МІНІСТЕРСТВО ОСВІТИ ТА НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
Кафедра конструкції літальних апаратів

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
д.т.н., проф.
_____________ Сергій ІГНАТОВИЧ
«_____»____________2022 рік

ДИПЛОМНА РОБОТА

ЗДОБУВАЧА ОСВІТНЬОГО СТУПЕНЯ "БАКАЛАВР"
ЗІ СПЕЦІАЛЬНОСТІ
«АВІАЦІЙНА ТА РАКЕТНО-КОСМІЧНА ТЕХНІКА»

Тема: «Аванпроект ближньомагістрального літака пасажиромісткістю 86 осіб»

Виконав: ___________ **Артем Терзі**

Керівник: ___________ **Юрій ВЛАСЕНКО**

Нормоконтролер: канд.техн.наук, доцент_____________Сергій ХИЖНЯК

Київ 2022

MINISRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
Department of Aircraft Design

PERMISSION TO DEFEND
Head of the department
Dr.Sc., Professor
_______Sergiy IGNATOVYCH
«___»________2022

BACHALOR DEGREE THESIS
ON SPECIALTY
"AVIATION AND AEROSPACE TECHNOLOGIES "

Topic: «Preliminary design of a short-range aircraft with 86 passenger capacity»

Prepared by: __________ **Artem Terzi**

Supervisor: __________ **Yuriy Vlasenko**

Standard controller: PhD, associate professor__________Sergiy KHIZNYAK

Kyiv 2022

NATIONAL AVIATION UNIVERSITY

Aerospace Faculty

Department of Aircraft Design

Academic Degree «Bachelor»

Specialty: 134 "Aviation and Aerospace Technologies"

APPROVED BY

Head of the Department

Dr.Sc., Professor _________

Sergiy IGNATOVYCH

«___»________2022

TASK

for the bachelor degree thesis

TERZI ARTEM

1. Topic: «Preliminary design of a short-range aircraft with 86 passenger capacity» confirmed by Rector's order № 489/ст from 10.05.2022.
2. Thesis term: from 23.05.2022 to 19.06.2022.
3. Initial data: cruise speed V_{cr}=820 kmph, flight range L=3100 km, operating altitude H_{op}=10.7 km, 86passengers.
4. Content (list of topics to be developed): choice and substantiations of the airplane scheme, choice of initial data; engine selection, aircraft layout, center of gravity position calculation, designing of automatic lifting aircraft luggage rack.
5. Required material: general view of the airplane (A1×1); layout of the airplane (A2×1); 3D model of aircraft passenger seat (A1×1).

Graphical materials are performed in AutoCAD, CATIA.

6. Thesis schedule:

Task	Time limits	Done
Task receiving, processing of statistical data	23.05.2022–28.05.2022	
Aircraft geometry calculation	28.05.2022–31.05.2022	
Aircraft layout	31.05.2022–03.06.2022	
Aircraft centering	03.06.2022–05.06.2022	
Graphical design of the parts	05.06.2022–12.06.2022	
Completion of the explanation note	12.06.2022–14.06.2022	
Defense of diploma work	14.06.2022–19.06.2022	

7. Date: 23.05.2022

Supervisor __________ Yuriy VLASENKO

Student __________ Terzi Artem

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, д.т.н, проф.
__________ Сергій ІГНАТОВИЧ
«_____» _____________ 2021 р.

ЗАВДАННЯ
на виконання дипломної роботи студента

Терзі Артем

1. Тема роботи: «Аванпроект ближньомагістрального літака пасажиромісткістю 86 осіб», затверджена наказом ректора № 489/ст від 10 травня 2022 року.
2. Термін виконання роботи: з 23 травня 2022 р. по 19 червня 2022 р.
3. Вихідні дані до роботи: максимальна кількість пасажирів 134, дальність польоту з максимальним комерційним навантаженням 3100 км, крейсерська швидкість польоту 820 км/год, висота польоту 10.7 км.
4. Зміст пояснювальної записки: вибір параметрів та обгрунтування схеми проектованого літака, вибір двигунів, розрахунок геометрії та центрування літака, проектування

5. Перелік обов'язкового графічного матеріалу: загальний вигляд літака (А1×1), компонувальне креслення фюзеляжу (А2×1), 3D модель пасажирського крісла літака (А1×1).

6. Календарний план-графік:

Завдання	Термін виконання	Відмітка про виконання
Вибір вихідних даних, аналіз льотно-технічних характеристик літаків-прототипів	23.05.2022–28.05.2022	
Вибір та розрахунок параметрів проєктованого літака	28.05.2022–31.05.2022	
Виконання компонування літака	31.05.2022–03.06.2022	
Розрахунок центрування літака	03.06.2022–05.06.2022	
Виконання креслень літака	05.06.2022–12.06.2022	
Оформлення пояснювальної записки та графічної частини роботи	12.06.2022–14.06.2022	
Захист дипломної роботи	14.06.2022–19.06.2022	

7. Дата видачі завдання: 23.05.2022 рік

Керівник дипломної роботи ___________ Юрій Власенко

Завдання прийняв до виконання ___________ Терзі Артем

РЕФЕРАТ

Дипломна робота «Аванпроект ближнньомагістрального пасажирського літака місткістю до 86 пасажирів» містить:
85 сторінок, 10 рисунків, 7 таблиць, 26 літературних посилань, 3 креслення

Об'єкт проектування: ближнньомагістрального пасажирського літак для 86 пасажирів.

Предмет проектування: конвертація пасажирського крісла.

Мета роботи: розробка ближнньомагістрального пасажирського літака місткістю 86 пасажирів та його конвертацію пасажирського крісла.

Методи дослідження: аналіз прототипів і вибір найбільш досконалих технічних рішень, оцінка геометричних характеристик, розрахунок центру мас літака, конвертація крісла, розрахунок міцності.

Наукова новизна результатів полягає у конвертації крісла із застосування новітніх технологій.

Практична цінність роботи: визначається зменшення маси крісла і підвищення його характеристик. Результати роботи можуть бути використані в авіаційній галузі та в навчальному процесі авіаційних спеціальностей.

В процесі написання роботи, було спроектовано та визначено основні льотно-технічні характеристики магістральній пасажирського літака місткістю 86 пасажирів. Для проектування літака, використовувався метод порівняльного аналізу літаків-прототипів для вибору найбільш обґрунтованих технічних рішень, а також метод інженерних розрахунків для отримання основних параметрів проектування літака. В спеціальній частині, застасовано зміна конструкції пасажирського крісла із застосуванням нових технологій. В спеціальній частині обґрунтовано застосування нового типу пасажирського крісла що зменшує його вагу.

Результати цієї роботи можуть бути використані в авіаційній галузі та в навчальному процесі авіаційних спеціальностей.

ABSTRACT

The thesis "Advanced design of a short-range passenger aircraft with a capacity of up to 86 passengers" contains:

85 pages, 10 figures, 7 tables, 26 references, 3 drawings

Design object: a short-haul passenger plane for 86 passengers.

Design subject: passenger seat conversion.

The purpose of the work: the development of a short-haul passenger plane with a capacity of 86 passengers and its conversion of a passenger seat.

Research methods: analysis of prototypes and selection of the most advanced technical solutions, evaluation of geometric characteristics, calculation of the center of mass of the aircraft, conversion of the seat, calculation of strength.

The scientific novelty of the results lies in the conversion of the chair using the latest technologies.

The practical value of the work: reducing the weight of the chair and increasing its characteristics is determined. The results of the work can be used in the aviation industry and in the educational process of aviation specialties.

In the process of writing the work, the main flight and technical characteristics of a mainline passenger plane with a capacity of 86 passengers were designed and determined. To design the aircraft, the method of comparative analysis of prototype aircraft was used to select the most reasonable technical solutions, as well as the method of engineering calculations to obtain the main parameters of the aircraft design. In a special part, a change in the design of the passenger seat with the use of new technologies was applied. The special part substantiates the use of a new type of passenger seat that reduces its weight.

