МІНІСТЕРСТВО ОСВІТИ ТА НАУКИ УКРАЇНИ

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

КАФЕДРА КОНСТРУКЦІЇ ЛІТАЛЬНИХ АПАРАТІВ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
д.т.н., професор.
___________ С.Р. Ігнатович
«___» __________ 2021 р.

ДИПЛОМНА РОБОТА

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ БАКАЛАВРА

ЗІ СПЕЦІАЛЬНОСТІ
«АВІАЦІЙНА ТА РАКЕТНО-КОСМІЧНА ТЕХНІКА»

Тема: «Аванпроект дальньомагістрального пасажирського літака місткістю до 550 пасажирів»

Виконавець: ___________ **А.П. Шпак**

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Київ 2021

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL AVIATION UNIVERSITY

DEPARTMENT OF AIRCRAFT DESIGN

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«___» _________ 2021.

BACHELOR THESIS

ON SPECIALITY
"AVIATION AND SPACE ROCKET TECHNOLOGY"

Topic: «Preliminary design of the long-range passenger aircraft with 550 passenger capacity»

Prepared by:	__________	**A.P. Shpak**
Supervisor: PhD, associate professor	__________	**V.S. Krasnopolsksii**
Standard controller: PhD, associate professor	__________	**S.V. Khyzhnyak**

Kyiv 2021

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет аерокосмічний

Кафедра конструкції літальних апаратів

Освітньо-кваліфікаційний ступінь «Бакалавр»

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ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
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«___» ___________ 2021 р.

ЗАВДАННЯ

на виконання дипломної роботи студента

Шпак Артур

1. Тема роботи: «Аванпроект дальньомагістрального пасажирського літака місткістю до 150 пасажирів», затверджена наказом ректора від 21 травня 2021 року №815/ст.

2. Термін виконання проекту: з 24 травня 2021 р. по 20 червня 2021 р.

3. Вихідні дані до проекту: крейсерська швидкість V_{cr} = 860 км/год, дальність польоту L = 8000 км, крейсерська висота польоту H_{op} = 10 км.

4. Зміст пояснювальної записки: вступ, основна частина, що включає аналіз літаків-прототипів і короткий опис проектованого літака, обґрунтування вихідних даних для розрахунку, розрахунок основних льотно-технічних та геометричних параметрів літака, компонування пасажирської кабіни, розрахунок центрування літака, спеціальна частина, яка містить проект відлякувача птахів для літака.

5. Перелік обов’язкового графічного матеріалу: загальний вигляд літака (А1×1), компонувальне креслення фюзеляжу (А1×1), проект відлякувача птахів для літака (А1×1).

6. Календарний план-графік

№ пор.	Завдання	Термін виконання	Відмітка про виконання
1	Отримання завдання, обробка статистичних даних.	24.05.2021-30.05.2021	
2	Розрахунок мас літака та його основних льотно-технічних характеристик.	31.05.2021-02.06.2021	

3	Розрахунок центрування літака.	03.06.2021-04.06.2021	
4	Розробка креслень по основній частині.	05.06.2021-06.06.2021	
5	Проектування відлякувача птахів для літака та розробка креслень по спеціальній частині.	07.06.2021-11.06.2021	
6	Оформлення пояснювальної записки.	12.06.2021-13.06.2021	
7	Захист дипломної роботи	14.06.2021-20.06.2021	

7. Дата видачі завдання: «24» травня 2021 року.

Керівник дипломної роботи ____________ В.С. Краснопольський
(підпис керівника) П.І.Б.

Завдання прийняв до виконання ____________ А.П. Шпак
(підпис студента) П.І.Б.

NATIONAL AVIATION UNIVERSITY

Faculty ____Aerospace______

Department __of Aircraft Design__

Educational degree __«Bachelor»__

Specialty 134 "Aviation and space rocket technology"

APPROVED BY

Head of department

D.Sc., professor

__________ S.R. Ignatovych

«___» _________ 2021.

TASK

for the bachelor thesis

Shpak Artur

1. Topic: «Preliminary design of the long-range passenger aircraft with 550 passenger capacity» approved by the Rector's order №815/ст. «21» May 2021 year.
2. Thesis terms: since 24.05.2021 year till 20.06.2021 year.
3. Initial data: cruise speed V_{cr}= 860 km/h, flight range L = 8000 km, operating altitude H_{op} = 10 km.
4. Content: introduction; main part: analysis of prototypes and brief description of designing aircraft, selection of initial data, wing geometry calculation and aircraft layout, landing gear design, engine selection, center of gravity calculation, special part: introduction and calculation of the bird scarer.
5. Required material: general view of the airplane (A1×1), layout of the airplane (A1×1), pilot's seat design (A1×1).
6. Thesis schedule

№	Task	Time limits	Done
1	Task receiving, processing of statistical data.	24.05.2021-30.05.2021	
2	Aircraft take-off mass determination and flight performances calculation.	31.05.2021-02.06.2021	
3	Aircraft centering determination.	03.06.2021-04.06.2021	
4	Graphical design of the aircraft and its layout.	05.06.2021-06.06.2021	
5	Design of bird scarer and calculations. Drawings of the special part.	07.06.2021-11.06.2021	
6	Completion of the explanation note.	12.06.2021-13.06.2021	
7	Preliminary examination and defense of the diploma work.	14.06.2021-20.06.2021	

7. Date: «24» May 2021 year.

Supervisor	______________	V.S. Krasnopolskii
Student	______________	A.P. Shpak

РЕФЕРАТ

Дипломна робота «Аванпроект дальньомагістрального пасажирського літака місткістю до 550 пасажирів» містить:

40 сторінок, 17 рисунків, 12 таблиць, 13 літературних посилань

Об'єкт дослідження: процес проектування літака транспортної категорії.

Предмет дослідження: аванпроект дальньомагістрального пасажирського літака місткістю до 550 пасажирів.

Мета роботи: створити аванпроект дальньомагістрального пасажирського літака та визначити його основні льотно-технічні характеристики.

Методи дослідження: в роботі застосовано метод порівняльного аналізу літаків-прототипів для вибору найбільш обґрунтованих технічних рішень, а також методи інженерних розрахунків для отримання основних параметрів проектованого літака. В спеціальній частині застосовано аналіз напружено-деформованого стану для розрахунку на міцність елементів кріплення відлякувача птахів.

Наукова новизна результатів: в спеціальній частині обґрунтовано застосування нового обладнання, а саме відлякувача птахів, що зменшує ймовірність зіткнення птаха з літаком під час зльоту, посадки та польоту, тим самим підвищуючи безпечність польоту літака.

Практична цінність роботи: результати роботи можуть бути використані в авіаційній галузі та в навчальному процесі авіаційних спеціальностей.

ПАСАЖИРСЬКИЙ ЛІТАК, АВАНПРОЕКТ ЛІТАКА, ЦЕНТРУВАННЯ ЛІТАКА, КОМПОНУВАННЯ ПАСАЖИРСЬКОЇ КАБІНИ, РОЗРАХУНОК НА МІЦНІСТЬ КРІСЛА

ABSTRACT

Bachelor thesis «Preliminary design of a long-range passenger aircraft with 550 passenger capacity»

44 pages, 17 figures, 12 tables, 13 references

Object of study – design process of a civil airplane.

Subject of study – is preliminary design of a long-range passenger aircraft with 550 passenger capacity.

Aim of bachelor thesis – is to create a preliminary design of an airplane and estimate its flight performances.

Research and development methods – the design methodology is based on prototype analysis to select the most advanced technical decisions and engineering calculations to get the technical data of designed aircraft. In special part the stress-strain analysis is used to estimate stress state of fastening of bird scarer.

Novelty of the results –is a new equipment of safety system, bird scarer. Which reduces the possibility of collision of the bird with the aircraft during take-off, landing and flight, thereby increasing the safety of aircraft.

Practical value – the results of the work can be used in the aviation industry and in the educational process of aviation specialties.

