МІНІСТЕРСТВО ОСВІТИ ТА НАУКИ УКРАЇНИ
Національний авіаційний університет
Кафедра конструкції літальних апаратів

ДОПУСТИТИ ДО ЗАХИСТУ
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«___» ____________ 2024 р.

КВАЛІФІКАЦІЙНА РОБОТА
ЗДОБУВАЧА ОСВІТНЬОГО СТУПЕНЯ
«БАКАЛАВР»

Тема: «Авіаційний контейнер для перевезення тварин»

Виконав:	__________	**Сергій ХЛОП'ЯЧИЙ**
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Київ 2024

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
National Aviation University
Department of Aircraft Design

PERMISSION TO DEFEND
Head of the department,
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_________Sviatoslav YUTSKEVYCH
"___"   ____________   2024

BACHELOR DEGREE THESIS

Topic: "Pet Container for Air Transportation"

Fulfilled by:	____________	**Serhii KHLOPIACHYI**
Supervisor: **PhD, associate professor**	____________	**Tetiana MASLAK**
Standards inspector: **PhD, associate professor**	____________	**Volodymyr KRASNOPOLSKYI**

Kyiv 2024

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Аерокосмічний факультет
Кафедра конструкції літальних апаратів
Освітній ступінь «Бакалавр»
Спеціальність 134 «Авіаційна та ракетно-космічна техніка»
Освітньо-професійна програма «Обладнання повітряних суден»

ЗАТВЕРДЖУЮ
Завідувач кафедри, к.т.н., доцент
_________Святослав ЮЦКЕВИЧ
«___» ____________ 2024 р.

ЗАВДАННЯ

на виконання кваліфікаційної роботи здобувача вищої освіти

ХЛОП'ЯЧОГО СЕРГІЯ ОЛЕКСАНДРОВИЧА

1. Тема роботи: «Авіаційний контейнер для перевезення тварин», затверджена наказом ректора від 20 травня 2024 року № 794/ст.
2. Термін виконання роботи: з 20 травня 2024 р. по 16 червня 2024 р.
3. Вихідні дані до роботи: максимальна вантажопідйомність 35 тон, дальність польоту з максимальним комерційним навантаженням 4000 км, крейсерська швидкість польоту 725 км/год, висота польоту 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 проектування контейнера для перевезень тварин.
5. Перелік обов'язкового графічного (ілюстративного) матеріалу: загальний вигляд літака (А1×1), компонувальне креслення фюзеляжу (А1×1), креслення контейнеру (А1×1).

6. Календарний план-графік:

№	Завдання	Термін виконання	Відмітка про виконання
1	Вибір вихідних даних, аналіз льотно-технічних характеристик літаків-прототипів.	20.05.2024 – 31.05.2024	
2	Вибір та розрахунок параметрів проектованого літака.	22.05.2024 – 23.05.2024	
3	Виконання компонування літака та розрахунок його центрування.	24.05.2024 – 25.05.2024	
4	Розробка креслень по основній частині дипломної роботи.	26.05.2024 – 27.05.2024	
5	Огляд літератури за проблематикою роботи.	28.05.2024 – 29.05.2024	
6	Розробка креслень по спеціальній частині дипломної роботи.	30.05.2024 – 31.05.2024	
7	Оформлення пояснювальної записки та графічної частини роботи.	01.06.2024 – 02.06.2024	
8	Подача роботи для перевірки на плагіат.	03.06.2024 – 06.06.2024	
9	Попередній захист кваліфікаційної роботи.	07.06.2024	
10	Виправлення зауважень. Підготовка супровідних документів та презентації доповіді.	08.06.2024 – 10.06.2024	
11	Захист дипломної роботи.	11.06.2024 – 16.06.2024	

7. Дата видачі завдання: 20 травня 2024 року

Керівник кваліфікаційної роботи ____________ Тетяна МАСЛАК

Завдання прийняв до виконання ____________ Сергій ХЛОП’ЯЧИЙ

NATIONAL AVIATION UNIVERSITY

Aerospace Faculty
Department of Aircraft Design
Educational Degree "Bachelor"
Specialty 134 "Aviation and Aerospace Technologies"
Educational Professional Program "Aircraft Equipment"

APPROVED BY
Head of the Department,
Associate Professor, PhD.
________ Sviatoslav YUTSKEVYCH
“___” ____________ 2024

TASK

for the bachelor degree thesis

Serhii KHLOPIACHYI

1. Topic: " Pet Container for Air Transportation ", approved by the Rector’s order № 794/ст from 15 May 2024.
2. Period of work: since 20 May 2024 till 16 June 2024.
3. Initial data: cruise speed V_{cr}=725 km/h, flight range L=4000 km, operating altitude H_{op}=10 km, cargo capacity 35 tons.
4. Content (list of topics to be developed): 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, a special part that contains the conceptual design of a container for animal transportation.
5. Required material: general view of the airplane (A1×1), layout of the airplane (A1×1), drawing of a container (A1×1).

6. Thesis schedule:

№	Task	Time limits	Done
1	Selection of initial data, analysis of flight technical characteristics of prototypes aircrafts.	20.05.2024 – 31.05.2024	
2	Selection and calculation of the aircraft designed parameters.	22.05.2024 – 23.05.2024	
3	Performing of aircraft layout and centering calculation.	24.05.2024 – 25.05.2024	
4	Development of drawings on the thesis main part.	26.05.2024 – 27.05.2024	
5	Review of the literature on the problems of the work.	28.05.2024 – 29.05.2024	
6	Development of drawings for a special part of the thesis.	30.05.2024 – 31.05.2024	
7	Explanatory note checking, editing, preparation of the diploma work graphic part.	01.06.2024 – 02.06.2024	
8	Submission of the work to plagiarism check.	03.06.2024 – 06.06.2024	
9	Preliminary defense of the thesis.	07.06.2024	
10	Making corrections, preparation of documentation and presentation.	08.06.2024 – 10.06.2024	
11	Defense of the diploma work.	11.06.2024 – 16.06.2024	

7. Date of the task issue: 20 May 2024

Supervisor: ____________ Tetiana MASLAK

Student: ____________ Serhii KHLOPIACHYI

РЕФЕРАТ

Пояснювальна записка кваліфікаційної роботи бакалавра «Авіаційний контейнер для перевезення тварин» містить:

50 с., 15 рис., 7 табл., 6 джерел

Метою дипломної роботи є попередня розробка вантажного літака середньої дальності вантажопідйомністю 35 тон, оцінка його конструктивних характеристик та розробка авіаційного контейнера для перевезення тварин.

Під час написання роботи було розроблено контейнер для перевезення тварин для різних цілей, з дотриманням всіх необхідних вимог IATA, та їх раціональне компонування у вантажній кабіні літака.

Матеріали кваліфікаційної роботи можуть бути використані в навчальному процесі та в практичній діяльності конструкторів спеціалізованих проектних установ.

Кваліфікаційна робота, аванпроект літака, компонування, центрування, обладнання літака, контейнер для тварин

ABSTRACT

Bachelor thesis «Pet Container for Air Transportation» consists of:

50 sheets, 15 figures, 7 tables, 6 references

The thesis present the preliminarily design of a medium-range aircraft with a carrying capacity of 35 tons. The initial analysis is performed for the evaluation of design characteristics for designing aircraft, based on statistic data of prototypes. The cabin layout is conducted, the cargo cabin is designed for the transportation of animals. The special task of the thesis ifs to develop cargo container for the transportation of animals by air.

All regulations and requirements for the animal's transportation are taking into account in compliance with IATA requirements.

The materials of the bachelor degree thesis can be used in the educational process and in the practical activities of designers of specialized design institutions.

Bachelor thesis, preliminary design, cabin layout, center of gravity position, aircraft equipment, animal's container

Format	№	Designation	Name	Quantity	Notes
			General documents		
A4	1	NAU 24 12K 00 00 00 78 TW	Task for work	1	
	2	NAU 24 12K 00 00 00 78	Mid-range cargo aircraft	2	
A1		Sheet 1	General view	1	
A1		Sheet 2	Fuselage layout	1	
A4	3	NAU 24 12K 00 00 00 78 EN	Mid-range cargo aircraft	50	
			Explanatory note		

	Sh.	№ doc.	Sign	Date	NAU 24 12K 00 00 00 78 EN			
Done by		Khlopiachyi S.S			Pet Container for Air Transportation (List of diploma work)	list	sheet	sheets
Supervisor		Maslak T.P				Q		
						404 ASF 134		
St.control.		Krasnopolskyi V.S.						
Head of dep.		Yutskevich S.S.						

CONTENT

	List	# document	Signat.	Date	NAU 24 12K 00 00 00 78 EN
Done by		Khlopiachyi S.S.			Content
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St.control		Krasnopolsky V.S			404 ASF 134
Head of dep.		Yutskevich S.S.			

INTRODUCTION

Recently, we have observed a significant increase in transport traffic across various aviation companies. This surge has dramatically heightened the demand for transporting people, cargo, and other goods. The ongoing conflict in Ukraine highlights the need for pet transportation abroad. Currently, there are two main ways to travel with pets:

In-Cabin Travel: Some airlines allow pets to travel with their owners in the cabin. In this case, pets are usually accommodated in a suitable travel container that fits under the seat. Passengers should check their specific documentation for pets and vaccination requirements [1].

Cargo Shipping: Alternatively, pets can be shipped as cargo by a licensed commercial shipper. However, this method is less popular because pet owners often worry about their pets’ comfort and safety during the journey.

For a bachelor’s thesis, the key idea would be to analyze the requirements for transporting pets by air. This includes designing appropriate pet containers and ensuring that mid-range aircraft with a total cargo capacity of 35 tons can accommodate multiple pets or animals from a zoo.