The results of this work can be used in the aviation industry and in the educational process of aviation specialties.

CONTENT

Statistical data

Name and dimension	An-158	An-72	A1
Max. paid load, kg	8500	7500	8514
Crew, people	2-5	3-5	2+2
Passenger seats	80-99	2	86
Wing load, kN/m^2	5	2,65	4,916
Average cruising quality	13	16	13,258
Flight range from $m_{kN\ max}$, km	3100	1000	3000
Cruising altitude range, km	10,77	9	10,77
V_{max}/N, km/g/km	820	550	830
$V_{cr\ econ}$/N, km/g/km		515	
Trust supply, kN/kg	2,6	2,6	2,84
Productivity, tkm/h			
Specific fuel consumption, g/t.km			
Power plant data			
Number and type of engines	2	2	2
Take-off thrust, kN	74	65	75
Cruising thrust, kN	38	36	40
Specific fuel consumption take off, kg/kN (kW)	36	34,55	35,82
Specific fuel consumption cruising, kg/kN (kW)	59	48,41	58,08
Degree of pressure increase	20	20	20,2
Degree of dual-circuit operation	5,6	5,6	5,6
Take-off and landing characteristics			
Home airfield class	G	G	G
Approach speed, km/h	243,65	165,73	243,65
Landing speed, km/h	228,65	150,73	228,65
Breakaway speed, km/h	258,3	168,06	258,3
Acceleration length, m	856	724	856
Runway length, m	685	320	685
Take-off distance, m	1435	1303	1435
Landing distance, m	1199	790	1199

Basic geometric parameters	An-158	An-72	A1
Wingspan, m	28,6	35,8	28,6
Sweep by 1/4 chord, deg	25	17	25
Geometric mean chord, m	3,32	3.55	3,32
Wing extension	9,6	10,32	9,6
Narrowing of the wing	3,8	3,3	3,8
Fuselage length, m	32,12	30,8	32,12
Fuselage diameter, m	3,4	3,1	3,4
Fuselage extension	8,6	9	8,6
Passenger cabin width, m	3,2	2,15	3,2
Passenger cabin length, m	19	10,5	20,5
Cab height, m	2,1	2,2	2,16
Cab volume, m*	389	280	420
Cargo space capacity, m^3	30	969	31,82
Chair pitch, m	860		870
Aisle width, m	0,49		0,5
Scope wing HT, m	10	9,697	10
Sweep of the wing by 1/4 chords HT, deg	32	35	32
Relative wing area, % HT			
Wing extension HT	5,0	3,45	5,0
Narrowing of the wing HT	3	3	3

Format	№	Designation	Name	Quantity	Notes
			General documents		
A4	1	NAU 22 T 00 00 00 47 FL	Brief technical description	1	
	2	NAU 22 T 00 00 00 47 FL	Aircraft layout	2	
A1		Sheet 1	neral view		
A1		Sheet 2	Fuselage layout		
A4	3	NAU 22 22T 00 00 00 47 EN	Short-range passenger aircraft	52	
			Explanatory note		
			Documentation for assembly units		
A1	4	NAU 22 T 00 00 00 47 FL	Design of passenger seat	1	

NAU 22.22T.00.00.00.47 EN

Done by	Terzi Artem	Preliminarydesignofshort-range passengeraircraftwith 86 passengercapacity (Listofdiplomawork)	list	sheet	sheets
upervisor	Vlasenko Y.V.			9	83
			ASF 402		
St.control.	Khyzhniak S.V.				
Head of dep.	Ignatovich S.R.				

Brief technical description

Purpose

The A1 aircraft is designed for passenger transportation on regional and short routes with a length of up to 3,100 km, with the possibility of being stationed on artificial runways and prepared dirt roads at an altitude of up to 1,500 meters above sea level in all climatic conditions . The cruising speed of the aircraft is 780-850 km / h, and the cruising altitude is up to 12,200 m. The length of the passenger compartment and the arrangement of passengers in a row according to the 2+3 scheme allow the operator to combine various single-class and mixed layouts in the range of 68-80 passengers with economy, business and first-class cabins. The arrangement of the A1 passenger cabin in economy class is carried out according to the scheme of 2+3 seats in a row. The aircraft is equipped with the most modern flight navigation and radio communication equipment, which complies with international ICAO standards; Flight information is displayed on five multifunctional liquid crystal displays. The complex of radio-electronic equipment provides an opportunity to land the car in difficult meteorological and night conditions in accordance with category IIIA ICAO.

The An-158 aircraft is equipped with two D-436-148- Two-circuit turbojet engines developed by ZMKB progress and manufactured by Motor Sich OJSC. Fuel consumption - 1458 kg/h at maximum payload. In addition, an AI-450-MS auxiliary power plant is used. In addition, the Oleg Antonov ANTK is additionally working on options for installing a foreign CF34-10 engine on the aircraft. The fuel efficiency of the A1 aircraft is 22.0 G/PCM.

Among the competitive advantages of the aircraft, experts note the traditional "on" high-engine arrangement - this allows the aircraft to land even on runways with a dirty surface, reducing the risk of dirt getting into the engine.

The developer has defined the service life of the aircraft at around 80,000 hours with a calendar service life of 30 years.

1. AIRCRAFT LAYOUT

1.1. General Provisions

By layout is meant the process of spatial connection of aircraft parts (wings, engines, tail, landing gear), structural and propulsion schemes into a single whole, placement of passenger and household fuselage equipment, cargo and equipment.
The layout of the aircraft can be divided into the following interrelated processes: aerodynamics, volume-mass and structure-power. The implementation of each of them is aimed at achieving high economy of the aircraft.
The main layout tasks that should be solved when performing CP: placement of units, target load on the aircraft, provided that the required range of operation of centering is provided; development and mutual linking of structural and power schemes of aircraft parts (fuselage, wings, tail, landing gear, etc.).
The requirements for the layout of an aircraft are mostly contradictory. Therefore, the requirements for ensuring easy maintenance require the presence of a large number of cutouts and operational connections in the design of the airframe, as a result of which, in order to ensure the required strength of the structure, it is necessary to further strengthen it zones, which in turn increases the weight of the structure, complicates production and leads to an increase in the cost of the aircraft. Therefore, compromise decisions must be made to meet these conflicting requirements.
When assembling the aircraft, if possible, use well-known technical solutions that have been successfully applied to other aircraft. In this case, you only need to make small changes to the design of the units (wings, landing gear, empennage, fuselage) in accordance with the specific technical, economic and other requirements. It is also necessary to use the principle of combining several functions performed by the same structural element or unit. For example, hatches are made in such a way that they perform technological and operational functions; the same power frames of the tail section of the fuselage were used both for fixing the horizontal stabilizer to the fuselage and for the engines. This approach makes it possible not only to reduce the weight of the structure, but also to get large volumes into the aircraft to accommodate the target load.
When developing the design and propulsion scheme of the aircraft, the following approaches should be implemented:
- The transfer and compensation of concentrated loads to the components should be carried out in the shortest possible way;
- It is desirable to transmit bending moments over the largest possible overall height and torques over a closed contour with the largest possible area.
It should be remembered that all units and loads inside the aircraft may require a strictly defined place on the aircraft or are not bound by strict requirements for their placement.

When designing the aircraft, first of all, fuel and cargo are placed, the weight of which varies from flight to flight (passengers, luggage, cargo). Then they place cargo that requires a certain location on the aircraft, and finally – all other cargoes that can be placed anywhere on the aircraft, provided that the volume of the fuselage, other parts of the airframe and aircraft operating facilities are rationally used, provided, etc. As a rule, the process of layout and centering is iterative, the achievement of the necessary operational and technical indicators of the designed aircraft is achieved after a series of successive approximations.

