МІНІСТЕРСТВО ОСВІТИ ТА НАУКИ УКРАЇНИ

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Кафедра конструкції літальних апаратів

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
д-р техн. наук, проф.
_____________ С. Р. Ігнатович
«_____»___________2021 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)
ЗДОБУВАЧА ОСВІТНЬОГО СТУПЕНЯ
"БАКАЛАВР"

Тема: «Аванпроект пасажирського дальньомагістрального літака пасажиромісткістю до 240 осіб**»**

Виконав: ___________**Ван Лулу**

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Київ 2021

MINISRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL AVIATION UNIVERSITY

Department of Aircraft Design

APPROVED
Head of Department
Professor, Dr. of Sc.
_________S.R. Ignatovych
«_____»_____2021

DIPLOMA WORK

(EXPLANATORY NOTE)

OF EDUCATIONAL DEGREE

«BACHELOR»

Theme: «Preliminary design of the long-range passenger aircraft with 240 passenger capacity»

Performed by: _____**Wang Lulu**

Supervisor: PhD, associate professor ______**V.I. Zakiev**

Standard controller: PhD, associate professor ______**S.V. Khyzhnyak**

Kyiv 2021

NATIONAL AVIATION UNIVERSITY

Aerospace Faculty

Department of Aircraft Design

Educational degree «Bachelor»

Major 134 "Aviation and space rocket technology"

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«______»_____2021р

TASK

for bachelor diploma work

Wang Lulu

1. Theme: «Preliminary design of the long-range passenger aircraft with 240 passenger capacity» Confirmed by Rector's order from 21.05.2021 year No 815/ст.
2. Period of work execution: from 24.05.2021 year to 20.06.2021 year.
3. Initial data of project: cruise speed V_{cr}= 871 km/h, flight range L = 8000 km, operating altitude H_{op} = 11 km.
4. Explanation note contains : introduction; course project part: analysis of prototypes and brief description of designing aircraft, selection of initial data; calculation part: wing geometry calculation and aircraft layout, landing gear design, engine selection, center of gravity calculation, special part: introduction and calculation of the passenger seat.
5. List of the graphical materials: layout of the airplane (A1×1); general view of the airplane (A1×1); passenger seats (A1×1).
6. Calendar Plan

Task	Execution period	Signature
Task receiving, processing of statistical data.	25.05.2021 – 27.05.2021	
Aircraft take-off mass determination.	28.05.2021 – 29.05.2021	
Aircraft centering determination.	28.05.2021 – 29.05.2021	
Graphical design of the aircraft and its layout.	30.05.2021 – 03.06.2021	
Procedure for Passenger seat design and calculations	01.06.2021– 04.06.2021	
Completion of the explanation note.	04.06.2020 – 9.06.2020	
Preliminary defense	9.06.2020	

7. Task issuance date: 25.05.2020

Supervisor of diploma work __________V.I. Zakiev

Task for execution is given for __________Wang Lulu

ABSTRACT

The diploma work «Preliminary design of a long-range passenger aircraft with 240 passenger capacity» include:

52 sheets, 7 figures, 9 tables, 17 references, and 3 drawings.

Object of the design is to development of long-range passenger plane with 240 passenger capacity.

The goal of the diploma work is to create a preliminary design for an airplane and estimate its characteristics.

The design methodology is based on prototype analysis and the selection of the most advanced technical judgements.

The diploma work includes drawings of design of the long-range passenger aircraft with a seating capacity of 240 people, drawings of the aircraft layout and calculations , the new passenger seat for preventing the pandemic.

PASSENGER AIRCRAFT, PRELIMINARY DESIGN, CENTER OF GRAVITY CALCULATION, CABIN LAYOUT, PASSENGER SEAT DESIGN, SEAT RECLINER.

Format	№	Designation	Na me	Quantity	Notes
			General documents		
A4	1	NAU 21 05W TT	Task of work	1	
	2		Long-range passenger aircraft	2	
A1		NAU 21 05W 00 00 00 11 GV	General view		
A1		NAU 21 05W 00 00 00 11 AL	Fuselage layout		
A4	3	NAU 21 05W 00 00 00 11EN	Long-range passenger aircraft	52	
			Explanatory note		
A1	4	NAU 21 05W 25 50 00 11 PS	Passenger seat development	1	

Ch.	Sheet	Doc.№	Sign.	Date	NAU 21 05W 00 00 00 11 EN			
Performed by	Wang Lulu.				List of diploma work	List	Sheet	Sheets
Supervisor	V.I. Zakiev.							
Adviser						AF 402 134		
Stand. contr.	Khyzhnyak S.							
Head. of dep.	gnatovych S.							

CONTENT

Department of Aircraft Design				NAU 21 05W 00 00 00 11 EN			
Performed by	Wang Lulu				List	Sheet	Sheets
Supervisor	V.I. Zakiev.						

Introduction

With the advancement of aviation science and technology, as well as the advancement of civilization, it is becoming increasingly difficult for ground transportation to satisfy people's travel demands. Because of its advantages like as speed and comfort, air transportation has been a thriving major sector since the invention of the airplane.

The primary phases of analysis and calculation include calculating the takeoff gross weight, the wing load, and the takeoff thrust weight ratio, and the wing load, selecting the kind of airfoil, determining component geometry parameters, designing the fuselage and cabin, and calculating the gravity center.

The following are the general requirements for civil aircraft design:

(1) Aerodynamic properties: the interference resistance of the airfoil-fuselage nacelle is low, and the overall lift-drag ratio is high.

(2) Structural characteristics: complete use of structural elements;

(3) Center of gravity: The position of the cargo, fuel, and the aircraft's center of gravity should be as near as feasible.

(4) Operation stability characteristics: the tail's critical Ma number is bigger than the wing's.

(5) Maintainability: The engine and all of the equipment are simple to inspect.

(6) Market factors: Research market (consumer) layout preferences.

The goal of this course project is to develop an aircraft capable of transporting 240 people and luggage across great distances.

1. PROJECT PART

1.1. Analysis of prototypes and brief description of aircraft

Before developing a new airplane, it's a good idea to look at statistics from other planes of the similar type [1]. These data should be presented in the form of tables, the contents and structure of which should meet the goals and tasks of the early design phases. The statistic tables provide the major metrics and features of prototype airplanes that are identical to the design airplane in terms of type and payload weight and flying range values. When it comes to prototype airplanes, you should choose mass-production planes with correct parameters that can be calculated from books over experimental planes with parameters and performance characteristics that are frequently preliminary and conditional. Furthermore, the experimental airplane's performance can be dramatically altered throughout development. Table 1 displays prototype statistical data.

The parameters of the aircraft in service are shown in the table 1.

Table 1 – Prototype operational-technical data [1] ;

PARAMETER	Planes		
	A340-200	A321	A310-300
The purpose	passenger	passenge r	passenger
Crew/flight attend. persons	2/2	2/2	2/2
Maximum takeoff weight, m_{tow}, kg	168708	89000	150000
Most pay-load, $m_{к.max}$, kg	51000	36400	33000
Passenger's seat	250	220	280
The height of the flight $V_{w.\ ек.}$, m	11000	11277	10668
Range $m_{к.max}$, km	8000	2300	4300
Take off distance $L_{зл.д.}$, m	2790	2000	2290

Number and type of engines	4xCFM-56-5C2	4xCFM-56-5B3	4152
The cross-section fuselage shape	circular	circular	circular
Extension of the fuselage	9	11.27	8.0
Extending the nose and tail unit part	4.1	4.8	4.2
Sweepback on 1/4 chord, ^{0}	34	29.7	28

1.1.1 Choice of the project data

The aircraft prototypes that were employed in the design of the aircraft were in the holding of 250 passengers. Airbus 240-200 is an example of such a plane.

The scheme is established by the aircraft units' relative position, number, and form. The layout and aerodynamic scheme of the aircraft affect its aerodynamic and operational characteristics. Lucky decisions can improve flying safety and regularity, as well as the aircraft's economic efficiency. The aircraft plan specifies the number, shape, and relative location of the aircraft's principal components, which include the wings, tail, fuselage, take-off and landing gear, and the number and location of engines and their air intakes. The aircraft schemes have a great influence on the aircraft's performance and characteristics, and ultimately determines the aircraft's overall efficiency. Each aircraft's schemes is tailored to its model, operational circumstances, and the primary needs of the aircraft design. The essential factors to consider while choosing an aircraft solution are optimal PR, minimal airframe and takeoff weight, optimum lift-to-drag ratio, and optimum aircraft efficiency.

1.1.2 Brief description of the aircraft the main components

The propeller, cockpit , landing gear, fuselage, wings, engine, tail assembly are the essential components of an airplane. The plane is a low-wing cantilevered monoplane with bypass turbojet engines and three-wheel landing gear beneath the wings, featuring a single nose landing gear and two main landing gear. A swept-back airfoil with a high aspect ratio based on a breakthrough supercritical airfoil. The fuselage is round. The moveable vertical caudal fin is linked to a conventional structure on the caudal fin. The rudder and elevator are both aerodynamically balanced.

1.1.3 Fuselage

Fuselage design requirements:

(1) Loading requirements: enough interior volume for passengers, crew, utilized objects, luggage, freight, system installation, and so on.

(2) Pneumatic needs: low aerodynamic resistance

(3) Structural needs: These are criteria that are favorable to structural arrangement, such as the installation of wings and tail fins and the engine layout.

(4) Requirements for seaworthiness: emergency evacuation and collision resistance. The fuselage is made entirely of metal and is built with beam strings (like a semi-single cabin). The presence of a rather thick skin supported by longitudinal beams and frames distinguishes this type of construction[2].

The cockpit has two seats for two pilots. The cockpit must have enough room for the pilot and any extra crew members. The approximate arrangement of the cockpit may be seen in the perspective depicted in Fig. 1.