1. ANALYSIS OF PROTOTYPES OF DESIGNING AIRCRAFT

1.1. Choice of the projected data

The selecting of the optimum design parameters of the aircraft is the multidimensional optimization task, aimed at forming a "look" promising aircraft. In its configuration mean the whole complex flight-technical, weight, geometrical, aerodynamic and economic characteristics. In forming the "Appearance of the plane" in the first stage is widely used statistics methods transfers, approximate aerodynamic and statistical dependence. The second stage uses a full aerodynamic calculation; aircraft specified formulas of aggregates weight calculations, experimental data.

The main aims to present the preliminary design of medium-range aircraft for transportation of carries up to 35000 kg, present the main parameters of projected aircraft, its design description, the wing geometry calculation and wing loading calculation for chosen aircraft. The main prototypes for the new aircraft are An-70, A400M and C-130J-30 are presented in tables 1.1.

Table 1.1

Flight performances of prototypes

Parameter	A400M	An-70	C-130J-30
The purpose of airplane	Transport	Transport	Transport
Crew/flight attend. persons	2/4	2/2	2/2
Payload, $m_{k.max}$, kg	35000	35000	18.955
The flight altitude, m	10000	11500	10670
Flight range, km	7870	1200-8000	5250
Take off distance, m	1193	1150	1135
Landing distance, m	1037	1015	990
Take-off weight of the aircraft, kg	135000	141000	79380
Fuselage diameter, m	4.60	4.50	4.35

The end of the table 1.1.

Parameter	A400M	An-70	C-130J-30
Wing area, m^2	221.5	204	162.12
Aspect ratio, m	9.16	9.4	10.1
Wing span, m	42.4	44.06	40.41
Cruise speed, Mach number	0.74	0.72	0.615
Sweepback angle of a wing, °	23	21	8

The scheme is determined by the relative position of the aircraft units, their numbers and shape. Aerodynamic and operational characteristics of the aircraft depends on the aircraft layout and aerodynamic scheme of the aircraft. Fortunately chosen scheme allows to increase the safety and regularity of flights, and economic efficiency of the aircraft.

On the basis of the same type of aircraft assembly schemes many aircraft building firms chosen scheme of the airplane: high-wing; T-shaped tail; four turbo fan engines located under the wing; one nose and two main landing gears, that does not exceed the fuselage.

Normal distribution scheme is prevailed in aviation.

The main advantages of the normal scheme are:

- the possibility of effective use of high lift devices of the wing;
- easy balance of the aircraft due to the deflected flaps;
- the tail unit after the wing gives a shorter nose part of the fuselage, which not only improves the overview of the pilot, but also reduces the area of airplane, because shorter nose part of fuselage causes a smaller road destabilizing moment;
- to reduce the area of HTU and VTU because shoulders of HTU and VTU are much more than in other schemes.

Such scheme also has disadvantages:

- HTU creates negative lift almost at all flight conditions, leading to a decrease in total lift aircraft;

- HTU operating in the turbulence air stream from the wing, which negatively affects on its work.

1.2. Brief description of the main parts of the aircraft

The aircraft fuselage is an all-metal semi-monocoque design with a set of longitudinal elements - stringers and beams, cross a set of frames and stressed skin with reinforcements in the areas of cutouts openings hatches, doors, glazing and aircraft equipment.

The cross-section of the fuselage is circular.

The fuselage is divided into a nose, middle and tail parts.

The forward fuselage between frames number 2-11 is the crew cabin, which is separated by a reinforced wall from the cargo compartment. In front of the cockpit is the emergency exit in the upper part, there is an escape hatch. Entrance to the cabin crew is from the cargo compartment for ladder through a hatch in the floor of the cockpit. Under the cockpit floor is a technical compartment, which has a nose landing gear wheel well, closed by doors, and the shaft with the lower emergency hatch open outward.

The cockpit canopy provides a clear view for the pilots in flight. Windshields maintain their attachment and protected from bird strike.

In the middle part of the fuselage, between the nose and tail section of the fuselage, between frames №14-66 there is a cargo compartment, which has a cargo floor. The floor deck has two hatches for access to the underground space. Load floor threshold with knots hinge ramp cargo hatch is located at 57 frames.

In the middle part of the fuselage is the central compartment, including the center wing box area connected with the fuselage center section, located between the frames 32-40, and the wheel well for the main landing gear between frames number 40-47. In front of the cargo compartment, on the left and right sides, there are two side doors. To enter the plane and exit using the left-hand door airstair, cleaned by hand and fitted to the board inside the fuselage. Doors open outside in the direction of flight, both manually operated and in remote way also.

The cargo compartment has two lower side hatches opened manually to the outside of the aircraft.

Windows on the side of the doorway and all side hatches on both sides of the fuselage, provide lighting with daylight and view from the truck cab.

On the ceiling of the cabin along two rails fitted for electric hoists.

The aft fuselage is a cargo hatch, consisting of a ramp with four bridges, hermetic airtight flap and two flaps limiting hermetical area of the fuselage. The tail unit structure is connected with the reinforced fuselage frames numbers 73-77.

The cargo cabin area of the fuselage and the wing is operating with hatches and removable panels for access to the equipment.

On both sides of the fuselage fairings are the main landing gears, having a wheel well for main landing gear, hatches for aircraft subsystems and equipment and at for the auxiliary power unit compartment.

Side door and cargo door are electro-hydraulically controlled. The aircraft has an electronic display system on the situation of the side doors and the cargo hatch, as well as warning pilots of alarm about unclosed position of all external doors and hatches displayed on the screen.

The design of all doors and hatches are performed in such manner that prevent any intrusion and opening in flight, as well as jamming doors and hatches in the event of an emergency landing or destruction of an aircraft during ditching. Devices opening side doors and hatches as well as the escape hatch are marked on the process of opening and does not require excessive force to open them manually.

The fuselage is protected from corrosion, deterioration or loss of strength of environmental influences in all operation conditions, and also have ventilation and drainage system in all compartments.

The aircraft wing consists of center wing box and two outer wing sections. The wing has two spars, made of high-strength aluminum alloy. Access inside the torsion box is provided through the hatches, holes in the top panel. To provide access to all the compartments in the center wing section the rib number 3 is made removable.

Torsion box is a center-integrated fuel tank inside a wing. Fasteners connect construction components, ensures tightness. Sealing system covers holes, providing pressurization, hole is made to provide easy access to replace the components and requires an additional application of the sealant.

The outer wing section consists of torsion box, removable leading edge compartment; removable trailing edge section; removable tip. The torsion box consists of front and rear spars; panels of the skin with stringers; normal and reinforced ribs and hinges for the attachment of high lift devices and ailerons.

Access to the torsion box is performed through removable panels on an upper surface of the wing. To service the fuel system units on removable panels is possible through hatches, manholes.

Wingtips made using polymer composite materials.

The leading edge high lift devices of a wing consists of two sections of droop nose and six sections of controlled slats. Section of droop nose is driven by two actuators.

The design of the slat section and droop nose are riveted.

The nose of the wing – the assembly of a three-layer structure composed of panels with use of reinforced members and the longitudinal beams.

The trailing edge high lift devices of a wing consists of flaps, ailerons, spoilers.

The trailing edge of the wing is made up of upper and lower panels of the three-layer structure using polymer composite materials.

Flaps – sliding, double-slotted. The flap section includes a main and outer sections. Each section of the flap extends with the hydraulically driven mechanisms. The drive mechanism is carried by ball lifts. Mechanisms for flap extension enclosed in a fairing using polymer composite materials, aluminum and titanium alloys.

The empennage of the aircraft performed as a cantilever, a T-shaped with a centrally located fin.

The stabilizer is made mostly of composite materials and consists of: solid frame made of composite materials with external three-layer panels, nose and rear part, tip, metal before stabilizer are ready-riveted constructions.

The elevator made of two sections and is made mostly of composite materials. As hosts sample elevator are removable covers for inspection of construction, repair and maintenance, and replacement of all mechanical parts.

Fin preferably made from composite materials and consisting of a frame and composite materials with three-layer outer panels, nose part, the tail section, fairing equipment.

Joint fin to the fuselage is produced by the fittings, which are manufactured by machining of forgings made of aluminum alloy.

Rudder made a three-section (lower, upper and middle sections) and is made mostly of composite materials. As nodes rudder linkage made removable covers for the construction inspection, repair and maintenance, and replacement of all mechanical parts. In plumage provided protection structure against deterioration or loss of strength of environmental influences in all anticipated operating conditions, and also have ventilation and drainage in all compartments.

Aircraft landing gear consists of six main and one nose wheel.

Each main support consists of shock struts, on which two wheels with hydraulic disc brakes and wheels fan cooling system are fitted.

Main wheels are retracted in compartments of the fairing towards the plane of symmetry of the aircraft. Compartments are closed by doors. When retracting the wheels of main supports are automatically braked.

Nose landing gear consists of a steerable strut with two non-braking wheels. The front support is retracted into the front compartment of the landing gear against the fuselage of the airplane. Compartment is closed by doors.

Aircraft landing gear are equipped with such subsystems: retraction and extension, wheel braking, temperature control and wheel cooling control, control of front landing gear turning, retraction and extension and elongation of auxiliary support;

The main structural components of the aircraft are presented at the figure 1.1.