1.2. Aerodynamic layout

The aerodynamic layout is carried out in order to obtain with the lowest energy costs:

-the minimum dimensions of the aircraft required to meet operational and technical requirements;

-optimal mutual arrangement of the main units of the aircraft (wing, tail, engine);

-a wide range of flight speeds - from take-off and landing to the maximum permissible;

-maximum aerodynamic quality of the aircraft in cruising flight mode;

-the maximum possible lift coefficient during take-off and landing;

-minimal losses for balancing and normalized reserves for stability and controllability in all flight modes;

-favorable conditions for the operation of the power plant;

- safe behavior of the aircraft in extreme flight modes (at high angles of attack or speeds) and the absence of the appearance of dangerous phenomena such as flapping, bafting, corkscrew, etc.

The necessary flight data of the aircraft can be provided due to the optimal choice of the parameters of the fuselage, the tail, the type of wing mechanics, its extension, the sweep and the narrowing of the relative thickness of the profile. At the same time, the location of the focus relative to the center of mass of the aircraft in different flight modes is important, which is given by the choice of the appropriate profile. The result of the aerodynamic design of the aircraft is a preliminary variant of the dimensional drawing in three projections, which is determined after carrying out the volumetric mass and structural power design.

1.3.Volume and mass layout

The purpose of the bulk layout is the optimal placement of commercial and service cargo, household equipment, landing gear, functional systems in a certain volume of the fuselage and other aircraft units. When choosing the shape and dimensions of the fuselage cross-section, it is necessary to be guided by the requirements of aerodynamics and passenger comfort. At this stage of CP development, it is necessary to make a decision on the number, type and placement of doors, hatches and emergency exits. Within the framework of volumetric mass design, calculations of aircraft centering are carried out for the most typical cases of operation, even if they are parked on the ground.

1.3.1. Passenger equipment

Passenger equipment includes seats, shelves for hand luggage, emergency and household appliances.

The arrangement of the passenger cabin must meet the requirements to ensure the specific volume of the cabin per passenger. This parameter is important due to the requirements to ensure the necessary comfort for passengers and crew members. The values of these values should not be less than those indicated in the Table 1.1.

Table1.1.

Minimum values of the specific volume of passenger cabins, m3/person.

Fuselage diameter	Flight duration, hour.					
	up to 1	1…2	2…4	4…6	6…8	8 and more
up to 4 m	0,84	0,85	0,92	0,98	1,2	1,2
4 m and more	0,96	0,98	1,06	1,13	1,27	1,36

The dimensions of the passenger cabin are determined by the number of passengers with standard seating. Currently, three classes of passenger cabins (salons) are used in air transport: first (usually on long-haul aircraft), business class (on aircraft where there is no first class) and economy. These classes differ in passenger comfort and terms of service. Airlines often practice their own passenger serviceclasses, which can combine the characteristics of neighboring classes. For example, economy comfort or economy premium classes are often practiced, which are located between business class and economy class. First-class passenger cabins can be equipped with 180 ° folding chairs or small sofas, and more and more airlines are equipping planes with separate compartments. Business class chairs are available in two versions: with 160° or 180° folding backrests, which form mini-sofas parallel to the floor. Economy class seats can be with a reclining backrest or deviate at an angle of up to 360 °.

In the cabins of the first class, only blocks with two seats are installed, and in other classes – blocks with two or three seats. The number of blocks of seats in the transverse row and in the aisles is selected based on statistical data that are similar in terms of passenger capacity and the purpose of the aircraft.

If cargo compartments are to be placed under the floor of the passenger compartment, then in order to form the contours of the lower part of the fuselage, it is necessary first to determine the type of standard aircraft containers, while fixing the thickness of the floor to approximately 5% of the cabin width. In the drawing of the hull section, the contours of the selected container should be drawn on the appropriate scale, taking into account the distance (top and side) between the container and the structural elements of the cargo compartment of at least 50 mm.

In the case of container-free cargo transportation, to ensure the convenience of service personnel, it is necessary to bring the height of the cargo compartment to 900 ... 1100 mm.

In the absence of an arrangement in the bottom surface of cargo compartments, the contours of the lower part of the fuselage are determined based on considerations of the purpose of the aircraft, the chosen aerodynamic scheme, etc.

1.3.2. Crew Cabin

On the one hand, the crew cabin should occupy the smallest volume, and on the other hand, provide the pilots with satisfactory working and rest conditions. It is necessary that the layout of the crew cabin, the location of the main and emergency control allow the crew members to control the aircraft without effort and fatigue. The general ergonomic requirements are as follows: the levers and handles most often used by pilots should be located in the visual zone, in the most optimal working area, and others - in the range zone and, if possible, in the visual zone. The crew of modern passenger aircraft consists of two or three people: two pilots or two pilots and an on-board engineer (on the long-haul)
Aircraft). Due to the recent widespread use of displays on dashboards, the workplaces of on-board engineers are most often located between pilots. Sometimes there are places for an inspector (instructor, trainee) in the crew cabins.

1.3.3. Cargo spaces

Cargo compartments can be located on the floor of the passenger cabin or under it in a sealed part of the fuselage. In the first case, cargo compartments tend to be placed in front of and behind the passenger cabin. This approach makes it possible, by adjusting the weight of the cargo, to ensure the necessary alignment of the aircraft depending on the number of passengers. The location of the cargo compartments is determined when assessing the length of the fuselage, while it is recommended to use the data of prototype aircraft. Having determined the types and sizes of containers when forming the hull section, it is possible to calculate the total length of cargo compartments and the number of containers.

1.3.4. Kitchens and sideboards

For the catering of passengers on flights on intercontinental and long-haul flights, depending on the number of passengers, from 1 ... 2 Kitchens went out. If the aircraft has passenger cabins of different classes, then it must have two kitchens. According to OST 54-3-61-93, with a flight duration of less than three hours, passengers are not offered hot meals, so the plane can only be equipped with a buffet of soft drinks, tea, coffee and light snacks. Buffets may not be installed on flights with a departure weight of up to 10 tons. The buffet and kitchen equipment must necessarily be located in front of the door. Kitchens and cabinets can not be placed near toilets or combined with wardrobes. In wide-body aircraft, buffet and kitchen appliances can be placed under the floor, and service trolleys with food are brought to the salons by elevator.

1.3.5. Wardrobes

Wardrobes for outerwear of passengers are located near the entrance and exit doors, near the passenger compartment. The crew's wardrobe is usually made separately. Clothes in wardrobes are hung on hangers suspended on fixed pipes. The width of one row is 500…600 mm, the pitch of the hangers is 70.80 mm.

1.3.6. Toilet rooms

In passenger aircraft, water supply and disposal systems are used to ensure normal living conditions for passengers and crew members. According to the principle of operation, there are two types of the latter systems: water vacuum (for example, in an A-320 aircraft) and circulation (Boeing 737 aircraft). In the first case, the waste is sucked into a special tank by vacuum, and the residues are washed off from the water supply tank with a relatively small amount of water. In the second case, the flushing water is taken from a separate tank, and special chemicals are added to the sewage tank to disinfect the water and deprive it of an unpleasant odor.

The number of toilet rooms depends on the number of passengers and the duration of the flight (Table 1.1).

If the flight duration is less than an hour, and the number of passengers is up to 15 people, then the toilet on the plane can not be made.

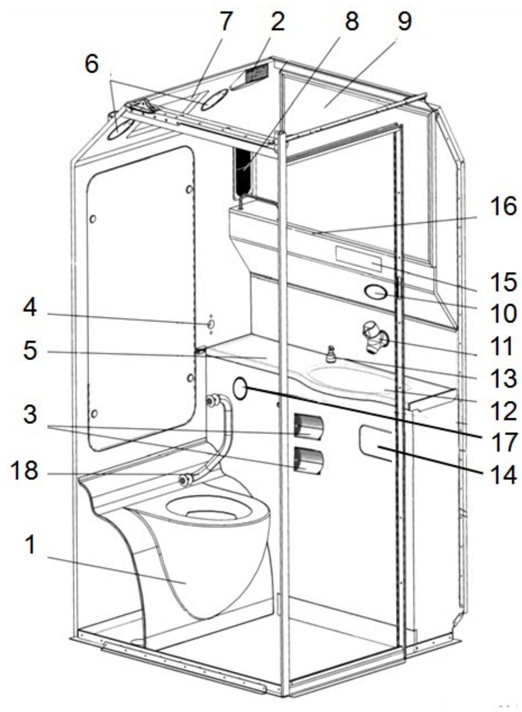


Fig. 1.1. Toilet room elements

1-toilet bowl; 2-ventilation grilles; 3-paper holders; 4-drain button; 5-Table; 6-lighting shades; 7-oxygen mask; 8-sound speaker; 9 - Mirror; 10 - napkin dispenser; 11-tap; 12 - washbasin sink; 13 - soap dispenser; 14-garbage container; 15-information panel; 16-locker; 17-individual ventilation nozzles; 18 – handrail.

