MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF AIR NAVIGATION, ELECTRONICS AND TELECOMMUNICATIONS
DEPARTMENT OF AVIONICS

APPROVED
Head of department
________Yu.V.Hryshchenko
'___'__________2023

GRADUATION WORK

(EXPLANATORY NOTES)

FOR THE DEGREE OF MASTER

SPECIALITY 173 'AVIONICS'

Theme: "Laws of Aircraft Flight Parameter Under Avionics Failures"

Done by: ___________AV-254Ma, Ivan Gorbachov__________________
(student, group, surname, name, patronymic)

Supervisor: ______PhD, As. Prof., Yu.V.Hryshchenko__________________
(scientific degree, academic rank, surname, name, patronymic)

Consultant on 'Labor protection': ___________ ____________
(signature)(surname, name, patronymic)

Consultant on 'Environmental protection': ___________ ____________
(signature) (surname, name, patronymic)

Standard controller: ___________ V.V. Levkivskyi
(signature) (surname, name, patronymic)

Kyiv 2023

NATIONAL AVIATION UNIVERSITY

Faculty of Air Navigation, Electronics and Telecommunications
Department of avionics
Specialty 173 ‘Avionics’

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_________ Yu.V.Hryshchenko
‘___’___________2022

TASK
for executiongraduation work

Ivan Gorbachov

1. Theme: “Laws of Aircraft Flight Parameter Under Avionics Failures” ,approved by order 1413/ст of the Rector of the National Aviation University of 13 September 2022.

2. Duration of which is from 05 September 2022 to 30 November 2022.

3. Input data of graduation work: Laws of aircraft flight parameter under avionics failures is an incredibly important aspect of flight safety. Improvements in this area will lead to a reduction in the number of accidents and will make it possible to better prepare the crew for emergency situations.

4. Content of explanatory notes: List of conditional terms and abbreviations, Introduction, Chapter 1, Chapter 2, Chapter 3, Chapter 4, 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	05.09.2022	
2.	Carry out a literature review	06.09.2022 – 20.09.2022	
3.	Develop the first chapter of diploma	21.09.2022 – 05.10.2022	
4.	Develop the second chapter of diploma	06.10.2022 – 20.10.2022	
5.	Develop the third chapter of diploma	21.10.2022 – 03.11.2022	
6.	Develop the fifth and fourth chapter of diploma	03.11.2022 – 10.11.2022	
7.	Tested for anti-plagiarism and obtaining a review of the diploma	15.11.2022	

7. Consultants individual chapters

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

8. Date of assignment: ‘___ ‘ ____________ 2023

Supervisor ______________ Yu.V.Hryshchenko

The task took to perform ______________ Ivan Gorbachov

(signature) (surname, name, patronymic)

ABSTRACT

Explanatory notes to graduation work ‘Laws of Aircraft Flight Parameter Under Avionics Failures’ contained 69 pages, 14 figures, 2 graph, 22 references.

Keywords:AIRCRAFT, MAINTENANCE, HUMAN FACTOR, ERROR, VIOLATION, MAINTENANCE ERROR DECISION AID.

Theobject of the research - process of functioning of the aircraft maintenance technician.

(OBJECT IS ALWAYS PROCESS OF!!!)

The subject of the research - Violations and their eliminations during aircraft maintenance’.

Purpose of graduation work – investigation the problem of human factors and violations in aircraft maintenance.

Research Method –Starting from big data, make an assessment by observing the distribution of flight attitudes.

Scientific novelty –Starting from the pilot, improve the quality of the pilot to ensure flight safety.

INTRODUCTION

Actuality. Deciding the totality of incorrect activities of flying masters is an fundamental and recognizably vital prepare within the usage of the standards of a tall degree of flight security. Guaranteeing the localization of wrong activities of flying masters can be done utilizing numerous devices and strategies. Among them - the strategy of preparing administrators to neutralize calculate stack in anti-stress preparing in arrange to progress their psychophysical qualities. Deciding the psycho-physiological qualities of a individual amid the determination and preparing of flying pros is one of the ways to make strides security, unwavering quality and productivity, as well as alter for the superior the number of flying mishaps. The method of psychophysiological determination in respectful flying is the recognizable proof of a set of forms pointed at evaluating the degree of improvement of professionally critical capacities and productivity of work within the cabin. The nature of psychophysiological determination emerges from foreseeing the adequacy of preparing and proficient working of administrators on the premise of their individual psychophysiological characteristics.

The topic "Laws of Aircraft Flight Parameter Under Avionics Failures" is quite relevant, it is reflected in the growing need for safety and efficiency of air transport. Here are some key arguments that emphasize the relevance of this topic:

Flight safety: Distribution of flight parameters is critical to ensure safety in the event of avionics system failure. Understanding the laws of distribution allows you to develop strategies to regain control of the aircraft and reduce the risk of emergency situations.

Flight efficiency: The study of the distribution laws of flight parameters allows to optimize flight efficiency. This means that aircraft can maintain optimal speeds, altitudes and other flight parameters even during avionics system failures.

Development of aviation technology: The laws of distribution of flight parameters become even more relevant in connection with the growth of aviation technology. New avionics systems such as autopilots, coherent control systems and automatic regulation require a deep understanding of distribution laws to ensure safety and efficiency.

Increasing reliability: The study of the distribution laws of flight parameters can contribute to increasing the reliability of avionics systems. This allows you to identify potential problems and develop strategies to respond to failures in order to ensure the uninterrupted operation of systems.

Ensuring passenger comfort: Understanding the laws of distribution of flight parameters helps to reduce the impact of avionics system failures on passenger comfort. Developing optimal failure management strategies can reduce vibrations, oscillations, and other inconveniences that may occur during flight.

All these factors confirm the relevance of the topic "Laws of distribution of aircraft flight parameters in case of failures in the avionics system" in the context of safety, efficiency and development of the aviation industry. This is an important area of research that contributes to the further improvement of aviation systems and ensuring the safety of passengers.

Chapter 1. Avionics systems and their influence on flight parameters. Failures in avionics systems.

1.1Flight parameters in avionic systems

Flight parameters in avionic systems refer to the various measurements and data that are monitored, recorded, and used for controlling and managing the flight of an aircraft. These parameters provide critical information about the aircraft's performance, position, attitude, speed, altitude, and other relevant variables.

Avionic systems, which encompass a wide range of electronic systems on an aircraft, collect and process data from various sensors and instruments to determine and monitor these flight parameters. Some of the key flight parameters include:

1) Attitude: This refers to the orientation of the aircraft in relation to the horizon. Attitude parameters include pitch (fore and aft movement), roll (side-to-side movement), and yaw (rotation around the vertical axis).
2) Altitude: It indicates the vertical distance of the aircraft from a reference point, typically measured in feet or meters above sea level.
3) Airspeed: This parameter represents the speed of the aircraft through the air, typically measured in knots or miles per hour (mph).
4) Vertical Speed: It denotes the rate at which the aircraft is climbing or descending, measured in feet per minute (fpm) or meters per second (m/s).
5) Heading: This refers to the direction in which the aircraft is pointing, usually expressed in degrees from north.
6) Mach Number: It represents the ratio of the aircraft's speed to the speed of sound in the surrounding medium. Mach number is used to indicate supersonic flight.
7) Acceleration: It measures the rate of change of the aircraft's speed or direction, typically expressed in G-forces.
8) Navigation Data: This includes information about the aircraft's position, course, distance to the destination, waypoints, and other navigational details.

9) Engine Parameters: Avionic systems collect and display various parameters related to engine performance, including engine speed (RPM), exhaust gas temperature (EGT), turbine inlet temperature (TIT), oil pressure, and fuel pressure. These parameters help monitor engine health, optimize performance, and detect any abnormalities or malfunctions.
10) Environmental Parameters: Avionic systems may also provide information about environmental conditions that can affect flight, such as outside air temperature (OAT), wind speed and direction, humidity, and atmospheric pressure. These parameters contribute to flight planning, performance calculations, and situational awareness.

These flight parameters are continuously monitored by avionic systems, such as the flight management system (FMS), inertial navigation system (INS), air data computer (ADC), and attitude and heading reference system (AHRS). The data gathered from these systems is displayed to the flight crew on primary flight displays (PFDs) and multifunction displays (MFDs) in the cockpit, allowing them to maintain situational awareness and make informed decisions during flight.

Flight parameters in avionic systems play a crucial role in ensuring the safety, efficiency, and control of an aircraft. They enable pilots and flight systems to monitor the aircraft's performance, navigate accurately, and respond to changing flight conditions. By understanding and managing these parameters effectively, pilots can maintain stable flight, optimize fuel efficiency, and ensure a smooth and safe journey for passengers.

There are various recording chains for collecting flight parameters.

The FDIU (Flight Data Interface Unit) is in charge of picking parameters on the A/C ARINC network.The FDIU provides the same Data to the DFDR and to a QAR LRU. This is the minimum equipment in order to be able to have an FDA program.

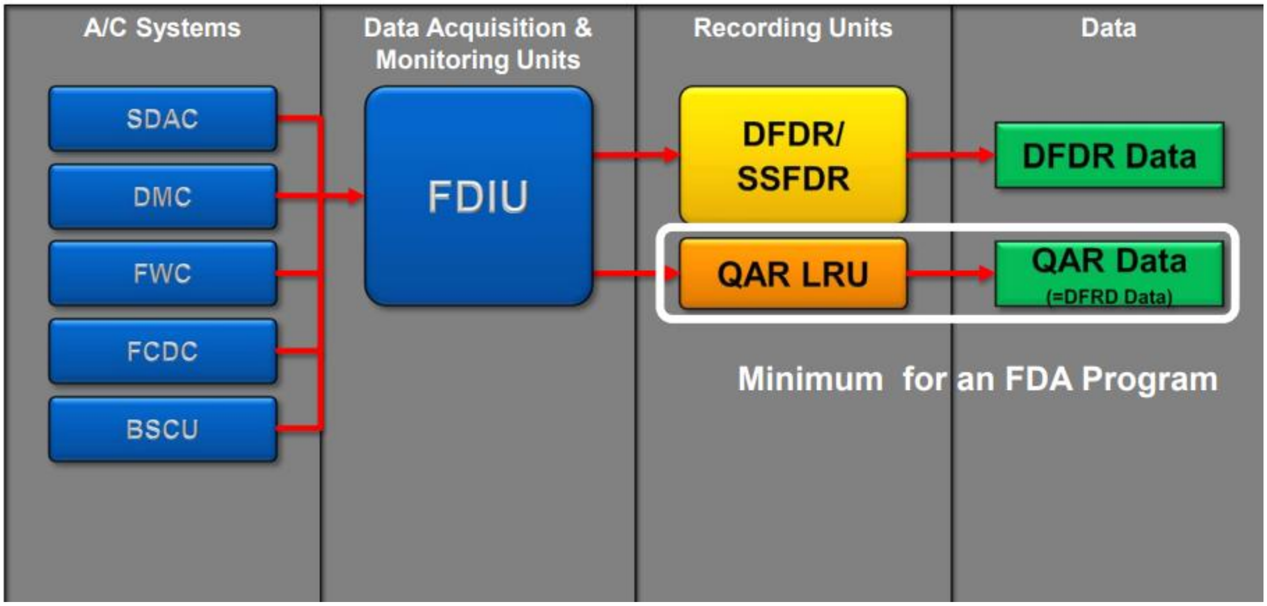


Fig. 1.1.1 Data recording chain

A Digital ACMS Recorder (DAR) records onboard flight parameters, contributing to preventative maintenance and analysis of system incident causes. See the separate article on Aircraft Condition Monitoring System (ACMS).

