguide runs reduce power and attenuation decrease sensitivity cause of Incubus' innovative design eliminates them.
Has a lower level of sensitivity and resolution.	The RDR-4000 radar uses pulse compression technology and is unprecedented in commercial radar. Pulse ramming

	technology provides longer range performance and higher resolution than conventional transmitter pulses
Weather risks are only scanned in a limited way.	The RDR-4000 provides the highest level of weather detection during weather sampling by interweaving multiple tilt angles and thus up to 17 scans.
While predicted windshear is operational, there is little weather detection.	The RDR-4000 has variable speed scanning capabilities, supporting predictive windshear scanning and full weather scanning, which allows for better situational awareness during takeoff and landing
Limited 2D scan coverage requires assumptions about expected weather types to adjust tilt , which can lead to under- or over-scanning	RDR-4000 interweaves up to 17 scans at multiple tilt angles to scan the entire airspace ahead of the aircraft. This detects all climate types and does not require any assumptions to be made

RDR-4000 3D Weather Radar Systems Benefits:

• Increase crew efficiency by reducing pilot effort with automated operations and informative displays on the RDR-4000 3D Weather Radar Systems.

• Provides predicted hail and lightning alerts, making it the only radar certified to do so.

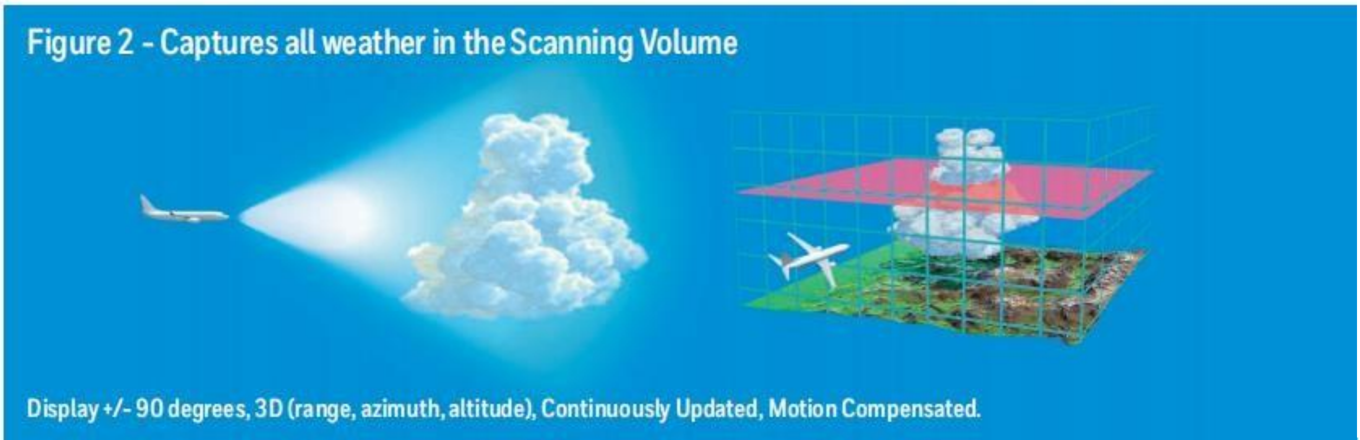
• The industry's most advanced technology for predictive windshear detection and warning capabilities, the first increased turbulence detection system to be certified by the Federal Aviation Administration as a MOPS (Minimum Operating Performance Standard)

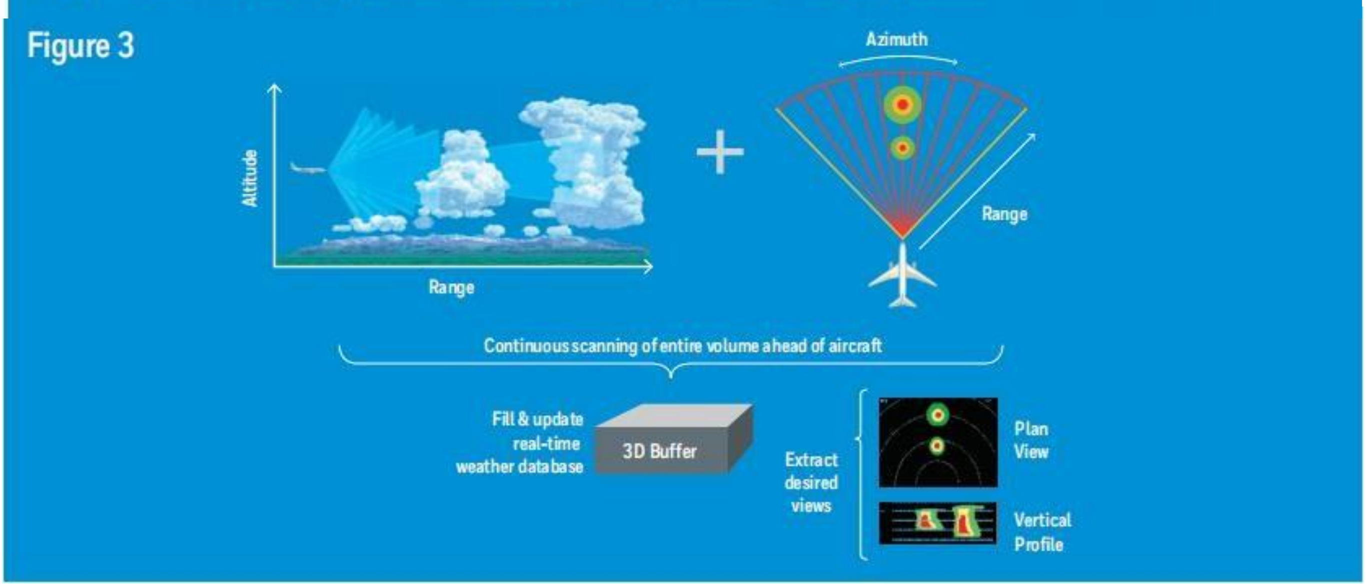
• Bring the fleet together, increase dependability, and use sophisticated weather hazard detection and analysis to improve staff and product performance.

The 3D radar has a range of -80 to +80 degrees from the aircraft fuselage and is capable of scanning all weather in the range of 0 to 60,000 feet. This allows AUTO weather mode to display weather conditions affecting the current path and changes affecting the flight plan, thus providing complete situational awareness.

The RDR-4000 is also the only radar capable of accurately separating weather and terrain returns, providing pilots with a complete picture of the weather.

Aircraft and east track, speed, heading, and altitude are provided, and a 3D buffer is continuously updated with new scans to obtain reflectivity data without interruption.(As show in Figure 2 and 3).





3.2 Enhanced Flight Vision System (EFVS).

Enhanced flight visibility system (EFVS) refers to the average forward horizontal distance seen from the cockpit of an enhanced aircraft, at which the pilot can clearly see the territory and distinguish particular forms of terrain we regardless of light conditions using the Enhanced flight visibility system.

Enhanced flight visibility system includes sensors, displays, central computer, controllers, power supply, and using HUD technology, will be displayed in the pilot's driving goggles. Such a display module can be combined with external scenes in real time to display data on various parts of the scene. To provide a real-time image of the external scene, the imaging sensor can use millimeter wave radiometry, millimeter wave radar, lowlevel light enhancement, or other real-time imaging techniques. Depending on the current atmospheric conditions and the intensity of the energy emitted or reflected from the exteriorof the cabin, the pilot can see the approach lights and the parameters related to the run to theenvironment through this display system. There are even some obstacles that cannot be viewed at all using natural vision.

An installed aircraft system that displays:

- Flight parameters
- Aircraft Current Information
- Real-time electronic sensing images of external scenes on a HUD or comparable display.

Image sensors include: millimeter wave radiometer, forward looking infrared, low light level image enhancement, millimeter wave radar and other real time imaging technologies.

The visual advantage is the difference between the distance a pilot can see with an EFVS (improved flight visibility system) and the distance a pilot can see without an EFVS (enhanced flight visibility system) (flight visibility). When conducting EFVS operations, the visual advantage is designed to maximize the possibility that the pilot will have the requisite enhanced flying visibility and be able to recognize the required visual references.