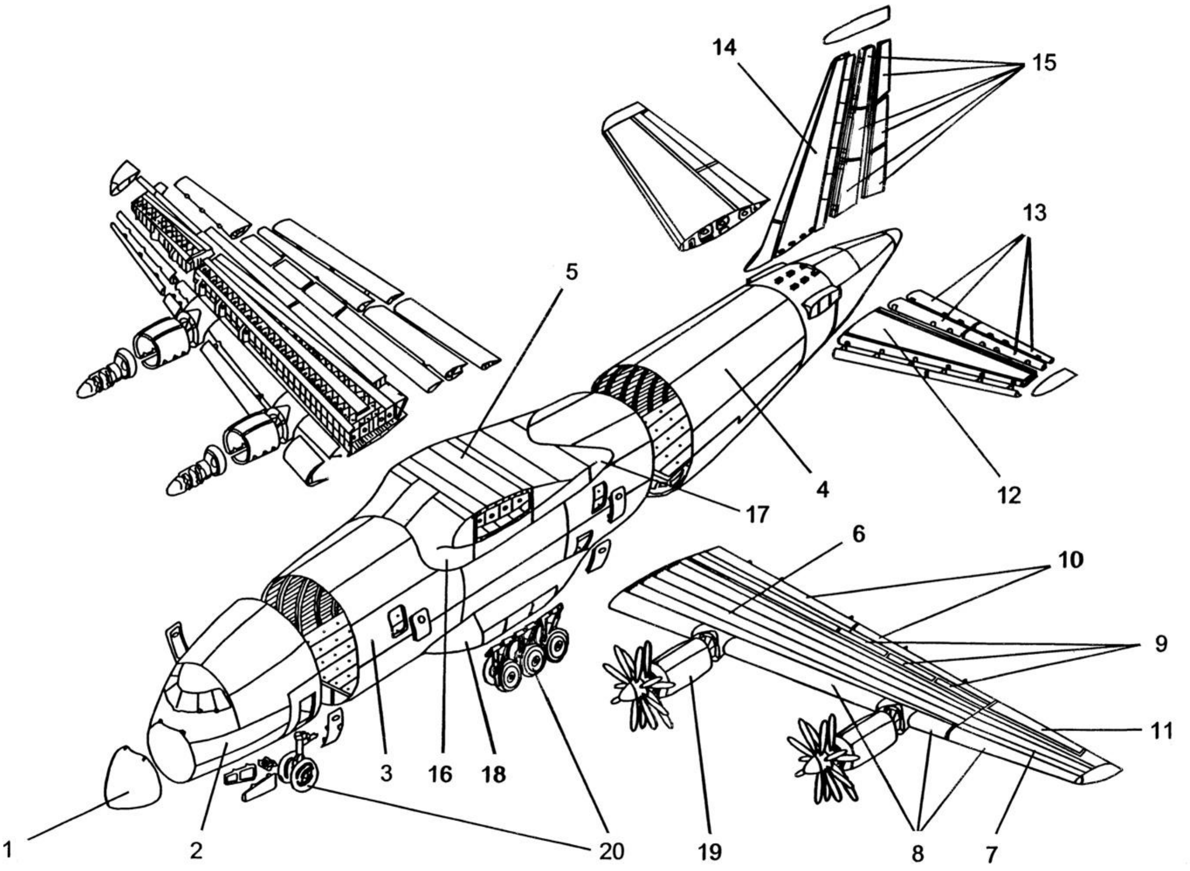

Fig. 1.1. Main parts of aircraft:

1 – front cowling; *2* – fuselage nose compartment; *3* – fuselage mid compartment; *4* – fuselage tail compartment; *5* – central wing box; *6* – middle part of a outer wing section; *7* – tip of a wing; *8* – slats; *9* - spoilers; *10* – flaps; *11* – ailerons; *12* - stabilizer; *13* – elevator with tabs; *14* – fin; *15* – rudder with tabs; *16* – front wing fairing; *17* – aft wing fairing; *18* – landing gear fairing; *19* – nacelle of engine; *20* – landing gear.

The cargo compartment of the aircraft is devoted for the transportation of cargo. The aircraft provides transportation of cargo of various types: special vehicles, self-propelled machine wheeled and tracked passages, small goods packed in boxes with dimensions not less than 0.3×0.3×0.3 m, cargo aircraft in containers, long loads such as pipes, rails in an appropriate container.

The aircraft has the ability to carry on the ramp loads of up to 5000 kg.

For the protection of crew and accompanying cargo from shifting cargo during the emergency landing the barrier device is installed.

Roller equipment ensures the movement of goods in containers and on pallets in the cargo compartment of the aircraft and their consolidation.

Loading, unloading and stowage of cargo handling equipment is provided in a cabin. The composition of transport equipment: upper loading equipment; lower loading equipment; roller equipment.

Upper loading equipment consists of four hoists, each carrying capacity of 3000 kg. The upper loading equipment consists of two winches; a block and tackle system; protective flooring on the floor and the ramp.

The upper and lower loading equipment in flight does not work and is regarded as the load mounted in the cabin. The strength of securing the cab is designed for all flight and landing load cases, including emergency landing.

Mooring equipment secures the cargo in the cargo cabin. Mooring equipment consists of mooring sites; mooring chain devices; mooring nets; belts; straps, clamps.

The roller table of the equipment are roller track; locking beams; the side guides; end locks.

Conclusions to the analytical part

In this part I have prepared the analysis of aircraft prototypes. The main prototypes are A400M, An-70, C-130J-30. These aircraft are mid-range cargo aircraft with cargo capacity 35000 kg, 35000 kg, 18955 kg respectively. The flight performances of the prototypes were the base for the performances for the designing aircraft. The main characteristics for a new cargo aircraft are: cruise speed 725 km/h, cargo capacity 35000 kg, the main dimensions of aircraft: fuselage length 45620 mm fuselage diameter 4600 mm, wing sweep back angle 15°.

The brief description of all parts of the aircraft are described.

2. PROJECT PART

2.1. Geometry characteristics for the main parts of the aircraft

Layout of the aircraft consists from composing the relative disposition of its parts and constructions, and all types of the loads (crew members, luggage, cargo, fuel).

Choosing the scheme of the composition and aircraft parameters is directed by the best conformity to the operational requirements.

2.1.1. Wing design

The paragraph is devoted to the calculation of geometrical parameters and composition of the aircraft wing. The main parameters of a wing will be calculated.

The area of the wing:

$$S_W = \frac{m_0 \cdot g}{P_0} = \frac{134338 \cdot 9.81}{4390} = 300.2\ \text{m}^2,$$

where m_0 – take-off weight, kg, g –gravity acceleration, m/s^2; P_0 –specific wing load.

]

Wing span:

$$l = \sqrt{S_W \cdot \lambda_W} = \sqrt{300.2 \cdot 9.6} = 53.68\ \text{m},$$

where λ_w – wing aspect ratio.

The root chord:

$$C_{root} = \frac{2S_W \cdot \eta_W}{(1+\eta_W)\cdot l} = \frac{2 \cdot 300.2 \cdot 3.5}{(1+3.5)\cdot 53.68} = 8.7\ \text{m},$$

where η_w – wing taper ratio.

The tip chord:

$$C_{tip} = \frac{C_{root}}{\eta_w} = \frac{8.7}{3.5} = 2.48\ \text{m},$$

Board chord:

$$b_b = C_{root}\left(1 - \frac{\eta_w - 1}{\eta_w} \cdot \frac{D_f}{l}\right) = 8.7\left(1 - \frac{3.5-1}{3.5} \cdot \frac{4.6}{53.68}\right) = 8.17\ \text{m},$$

where D_f –fuselage diameter.

The relative position of spars in the wing chord is equal to:

$$\bar{x}_i = \frac{x_i}{b_i}$$

where x_i – position of i-th spar from the tip of the wing; b_i – wing chord i-th section.

Front spar:

$$x_1 = \bar{x}_1 \cdot b_o = 0.2 \cdot 8.7 = 1.74\ \text{m}$$

$$x_1 = \bar{x}_1 \cdot b_t = 0.2 \cdot 2.48 = 0.496\ \text{m}$$

Rear spar:

$$x_2 = \bar{x}_2 \cdot b_o = 0.6 \cdot 8.7 = 5.22\ \text{m},$$

$$x_2 = \bar{x}_2 \cdot b_t = 0.6 \cdot 2.48 = 1.488\ \text{m},$$

Average of thickness ratio:

$$\overline{c_{av}} = 0.12,$$

Determine the value MAX:

$$b_{MAX} = \frac{4}{3} \cdot \frac{\eta_w^2 + \eta_w + 1}{(\eta_w + 1)^2} \cdot \frac{S_w}{l_w} = \frac{4}{3} \cdot \frac{3.5^2 + 3.5 + 1}{(3.5+1)^2} \cdot \frac{300.2}{53.68} = 6.17\ \text{m},$$

Mean aerodynamic chord is equal: b_{max}= 6.17 m

Geometric parameters of the aileron.

Span aileron:

$$l_{ail.} = 0.22 \cdot \frac{l}{2} = 5.9\ \text{m}.$$

The square of the spar:

$$S_{ail.} = 0.031 \cdot \frac{S_w}{2} = 4.65\ \ \text{m}^2.$$

Wing aileron compensation is not required.

Aileron deflection range: upper $\delta_{ail} \geq 25^{\circ}$, down $\delta_{ail} \geq 15^{\circ}$.

2.1.2. Fuselage layout

Determination of geometrical and parameters of the fuselage.

From the initial data, the diameter of the fuselage is 4.6 m, fineness ratio is 9.05.

The length of the fuselage is calculated by the formula:

$$l_f = D_f \cdot \lambda_f = 41.63\ \text{m},$$

where λ_f – fineness ratio; D_f – diameter of the fuselage.

Normal and emergency exits, emergency funds are designed like in prototypes.

The dimensions of the side door on the left and right sides of the cargo compartment: width – 0.8 m; height – 1.8 m.

Dimensions of escape hatches in the left and right sides of the cargo compartment are the next: width – 0.61 m; height – 1.22 m.

Dimensions of the recess of the lower escape hatch in the cockpit are 0.7×0.95 m. Dimensions of cargo compartment 25.84×4 m.

Due to this size of the cargo cabin, it can accommodate any standard Unit Load Device with a total weight not exceeding 35 tons.

2.1.3. Landing gear layout

The designed aircraft is equipped with the tricycle landing gear which consists of the one-strut-mount nose support with the operated wheels, the two one-strut-mount main support with brake wheels and the mechanisms of management of compartments of the main and nose support.