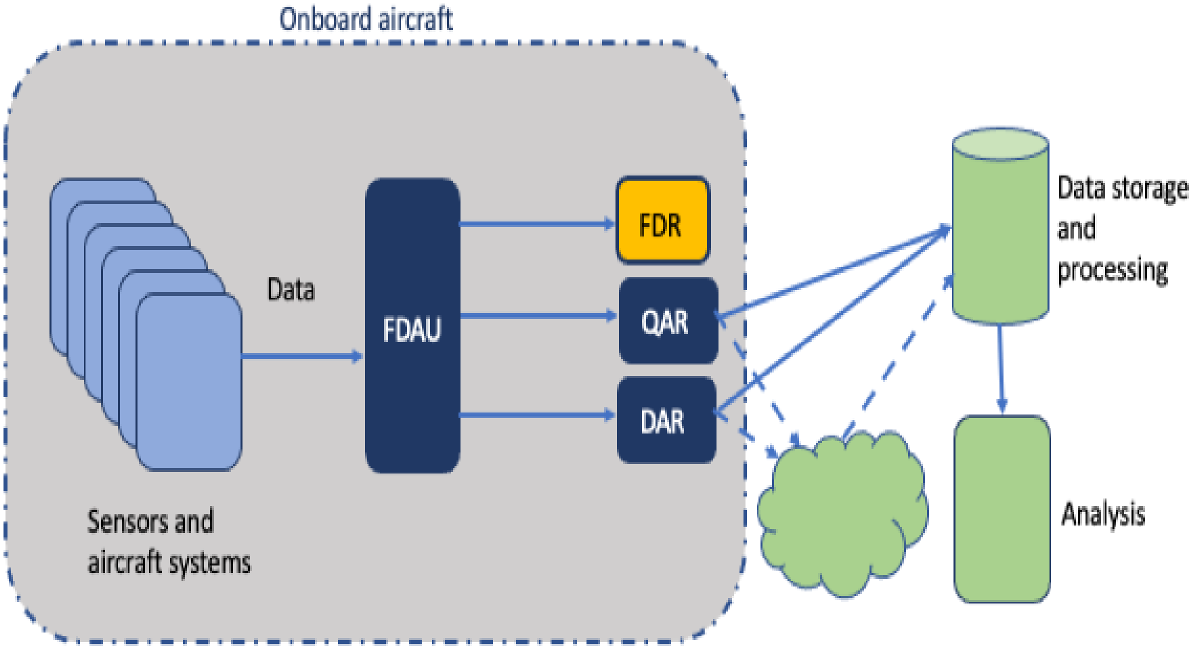


Fig.1.1.2 Flight Data system components

DAR Data stands for Digital ACMS Recorder Data. DAR Data and QAR Data are used for FDA program.

A DMU can be programmed by the operator in order to record any convenient parameters (e.g.: FDA, Maintenance or Fuel Monitoring, …) provided they are available on the ARINC network.

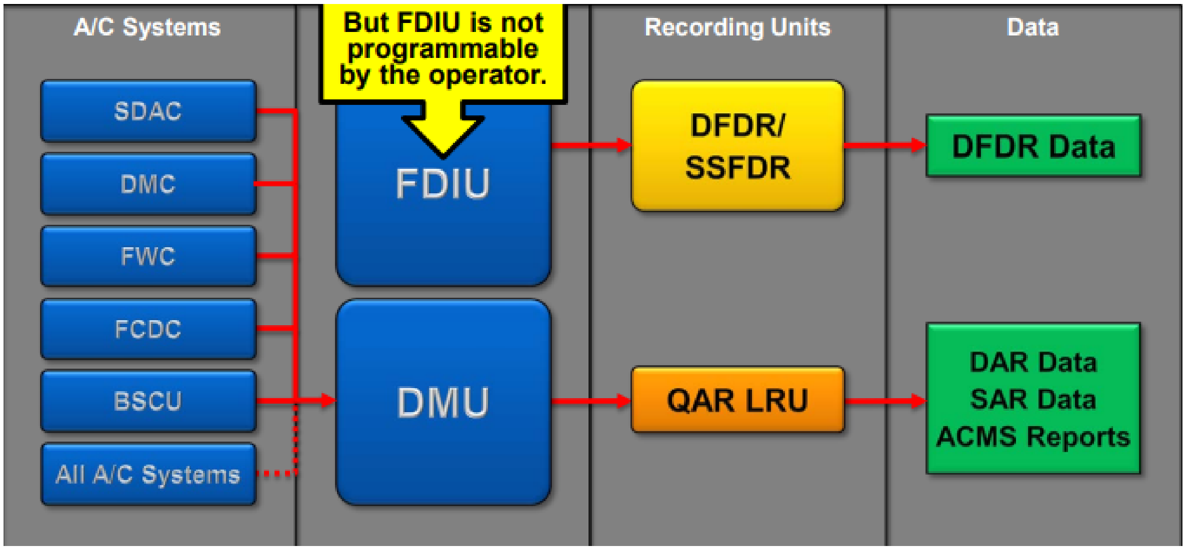


Fig.1.1.3

FDIU and DMU are often combined into a single equipment: FDIMU

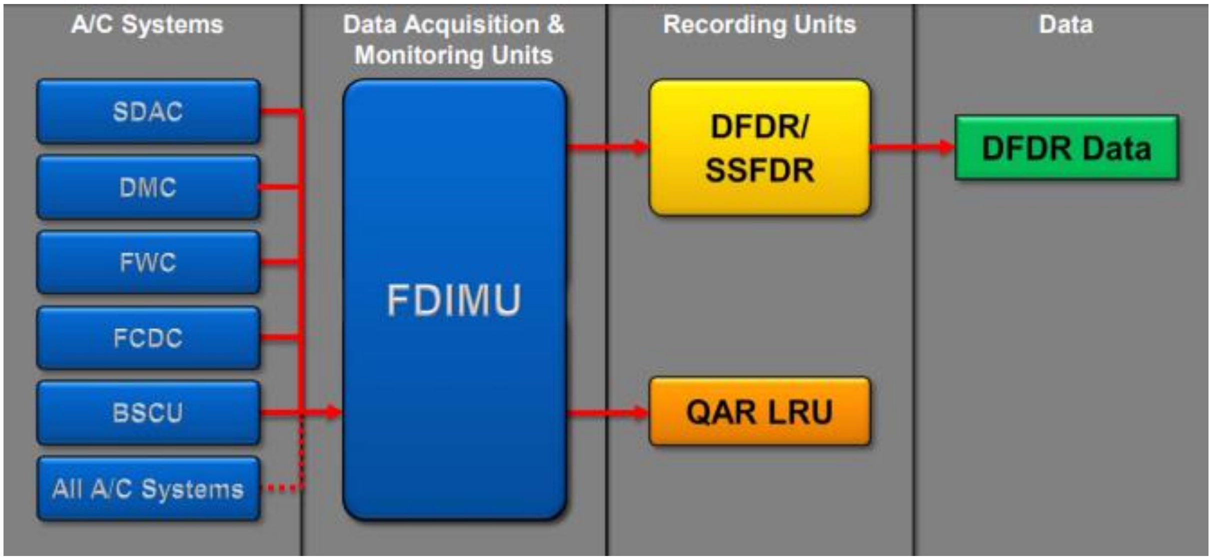


Fig.1.1.4 Data recording chain with FDIMU

FDIU and DMU are often combined into a single equipment: FDIMU In that case both QAR and DAR data can be recorded on the same media.

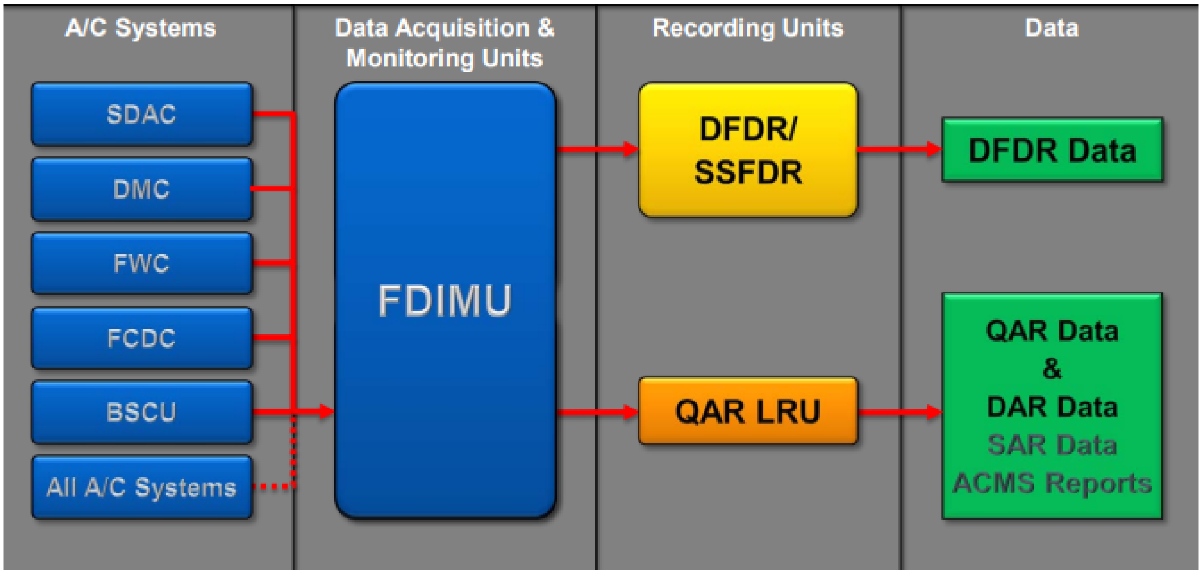


Fig.1.1.5Data recording chain with FDIMU and both QAR and DAR

1.2Failures in avionics systems and their consequences

Avionics systems include a complex of electronic devices that control aircraft functions. These systems provide flight safety, navigation, communication, system control, and automated functions. However, despite the high reliability of modern avionics systems, they can fail.

An avionics system failure means that it has stopped working or is not functioning properly. Failures can be caused by a variety of factors, including technical problems, electromagnetic interference, software errors, hardware damage, or improper operation.

The consequences of failures in avionics systems can be serious and affect flight safety. Here are some possible consequences:

1. Loss of navigation information: Failure of the navigation system can lead to loss of information about position, speed, altitude and other flight parameters. This can make piloting difficult and lead to incorrect control of the aircraft.
2. Loss of control of the aircraft: A failure of the control system may result in the loss or limitation of the ability to control the aircraft. This can be caused by a breakdown in the mechanical or electronic components responsible for controlling the steering surfaces or motors.

3. Loss of Communications: Failure of the communications system may result in loss of contact with control points, aircraft or ground services. This can make it difficult to coordinate flights, get help in an emergency, or transmit important information.
4. Reduction of Safety Systems: Failure of safety systems, such as fire safety systems, anti-flood protection systems, or collision avoidance systems (TCAS), can increase the risk of a hazard or make it more difficult to avoid.
5. Loss of System Lives My apologies, but my previous response was completed incorrectly. Here is the continuation of the information:
6. Power System Loss: A power system failure can cause electronic devices to shut down or limit power. This could result in the disabling of critical control, navigation or communications systems, which could seriously compromise the flight and safety of the aircraft.
7. Failure of the automatic control system: Failure of the automatic control system may result in the loss of automated functions such as autopilot or stability control systems. This can force the pilot to be more active in controlling the aircraft and increase the load on him.
8. Fault detection system failure: Failure of the fault detection system can lead to incorrect diagnosis and detection of problems in other systems. This can hide the problem or cause the pilot to take incorrect actions to solve it.
9. Decreasing system reliability: Repeated failures in avionics systems can lead to a general decrease in aircraft reliability. This can create serious problems for flight safety and require careful analysis and correction of the causes of failures.

It is important to note that aviation manufacturers, operators and flight safety organizations place great emphasis on the reliability of avionics systems and the development of procedures to resolve failures. Regular inspections, maintenance, testing and pilot training are aimed at ensuring flight safety and reducing risks associated with avionics system failures.

Failures in avionics systems can have various causes, including hardware failures, software errors, overvoltages, electromagnetic effects, environmental effects, and human factors.

Hardware failures can occur due to malfunctions of power supplies, processors, memory, sensors, actuators, and other components. For example, overheating, short circuits, loss of connection between boards, fatigue of materials or mechanical damage can lead to system failure.

Software errors in avionics systems can occur due to software defects, misconfiguration, or improper interaction with other systems. Insufficient error checking, incorrect algorithms, or incorrect input data can cause the system to crash.