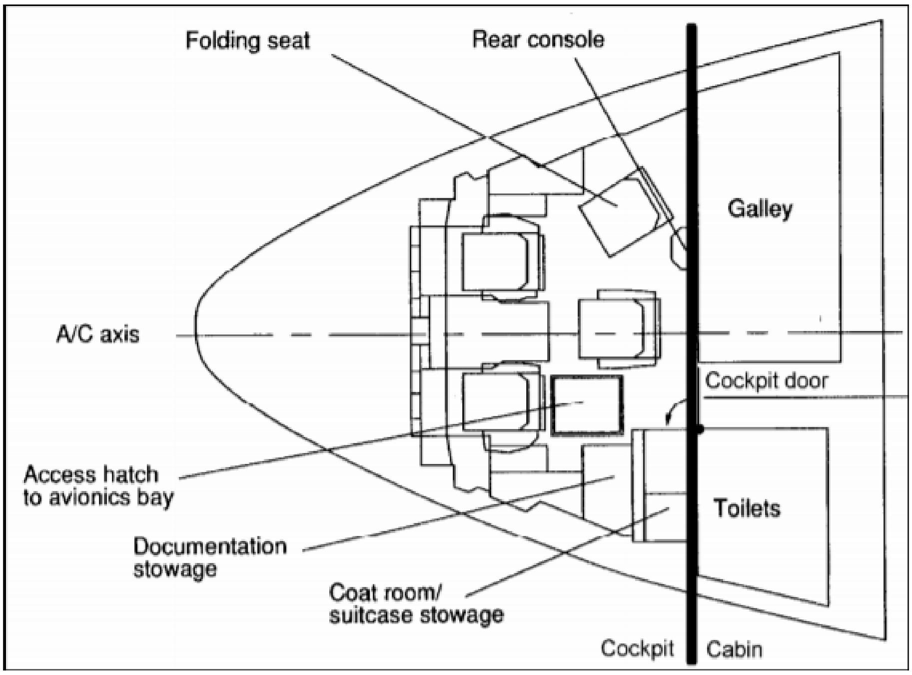


Figure 1. – Cockpit layout

The cabin design specifications are as follows:

(1) Shapes: Circular or multi-segment arc shape; A small surface area is advantageous for reducing friction resistance. It is effective at withstanding internal pressure in confined compartments.

(2) Width: Breadth varies according on the number of seats in each row, the width of the seats, the number of aisles, and the width of the aisles.

(3) Height: This is determined by cargo space, floor height, cabin height, and luggage rack space.

(4) Cabin length: the number of seats in each row, the total number of passengers, and the row spacing. The kitchen, cloakroom, boarding gate, and both emergency exits are all included.

The length of the hallway is also somewhat longer for comfort and space demands, which is also a future trend.

Passengers' personal things can be stored on overhead racks on both sides of the cabin. At the bottom of the racks, there are separate ventilation nozzles, lamps, buttons to switch on separate lighting, call buttons for flight attendants, and seat lights. The general interior illumination is positioned in the center of the ceiling, and both sides and the bottom portion of the luggage compartment are lighted.

The following chambers and compartments are placed underneath the fuselage's floor: the cargo compartment in front, the cargo compartment in back, and the technical compartment The cargo compartments in the front and back are hermetic, have a hatch on the right side, and are fitted with a container locking mechanism.

1.1.4 Wing

Wings, which are connected to the fuselage, are one of the most significant elements of an airplane. Its primary function is to provide lift, but it may also be installed in the wings of ammo and fuel tanks, and it may also be a collection of landing gear in flight. Furthermore, flaps and ailerons used for aircraft lateral control are put on the wing to improve takeoff and landing performance, with some placed on the leading edge of the wing slits and other devices to increase lift [3] .

Airplanes, since they fly in the air, are significantly distinct from other modes of transportation and machinery. In the case of can satisfy the structural strength and stiffness as light as possible, the wing is no exception, combined with the wings is a major part of the lift, and many of the plane's engine is mounted on the wing or wing, so on the load is larger, this requires the wings have a very good structural strength to withstand a load of this huge, but also has great elasticity.

The wing is made up of a longitudinal and transverse set, as well as a skin.

The connection between the wing SPAR and the fuselage is made of high strength structural steel. The wing skin is constructed of duralumin, which has strong compression capabilities as well as tensile and fatigue capabilities. The front and rear margins of the wings are built of fiberglass reinforced plastics (fiberglass reinforced plastics) or aluminum honeycomb laminates to save weight (cores).The tail wing's structural material is super duralumin.

Maneuverability is not a high priority for airplanes. Side straps, low-speed ailerons on the outside, high-speed ailerons on the inside, three-slit trailing edge flaps, and aluminum structure spoilers on the upper surface of each wing are all absent. Small wings are attached to the wing tips to enhance the aspect ratio and minimize induced drag. I make use of sweeping wings. It has the benefit of successfully increasing the critical Ma number, delaying the creation of shock waves, and avoiding early wave resistance. The downside of the swept-back wing is that when the angle of attack is high, the wingtip is more likely to stall first, reducing the aircraft's stability and agility. This is a negative impact on the structural arrangement of the airfoil as well as its strength, stiffness, and weight.

1.1.5 Tail unit

The tail unit consists of a sweeping tail with a longitudinal tail and a horizontal tail. The tail unit is a device that is fitted in an aircraft's tail to improve flying stability, including horizontal tail and vertical tail. The vertical tail is made up of the tail and rudder, and the horizontal tail is made up of the elevator and the horizontal tail.

The tail wing may be used to adjust the aircraft's fly attitude by controlling its pitch, yaw, and tilt. The tail is an essential component of the flight control system.

The horizontal tail position is required in the following manner:

(1) to avoid wing tail vortex interaction.

(2) The horizontal tail is positioned above and below the wing's chord plane, and its location is less than 5% of the average aerodynamic chord length, which may fulfill the requirements of longitudinal stability at high angles of attack[4].

(3) to avoid unwanted influence from jet flow near the engine's tail.

(4) favorable to structural layout

(5) The horizontal tail fin mounted on the fuselage helps to lower the structure's weight.

The top horizontal tail is used for the economy and safety of the structural weight, and flow interference may be prevented to some extent. A single vertical tail can suit aircraft control needs.

1.1.6 Crew cabin

The ergonomic cockpit design may give pilots with a comfortable posture, adequate flying vision, and a suitable controller layout. In order for the pilot to fulfill the air mission safely and successfully, the aircraft's performance is indirectly improved. A commercial airline's air cabin crew is jointly responsible for the safety and comfort of its passengers. Among the responsibilities include welcoming passengers as they board and depart the plane. directing guests to their seats and paying extra care to specific guests, such as the elderly or disabled.

The crew's haphazard employment of a tapered windscreen gives the pilot an excellent overview and fits the criteria of fly operation under predicted conditions. The pilot may be controlled manually or automatically from anywhere.

Equipment and optical signal equipment are installed on the pilot control panel in line with airworthiness norms. Review the rapid use of the control panel to command the radio and automatic control system at the top of a control panel, in an ideal place.

On the top control panel of the onboard system is a panel for gasoline, hydraulic, power, antifreeze, air conditioning, engine and APU start, fire switches, and alert alarm systems. The navigation and landing equipment panels, as well as the typical joystick engine, are located in the center pilot panel [5] .

1.1.7 Passenger furnishing

The plane's passenger equipment supplies the plane with the essential convenience. It has adjustable flight attendant seats, pilot chairs and passenger seats, as well as light-protective shutters light filters, and a toilet.

The following items are included :

• Lining and insulation

• Passenger seats

• Overhead stowage bins

• Attendant/lavatory service units

• Class dividers
• Cabin attendant station
• Air return grilles
• Passenger service units
• Windscreens

The restroom and kitchen are located between the crew and the cabin (the toilet is on the left and the kitchen on the right). The toilet has a surface size of one square meter. In the toilet, there is a tank that stores water and technical fluids. The flush toilet has a water vacuum flush toilet. On board, there were three first-aid kits (one in the cabin, one included in the structure of the crash equipment, and one at the tail) [6].

Oxygen masks, ropes, oxygen equipment smoke masks, manual fire extinguishers, axes, first aid kits, radio beacons, emergency radio stations and light marked evacuation methods, emergency lighting, board "exit" of each emergency exit, life jackets for crew members and observers working in the vicinity are all part of the emergency equipment. The crew and passengers were transported on the life raft.

1.1.8 Control system

The airplane control system includes the stabilizers, ailerons, air brakes, elevator control system, rudder, spoilers, fins, and flaps.

The function of the flight control system is to guarantee the aircraft's stability and operability, to increase the aircraft's flying performance and capacity to accomplish tasks, to increase flight safety, and to minimize the pilot's workload. The flight control system is separated into two parts: manual flight control and automatic flight control [7] .

The artificial flight control system is the mechanism in which the pilot controls the steering stick and pedal. The mechanical control system is the most basic manual flight control method.

The automatic flight control system is the flight control system that completes the control task without the pilot having to use the joystick and pedals. The most basic automatic flight control system is the autopilot. The flight control system is made up of the following components: a control display device, a sensor, a flight control computer, an actuator, a self-testing device, an information transmission chain, and an interface device.

The control display device is a device that allows the pilot to submit flight control commands and retrieve flight control system status information. It consists of the pilot lever, pedal, throttle lever, control panel, specific indication board, and electronic display.

1.1.9 Landing gear

Landing gear is a type of take-off and landing equipment that allows an aircraft to taxi, take off, land, taxi, and taxi after landing at an airport. The landing gear bears all of the aircraft's weights and loses the majority of its kinetic energy while taxiing.

Landing gear as an aircraft component, of course, must fulfill the standard criteria of aircraft structural design, that is, to minimize the weight of the landing gear structure while providing strength, stiffness, and a specified life. Landing gear must be simple to operate and maintain, as well as simple to inspect, repair, and replace, and must fulfill aerodynamic, technical, and economic requirements.

The main requirement of landing gear :

• The landing gear must ensure the aircraft's good stability, maneuverability, and adaptability as it moves on the ground.

• The landing gear must be able to absorb a certain quantity of vertical and horizontal kinetic energy and normal impact loads on landing, in order to reduce the effects of overload on landing and high-speed slip, and quickly dissipate the impact of kinetic energy, so that the aircraft can land safely.

• The landing gear must have high braking capability in order to decrease landing distance and runway length. The connection between the landing gear and the fuselage structure should be reasonable and reliable, and it should be readily compressed into the fuselage during flight to minimize flight resistance and increase the aircraft's flying performance [8].

• Landing gear is frequently employed in extreme conditions such as temperature, humidity, vibration, dust, and salt spray. Sealing must be considered during design to avoid dust from entering the shock absorber or shaft chamber. Landing gear accessories should also be well-organized.

To ensure the safety of the landing gear compartment, avoid tires entering exposed mechanisms, cables, and hydraulic pipes, etc. that are damaged by external objects.

1.2 . Main parts of the aircraft geometry calculations

The purpose of the planned aircraft, its major size, and the usage requirements are used to calculate aircraft layout. The geometrical calculating principle of the wing, fuselage, tail fin, landing gear, and other structural parts is included in the layout.