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

Format	№	Designation	Name	Quantity	Notes
			<u>General documents</u>		
A4	1	NAU 21 21S 00 00 27 TW	Task for work	1	
	2	NAU 21 21S 00 00 27	Long-range passenger aircraft	2	
A1		Sheet 1	General view		
A1		Sheet 2	Fuselage layout		
A4	3	NAU 21 21S 00 00 27 EN	Long-range passenger aircraft	65	
			Explanatory note		
			<u>Documentation for assembly units</u>		
A1	4	NAU 21 21S 00 00 27	Design of bird scarer	1	

		NAU 21.21S.00.00.00.27 EN	
Done by	Shpak A.P.	Preliminary design of long-range passenger aircraft with up to 550 seats capacity (List of diploma work)	list / sheet 9 / sheets 65
Checked by	Krasnopolskii V.S.		
St.control.	Khyzhniak S.V.		ASF 402
Head of dep.	Ignatovich S.R.		

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REFERENCES...

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list	sheet	sheets
	10	65

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INTRODUCTION

Nowadays aviation is one of the most demanded and developed branches of the transport system. Therefore, there are different types of aircraft. This is justified by the need for: transportation of goods, passengers, military equipment to distant and hard-to-reach places.

In this regard, it is important to create an aircraft that will meet modern standards, large capacity and flight range.

The main performances are taken: cruise speed V_{cr} = 860 km/h, flight range L= 8000 km, operating altitude H_{op} = 10 km, 550 passenger capacity.

The purpose of this diploma work is to create an aircraft that will meet the following requirements:

-comfortability

-high safety level

-reliability and ease of operation

-reducing harm to the environment

-easy maintenance support

Furthermore the aircraft should meet safety requirements, that why it was decided to decrease the probability of bird strike by installing bird scarer device.

1. PROJECT PART. PRELIMINARY DESIGN OF THE LONG-RANGE AIRCRAFT

1.1 Analysis of prototypes and short description of designing aircraft

1.1.1 Overview general performances

During design of a new aircraft, the choice of optimal design parameters depends on the area of application, passenger and cargo capacity, assembly method, economic requirements for material consumption and design complexity.

Aerodynamic calculation, calculation of geometric parameters and centering of the fuselage and wing are used to create the final look of the exterior and interior of the aircraft.

For designed aircraft there were chosen the prototypes in range of 500-600 passengers and long-range of usage. Such aircraft like Airbus A380, Boeing 747-8 and Boeing 747-400 will compete with designed one in chosen market segment. Performances of prototypes are presented in table 1.1.

Table 1.1

Performances of prototypes

PARAMETER	PLAINES		
	Airbus A380	Boeing 747-8	Boeing 747-400
The purpose of airplane	Passenger	Passenger	Passenger
Crew/flight attend. persons	2/15	2/11	2/11
Maximum take-off weight, m_{tow}, kg	365508 kg	447696 kg	412770 kg
Maximum payload, $m_{p\ max}$, kg	67925 kg	82100 kg	67177 kg
Passengers	550	605	550
The flight altitude, $V_{w.ex}$, m	13100 m	13720 m	13720 m

Flight range m_{fmax}, km	8000 km	10930 m	11300 m
Take-off distance $L_{to\ d.}$, m	2374 m	2970 m	2940 m
Number and type of engines	4 × GP7270	4 × GEnx-2B67	4 × RR RB211-524G
The shape of the fuselage cross-section	circular	circular	circular
Fineness ratio	10	10,56	10,56
Extension of the fuselage	55,15 m	59,25 m	56,39 m
Extending the nose and tail unit part	27,66 m	28.2 m	27,1 m
Sweepback angle at 1/4 chord line, °	32°	37°	37,5°

For the successful formation of the layout, a combination of the effective characteristics of all three aircraft prototypes is used. The A380 was chosen as the basis for the designed airplane, as it meets all safety requirements and is the most economically efficient among long-range large liners.

1.1.2 Brief description of the main parts of the aircraft

The plane is a double-deck wide-body low-wing monoplane with four turbofan engines attached under the wing. The undercarriage consists of four main landing gear and one front gear, with the two inboard landing gear each supporting four wheels. A swept wing with a high aspect ratio and leading edge extension is used. Along the leading edge of the wing is located high-lift device, on the trailing edge there are two slotted flaps with a fixed deflector and slotted ailerons with horn and axial balance.

Fuselage has circular cross section. Empennage is single-fin with fixed stabilizer mounted on the fuselage. Rudders and elevators are double-link, with horn and axial balance.

1.1.2.1 Wing

The aircraft is made according to the scheme of a low-wing. The 36-meter wings are designed for a maximum take-off weight of over 650 tons. Moreover, the wing area is 845 m^2.

The wing consists of nose, central (middle), tail parts and ailerons, slotted flaps, end fairings. The central part are made of solid-pressed large-sized panels and spars. It helps wing structure to increase its reliability and reduce its weight, also simplifies the process of its assembly. The low-wing is box type wing that include attachment fitting to fuselage and wing panel. The wing box is a two-spar structure made of high-strength aluminum alloy. There are fuel tanks in the middle part of the wings.

The low-wing scheme is the most often used for passenger aircraft because it provides greater safety in comparison with other configuration during an emergency landing on the ground or water. When aircraft is landing on the ground with the gear retracted, the wing absorbs the impact energy, protecting the passenger cabin. When landing on water, the aircraft is submerged in the water at wing level, which gives the fuselage additional balance and simplifies the evacuation of passengers.

An important advantage of the low-wing scheme is the lowest weight of the structure, because the main landing gear is the most often mounted to the wing and their dimensions and weight are less than in a high-wing aircraft. The wings incorporate wingtip fences that extend above and below the wing surface. These increase fuel efficiency and range by reducing induced drag. The wingtip fences also reduce wake turbulence, which endangers following aircraft.

The so-called supercritical airfoil (airfoils of double curvature) are used that in comparison with conventional airfoil of the same relative thickness, have higher (by 0.08 ... 0.1) M_{crit} values. The supercritical airfoil serves to increase the values of M_{cr}. It has a large leading edge radius, an almost flat top and convex bottom and a thin, curved tail. The distribution of pressures along the airfoil leads to a decrease in the velocities in sections with the maximum airfoil thickness, hence the increase in the M_{cr} values by 0.07 ... 0.08. Since the CP in such a airfoil is displaced to its tail, it creates a large descend moment, which requires deflection of the elevators (stabilizer) for balancing.

1.1.2.2 Fuselage

The fuselage of the aircraft is an full-metal semimonocoque design with a longitudinal set of stringers and beams, a transverse set of frames and working skin with reinforcements in the areas of cut-outs for hatches, doors, windows and aircraft equipment.

The fuselage is divided into nose (front), middle and tail (rear) sections. The cockpit is located on the lower deck of fuselage nose part, which is separated by a partition from the passenger cabin. There is a canopy with sliding window in the front part of the cockpit. There is an emergency hatch is located in the upper part. The window of the cockpit canopy provides great visibility to the pilots in flight. There are seats for the captain and first-officer in the cockpit. There are side steak for control of aircraft attitude. Flight-navigational displays for monitoring the operation of the power plant signaling devices and other systems are mounted on the dashboard. The passenger cabin is located in middle part of fuselage. On this aircraft, the fuselage is divided into two floors. There are 8 doors (entrance and emergency).

1.1.2.3 Tail unit

The horizontal tail is located behind the wing. This scheme has become widespread in civil aircraft. Empennage of the aircraft is made cantilever with one centrally located fin. The elevator is made of double-link and is divided in two-section. The rudder is made of two-link and is divided in three-section.

The main advantages of this design are:

- The effective use of high-lift device of the wing;
- Provides balance of aircraft, when flaps are extended;
- The location of tail unit behind wings improves the visibility to pilots and reduces the area of stabilizers.

The geometrical parameters are chosen so that the crisis flow around the empennage occurs later than on the wing. This allows the aircraft to be removed from the crisis flow and increases flight safety.

The stabilizer is made of composite materials. The fin joint is made by means of fittings, which are made of aluminum alloy. In designed aircraft, part of the fuel is placed in the tail unit.

1.1.2.4 Landing gear

The landing gear provides the aircraft with high stability during the take-off and run, good controllability when moving on the ground and effective braking of the wheels. The aircraft landing gear consists of four main gear (two on the fuselage and two on the wings) and one front gear under the cockpit.