1.3.7. Normal emergency exits and emergency exits for exiting the aircraft

The design of the passenger compartment of the aircraft is greatly influenced by the placement of emergency rescue equipment. One of the main factors is the number and parameters of normal and emergency exits, the provision of passages to them. Normal doors for boarding and disembarking passengers are located on the port side of the fuselage, and on wide-body aircraft they can be located on both sides. According to the requirements of the aviation regulations (AR-25) [1], the evacuation of passengers and crew members must be carried out in a time not exceeding 50% of the normal and emergency exits on both sides of the fuselage are open in 90 seconds. To meet these requirements, the following types of emergency exits are used on airplanes (table.1.2).

In addition to these emergency exits, lower hull exits and exits to the rear of the hull, sealed partitions can also be used everywhere.

The minimum number and types of emergency exits for the number of passenger cities from 1 to 179 are determined according to the data in the table. 1.3, if the number of passengers exceeds 179 people, additional emergency exits are required according to the table. 1.4.

Table 1.2.

Types and parameters of emergency exits

Type	Width x height, mm (not less)	Radii of rounding corners from the opening width (max)	Location
I	610x 1220	1/3	At floor level
II	510x1120	1/3	For high wing planes-at floor level. When placed above the wing, there can be a threshold: inside the aircraft with a height of no more than 250 mm; outside – no more than 430 mm
III	510x915	1/3	When placed above the wing, there can be a threshold: inside the aircraft with a height of no more than 510 mm; outside – no more than 685 mm
IV	485x660	1/3	When placed above the wing, there can be a threshold: inside the aircraft with a height of no more than 735 mm; outside – no more than 915 mm
A	1070x1830	1/6	At floor level

With more than 299 passenger seats, each emergency exit on board the fuselage must be an exit of type A or I. Each pair of type A exits is allowed to have 110 passenger seats, and each pair of type I exits is allowed to have 45 seats.

In the event of an emergency flood, emergency exits must be provided in accordance with the following requirements:

- in aircraft with 9 or fewer passenger seats – one exit on each side of the aircraft above the waterline, which corresponds in size to at least one Type IV exit;
- in the case of aircraft with 10 or more passenger seats – one exit for each side of the aircraft above the waterline, corresponding in size to at least one type III exit, for each block or part of a block of 35 passengers – at least two such exits in the passenger cabin, that is, one for each side of the aircraft.

Table 1.3.

Minimum number and types of emergency exits with passenger capacity up to 179

Number of passenger seats	Number of emergency exits on each side of the fuselage			
	Type I	Type II	Type III	Type IV
1…9	-	-	-	1
10…19	-	-	1	-
20…39	-	1	1	-
40…79	1	-	1	-
80…109	1	-	2	-
110…139	2	-	1	-
140…179	2	-	2	-

Table 1.4.

Additional emergency exits if the number of passenger seats exceeds 179

Additional emergency exits	Allowable increasing of amount of passenger seats
Type A	110
Type I	45
Type II	40
Type III	35

On aircraft with a passenger capacity of more than 20 people, emergency exits for crew members should be located in the area of crew accommodation - one for each side of the hull or an upper hatch should be provided. The outputs must have a rectangular shape with a size of at least 485 x 510 mm.

The distribution of emergency exits along the fuselage should be as uniform as possible, taking into account the peculiarities of passenger accommodation, but it is not necessary that the dimensions and location of the emergency exits on the sides of the cabin be symmetrical.

If only a ground-level emergency exit is required on each side of the fuselage, and the aircraft does not have an emergency exit in the tail section or a ventral emergency exit, then the ground-level emergency exit should be located behind the passenger compartment. If more than one exit is required on each side of the hull, they should be located at the ends of the cabin.
If the aircraft has a longitudinal passage in the passenger compartment, the emergency exits must be arranged in such a way that passengers have the opportunity to reach them both from the front and from the rear. If there are two or

more longitudinal aisles for unhindered access of passengers to emergency exits, the transverse aisles between the longitudinal aisles should have a width of at least 510 mm.
The passage from one passenger compartment to another for access to the emergency exit must be free, but the salons can be separated from each other by curtains.
If an emergency exit, including type A, is located at a height of more than 1830 mm from the ground, when the aircraft is on the ground with the landing gear loosened and is not above the wing, then in this case it must be equipped with means that can help people get to the ground. One such means is a self-supporting inflatable emergency ladder, for example, TNO-2M (TND) or foreign analogues. Their weight with a container is 22, depending on the type of aircraft ... 70 kg. Ladders should be located near the entrance door or emergency exits. Considering that in medium and long-range aircraft of such ladders, their mass can be taken into account several times when calculating the masses and centering capabilities of the aircraft.
On airplanes that make long flights over water areas, individual inflatable vests for crew members and passengers, as well as group rescue islands, are required. For example, the ASJ-63P flying vest has a mass of 1.12 kg, and the mass of a raft of the PSN-20AK type (designed for 20 people) or PSN-6AK type (designed for 6 people) is 82 and 41 kg, respectively .

1.4. Structure and performance layout

The main task of the structure and power layout is the creation or selection of such circuits of aircraft parts that would ensure:
- the minimum weight of the structure of the parts of the aircraft and the entire aircraft as a whole;
- organic unification (connection) of power elements of the structure with the placement of the target cargo, crew, equipment, power plant;
- Consideration of the requirements for production and operational manufacturability;
- the necessary rigidity of the structure, taking into account the dynamic load and damping agents for the static and dynamic structural strength in the air flow;
- Obtaining the necessary resources and safety in case of local fatigue damage.

In structural and power supply planning, operational accesses (accesses) to the areas where the units are located, wiring of equipment systems and aircraft control, as well as accesses to parts of the structure that should be inspected during the operation of the aircraft should be provided.
The layout of the aircraft is completed by assembling its drawing. The drawing should depict the longitudinal section of the aircraft and the type of cabin in the plan, as well as cross sections in the places of the cargo (passenger) cabin, engine mounts, tail, landing gear, etc. The drawing should also show the placement of cargo, passengers and crew.

The contours of the main units are drawn and the scheme of their attachment to the power frame is marked.
The tasks of the structure and performance layout also include the installation of operational and technological (production) connections of aircraft parts.
Simultaneously with the process of structural and power design, possible technologies for manufacturing parts of the aircraft and its assembly are considered, since the selected technological processes can determine the features of the power scheme of the design.
The layout drawing, together with the general view of the aircraft (in three projections), serves as the basis for theoretical drawings of the fuselage and its interface with other parts of the aircraft.
The general appearance of the aircraft allows you to associate its main overall dimensions with external shapes. It is necessary, for example, to make drawings of a model intended for aerodynamic research (blowing in the wind tunnel). The execution of the overall view drawing is inextricably linked with the layout and alignment, aerodynamic calculation, calculation of stability and controllability, etc. According to their results, the necessary changes and additions are made to the drawings of the general appearance of the aircraft.
The drawing of the overall view of the aircraft must be in accordance with
The requirements of the ESKD and DSTU relate to the layout and text part of the CP, in which the necessary calculations and justifications of the decisions made should be included.