The selection of a power plant and an interior scheme is also part of the analysis .Dimensional estimates based on aircraft capacity needs are included in the internal program estimates. This design adheres to contemporary standards and employs complex mathematical methods.

1.2.1. Wing geometry calculation

The wing geometrical properties are dictated by the takeoff weight m_0 .

Also, the particular wing load should be considered.

Extension full wing area is equal:

$$S_{wfull}=\frac{m_0 \cdot g}{P_0}=\frac{168708 \cdot 9.8}{6567}=252 m^2$$

The area of the relative wing expansions is 0.1.

The are of wing:

$$S_w = 252 \cdot 0.9 = 226.8\text{m}^2$$

Wing span :

$$l = \sqrt{s_w \cdot \lambda_m} = \sqrt{252 * 9.26} = 48\text{m}$$

Tip chord :

$$b_t = \frac{b_0}{\eta_w} = 2.108m$$

Root chord :

$$b_0 = \frac{2S_w\eta_w}{(1+\eta_w)\cdot l} = 8.39m$$

The maximum wing width is defined in the forehead i-section and is equal to its span:

$$c_i = c_w \cdot b_t = 0.128 \cdot 2.108 = 00.2698m$$

For a trapezoidal-shaped wing, the on-board chord is:

$$B_{ob} = b_0 \cdot (1 - \frac{(\eta_w - 1)\cdot D_f}{\eta_w \cdot l_w}) = 8.39 \cdot (1 - \frac{(3.98-1)\cdot 5.64}{3.98 \cdot 48}) = 7.652m$$

To select the force scheme of the wing, the kind of its internal design must be determined. The box-spar type with three spars was chosen to satisfy the criteria for strength while keeping the construction relatively light[9].

We employ a triple – slotted flap wing on contemporary aircraft; the wing also has three longerons.

I used the geometrical approach of determining the mean aerodynamic chord (figure 2.). The mean aerodynamic chord equals:

$$b_{MAC} = 5.8755m$$

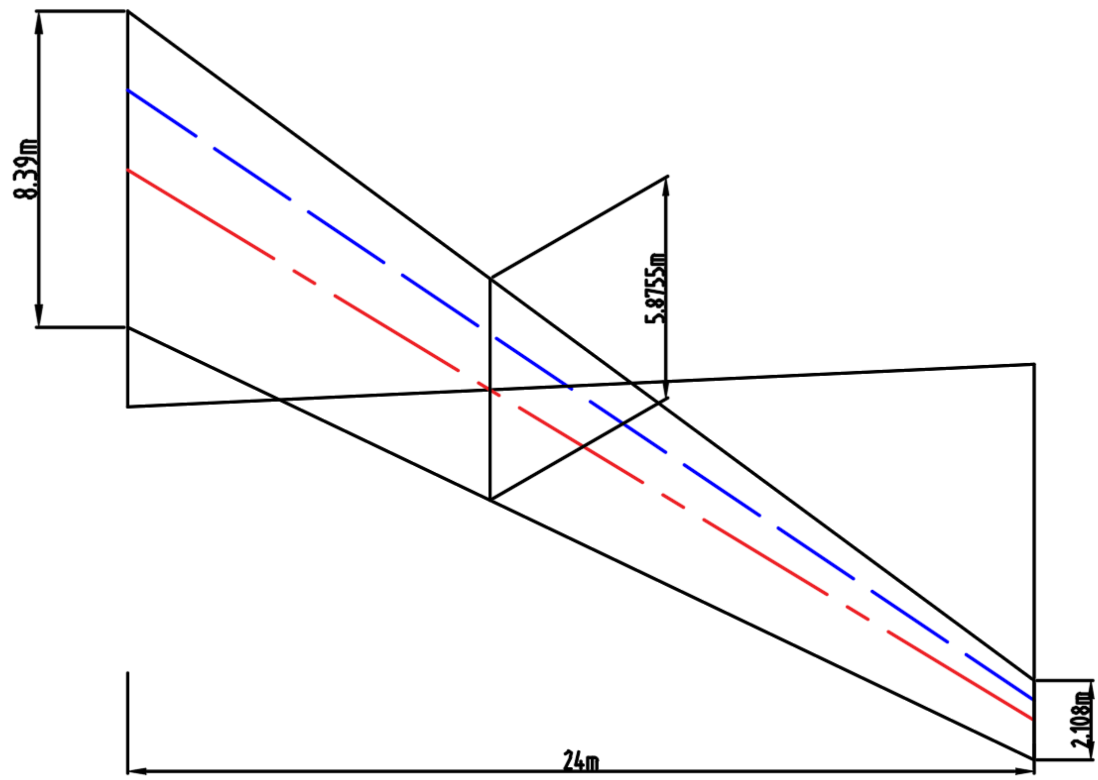


Figure 2.– Determination of mean aerodynamic chord

We can estimate the geometrics of the aileron and high-lift devices after establishing the geometrical features of the wing.

The geometrical parameters of the ailerons are determined as a result of the following:

Ailerons span:

$$l_{ai} = 0.35\frac{l_w}{2} = 0.35 * \frac{48}{2} = 8.4m$$

Aileron area:

$$S_{ail} = 0.06\ \frac{S_w}{2} = 0.06 * \frac{252}{2}=7.56\ m$$

Area of ailerons trim tab.

For four engine airplane:

$$S_{tail}=0.06\cdot S_{ail}=0.06\cdot 7.56=0.4536\ m^2$$

The purpose of calculating the geometric parameters of the wing high-lift devices is to offer the high coefficients of wing during landing and taking off, which were predicted in early calculations based on the high-lift device selection rate and type of airfoil.

Before doing the following calculations, it is required to choose the kind of airfoil from the airfoil catalog, choose the amount of the lift coefficient, and estimate the necessary increase due to the high-lift devices outlet. The formula is :

$$\Delta C_{ymax} = \frac{Cy\,max\,l}{C_y\,max\,b_w} = \frac{2.29}{1.879} = 1.2187$$

Where $C_{y\max l}$ is the coefficient of lifting force required in the landing configuration of the wing by the airplane landing insuring (This parameter is determined when selecting the aircraft)

The rate of the relative chords of wing high-lift devices in current design is according to the standard :

b_f = 0.3..0.4 – for three slotted flaps.

b_s = 0.1..0.15 – slats.

The effectiveness of high-lift devices (C^*_{ymaxl}) increases proportionately to the increase in wing span served by high-lift devices. as a result, we need to maximize the spread of high lift devices ($l_{hld} = l_w - D_f - 2l_{ail} - l_n$) by the employment of a flying spoiler and minimize the size of the engine and landing gear nacelles [11].

To pick the structural dynamic scheme, kinematics of the high lift device, and hinge mounting scheme, we must utilize data and experience from domestic and foreign aircraft manufacture. It is worth noting that the bulk of present high-lift device components are accomplished by longeron structurally-power systems.

1.2.2 Fuselage layout

In general, fuselage layout estimates comprise of calculating the primary geometrical dimensions and designing the inside scheme.

Wave resistance has little effect on its suitability for subsonic passenger and freight aircraft (V < 800 km/h) [12].

As a result, we must choose the friction resistance C_{xf} and the profile resistance C_{xp} from the condition table.

The design of the fuselage nose portion impacts the value of wave resistance C_{xw} during transonic ,the same for subsonic flights.

The C_{xw} value of wave resistance during transonic and subsonic flight is influenced by the design of the fuselage nose part. The round form of the fuselage nose portion considerably reduces its wave resistance.

For transonic airplanes fuselage nose part has to be:

$$l_{nfp} = 1.8 \cdot D_f = 1.8 \cdot 5.64 = 10.152m$$

In addition to considering aerodynamic needs while selecting a cross section form, we must also consider strength and layout needs.

The most suitable fuselage cross section design for guaranteeing least weight is circular cross section. In this situation, we have the smallest possible fuselage skin width. As an example, consider combining not less than two horizontal or vertical series of circles.

We are concerned with the following geometrical parameters: fuselage length l_f; fuselage diameter D_f; fuselage aspect ratio λ_f; tail unit aspect ratio λ_{TU} ;The length-to-diameter ratio of the fuselage nose λ_{TU} . The fuselage length is decided by taking into account the aircraft design, layout, and airplane center-of-gravity position peculiarities, as well as the landing angle of α_{land} assuring requirements.

The length of the fuselage is :

$$l_f = \lambda_f \cdot D_f = 9 \cdot 5.64 = 50.76m$$

The aspect ratio of nose part is:

$$\lambda_{fnp} = \frac{l_{fnp}}{D_f} = \frac{10.152}{5.64} = 1.8$$

The rear part of fuselage length is:

$$l_{frp} = \lambda_{\mathrm{fr}\,p} \cdot D_f = 3.5 \cdot 5.64 = 19.74m$$

One of the primary criteria used to calculate an airliner's middle section is its altitude. We attempted to approach the minimal middle S_{ms} from one side and the layout criteria from the other while deciding the airframe length.

The size of the passenger saloon or freight cabin determines the mid-section of the fuselage for both passenger and freight aircraft.

For long range airplanes correspondingly: the height as: h_1=1.9m; passage width b_p=0.6m; the distance from the window to the flour h_2=1m; luggage space h_3=0.9...1.3m.

The equivalent height for long-range aircraft is:h_1=1.9m; the channel width is b_p=0.6m ; and the distance from the window to the flour is h_2=1m. The range of luggage compartment H_3 = 0.9...1.3 .

I choose the next parameters:

Cabin height is equal:

$$H_{cab}=0.296+0.383B_{cabin}=0.296+0.383\cdot 5.16=2.27m$$

From a design standpoint, it is preferable to have a circular cross section since it will be the strongest and lightest. In most circumstances, one of the most appropriate techniques is to use the intersection of two circles or the oval form of the fuselage. We must keep in mind that the oval form is not viable for manufacturing since the upper and lower panels would flex owing to excess pressure, necessitating additional bilge beams and other construction amplifications.

The standard fuselage bulkhead step is 360...500mm, depending on fuselage type and cabin class. We do not employ this form since the diameter of the crossing circle is smaller than 2800mm. Instead, we follow the cross section of the intersecting circle. In this scenario, the flour from Passenger cabin was produced aboard a plane that was about to be grounded.

The windows were arranged in a row. The window has a circular form with a diameter of 300...400mm, or a rectangle with rounded edges. The window level is 500...510 mm, which corresponds to the bulkhead level.