Each main landing gear contain shock absorber and is equipped with four wheels with hydraulic disc brakes and a wheel cooling system. The main gears are retracted into the fairing wheel well. The nose landing gear consists of shock absorber with two non-braking wheels. The front gear is retracted into the front wheel well of the fuselage landing gear. The nose landing gear is used to steering the aircraft. The wheel well are fully closed by doors, when landing gear are extended or retracted. The wheel braking system is designed for braking, taxiing and landing run of aircraft.

1.1.2.5 Power plant

In accordance with the performance of aerodynamic calculations for the aircraft design, the required maximum thrust at take-off mode is 365 kN. In accordance with this value was chosen the GP 7270. It is a two-spool dual rotor, axial airflow, high bypass ratio turbofan engine consisting of turbomachine and reduction gearbox modules connected by a drive shaft and integrated structural intake case. It has a single-stage fan, a five-stage low-pressure compressor, a nine-stage high-pressure compressor, a low-emission annular combustion chamber, a two-stage high-pressure turbine, and a six-stage low-pressure turbine.

The turbomachine is a three concentric shaft design incorporating two centrifugal compressors each driven separately by two-stage turbines and a six-stage power turbine.

The reduction gearbox features a twin lay shaft design with antifriction bearings and an offset propeller shaft. The combustion system is comprised of an annular reverse flow combustor, 14 piloted air blast fuel nozzles and two ignitors.

Table 1.4

Examples of application GP7270

Type	Two-spool high bypass ratio turbofan
Compressor	24 swept wide-chord hollow titanium fan blades,; 5-stage low-pressure axial compressor; 9-stage HP axial compressor
Weight	14,797 lb 6,712 kg
Thrust	81,500 lbf 363 kN
Length	194 in (492 cm)
Bypass Ratio	8.8:1
Diameter	124 in (316 cm)
Overall Pressure Ratio	43.9:1

1.2 Aircraft layout calculation

1.2.1 Geometry calculations for the aircraft principles structural units

The determination of basic dimensions and operational requirements is the basis for calculation of aircraft layout.

The wing, fuselage, tail and landing gear are the main structural units from which the layout is folded. Moreover, this analytical part provides an opportunity to choose the interior layout.

To define the layout of the cabin, it is necessary to calculate the dimensions of the cabin in accordance with the requirements of the aircraft's capacity. The layout was implemented in accordance with both modern standards and advanced calculation methods.

1.2.1.1 Wing geometry calculation

Full wing area is:

$$S_w = \frac{m_0 \cdot g}{P_0}$$

where m_0 – take-off weight, kg; g – gravity acceleration; P_0 – specific wing load.

$$S_w=\frac{365508\cdot 9.8}{6809}\approx 527\ (m^2)$$

Wing span is:

$$I_w=\sqrt{S_w\cdot\lambda_w}$$

where λ_w – wing aspect ratio.

$$I_w=\sqrt{527\cdot 8.16}=65.55\ (m)$$

Root chord is:

$$b_0=\frac{2S_w\cdot\eta_w}{(1+\eta_w)\cdot I_w}$$

where η_w – wing taper ratio.

$$b_0=\frac{2\cdot 527\cdot 3}{(1+3)\cdot 65.55}=1205\ (m)$$

Tip chord is:

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

$$b_t=\frac{12.05}{3}=4.02\ (m)$$

Maximum wing thickness is:

$$C_{max}=C_w \cdot b_t$$

where c_w – medium wing relative thickness.

$$C_{max}=0.11 \cdot 4.02=0.4422\ (m)$$

On board chord is:

$$b_{ob}=b_0 \cdot (1-\frac{(\eta_w-1) \cdot D_f}{\eta_w \cdot l_w})$$

where D_f – fuselage diameter.

$$b_{ob}=12,05 \cdot \left(1-\frac{(3-1) \cdot 7,1}{3 \cdot 65,55}\right)=11.18\ (m)$$

For mean aerodynamic chord determination the geometrical method was used (fig. 1.1).

The geometrical method was used to determine the length of MAC. Thus, the mean aerodynamic chord is equal: b_{mac}= 8.7 m.

To choose the structure scheme of the wing it is necessary to determine the type of its internal design. The torsion-box type with two spars was chosen to meet the requirements of strength and at the same time to make the structure comparatively light.

For wing geometry estimation it is necessary to determine and calculate the main parameters of control surfaces.

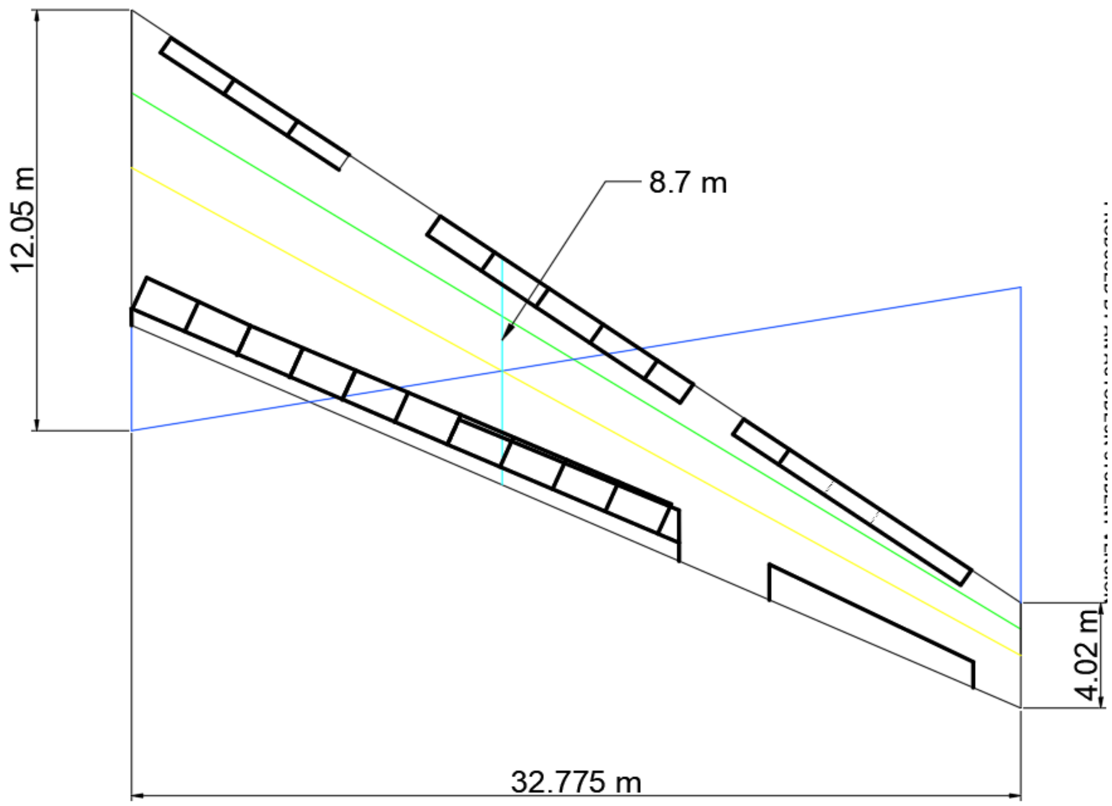

Fig. 1.1 Geometrical method of determination of mean aerodynamic chord

Ailerons geometrical parameters are determined in the next order:

Ailerons span:

$$I_{ail}=0.35\cdot\frac{I_w}{2}$$

$$I_{ail}=0.35\cdot\frac{65.55}{2}=11.47\ (m)$$

Aileron chord:

$$b_{ail}=0.44\cdot b_t$$

$$b_{ail}=0.44\cdot 4.02=1.7688\ (m)$$

Aileron area:

$$S_{ail}=0.065\cdot\frac{S_w}{2}$$

$$S_{ail}=0.065\cdot\frac{527}{2}=17.11(m^2)$$

Increasing of aileron span and chord more than these values are not convenient because with the increase of aileron span the increase of the aileron’s coefficient decreases as well as the high-lift devices span. In the case of aileron chord, its value increase lead to the decreasing of wing box width.