Figure 3.4 Difference between the natural vision and enhanced vision

The difference between the pilots when using EFVS and when not using EFVS is depicted in the figure below. When EFVS is used in a landing situation, the pilot's visual range is greatly increased, allowing him to observe the situation around the landing site from a more distant vantage point, allowing him to better deal with various unknowns

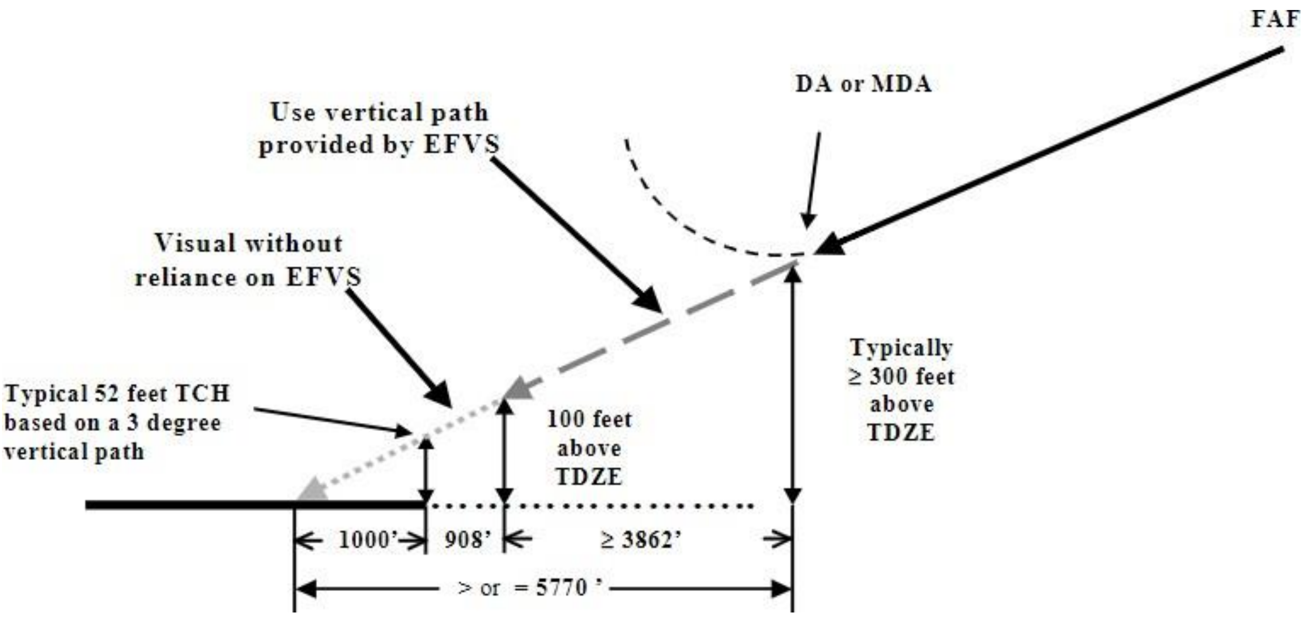


Figure 3.5 Advantage of the vision of the EFVS

3.3 TCAS: Traffic Alert and Collision Avoidance System

In the year 2002, a catastrophic occurrence occurred in the history of commercial aviation. Two planes collided in mid-flight above Überlingen, a city in southern Germany near Lake Constance. A Boeing 757 and a Russian Tupolev were on the verge of colliding when both planes' TCAS activated, and the Tupolev pilot supplied a bogus input. The Tupolev crew was directed to drop to a lower level by the air traffic controller, despite the Tupolev's TCAS ordering the crew to rise while the Boeing crew was commanded to descend. The Tupolev pilot followed the air traffic controller's directions and commenced descent, ignoring his TCAS's resolution indication, and both planes crashed in mid-air a few seconds later. Such a disaster might not have occurred if the pilots had followed TCAS's response advice at the time. This demonstrates that TCAS is critical in responding to specific emergency flying circumstances.

Figure 3.6 TCAS location distribution in the aircraft

The TCAS checks the airspace surrounding the aircraft for other planes equipped with such a transponder across a 40-mile horizontal radius and 9900 vertically upwards and downwards. As a result, the TCAS includes two antennas: one at the top and one at the bottom of the fuselage. As a result, the antennas are always on the watch for intruder transponders, since the TCAS uses the transponder signals to estimate each intruder's relative direction, range, and closing rate, as well as its relative height (if available). Once another aircraft gets into your TCAS airspace, this little diamond will pop up on the navigation display, showing you where the aircraft is, and its vertical separation to your aircraft. So, in this example, the airplane is 2,000 feet above you. (Above, indicated by the little plus symbol -- minus would be below), but in this example, there is no imminent threat. The little arrow pointing down or upward indicates that the aircraft is either in a climb or descent relative to your aircraft.

Figure 3.7 TCAS display description

The small diamond has now turned completely white in this image, signifying a proximal intruder, which means the other plane is within six nautical miles but poses no threat if it maintains its altitude separation. The intruder is now descending, and the diamond has transformed into an amber dot. This is when the collision avoidance and avoidance mechanism come into action. Because the TCAS has now identified the other jet as a potential threat, an audible warning is automatically sent [Traffic! Traffic!].

Figure 3.8 TCAS display description

Within 40 seconds of the intrusion, TCAS anticipates what is called the closest approach point. When the amber dot turns red, TCAS anticipates the closest approach point within 25 seconds and issues a solution advisory to both aircraft. To increase the vertical clearance between the bits, an advisory is issued [Climb! Climb!] and the other will be advised to [Descend! Descend!] .

3.4 Methodical recommendations

It is inevitable that there will be special emergencies during the flight, just like the special incident of Sichuan Airlines Flight 8633. The pilot was unable to control the aircraft normally due to some force majeure factors in the cockpit. At this time, if the ground station knows about the flight problems, and after negotiating with the pilot, if it can complete part of the aircraft operation (such as controlling the steering wheel) on his behalf, it can greatly reduce the aviation accidents caused by the pilot's force majeure.

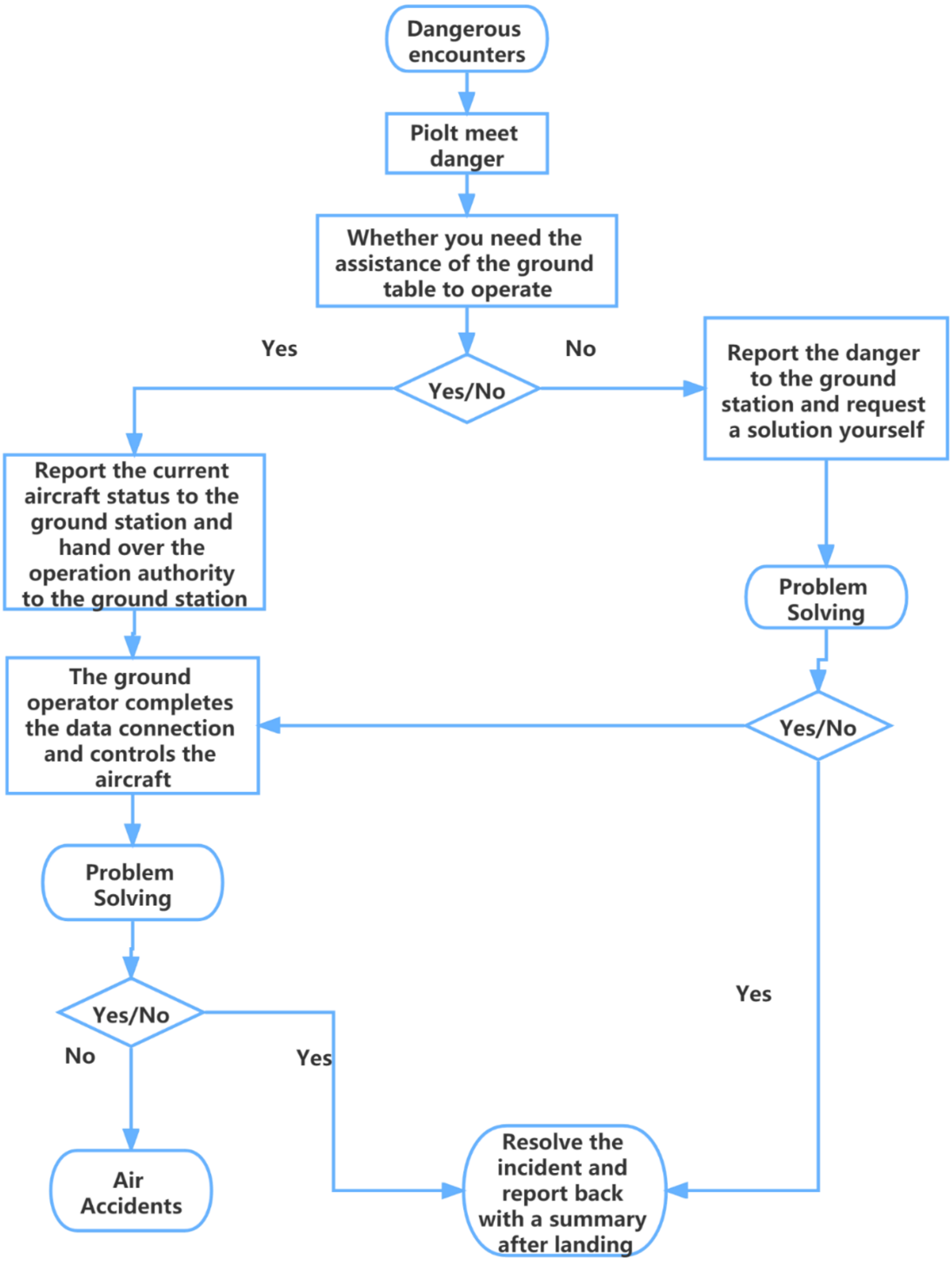


Figure 3.9 Flow chart of interaction between ground console and aircraft in case of distress

To complete such a function, need to increase the stepper motor in the steering wheel, motor selection stepper motor reason is the servo drive precision is not enough, but with brushless servo motors the precision and response are very good but not suitable for placing in the steering wheel such a compact structure. Stepper motor has the advantage of high precision, but the disadvantage is that the torque at high speed is small, in order to solve the problem of torque, usually to the motor equipped with a reducer, so that the output speed while multiplying the output torque. About the use of reducer, use to harmonic reducer: under the action of flexible wheel and wave generator, harmonic reducer has the advantages of zero backlash, high reduction ratio and ultra-small size. For the drive: 1. use a stepper motor plus integrated closed-loop drive. 2. use zero-backlash harmonic reducer. 3. perform high-precision compensation in the subsequent algorithm practice. After the drive module is completed, the communication system and the calculation module are added.