1.5. Selection and justification of layout schemes

To meet the requirements indicated above, the following parameters are selected: the aerodynamic scheme is a classic low-wing aircraft, which is justified by the following factors:
- increased passenger safety in the event of a possible fall (part of the impact energy is taken over by the wing);
-Improved buoyancy when landing on water terrain.
- in case of an emergency landing, an umbrella effect is possible (reduction of the force of the impact energy)
- The ventral part of the wing is more effectively involved in the generation of aerodynamic lift.

- Since the landing gear supports are connected to the wing, and the landing gear is removed in the fuselage in flight mode, the mass of such a structure is less than in the high-wing scheme.
- Since the engines are placed on pylons under the wing, air losses due to shading of the air intakes are minimal.

Minuses:
- As the degree of two-circuit increases, the total and mass parameters of the engine increase, this must be taken into account when calculating the chassis in order to ensure the normal functioning of the engine.
- Dust and other elements can get out of the runway if the engines are placed under the wing, which can lead to engine failures.

The tail of this aircraft is placed according to the normal scheme - (horizontal tail) HT and VT are located behind the wing and are attached to the tail section.

Main benefits:
- the possibility of effective use of wing mechanization;
-easy balancing of the aircraft with the flaps open;
-The placement of the tail behind the wing allows you to make the nose of the fuselage shorter, which improves visibility for the pilot, and also reduces the plane of the VT, since the shortened nose of the fuselage causes the appearance of a smaller destabilizing travel moment;
-the possibility of reducing the range of VT and HT, since their shoulders are much larger than in other schemes.

Minuses:
-HT generates a negative lift force in almost all flight modes, this leads to a decrease in the lift force of the entire aircraft;
- Since the HT works in an excited flow behind the wing, this negatively affects its functioning.

1.6. Selection of the main parameters of the sash

The main parameters of the wing include the profile and the relative thickness or , the arrowhead length of 0.25 sinews, the extension length, the narrowing length, the angle of the transverse V-wing and the specific load of the wing, the shape of the wing in the floor plan. Combinations of the parameters given in Table 1.5 are typical for modern aircraft.

Table 1.5

Typical parameter combinations

Aircraft Wing parameters	Take-off weight of the aircraft			
	up to 15 t	from 20 to 40 t	from 50 to 100 t	above 150 t
λo	8...12	7...9	6,5…8	6,5.. .9,0
χ°	6°...8°	20°...25°	30°...32°	32°...35°
$\overline{C}_A$	0,12...0,14	0,11...0,12	0,10...0,12	0,12...0,14
Po(CPa)	2,0...3,0	3,5...4,0	4,5...5,5	8,5...6,0

The aerodynamic characteristics of the wing are largely determined by the shape of the wing in plan. The profile parameters ($\overline{x}_C, f$) and the relative thickness of the wing ($\overline{C}_A$), as the practice of aircraft construction shows, depend on the number of Mach M of cruising flight-M_k (see Table 1.6.).

Table 1.6

Dependence of profile parameters on the Mach number

M_K	χ °	λ	η	$\overline{C}_A$,%	$\overline{x}_C$	f,%
0,85…0,9 0,6…0,8	35°…40° 0°…25°	6,5…8,5 7…12	3,5…4,5 2,5…3,5	9…12 12…18	35…45 30…40	0…2,5 1…3,5

The appropriate range of application of different types of profiles:
High - carrying type NACA - when V> 400 km/h.
Latinized type NACA- when 400 km/h < V<650 km/h.
Laminated high - speed at 600 km/h<V <750 km/h
Critical (peak) - when 750 km/h< V< 850 km/h
Supercritical - at V> 800 km/h.

For the wings of modern aircraft, the speed of which is close to sound, use symmetrical and asymmetric profiles with a sharper leading edge and a relatively rear position of the maximum thickness x_C= 35 ... 45%. They are characterized by a smoother pressure distribution along the wing chords, which reduces the value of the local airspeed over the upper surface of the wing and contributes to an increase in the critical number of M_{cr}. flights. From the same understanding, the relative thickness of the wing of aircraft whose speed is close to sound (M_{cr}. = 0.8 .... 0.9) is usually reduced (12 ... 14% at the root and 8.....9% at the end of the wing). In recent years, so-called supercritical profiles (double curvature profiles) have also been used for the wings of passenger aircraft whose speed is close to sound, compared with conventional profiles of the same relative thickness, they have higher (by 0.08" ... 0.1) M_{cr} values.
It should be borne in mind that all of the above measures aimed at increasing the flight M_{cr} adversely affect the stiffness properties and weight characteristics of the wing, and also lead to a noticeable decrease in the maximum values of the lift coefficients of the Su max.
The swing of the wing is a means of increasing the critical flight power figure. An increase in the swing of the wing not only postpones the onset of the wave crisis at high flight speeds, but also softens its course, reduces the increase in resistance, improves the stability and control characteristics of the aircraft, the speed of which is close to the sound . In addition, the swing of the wing increases the critical speed of the flapper and divergence. However, as the swing angle increases, the wing width and wingspan decrease, and the effectiveness of the take-off and landing mechanics decreases. Due to the lateral flow of the boundary layer to the ends of the arrow wing, it tends to eventually interrupt the flow at high angles of attack,

which can lead to a loss of the transverse controllability and longitudinal instability of the aircraft during landing. Sweep complicates the manufacture and increases the weight of the wing.

These circumstances cause the "careful" use of sweep, that is, the sweep angle of the wing of aircraft whose speed is close to sound, is usually selected at a minimum determined by the value of a given speed (number of M_{cr}) of cruising flight.

Wing elongation is a parameter that significantly affects the value of inductive resistance and the maximum quality of the wing and the aircraft. In addition, λ affects the weight and stiffness of the wing.

Transport aircraft, whose speed is close to sound, have wings with zero and low sweep. The elongation of such wings is in a fairly wide range $\lambda = 8 ... 12$, and large values of elongations are, as a rule, for large-sized aircraft with a long-estimated flight range. Increased wing elongation values are sometimes chosen for aircraft with a short flight range in connection with the desire to improve their take-off and landing characteristics. For an approximate estimate of the elongation of the projected aircraft wing, the formula $\lambda=10,5\cos^2\chi$ can be used. The obtained elongation value is adjusted based on data on the parameters of the wing of analog aircraft.

The narrowing of the wing has an opposite effect on the aerodynamics, weight and stiffness of the wing. The increase in taper has a positive effect on the distribution of external loads, stiffness and weight of the wing. It also leads to an increase in the overall height and volume of the central part of the wing, which facilitates the placement of fuel and various power units, and the growth of the wing area serviced by mechanization significantly increases its efficiency, however, an increase in wing narrowing has negative sides. The most important is the trend Wings with a large narrowing until the final disturbance of the flow, while reducing the efficiency of the ailerons. In connection with these circumstances, the narrowing of the straight wings of aircraft, the speed of which is close to the sound, is usually carried out small and is the value of η = 2.....2.5, which ensures that the inductive resistance of the wing is close to a minimum and high. the value of C in max pos $\mathbf{C}_{\mathbf{y\,max}}$. The angle of the transverse V wing, as it is clear, serves as a means of ensuring the degree of transverse stability of the aircraft. Its magnitude and sign depend mainly on the layout of the aircraft, and for aircraft with swept wings - also on the angle of the sweep. For straight wings of aircraft whose speed is close to sound, the value of the transverse V angle is in the range of 5 °...7° - for the low-plane scheme, up to -1°..-2° - for high-altitude. Sweep increases the lateral stability of the wing and therefore swept wings should add a negative transverse V. However, layout and other requirements (for example, landing with a roll) may cause a positive V swept wing. This will lead to the installation of automatic yaw dampers in the control system and will require some increase in the area of the vertical tail

Select the following parameters

$\lambda = 9,6$; $\eta = 3,8$; $C = 0,11$; $\chi 0.25 = 25°$.