To establish the necessary cabin width, seats in economy class cabins are assigned in a row (2+4+2).

$$B_{cab} = n_2 b_2 + n_3 b_3 + n_{aisle} b_{aisle} + 2\delta = \ 2 \cdot 1000 + 2100 + 2 \cdot 480 + 2 \cdot 50 = 5.16$$

m

The length of passenger cabin is as follow:

For Business Class:

$$L_{cab} = L1 + (n_{rows} - 1) \cdot L_{seatpitch} + L2 = 1400 + (5-1)*1050 + 300 = 5900 \text{ m}$$

For Economy Class:

$$L_{cab} = L1 + (n_{rows} - 1) \cdot L_{seatpitch} + L2 = 1300 + (30-1)850 + 300 = 27.1 \text{ m}$$

So, the total length is equal:

$$L_{cab} = 5.9 + 27.1 = 33m$$

1.2.3 Luggage compartment

Due to the standards, I choose the unit load on floor K = 600 kg/m^2

The cargo compartment area is defined as follows:

$$S_{cargo} = \frac{M_b ag}{0.4k} + \frac{Mcargo}{0.6K} = \frac{20 \cdot 240}{0.4 \cdot 600} + \frac{15 \cdot 240}{0.6 \cdot 600} = 30m^2$$

The volume of the cargo compartment is :

$$V_{cargo} = v \cdot n_{pass} = 0.2 \cdot 240 = 48m^3$$

Luggage compartment design similar to the prototype

1.2.4 Galleys

International rules require that if the plane has a mixed configuration, two servings be prepared. During the flight, there should be cupboards for water and tea. Kitchen cabinets should be placed near the entrance, especially between the cockpit and the cabin entrance or cargo door. Refreshment and food cannot be put near the restrooms or connected to the wardrobe.

Volume of galleys is equal:

$$V_{galley} = 0.1 \cdot 240 = 24 \ m^3$$

Area of galleys is equal:

$$S_{galley} = \frac{V_{galley}}{H_{cab}} = \frac{24}{2.27} = 10.5 \ m^2$$

The Weight of breakfast, lunch and dinner for every passenger– 0,8 kg; tea and water – 0,4 kg;

The food weight is :

$$W_{food}=(0.8+0.4)\cdot 240=288kg$$

Galleys design similar to prototype.

1.2.5 Lavatories

The number of bathroom facilities is dependent on the number of passengers and the length of the flight. The plane which I designed duration time is more than 4 hours, So one toilet is use for 40 passengers.

The number of lavatories I select is determined by the original airplane and is equal to:

$$N_{lav}=\frac{240}{40}=6$$

Area of lavatory:

$$S_{lav}=1.5m^2$$

1m is the width of the lavatory. Toilets with a similar design to the prototype.

1.2.6 Layout and calculation of basic parameters of tail unit

One of the most important roles of the aerodynamic layout is the positioning of the tail unit. To provide longitudinal stability under overloading, the aircraft's center of gravity should be located in front of the aircraft focus, and the distance between these locations, related to the wing mean aerodynamic chord, determined the rate of longitudinal stability.

$$m_x^{Cy}=\bar{x}_T-\bar{x}_F<0$$

Where $m^{Cy}{}_x$ – is the coefficient of moments and $x_{T.}$ x_F- is the center of mass and focus coordinates. If $m^{Cy}{}_x=0$, the airplane possesses neutral longitudinal static stability. If $m^{Cy}{}_x>0$,, then the aircraft is in a static state of instability. The center of the composite wing-fuselage is relocated into the standard aircraft configuration when the tail wing element is installed (the tail wing unit is behind the wings). Static moment coefficient range: horizontal A_{htu}, vertical A_{vtu} . The table shows the relationship between typical arm H_{tu} and V_{tu}. Tables may be used to find the initial technique of calculating geometric parameters [14].

The geometrical parameters of the tail unit are determined.

The area of the vertical tail unit is :

$$S_{VTU}=\frac{l_w S_w}{L_{VTU}}\cdot A_{ATU}=\frac{48\cdot 252}{25.5}\cdot 0.065=31.2m^2$$

Area of horizontal tail unit is equal:

$$S_{HTU}=\frac{b_{MAC}\cdot S_w}{L_{HTU}}\cdot A_{HTU}=\frac{7.8462\cdot 252}{25.5}\cdot 0.66=51.175m^2$$

Some factors influence the L_{htu} and L_{vtu} values.. First and foremost, their worth is controlled by the length of the nose and tail parts of the fuselage, sweptback and wing placement, as well as the airplane's stability and control circumstances.

The elevator's area and direction are determined as follows:

Area of the altitude elevator:

$$S_{el}=0.35\cdot S_{HTU}=17.911\ m^2$$

Rudder area:

$$S_{rud}=0.4\cdot S_{vtu}=12.48\ m^2$$

Choose the area of aerodynamic balance.

$0.3\le M\le 0.6$, $S_{eb}=(0.22..0.25)S_{ea}$, $S_{rb}=(0.2..0.22)S_{rd}$

Elevator balance area is equal:

$$S_{eb}=0.235\cdot S_{HTU}=12.026\ m^2$$

Rudder balance area is equal:

$$S_{rb}=0.22\cdot S_{vtu}=6.864\ m^2$$

The area of altitude elevator trim tab:

$$S_{te}=0.10\cdot S_{el}=1.7911\ m^2$$

Area of rudder trim tab is equal:

$$S_{tr}=0.05\cdot S_{rud}=0.624\ m^2$$

Root chord of horizontal stabilizer is:

$$b_{0HTU} = \frac{2S_{HTU} \cdot \eta_{HTU}}{(1+\eta_{HTU}) \cdot l_{HTU}} = \frac{2 \cdot 51.175 \cdot 2.857}{(1+2.857) \cdot 13.236} = 5.7278\text{m}$$

Tip chord of horizontal stabilizer is:

$$b_{0HTU} = \frac{b_{0HTU}}{\eta_{HTU}} = \frac{5.7278}{2.857} = 2.0048m$$

Root chord of vertical stabilizer is:

$$b_{0VTU} = \frac{2S_{VTU} \cdot \eta_{VTU}}{(1+\eta_{VTU}) \cdot l_{VTU}} = \frac{2 \cdot 32.572 \cdot 2.778}{(1+2.778) \cdot 7.0417} = 6.802m$$

Tip chord of vertical stabilizer is:

$$b_{0VTU} = \frac{b_{0VTU}}{\eta_{VTU}} = \frac{6.802}{2.778} = 2.449m$$

1.2.7 Landing gear design

Only a portion of the landing gear characteristics may be calculated at the primary stage of design, when the airplane's center-of-gravity location is known and there is no depiction of the airplane's general view.

Main wheel axel offset is:

$$e = 0.275 \cdot b_{MAC} = 0.275 \cdot 5.8755 = 1.616\ m$$

When the back of the airplane is loaded first, the lift-off of the front gear during takeoff is complicated, and when it is minor, the airplane may drop on the tail. The term "landing gear wheelbase" is derived from the phrase:

$$B = 0.395 \cdot L_f = 0.395 \cdot 50.76 = 20.05m$$

The last equation means that the nose support carries 6...10% of aircraft weight.

Front wheel axial offset will be equal:

$$d_{ng} = B - e = 18.434m$$

Wheel track is:

$$T = 0.502 \cdot B = 0.502 \cdot 20.05 = 10.07m$$

In order to prevent a side nose-over, the value K should be more than 2H, where H is the distance from the runway to the center of gravity.

The take off weight determines the size and run stress on the landing gear wheels; for the front support, we also consider dynamic loading.

The type of pneumatics (half balloon ,balloon, arched) and pressure in it are determined by the runway surface. We use breaks on both the main wheel and, on sometimes, the front wheel.

The load on the wheel is determined:

Kg = 1.75 was used as the dynamics coefficient.

The nose wheel load is :

$$P_{NLG}=\frac{9.81\cdot e\cdot k\cdot m_0}{B\cdot z}=\frac{9.81\cdot 1.616\cdot 1.75\cdot 168708}{20.05\cdot 2}=108918N$$

Main wheel load is equal:

$$P_{NLG}=\frac{9.81\cdot (B-e)\cdot m_0}{(B\cdot n\cdot z)}=\frac{9.81\cdot (20.05-1.616)\cdot 168708}{(20.05\cdot 2\cdot 10)}=133922N$$

According to the load on the wheels, I will choose the following tire type on the table 2.

Table 2. Aviation tires for designing aircraft [15].

Main gear		Nose gear	
Tire size	Ply rating	Tire size	Ply rating
1400x 530R23	32	1050x395 R16	28

1.2.8 Choice and description of power plant

The CFM International CFM56 (US military designation F108) series of high-bypass turbofan aircraft engines is a French-American collaboration. With thrust ratings ranging from 31,200 to 34,000 lbf, the CFM56-5C series is the most powerful of the CFM56 family (139 kN to 151 kN). It first flew in 1993 and now powers Airbus' long-range A340-200 and -300 jetliners. The primary distinctions include a larger fan, a fifth low-pressure turbine stage, and the same four-stage low-pressure compressor as in the preceding series. The various parameters of the engine are presented in the table 3.

Table 3 – Examples of application CFM56 [16].

Model	Thrust	Bypass ratio	Dry weight	Applications
CFM56-5C2	31,200 lbf (139 kN)	6.6	8,796 lb (3,990 kg)	Airbus A340-211/-311
CFM56-5C3	32,500 lbf (145 kN	6.5	8,796 lb (3,990 kg)	Airbus A340-212/-312
CFM56-5B2	31,000 lbf (140 kN)	5.5	5,250 lb (2,380 kg)	Airbus A321

1.3 Center of gravity calculation

1.3.1 Trim-sheet of the equipped wing

The quality of an equipped wing includes the structure's quality, the equipment mounted on the wing's quality, and the fuel's quality. The main landing gear and nose landing gear are included in the mass register of the equipped wing regardless of where they are placed (on the wing or on the fuselage).The mass register stores the object's name, mass, and barycenter coordinates. The projection of the mean pneumatic string head point (MAC) on the XOY plane determines the origin of the provided centroid position. The positive interpretation of the centroid coordinate is accepted for the aircraft's tail.