Landing gear strut:

$$K = 0.905 \cdot D_f = 4.16 \text{ m}.$$

Wheel base:

$$B = 0.345 \cdot l_f = 14.36 \text{ m}.$$

Removal of the main support:

$$e = 0.15 \cdot b_A = 0.15 \cdot 6.17 = 0.925 \text{ m}.$$

Coordinates of the center of mass of the aircraft taking:

$$Y_{cen.mass} = 0.09 \cdot D_f = 0.414 \text{ m}.$$

Removal of the front support:

$$d = B - e = 14.36 - 0.925 = 13.435 \text{ m}.$$

The load on the wheel main landing:

$$P_{main} = \frac{(B-e) \cdot m_o \cdot g}{B \cdot n \cdot z} = 102.747 \text{ kN}.$$

The load on the wheel front support:

$$P_{front} = \frac{e \cdot m_o \cdot g \cdot k_{Д}}{B \cdot z} = 63.667 \text{ kN}.$$

We select the tires for wheels, the results are presented in table table 2.1. All wheel on main landing gear have brakes, which makes it possible to reduce the landing run.

Table 2.1.

Tires for wheels

Wheel size	$P_{take\ off}$, N	P_{land}, N	P_o, 10^5Pa	$\delta_{ст.}$, mm	$P_{разр.}$, N	$V_{land.}$, km/h	$V_{take\ off.}$, km/h
For the main landing gear							
1100×330A	110000	86000	10	81	540000	260	330
For the nose landing gear							
1000×280A	66000	5750	10	65	345000	240	330

2.1.4. Engines selection

Power unit consists of four propfan engines D-27 and propfans CB-27, mounted on the wing; control system of engines; Auxiliary Power Unit; fuel system; fire protection system.

The main characteristics of the engine are presented in the table 2.2.

Table 2.2

Type of engines	TPFE D-27
Power, h/p	14000
Number of engines	4
The degree of pressure increases during cruise flight	9.0
Efficiency prop-fan (cruise)	0.9 ($M_п$ =0.7)
Mass of engine (without prop-fan), kg	1650
Length of engine, mm	4198
Diameter of fan, mm	4500
Air consumption, kg/s	27.4
Temperature before turbine during takeoff, K	1640
Power on the cruising speed, h/p	6750
Manufacturer country	Europrop Inter.

2.1.5. Tail unit design

Length of HTU: $L_{htu} = 1.75 \cdot b_{MAX}$ =5.758 m.

Length of VTU: $L_{vtu} = 1.95 \cdot b_{MAX}$ =6.416 m.

Coefficients of the static moments:

A_{HTU} = 0.75, A_{VTU}= 0.1

The square of HTU:

$$S_{htu} = A_{htu} \frac{b_{cax} \cdot S_w}{L_{htu}} = 66.1 \text{ m}^2,$$

where L_{HTU} – length of horizontal tail unit; A_{HTU} – coefficient of static moment of horizontal tail unit.

The square of VTU:

$$S_{vtu} = A_{vtu} \frac{l_w \cdot S_w}{L_{vtu}} = 54.1 \text{ m}^2,$$

where L_{VTU} – length of vertical tail unit; A_{VTU} – coefficient of static moment of vertical tail unit.

The square of elevator: $S_{el} = (0.3...0.4) \cdot S_{htu} = 0.35 \cdot 33.865 = 23.13$ m^2.

The area of the rudder: $S_{rd} = (0.35...0.45) \cdot S_{vtu} = 0.4 \cdot 35.506 = 21.64$ m^2

The span HTU: $L_{htu} = (0.32...0.5) \cdot L_w = 0.32 \cdot 27.867 = 17.498$ m.

Height VTU: $H_{vtu} = 0.2 \cdot L_w = 10.5$ m.

Tapper ratio of a HTU: $\eta_{htu} = 2.5$

Tapper ratio of a VTU: $\eta_{vtu} = 2.15$

Aspect ratio HTU: $\lambda_{htu} = 4$

Aspect ratio VTU: $\lambda_{vtu} = 1.2$

Definition chords of the tail unit. Horizontal tail:

Tip chord

$$b_{tchtu} = \frac{2 \cdot S_{htu}}{(\eta_{htu} + 1) L_{htu}} = 2.16 \text{ m},$$

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

Root chord

$$b_{rchtu} = b_{tchtu} \cdot \eta_{htu} = 5.4 \text{ m} .$$

Vertical tail unit:

Tip chord

$$b_{tcvtu} = \frac{2 \cdot S_{vtu}}{(\eta_{vtu} + 1) L_{vtu}} = 2.58 \text{ m} ,$$

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

Root chord

$$b_{rcvtu} = b_{tcvtu} \cdot \eta_{vtu} = 7.74 \text{ m} .$$

The relative thickness of the profile for HTU and VTU in the first approximation equal to: $\bar{C}_{on} = 0.07$.

2.2. Aircraft center of gravity calculation

In the operation of the aircraft position the center of gravity may change. Rear centering with this should be such as to ensure the necessary supply of static stability of the aircraft. Maximum allowable forward center of gravity determined by the efficiency of its longitudinal control (balancing).

2.2.1. Trim sheet of equipped wing

Mass of the equipped wing contains the mass of its structure, mass of the equipment placed in the wing and mass of the fuel. Regardless of the place of mounting (to the wing or to the fuselage), the main landing gear and the front gear are included in the mass register of the equipped wing. The mass register includes names of the objects, mass themselves and their center of gravity coordinates. The origin of the given coordinates of the mass centers is chosen by the projection of the nose point of the mean aerodynamic chord for the surface XOY. The positive meanings of the coordinates of the mass centers are accepted for the end part of the aircraft. The centering of the equipped wing is shown at the table 2.3.

Table 2.3

Trim sheet of equipped wing

№	Object	Mass		C.G. coordinates	Mass Moment
	Name	units	total, kg	X_I, m	kg m
1	2	3	4	5	6
1	Wing (structure)	0.10772	14470.89	2.318	33543.52
2	Fuel system	0.0055	738.86	2.307	1704.55
3	Airplane control, 30%	0.00135	181.35	3.21	582.13
4	Electrical equipment	0.00792	1063.95	1.06	1127.78
5	Anti-ice system, 70%	0.00917	1231.88	2.849	3536.41
6	Hydraulic systems, 70 %	0.00924	1241.28	3.216	3991.96
7	Equipped wing without landing gear and fuel	0.1409	18928.22	2.35	44486.35
8	Nose landing gear 8%	0.0031632	416.45	-14.03	-5842.79
9	Main landing gear 92%	0.003637	4876.69	2.401	11708.93
10	Fuel	0.18667	25076.87	2.397	60109.26
	Total	0.36711	48082.82	2.29	110461.75

Determine the coordinates of the center of gravity of the loaded wing:

$$X'_W = \frac{\sum m'_i \cdot x'_i}{\sum m'_i} \ ,$$

where X'_w – center of mass for equipped wing, m; m'_i – mass of a unit, kg; x_i – center of mass of the unit, m

2.2.2. Trim sheet of the equipped fuselage

Origin of the coordinates is chosen in the projection of the nose of the fuselage on the horizontal axis. For the axis X the construction part of the fuselage is given. We make centering of the fuselage, which is shown at the table 2.4.

After we determined the center of gravity (CG of FEW) and fuselage, we construct the moment equilibrium equation relatively fuselage nose:

$$m_f \cdot x_f + m_w \cdot (x_{MAC} + x'_w) = m_0 \cdot (x_{MAC} + C).$$

Table 2.4

Trim sheet of equipped fuselage masses

№	Objects	Mass $m_i{}^{/}$		C.G. coordinates	Moment of mass
	Name	units	total	X_I, m	$m_i{}^{/} X_I$, kg· m
1	2	3	4	5	6
1	Fuselage	0.10722	14403.72	20.7	298157.01
2	Horizontal stabilizer	0.01204	1617.43	38.42	62141.66
3	Vertical stabilizer	0.01186	1593.25	36.94	58854.65
4	Radar	0.0013	174.64	1	174.64
5	Radio equipment	0.0013	174.64	1	174.64
6	Instrument panel	0.0061	819.46	3.86	3163.11
7	Aero-navigation equipment	0.0402	5400.39	3.86	20845.51
8	Aircraft control, 70%	0.00315	423.16	20.7	8759.41
9	Electrical equipment, 70%	0.01848	2482.57	20.7	51389.2
10	Furnishings and Thermal	0.0052	698.56	17.37	12133,98
11	Anti-ice system, 30% of mass	0.001965	263.97	40.37	10656.47
12	Additional equipment	0.00074	99.41	18.32	1821.19
13	Power plant	0.14538	19530.06	18.95	370094.64
14	Operational items	0.0106	1423.98	8.68	12360.15
15	Equipped fuselage without payload	0.3675	49369.21	–	910726.26
16	Payload	0.26054	35000	18	630000
17	Cargo cabin equipment	0.0004	53.73	21.7	1165.94
18	Furnishing equipment	0.0316	4245.08	21.7	92118.24
19	No typical equipment	0.0002	26.87	16	429.92
20	Crew	0.004168	559.92	2.86	1601.37
21	Total	0.664408	86255.18	–	1636041.73

From here we determined the wing MAC leading edge position relative to fuselage, means X_{MAC} value by formula:

$$X_{MAC} = \frac{m_f \cdot x_f + m_w \cdot x_w - m_0 \cdot c_n}{m_0 - m_w} = 16.72,$$

Where m_0 – AC takeoff mass, kg; m_f – mass of FEF, kg; m_w – mass of FEW, kg; C – distance from MAC leading edge to the CG point, determined by the designer.

2.2.3. Calculation of center of gravity positioning variants

The list of mass objects for center of gravity variant calculation given in Table 2.5 and Center of gravity calculation options given in table 2.6, completes on the base of both previous tables.