1.7. Selection of the main parameters of the fuselage

The aerodynamic and weight characteristics of the fuselage depend significantly on its shape and dimensions, determined by such geometric parameters as the shape of the cross section, elongation λ_ϕ and diameter of the fuselage D_f. It should be noted that the elongation and length of the fuselage are specified in the layout of the aircraft with the conditions for providing the necessary volumes to accommodate the crew, passengers and cargo, as well as acceptable shoulders L_{VP} and L_{GP} horizontal and vertical tail of the aircraft. The lengthening of the fuselage and its parts (nose λ_n and tail λ_t) are selected from the understanding of aerodynamics and the weight of the fuselage.

When choosing λ_f a projected aircraft, you can focus on the following statistics of modern aircraft.

At $M_k \leq 0{,}7$: λ_f=7...8 - passenger aircraft MPL and BMS λ_f =8...9 - medium long-haul aircraft.

At $M_k \leq 0{,}9$: λ_f = 9...10 - large passenger aircraft; λ_f =10...13 - long-range mainline aircraft.

It should be borne in mind that the value of λ increases slightly if the aircraft engines are placed on the tail of the fuselage. The elongation of the nose and tail parts of the fuselage lie within:

at $M_k \leq 0{,}7$; λ_n=1,2..1,5; λ_t =2,0...2,5;

at $M_k \leq 0{,}9$; λ_n =1,7...2,0; λ_t =3,0...3,2;

Since the passenger capacity of this aircraft is 86 people, the following parameters were adopted to ensure comfortable flight conditions:

D_f=3,4 m, λ_f =8,6 m

2. DETERMINATION OF THE MAIN GEOMETRIC PARAMETERS OF THE AIRCRAFT LAYOUT

2.1. Determination of the geometric parameters of the wing

The geometric characteristics of the wing are determined based on the take-off mass m_0 and the specific load on the wing R_o. First find the wing area: $S_{wa} = \frac{m_0 \cdot g}{P_0}$ =85,22 m^2.

The wingspan is calculated by the formula: $l = \sqrt{S_{wa} \lambda_w}$ =28,60 m.

Root chord: $b_0 = \frac{2S_{wa} \cdot \eta}{(1+\eta) \cdot l}$ =4,72 m, and the tip chord $b_K = \frac{b_0}{\eta}$=1,24 m.

The lateral chord for a trapezoidal wing is defined by the expression:

$$b_0 = b_0 \left(1 - \frac{\eta - 1}{\eta} \cdot \frac{D_\Phi}{l} \right) = 4{,}30 \text{ m.}$$

where D_Φ is taken according to preliminary calculations.

The maximum thickness of the wing in any section of its span is equal to

$$C_i = \bar{C} \cdot b_i .$$

When choosing the power scheme of the wing, the number of spars and their position are determined, as well as the places of division of the wing.

On modern aircraft, a caisson wing and two or three spars are used; a single-spar wing is used on light sports, sanitary and other aircraft.

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

$$\bar{X}_i = \frac{X_i}{b}$$

wnere X_i - the distance of the i-th spar from the wing tip, b - chord.

In the wing with two spars: $\bar{X}_1 = 0{,}2$; $\bar{X}_2 = 0{,}6$.

In the wing with three spars: $\bar{X}_1 = 0{,}15$; $\bar{X}_2 = 0{,}4$; $\bar{X}_3 = 0{,}65$

This determines the width of the caisson and the capacity of the fuel tanks.

Value b_{cax} = 3,32 m.

After determining the geometric characteristics of the wings, they proceed to the evaluation of the geometry of the ailerons and the mechanization of the wing.

The geometric parameters of the aileron are determined in the sequence:

the span of the ailerons: $l_{el} = (0{,}3 \ldots 0{,}4) \cdot l/2$;

aileron chord: $b_{el} = (0{,}22 \ldots 0{,}26) \cdot b_i$;

Aileron square: $S_{el} = (0{,}05 \ldots 0{,}08) \cdot S_w/2$;

Increasing the recommended values of l_{el} and b_{el} is not rational. With an increase in the cases above the specified values, the growth of the aileron torque coefficient slows down, and the scope of mechanization decreases. As the white increases, the width of the caisson decreases.

On the aircraft of the third generation, there was a tendency to decrease the relative span and area of the ailerons. So, on Tu-154 aircraft $l^{\#}_{el}$=0,122. In this case, in addition to ailerons, interceptors are also used for transverse control of the aircraft. Due to this, the scope and area of mechanization can be increased, which improves the take-off and landing characteristics of the aircraft.

2.2. Determination of the geometric characteristics of the hull

When choosing the shape and dimensions of the fuselage cross-section, it is necessary to proceed from the requirements of aerodynamics (flow and cross-sectional area).

In relation to passenger and transport aircraft, the speed of which is less than the speed of sound (V < 800 km / h), the wave resistance has almost no effect. Therefore, the shape should be chosen in conditions of ensuring the smallest values of the corresponding friction resistance C_{xf} and profile resistance C_{xp},
On supersonic flights, the value of the C_{xf} wave drag is influenced by the shape of the nose of the fuselage.
The use of the chewing shape of the nose of the fuselage significantly reduces its wave resistance.
For around sound aircraft, the nose of the fuselage should $l_{nf.}=(2\ldots3)\cdot D_f$, where D_f is the diameter of the fuselage.
In addition to taking into account the requirements of aerodynamics, when choosing the shape of the intersection, it is necessary to take into account the conditions of the layout and strength requirements.
To ensure a minimum weight, the most preferred form of the fuselage cross-section must be recognized as a circular cross-section. In this case, the thickness of the fuselage skin is obtained less. As a variation of such a section, combinations of two or more occiles can be used both vertically and horizontally.
For transport aircraft, when choosing the shape of the fuselage cross-section, the issues of aerodynamics do not become paramount and the shape of the cross-section can be rectangular or close to it.
The geometric parameters of the fuselage include:
-fuselage diameter D_f;
-fuselage length L_f;
- fuselage extension $\lambda_{\$} = \frac{L_f}{D_f}$;
- extension of the nose of the fuselage: $\lambda_{n\$} = \frac{L_{nf}}{D_{nf}}$
- fuselage tail extension: $\lambda_{te} = \frac{L_{te}}{D_{te}}$
where L_{nf} i $L_{te.}$- the length of the nose and tail parts of the fuselage.

The length of the fuselage is determined taking into account the layout of the aircraft, the layout and alignment features, as well as providing a landing angle of attack $\alpha_{attc.}$

We define the following fuselage parameters:

$$L_{\$} = \lambda_{\$} \times D_{\$}\, l_{\Phi} = \lambda_{\Phi} \cdot D_{\Phi} = 8{,}6*3{,}4 = 28{,}5438 \text{ m.}$$

$$L_{n\$} = \lambda_{n\$} \times D_{n\$}\,;\ L_{n\$} = 1{,}5*3{,}4 = 5{,}1 \text{ m.}$$

$$L_{te} = \lambda_{te} \times D_{n\$}\,;\ L_{te} = 2{,}5*3{,}4 = 8{,}5 \text{ m.}$$

At the stage of preliminary design, in the process of preliminary surveys to determine the length of the fuselage, we can recommend the ratio for aircraft:

with direct angle: $L_f/l_w = 0{,}65\ldots0{,}75$ when $\lambda_w = 9\ldots11$;

$L_f/l_w = 0{,}75\ldots0{,}85$ when $\lambda_w = 8$;

with sweepback angle $L_f/l_w = 0{,}8\ldots0{,}95$ when $\lambda_w = 8\ldots10$;

when $X^0 - 35\ldots45°$: $L_f/l_W = 0{,}95\ldots1{,}25$ when $\lambda_W = 3\ldots5$.

When determining the fuselage diameter, they strive to ensure a minimum mid-section of the $S_{m\phi}$ on one side and ensure layout requirements on the other.For passenger and transport aircraft, the fuselage midsection is primarily determined by the dimensions of the passenger compartment or cargo cabin.

For short-haul aircraft, you can approximately take:

cabin height h_1 =1,75 m;

the width of the aisle b_{ai} =0,45... 0,5m;

distance from the window to the floor h_2 =1,0 m;

luggage compartment height h3 = 0,6... 0,9m.