At the same time, the configuration (Attitude and heading reference system) AHRS system force sensing and force feedback device is equipped with Huawei Ascend's Atlas chip to calculate the real-time information of the steering wheel position.

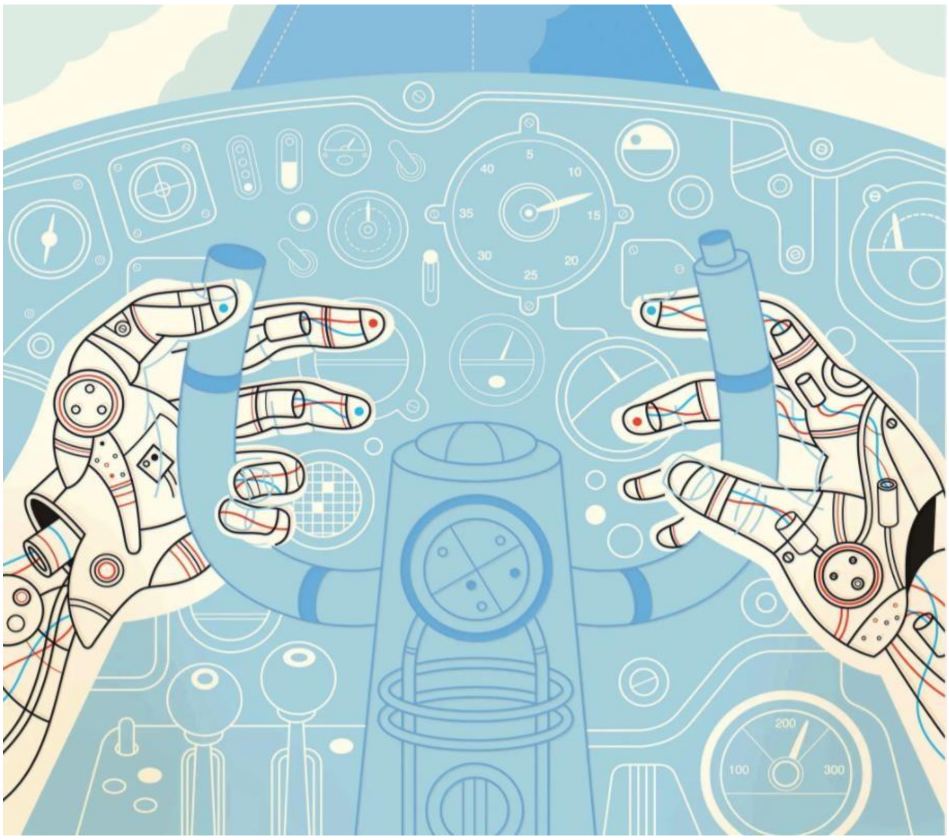


Figure 3.10 Control of the aircraft on the ground

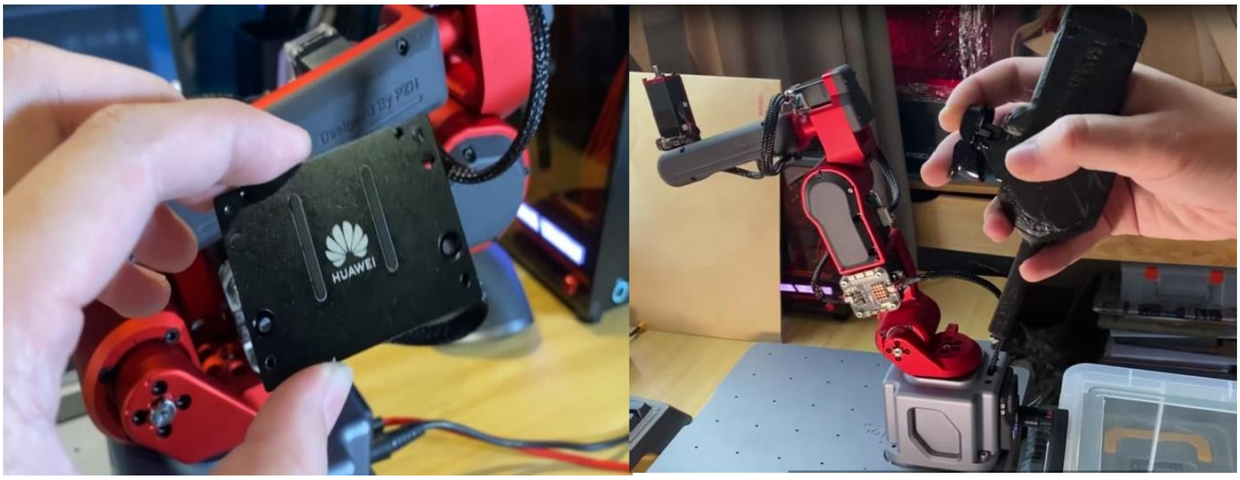


Figure 3.11 Huawei Ascend's Atlas chip and Robotic arm that simulates a steering wheel

Through wireless transmission to the ground control steering wheel, and then the ground control steering wheel can be added to the force feedback motor, so that not only can synchronize the movement to the aircraft steering wheel in real time, but also can feel the aircraft end of the force feedback in real time

Analysis of 11 flights on a B-737-500 aircraft shows that: The pilot's psychology is significantly related to the change of the roll angle when the plane is landing. The maximum amplitude of the autocorrelation function spectrum of the mental with roll angle significantly different. It can be described by the formulas of the normalized autocorrelation function K(t).

$$K(t) = \frac{1}{\sigma \cdot N} \cdot \sum_{i=0}^{N-t-1} [(\gamma_t - m) \cdot (\gamma_{t+i} - m)] \quad (3.1)$$

where N is the number of observations in the time series t, γi is the amplitude of the roll angle, i = 1, 2, 3, N, m – mathematical expectation, σ – standard deviation.
Analysis of the autocorrelation function and its roll angle spectrum