Aerodynamic balance of the aileron:

$$\text{Axial } S_{ax.ail}\leq(0.3\ldots0.31)\cdot S_{ail}$$

$$S_{ax.ail}=0.3\cdot17.11=5.13\ (m^2)$$

Area of ailerons trim tab for four engine airplane:

$$S_{tail}\leq(0.07\ldots0.08)\cdot S_{ail}$$

$$S_{tail}=0.07\cdot17.11=1.2\ (m^2)$$

Range of aileron deflection: upward $\delta_{ail}\geq 20°$, downward $\delta_{ail}\geq 10°$.

1.2.1.2 Fuselage layout

Generally, the fuselage layout estimation consists of main geometrical dimensions calculation and interior scheme creation.

In case of geometrical calculation, it is necessary to take into account the expected aerodynamic characteristics of designed airplane, typical resistances during normal and extreme flight conditions in accordance with estimated purpose. Airplane's fuselage geometry should allow to avoid high values of parasitic, skin friction and wave drags, withstand the aerodynamic loads and have as greater as possible safety factor value. To decrease form and wave drug and to provide necessary strength characteristics avoiding the stress concentrators in fuselage cross-section the round shape was chosen.

Another part of fuselage calculation as interior scheme creation is based on the required capacity of designed aircraft. Besides that, the requirements of ergonomics and sanitary standards must be considered for passenger aircrafts.

The next steps are necessary to calculate the main geometrical characteristics of the fuselage and consequently to obtain its outline.

Nose part length is:

$$I_{nfp}=1.9 \cdot D_f$$

$$I_{nfp}=1.9 \cdot 7.1=13.49 \ (m)$$

Fuselage length is:

$$I_f=\lambda_f \cdot D_f$$

where: λ_f– fuselage fineness ratio.

$$I_f=10 \cdot 7.1=71 \ (m)$$

Fuselage nose part fineness ratio is:

$$\lambda_{fnp} = \frac{I_{fnp}}{D_f}$$

$$\lambda_{fnp}=\frac{13.49}{7.1}=1.9$$

Length of the fuselage rear part is:

$$I_{frp}=\lambda_{frp}\cdot D_f$$

where: λ_{frp} – fuselage fineness ratio.

$$I_{frp}=3\cdot 7.1=21.3\ (m)$$

For economic and business class passenger cabin the configuration of seats is in the one row (2+2+2).Width of the cabin is:

$$B_{cab}=n_{2chblock}\cdot b_{2chblock}+n_{aisle}\cdot b_{aisle}$$

where $n_{3chblock}$ – width of 2 chairs; $b_{3chblock}$ – number of 2 chair block; b_{aisle} – width of aisle; n_{aisle} – width of aisle.

$$B_{cab1fl}=3\cdot 1070+2\cdot\ 510+2\cdot 500=5.33\ (m)$$

$$B_{cab2fl}=3\cdot 1070+2\cdot\ 510+2\cdot 100=4.63\ (m)$$

$$B_{busscab}=3\cdot 1450+2\cdot\ 580+2\cdot 100=5.51\ (m)$$

Cabin height is:

$$H_{cab}=1.48+0.17B_{cab}$$

where B_{cab} – width of the cabin.

$$H_{cab1fl}=1.48+0.17\cdot 5.33=2.38\ (m)$$

$$H_{cab2fl}=1.48+0.17\cdot 4.63=2.26\ (m)$$

$$H_{busscab}=1.48+0.17\cdot 5.51=2.41\ (m)$$

The length of passenger cabin is:

$$L_{cab}=L_1+(n_{raws}-1)\cdot L_{seatpitch}+L_2$$

where L_1 – distance between the wall and the back of first seat; n_{rows} – number of rows; $L_{seat\ pitch}$ – seat pitch; L_2 – distance between the back of last seat and the wall.

$$L_{cab1fl}=1200+(50-1)\cdot 760+235=38.185\ (m)$$

$$L_{cab2fl}=1200+(31-1)\cdot 750+235=23.93\ (m)$$

$$L_{busscab}=1300+(12-1)\cdot 960+300=12.16\ (m)$$

1.2.1.3 Luggage compartment

The area of cargo compartment is:

$$S_{cargo}=\frac{M_{bag}}{0.4K}+\frac{M_{cargo\&mail}}{0.6K}=\frac{20\cdot 550}{0.4\cdot 600}+\frac{15\cdot 550}{0.6\cdot 600}=68.75\ m^2$$

Cargo compartment volume is:

$$V_{cargo}=v\cdot n_{pass}$$

where v – relative mass of baggage; n_{pass} – number of passengers.

$$V_{cargo}=0.17 \cdot 550=93.5\ (m^3)$$

Luggage compartment design is similar to the prototype.

1.2.1.4 Galleys and buffets

Volume of buffets (galleys) is:

$$V_{galley}=(0.1 \ldots 0.12) \cdot n_{pass}$$

where v – volume of buffets; n_{pass} – number of passengers.

$$V_{galley}=0.11 \cdot 550=60.5\ (m^3)$$

Area of buffets (galleys) is:

$$S_{galley}=\frac{V_{galley}}{H_{cab}}$$

$$S_{galley}=\frac{60.5}{2.38}=25.42\ (m^2)$$

Number of meals per passenger breakfast, lunch and dinner – 0.8 kg, tea and water – 0.4 kg. Buffet design is similar to prototype.

1.2.1.5 Lavatories

Number of toilet facilities is determined by the number of passengers and flight duration: with t> 4:00 one toilet for 40 passengers.

$$n_{lav} = 11$$

Area of lavatory:

$$S_{lav} = 1.6\ (m^2)$$

Width of lavatory: 1m. Toilets design similar to the prototype.

1.2.1.6 Layout and calculation of basic parameters of tail unit

The chosen tail unit scheme is conventional. This choice is based on all three prototypes empennage schemes.

To estimate the general tail unit outlines it is necessary to calculate the geometrical dimensions of vertical and horizontal stabilizers and dimensions of control surfaces. In general tail unit must to meet the requirements of aircraft stability and controllability.

Area of vertical tail unit is:

$$S_{VTU}=(0.12\ldots0.2)\cdot S_w$$

$$S_{VTU}=0.15\cdot527=78.99\ (m^2)$$

Area o horizontal tail unit is:

$$S_{HTU}=(0.18\ldots0.25)\cdot S_w$$

$$S_{HTU}=0.22\cdot527=115.85\ (m^2)$$

Determination of the elevator area and direction:

Altitude elevator area is:

$$S_{el}=k_{el}\cdot S_{HTU}$$

where k_{el} – relative elevator area coefficient.

$$S_{el}=0.3\cdot115.85=34.76\ (m^2)$$

Rudder area is:

$$S_{rud}=k_r\cdot S_{VTU}$$

where k_r – relative rudder area coefficient.

$$S_{rud}=0.4\cdot 78.99=31.6\ (m^2)$$

Choose the area of aerodynamic balance:

$$M\geq 0.75, S_{eb}\approx S_{rb}=(0.18\ldots 0.2)S_{el/rud}$$

Elevator balance area is:

$$S_{eb}=0.18\cdot S_{el}$$

$$S_{eb}=0.22\cdot 34.76=6.2568\ (m^2)$$

Rudder balance area is:

$$S_{rb}=0.2\cdot S_{rud}$$

$$S_{rb}=0.2\cdot 31.6=6.32\ (m^2)$$

The area of altitude elevator trim tab is:

$$S_{te}=0.06\cdot S_{el}$$

$$S_{te}=0.08\cdot 34.76=2.0856\ (m^2)$$

Area of rudder trim tab is:

$$S_{tr}=0.06\cdot S_{rud}$$

$$S_{tr}=0.06\cdot 31.6=1.896\ (m^2)$$

Root chord of horizontal stabilizer is:

$$b_{OHTU}=\frac{2S_{HTU}\cdot\eta_{HTU}}{(1+\eta_{HTU})\cdot I_{HTU}}$$

where η_{HTU} – horizontal tail unit taper ratio; l_{HTU} – horizontal tail unit span.