The names supplied in table 4. were included in the example list of mass objects for the airplane, where the engines are positioned in the wing. AC has a mass of 91295 kg. The following formulae establish the coordinates of the equipped wing's center of power:

$$X_w^/ = \frac{\Sigma m_i^/ x_i^/}{\Sigma m_i^/}$$

Table 4. - Trim sheet of equipped wing

object name	Mass		Coordinat e of C.G Xм	Mass moment(kgm)
	units	total mass m(kg)		
wing (structure)	0.10688	18031.5110 4	2.46771	44496.54011
fuel system	0.01190	2007.62520	2.46771	4954.23678
airplane control, 30%	0.00132	222.69456	3.52530	785.06513
electrical equipment, 10%	0.00283	477.44364	0.58755	280.52201
anti-ice system , 50%	0.00945	1594.29060	0.58755	936.72544

hydraulic systems , 70%	0.00924	1558.86192	3.52530	5495.45593
power plant Engine1， 2	0.04279	7218.17178	-1.17510	-8482.07366
Engine 3， 4	0.04279	7218.17178	2.35020	16964.14732
equipped wing without landing gear and fuel	**0.22719**	**38328.7705 2**	**1.70709**	**65430.61906**
Nose landing gear	0.00446	752.94380	-18.16225	-13675.1536
Main landing gear 1,2	0.02078	3505.41482	3.23153	11327.8356 4
Fuel	0.38059	64208.5777	2.93775	188628.749 2
Total	**0.63302**	**106795.706**	**2.35695**	**251712.050**

1.3.2 Trim-sheet of the equipped fuselage

The origin of the coordinates is picked in the horizontal axis projection of the fuselage's snout. The fuselage construction portion is presented for axis X. Table 5. shows an example list of the items for the AC, which engines are positioned under the wing.

The FEF's CG coordinates are obtained using the following formulas:

$$X_f = \frac{\Sigma m_i' X_i'}{\Sigma m_i'};$$

We constructed the moment equilibrium equation relative to the fuselage nose after determining the C.G. of the fully equipped wing and fuselage:

$$m_f x_f + m_w (x_{MAC} + x_w') = m_0 (x_{MAC} + C)$$

From here, we calculated the wing MAC leading edge location relative to the fuselage, which yielded the following X_{MAC} value:

$$X_{MAC} = \frac{m_f x_f + m_w \cdot x_w^{/} - m_0 C}{m_0 - m_w}$$

where $\boldsymbol{m_0}$ – aircraft takeoff mass, kg; $\boldsymbol{m_f}$ – mass of fully equipped fuselage, kg; $\boldsymbol{m_w}$ – mass of fully equipped wing, kg; ***C*** – distance from MAC leading edge to the C.G. point, determined by the designer.

C = (0,22...0,25) $\mathbf{B_{MAC}}$ –low wing ;

C = (0,25...0,27) $\mathbf{B_{MAC}}$ – center wing;

C = (0,23...0,32) $\mathbf{B_{MAC}}$ – high wing;

For swept wings; at ***X*** = 30°...40° ***C*** = (0,28...0,32) $\mathbf{B_{MAC}}$

at ***X***= 45° C = (0,32...0,36) $\mathbf{B_{MAC}}$

Table 5. – Trim sheet of equipped fuselage

objects names	Mass		C.G coordinates Xi, м	
	units	total mass		mass moment
fuselage	0.08207	13845.8656	25.38	351408.0679
horizontal tail	0.00814	1373.28312	48.75	66947.5521
vertical tail	0.00863	1455.95004	48.75	70977.56445
radar	0.0026	438.6408	2.1	921.14568
radio equipment	0.0019	320.5452	1.1	352.59972
instrument panel	0.0045	759.186	2.2	1670.2092
aero navigation equipment	0.0038	641.0904	2.5	1602.726
lavatory1,2 galley 1,2	0.00327	551.67516	5.076	2800.303112
lavatory3,4 galley 3,4	0.00327	551.67516	20.304	11201.21245

lavatory5,6 galley 5,6	0.00436	735.56688	38.07	28003.03112
aircraft control system 70%	0.00308	519.62064	25.38	13187.97184
hydro-pneumatic sys 30%	0.00396	668.08368	35.532	23738.34932
electrical equipment 90%	0.02347	3959.57676	25.38	100494.0582
not typical equipment	0.0025	421.77	25.38	10704.5226
operational	0.0169	2851.1652	22.842	65126.3155
lining and insulation	0.0068	1147.2144	22.842	26204.67132
anti ice and air conditioning system	0.00367	619.15836	22.842	14142.81526
passenger seats (business)	0.0020864	352	9.6444	3394.8288
passenger seats (economic class)	0.009377	1582	30.456	48181.392
seats of flight attendance	0.0002964	50.0050512	27.918	1396.041019
seats of pilot	0.0002667	44.9944236	3.5	157.4804826
additional equipment	0.0082	1383.4056	22.842	31599.75072
loading device	0.0082	1383.4056	22.842	31599.75072
equipped fuel without payload	**0.2031465**	**34272.43972**	**26.4297**	**905812.3595**
main landing gear 3	0.01054	1778.18232	28.9332	51448.5047
Passengers(business)	0.0111529	1560	9.6444	15045.264

on board meal	0.00275	463.947	17.766	8242.482402
baggage	0.02845	4799.7426	25.38	121817.4672
cargo, mail	0.022725	3833.8893	25.38	97304.11043
crew	0.00119	200.76252	5.2	1043.965104
Passengers(economy)	0.08707	14690	30.456	447398.64
TOTAL	**0.3670244**	**61598.96346**	**26.755528**	**1648112.793**
TOTAL fraction	**1.0000454**	**168394.6703**	**27.203511**	**4580926.19**

1.3.3 Calculation of center of gravity positioning variants

Mass objects for center of gravity variant calculations are shown on the Table 6 .

Table 6. – Calculation of C.G. positioning variants

Name	mass in Kg	coordinate	mass moment
object	m_i	$X_{i,}$, м	Kg.m
equipped wing (without fuel and landing gear)	38328.77052	27.26948904	1045206
Nose landing gear (extended)	584.235804	7.400150135	4323.4327
main landing gear (extended) 1,2	3505.414824	28.79392514	100934.65
main landing gear (extended)3	1778.18232	28.9332	51448.505
fuel/fuel reserve	64208.57772	28.50015014	1829954.1

Equipped fuselage (without payload and lading gear3)	34272.43972	26.42976009	905812.36
passengers of business class	1560	9.6444	15045.264
passengers of economy class	14690	30.456	447398.64
baggage	4799.7426	25.38	121817.47
cargo	3833.8893	25.38	97304.11
crew	200.76252	5.2	1043.9651
nose landing gear (retracted)	584.235804	8.500150135	4966.092
main landing gear (retracted) 1,2	3505.414824	29.89392514	104790.61
main landing gear (retracted) 3	1788.18232	30.0332	53704.837
reserve fuel	6275.9376	28.32114	177741.71

Center of gravity calculation are giving in the following the Table 7.

Table7 – Airplanes C.G. position variants

Name	Mass(kg)	mass moment X_i	center of mass $X_{цм}$	center X_C %
take off mass(L.G. extended)	167762.0153	4620288.488	27.540731	0.336708464
take off mass(L.G. retracted)	167762.0153	4627043.437	27.580996	0.343444601
landing weight (LG extended)	109829.3752	2968076.091	27.024428	0.248834704
ferry version	142888.3834	3945477.955	27.612307	0.348890678
parking version	78469.04319	2107724.937	26.860592	0.220949987

1.4 conclusions

During this analytical aircraft design were defined next achievements:

- Preliminary design of the long-range passenger aircraft with 240 passenger capacity;
- cabin layout of the long-range passenger aircraft with 240 passenger capacity;
- center of gravity position for different load situations;
- selection of wheels that meet a requirement for theoretical load of 180 km/h: tire size for main wheel 1400x 530 mm and for nose wheel 1050x395 mm;
- applying of turboprop engines type CFM56-5C2, which are located on the wing, provides high cruise speed and good power-to-weight ratio.

During the center of gravity calculation, the final center of gravity, comprising wing geometry calculation, fuselage center gravity calculation, and types of equipment, should be at 50-60% of the fuselage. When it comes to engines, the CFM56-5C2 can offer considerable thrust.

The geometrical characteristics are nearly identical to the chosen prototype. This implies that my plane will be able to fly safely and successfully, as well as be recognized by passengers and join the market and compete with existing models

2. SPECIAL PART

2.1 Introduction

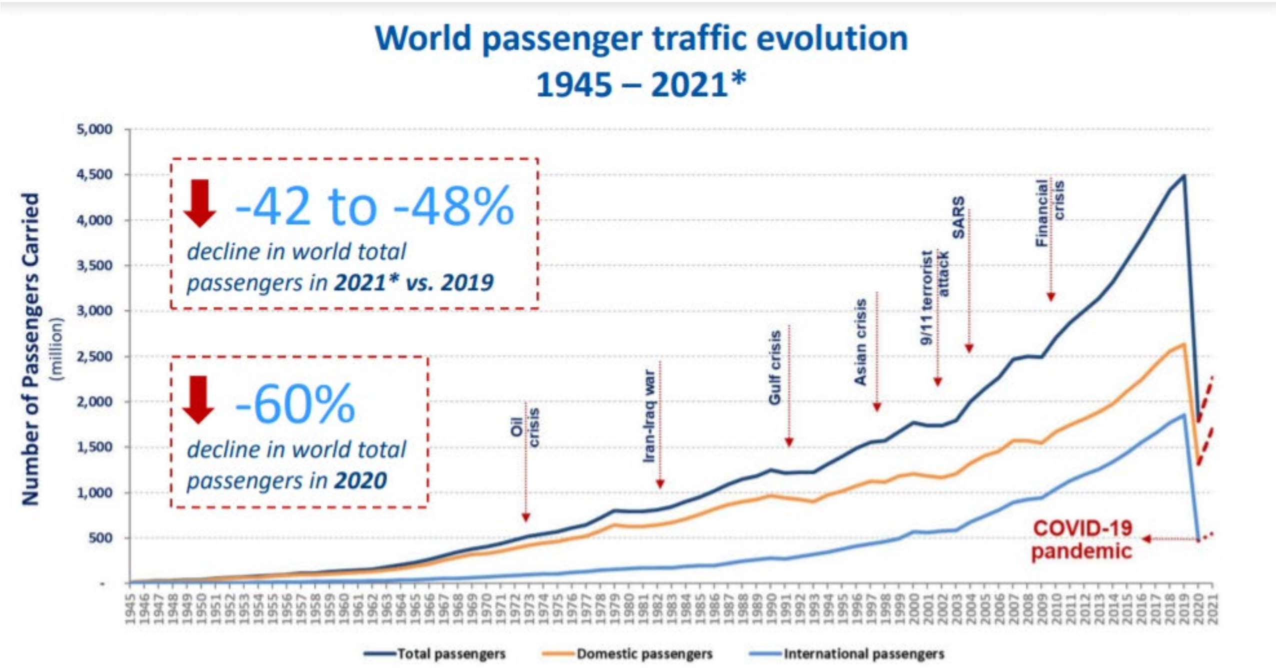
Because of travel limitations and a drop in demand, the COVID-19 pandemic has had a substantial impact on the aviation business.