Surge in avionics systems can occur due to excessive stress or unexpected changes in production conditions. For example, sudden changes in temperature, humidity, atmospheric pressure or electromagnetic field can cause system failures.

Electromagnetic influences can occur from radio frequency radiation, electrostatic discharge, lightning, or other sources of electromagnetic signals. This can cause interference or distortion of signals, disrupt system operation, and cause failure.

Environmental conditions such as strong turbulent flows, dust, hail, heavy precipitation or chemicals can also cause avionics systems to fail. These factors can cause physical damage to the equipment or contamination resulting in malfunctions.

Human factors can also affect failures in avionics systems. Inadequate qualification or ignorance of operating procedures, errors by pilots or maintenance personnel, improper maintenance or failure to follow protocols can cause avionics systems to fail.

The consequences of failures in avionics systems can be critical to flight safety. These may include loss of communications, navigational errors, loss of control of the aircraft, reduced effectiveness of safety systems, loss of data or inaccurate information, as well as threats to the safety of passengers and crew.

Various strategies are used to prevent failures in avionics systems. One of them is the development of reliable hardware and software that has passed the appropriate inspections and testing. System components must have high quality and reliability, and algorithms must be developed taking into account possible errors and failures. Redundancy and duplication of systems are also used. This means that a system can have several independent components that can be started and run in parallel. If one component fails, the other can continue to work without interruption. This ensures higher system availability and reliability.

Monitoring and diagnostic systems are used to identify and diagnose failures. These may include sensors that measure various parameters of the system, analytical algorithms that analyze this data and detect anomalies, and alert systems that inform the crew or technical personnel of failures or potential problems.

In the event of an avionics system failure, it is important to have recovery procedures and backup plans in place. Crew and maintenance personnel must be trained in how to properly respond to failures, perform necessary recovery procedures, and ensure flight safety.

In general, the safety of avionics systems is a complex and multifaceted process that includes the development of reliable equipment, rigorous testing and inspection procedures, the implementation of monitoring and diagnostic systems, as well as the training of crew and technical personnel. Only a combination of all these factors can ensure reliable and safe operation of avionics systems.

Modern avionics systems use advanced technologies such as embedded systems, microprocessors, high-performance computing devices, high-reliability software, and extensive security capabilities.

One of the innovative technologies is the use of artificial intelligence (AI) systems in avionics. AI can perform analysis of large volumes of data, predict failures and detect anomalies in the operation of systems. It can automatically adapt system parameters, optimize performance and provide more efficient resource management.

An additional initiative in avionics is the use of unmanned aerial vehicles (UAVs). UAVs can be equipped with various avionics systems, such as autopilots, navigation and satellite communication systems. They are able to perform missions without the participation of a pilot, which allows to reduce the risk to people and perform tasks in conditions that require high precision and safety.

Another important component of modern avionics is flight quality management systems (FMS). They include stabilization systems, automatic course maintenance, autopilots and air control systems. These systems ensure flight accuracy and stability, improve maneuverability and ensure flight safety.

Modern aircraft also use global positioning systems (GPS) and satellite-based navigation systems. They provide accurate information about the location, speed and direction of flight. This allows pilots to accurately determine their position, plan routes and ensure safe navigation.

One of the key technologies in avionics is communication systems, such as radio and satellite communications. They provide communication between the aircraft and ground controllers, as well as data transmission and interaction with other aircraft. These systems ensure safe and effective communication at various stages of the flight.

In the field of avionics, significant changes are also taking place in the field of cable systems. Using fiber optic cables allows you to transfer large amounts of data at high speed and with minimal signal loss. This helps to ensure that information is quickly transferred between the various systems of the aircraft and provides more reliable communication.

One of the important components of avionics is the system of control and diagnostics of the state of the aircraft. These systems include sensors that monitor various parameters such as pressure, temperature, vibration, etc. Collected data is analyzed and used to identify deviations from normal operation, prevent failures and take necessary measures to maintain flight safety.

Encryption and cyber security technologies are also actively used in modern avionics. Ensuring the confidentiality and integrity of data is a critical task in airspace. Data encryption and tamper protection help prevent hacking of avionics systems and ensure flight safety.

In the future, with the introduction of the Smart Aircraft concept, further development of avionics is expected. This includes the use of advanced AI, machine learning and data analytics technologies to enable autonomous decision-making, improve flight efficiency and safety. In addition, the use of drones and electric aircraft is expected to increase, which will require new developments in the field of avionics.

The latest avionics systems use advanced technologies such as embedded systems, microprocessors, high-performance computing devices, high-reliability software, and extensive safety and performance capabilities.

System integration is one of the main areas of avionics development. This means the combination of various systems and subsystems into a single integrated structure, which allows to optimize the use of resources and improve the overall performance of the aircraft. For example, the integration of air quality management, navigation and communication systems allows for smooth and safe navigation while meeting air traffic and flight safety requirements.

In the field of avionics, the concept of "smart aircraft" (Smart Aircraft) is gaining more and more popularity. This concept involves the use of smart sensors that are able to collect data about the state of the aircraft and its surroundings, analyze this data and make autonomous decisions. A smart aircraft can independently optimize paths, respond to changes in flight conditions and ensure optimal efficiency and safety.

One of the key technologies used in avionics is artificial vision systems. These systems use cameras and high-precision sensors to collect data about the environment. With the help of image processing and machine learning algorithms, artificial vision systems can recognize objects, estimate distances and perform automatic control, improving the safety of take-off, landing and maneuverability of the aircraft.

Another innovation in avionics is the use of wireless technologies such as Wi-Fi and Bluetooth networks to transfer data and communicate between systems on board the aircraft. This makes it possible to simplify communication and data exchange processes, ensuring fast and efficient transfer of information without the need for physical connection by wires.

The use of unmanned aerial vehicles (UAVs) is also becoming increasingly common in the field of avionics. UAVs are used for a variety of tasks, such as surveillance missions, area mapping, environmental studies, and many others. These aircraft are usually equipped with autopilot systems, navigation instruments, a high-definition camera and other sensors that allow them to perform tasks independently and collect useful information.

Artificial intelligence (AI) and machine learning technologies are also used in modern avionics systems. This allows systems to analyze large amounts of data, predict possible failures or problems, and make decisions based on the information gathered. For example, machine-learning systems can detect anomalies in engine or electrical power systems and predict potential failures, enabling predictive maintenance and accident prevention.

One of the important aspects of the development of avionics is cyber security. With the growing number of connected devices and data sharing on board aircraft, ensuring secure communication and protection against unauthorized access is becoming critical. Avionics systems have high security and reliability requirements, and for this, various encryption methods and protocols, authentication and monitoring systems are used to prevent possible cyber-attacks and ensure the confidentiality and integrity of data.

In general, the development of avionics provides opportunities to improve performance, safety and comfort in the aviation industry.

Chapter 2. Flight Safety. Human Factor. James Reason’s Swiss Cheese model.

2.1Aviation safety

Aviation safety is a set of practices, procedures, regulations, and techniques used in the aviation industry to prevent accidents, minimize risks, and ensure the health of passengers, crew, and aircraft.

It covers various aspects of aviation operations, including flight preparation, aircraft design and maintenance, pilot training, air traffic control, and regulatory oversight.

Important factors and considerations related to aviation safety include: Aircraft Design and Maintenance: Aviation safety begins with the design and manufacture of the aircraft.

Manufacturers adhere to strict technical standards and regulations to ensure aircraft structural integrity, reliability, and performance.

In addition, regular maintenance and inspections are performed to identify and correct potential problems or malfunctions.

Pilot Training and Competency: pilots complete an extensive training and certification process to acquire the knowledge, skills, and experience necessary to safely operate the aircraft.

Training programs cover areas such as aircraft systems, flight operations, emergency procedures, decision making, and crew resource management.

Ongoing training and performance reviews are conducted to maintain and update skills throughout a pilot's career.

Regulatory Framework: Aviation regulatory authorities establish and enforce safety regulations, standards, and guidelines to govern all aspects of airline operations. These regulations include aircraft certifications, pilot licenses, maintenance procedures, operational requirements, air traffic control protocols, and more.

Compliance with these regulations is essential to maintaining a high level of aviation safety.

Risk Management and Safety Culture: Aviation organizations promote a safety culture that emphasizes risk management and continuous improvement.

This includes identifying potential threats, assessing risks, implementing safety management systems (SMS), and encouraging the reporting of safety incidents and concerns.

Safety management focuses on proactive measures to prevent accidents and incidents, rather than reactive measures.

Air Traffic Control: Air Traffic Control (ATC) plays an important role in maintaining separation between aircraft and guiding pilots during takeoff, landing, and in-flight stages.

Air traffic controllers monitor the airspace, issue clearances, provide weather information, and ensure the safe and efficient movement of aircraft within controlled airspace.

Weather Monitoring and Analysis: Weather conditions have a significant impact on flight safety.

Aviation weather services provide current weather information, forecasts, and warnings to pilots and air traffic control.

Pilots receive weather information before flight and continuously monitor weather conditions during flight to make informed decisions and avoid dangerous situations.

Accident Investigation and Safety Analysis: When an accident or incident occurs, a thorough investigation is conducted to determine the cause and contributing factors.

These investigations are intended to improve safety by implementing corrective actions, updating procedures, and disseminating lessons learned throughout the aviation industry.

Analyzing safety data and sharing best practices also helps improve aviation safety.

Continuous Monitoring and Improvement: Aviation safety is a continuous process and requires continuous monitoring, analysis, and improvement.

Airlines use safety management systems and data-driven approaches to identify trends, potential risks, and opportunities for improvement.

This allows you to implement preventive measures and develop more effective security strategies.

Aviation safety is a collaborative effort between aircraft manufacturers, airlines, pilots, air traffic controllers, regulators, and other stakeholders.

The aim is to create a robust, connected system that reduces risk, maintains the highest level of safety and ensures the health of everyone involved in flight operations.

Aviation regulators enforce aviation safety regulations through a combination of supervision, inspections, audits, certification processes, investigations, and enforcement actions.

Below are some common methods used by regulators to ensure compliance with aviation safety regulations.

Rulemaking and Standards: Regulatory authorities develop and issue aviation regulations, standards, and guidelines covering various aspects of airline operations.

These rules are based on international standards, best practices, and security considerations.

Regulators will work with industry experts, stakeholders, and international organizations to establish and update these rules as necessary.

Regulatory Oversight: Regulatory authorities have oversight responsibilities to monitor compliance with regulations.

We inspect, audit and evaluate aviation organizations such as airlines, maintenance facilities, training centers and airports.

Through these activities, regulators evaluate the implementation and effectiveness of safety management systems, operating procedures, training programs, and maintenance practices.

Certifications and Licenses: Aviation regulatory authorities issue certifications and licenses to aviation organizations, aircraft, and personnel.

These certifications include Airline Operator Certificates (AOCs) for airlines, type certificates for aircraft models, and licenses for pilots, mechanics, and other aviation professionals.

To obtain these certifications, organizations and individuals must demonstrate compliance with safety regulations, standards, and operating procedures.

Safety Management System (SMS): Regulatory authorities require aviation organizations to implement a Safety Management System (SMS).

SMS is a structured approach to managing security risks and promoting a culture of security within an organization.

Regulators review and evaluate the effectiveness of an organization's SMS, including hazard identification, risk assessment, safety reporting, and safety performance monitoring processes.

Incident and Accident Investigations: Regulatory authorities conduct aviation incident and accident investigations to determine the causes and contributing factors.

These investigations are intended to identify security flaws, recommend corrective actions, and improve security practices.

The investigation will be carried out in collaboration with other stakeholders such as aircraft manufacturers, operators and air traffic control.

Enforcement Action: Regulators have the power to take enforcement action against organizations or individuals who violate security regulations.

These actions may include warnings, fines, suspension or revocation of certificates or licenses, and the imposition of other penalties.

Enforcement measures act as a deterrent and ensure compliance with safety regulations.

Collaboration and Information Sharing: regulators collaborate with international aviation organizations, industry associations, and other regulators to share safety information, best practices, and lessons learned.

Participate in forums, conferences, and working groups to stay abreast of emerging security issues and harmonize security regulations and practices around the world.