$$\eta_{HTU}=2.5$$

$$l_{HTU}=(0.32\ldots 0.5)\cdot l_w$$

$$l_{HTU}=0.4\cdot 65.55=26.22\ (m)$$

$$b_{OHTU}=\frac{2\cdot 115.85\cdot 2.5}{(1+2.5)\cdot 26.22}=6.31\ (m)$$

Tip chord of horizontal stabilizer is:

$$b_{OHTU}=\frac{b_{OHTU}}{\eta_{HTU}}$$

$$b_{OHTU}=\frac{6.31}{2.5}=2.524\ (m)$$

Root chord of vertical stabilizer is:

$$b_{OVTU}=\frac{2S_{VTU}\cdot\eta_{VTU}}{(1+\eta_{VTU})\cdot l_{VTU}}$$

where η_{VTU} – vertical tail unit taper ratio; l_{VTU} – vertical tail unit span.

$$\eta_{VTU}=2$$

$$l_{VTU}=(0.14\ldots0.2)\cdot l_w$$

$$l_{VTU}=0.18\cdot65.55=11.8\ (m)$$

$$b_{OVTU}=\frac{2\cdot78.99\cdot2}{(1+2)\cdot11.8}=8.93\ (m)$$

Tip chord of vertical stabilizer is:

$$b_{OVTU}=\frac{b_{OVTU}}{\eta_{VTU}}$$

$$b_{OVTU}=\frac{8.93}{2}=4.465\ (m)$$

1.2.1.7 Landing gear design

To estimate the landing gear outline in this project it is necessary to calculate the location of every strut in relatively to each other, to determine the loads on landing gear system, and its location considering center of gravity of an airplane.

In this layout the principal scheme of landing gear is fully based on the prototype data.

As in the case with the tail unit it is necessary to provide the aircraft with the stable and controllable base during operation on the ground including landing and take-off.

Main wheel axes offset is:

$$e=0.17 \cdot b_{MAC}$$

where b_{MAC} – mean aerodynamic chord.

$$e=0.17 \cdot 8.7=1.48 \text{ (m)}$$

Landing gear wheel base is:

$$B=k_b \cdot L_f$$

where k_b – wheel base calculation coefficient.

$$B=0.35 \cdot 71=24.85 \ (m)$$

Front wheel axial offset is:

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

$$d_{nd}=24.85-1.48=23.37 \ (m)$$

Wheel track is:

$$T=k_T \cdot B$$

where k_b – wheel track calculation coefficient.

$$T=0.43\cdot24.85=10.69\ (m)$$

Nose wheel load is:

$$P_{NLG}=\frac{(9.81\cdot e\cdot k_g\cdot m_0)}{(B\cdot z)}$$

where K_g – dynamics coefficient; z – number of wheels.

$$P_{NLG}=\frac{(9.81\cdot1.48\cdot1.5\cdot365508)}{(24.85\cdot2)}=160106\ (N)$$

Main wheel load is equal:

$$P_{MLG}=\frac{(9.81\cdot(B-e)\cdot m_0}{(B\cdot n\cdot z)}$$

where n – number of main landing gear struts.

$$P_{MLG}=\frac{(9.81\cdot(24.85-1.48)\cdot365508)}{(24.85\cdot4\cdot4)}=210759\ (N)$$

Table 1.2

Nose Gear

Size	Construction			Service Rating				Tread Design/Trademark	Weight (Lbs)
	Ply Rating	TT or TL	Rated Speed(mph)	Rated load(Lbs)	Rated Inflation(Psi)	Max Breaking Load(Lbs)	Max Bottoming Load(Lbs)		
H 40x14.5-18	26	TL	225	36800	220	53360	99360	Flight Leader	71

Ending of the table 1.2

Inflated Dimensions (in)				Static Loaded Radius(in)	Aspect Ratio	Wheel(in)			
Outside DIA		Section Width				Width Between Flanges	Specified Rim Diameter	Flange Height	Min Ledge Width
Max	Min	Max	Min						
40	39.1	14.5	13.75	16.64	0.726	9.5	19	1.4	3.1

Table 1.3

Main gear

Size	Construction			Service Rating				Tread Design/Trademark	Weight (Lbs)
	Ply Rating	TT or TL	Rated Speed(mph)	Rated load(Lbs)	Rated Inflation(Psi)	Max Breaking Load(Lbs)	Max Bottoming Load(Lbs)		
46x16	32	TL	225	48000	245	72000	144000	Flight Leader	93

Inflated Dimensions (in)				Static Loaded Radius(in)	Aspect Ratio	Wheel(in)			
Outside DIA		Section Width				Width Between Flanges	Specified Rim Diameter	Flange Height	Min Ledge Width
Max	Min	Max	Min						
45.25	44.3	16	15.05	19	0.797	13.25	20	1.88	3.4

1.3 Determination of the aircraft center of gravity position

1.3.1 Determination of centering of the equipped wing

The distance from the main aerodynamic chord to the center of gravity of the airplane is called the centering. During the changing of the aircraft loading variants or because of the changing of weight during flight the position of aircraft center of mass is changing. The moving of the cargo inside the aircraft leads to changing of center of mass position too.

The centering is important aircraft characteristic as it affects on the balancing, stability and controllability of the aircraft. That's why it is necessary to keep it inside strict limits.

To calculate the centering, it is necessary to determine the mass of main structural units and devices. The list of the units masses for the aircraft given in the table 1.5. The mass of aircraft is 280000 kg.

The longitudinal static stability of the aircraft is determined by the location of its center of mass relatively to the focuses.

The closer the center of mass is to the nose part of the aircraft, the more longitudinally stability the aircraft have.

Coordinates of the center of gravity for the equipped wing is determined by the formula (1.1).

$$X'_w = \frac{\Sigma m'_i X_i}{\Sigma m'_i} \tag{1.1}$$

Table 1.5

Trim sheet of equipped wing masses

N	Name	Mass		C.G. coordinates x_i (m)	Moment $m_i\, x_i$ (kgm)
		Units	total mass m_i (kg)		
1	Wing (structure)	0,0979	35772,27	3,66	130753,73
2	Fuel system	0,0130	4751,60	3,78	17938,11
3	Control system, 30%	0,0011	416,68	5,22	2175,76
4	Electrical equipment	0,0056	2061,47	0,87	1794,05
5	Anti-icing system 70%	0,0136	4963,60	0,87	4319,71
6	Hydraulic system, 70%	0,0087	3172,61	5,22	16566,32
7	Equipped wing without fuel and LG	0,1661	51138,22	3,39	173547,69
8	Nose landing gear, 40%	0,0097	3551,82	-19,51	-69299,64
9	Main landing gear	0,0292	10655,47	5,34	56889,56
10	Fuel	0,3774	137957,34	3,78	520812,43
	Equipped wing	0,5824	203302,86	3,35	681950,04

1.3.2 Determination of the centering of the equipped fuselage

The list of the unit for the aircraft is given in table 1.6. The center gravity coordinates of the equipped fuselage is determined by the formula (1.2).

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$$X_f' = \frac{\Sigma m_i' X_i}{\Sigma m_i'} \tag{1.2}$$

Table 1.6

Trim sheet of equipped fuselage masses

№	Objects	Mass		Coordinates of CG	Moment (kgm)
		Units	Total (kg)		
1	Fuselage	0,0875	25314,625	34,72	878923,78
2	Horizontal TU	0,01152	3332,8512	60,29	200937,5988
3	Vertical TU	0,00877	2537,2487	60,29	152970,7241
4	Instrument panel	0,0028	1023,42	3,11	3182,84
5	Aero navigation equipment	0,0024	877,22	1,12	982,49
6	Power unit	0,0915	33451,29	28,89	966407,83
7	Radio equipment	0,0012	438,61	2,52	1105,3
8	Lavatory	0,0027	990	46,41	45945,9
9	Coatroom	0,0010	378,89	21,10	7994,56
10	Galley	0,0029	1045	32,54	34004,3
11	Cargo equipment	0,0185	6761,9	31	209618,84
12	Control system, 70%	0,0027	972,25	35,5	34514,92
13	Electrical equipment	0.0132	4810,09	35,5	170758,03
14	Hydraulic system, 30%	0,0037	1359,69	42,6	57922,78
15	Covering	0,0055	2010,29	35,5	71365,44
16	Chemical liquid	0,003	1100	46,41	51051
17	Anti-icing system 30%	0,0058	2127,26	49,7	105724,65
18	Seats of passenger	0,0316	11550	35,41	408985,5
19	Rescue equipment	0,0075	2750	35,41	97377,5
20	Seats of crew	0,0010	357	4,85	1731,45
	Equipped fuselage without payload	0,2828	103356,18	33,73	3485877,02
Payload					
21	Crew	0,0035	1275	4,85	6183,75
22	Baggage	0,0447	16323,96	31	506042,76
23	Passengers	0,1129	41250	35,41	1460662,5
	Equipped fuselage with payload	0,4438	162205,14	33,65	5458766,03

1.3.2.3 Calculation of center of gravity positioning variants

The list of mass objects for center of gravity variants calculation given in Table 1.7 and center of gravity calculation options given in table 1.8 completes on the base of both previous tables.