Significant decreases in passenger numbers have resulted in flight cancellations or planes flying empty between airports, resulting in dramatically reduced income for airlines and forcing several to lay off personnel or declare bankruptcy. To reduce business losses, some have sought to avoid refunding cancelled visits. Employees from airline manufacturers and airport operators have also been laid off.

Aviation may be one of the most damaged industries overall. Most airlines have been grounded due to an extraordinary decline in passenger demand (coupled with a countrywide travel prohibition).Numerous firms have had to suspend nearly all operations, grounding whole fleets; many airports have blocked runways to create place for planes to park, or are simply closed forever; and the majority of enterprises in the aviation sector are on strict rotation with low employees. Aircraft manufacturers' and downstream businesses' production lines have essentially been stopped down. Overall, the 2019 coronavirus epidemic has had a considerable impact, as seen by the number of canceled flights given in Table 1 (relating to the previous year).

Nonetheless, the aviation business has faced enormous obstacles in the past, including oil shocks, financial crises, wars, and early sickness; it may be able to overcome COVID-19. However, aviation is not only a victim of COVID-19, but it also plays a critical role in disease transmission, transforming (local) epidemics into (global) epidemics, the majority of which are contained before they develop into pandemics on the scale of carbon monoxide, as this phenomenon has been observed in some early diseases. They have shown to be robust in the face of oil shocks, financial crises, wars, and early sickness. And may be able to defeat COVID-19. Is frequently overlooked, but the industry is not only the victims of COVID - 19, and is known to play a key role in the disease's spread, transforming the (local) epidemic into the (global) epidemic, as observed in some early disease, most of the disease in the evolution of COVID - 19 size before the pandemic is under control.

Figure 3. World passenger traffic collapses with unprecedented decline in history



There is no doubting that COVID-19 has altered the aviation scene in the near term, and analysts believe the sector will be unable to fully recover in the coming years. However, not all is lost. If there is a silver lining, it is that the epidemic has forced the tourism industry and the general people to focus on what is truly important. There is always opportunity in adversity, and the aviation business, like so many others, has demonstrated that firms who innovate, think imaginatively, and utilize technology to confront apparently insurmountable obstacles can eventually triumph.

So I want to install cushioned seat wings, which will not only keep passengers safer during flight, but will also make planes a much more comfortable place for passengers to fly in the future.

2.2 New type of passenger seat

These seats are used to increase the comfort and safety of passengers. This equipment increases the comfort of economy passengers by having two readily deployable cushioned wings that fold out from the seat back. These padded wings allow riders to spin and rest on a cushioned surface, providing more lateral support. Because the system is retrofittable, airlines may incorporate it into their fleet without replacing current seat units.

Simultaneously, when the padded wings are deployed, they can give demarcation and privacy between passengers, as they are an effective detachable divider that separates surrounding people.

With the travel sector being badly impacted by the spread of coronavirus, we aimed to give a remedy through the new seat equipment solution, which may help airlines to get back on their feet far sooner than if ordinary airplane seats remained unchanged. It will be a huge step in assisting the business while also making planes a far more comfortable place for passengers when they return to fly in the future.The primary idea should be met by this type of seat upholstery.

2.3 Basic requirements for the passenger seat

Friction ability is especially critical during transmission since the user might quickly fall over if the cushion slips. However, fairly reduced upper limb surface friction is good for users with weak upper limbs. One solution is to use a knot or Velcro to fasten the seat cushion. When straps are important for keeping the mat in position while sitting, installing the straps separately before transferring might be difficult, if not impossible. Ties are impractical for customers who must fold their chairs on a frequent basis, and most wheelchair users do not utilize them even when cushion makers give them. Matching clasp strips (e.g., Velcro) can be sewed on the cushion cover's underside and fastened to the strap seat.

Cushions and seats should be specified together wherever feasible, so that the seat size meets the thickness of the cushions. When evaluating the user's posture in relation to the seat and backrest, keep in mind that cushions might compress when utilized. As a result, this cushion should be 3 cm in size. The thickness allows passengers to sleep on their side while also protecting them from the impact of passenger side seats, essentially separating them.

2.3.1 Calculations of seat cushion weight

Every little weight added to an aircraft reduces its payload capacity, so seat cushions should be designed to be as light as possible. This picture include the dimensions of I designed aircraft passenger seats.

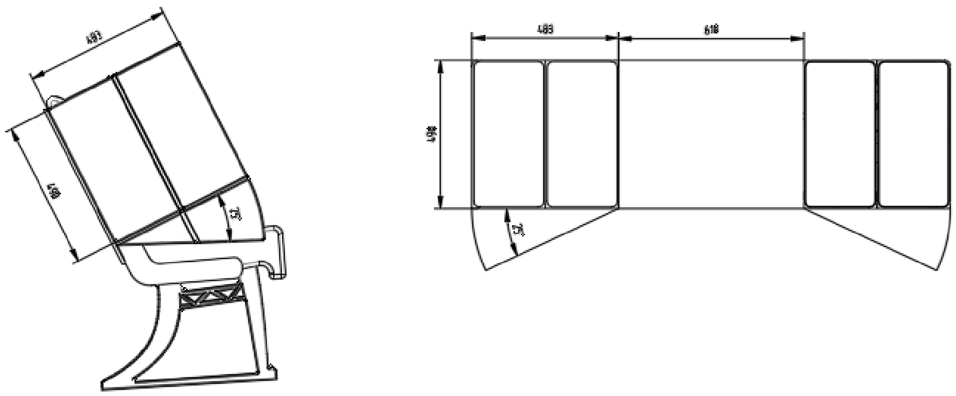


Figure 4. - Sketch of passenger seat and padded cushion with dimensions

So the volume of this padded cushion is :

$$S_{sector}=\theta R^2$$

$$V_{cushion}=L_c*W_c*T_{thickness}=1.576*0.49*0.03+25/360\pi\cdot0.483^2*0.03=0.025287m^3$$

Aircraft seat interiors are often constructed of materials such as leather, fabric, vinyl, polyester, and synthetic leather that have been designed to be long-lasting, fire-resistant, oil-resistant, water-resistant, and simple to clean.

The most popular form of foam for couch cushions weighs between 8.83 to 13.74 kilograms per square meter. Density bubbles have a longer lifespan and outlive low-density bubbles. The optimal density depends on how long you want the foam to last and how frequently it will be used.

2.3.2 Material selection

All of the cushions are created using a one-of-a-kind high-speed method. Because of the advantages of this technology, we can manufacture buttocks, backs, head pillows, arm rests, and leg pillows that are extremely pleasant, light in weight, and cost effective. Seat cushions are supplied to international and national airlines, aircraft seat makers, and aircraft manufacturers all over the world. These specifically manufactured foams contain flame retardant chemicals and are intended to fulfill aviation regulations for cabin components in commercial airplanes. Ethafoam material has a density of 28.8 kg/m3 are displayed on the next table.

Table 8 Compare of seat cushion material

Material	Density (kg/m^3)	Volume of cushion (m^3)	Weight(kg)
Common foam	40	0.025287	1.001149
Ethafoam	28.8		0.7282

The weight of these 2 kinds material is equal :

$$W_{cpmmon\ foam}=\rho\cdot V=40*0.025287=1.001149\ kg$$

$$W_{cpmmon\ foam}=\rho\cdot V=28.8*0.025287=0.7282\ kg$$

The total added weight on my designed airplane is :

$$W_{cushion} = 240*0.7282kg = 174\ kg$$

The biggest risks emerge in institutions, where a huge number of cushions can provide a major fire threat. When burnt, plastic foams emit very hazardous fumes that can incapacitate people even faster than the fire.

The typical laboratory test typically used on polyethylene foams treats the foam samples to a 24-hour oven temperature of 70°C (158°F). Ethafoam products routinely exhibit less than 1% linear change in this test. So I'll go with Ethafoam because it's lighter than regular foam.

Water can be irritating and, in some situations, increase the risk of soft tissue injury. The origin and prevention of moisture buildup are determined by a variety of circumstances. It generates far too much heat. Sweat is normally generated to assist the body in regulating its temperature by draining water from the skin's surface. Sweating is normally reduced by local pressure. However, after a spinal cord injury, sweating can occur in ways that are not regulated by temperature regulation. A complicated buffer system can be used to minimize stress..

Using mats and covers to encourage air flow between the mat and the skin are two ways to reduce moisture buildup. Cushions with high heat dissipation capabilities assist to decrease moisture buildup when appropriately covered with absorbent materials such as sheepskin or knitted textiles. Wearing cotton or flannel underwear can also aid in moisture reduction. As a result, I'm going to use sheepskin to cover the custom-made cushion.

2.3.3 General view

Many individuals place a high value on looks, which should not be overlooked. A clever use of cover material, color and design can disguise the utilitarian look of the "core" of the seat.

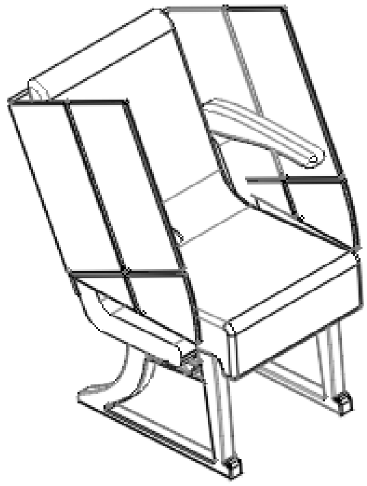


Figure 5. Isometric view of seat

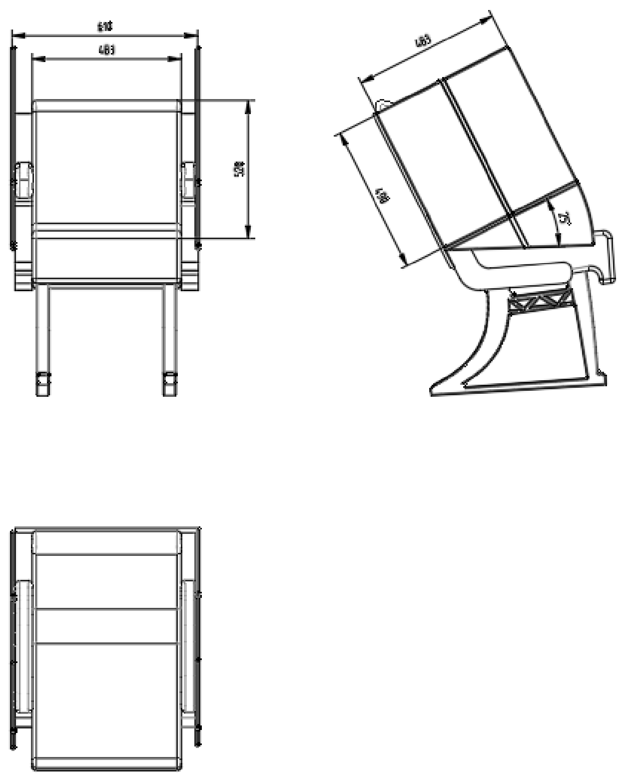


Figure 6 .Three views of the seat

2.3.4 Description of padded wing

During the COVID-19 period, the seat with cushioned wings is intended to allow passengers to separate themselves more efficiently and safely aboard flights. Those wings are folded over the back of the seats before flying. The Hoop&Loop system fixes it. Because of the airplane takeoff, people on abord are unable to instantly open the wing. After takeoff, passengers may unfold this pair of cushioned wings from their side and simply adjust them in the right position.