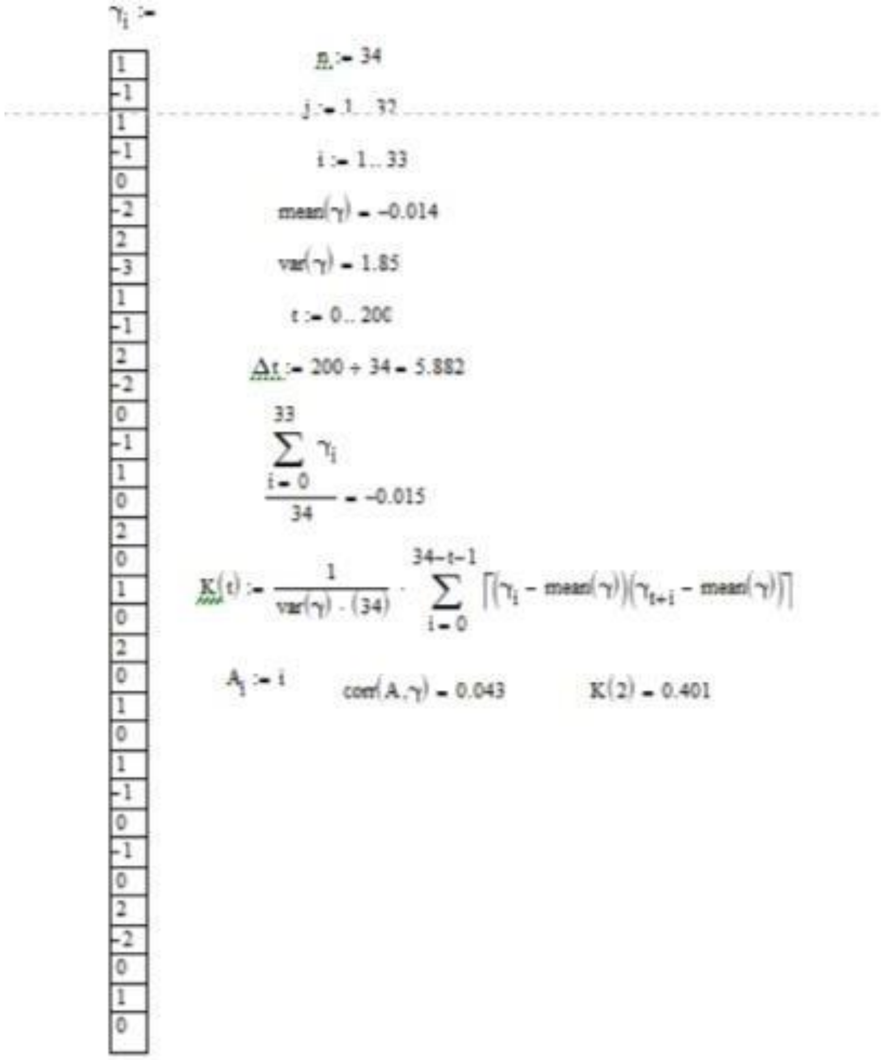


Figure3.12 Experimental data and mathematical modeling

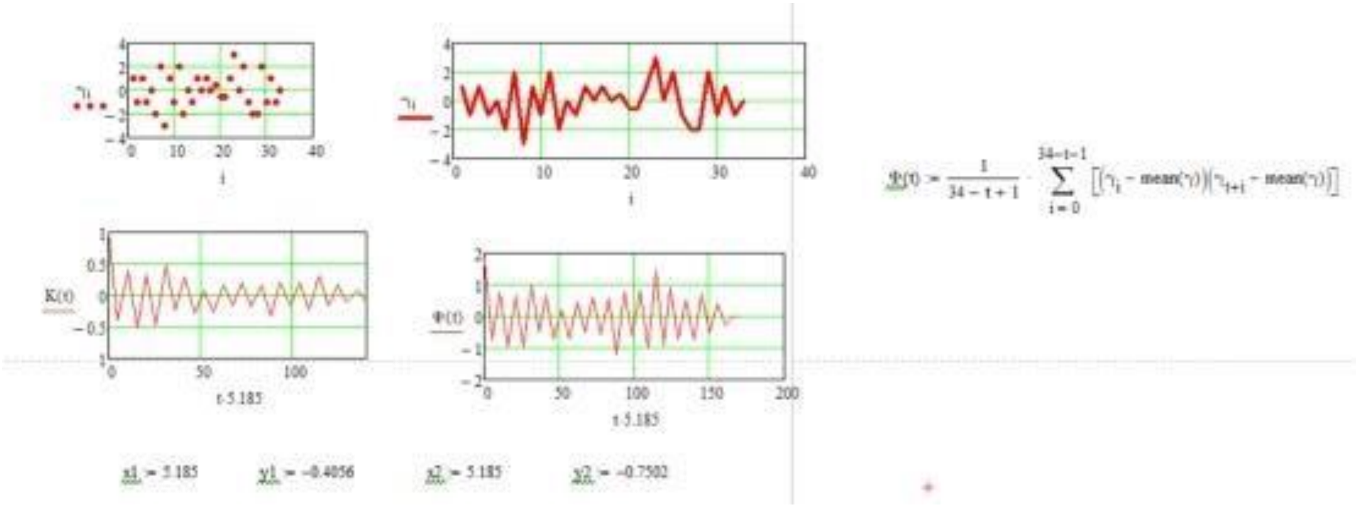


Figure3.12 Experimental data and mathematical modeling

Analysis of the autocorrelation function and its roll angle spectrum

Large roll angles, which are associated with the psychophysiological state of the pilot, affected the flight quality in the air.

Let us analyze the flight quality in the air plane in roll in the real flight of the Boeing-737 aircraft from before landing.

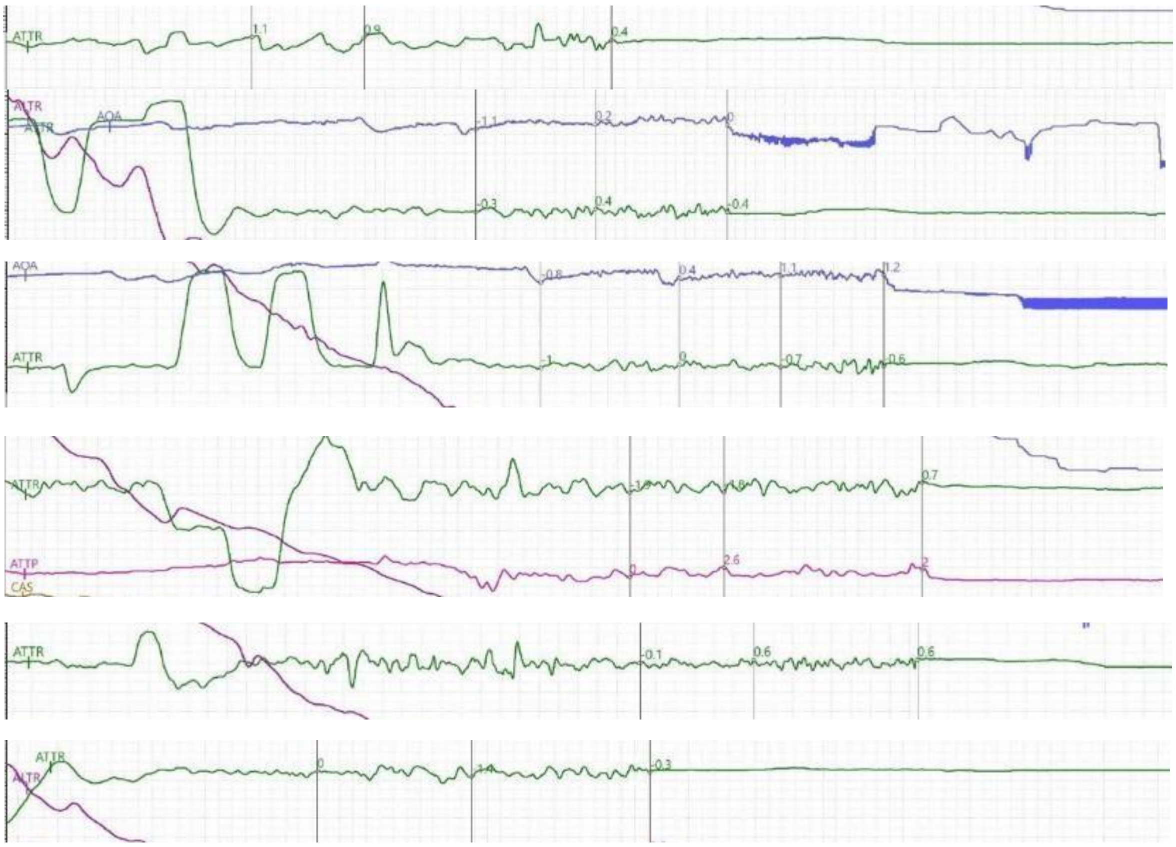


Figure 3.13 Mental state of the pilot

The range of values of normalized autocorrelation functions during landing at the airport A presented in the Table.

Table 3.2 Flight quality of pilots

No.	Pilot	Flight during the Base Leg	Pilot	Flight after the Base Leg before landing
1	3	0.17819	2	0.091785
2	3	0.21424	3	0.12093
3	3	0.23082	2	0.24683
4	3	0.23975	1	0.30708
5	3	0.27361	4	0.30907
6	1	0.31251	3	0.33677
7	4	0.33913	3	0.37931
8	1	0.40327	2	0.46557
9	2	0.41642	3	0.60857
10	2	0.46975	3	0.63843
11	2	0.76226	1	0.66751

The above image shows the psychological changes of the pilot during the landing due to the change of roll angle, using the normalized autocorrelation function K(t), and from the above image and Table 1 we can find that the change of roll angle during the landing will affect the pilot's psychological state, but these states of the changes are within the range and the psychological stability is quickly restored.

In conjunction with the previous "ground console-pilot interaction flowchart" in case of danger, this schematic. detects psychological changes in the operator when the Roll angle changes and allows the ground console to communicate with the pilot if the value exceeds the operator's psychological stress parameters. and assist the pilot in maneuvering the aircraft for a better landing.