Table 2.5

Calculation of C.G. positioning variants

Objects name	Mass, kg	C.M. coordinate X_I, *m*	Mass moment $m_i X_I$, *kg· m*
Equipped wing (without fuel and LG)	17712.81	19.03	337074.77
Nose L.G (extended)	416.45	-14.03	-5842.79
Main L.G (extended)	48764.69	18.67	910436.76
Fuel	25076.87	18.67	468185.16
Empty fuselage (without payload and crew)	50695.26	21.34	1081836.85
Cargo	35000	18	630000
Crew	559.92	2.86	1601.37
Nose L.G (retracted)	416.45	-12.86	-5355.55
Total	178642.45	–	3417936.57

Table 2.6.

Airplane C.G. position variants

№	Variants of the loading	Mass, kg	Moment of the mass, kg ·m	Centre of the mass, m	Centering
1	Take off mass (LG extended)	134338	2651563.44	19.738	0.301
2	Take off mass (LG retracted)	134338	2619187.98	19.497	0.298
3	Landing weight (LG extended)	114276.5	2162225.65	18.921	0.282
4	Ferry version	99338	1854938.47	18.673	0.276
5	Parking version	73761.12	1343632.56	18.216	0.272

Conclusions to the project part

In the project part we have determined the main geometrical parameters of designed aircraft, determined the layout of landing gear and tail unit. Also, we have determined the mass centers for equipped wing and the equipped fuselage. We have calculated the main loads on wheels during takeoff and landing. According to the obtained data we have chosen wheels, which will be the best in our case. We have chosen the type of landing gear taking into account service conditions and values of speeds during landing and takeoff.

3. PET CONTAINER FOR AIR TRANSPORTATION

3.1. IATA documentation and standards for animal transportation

Nowadays, the issue of exporting animals from zoos and temporary collections located in the frontline zones has become urgent. The cargo container is designed in accordance with all standards and requirements to transport animals for further treatment if necessary, or simply for their safe existence**.**

The dimensions of the animal transport container must match the dimensions of the standard pallet of the aircraft; it must not be made of materials that could endanger the health or welfare of the animals; it must permit animal observation; it must permit animal access in an emergency; it must permit the animal to stand in its normal position without coming into contact with the container's roof or, in the case of open containers, the restraining nets; it must shield the animals from inclement weather; it must guarantee that the animals are kept on a floor that prevents injuries or slipping; make sure doors are easily opened and closed, but secured so that they cannot be opened unintentionally; be free of any nails, bolts, and other protrusions or sharp edges that could cause injuries; be made to minimize the risk of any opening or space entangling any part of the animal's body; if reusable, crates should be made of impermeable material that is simple to clean and disinfect; make sure faces and urine cannot escape the crate; ensure the animals' safety and prevent them from escaping; allow for the provision of water and possibly food during transportation lasting longer than six hours. Permit certain species and young animals to establish their typical resting or sleeping positions; make sure the container is airtight; make sure the walls have ventilation openings that make up at least 16% of the wall area; if the container has an open top, this number may be lowered; have ventilation openings on all four sides of the crate, with the exception of two walls that may have less space for ventilation and the other walls that have more space when necessary due to the arrangement of the crates during transportation and/or the aircraft's ventilation pattern; make sure that no internal supports or dividers obstruct cross ventilation [4].

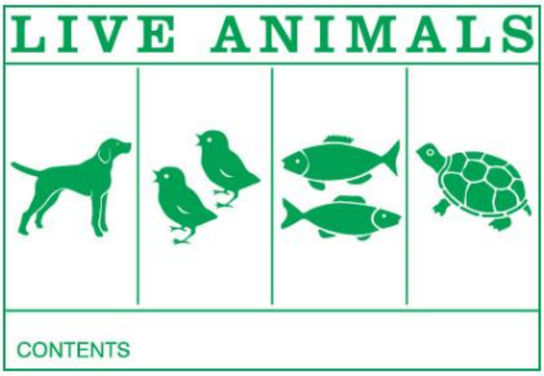

Fig. 3.1. “Live Animals” label.

In order to create universal standards, IATA formed the Live Animals Board and started reviewing the requirements for safe and ethical animal transportation in 1967. First released in 1969, the IATA Live Animals Regulations (LAR) serve as industry guidelines for aviation transport. IATA members decided to adopt the LAR as an industry standard under CSC Resolution 620 in 1974 since transportation parties were not always following recommended standards.

All consignments of live animals must have either a red “Laboratory Animals” label (Fig. 3.1) or tag or a green “Live Animals” label (Fig. 3.2). Additionally required are "This Way Up" labels (Fig. 3.3) or tags, which need to be positioned on at least two opposing sides. The container may bear an impression of the label or tag [5].

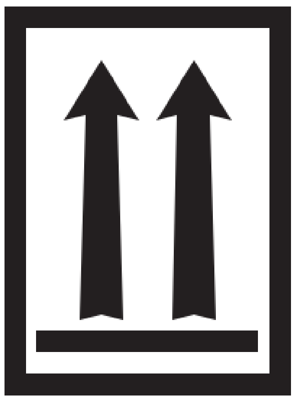

Fig. 3.2. “Laboratory Animals” label. Fig. 3.3. “This Way Up” label.

Container’s parameters.

Animal length measured from tip of nose to base/root of tail is represented by the letter A. Height of elbow joint from the ground is B. C is the breadth measured across the shoulders or the broadest point, whichever is larger. D is the height of the animal in its normal standing position measured from the top of its head to the tip of its ear, whichever is higher. All these dimentions are shown in the figure 3.4 [5].

For a single animal, the minimum interior container dimensions are:

$$Lenght = A + \frac{1}{2}B$$

$$Width = 2C$$

$$Height = D + bedding$$

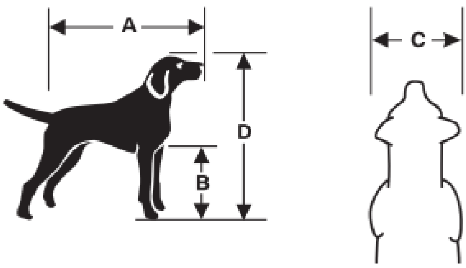

Fig. 3.4. Animal dimension.

Attendants and veterinarians.

Veterinarians: Assist in keeping an eye on the animals' health during the journey. If necessary, they should to be able to offer emergency medical attention.

Attendants: People who are familiar with leopards behavior and have worked with them in the past. They ought to be adept in managing big carnivores and capable of seeing to it that they are comfortable and secure while being transported. Attendants should have access to the animals to periodically check their condition.

There is no set international agreement that specifies the precise number of attendants and veterinarians needed when transporting large predators like leopards.

The number of veterinarians and attendants depends on the number of animals, their size, nature and specific needs. Usually, it is recommended to have one caretaker for every 2-3 large animals who is familiar with their behavior.

One or two veterinarians for a group of 10 leopards ensure constant monitoring of the animals' health and can provide necessary medical care.

These recommendations are based on generally accepted practices and the experience of specialists in the field of animal transportation.

Emergency killing.

The majority of animals on airplanes should only be killed in an emergency when it poses a threat to the crew, other animals, or the aircraft itself. Every airplane that transports animals has to have a technique for killing them with the least amount of agony possible, as well as a person skilled in doing it. The technique of killing should always be negotiated with the airline during the planning phases when carrying large animals. Appropriate techniques include [4].

1. A fatal chemical infusion after a captive bolt shock

a) The operator needs to be instructed on how to use the captive bolt stunner to the particular kind or species of animal being moved.

b) A specialist ought to ascertain whether the kind of captive bolt pistol and cartridge power are sufficient for every animal being conveyed.

c) Carrying captive bolt handguns may be prohibited by certain airlines and nations.

d) The user needs to be aware that other animals may become agitated by the noise made by the captive bolt.

e) It could be challenging to correctly set the captive bolt pistol while dealing with an agitated animal.

2. Chemical injection

a) Animals can be made unconscious, sedated, or killed with a variety of chemicals.

b) In order to be effective, central nervous system depressants such barbiturate euthanasia solutions must be administered straight into a vein. When an animal is sufficiently agitated to necessitate euthanasia, this is typically not feasible for anyone other than a skilled veterinarian or a highly trained and experienced attendant.

c) Animals may become more agitated when given sedatives such promazine and its derivatives.

d) Non-human immobilizing agents, including succinylcholine, are inhumane.

3. Weapons

Due of the risk to the aircraft, airlines do not allow the use of firearms that can discharge a free bullet.

3.2. Design and development of a container for animals

To begin with, we need to take into account the size of the animal itself, let's take a leopard with dimensions 1200×300×800, so from the formulas presented in paragraph 3.1 we have the following container parameters:

$$Lenght = A + \frac{1}{2}B = 1200 + \frac{1}{2}40 = 1220 \text{ mm}$$
$$Width = 2C = 2 \cdot 300 = 600 \text{ mm}$$
$$Height = D + bedding = 800 + 200 = 1000 \text{ mm}$$

In all parameters, I will take a little more for the possibility of transporting other animals if necessary, and in height, an additional space for the convenience of placing the animal in the container, so final size is: 1700×680×1530.

The model consists of 7 elements: container body, safety door, door with a hole for the feeder, safety grate, bedding, excrement trays, and feeder.