The mean aerodynamic chord center of gravity is:

$$X_{MAC}=\frac{m_f{\cdot}x_f+m_w{\cdot}x_w\text{-}m_0{\cdot}c_n}{m_0\text{-}m_0} \qquad (1.3)$$

where m_0 – aircraft takeoff mass, kg; m_f – mass of equipped fuselage, kg;m_w – mass of equipped wing, kg.

Table 1.7

Calculation of center of gravity positioning variants

Name	Mass, kg	Coordinates	Moment
Object	m_i	C.G. M	kgm
Equipped wing without fuel and L.G.	51138,22	35,8	1830937,54
Nose landing gear (extended)	3551,82	12,9	45814,98
Nose landing gear (extended)	10655,47	37,75	402233,41
Fuel	137957,34	36,19	4992009,8
Equipped fuselage	1033556,18	33,73	3485877,02
Passengers	41250	35,41	1460662,5
Baggage of passenger	16323,96	31	506042,76
Cargo	16403,877	25	410096,9
Crew	1275	4,85	6183,75
Nose landing gear (retracted)	1038,33359	8,57076	8899,308
Main landing gear (retracted)	9345,00231	36,34076	339604,5
Fuel whilst landing	34489,33	36,19	1248002,45

Table 1.8

Aircrafts center of gravity position variants

№	Variants of the loading	Mass, kg	Moment of the mass, кg*m	Centre of the mass, *m*	Centering, %
1	Take-off mass (L.G. extended)	365508	12729761,76	34,83	27,78
2	Take-off mass (L.G. retracted)	365508	12725499,57	34,82	27,65
3	Landing variant (L.G. extended)	262040	8985754,41	34,29	21,62
4	Transportation variant (without payload)	307934,04	10758794,31	34,94	29,06
5	Parking variant (without fuel and payload)	168701,7	5764862,95	34,17	20,25

Conclusion to the project part

The aircraft meets the requirements for basic geometric parameters, such as operational purpose, planned number of passengers and cargo, speed, flight altitude, landing and take-off conditions.

Geometric alignment parameters correspond to the selected prototype. This allows us to conclude that the developed aircraft will successfully compete with other models in the selected market segment.

In addition, the GP7270 engine was selected based on the efficiency requirements of the aircraft being designed.

2. SPECIAL PART. DESIGN OF BIRDS SCARERS FOR AIRCRAFT

2.1 Basic concept

Birds are an integral part of all natural ecosystems. As in natural ecosystems, many birds are often associated with agroecosystems for their survival and have some impact on such systems. Due to land-use change, which often resulted in the loss of natural habitats such as forests, grasslands and wetlands, many birds had to rely on artificial habitats and crops.

Airports are one of these places. Most of the pests consisted of seed or grain eaters and fruit eaters birds. Since most of the airfields are meadows and fields, this is an excellent place for pests to feed. Therefore, there is a high probability of a collision of a bird directly with the aircraft itself during takeoff, landing and even flight.

A whole set of rules and ornithological services have been created to combat this problem. There are also different types of bird scarers (repellers) that have proven their effectiveness.

Bird repellers are devices used to control and scare birds away from places where their presence is undesirable or unacceptable, for example airports or aircraft.

There are many ways to scare birds away from primitive scarecrows to ultrasonic devices. The purpose of this work is to determine as efficiently and safely as possible the necessary device to protect the aircraft itself during takeoff and throughout it. The main goal of this experiment is to select the most effective and safe bird repeller, which is optimal for installation in the aircraft structure.

Types of scarers:

- Scarecrow is one of simplest and oldest designs of bird scarers, which is in the shape of a human figure. But scarecrow can be another forms like "Flashman Birdscarer," Iridescent tape, "TerrorEyes" balloons, and other visual deterrents are all built on the idea of visually scaring birds.

This method doesn't work so well with all kinds of birds, because that some birds often perch on scarecrows [].

- Hawk kites are shaped like a bird of prey. These many species of birds are also naturally afraid of predators such as birds of prey. Hawk kites are designed to fly in the wind over the field and protect them from pests.[]
- The Helikites Bird Repeller is a combination of a helium balloon and a kite. Helikites fly up to a height of 60 meters. Although they fly and hover high in the sky, behaving like birds of prey, but they do not look like hawks. Helikites exploit the birds-pest's instinctive fear of hawks and can reliably protect large areas of the airfields[].
- Laser is a device that converts energy into a narrow beam of light. Lasers can be effective at repelling birds because the laser beam creates a richer contrast than ambient light. It is recommended to use the laser during dusk or dawn as its effectiveness diminishes with increasing light levels. This method also requires careful tuning to a specific wavelength and frequency of waves that birds do not like to prevent widespread disturbances, especially at night. In any case, lasers can only be considered as an additional scaring system, since there is a possibility that some species of birds are resistant to this device [].
- Dead beards - a dummy or a real dead bird is also used as a danger signal to others. This method has often been used in the past to keep pests away from airport runways. Fixed models are less effective, since the birds still flew up to the corpse.
- Balloons - are an ordinary helium balloons with the addition of an image in the form of "frightening eyes" or the figure of a hawk or other predator. The main purpose of the balloon is to move through the air and create the impression that a pest is being watched. For greater efficiency, their placement is periodically changed. However, it does not prevent bird-pests from getting used to this repeller.
- Propane cannon - is a gas cannon that uses propane to produce periodic explosions. These explosions are similar to the sound of a gun shot, which in turn causes the pests to feel fear and fly away. The explosion volume reaches 150 dB. While gas cannons are considered to be eco-friendly and humane way to scare birds away, pests can

get used to the regularity of explosions, especially if they do not change in magnitude, pitch or time interval of shots. It can also cause some discomfort to people living nearby [].

- Acoustic (sound) scarers - are a system consisting of a record player and several speakers. Distress signals of birds or calls of various avian predators are recorded in it. Also, some models change the pitch, time interval, magnitude and sequence of the sound to prevent birds from getting used to this system. In many cases, sonic bird scaring is the only effective and satisfactory way to protect airfields from pests without harming them. In addition to the quick addiction of birds to the emitting sounds, a lot of the sounds they make annoy people, which is the main disadvantage of this method [].

- Ultrasonic scarers are devices that emit sound at a high frequency, which negatively affects some species of birds, keeping pests away from the protected area. Most people do not hear ultrasound due to the high frequency, but for some (such as children or adolescents) it can cause discomfort and headaches. Theoretically, this method is effective for scaring birds, but is not fully understood. Some studies show that birds have the same hearing as humans and cannot hear at ultrasonic levels [].

- Cartrige scarers - are modified pistols and shotguns loaded with special noise-producing cartridges. A shot from such rifles produces a loud bang and a flash of light. The cartridges are crafted from a light explosive instant flash powder. There are different types of these cartridges: shellcrackers, screamer shells and whistling projectiles, exploding projectiles, bird bangers and flares. These cartridges are designed for weapons with a range of 25-90 meters before the explosion, depending on their type. The noise level from the explosion is about 160 dB.The main disadvantage of this method of scaring away, as in others, is the high risk of addiction of pest birds to the sounds of a shot [].

- Benign acoustic deterrence - is a method of repelling birds using so-called benign sounds or Sonic Net. This sound is produced by conventional and directional (parametric) speakers. Sonic Net is a combination of waveforms, collectively referred to as "color noise", which creates non-constructive and constructive interference with the way birds communicate. This technology does not scare birds away, but it also prevents them from staying in the Sonic Net area. Since this method is still in the development stage, it is not fully known whether birds will really be able to get used to it [].