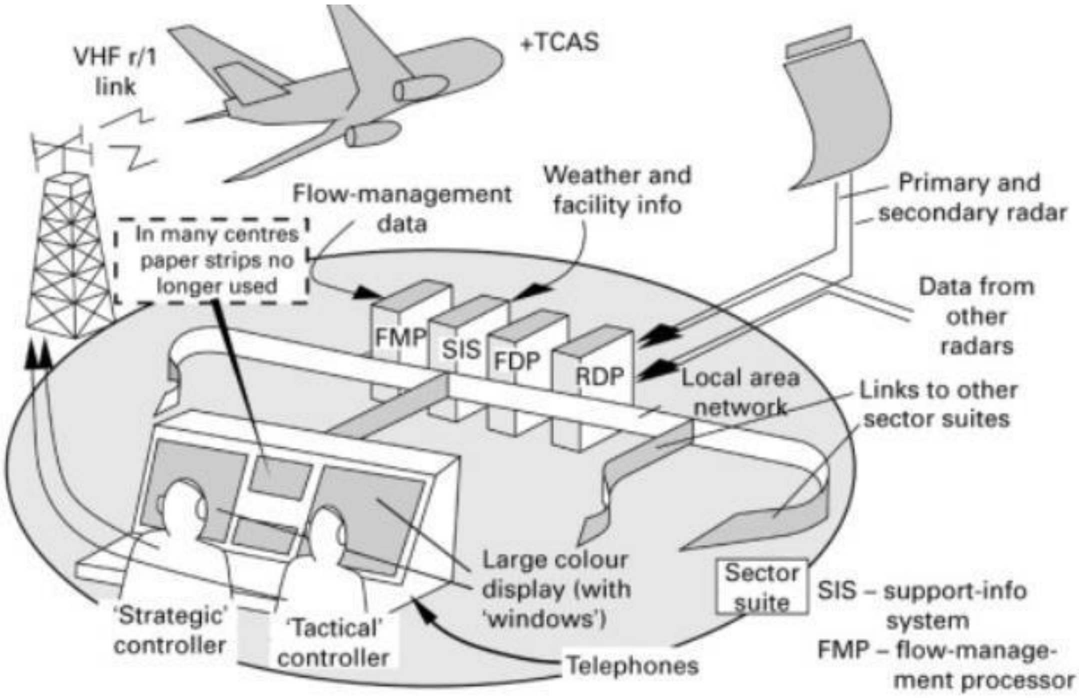


Figure3.13 Ground console and cabin pilot interaction process

CHAPTER 4

LABOUR PROTECTION

4.1 Introduction

Occupational safety refers to a set of legal, socioeconomic, organizational-technical, sanitary-hygienic, treatment-and-prevention measures and methods aimed at preserving human life, health, and ability to work during the course of work.

Employer - the owner of a business, institution, organization, or authorized body, regardless of ownership, type of operation, management, or whether or not hired labor is used.

Employee - a person who works for a company, organization, or institution and performs activities or functions as specified in the employment contract.

4.2. Analysis of working conditions

4.2.1. Workplace organization

The existence and severity of harmful variables in the production environment, as well as the severity and intensity of the labor process, form the basis of sanitary classification.

The principle of working conditions and nature differentiation determines the degree of divergence of production parameters, environment, and labor process from current hygienic norms, as well as the impact on employees' functional status and health. On these indicators, three types of working conditions and nature are distinguished.

I class - Optimal working conditions and nature of work in which hazardous and damaging production elements are avoided, and preconditions are established to maintain a high level of performance (lack of either compliance with levels considered safe for the population).

II - Permissible conditions and nature of work in which the level of dangerous and harmful production factors does not exceed established hygienic standards in the workplace, and possible functional changes caused by the labor process are restored during a regulated rest during the working day or at home until the start of the next shift, and do not have an adverse effect on the health of workers and their offspring in the near and long term.

III class - Harmful and dangerous working conditions and nature, where the impact of hazardous and harmful factors of the production environment values exceeding hygienic standards, and psychophysiological factors of labor activity, causing functional changes in the body that can lead to persistent disability and/or impairment of health working, is possible due to violations of sanitary norms and rules.

4.2.2. List of harmful and dangerous production factors.

Physical and psychological aspects that impact pilots are among the harmful factors in the flight environment. External weather conditions, noise generated during flight, and equipment damage are all physical issues. The pilot's stress in the face of an emergency is one psychological aspect.

4.2.3. Analysis of harmful and dangerous production factors in aviation

In the flight environment, the key factors that should be considered are: the impact of noise and vibration on the pilot, the impact of light on the pilot, and the impact of circuit damage on the pilot’s operating environment

Electrical safety.

Electrical safety in aviation includes various electronic instruments. The main consideration in aviation is the working stability of electronic instruments, because the stable working of various instruments is crucial to the pilot's judgment of the current flight conditions. The instruments mainly include: Flight Management Systems， Insight， Display System， Integrated Displays， Enhanced Flight Vision System， Situational Awareness，Communications.

The noise, ultrasound, infrasound：

Noise ultrasound and infrasound are most noticeable in the flying environment during the aircraft's take-off and landing, as well as in some extreme weather conditions. The noise and ultrasound and infrasound generated at this time will not only have a negative impact on the pilot's health, but also on his or her judgment during the flight.

The sight：

During the flight, the light in the cockpit environment and the light from the outside have a great influence on the pilot. If the light in the cockpit is too bright, the pilot's spirit will be in a state of high tension and unable to relax for a long time. If the light from the external environment is too strong (such as direct sunlight at noon), the driver's eyes will be damaged.

4.3. Development of labor protection measures

This section covers employee health measures as well as safe and healthy working conditions.

Measures are aimed to address one or two of the most damaging and risky production issues discovered during the workplace study.

4.3.1 Electrical safety

Develop a set of electrical equipment to deal with the problems of the circuit environment. Add a protection circuit to each circuit containing components with a high risk factor, and disconnect the circuit in time in the event of a short circuit or component overload 。Provide mechanisms to avoid electrification of substances and the accumulationof static electricity, as well as instruments to monitor static electricity, if necessary.

4.3.2 Protection against industrial noise and vibration.

Develop an environmental structure plan that filters outside noise and absorbs noise emitted by the environment. Also, workers can be provided with protective equipment, lowering the influence of noise and vibration on their health in two ways.

4.3.3 Reduce the impact of light

Provide the right amount of light for the pilot's operational conditions. Too much light will induce confusion and a tense operation, while too little light will lead the pilot to become fatigued quickly. To combat the effects of external light, utilize light-transmitting glass that minimizes the intensity of light, and make sure the driver is wearing appropriate light-blocking glasses.

4.4. Fire safety

The figure below is the structural layout of the Boeing 737 aircraft. There are eight emergency escape routes, which are distributed in the nose, tail and fuselage.

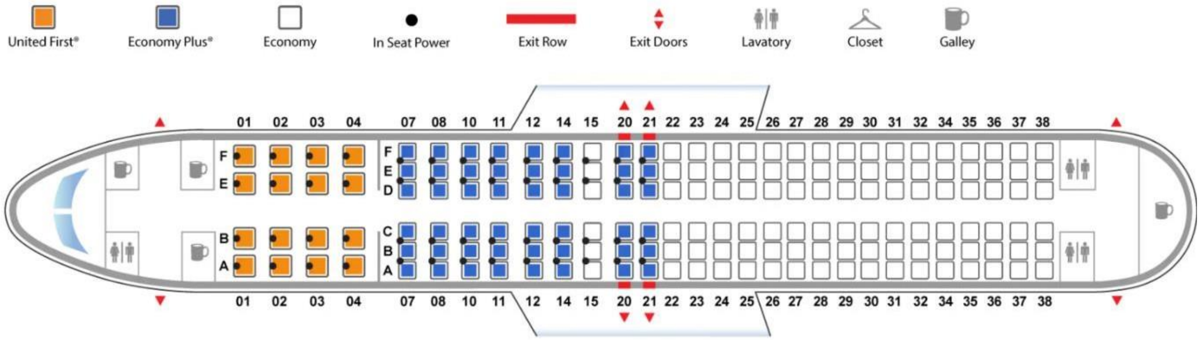


Figure 4.1 Boeing 737 internal escape structure

The emergency exits range from the largest, a "Type A" (a floor level exit door with dimensions of at least 42 inches wide and 72 inches high), to the smallest, a "Type IV" (a floor level exit door with dimensions of at least 42 inches wide and 72 inches high) (an overawing exit with dimensions of at least 19 inches wide and 26 inches high). Exits of "Type III" are depicted in Figure 5–1. (An exit, typically overawing, with dimensions of at least 20 inches wide and 36 inches high).

Figure 4.2 Type III exits

"The means of opening emergency exits must be simple and obvious and may not involve extreme effort," according to federal standards. During first training and every two years thereafter, crewmembers must operate each type of egress on their aircraft. Prior to a real evacuation, passengers are unlikely to have the opportunity to unlock an airplane emergency escape.