Passengers can fold half of the wing if no one is sitting next to them or if they wish to chat to their friends or relatives. It will be a more practical and humane design.

Passengers, as we all know, typically wish to sleep on lengthy journeys. However, owing to the design of airline seats, there is no side support for the head while people sleep, so their head is always tilted to and from side to side, leading them to sleep in an unpleasant position and occasionally producing the phenomena of stiff pillow.

Another feature of this seat is that the cushioned wing may give lateral support for passengers, allowing them to put their heads on it. Passengers will have a more comfortable ride as a result.

The recliner mechanism's seat consists of a base and an arm mounted on the seat cushion and seat back, respectively, the house internal and external locking, unlocking the way unlocked, by a rotatable influence CAM by the operating lever, which is mechanical with the CAM to produce the rotating motion of the CAM.

Passenger seats must pass the following tests: headrest performance, seat back strength, headrest energy absorption, and front and rear impact. The maximum load on the recliner is determined by this headrest performance test. According to the headrest performance test requirements, 373Nm torque is applied to the seat back and the spherical head with a diameter of 165mm, the initial force produced at the moment of 373 nm to the H point is applied to the right-angle displacement of the reference line to the distance below the headrest with a distance of 65 mm, and the load is increased up to 890 N or unless the seat is regardless. To achieve this criteria, the recliner's design torque value must be more than 1000Nm.

2.4.1 Recliner Strength Calculation

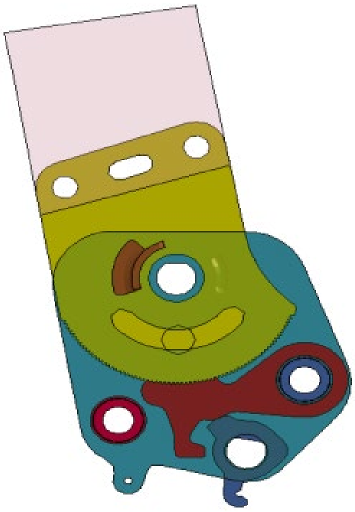


Fig. 7 Recliner Internal Mechanism

Width of tooth at centre is equal :

$$W = 0.75mm$$

Tooth cross-sectional area :

$$A_{tooth} = 3.665mm^2$$

Thickness of sector :

$$T_{Sector} = 5mm$$

The number of teeth that are engaged :

$$N = 17.$$

Distance of teeth's from pivot

$$L = 41mm$$

Tensile strength of sector/pawl material for the material of *16MnCr5:*

$$\sigma = 616MPa$$

Shear strength τ should be 2/3 times of tensile strength as usual:

$$\tau=\sigma/1.5=410.67\text{Mpa}$$

Shear failure load on each teeth is equal：

$$\tau_{each\ tooth}= 410.67 \text{ x } 3.665=1505.1\text{N}$$

For the recliner strength is equal:

$$\tau_{recliner}= \tau_{each\ tooth} \text{ x } N \text{ x } L=1505.1 \text{ x } 17 \text{ x } 0.041=1049.05Nm$$

2.4.2 End Stopper Calculation

Diameter of semi pierce feature is equal:

$$D= 0.65mm$$

The area of cross section is :

$$A_2 =\pi D^2/4=3.14/4 \text{ x } 0.65 \text{ x } 0.65 = 33.166mm^2$$

Sector/pawl material tensile strength is equal ： σ = 616MPa

The material hear strength is ：

$$\tau= 616/1.5= 410.67\text{Mpa}$$

Shear load is equal :

$$\tau_{shear\ load}= \tau A_2= 410.67 \text{ x } 38.46= 15796\ N=15.7 \text{ kN}$$

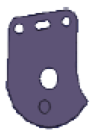
The regulation standard for Recliner Design is 1000Nm.

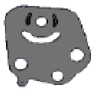
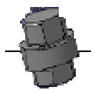
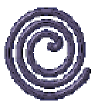
Factor of safety with calculation：

$$n=1049/1000=1.049$$

Material Specification of the recliner displayed as Table 7.

Table 9. Parameter for the recliner parts[17-1]

Sr No.	Name	Snap	Material	Thickness （mm)	YS(MPa)	TS(MPa)
1	Upper sector		16MnCr5	5	425	616
2	Pawl		16MnCr5	5	425	616

3	Cam		16MnCr5	5	425	616
4	Mounti ng rivet		EN8	ϕ18.2	465	899
5	Handle Rivet		EN8	ϕ13.9	465	899
6	Side plate		E34	2.5	340	492
7	Cam spring		IS4454 DM	ϕ1.8	-	1710
8	Pivot rivet		EN8	ϕ12.9	465	899
9	Clock spring bracket		E34	2.5	340	492
10	Clock spring		IS45 4DM	ϕ6	-	1470

To pass headrest performance testing, the recliner assembly is expected to endure a maximum torque of roughly 1,000 Nm. The recliner assembly can sustain a maximum torque of roughly 1023Nm, according to the estimate. The average stress-strain properties of the sector plate and pawl are at their peak.

Conclusion for special part

The unique element of this seat that I developed is the difference in its seat cushion. The folding wings fitted on the back of the seat can prevent the spread of the epidemic illness in a safe and effective manner.

Unfolding the cushioned wings would create a distinct, private space, allowing passengers to feel less alone. The wings also provide lateral head support, allowing passengers to sleep more easily without having anyplace to lay their head, as in a standard seat. The chairs are intended to be adaptable in order to halt the spread of diseases. Engineers can easily remove the extra wings from the seat and return it to its conventional shape if the coronavirus is neutralized globally in the future and individuals do not need to be separate during flight.

At the same time, we may study these seat occupants, asking whether they obtained a decent night's sleep as a result of these cushioned wings. If the majority of the passengers want lateral support while sleeping, here is the area for wings again; just construct small wings, around 10 cm long, to give excellent head support.

General conclusions

During the design process, I obtained the following results:

– Preliminary design of the long-range passenger aircraft with 240 passenger capacity；
– Cabin layout of the long-range passenger aircraft with 240 passenger capacity；
– General view of the long-range passenger aircraft with 240 passenger capacity;
– The center of gravity calculations of the airplane;
– The choice of engine accord to the aircraft thrust;
– The design of passenger seats for prevent COVID-19;
– The the strength analysis for passenger seats' recliner .

The plane was a low-wing cantilevered monoplane with bypass turbojet engines under its wings. Due to the massive size of the aircraft, a six-wheel landing gear with a front single-strut landing gear and four main landing gear was chosen to better sustain the aircraft's weight. A swept-back airfoil with a high aspect ratio based on a novel supercritical airfoil. The tail fin has a standard frame on which the movable vertical tail fin is mounted. Both the rudder and the elevator are aerodynamically balanced.

When determining the center of gravity, the final center of gravity should be 50-60% of the fuselage, taking into account wing geometry, fuselage center of gravity calculation, equipment type.

Department of Aircraft Design				NAU 21 05W 00 00 00 11 EN			
Performed by	Wang Lulu			General Conclusion	List	Sheet	Sheets
Supervisor	V. I .Zakiev						
Adviser					AF 402 134		
Stand. contr.	Khizhnyak S.V.						
Head of Dep.	Ignatovych S.R.						

The seat and cushion can safely and effectively prevent the spread of the pandemic sickness. The cushions' wings would provide a separate, private environment, making passengers feel less alone. The wings also provide lateral head support, allowing passengers to sleep more comfortably without the need for a pillow.

All parts are geared to make planes safer and more efficient while in flight.The results are consistent with long-range aircraft standar

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Head of Dep.	Ignatovych S.R.								

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Appendix A

REQUEST FOR CALCULATION WORK（A340-200）

Student ………WangLulu…………………………

Instructor ....Maslak.............................

ADMITTED TO CALCULATION.. (Data, Instructor's Signature)

МАКСИМАЛЬНОЕ ЧИСЛО ПАССАЖИРОВ **N** =..240....... ИЛИ МАКСИМАЛЬНАЯ МАССА ГРУЗА 51000 .... **kg**;
Passenger Number or Maximum Payload

КОЭФФИЦИЕНТ ДОПОЛНИТЕЛЬНОЙ ЗАГРУЗКИ **К1**=..1.1.....; МАССА БЕЗПЛАТНОГО БАГАЖА **М.ББ** =....................................20**kg**;
Extra Load Factor Passenger Baggage

ЧИСЛО ЧЛЕНОВ ЭКИПАЖА **Ncrew** =...2....;.....................РЕИСОВОЕ ВРЕМЯ ПОЛЕТА С МАС. ГРУЗОМ **T** =. 10 ....**hours**;
Flight Crew Number Block Time with Maximum Payload

КОЛИЧЕСТВО БОРТПРОВОДНИКОВ **N** =......6..... ИЛИ СОПРОВОЖДАЮЩИХ **N** =. ;
Attendant Number or Load Master Number

ОТНОСИТЕЛЬНАЯ МАССА МАКСИМАЛЬНОЙ КОММЕРЧЕСКОЙ НАГРУЗКИ=0.185 ....;
Payload Fraction

ОТНОСИТЕЛЬНАЯ МАССА ТОПЛИВА ПРИ ПОЛЕТЕ С МАКСИМАЛЬНОЙ КОММЕРЧЕСКОЙ НАГРУЗКОЙ. 0.401.;
Fuel Fraction under Maximum Payload