For mainline aircraft, you can recommend accordingly:

interior height h_1 =1,9 m;

aisle width b_{ai} =0,6m;

distance from the window to the floor h2 = 1,0 m;

baggage compartment height h_3 = 0,9.. .1,3m.

It should be noted that determining the required width of the passenger compartment does not yet make it possible to determine the optimal dimensions of the fuselage cross-section. From a constructive point of view, it makes sense to have a round trunk cross-section, since in this case it is the most durable and lightweight. However, for the accommodation of passengers and cargo, this form is not always optimal. It is more expedient to form a trunk cross-section through an oval or a cross-section of two circles. It must be remembered that the oval shape is inconvenient in manufacturing, and the upper and lower plates bend under excessive pressure and require the introduction of yoke beams and other reinforcements into the structure.

The division of conventional frames into hull structures ranges from 360 to 500 mm, depending on the size of the hull and the layout class of passenger cabins. For hull diameters smaller than 2800 mm, this shape is often deviated from after understanding the layout.

Use a section consisting of two ordinary circles. In this case, the floor of the passenger cabin is made in the plane of the arch termination.

The windows of the passenger cabin are arranged in a light line (in the case of a multi-decker by the number of decks). The shape of the windows is round with a diameter of 300...400 mm or rectangular with rounded corners. The division of the windows corresponds to the division of the frames 500 ...510 mm.

It is also necessary to check the volume per man.

The length of the passenger cabin of the Cab. to accommodate the same type of seats placed in N transverse rows with a constant step of Dcr., can be calculated by the formula

$L_{cab}=L_1+(N-1)L_{cab}+L_2,$

where L_1 - distance from the plane of the front partition to the first row of seats,mm

L_2 - distance from the plane of the rear partition to the back of the chair, mm.

1 class ν_{pas}=Vcab/n =1,5…1,8m^3

Tourist class ν_{cab}= 1,2…1,3m^3

Econom class ν_{cab}= 0,9…1,0m^3

The longer the flight range, the larger the specific volume per man should be.

2.3. Crew cabin

The length of the cabin depends on the number and relative location of the crew's work places. The average length of the cockpit it is 2300...3300 mm. The crew cabin is separated from other areas of the fuselage by a strong partition equipped with a door with a lock.

When designing the cockpit, it is also necessary to remember that during a visual flight, the pilot should be able to see such a part of the airspace that allows controlling the flight path and preventing collisions with other aircraft or obstacles. Practically, this is ensured by minimal viewing angles during cruising flight, takeoff, run and taxiing. To determine the viewing angles, the starting point is the point of the calculated position of the pilot's eyes. For example, the forward view in cruising flight mode from the estimated position of the pilot's eyes should be 17^0 down and 20^0 up. Therefore, in order to ensure the necessary inspection, zones are determined in which objects should be absent, for example, the lamp posts of the crew cabin that limit the fields of view, as well as zones in which the dimensions of these objects should be limited. For the same purpose, the windows of the crew cabin lamp are produced in a special form.

As an example in Fig.2.1. a diagram of the minimum external view from the left pilot's cocpit place in horizontal flight is shown

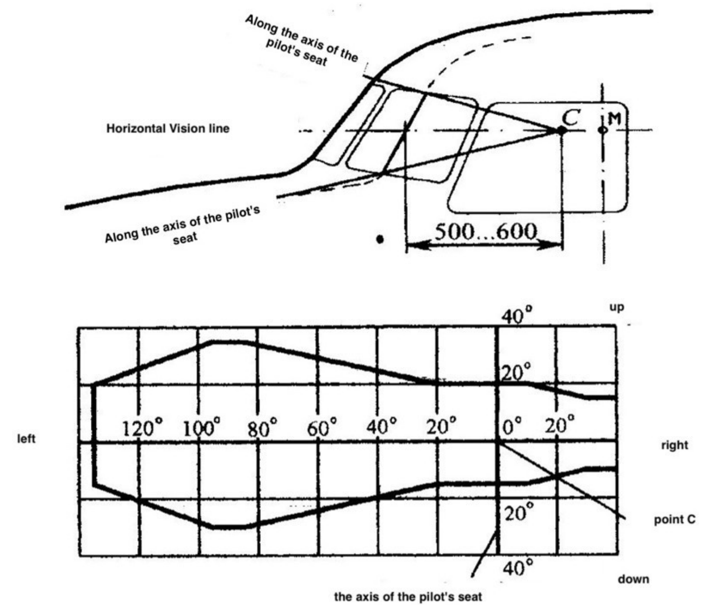


Figure 2.1. Diagram of the external inspection zone of the left pilot

Each passenger plane must have the following number of flight attendants:
For aircraft with a passenger capacity of more than 9, but less than 51passengers – 1 flight attendant;

1) For aircraft with a passenger capacity of more than 50, but less than 101passengers – 2 flight attendants;
2) For aircraft with a passenger capacity of more than 100 passengers - 2 flight attendants and one additional flight attendant for each compartment (or part of thecompartment) containing 50 seats over the specified 100.

During takeoff and landing, flight attendants should be as close as possible (as possible) to the necessary exits at floor level and be evenly distributed throughout the aircraft to ensure the most efficient exit of passengers in emergency evacuationconditions. This determines the location of the flight attendants' work places.

2.4. Cargo comparetmens

Cargo compartments can be located on the floor of the passenger cabin or under itin the sealed part of the fuselage. In the first case, the cargo compartments tend tobe located in front and behind the passenger cabin. This approach allows you to adjust the weight of the cargo to ensure the necessary alignment of the aircraft depending on the number of passengers. The location of cargo compartments is determined when estimating the length of the fuselage, and it is recommended to use data from prototype aircraft.
Approximately the volume of cargo compartments in m^3 located on the floor of thepassenger cabin can be estimated by the formula

$$V_{C.C.}=0,0074G_{P.W.}-0,59N_{PAS.}\ m^3, [1.1]$$

where $G_{K.H.}$- payload weight in H;
$N_{pass.}$ - maximum number of passengers.

Under payload according to OCT 1 00434-81[15] refers to the sum of the weight of the commercial load (passengers with luggage, mail, cargo including the weightof pallets) and the weight of fuel.

When cargo compartments are located under the floor of a passenger cabin, theirvolume is determined based on the weight of cargo and Mail and the method of transportation (in containers or on pallets).

For passenger aircraft, the total weight of passengers ' baggage, cargo, and Mailcan be determined by the formula

$$G_{cargo}=G_{P.W}-77G_{PASS}$$

where $G_{P.W.}$- payload weight in H;

$N_{pass.}$ - maximum number of passengers.

Under payload according to GOCT 1 00434-81[15] refers to the sum of the weight of the commercial load (passengers with luggage, mail, cargo including the weightof pallets) and the weight of fuel.

When cargo compartments are located under the floor of a passenger cabin, theirvolume is determined based on the weight of cargo and Mail and the method of transportation (in containers or on pallets).

For passenger aircraft, the total weight of passengers ' baggage, cargo, and Mail can be determined by the formula.

$$G_{cargo}=G_{P.W}-77G_{PASS}$$

After that you can determine the total required volume in m^3 of cargo compartments

$$V_{c.c.}=\frac{15\ Npas}{\gamma_{B.M.}}+\frac{G_{K.N.}-9015\ Npas}{\gamma_{car1o}}$$

where $\gamma_{B.M.}$- the specific weight of baggage and Mail (when transported in containers is assumed to be equal to 250 H/m^3, when container-free - 120 H/m^3);

γ_{cargo}- specific gravity of the cargo (when transported in containers, it is assumedto be equal to 350 H/m^3, when container-free - 290 H/m^3).

Having decided on the types and sizes of containers at the stage of forming the fuselage cross section and knowing $V_{C.C.}$ you can calculate the total length of cargocompartments and the number of containers.