- Infrasonic repeller - is an infrasonic wave generator consisting of a sound source, an amplifier and a subwoofer. This device operates in a low frequency range below 20 Hz, so it is harmless to people. Since this method is only at the stage of successful simulation, it is not clear how effective the use of infrasound can be to scare birds away in practice [5].
- Optical gel - is a kind of mass made from resins and oils. It is used during daylight hours, as it reflects ultraviolet radiation. This radiation affects the visual sense organs, the pest perceives it as fire and flies away. Also, some gels contain substances that cause an unpleasant odor and a gag reflex.

The radar system is also used to detect and control the threat of a bird strike on an aircraft. This system improves the efficiency of bird scarers and reduces the possibility of collisions and subsequent damage.

There are also scare alternatives, such as spiraled prints on the cones of aircraft jet compressors. This pattern creates a visual flicker that resembles the eyes of a predator, which causes the pest bird to fly away.

2.2. Choosing of the optimal method of bird repellent

The main task of the scarers is to effectively prevent a collision of a bird with an aircraft during takeoff, landing or in flight.

Some manufacturers, such as Boeing, are developing special aircraft engine designs to reduce damage and possibly ignore bird strikes. Others are developing special drones to accompany aircraft during flight, or focus on creating a repellers located exclusively on the territory of the airport.

All the above-mentioned methods were not effective due to various reasons.
Their main disadvantage is the lack of the possibility of using repellers on the aircraft. The best solution would be to create a repeller located directly in the aircraft itself, which will not interfere with the operation of other aircraft systems.

Hence another effective method was using the “light source” repelling the birds using radiation which disturbs the birds (with-out harming) and repels them.

By combining this method with others, they can achieve the most effective result.

The purpose of this method is to provide the aircraft with a light source at different stages of flight. The light source produces flashes of light, the frequency of which changes during at least one cycle period. These flashes are a kind of warning signal for a flying plane. This warning is specifically designed for bird control.

After all, the perception of the surrounding world in a bird is different from that of a human, its hearing and eyes react to different frequency ranges. To understand a bird's reaction, you need to carefully study its behavior. The results of these studies show that the behavior of a bird is mainly determined by its visual means, which means that vision is primarily dominant and determines its further behavior. Also, the bird's instincts play an important role. For example, they have a pronounced escape instinct, which works in a certain way. If it is desired for the bird to fly in a certain direction or away from a certain area, it is necessary to induce the instinct to escape. To do this, it is necessary to identify three main factors influencing instinct: attention, speed and direction. It is after attracting attention that the bird will have an instinct to flee. Flashing light has proven to be effective in attracting attention compared to constant light. But on the other hand, a real flash of light attracts ten times more attention than a simple blinking light. The brief flashing of the light source is therefore important, because it produces the so-called solar effect in birds. This means that a fleeing bird tends to fly in a direction toward a bright light, even if this is a blinking light.

On the other hand, this effect is not observed with a flashing light. It is obvious that a bird will escape faster, the faster a potential enemy approaches it.

The process of the present invention therefore makes use of the fact that a strobe light flashing at an increasing frequency gives a bird the impression of a rapidly approaching enemy, so that it flees at a high speed from this flashing light source.

After extensive experiments, an increase in the flashing frequency in the range of about 0.1 Hz to about 3.0 Hz proved to be the most effective. Even after long-term use, a strong escape reaction away from the flashing light was provoked in the birds. The simple scaring of the birds cannot alone prevent a bird impact. It is necessary that the birds leave a certain area, namely, the collision zone, and in addition, that they remain outside this area and not return to the collision zone after being scared away. A further, and very important point, is that the process utilizes two light sources which are visible to the bird. In this way, it is easier for the bird to determine the direction and speed of the flashing lights, so that it can fly in the direction away from and not into the path of the approaching aircraft. Light sources for executing the process in accordance with the present invention are preferably in stalled on the aircraft so that two light sources are always visible to birds in the danger zone. The danger zone includes, on the one hand, the actual collision zone, which comprises the cross-sectional profile of the aircraft along its flight path. The danger Zone also includes, on the other hand, the space from which a bird can escape into the collision zone within the approach time of the aircraft. This space is delineated approximately by a cone which extends forward from the wing tips of the aircraft, the opening angles of which become smaller, the faster the aircraft moves. In a commercial airliner which is taking off with a take-off speed of approximately 80 m/s, this opening angle amounts to is about 15. If the aircraft is taxiing at the flying speed of the bird, the angle amounts to approximately 90'. Installation of the light sources is therefore advantageously carried out on both wings, most preferably in the area of the engines. It has been found in tests that the ideal cycle time for the light sources corresponds approximately to the time from taxiing up until take-off, approximately 20 to 30 seconds, and the flashing frequency during one cycle is preferably increased from is approximately 0.5 Hz to approximately 2.0 Hz. Since , the ideal cycle time is dependent upon the type of aircraft, the apparatus of the present invention provides "for variable selection of the cycle time. The cycle may proceed successively, either once or repeatedly, since the frequency of flashing returns to the initial value after each cycle. After the expiration of one or more cycles, the light source or sources advantageously flash at the maximum end frequency, until the device is switched off again.

The light source itself preferably comprises a discharge lamp, which produces a very dazzling and rap idly flashing light, which is particularly well suited for the execution of the process of the present invention. This discharge lamp may be provided with current by means of an onboard power system and may be con trolled by means of a special control unit in the form of a microprocessor. The efficiency of these lamps exceeds 200 lm / W, and the power is 131 W. Various cycles and frequencies may be programmed into its storage memory and may then be individually recalled by making a corresponding program selection. Cycles and flashing frequencies are thereby available and can be selected for the types of birds which need to be scared away, and the speeds of the corresponding types of aircraft. The illumination time of each flash is preferably short to produce the most dazzling high intensity light flashes possible. With corresponding lamps, however, longer illumination times may be achieved in the range of the lower initial frequencies, which times become shorter with increasing flashing frequencies [].

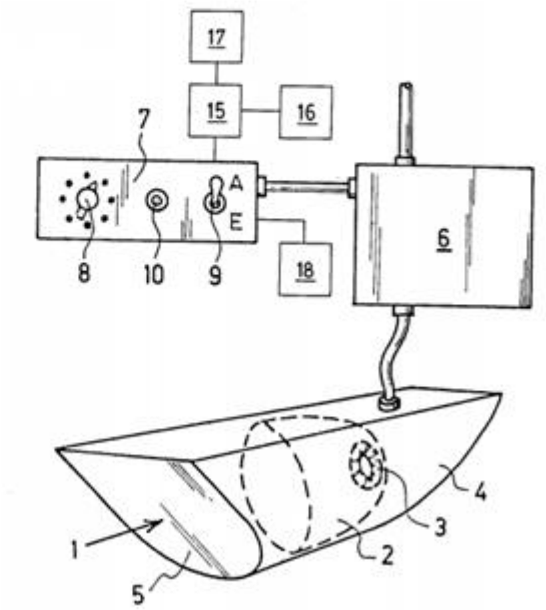

Fig. 2.1 Light source with a control unit and a power supply

As shown in fig. 2.1, light source (1) comprises a reflector (2) and a discharge tube (3), which are accommodated in a housing (4), which is shaped in an aerodynamically favorable manner. On its forward side, housing (4) may be sealed with a glass disk (5) positioned obliquely to the direction of flight. This may be heated to ensure the penetration of the full intensity of light. One side of housing (4) is substantially flat. This makes it possible to subsequently attach the apparatus below and on a wing of the aircraft.

Discharge tube (3) may be energized by power supply (6), in which a condenser is continuously charged with current from the onboard power supply.

The discharge tube (3) is controlled by control unit (7) which comprises a microprocessor, in which various flashing frequencies and cycle durations are stored. The programmed frequencies and cycle durations may be individually selected by means of a program selector switch (8). The process may be activated by means of a simple on/off switch (9), and deactivated in the same way, as shown in Fig. 1. Control lamp (10) lights up when the device is in operation.