By using these methods, aviation regulators ensure that aviation safety regulations are complied with, monitored and enforced throughout the aviation industry.

The ultimate goal is to reduce risk, improve safety, and maintain public confidence in the safety of air travel.

Aviation regulators conduct incident and accident investigations to determine the causes and contributing factors to aviation accidents.

These investigations are intended to improve safety by identifying safety deficiencies, recommending corrective actions, and improving flight practices.

The key steps and processes involved in the investigation of incidents and accidents by regulatory authorities are: Notification and Triggering: When an incident or accident occurs, the relevant regulatory authority will normally be notified.

This can be done through interested parties, air traffic control, or other sources.

The supervisory authority will set up an investigation team or contact a specialized agency responsible for investigating the accident.

On-Scene Response: Dispatch investigators to the accident scene as soon as possible.

They will set up a command center and liaise with local authorities, emergency services and other relevant organizations.

The immediate focus is on securing the accident scene, preserving evidence, and ensuring the safety of personnel involved in the operation.

Evidence Collection and Preservation: Investigators collect and preserve evidence related to an incident or accident.

This includes documenting the accident scene, conducting interviews with witnesses, and recovering associated parts, debris, flight data recorders (FDRs), cockpit voice recorders (CVRs), and other data sources.

Evidence will be carefully handled, documented, and securely stored to maintain its integrity for analysis.

Data Analysis: Investigators analyze a variety of data to reconstruct the sequence of events that led to an incident or accident.

This includes analysis of flight data from the FDR, audio recordings from the CVR, radar data, air traffic control communications, maintenance records, weather data, and other relevant information.

This analysis helps identify potential influencing factors and evaluate the performance of systems, processes, and stakeholders.

Human Factors Analysis: Investigators examine human factors aspects such as crew performance, decision-making, training, and interactions.

This analysis focuses on understanding how human actions or inactions contributed to the incident or accident.

Factors such as fatigue, stress, communication difficulties, and workload management are taken into account.

Technical and Engineering Analysis: An investigator with expertise in aircraft systems, structure, and operations evaluates the technical aspects of an incident or accident.

They examine maintenance records, analyze aircraft components, assess system performance, and consider any technical failures or malfunctions that may have played a role.

Documentation of Results: The researcher will summarize the results, conclusions, and recommendations in a final report.

The report typically includes a factual description of the event, an analysis of contributing factors, a description of possible causes, and safety recommendations.

Reports are subject to internal review and may undergo a peer review process prior to publication.

Security Recommendations and Implementation: Based on the results of the investigation, regulators issue security recommendations to address identified deficiencies and improve security practices.

These recommendations may target specific areas such as training, procedures, regulations, maintenance practices, and aircraft design.

The recommendations will be communicated to relevant stakeholders, including aircraft manufacturers, operators and other regulators.

Tracking the implementation and effectiveness of these recommendations is an ongoing process.

It is important to note that the investigation of incidents and accidents occurs independently and in parallel with criminal investigations and legal proceedings. Regulators are focused on understanding safety aspects and taking preventive measures to improve aviation safety.

The ultimate goal of incident and accident investigations conducted by regulatory agencies is to improve aviation safety by identifying systemic problems, learning from past events, and taking steps to prevent similar incidents and accidents in the future.

2.2 Human Factor

It defines science as a kind of holistic way of knowing the world

not only the subject, but also the research method. If the subject is a clearly defined content, then the method is a way of scientific knowledge, a means by which scientists obtain reliable information, which is used to build theories and develop methodological recommendations.

The scientific analysis of interrelated maintenance processes begins with the construction of formalized models that allow solving the task of analyzing the impact of various factors on the effectiveness of maintenance of oil and gas plants.

To understand the human factor, it is advisable to use the "SHEL" conceptual model, as it allows for a step-by-step systematic study.

Fig.2.3.1. Model "SHEL",

where: S - settings (procedures, symbols, rules, etc.);
H - object (machine, equipment);
E - environment;
L - subject (person).

This model does not reflect all the interrelationships between the components of the system, but serves only as a basis for understanding the human factor in the activity.

At the center of the model is a person - the most critical and flexible system component. The boundaries of this block are complex and amorphous, and therefore the other components of the system must be carefully adjusted to it to avoid unwanted stress and possible system failures.

The entity is a nodal part of the "SHEL" model. Other parts must be appropriately adapted and coordinated with this nodal part. To ensure such compatibility, it is important to know the characteristic features of the nodal component of the system.

The most important characteristics of the nodal component of this model are:

Physical size and shape. In the design of any workplace and most of the equipment, data on the dimensions and parameters of movement of various parts of the human body play a decisive role, although they may be different depending on the person's age, ethnicity, gender, etc.

Physiological needs. Data on human needs for food, water and oxygen can be taken from physiology and biology.

Characteristics of information perception. To perceive information about the external and internal world, a person has various sense organs that enable him to react to events and perform necessary tasks. However, these organs, for one reason or another, are prone to degradation as they age.

Information processing. Human capabilities in this area severely limited. Imperfect design of a device or warning alarm system is very often the result of the fact that during design, the capabilities and limitations of a person to process information were not taken into account, that is, factors such as nervous tension, motivation, features of short-term and long-term memory.

Peculiarities of human reaction to received information. As soon as the information is received by the senses, the brain sends a signal to the muscles to react to it. The reaction can be manifested in the form of physical movements, or in some other form.

Environmental conditions. Temperature, pressure, humidity, noise, time of day, level of illumination affect the work and well-being of a person. Height, confined space, stressful or monotonous work conditions can also affect a person's ability to work.

Consider the relationship between individual blocks of the model.

The subject is the object. The question of interaction often arises when

it is about human-machine interface systems, namely:

operational manufacturability of aircraft systems, repairability of products, design of the technical compartment taking into account the characteristics of the human body, displays, taking into account the possibilities of assimilation of information by the user, as well as control bodies, their coding and placement.

The subject is procedures. Refers to human relationships with such intangible system components as rules, guidelines, checklists, procedures, symbols, and maintenance process software.

The subject is the environment. The importance of the human-environment interface during flight was one of the first to be established.

The measures that were initially taken are aimed at adapting a person to the appropriate environmental conditions.

The subject is the subject. This is a type of human interaction. Training of personnel and verification of their professional suitability is traditionally conducted on an individual basis. If each member of the production team has serious professional training, then it is natural to assume that such a team will generally act professionally and efficiently.

2.3 James Reason’s Swiss Cheese model

The Swiss Cheese Model was developed by Reason in 2000 in the British Medical Journal (BMJ) in an article titled "Human Error: Models and Management." Commonly used in risk analysis and management to explain how different layers of protection can theoretically prevent failure.

In this model, Reason uses slices of Swiss cheese to represent layers of defense against what he calls active disorders and latent conditions.

The idea is that each layer has a "hole" or weak point, and the holes in all layers are unlikely to line up to allow a hazard to pass through.

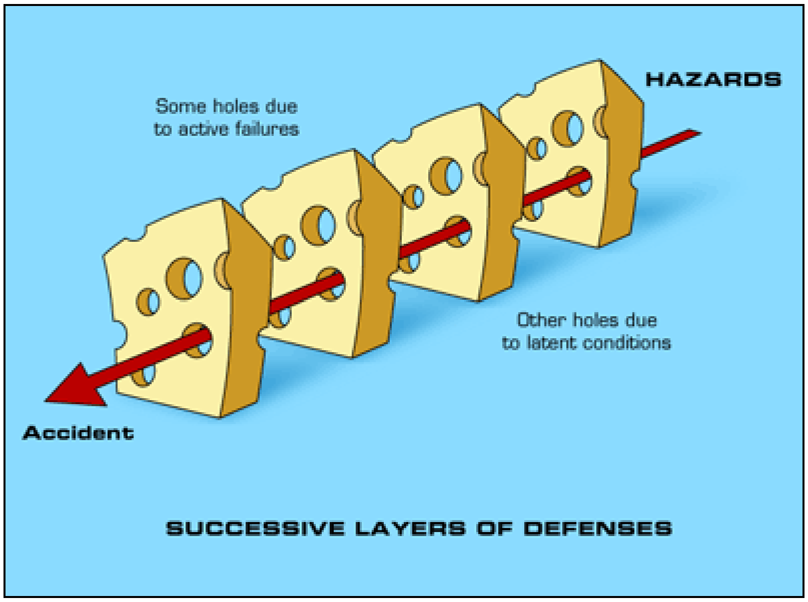


Fig.2.3.1 Reason’s Swiss Cheese model

The Swiss Cheese Model was born out of Reason's desire to communicate the tissue accident model to the BMJ's medical readership.

Many of its readers were not as familiar with human factors safety concepts as those in industries such as nuclear energy and aviation.

It is now used in everything from construction and patient safety to cybersecurity and energy production.

In rational theory, most accidents are due to his organizational influences, unsafe supervision, preconditions for unsafe behavior, and his level of failure in unsafe behavior itself.

It states that it arises from one or more.

While SCM is useful for describing deterministic and linear systems, it can be less useful (or at least more difficult) for non-deterministic and social systems.

Critics of the Swiss cheese model point out several important problems:

Complacency: If people believe that failure is impossible in multilayered structures, then the model is false.

It can create a sense of security.

Reason's original model included "unsafe actions", but these are omitted in most cases where the model is applied today.

Interaction: Layers are often treated as independent, but they are rarely independent.

One failure can lead to other failures.

This is especially true when failures change the amount or load on the system, or when it comes to social systems.

Complexity: Real systems are more complex than a simple linear layered model can capture.

Adaptability: This model does not easily accommodate system changes or adjustments.

In complex systems, changes can occur that unknowingly create invisible "holes" in various layers, create new layers, or allow errors to bypass entire layers of protection. there is.

Human Factors: does not fully consider human psychology, socio-culture, human error, or human adaptability in resolving and preventing errors.

Resource-intensive: Implementing multiple layers of defense can be expensive, time-consuming, and may not be a good idea.

In fact, as Perrault points out in "Normal Accidents," many of these additional layers can actually make the system more vulnerable and introduce new and unexpected failure conditions.

Chapter 3. Laws of distribution of flight parameters in case of failures in avionics systems

3.1 Laws of distribution of flight parameters. Types of distributions.

The laws of the distribution of flight parameters during failures in avionics systems are studied in the field of aviation safety and are aimed at analyzing and predicting the possible consequences of failures or malfunctions in avionics systems on flight safety and aircraft operation.

Failures in avionics systems can cause various problems, such as loss of navigation information, malfunction of automatic control systems, problems with stabilization and control of the aircraft, etc. The distribution laws of flight parameters help to understand how these failures affect various aspects of flight safety.

One of the key aspects of studying the laws of the distribution of flight parameters is the analysis of aircraft crash statistics, which allows to identify the frequency and consequences of failures in various avionics systems. This may include analysis of data from aircraft crash registers, accident reports, and failure information recorded during routine aircraft inspections and maintenance.

The laws of distribution of flight parameters can be calculated on the basis of statistical data and mathematical models. For example, distribution laws such as the normal distribution (Gaussian distribution), exponential distribution, Weibull distribution, or others may be defined for known failure types. These laws help determine the probability of failure and assess the consequences for flight safety. Researching the laws of the distribution of flight parameters during failures in avionics systems allows aviation engineers and designers to develop more reliable and safer avionics systems. They can also be used to plan piloting procedures in case of failures and to train pilots in critical situations.

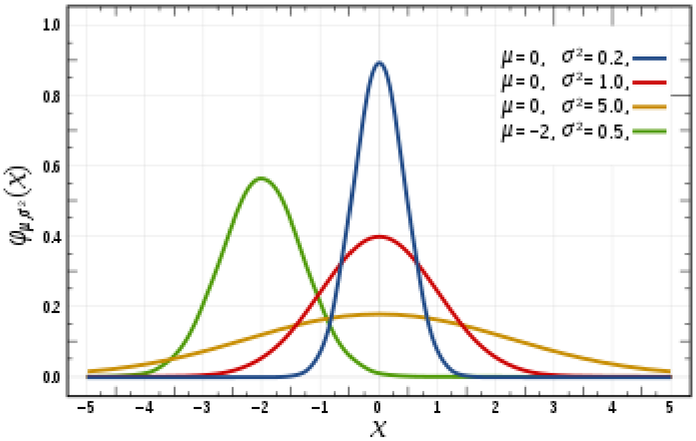
It is important to note that the laws of the distribution of flight parameters in case of failures in avionics systems can vary depending on the type of aircraft, its configuration and the properties of avionics systems. Factors such as the age of the aircraft, its service and operational history, and certification requirements set by the relevant aviation organizations are also taken into account.