ЭНЕРГОВООРУЖЕННОСТЬ САМОЛЕТА.............**kW/kg** ИЛИ ТЯГОВООРУЖЕННОСТЬ САМОЛЕТА. 2.8 ....**N/kg**;
Power-to-mass Ratio or Thrust-to-mass Ratio

КОЛИЧЕСТВО ОСНОВНЫХ ДВИГАТЕЛЕИ ....4....; КОЛИЧЕСТВО РЕВЕРСИРУЕМЫХ ДВИГАТЕЛЕЙ 4 ;
Engine Number Engine Number Reversed

ДАЛЬНОСТЬ ПОЛЕТА С МАКСИМАЛЬНОЙ КОММЕРЧЕСКОЙ НАГРУЗКОЙ **L**=. 8000 **km**;
Flight Range with Maximum Payload

СОТА НАЧАЛА КРЕИСЕРСКОГО ПОЛЕТА ...11..**km**; КРЕИСЕРСКАЯ ЭКОНОМИЧЕСКАЯ СКОРОСТЬ 871 ....**km/h**;
Cruise Altitude Cruise Speed

СТРЕЛОВИДНОСТЬ КРЫЛА ПО 0.25 ХОРД В ГРАД. ..... 34°..... ; СРЕДНЯЯ

ОТН. ТОЛЩИНА КРЫЛА 0.128......................................(в долях);
Sweep Angle on One Quarter Line Mean Thickness Ratio (in fractions)

УДЛИНЕНИЕ КРЫЛА ПО ПОЛНОИ ПЛОЩАДИ .....9.26......; СУЖЕНИЕ КРЫЛА ПО ПОЛНОЙ ПЛОЩАДИ. 3.98.............................. ;
Aspect ratio for Total Wing Area Taper Ratio for Total Wing Area

ТИП АЭРОДИНАМИЧЕСКОГО ПРОФИЛЯ КРЫЛА ....low wing....;
ЗАКОНЦОВКИ "УИТКОМБА" No.........................(применяются или нет);
Airfoil Type Winglets (used or not)

ОТНОСИТЕЛЬНАЯ ПЛОЩАДЬ ПРИКОРНЕВЫХ НАПЛЫВОВ КРЫЛА (в долях). 0.01..;
Relative Area of Wing Extensions (in fractions)

УСТАНОВЛЕНЫ НА КРЫЛЕ СПОЙЛЕРЫ ИЛИ ИНТЕЦЕРТОРЫ (да или нет) yes..;
Spoilers used (yes or no)

МАКСИМАЛЬНЫЙ ЭКВИВАЛЕНТНЫЙ ДИАМЕТР ФЮЗЕЛЯЖА...5.64...........**m**; УДЛИНЕНИЕ ФЮЗЕЛЯЖА 9 ;
Fuselage Maximum Equivalent Diameter Fuselage Fineness Ratio

СУММА УДЛИНЕНИЙ НОСОВОЙ И ХВОСТОВОЙ ЧАСТЕЙ ФЮЗЕЛЯЖА. 4.1 ;
Sum of Fineness Ratios for Forward and Aft Fuselage Parts

МИНИМАЛЬНАЯ (**техническая**) ПОСАДОЧНАЯ СКОРОСТЬ **Vmin.** =…238..**km/h**;
Minimal Landing Speed

СТЕПЕНЬ МЕХАНИЗИРОВАННОСТИ КРЫЛА slotted flap (указать индексом по МУ);
High-lift Device Coefficient (index from Methodological Guide)

СТЕПЕНЬ ПОВЫШЕНИЯ ДАВЛЕНИЯ ДВИГАТЕЛЯ …37.4…....; СТЕПЕНЬ ДВУХКОНТУРНОСТИ ДВИГАТЕЛЯ .... 7.6 ;
Engine Pressure Ratio Engine By-pass Ratio

ДЛИНА ЛЕТНОЙ ПОЛОСЫ АЭРОДРОМА БАЗИРОВАНИЯ (ВПП + КПБ) 4.96 ....**km**;
Field Length Available (Runway + Stopway)

МАКСИМАЛЬНАЯ ВЫСОТА КРЕЙСЕРСКОГО ПОЛЕТА (практический потолок) **Hcr.max**. = 12.572 ....**km**;
Maximum Cruise Altitude (Flight Ceiling)

УГОЛ СТРЕЛОВИДНОСТИ ГОРИЗОНТАЛЬНОГО ОПЕРЕНИЯ В ГРАДУСАХ 30°..;
Horizontal Tail Sweep Angle (in degrees)

УГОЛ СТРЕЛОВИДНОСТИ ВЕРТИКАЛЬНОГО ОПЕРЕНИЯ В ГРАДУСАХ 45°... ;

Vertical Tail Sweep Angle (in degrees)

СУММА НЕУЧТЕННЫХ МАСС 100 **kg**. (*массы нетипичных систем и механизмов, дополнительные массы для оборудования салонов экстра класса, массы систем диагностики и встроенного контроля оборудования и основных систем самолета).*

Weights for Additional Equipment (equipment for high class passenger cabins)

INITIAL DATA AND SELECTED PARAMETERS

Passenger Number	240
Flight Crew Number	2
Flight Attendant or Load Master Number	6
Mass of Operational Items	2851.09 kg
Payload Mass	2500kg

Cruising Speed	871km/h
Cruising Mach Number	0.8163
Design Altitude	11km
Flight Range with Maximum Payload	8000km
Runway Length for the Base Aerodrome	2.55km

Engine Number	4
Thrust-to-weight Ratio in N/kg	2.8
Pressure Ratio	37.4
Assumed Bypass Ratio	5.00
Optimal Bypass Ratio	5.00
Fuel-to-weight Ratio	0.4300

Aspect Ratio	9.26
Taper Ratio	3.98
Mean Thickness Ratio	0.128
Wing Sweepback at Quarter Chord	34°
High-lift Device Coefficient	1.100
Relative Area of Wing Extensions	0.010

Wing Airfoil Type
Winglets
Spoilers

Fuselage Diameter	5.64m
Finess Ratio	9.00
Horizontal Tail Sweep Angle	30°

Vertical Tail Sweep Angle 45°

CALCULATION RESULTS

Optimal Lift Coefficient in the Design Cruising Flight Point
Cy=0.49477
Induce Drag Coefficient
Cx 0.00915

ESTIMATION OF THE COEFFICIENT $D_m = M_{critical} - M_{cruise}$

Cruising Mach Number	0.81628
Wave Drag Mach Number	
Calculated Parameter D_m	0.00605

Wing Loading in kPa (for Gross Wing Area):

At Takeoff	6.567
At Middle of Cruising Flight	5.251
At the Beginning of Cruising Flight	6 .323

Drag Coefficient of the Fuselage and Nacelles	0.01294
Drag Coefficient of the Wing and Tail Unit	0.00916

Drag Coefficient of the Airplane:

At the Beginning of Cruising Flight	0.03409
At Middle of Cruising Flight	0.03233
Mean Lift Coefficient for the Ceiling Flight	0.49477
Mean Lift-to-drag Ratio	15.35307
Landing Lift Coefficient	1.527
Landing Lift Coefficient (at Stall Speed)	2.290
Takeoff Lift Coefficient (at Stall Speed)	1.879
Lift-off Lift Coefficient	1.371
Thrust-to-weight Ratio at the Beginning of Cruising Flight	0.573
Start Thrust-to-weight Ratio for Cruising Flight	2.397
Start Thrust-to-weight Ratio for Safe Takeoff	2.868
Design Thrust-to-weight Ratio Ro	2.982
Ratio $D_r = R_{cruise} / R_{takeoff}$ Dr	0.836

SPECIFIC FUEL CONSUMPTIONS (in kg/kN*h):

Takeoff	35.4526

Cruising Flight	58.3442
Mean cruising for Given Range	63.4647

FUEL WEIGHT FRACTIONS:

Fuel Reserve	0.03720
Block Fuel	0.34339

WEIGHT FRACTIONS FOR PRINCIPAL ITEMS:

Wing	0.10688
Horizontal Tail	0.00814
Vertical Tail	0.00863
Landing Gear	0.03463
Power Plant	0.09747
Fuselage	0.08207
Equipment and Flight Control	0.10807
Additional Equipment	0.00820
Operational Items	0.01690
Fuel	0.38059
Payload	0.14866

Airplane Takeoff Weight M =168708kg
Takeoff Thrust Required of the Engine 125kN

Air Conditioning and Anti-icing Equipment Weight Fraction	0.0189
Passenger Equipment Weight Fraction (or Cargo Cabin Equipment)	0.0115
Interior Panels and Thermal/Acoustic Blanketing Weight Fraction	0.0068
Furnishing Equipment Weight Fraction	0.0109
Flight Control Weight Fraction	0.0044
Hydraulic System Weight Fraction	0.0132
Electrical Equipment Weight Fraction	0.0283
Radar Weight Fraction	0.0026
Navigation Equipment Weight Fraction	0.0038
Radio Communication Equipment Weight Fraction	0.0019
Instrument Equipment Weight Fraction	0.0045
Fuel System Weight Fraction	0.0119

Additional Equipment:

Equipment for Container Loading	0.0057
No typical Equipment Weight Fraction (Build-in Test Equipment for Fault Diagnosis, Additional Equipment of Passenger Cabin)	0.0025

TAKEOFF DISTANCE PARAMETERS

Airplane Lift-off Speed	314.98km/h
Acceleration during Takeoff Run	2.23m/s^2
Airplane Takeoff Run Distance	1711m
Airborne Takeoff Distance	472m
Takeoff Distance	2183m

CONTINUED TAKEOFF DISTANCE PARAMETERS

Decision Speed	283.48 km/h
Mean Acceleration for Continued Takeoff on Wet Runway	0.94m/s^2
Takeoff Run Distance for Continued Takeoff on Wet Runway	2115.51m
Continued Takeoff Distance	2587.75m
Runway Length Required for Rejected Takeoff	2681.1m

LANDING DISTANCE PARAMETERS

Airplane Maximum Landing Weight	117930kg
Time for Descent from Flight Level till Aerodrome Traffic Circuit Flight	21.8min
Descent Distance	52.81km
Approach Speed	268.37km
Mean Vertical Speed	2.13m/s
Airborne Landing Distance	524m
Landing Speed	253.37km/h
Landing run distance	854m
Landing Distance	1378m
Runway Length Required for Regular Aerodrome	2302m
Runway Length Required for Alternate Aerodrome	1957m

ECONOMICAL EFFICIENCY

THESE PARAMETERS ARE NOT USED IN THE PROJECT