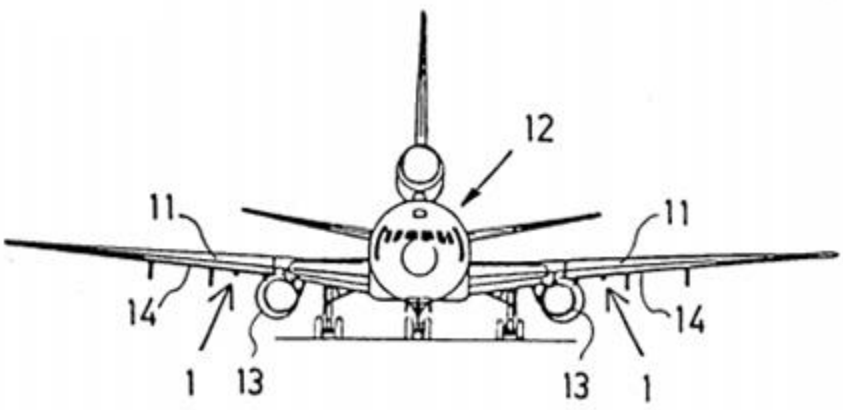

Fig. 2.2 Advantageous installation of the light source on an aircraft

Fig. 2 shows the possible and advantageous installation placement of two light sources (1) on the wing (11) of an aircraft (12). The light sources are located on the lower side (14) of wing (11), near engines (13), which are particularly endangered. In that location, airflow over the profile of the wing is not impaired, and the lift is therefore not reduced, or only minimally reduced. The process of the present invention may be initiated by means of various release circuits. In the simplest manner, this occurs when the pilot activates control unit (7) by means of a separate switch (9). He generally does so immediately before taxiing out and before the throttle is pushed forward. As soon as he judges the ascent to be adequate, he again deactivates the apparatus. By means of this switching device, it is also possible for the pilot to activate the bird-alarming lights, which may be referred to as "ABC Lights' (Anti-Bird-Collision Lights), according to his own best judgment in any situation, even in flight and particularly during take off and landing.

Other switch means may be specially provided for automatically switching on and off the ABC lights.

For example, the control unit may be switched on and off by a switching relay means (15), which may be controlled by means of an on-board, acceleration-sensitive device (16).

As soon as the acceleration-sensitive device (16) registers that a certain acceleration value has been exceeded, it activates the relay means (15) which then activates the control unit. A timing means (17) then ensures that the relay means (15), after a predetermined time, deactivates the control unit. According to another embodiment, the ABC lights may be controlled by means of a special on-board radar system (18) which responds to birds in the danger zone, and then, by means of switching relay, automatically activates the ABC lights as soon as birds are detected. The ABC lights then remain on until the radar no longer detects any birds in the danger zone.

2.2. Calculation of bolted connection on cut, bearing resistance.

Specific load on bolted connection:

$$F=m\cdot g\cdot f\cdot n_w^e$$

where: m – mass of scarer; g - f-.

$$F=10\cdot 9.81\cdot 1.5\cdot 2.5\cdot=367.875\ H$$

Specific load on one bolt:

$$F_1=\frac{F}{n}$$

where: n – number of bolts.

$$F_1=\frac{367.875}{4}=91.96$$

Diamater of bolts:

$$D=\sqrt{\frac{4\cdot F}{\pi\cdot\sigma}}$$

where: σ – ultimate strength.

$$D = \sqrt{\frac{367.875}{3.14 \cdot 610}} = 0.438$$

According to the assortment, take a bolt with *d* = 3 mm.

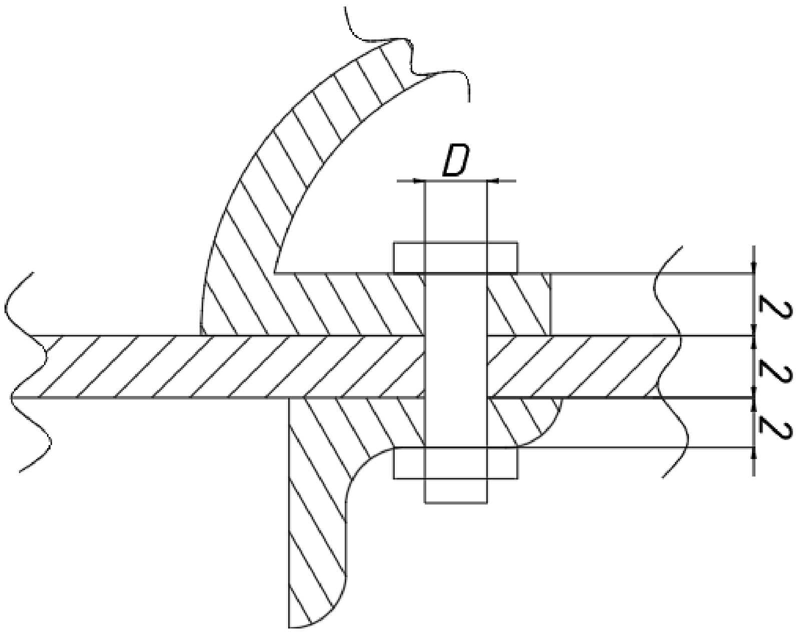

Fig. 2.3 Design of bolted connection

Cutting of bolted connection:

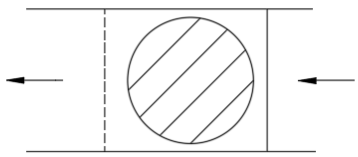

Fig 2.4 Cutting of connection

$$[F_c] = [\tau] \cdot \frac{\pi \cdot D^2}{4}$$

$$[F_c] = 283 \cdot \frac{9 \cdot 3.14}{4} = 1999.395\ H$$

Bearing resistance of bolted connection:

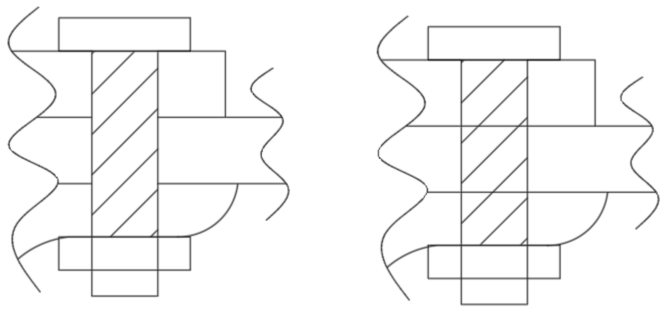

Fig 2.5 Bearing resistance of connection

$$[F_b] = [\sigma] \cdot A$$

$$[F_b] = 285 \cdot 6 = 1710\ H$$

The choice of bolted connection meets the requirements

$$F < [F_c] = [F_b]$$

Conclusion of special part

The main calculate equation and design of birds repeller were determined in this part.

When choosing the right type of scarer, many factors were taken into account, such as the efficiency of using this device and the ability to install it without affecting the operation of the aircraft's navigation systems. An important role was played by the fact that the light sources can be installed in several places on the plane at the same time, which will only increase the efficiency of scaring away birds.

It is also assumed the simultaneous use of several scarers at once. That is, a combination of an optical gel applied to the nose of the aircraft and the leading edge of the wing, a spiral pattern on the compressor cones of the aircraft engines, light sources mounted on the nose and wings of the aircraft, and the use of a ground-based radar navigation system to predict the movement of a flock of birds. This combination will help to reduce the required time and number of light source switching cycles.

It can be concluded that this is the most humane, economical and eco-friendly way of scaring away birds, which does not cause further addiction of these pests.

General conclusions and recommendations

During this designing work I've got the next results:

- preliminary design of the long-range aircraft with 550 passengers;
- the schematic design of the layout of the long-range aircraft with 550 passengers;
- the center of gravity of the airplane calculations;
- the calculation of stress-strain analysis fastening of the bird scarer;
- the design of bird scarer.

The created aircraft meets the intended purpose of use, its geometric characteristics will provide the necessary aerodynamic characteristics, which will lead to efficient use of it.

A new device for scaring away birds, which has no analogues in efficiency, has been proposed. This will reduce the number of aircraft colliding with birds.

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