4.5. Calculation part（Methods and means of noise protection）

Among the acoustic methods of protection, the most common method is the use of sound insulation in the form of casings, screens, fences, surveillance booths (for remote control). The method of sound insulation is based on the principle of reflection - most of the sound energy falling on the fence is reflected and only a small part of it (about 0.001) penetrates through the fence. The sound insulation efficiency R, dB is characterized by the sound conductivity coefficient τ and is calculated by the formula:

$$R = 10\lg (1/\tau) \quad \#(4.1)$$

where τ = Epron / Epad - the coefficient of sound conductivity of the obstacle, where Epron - the energy of the sound wave that penetrated through the sound barrier structure, W; Epad - the energy of the sound wave falling on the sound barrier structure, W.

Usually, R = 20… 40 dB. The sound insulation capacity of a multilayer structure R, dB is determined by the formula

$$R = 20\lg mf – 47{,}5 \ (4.2)$$

where m is the mass of the structure, kg / m2; a - oscillation frequency, Hz;

The calculation is performed in eight octave bands. The total sound insulation of the partition with a layer of sound-absorbing material (SPM) Rc is determined by the formula:

$$R_c = R + \Delta R \quad \#(4.3)$$

where R is the sound insulation of the partition (selected from table 5.1 depending on the material of the partition);

ΔR - additional sound insulation due to the layer of SPM, dB is determined by the formula:

$$\Delta R = 8{,}7\beta\cdot\delta + 20\lg [(m_n + m_{nc})/m_n] \ \#(4.4)$$

where β is the attenuation coefficient, 1 / m, (determined according to table 4.2);

δ is the thickness of the layer ZPM, m;

$m_п$- surface density of the partition material, kg / m2. (Selected from table 4.1);

$m_{пс}$ - surface density of the SPM layer, kg / m2 is according to the formula:

$$m_{пс} = \rho \cdot \delta \ \#(4.5)$$

where, ρ is the bulk density of SPM, ρ = 20 kg / m³; δ is the thickness of the layer ZPM, m.

Table 4.1 - Sound insulation of walls and partitions, dB

Construction	Thicker, mm,	Superficial density, kg / m2	Geometric mean octave band frequency, Hz							
			63	125	250	500	1000	2000	4000	8000
Brickwork	140 270 410	220 420 620	32 36 41	39 41 44	40 44 48	42 51 55	48 58 61	54 64 65	60 65 62	60 65 65
Reinforced concrete panel	100 160 200 300	250 400 500 750	38 43 40 44	38 43 42 44	38 43 44 50	44 51 51 58	50 60 59 65	58 63 65 69	60 63 65 69	60 63 65 69
Gypsum concrete panel	80	115	32	32	33	39	47	54	60	60
Slag concrete pane	140 250	250 400	39 42	39 42	39 42	46 50	53 59	60 64	60 64	60 64

Table 4.2 - Attenuation coefficients β, 1 / m

Absorbent material	Geometric mean octave band frequency, Hz							
	63	125	250	500	1000	2000	4000	8000
Canvas made of super-thin fiberglass	3	5	6	9	14	24	34	45
Canvas from superfine basalt fiber	3	6	8	11	25	34	37	38

4.6. Conclusion on the section "Labor protection"

This chapter focuses on the preservation of pilots' health in the workplace in aviation. Analyze the physical and emotional health of pilots at work, and improve the working environment's light, noise, electrical appliances, and other elements to assure the pilots' physical well-being. Allow the operator to work in a more pleasant environment and in a better mental condition in order to accomplish the flying work.

CHAPTER 5

Environmental Protection

5.1 China's organizations responsible for environmental safety in aviation

The agency responsible for China's aviation environmental safety is the Civil Aviation Administration of China（CAAC）. The safety indicators of civil aviation information system are divided into six types:

-Indicators of physical environmental safety evaluation

-Indicators for assessing business safety;

-Indicators for assessing data security

-Indicators for assessing communication security

-Indicators for assessing business continuity

-Indicators for evaluating safety management organizations

-Indicators for main business condition assessment

The following are some of the physical environment safety evaluation indicators:

5.1.1 Site selection

According to the principle of avoiding strong electric field, strong magnetic field, areas prone to fire, damp, vulnerable to lightning strike and severe environmental pollution.

5.1.2 Fire prevention facilities in room

Fire resistance grade of building materials, suitable firefighting equipment and relevant fire control measures of the machine room.

5.1.3 Power supply system

Capacity of power supply equipment, line stable voltage and filter device, power protection device, voltage resistance device and performance of distribution line wires.

5.1.4 Electrostatic protection

Access to antistatic wires.

5.1.5 Thunder protection

Performance of power surge protector and laying planning of power supply or signal line.

5.1.6 Landing

Equipotential connection network performance, equal potential connection network media characteristics, grounding resistance characteristics, and other grounding measures.

5.1.7 Temperature and humidity control

Performance of the air conditioning equipment and the corresponding temperature and humidity monitoring measures of the machine room.

5.1.8 Waterproof

Pipe laying planning and measures to prevent rainwater, drainage and water firefighting leakage through the roof and walls.

5.1.9 Inning and mouse

Use of insect repellent and rat agent, and equipment of rat mouse repellent device.

5.1.10 Anti-theft and destruction

Equipment of protective Windows and anti-theft doors and other access control equipment.

5.1.11 Entrance and exit control

Configuration of separate entrances and exits of machine room, configuration of evacuation lighting equipment and strict access management system of machine room.

5.1.12. Record the media safety

Anti-theft and destruction measures of useful data and measures to prevent illegal copy of the destroyed useful data media before destruction should be deleted.

5.2. The ways how to decrease noise pollution for passenger aircrafts

This chapter will discuss the impact of airport noise on people and its degree of impact, and then focus on the main methods to reduce the impact of airport noise, including noise sources, the number and timing of aircraft take-offs and landings, silencing flight procedures, land use planning, sound insulation measures, airport selection Site and layout.

5.2.1 The influence of noise

The bass is often satisfactory, but the treble is intolerable. Jet jets are becoming more common, and the high-pitched section of jet flights is becoming more prevalent. As a result, despite the fact that the high-pitched element of sound decays faster in air and building materials, the noise problem continues to grow.

In general, the public is increasingly concerned about quality of life and wants to reduce disruptions to their daily lives. The general public is becoming more environmentally conscious, and they are becoming more sensitive to aircraft noise. The effects of airport noise on sleep and conversation are objective and do not vary from person to person. However, attitudes toward flying, antipathy toward airports, and fear of aircraft crashes are subjective. These factors all have varying degrees of influence on people's perception of airport noise, so adequate public awareness and education can help mitigate subjective stimuli

The survey shows that the impact of airport noise on individuals is different and very different, but the impact on groups is predictable. Obviously, the greater the intensity of the noise, the more annoying it is. When the noise intensity is lower than 55 DNL (Day Night Sound Level) and 35 NNI (Noise and Number Index), few people find it unbearable; but when the noise intensity increases to 80DNL and 55NNI, more than half of the people can't stand it. What's interesting is that even if the noise intensity is very high, there are still about 1/10 of the people who are almost unaffected; on the other hand, even if the noise intensity is low, there are still a small number of people who feel dissatisfied. The impact of noise on people is not only related to noise intensity, but also directly related to noise duration, time of occurrence and frequency of occurrence.

According to the survey:

- Interferes with family, medical and cultural activities in case the noise intensity is more than 40dBA;

- Interfere with the activities of residential buildings, hotels and schools in case the noise intensity is more than 45dBA;

- Interfere with communications, commercial activities and indoor entertainment in case the noise intensity is higher than 55dBA

Considering that general buildings can reduce the noise of 20dBA, Dorval Airport has divided three noise zones around the airport according to 75dBA, 65dBA and 60dBA to control land use. Currently, Doval Airport uses the noise impact forecast as the noise measurement unit.