The study and analysis of the laws of the distribution of flight parameters during failures in avionics systems are aimed at ensuring the safe operation of aircraft by identifying potential problems and developing risk management strategies. This may include emergency recovery scenarios, failure piloting procedures, safeguards and redundancy systems that minimize the impact of failures on flight safety.

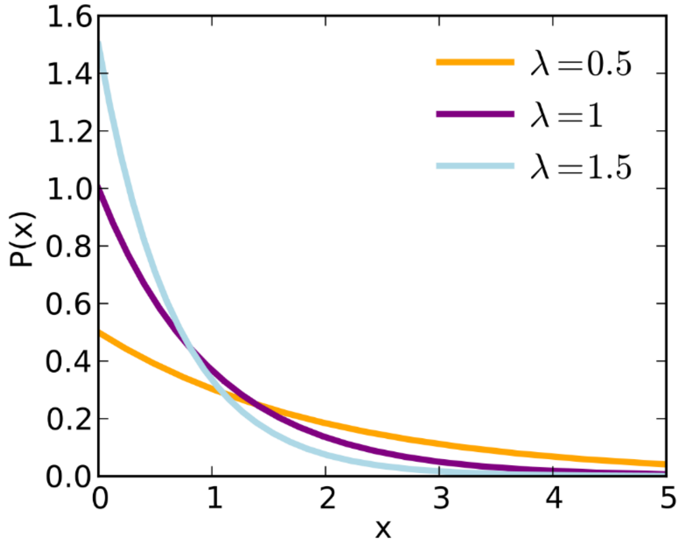
Research in the field of the laws of the distribution of flight parameters during failures in avionics systems is complex and requires a large amount of data, mathematical modeling, statistical analysis and specialized computer tools. It is an essential part of the avionics design and certification process to ensure flight safety.

The laws of the distribution of flight parameters during failures in avionics systems can be divided into several main types, depending on the nature of the failure and its effect on the flight parameters. Some of them include:

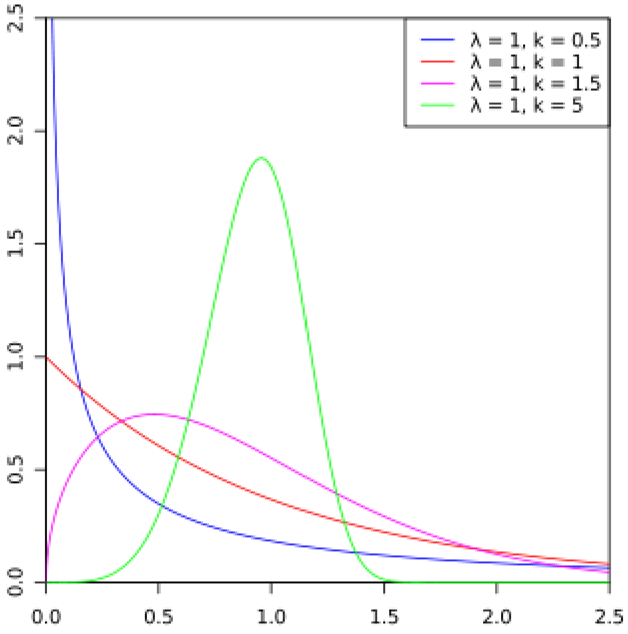
Normal distribution: This distribution, also known as the Gaussian distribution, is one of the most common and is used to determine parameters that have statistical normality. Some flight parameters that may have a normal distribution for failures include speed, altitude, and bank angle.



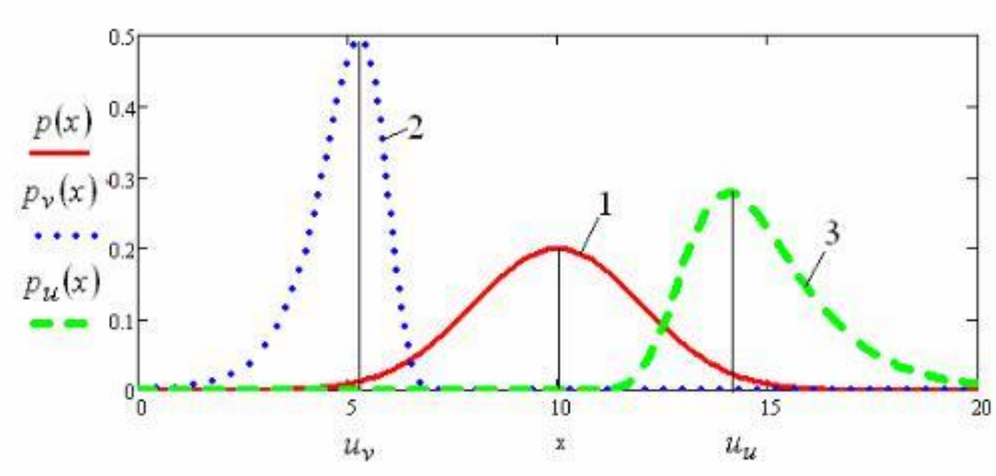
Exponential Distribution: This distribution is used to model random events that occur with uniform intensity over time. It can be applied to time-to-failure analysis in avionics systems, such as the time-to-failure of electrical components or the time-to-failure of an autopilot system.



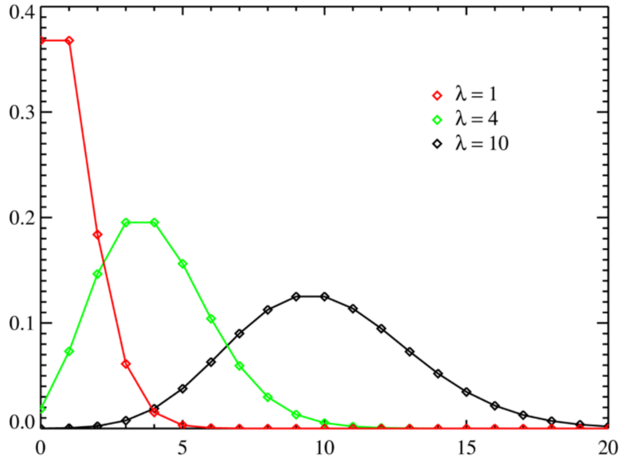
Weibull Distribution: This distribution is often used to model failures that occur over time and are subject to wear or aging. It can be used to analyze the failure of components such as engines or generators that change with time and operation.



Gumbel Distribution: This distribution is used to model extreme values and is used to analyze failures that have large impacts or consequences. It can be applied to failures that cause critical situations, such as failures of main controls or braking systems.



Poisson Distribution: This distribution is used to model the number of random events occurring in some time interval or sample. It can be applied to analyze the number of failures that occur at a certain time or on a certain number of flights.



3.2 Existing methods for mathematical assessing the quality of training of pilots.

At the entrance to the float way changes the streamlined arrangement of the air ship, which is related with the discharge of folds and landing equip. When flying in chief mode, this forces extra activities on the pilot within the control of the airplane. The working stack on the team moreover increments. At synchronous event of failures or failures at team individuals there can be the raised psychophysiological pressure. Already, this issue was considered within the zone from the conclusion of the fourth turn to landing on obsolete airplane. Failures alone may not posture a risk, but in a state of stretch, the crew may exasperate the circumstance. Since the alter within the parameters of the aircraft in this zone is ergodic and stationary, the pick up (increment within the amplitude of the parameters) can be decided by autocorrelation capacities. Calculations are performed concurring to the equation:

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

where n is the number of observations in the time series, Apar (amplitude of the parameter), j = 1, 2, 3,… L represents the delay of the argument at 0, 1, 2… (L - 1). To perform spectral analysis of autocorrelation functions in Mathcad engineering mathematical software using the function A = cfft (K) for continuous functions. The following Fourier integral formula can be used to calculate the spectrum from discrete values:

$$S_t = \sum_{i=1}^{N-1} \left(K_i \cdot e^{\frac{-i \cdot 2\pi \cdot i \cdot t}{N}} \right)$$

In addition, there are often potential manifestations of increased human operator stress, manifested in a transition from a stationary stochastic process to deterministic oscillations of a sinusoidal form.

Sometimes this is not accompanied by an increase in the amplitude of the parameters.

This will be reflected in the fact that with the subsequent impact of other negative factors, the amplitude values of the parameters will increase many times (Figure 3.2.1)

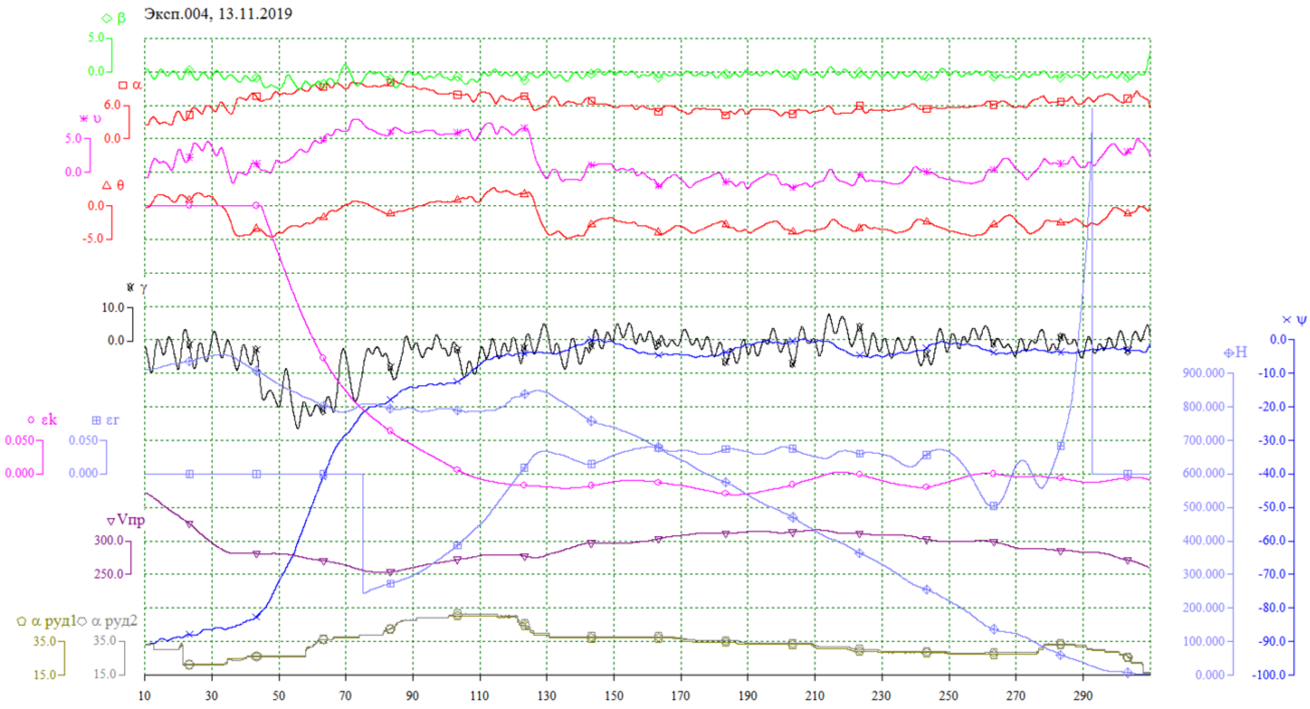


Fig. 3.2.1. "Flight" on FFS with failures of the first and third channels of fly-by-Wire and lack of control of the left aileron and interceptors on the left half-wing, where: Vpr - instrument speed (km / h); ψ - magnetic course (deg.): Θ - trajectory angle (deg.); ϒ - roll angle (deg.); υ - pitch angle (deg.); α - angle of attack (deg.); β - sliding angle (deg.); H - geometric altitude (m); εκ - deviation from the course equal

signal zone (RGM); εг - deviation from the glide path (RGM); α - position of the engine control lever (deg.)