The modeling takes place in the Catia environment and begins with the main body (Fig 3.5), when modeling, you should remember that we need door guides, handles, ventilation holes, a place for litter trays, holes for locking pins and handles for transportation

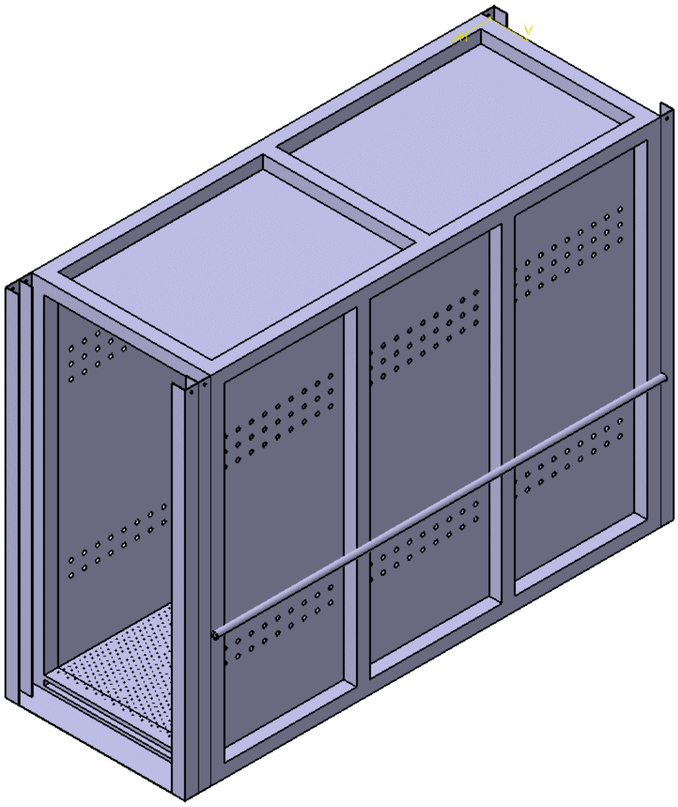

Fig. 3.5. Container Body.

The main doors (Fig. 3.6) have two additional stiffeners, they are retractable, for greater reliability of closing, which will prevent their accidental opening or incorrect closing, they are fixed with locking pins, operated manually.

70% of the total area of the door with the feeder (Fig. 3.7) is occupied by openings 5mm diameter, and the food opening has a slide mechanism. It has one stiffening rib due to the space for the feeder.

The safety grate (Fig. 3.8) is made taking into account the access for injections, it is also possible to swap the doors for better air circulation, remove the main door, put the grate on one side, and the door with the feeder on the other side or simply raise the door behind the grate. Also, if the trough is full of water, you can give the animal food through the grate.

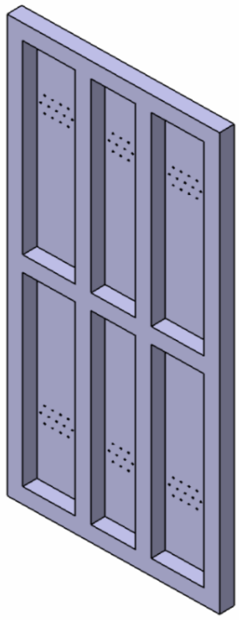

Fig. 3.6. Safety Door.

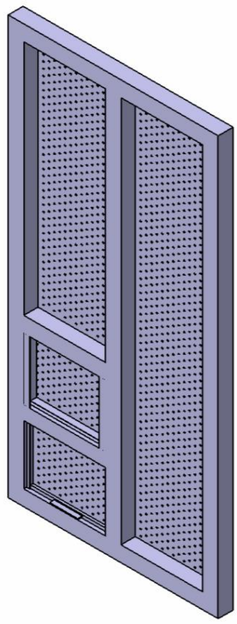

Fig. 3.7. Feeder Door.

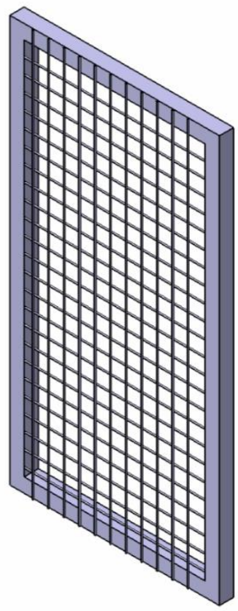

Fig. 3.8. Safety Grate.

You should also remember about the bedding (Fig. 3.9). The distance between the boards is made taking into account the ability to let in all the waste of the animal. The feces tray and feeder are also designed to fit into their seats on the main body, have a one-piece construction and have corresponding “handles” for convenience and are shown in figures 3.10 and 3.11 respectively.

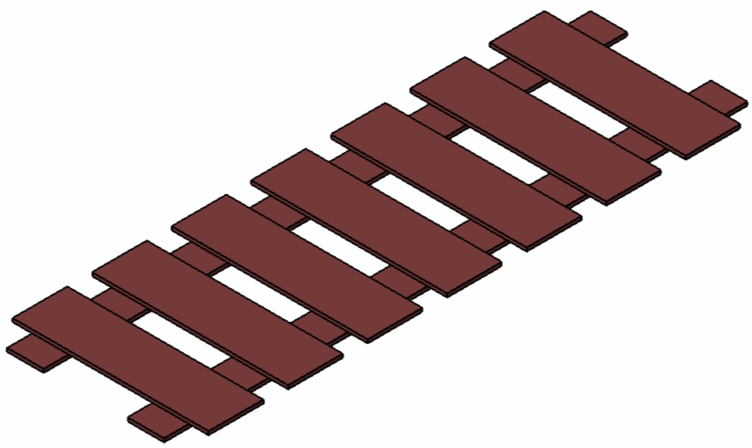

Fig. 3.9. Bedding.

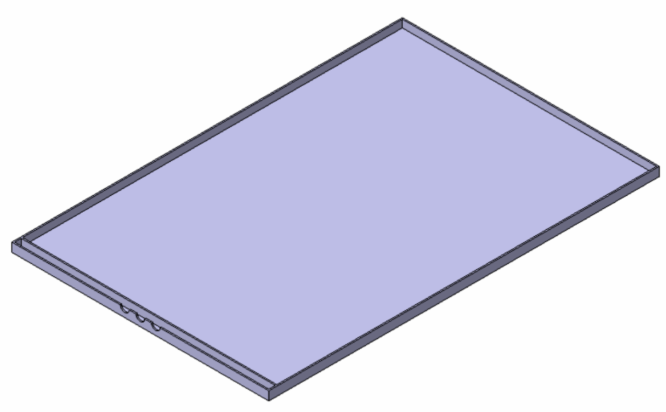

Fig. 3.10. Feces tray.

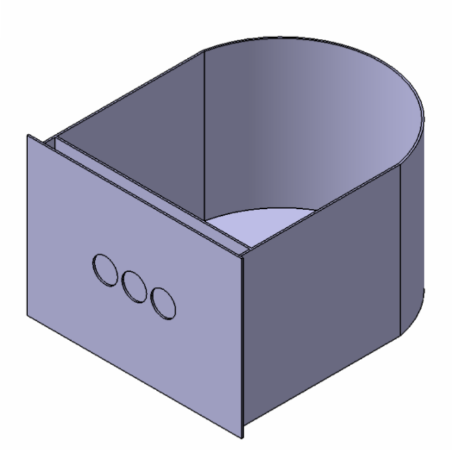

Fig. 3.11. Feeder.

In Figure 3.12, you can see a ready-to-use container with all the components.

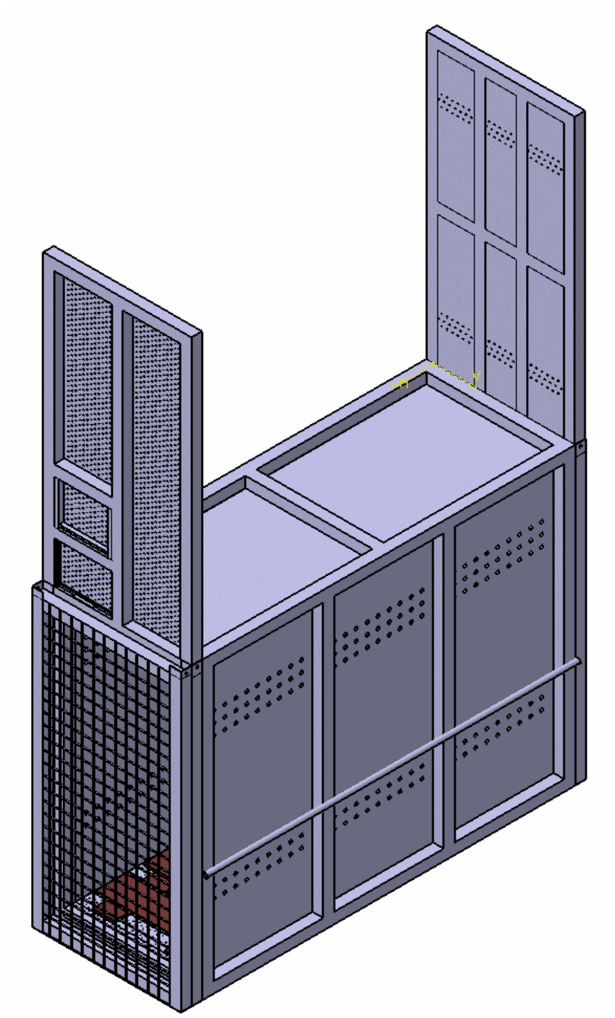

Fig. 3.12. Animal container for air transportation.

3.3. Details production and recommendations of operation

Production. The container is made of aluminum grade 2024 T3, the walls are made of solid sheets, all the ribs are shaped pipes 50×50 mm in size. the connection of all the power ribs is made by tag welding, the sheets are fastened with aluminum rivets 4.8 mm in size the holes in the side walls and the main door are located at intervals of 50 mm and have a diameter of 15 mm, the holes in the floor and the door with the feeder have an interval of 35 mm and a diameter of 5 mm.