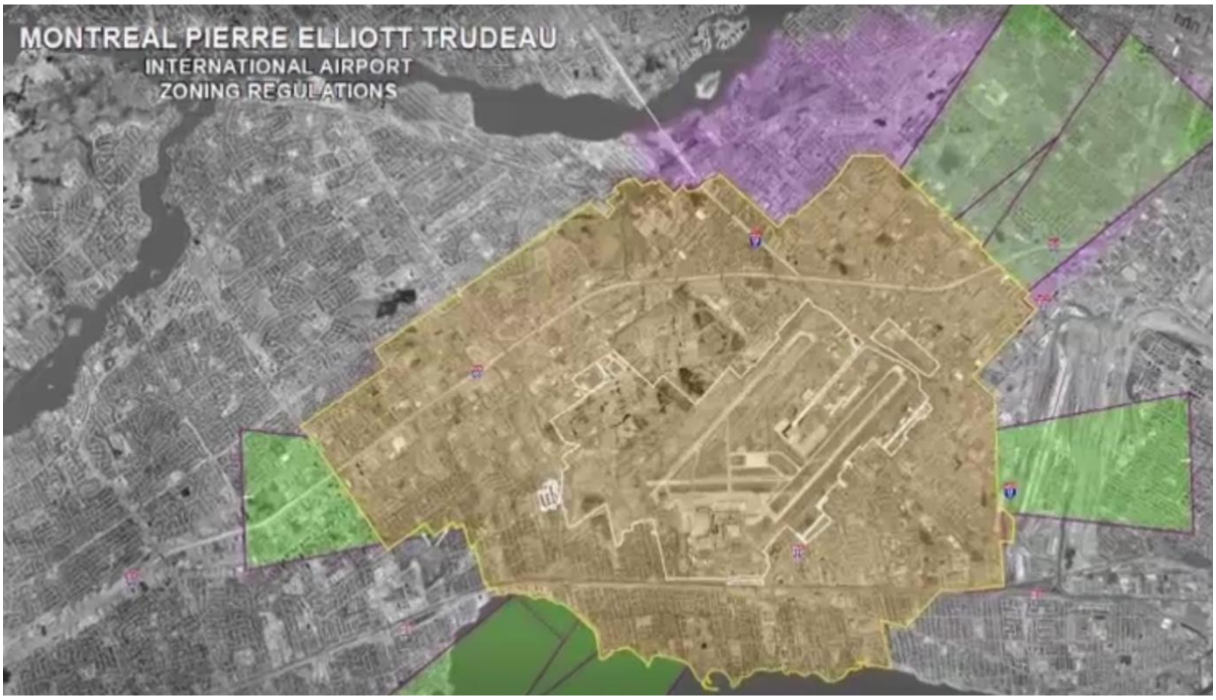


Figure 5.1 Dorval Airport, Montreal, Canada

For decision-making needs, it is necessary to establish the relationship between the proportion of people who feel annoyed and the impact of noise. Some research results show that:

Percentage of people who feel upset = 2 (NNI-25)

Depending on the method unit used, here you can replace 2 (NNI-25) with 2 (CNR (Composite Noise Rating)-85) or 2 (NEF-15). In other words, if the noise is reduced by 10dBA, the number of people who feel upset will drop by about 20%. According to the above formula, the annoying ratio can be determined from the degree of noise influence, and then the known distribution of residents can be used to determine the total number of annoying. Relevant departments can determine takeoff and landing routes, noise reduction procedures, runway selection, etc. based on this, so as to minimize the number of people affected.

Some countries act based on the number of residents' protests and complaints. Although the proportion of disturbed people can be predicted based on the degree of noise impact, social, political, economic and other factors must also be considered to predict the number of protests and complaints. The United States has concluded an empirical formula through surveys, that is, for every thousand households affected by noise:

The number of severely disturbed households = 195.5 + 2.07 × the number of households complaining

Since China and the United States have different national conditions, this formula has only a reference value.

However, the average annoyance curve from the latest study differs from the average stimulus curve using older data by about 5-6 dB(A). Newer studies have shown that people exposed to various noise levels are perceived to be more disturbed than they were decades ago, as shown in the figure. These findings are critical in determining whether existing aircraft noise is relevant and whether improvements are needed.

The development of irritation curves must be taken into account in aircraft noise management programs. This is particularly noteworthy because the results show that aircraft noise is more irritating than noise from other sources for the same noise level. Individual complaints are clearly triggered by a level of discomfort that exceeds the tolerance threshold for a particular nuisance.

It is now widely accepted that the unpleasantness of noise is not only related to noise levels. The non-auditory effects of noise can also be irritating and are more difficult to characterize and quantify. Poor expectations of noise development; perceived control and coping ability; anxiety about the negative health effects of noise and pollution, etc., are among the most powerful non-acoustic elements (closely linked to the end result). Although various social and economic factors have been identified as influencing community responses to noise, there is no consensus on how to combine these nuisance factors into a single explanatory model. Acoustical considerations explain about one-third of the noise irritation variation (considered to be about one-fifth).

Therefore, noise control strategies should be considered as a dynamic process that should be periodically examined and changed as necessary in response to new scientific findings. There is still a need to develop a truly valid model for irritation measurement. This should be comparable to the development of a model to assess the impact of all parameters described in the ICAO Aircraft Noise Control Technical Balance. Nevertheless, the perceived discomfort is determined by the level of noise exposure. Therefore, efficient aircraft noise management and control should reduce the negative impact of aircraft noise on health and quality of life. However, future research should focus on the link between actual sound levels and perceived noise levels. As the focus shifts from noise to irritation, new and additional legislative measures may emerge to minimize the consequences of noise.

Better communication with the communities surrounding the airport helps to promote mutual understanding and leads to a more favorable response to aircraft operations and noise levels.

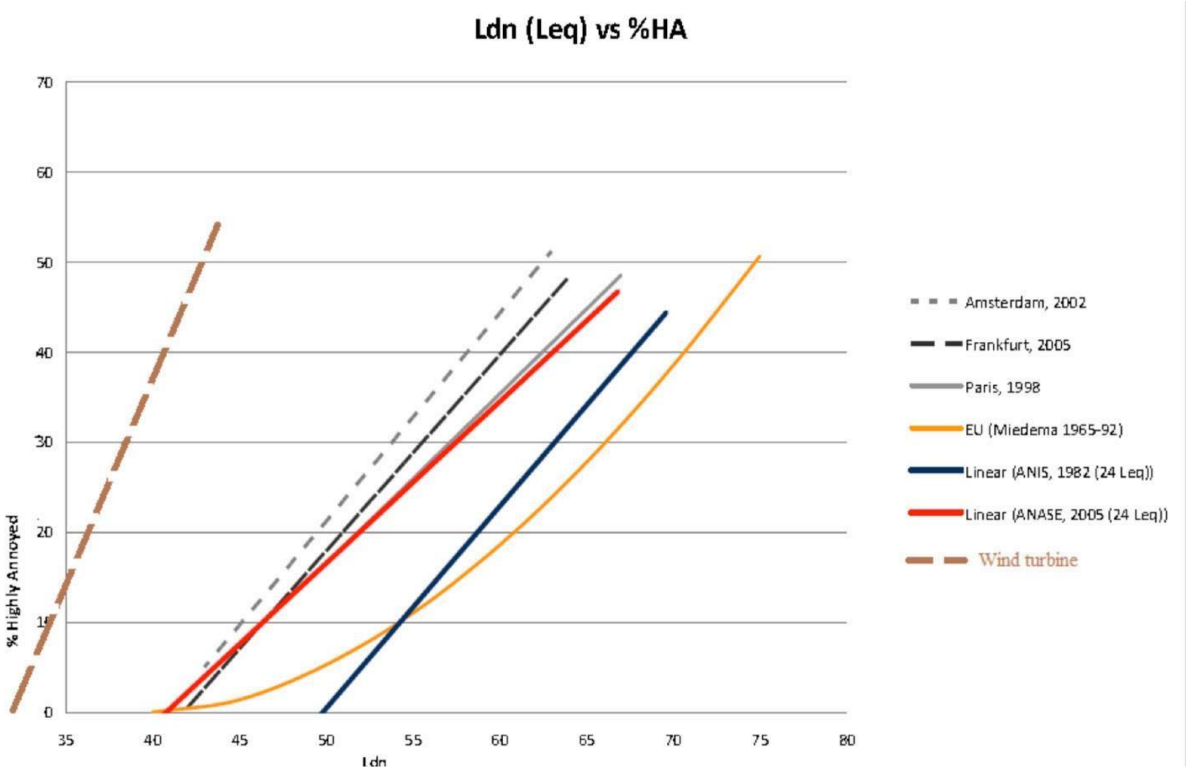


Figure 5.2Trouble curves for comparable survey data collected in 20 different European, North American and Australian studies

5.2. Reduce the impact of noise

Aircraft are an important source of noise and the noise generated by their operation has a significant impact on the airport surroundings. The magnitude of aircraft noise impact depends on the number of takeoffs and landings, as well as the timing, intensity, spectral distribution, duration, distance and propagation path. To mitigate noise impacts, four factors must first be addressed: noise reduction from noise sources, silent flight technology and effective land use planning.(1) Noise source

The most successful approach is to get to the root of the problem. The main sources of noise when an aircraft fuselage is in the air are engine operation noise and air friction noise, and the latter is difficult to eliminate. Thanks to the continuous efforts of the industry, the noise of jet engines has been greatly reduced. Air friction noise from the airframe accounts for a significant amount of aircraft noise in some aircraft equipped with modern engines. As the number of large and bulky aircraft continues to increase, noise levels at airports will rise in tandem with the increase in takeoff weight. With the current technical parameters, simply reducing noise will eventually lead to increased engine weight and reduced performance. Environmental standards, technical feasibility and economic effectiveness are all factors that need to be considered, further reduction of noise is facing certain difficulties.

The ICAO noise rules have not changed much in the last 20 years and there is no prospect of major changes in the near future.