According to the Neumann-Pearson test, the choice of the decision threshold V is based on solving the following equation for the case of no sinusoidal oscillations in the analytical mixture:

$$\Pr\left(\frac{1}{\sigma^2}\sum_{i=1}^{N} S_i(x_i-\bar{x})-\frac{1}{2\sigma^2}\sum_{i=1}^{N} S_i^2 \geq V \Big/ H_0\right)=\alpha .$$

In this case, the decision threshold is determined using a statistical model based on the Monte Carlo method.

For a given sample size, sinusoidal oscillation parameters are detected and α = 0. 01, we obtain V ≈ 0.

When training pilots on a complex simulator, it is necessary to perform Conduct exercises involving 'familiarization with the flight situation of two or three equipment failures on board and determining the interests of each crew member.

The damage block must include damage that does not affect the aerodynamics of the aircraft and the ability to control the aircraft.

Experience shows that uncertainty in assessing the situation in severe flight conditions in 70-80% of cases leads to an increase in the amplitude of flight parameters due to increased pilot stress .

Therefore, the simulator should be used not only to learn specific actions, but also for anti-stress training.

Let us consider one of the variations of the order of application of trend algorithms to analyze the degree of resistance of drivers to factor overlay.

Having numerical or graphical data on the change in direction (ψ), roll, pitch (ν) and vertical speed (Vy) from the end of the 4th turn until touchdown, it is necessary to determine the the distance from the extreme points of these functions to zero.

Calculate the difference between the extremes (without modulus) of the change of each parameter.

The results of the amplitude values (A) are taken modulo.

Determine the largest and smallest A of each parameter.

Calculate the half cycles (T) corresponding to the maximum and minimum value of each parameter.

$$\Delta A = \frac{A_{\max} - A_{\min}}{A_{\min}}; \Delta T = \frac{\mathrm{T}_{\max} - \mathrm{T}_{\min}}{\mathrm{T}_{\min}}.$$

After that make the general picture of polycanal change of parameters:

$$\Delta\Delta A_{\gamma,\psi,\vartheta} = \sqrt{\Delta A_{\gamma}^{2} + \Delta A_{\psi}^{2} + \Delta A_{\vartheta}^{2} + \Delta A_{V_y}^{2}};$$
$$\Delta\Delta \mathrm{T}_{\gamma,\psi,\vartheta} = \sqrt{\Delta \mathrm{T}_{\gamma}^{2} + \Delta \mathrm{T}_{\psi}^{2} + \Delta \mathrm{T}_{\vartheta}^{2} + \Delta \mathrm{T}_{V_y}^{2}}$$

Amplitude can be measured and plotted on the coordinate axis when working with numbers in degrees, and when working with graphs - in conventional units and periods - in seconds and conventional units, respectively.

Using the trend algorithm, it is recommended to compare (ΔΔδE.H.B) the rudder deflection, rudder direction and altitude with the changes of parameters (ΔΔAγ, ψ, ϑ):

$$\Delta\Delta\delta_{E,\mathrm{H},\mathrm{B}} = \sqrt{\Delta\delta_{E}^{2} + \Delta\delta_{\mathrm{H}}^{2} + \Delta\delta_{\mathrm{B}}^{2}};$$

$$\Delta\Delta A_{\gamma,\psi,\vartheta} = \sqrt{\Delta A_{\gamma}^{2} + \Delta A_{\psi}^{2} + \Delta A_{\vartheta}^{2}}.$$

For example, when "crawing", the quality of the steering technique can be judged by the deviation, because with a strong rattle, an experienced pilot does not allow strong deviations in the parameters, although Consumption of the rudder and ailerons increases.

With the presence of an objective control system on a full flight simulator (FFS), you can get away with it as the "chatter" can be eliminated from the instructor's control panel.

Algorithms and training programs for resisting minimal bias are shown in "Methodological recommendations for increasing pilot resistance to factor overlays (for instructors and engineers)" №782 B90 for aircraft of that time.

The degree of FN pilot resistance can be assessed by the difference between ΔΔAFN and trouble-free flights.

The smaller the difference, the greater the degree of resistance, the qualitative changes that need to be quantified.

Erroneous and illogical actions of crew members during flight, mainly associated with changes in mental processes due to the impact of load factors on them.

By receiving spatial cues from the effects of factorial loads, in sufficient amounts, the pilot can enter the reflected motion zone.

The pilot's inability to actively resist factor loading can lead to incorrect actions during aircraft control (confusion about levers, levers, buttons, etc.).

The counterpart of this phenomenon is the spatial delay of movements.

And that is why it is so important to train the entire crew to master the technique of spatial delay in aircraft control.

The problem of converting to dimensionless coefficients in the processing of flight information oscillograms of the transition from instantaneous to time interval estimates is successfully solved using the algorithm trend calculation.

By trends we mean continuous changes in the process that are observed and give an opinion on its predictions in the future.

According to the processed statistics, the above method revealed several patterns that showed the necessity of anti-stress training for most pilots.

Using the developed procedure to apply the trend algorithm, the occurrence of negative phenomena among pilots of An-26, Yak-40, Yak-42, Mi-8 helicopters and other aircraft Other helicopters were analyzed.

During the flight, pilots cannot always avoid making mistakes.

Furthermore, as statistics collected on FFS-74 show, aircraft mishandling time increases with the increasing number of simultaneously operating elements (in this case, errors).

The most typical errors in driving techniques under the influence of negative factors are: failure to maintain a glide path and failure to maintain speed on the planned glide path, failure to maintain course, incorrect course correction , not maintaining vertical speed, etc.

Additionally, as the pilot begins to correct errors, the dynamic pattern in amplitude and frequency increases, which is corrected by flight recording.

In the existing literature, there is a completely opposite view: the action of loading elements is not an amplification, but a so-called “breaking” of the dynamic pattern of actions.

FFS tests and statistics do not support this.

The difference is especially visible in the waveform of the "roll angle" parameter.

Verifying this regulation has very important practical implications for developing new training programs as well as providing practical recommendations for pilots to improve their piloting skills.

The pilot begins to rotate the aircraft around the desired parameter, which indicates the pilot's action in the reflected motion zone, that is, quantitative (qualitative) or temporary muscle fluctuations are recorded (quantitative) of the rider, starting with space, originating from purely visual and tactile receptors.

Furthermore, visual sensations are objective and muscular – subjective.

Erroneous and illogical actions in flight, mainly associated with changes in mental processes, spatial signals arising from the operation of load elements.

By receiving a sufficient number of spatial signals from the impact of the load factor, the pilot can enter the spatially reflected motion region.

The inability to proactively counteract loading coefficients can lead to incorrect actions by flight engineers (confusion about levers, levers, buttons, etc.).

Therefore, we see the importance of causing space delay for the entire crew.

An important factor in understanding this type of delay may be understanding the logic of the flight.

This is an important basis for training it as well as for choosing the only correct solution when encountering an unexpected stimulus.

After performing the logic, some pilots fell into the temporary reflex zone, which showed their inability to delay temporary reflex movements.

Guided by Sechenov's reaction theory, this theory demonstrated that all conscious movements are typically arbitrary but can be disproved.

Reinforcement of the dynamic pattern without changing the “form” of the movements was observed in most teams during training.

We see from flight calculations on the FFS that the composite rating of dynamic pattern gain during engine-idle landing is greater than the composite rating when landing with tip flaps Do not loosen.

Ideally, amplitude values should be compared when analyzing flights by the same pilot without incidents and with recorded incidents.

Therefore, from this difference we can determine the amplitude increase that occurs in the driver under the influence of factorial loads, simulated on complex FFS faults.

Preliminary roll calculations show a flight with a smaller influence of factors on the pilot other than the maximum (engine failure, air horizon, failure of other systems).

Studies were also performed on three identical errors from the instructor's control panel, which did not affect the aerodynamics of the aircraft.

The data show that in 80% of pilots, this leads to an amplification of the amplitude of the dynamic pattern, thereby increasing the flow of comments about pilot errors.

Tests using a trend algorithm show that this phenomenon occurs as multiparameter fluctuations.

3.3 Algorithms for processing aircraft flight parameters.

Thebasisofthealgorithmsforprocessingtheflightparametersoftheaircraftis a systemforestimatingthedeviationfromthenormaldistributionaccordingtothecriterionofagreement– χ^2 .

BasedonthesimulationofflightswithcertaindeviationsonFFSfromtheworkofHryshchenkoYurii, ZaliskyiMaksym, PavlovaSvitlana, SolomentsevOleksandr, FursenkoTetiana. DataProcessinginthePilots` TrainingProcessontheIntegratedAircraft Simulator. Electrical, ControlandCommunicationEngineering. 2021, Riga, RTU, 2021 [8] wecancalculatethedistribution χ^2 , theprobability p thatduetopurelyrandomreasonsthedegreeofdiscrepancywillbenotlessthanweactuallyobserve (inthesetests) anddrawconclusionsabouttheplausibilityofthehypothesis. Firstly, let’s calculatethedataforthefirstandthirdflights.

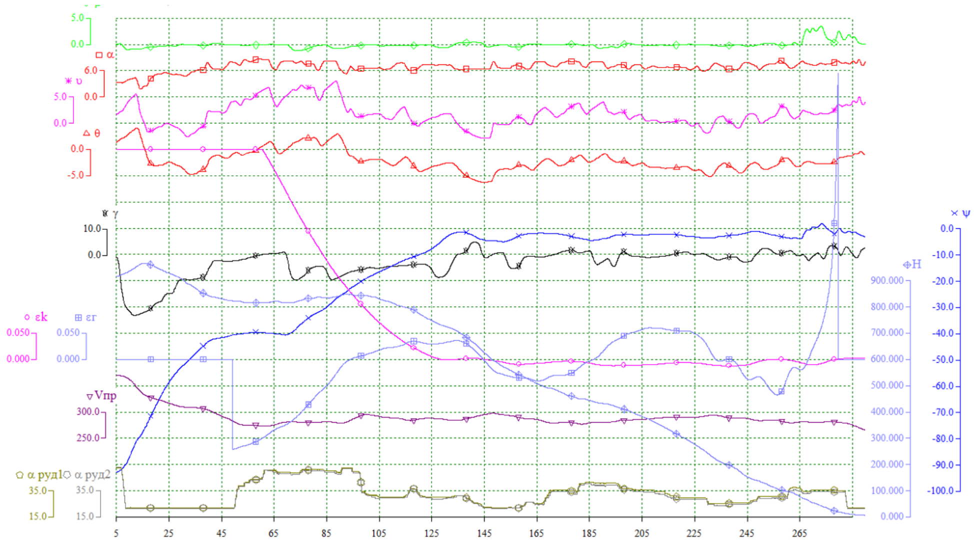


Fig. 3.3.1. Flight 1. Regularflightofthe An-148 aircraft

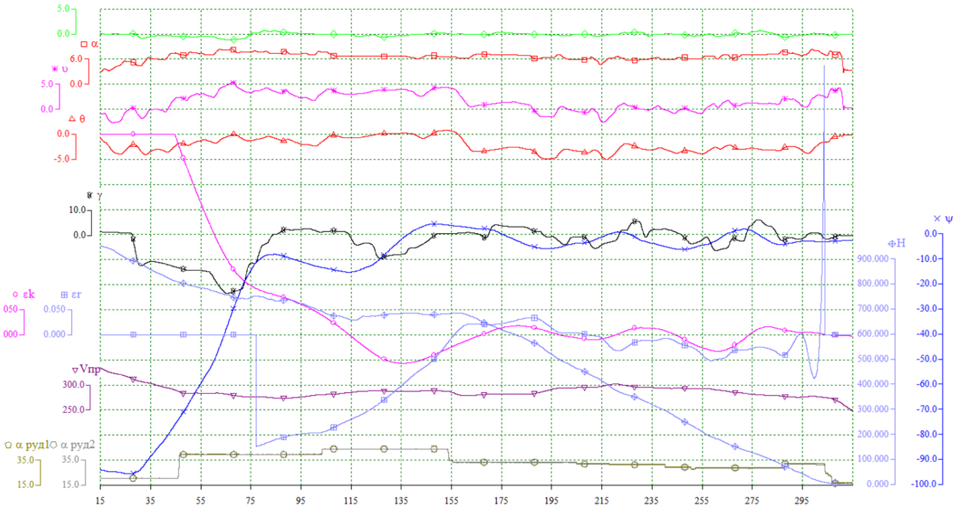


Fig. 3.3.2. Flight 3. Asymmetryoftheflaps, theflapoftheleftwing

Data of 1 nd 3 flights

$$\gamma := \begin{pmatrix} -9 & 5 & -2 & 0.5 & 5 & 2 & 0.5 & 2 & -4 & -2 & -5 & 1 & -2 & 1 & 0 & -2 & -1 & -3 & 2.5 & -0.5 & 0 & -2 & 0 & -1 & 4 & 0 & -8 \\ -6 & 0 & -2 & 4 & 1 & -1 & -4 & -1 & -6 & -3 & 2 & 5 & -1 & 3 & -4 & -1 & -6 & -2-3 & 6 & 3 & -3 & -2 & 0.5 & -3 & -0.5 & -0.5 & 0 \end{pmatrix}$$

$$n := \mathrm{hist}(7,\gamma) = \begin{pmatrix} 2 \\ 5 \\ 7 \\ 16 \\ 12 \\ 6 \\ 6 \end{pmatrix} \qquad fg := \mathrm{histogram}(7,\gamma) = \begin{pmatrix} -7.929 & 2 \\ -5.786 & 5 \\ -3.643 & 7 \\ -1.5 & 16 \\ 0.643 & 12 \\ 2.786 & 6 \\ 4.929 & 6 \end{pmatrix}$$