Holes in the walls are made with a drill of the appropriate diameter, but for holes in the floor it will be better to choose an already perforated sheet of metal with the necessary parameters. All riveted joints should be made in such a way that there are no stick-out elements inside the container that could injure the animal, e.g. The protective grating is also a one-piece welded structure made of 4 mm diameter bars. The bedding is made of 7 parallel wooden or textolite boards with a span of 540 mm and a width of 150 mm at 70 mm intervals, and two longitudinal boards, 1600×100 mm. The total weight of the empty container is 130 kilograms, the total weight is 400 kg, the weight of one pallet of PG is 400 kg, and the maximum total weight is 13608. 400·8+400=3600 is the weight of one loaded pallet, and we have three of them, i.e. 3600·3=10800. The total weight of a PA pallet is 4626 kg, it has 4 containers, that is, 4·400+120=1720. And 16 LD-2 containers with a total weight of 1225, that is, 161225=19600

The total weight of the cargo is 10800+1720+19600=32120 with a maximum carrying capacity of 35000 kg

Layout.

Containers for the convenience of loading and unloading are placed on Main Deck Pallet with Net-IATA Type 1/1S-IATA Prefix: PG (Fig. 3.13), with parameters 6058×2438×2438 mm, each of which contains 8 containers with animals, i.e. the floor area is calculated by pallets. Optimal for ease of access to all animals will be a longitudinal arrangement, so the minimum number of attendants will have free visibility and access to each container, the length of the cargo cabin can accommodate 4 of them, but the winch interferes with the last one, so instead we put a Pallet with

Net-IATA Type 5-IATA Prefix: PA (Fig. 3.14), with parameters 3175×2235×1626 mm, it can accommodate 4 containers.

It is fashionable to arrange them in two rows along the width of the cargo cabin thus, the total number of containers with animals per load is $(6 \cdot 8) + (4 \cdot 2) = 40$ containers.

But rarely there is a situation when it is necessary to transport so many animals at once, so instead of one row, you can place, for example, containers IATA Type 8D-IATA Prefix: APA-APA: LD-2 (Fig. 3.15), with parameters 1194×1534×1626 mm, they fit in a row of 16 units, they can be transported as well as medicines for animals or some related things, and any other cargo not related to animals.

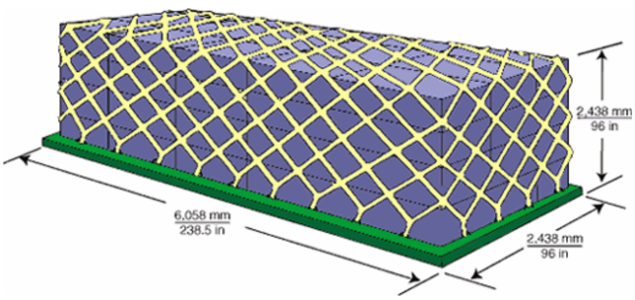

Fig. 3.13. PG.

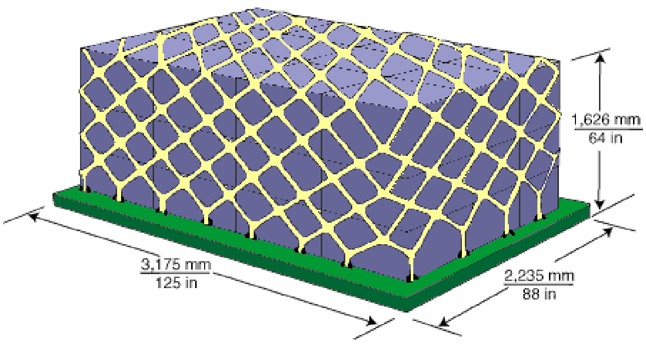

Fig. 3.14. PA.

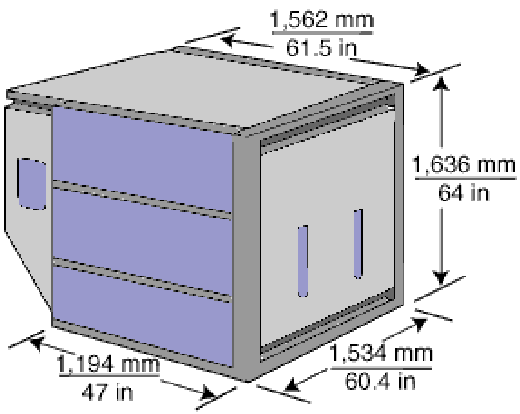

Fig. 3.15. LD-2.

Conclusions to the special part

In this part, the standards and requirements for the animals transportation by air were described. The pet containers were designed according to them. The cargo cabin layout was developed. The process of its production with all the necessary parameters that should be taken into account is presented. This container is suitable for any animal with dimensions not exceeding 1600×750×1300 and not exceeding 270 kg.

GENERAL CONCLUSIONS

During this research work the next results are obtained:

1. Preliminary design of the middle range cargo aircraft with cargo capacity 35 tons and the ability to operate with unprepared runway is presented. Designed aircraft has the modern powerful and efficient engines, increased the cargo compartment, installation the refueling bar in order to refueling in the air, when the aircraft performed the flight on long distance, decrease the fuel weight, but range of flight not change.

2. During the preparation of this work the statistical analysis of modern aircraft designs, prototypes were conducted. Based on these data and methodical guide at the department of Aircraft Design were selected optimum parameters for this class of aircraft, including flight safety, mass, geometric, aerodynamic and economic parameters. Basic calculations were performed using special computer program at the department.

3. The geometrical parameters were calculated, fuselage layout and wing design parameters are obtained, high lift devices of a wing, layout and geometrical parameters of tail unit are performed, the landing gear scheme and calculation of the main parameters of the landing gear are done with the choice of tires: for the main landing gears are 1100×330A and for the nose landing gear is 1000×280A , determining the coordinates of the center of gravity, and defined the range of the centers of gravity position - the most forward center of gravity position is equal 0.272 and the most aft center of gravity position is equal 0.301.

4. An aviation container for the transporting of animals was developed taking into account all possible international standards and requirements, a version of the layout in airplane was developed, and container production process was described.

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Appendixes

INITIAL DATA AND SELECTED PARAMETERS

Passenger Number	0.
Flight Crew Number	4.
Flight Attendant or Load Master Number	3.
Mass of Operational Items	1423.73 kg
Payload Mass	35000.00 kg
Cruising Speed	725. km/h
Cruising Mach Number	0.6713
Design Altitude	10.000 km
Flight Range with Maximum Payload	4000. km
Runway Length for the Base Aerodrome	1.90 km
Engine Number	4.
Power supply in kw/kg	0.3000
Pressure Ratio	9.00
Fuel-to-weight Ratio	0.3000
Aspect Ratio	9.60
Taper Ratio	3.50
Mean Thickness Ratio	0.120
Wing Sweepback at Quarter Chord	15.0 grad
High-lift Device Coefficient	1.160
Relative Area of Wing Extensions	0.050
Wing Airfoil Type - supercritical	
Winglets – not established	
Spoilers - install	
Fuselage Diameter	4.60 m
Fineness Ratio	9.40
Horizontal Tail Sweep Angle	25.0 grad
Vertical Tail Sweep Angle	30.0 grad

CALCULATION RESULTS

Optimal Lift Coefficient in the Design Cruising Flight Point

Cy 0.47406

Induce Drag Coefficient Cx.ind. 0.00929

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

Cruising Mach Number	M_{cruise}	0.67127
Wave Drag Mach Number	$M_{critica}$	0.71774
Calculated Parameter	D_m	0.04647

Wing Loading in kPa (for Gross Wing Area):

At Takeoff	4.390
At Middle of Cruising Flight	3.973
At the Beginning of Cruising Flight	4.238

Drag Coefficient of the Fuselage and Nacelles	0.00794
Drag Coefficient of the Wing and Tail Unit	0.00930

Drag Coefficient of the Airplane:

At the Beginning of Cruising Flight	0.02866
At Middle of Cruising Flight	0.02804

Mean Lift Coefficient for the Ceiling Flight	0.47406
Mean Lift-to-drag Ratio	16.90803
Landing Lift Coefficient	1.948
Landing Lift Coefficient (at Stall Speed)	2.921

Takeoff Lift Coefficient (at Stall Speed)	2.380
Lift-off Lift Coefficient	1.714
Power supply Ratio at the Beginning of Cruising Flight	0.127
Start Power supply Ratio for Cruising Flight	0.219
Start Power supply Ratio for Safe Takeoff	0.159
Design Power supply Ratio R_{cruise}	0.226
Ratio $D_r = R_{cruise} / R_{takeoff}$ D_r	1.381

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

Takeoff	0.2045
Cruising Flight	0.1616
Mean cruising for Given Range	0.1628

FUEL WEIGHT FRACTIONS:

Fuel Reserve	0.02408
Block Fuel	0.16259

WEIGHT FRACTIONS FOR PRINCIPAL ITEMS:

Wing	0.10772
Horizontal Tail	0.01204
Vertical Tail	0.01186
Landing Gear	0.03954
Power Plant	0.15088
Fuselage	0.10722
Equipment and Flight Control	0.11227
Additional Equipment	0.00074
Operational Items	0.01060
Fuel	0.18667
Payload	0.26054

Airplane Takeoff Weight	134338 Kg
Power supply Required of the Engine	7583.9 KW

Air Conditioning and Anti-icing Equipment Weight Fraction	0.0131
Passenger Equipment Weight Fraction (or Cargo Cabin Equipment)	0.0004
Interior Panels and Thermal/Acoustic Blanketing Weight Fraction	0.0052
Furnishing Equipment Weight Fraction	0.0316
Flight Control Weight Fraction	0.0045
Hydraulic System Weight Fraction	0.0132
Electrical Equipment Weight Fraction	0.0264
Radar Weight Fraction	0.0035
Navigation Equipment Weight Fraction	0.0052
Radio Communication Equipment Weight Fraction	0.0026
Instrument Equipment Weight Fraction	0.0061
Fuel System Weight Fraction	0.0055

Additional Equipment:

Equipment for Container Loading	0.0000
No typical Equipment Weight Fraction (Build-in Test Equipment for Fault Diagnosis, Additional Equipment of Passenger Cabin)	0.0007

TAKEOFF DISTANCE PARAMETERS

Airplane Lift-off Speed	228.79 km/h
Acceleration during Takeoff Run	2.79 m/s^2
Airplane Takeoff Run Distance	721. m
Airborne Takeoff Distance	472. m
Takeoff Distance	1193. m

CONTINUED TAKEOFF DISTANCE PARAMETERS

Decision Speed	205.91 km/h
Mean Acceleration for Continued Takeoff on Wet Runway	1.38 m/s^2
Takeoff Run Distance for Continued Takeoff on Wet Runway	861.78 m
Continued Takeoff Distance	1334.02 m
Runway Length Required for Rejected Takeoff	1377.00 m

LANDING DISTANCE PARAMETERS

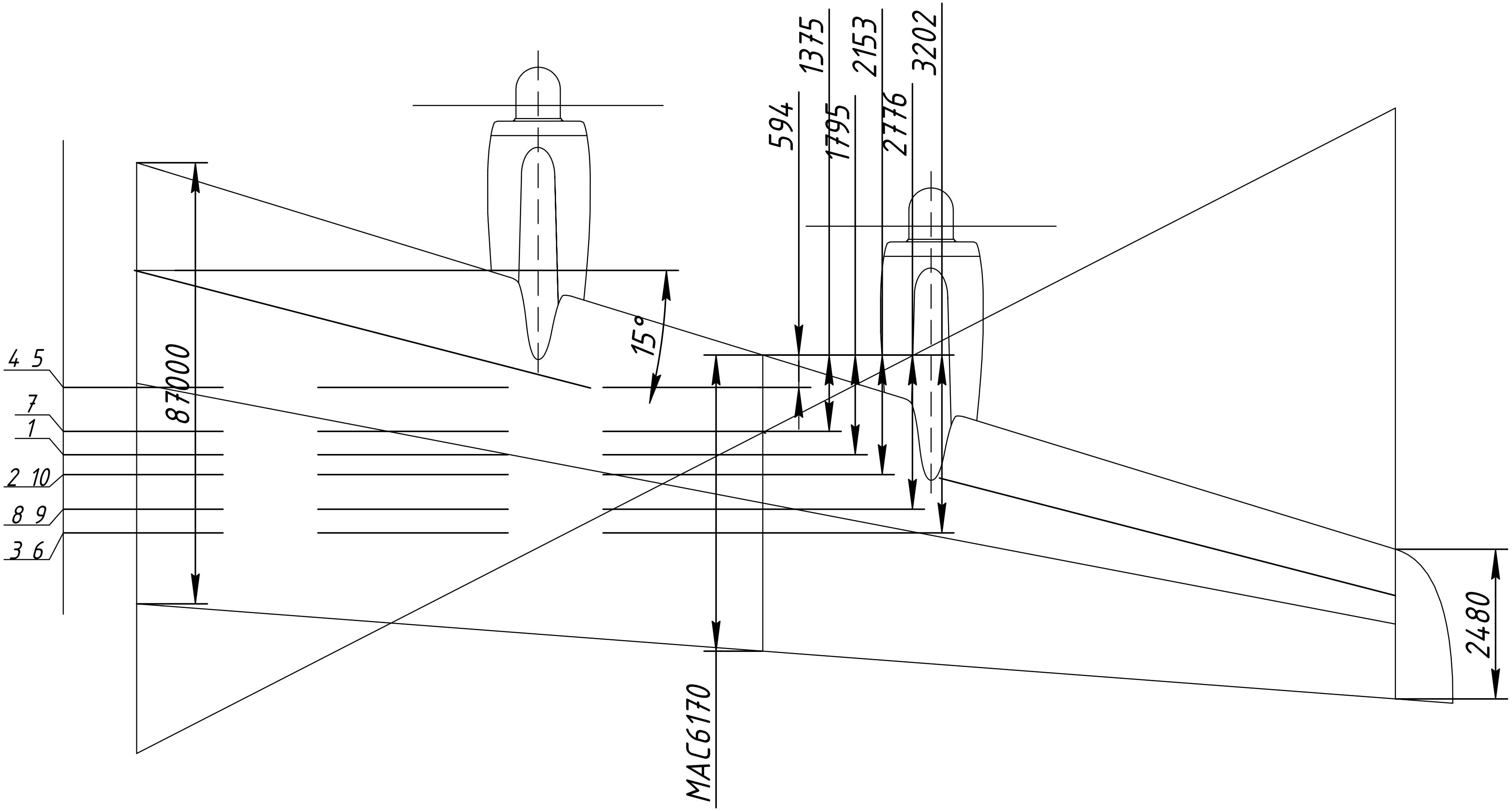
Airplane Maximum Landing Weight	118668 kg
Time for Descent from Flight Level till Aerodrome Traffic Circuit Flight	20.4 min
Descent Distance	41.02 km
Approach Speed	218.41 km/h
Mean Vertical Speed	1.81 m/s
Airborne Landing Distance	513. m
Landing Speed	203.11 km/h
Landing run distance	524. m
Landing Distance	1037. m
Runway Length Required for Regular Aerodrome	1732. m
Runway Length Required for Alternate Aerodrome	1472. m

AIRCRAFT EFFICIENCY INDICATORS

The ratio of the mass of the equipped aircraft to Weight of commercial load	2.1192
The weight of the empty outfit is the arrival. For 1 passen.	0.00 kg / pass
Relative productivity at full load of	324.22 km / h
Capacity c-ta with a max. Commercial Load	24066.4 t * km / h
The average hourly fuel consumption is	3754.651 kg / h
Average kilometers of fuel consumption	5.46 kg / km
The average fuel consumption per ton kilometer is	156.012 g / (t * km)
Average fuel consumption per passenger kilometer is	0.0000 g / (pass * km)
An approximate estimate is given. Costs per ton/km	1.2314 $ / (t * km)

Apendix B

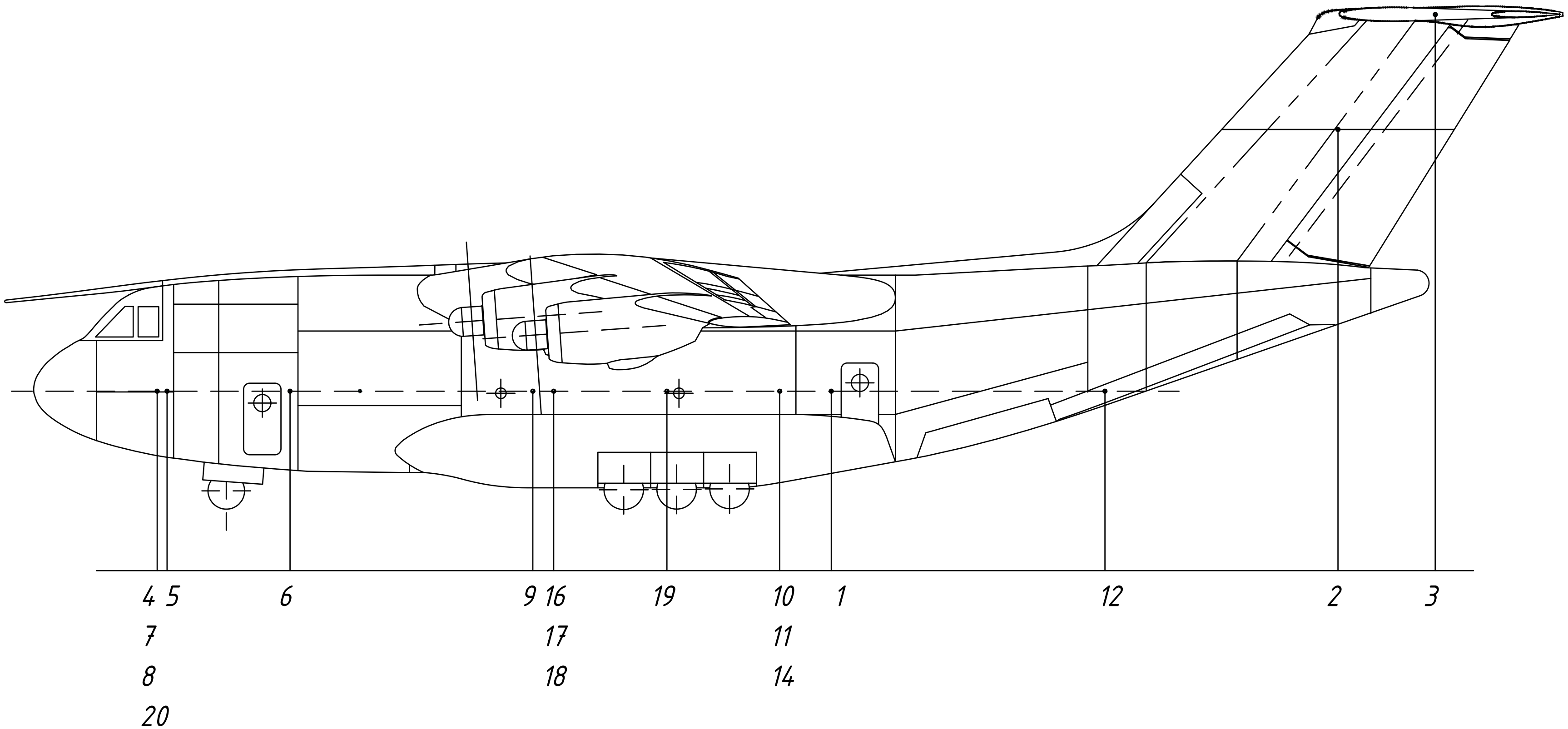
M 1:100



Picture 1. Coordinates of C.G. of equiped wing

Appendix C

M 1:200



Picture 2. Coordinates of C.G. of equiped fuselage