For some old aircraft that are still in use and noisy, noise reduction measures can be taken for their engines. Generally speaking, after silencing, the noise of this type of aircraft is reduced by 10-15 EPNdB(Effective perceived noise in decibels) when landing and 3EPNdB when taking off. The cost of noise cancellation for an aircraft is hundreds of thousands of dollars.

Sometimes the adoption of hard and fast rules will bring certain side effects, but it may be better to adopt some incentive measures. The practice of Manchester Airport in the United Kingdom is worth learning: the aircraft has low noise and preferential take-off and landing fees.

(2) Number and timing of aircraft takeoffs and landings

The greater the impact of noise, the greater the number of aircraft takeoffs and landings. In order to reduce airport noise, Amsterdam Airport stated on November 6, 1997 that the number of aircraft takeoffs and landings would be reduced by 10% starting in 1998. In most cases, however, airport authorities are reluctant to limit the number of aircraft departures and landings to reduce noise pollution. The airport authorities seek to increase the number of aircraft takeoffs and landings as much as possible for their own economic benefit, as airport capacity allows.

While reducing the number of aircraft takeoffs and landings is challenging, the number of aircraft takeoffs and landings can be appropriately adjusted. Since aircraft noise has the greatest impact on people at night, proper regulation of aircraft takeoffs and landings is needed, and it is even conceivable to restrict aircraft from landing and taking off from airports at night.

Many airports around the world (such as Zurich and Sydney) have imposed curfews, although there are significant differences in how they are enforced. Some airports prohibit aircraft from taking off and landing and runways are blocked; other airports allow low-noise propeller aircraft to take off and land. Certain aircraft meeting noise restrictions (including wide-body aircraft) were allowed to be excluded at airports in Amsterdam, London, Frankfurt and Hong Kong. Delayed aircraft can arrive at airports in Hong Kong, London, Tokyo and Paris. The strictest curfew is in effect at Sydney Airport, with no jet activity allowed for seven hours.

Curfews are an effective way to reduce nighttime disruptions, but there are some negative effects, such as overcrowding during peak hours, long aircraft layovers on the ground, loss of airport revenue due to airlift from other airports, long-haul flights, etc. due to time differences. Difficulty in determining departure times (e.g., flights from Europe to China), etc. This is especially true at airports where aircraft landing delays are not tolerated.

(3) Silencing flight procedures

Many international airports in the world implement noise-silenced flight procedures in order to reduce the number of people affected by aircraft noise. In summary, the current silencing flight procedures in use mainly include the following methods.

- Control runway use and alternate takeoff and landing aircraft on each runway to minimize concentrated disturbance in one area. Since modern aircraft are not very sensitive to lateral winds during takeoff and landing, wind selection requirements can be appropriately reduced if runway selection can limit noise disturbance to residents. Los Angeles International Airport has two main runways. Heavy aircraft are usually concentrated on one runway and take off primarily in the west, away from the ocean.

- Turn after takeoff and before landing to avoid densely populated areas;

- Fly using a multi-stage approach and reduce altitude as late as possible;

- Climb quickly to high altitude after takeoff;

- Isolate the airport aircraft maintenance test site;

- No excessively noisy aircraft should take off or land.

Since aircraft noise is usually assumed to have a greater impact during takeoff than during landing, takeoff quiet flight practices have been given more consideration. Currently, the takeoff noise reduction process is used only at Beijing Capital International Airport in China. The takeoff noise reduction method is used as a noise reduction method. The International Civil Aviation Organization (ICAO) established the standard in 1982 to reduce the impact of takeoff second stage noise. ICAO revised the takeoff noise reduction rules in late 1996 and proposed two strategies to reduce noise at the end of the runway and in the direction of runway expansion.

To reduce the effects of noise at the end of the runway, takeoff silence measures include:

-The aircraft leaves the ground and climbs more than 240 meters;

-Reduces throttle, but maintains final takeoff climb gradient with at least one engine inactive;

-Retracts flaps or slats as needed;

-After 900 meters above the airport ground, increases speed to airway climb speed and transitions to normal airway climb procedures. The takeoff silencing procedure used to reduce the influence of noise at a certain distance from the runway direction is similar to the above procedure, except that the order of step 2 and step 3 are exchanged.

The specifics are:

- When the aircraft is off the ground and climbs above 240 meters, start retracting the flaps or slits;

- When one engine fails, reduce the throttle but maintain the final takeoff climb gradient;

- After 900 meters from the airport ground, increase the speed to the airway climb speed and transition to the normal airway climb procedure.

(4) Land use planning

According to ICAO, land use planning and management is an effective way to address airport noise issues and is ultimately the primary tool to be created. In order to minimize the construction of noise sensitive structures in critical noise areas, ICAO encourages Contracting States to plan and manage land use around airports. The creation of noise zones around airports is the basis for land use planning and regulation, as well as the fact that noise zones must be delineated based on the impact of aircraft noise and community response. The International Civil Aviation Organization (ICAO) has issued Circular 205, "Recommended Methodology for Noise Contour Mapping in the Vicinity of Computer Fields," which explains how to predict the effects of aircraft noise and community response.

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"Recommended Methodology for Noise Contour Mapping in the Vicinity of Computer Fields," which explains how to predict the effects of aircraft noise and community response.

Noise zone delineation is used for land use planning and management. First, a noise zone is established around the airport based on existing noise impacts and expected future noise impacts. Second, the maximum amount of noise that can be tolerated is determined based on various land uses. For example, residential, schools and hospitals are most afraid of noise disturbance, so the maximum noise they can tolerate is very low and as far away from the noise source as possible; while heavy industry, which is noisy, is not afraid of aircraft noise, so the maximum noise they can tolerate is very low and as far away from the noise source as possible; the next location may be close to the airport. Finally, the two are compared to see if there is a suitable link between land use and noise areas, which can be used to help plan land use near the airport.

For incompatible land development or existing incompatible land use in high-noise areas, such as building hospitals in high-noise areas, it is necessary to use sound insulation materials and adjust the internal layout of the building to reduce the noise impact to an acceptable level.

The largest difficulty for airport authorities is that as the number of takeoffs and landings of aircraft (particularly large aircraft) has increased, so has the noise area, which has resulted in the emergence of some conflicting land uses. Only the airport authorities can talk with neighbors to fix problems or pay supplements if different noise reduction measures fail to fulfill the standards.

Compensation, relocation, and rehabilitation methods, including airstrip reconstruction, are all options.

What is the right amount of compensation for the homeowner? The amount of compensation is often thought to be equal to the extent of the property depreciation caused by noise. The compensation for properties in the noise zone with a noise effect of greater than 30 NEF at various airports in the United States is around 20% of the property value.

(5) Sound insulation measures

Sound insulation measures usually refer to the sound insulation material and sound insulation structure design of the building itself. Normal buildings can reduce noise by about 20dB, and buildings using special sound insulation materials can reduce even more. The soundproof structure design of the building can be fully utilized, and the rooms most sensitive to noise can be placed in the part that is least affected by noise.

Muffler walls and woods can also effectively reduce the noise impact. Studies have shown that the sound attenuates 25-30dB after passing through 100 meters of woods. But pay attention to the choice of trees when planting trees to avoid attracting bird disasters.

(6) Airport location and layout

When there are residents in the vicinity of the airport, runways are often chosen in the direction that will have the least impact on people during aircraft takeoffs and landings, and occasionally lengthened to allow aircraft to take off at the far end, away from residents. Of course, sound walls or hangars or other airport structures can be used to block the direction of residential areas. To reduce the noise impact on residents, airports are often located on the outskirts of cities, away from densely populated metropolitan areas. In this regard, airport authorities have to take into account the interests of all parties as well as the big picture;

CONCLUSION

Avionics plays a very important role in air transportation, helping pilots to obtain various information about the aircraft, including information about the aircraft itself and the current external environment in which the aircraft is located. The display module inside the cabin of the aircraft can obtain the current status of the aircraft, the current remaining gasoline storage capacity of the fuel tanks, and the current information of each controllable device of the aircraft such as Stabilizer, Elevators, Rudder, Speed Brakes, Trailing Edge Flaps and so on. Generally speaking, the operation of these devices requires human intervention, which creates a lot of uncertainties, such as the operator's ability to operate correctly during hazardous conditions, which is influenced by the operator's psychological stress level.

During the landing process, the external environment becomes more and more influential because the aircraft is operating at high speed and as the altitude decreases. The change in the roll angle of the aircraft has an impact on the operator's psychology, which is closely related to the change in the current roll angle of the aircraft by combining the autocorrelation function with the pilot's psychological parameters. In the above-mentioned experimental parameters, we can find that although the pilot's psychological parameters change, the flight quality is still within the safe range. The paper also proposes an alternative solution in case of emergency: the ground console can assist the pilot in the operation of the aircraft by using the new control system.

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