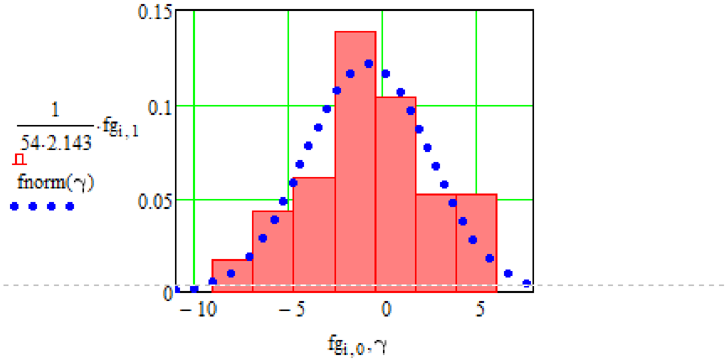
$K := 7$ $\quad \Delta\gamma := 2.143$ $\quad N := 54$ $\quad k := 0..6$ $\quad q := \min(\gamma) = -9$

$\mathrm{mean}(\gamma) = -0.787$ $\quad \mathrm{var}(\gamma) = 10.58$ $\quad \sigma := \sqrt{\mathrm{var}(\gamma)} = 3.253$ $\quad d := \mathrm{var}(\gamma) = 10.58$

$\mu := -0.787$ $\quad c := \dfrac{1}{\mathrm{mean}(\gamma)} = -1.271$ $\quad \gamma := -11..11$ $\quad \nu := \dfrac{\sigma}{\mu} = -4.133$

$int_k := -9 + \Delta\gamma \cdot k$

$$int = \begin{pmatrix} -9 \\ -6.857 \\ -4.714 \\ -2.571 \\ -0.428 \\ 1.715 \\ 3.858 \end{pmatrix} \qquad k = \begin{array}{|c|} \hline 0 \\ \hline 1 \\ \hline 2 \\ \hline 3 \\ \hline 4 \\ \hline 5 \\ \hline 6 \\ \hline \end{array} \qquad \mathrm{fnorm}(\gamma) := \frac{1}{\sigma\sqrt{2\cdot\pi}} \cdot \exp\left[-\frac{(\mu-\gamma)^2}{2\cdot\sigma^2}\right]$$



$$fnorm(\gamma) := \frac{1}{\sigma\sqrt{2 \cdot \pi}} \cdot \exp\left[-\frac{(\mu - \gamma)^2}{2 \cdot \sigma^2}\right]$$

Analysis of consent Norm-model

The theoretical probability of failure in the k-th interval Δt

$N := 54$ $\quad a := 0..6$ $\quad K := 7$ $\quad k := -9 + K - 1$

$\gamma := -9..6$ $\quad r := K - 3 = 4$ $\quad \Sigma n := 54$

$$Qnorm_a := \int_{int_a}^{int_a + \Delta\gamma} fnorm(\gamma)\, d\gamma$$

$$Qnorm_6 := 1 - \sum_{a=0}^{5} Qnorm_a$$

$Qnorm_a =$

0.025
0.083
0.178
0.252
0.235
0.144
0.082

$$n = \begin{pmatrix} 2 \\ 5 \\ 7 \\ 16 \\ 12 \\ 6 \\ 6 \end{pmatrix}$$

$$\chi 2norm := \sum_{a=0}^{K-1} \left[\frac{\left[\left(n_a\right) - N \cdot Qnorm_a\right]^2}{N \cdot Qnorm_a}\right] = 2.478$$

$P \approx 0,7$

Accordingtocalculations, thecriterionofagreement “*xi*-квадрат” – χ^2 is 2.478, andtheprobability p = 0.7. Since, $p \geq 0,10$, thehypothesisisconsideredplausible (atleastnotinconsistentwiththestudieddata).

Andnowyouneedtocalculatethesameparametersfor 10 flights.

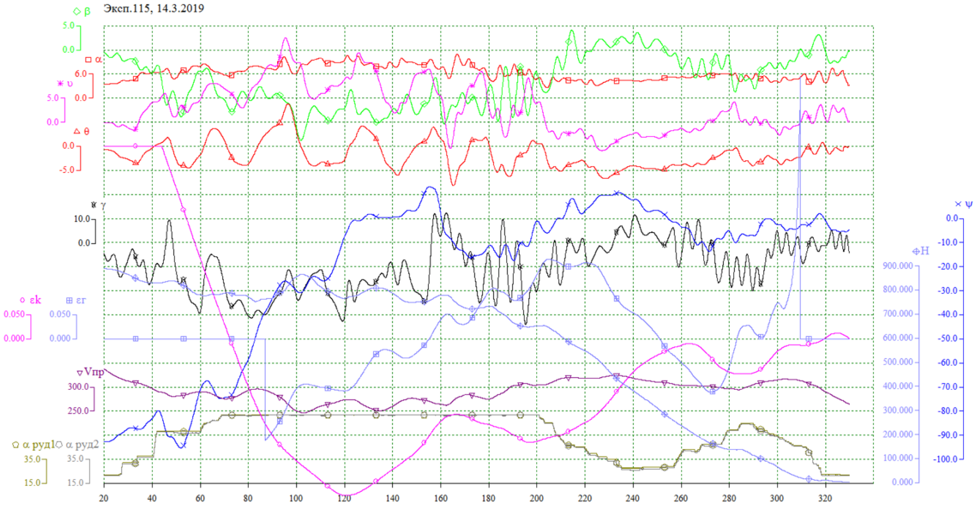


Fig.3.3.3. Flight 10. Completefailureoffly-by-Wire (backupcontrolwithoutdamping) + Failureofthesecond (right) engine

10 flight, 210 sec

$$\gamma := \begin{pmatrix} -32 & -15 & -25 & -15 & -18 & -13 & -14 & -8 & -17 & -7 & -24 & 12 & 3 & 12 & -3 & 4 & -10 \\ -4 & -25 & -4 & -25 & 10 & -23 & 0 & -33 & -17 & -20 & -9 & -14 & 1 & -18 & 1 & -4 & 2 \\ -10 & -2 & -3 & 7 & 12 & 4 & -1 & 7 & -10 & 9 & -2 & 10 & -10 & 1 & -17 & -3 & -19 \\ -6 & -17 & -5 & -20 & -10 & -18 & -3 & -5 & 5 & -4 & 4 & -5 & 3 & -9 & 2 & -3 & 5 \\ -3 & 4 & -3 & 3 & -7 & -13 & -2 & -4 & 6 & 1 & 6 & 3 & 9 & -3 & 1 & -7 & 0 \\ -11 & -6 & -5 & -9 & -3 & -4 & 6 & 4 & 9 & 6 & 12 & -2 & 3 & 13.5 & -4 & -9 & -2 \\ -5 & 2 & 0 & 8 & 0 & 5 & 2 & 5 & -3 & 0 & -5 & -4 & -7 & 0 & -13 & -6 & -13 \\ 4 & 3 & 4 & 2 & 1 & 3 & 0 & 3 & 3 & 2 & -3 & -2 & -3 & 1 & 3 & 0 & 3 \end{pmatrix}$$

$$\gamma := \begin{pmatrix} 32 & 15 & 25 & 15 & 18 & 13 & 14 & 8 & 17 & 7 & 24 & -12 & -3 & -12 & 3 & -4 & 10 \\ 4 & 25 & 4 & 25 & -10 & 23 & 0 & 33 & 17 & 20 & 9 & 14 & -1 & 18 & -1 & 4 & -2 \\ 10 & 2 & 3 & -7 & -12 & -4 & 1 & -7 & 10 & -9 & 2 & -10 & 10 & -1 & 17 & 3 & 19 \\ 6 & 17 & 5 & 20 & 10 & 18 & 3 & 5 & -5 & 4 & -4 & 5 & -3 & 9 & -2 & 3 & -5 \\ 3 & -4 & 3 & -3 & 7 & 13 & 2 & 4 & -6 & -1 & -6 & -3 & -9 & 3 & -1 & 7 & 0 \\ 11 & 6 & 5 & 9 & 3 & 4 & -6 & -4 & -9 & -6 & -12 & 2 & -3 & -13.5 & 4 & 9 & 2 \\ 5 & -2 & 0 & -8 & 0 & -5 & -2 & -5 & 3 & 0 & 5 & 4 & 7 & 0 & 13 & 6 & 13 \\ -4 & -3 & -4 & -2 & -1 & -3 & 0 & -3 & -3 & -2 & 3 & 2 & 3 & -1 & -3 & 0 & -3 \end{pmatrix}$$

$$n := \mathrm{hist}(8,\gamma) = \begin{pmatrix} 11 \\ 34 \\ 34 \\ 26 \\ 14 \\ 10 \\ 5 \\ 2 \end{pmatrix} \qquad fg := \mathrm{histogram}(7,\gamma) = \begin{pmatrix} -10.179 & 13 \\ -3.536 & 39 \\ 3.107 & 44 \\ 9.75 & 19 \\ 16.393 & 12 \\ 23.036 & 7 \\ 29.679 & 2 \end{pmatrix}$$

$30.094 - 24.281 = 5.813$

$29.679 - 23.036 = 6.643$

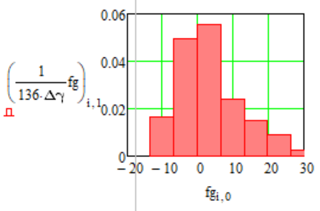
$d := \mathrm{var}(\gamma) = 86.324$ $\sigma := \sqrt{\mathrm{var}(\gamma)} = 9.291$ $q := \min(\gamma) = -13.5$ $q1 := \max(\gamma) = 33$ $\mathrm{skew}(\gamma) = 0.808$

$K := 8$ $\mathrm{mean}(\gamma) = 3.57$ $\mathrm{var}(\gamma) = 86.324$ $c := \frac{1}{\mathrm{mean}(\gamma)} = 0.28$ $Cv := \frac{\mathrm{stdev}(\gamma)}{(\mathrm{mean}(\gamma))} = 2.603$ $b := 1.75$ $a1 := \frac{\mathrm{stdev}(\gamma)}{0.52} = 17.867$

$\gamma := -13.5 .. 33$ $k := 0 .. K - 1$ $N := 136$ $\Delta\gamma := \frac{q1 - q}{K} = 5.813$

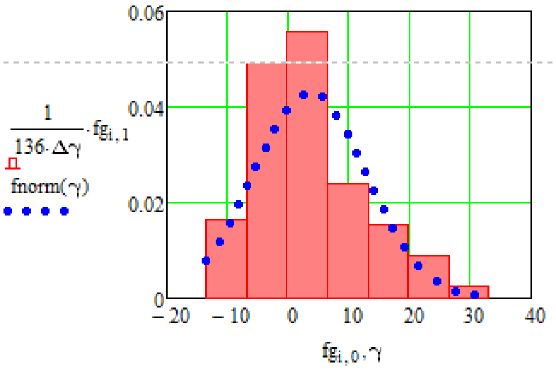
$\mu := 3.57$ $\nu := \frac{\sigma}{\mu} = 2.603$ $\mathrm{int}_k := -13.5 + \Delta\gamma \cdot k$

$$n = \begin{pmatrix} 11 \\ 34 \\ 34 \\ 26 \\ 14 \\ 10 \\ 5 \\ 2 \end{pmatrix}$$



Normal

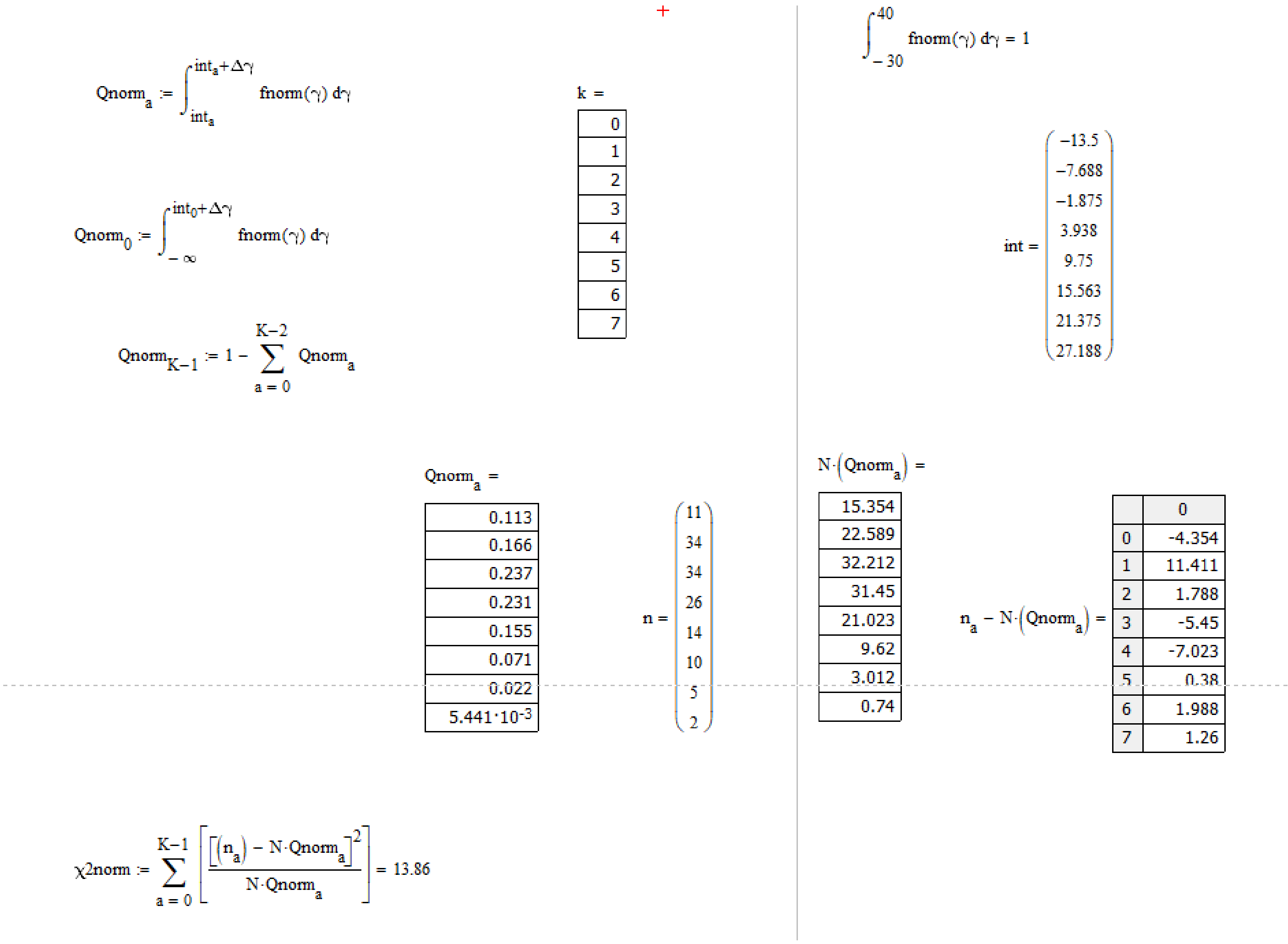
$$\mathrm{fnorm}(\gamma) := \frac{1}{\sigma\sqrt{2\cdot\pi}}\cdot\exp\left[-\frac{(\mu-\gamma)^2}{2\cdot\sigma^2}\right]$$



Analysis of consent Norm-model

The theoretical probability of failure in the k-th interval Δt

$a := 0 .. K - 1$



$$Qnorm_a := \int_{int_a}^{int_a+\Delta\gamma} fnorm(\gamma)\,d\gamma$$

$$Qnorm_0 := \int_{-\infty}^{int_0+\Delta\gamma} fnorm(\gamma)\,d\gamma$$

$$Qnorm_{K-1} := 1 - \sum_{a=0}^{K-2} Qnorm_a$$

k =

0
1
2
3
4
5
6
7

$$\int_{-30}^{40} fnorm(\gamma)\,d\gamma = 1$$

$$int = \begin{pmatrix} -13.5 \\ -7.688 \\ -1.875 \\ 3.938 \\ 9.75 \\ 15.563 \\ 21.375 \\ 27.188 \end{pmatrix}$$

$Qnorm_a =$

0.113
0.166
0.237
0.231
0.155
0.071
0.022
$5.441\cdot10^{-3}$

$$n = \begin{pmatrix} 11 \\ 34 \\ 34 \\ 26 \\ 14 \\ 10 \\ 5 \\ 2 \end{pmatrix}$$

$N\cdot(Qnorm_a) =$

15.354
22.589
32.212
31.45
21.023
9.62
3.012
0.74

$n_a - N\cdot(Qnorm_a) =$

	0
0	-4.354
1	11.411
2	1.788
3	-5.45
4	-7.023
5	0.38
6	1.988
7	1.26

$$\chi2norm := \sum_{a=0}^{K-1} \left[\frac{\left[(n_a) - N\cdot Qnorm_a\right]^2}{N\cdot Qnorm_a} \right] = 13.86$$

Accordingtothecalculationsof 10 flights, thecriterionofagreement – χ^2 is 13.86, and the probability p is close to 0.02. Since $p \leq$ 0,10, it is recommended to test the experiment (if possible) and in case noticeable discrepancies reappear, try to find a more suitable model for failure to describe statistics.

After these calculations, we can conclude that with simple failures enough normal distribution, failures should be trained to normal, failures should not be more than three, they should not affect the aerodynamics of the aircraft, duplicates should work and failures should not affect the system management.

Flight quality can be improved by controlling the aircraft's flight attitude, and the pilot's flight quality can also be evaluated by evaluating the aircraft's flight attitude.

Pilot flight attitude control can be trained through flight simulators to improve the reliability and safety of air flight.

By analyzing the autocorrelation function of the pitch angle and its frequency spectrum, evaluates the quality of the pilot technology in accordance with the distribution law-based estimation method.

Develop good techniques for pilots to fly the AN-148 in normal flight conditions.

Propose an early warning system for damage to the speed indicator or angle of attack indicator.

And give recommendations on the pilot's actions in this situation.

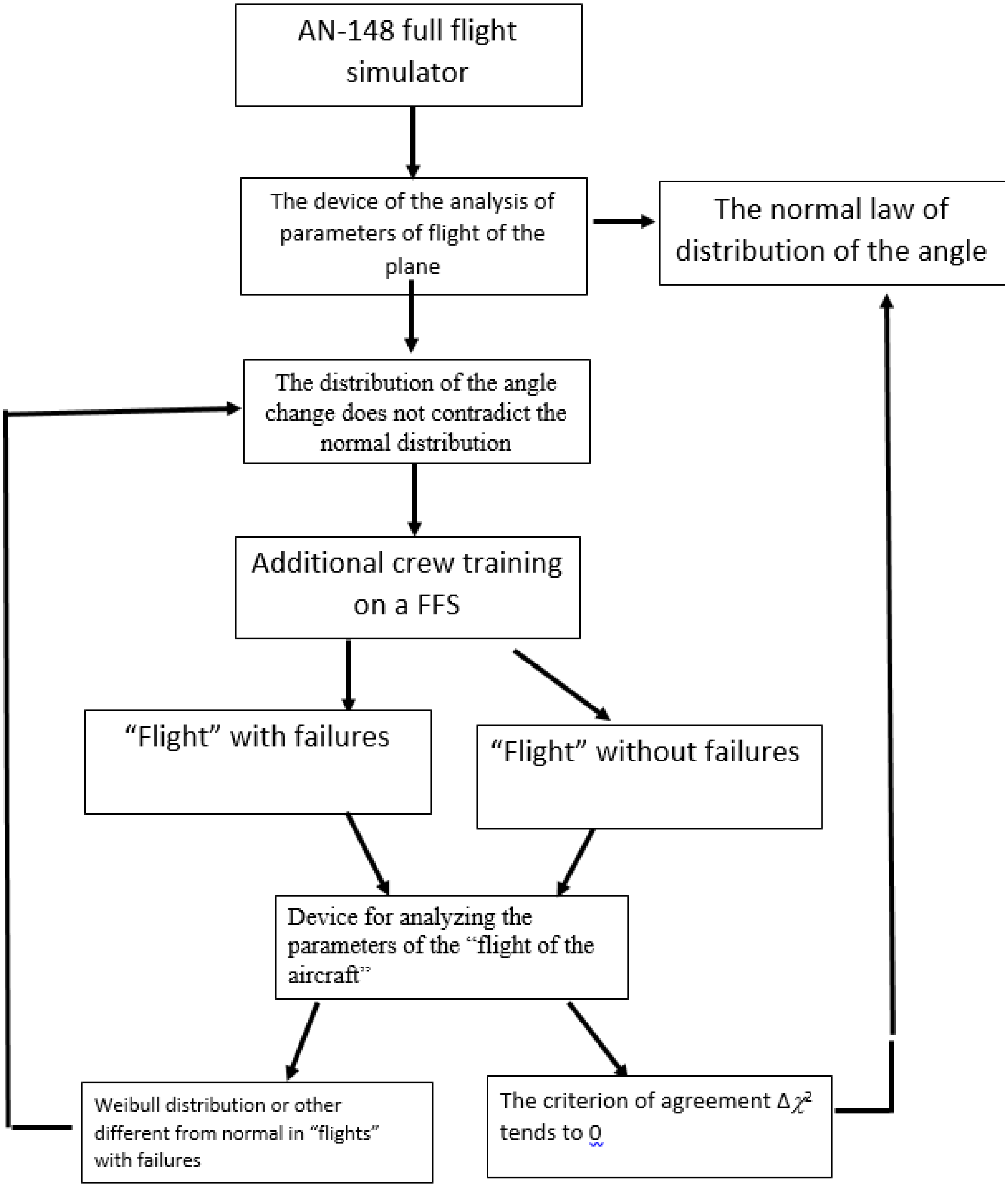
Propose a design diagram for the error reporting system of the speed indicator light or angle of attack indicator light.

And give recommendations on the pilot's actions in this situation.

When the tension (pressure) of the crew increases, the crew will behave incorrectly.

The proposed method for assessing the quality of driving skills should be applied to full-fledged flight simulators.

According to our recommendation, if the system indicates an error rate or the speed of the faulty device, you should also manage the simulator's performance.



When processing a large amount of data, it was found that with positive flight results, the distribution of the bank angle change does not contradict the normal distribution, and with negative results, it does not contradict the Weibull distribution.

Conclusion

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