Hatches for loading cargo are placed on the starboard side of the aircraft. The dimensions of hatches for loading containers are selected in accordance with GOST1 03625-84 [16]

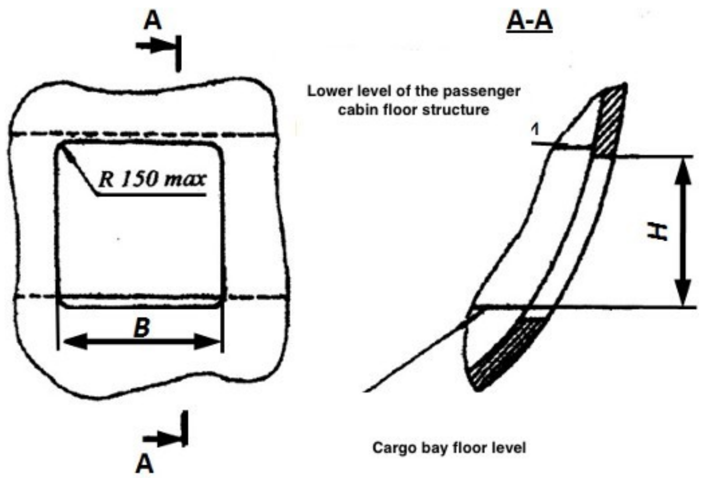


Fig. 2.2. Dimensions of luggage

hatches More simply, you can calculate

it as follows:
We determine the specific load on the trunk floor in the range of K= 400...600kgf/m^2, we assume K=600 kgf/m^2.
We determine the mass of almost and commercial baggage m_{com}=200 kg.
$M_{bagg.}$=8514,09585 kg.
We use the formula to determine the area of the luggage compartment

$$S_b = m_{bp}/0.4K+m_c/0.6K$$

Required lugged capacity
$V_{lc}=V_b \times n_{pas}$=0,37*86=31,82 m^3$V_b$ = 0,20. ..0, 24 -for fuselage $D_f \leq$ 4 m;
V_b = 0,36. ..0, 38 -for fuselage Df.> 5,5 m;

2.5 Kitchens and Sideboards

On wide-body aircraft, buffet and kitchen equipment can be located under the floor, and service trolleys with food are served to the salons by elevator. The total volume of V_K in m^3 and its area S_K in m^2 can be defined as. On wide-body aircraft,buffet and kitchen equipment can be placed under the floor, and service trolleys with food are served to the salons by elevator. The total volume V_K in m^3 and its area S_K in m^2 can be defined as

V_K=(0,1…0,12)
N_{pas}=9,46 m^3;$S_K=V_K/h_K$=4,11 m^2;
where h_K=2,3- kitchen height.

An example of the buffet layout is shown in Fig. 2.3.

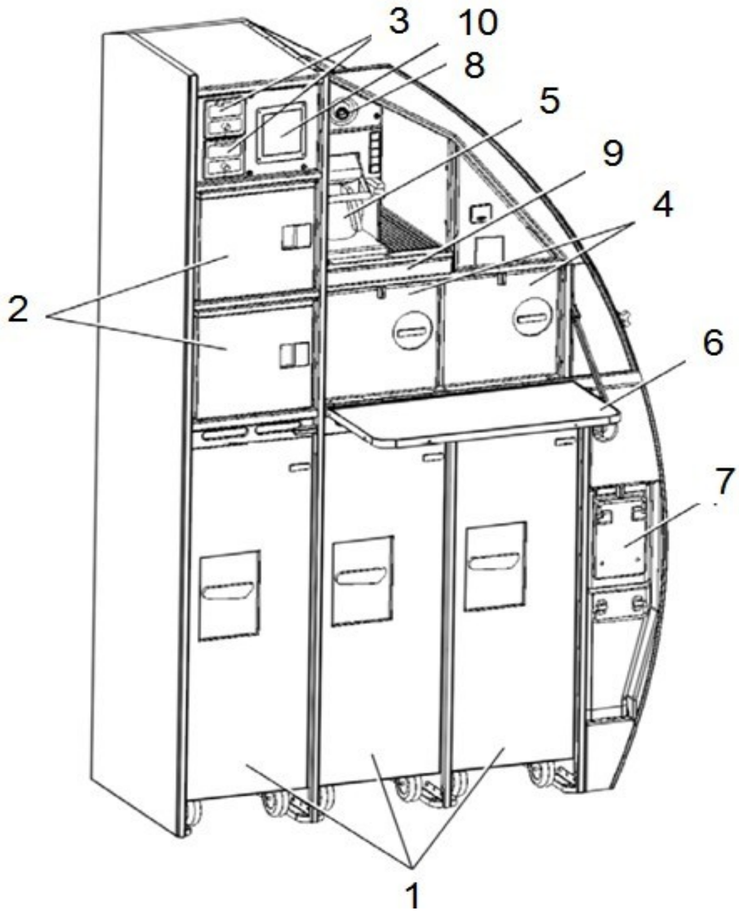


Fig. 2.3. location of buffet elements
1-service trolleys; 2-convection ovens; 3-oven control panels; 4-flight attendant containers; 5-coffee maker; 6-Table; 7 - garbage container; 8-individual ventilationnozzles; 9 - water tray; 10-Mirror.

2.5 Wardrobes

The area of the wardrobe S_w in m^2 can be defined as

$$S_w=(0,035…0,04)N_{pas}=4,3\ m^2,$$

where N_{pas} – number of passengers.

For long haul aircraft wardrobes have a large area

$$S_w=(0,035…0,04)N_{pas}$$

An example of the wardrobe of a long-haul aircraft is shown in Fig. 2.5.

Hand luggage and hats are stored on shelves located along the sides of the passenger compartment above the seats. Shelves are equipped with doors. The height of the shelves from the cabin floor depends on the class of aircraft and isusually 1500 1 1800 mm (fig. 2.4.).

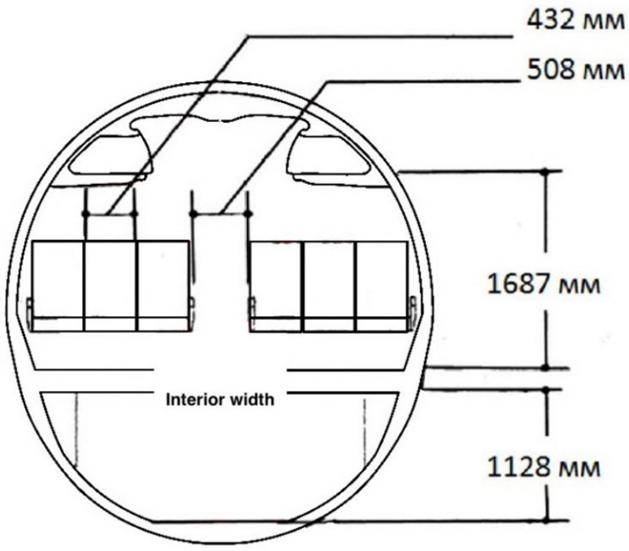


Fig. 2.4. location of hand luggage shelves

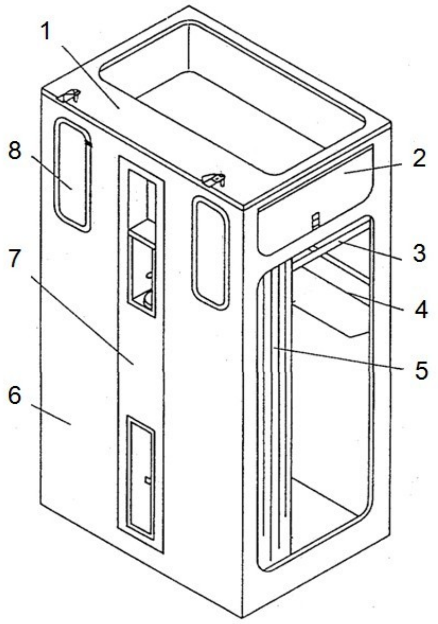


Fig. 2.5. wardrobe

1-top panel; 2-cabinet for removable equipment; 3-pipe; 4 - Box; 5 - curtain; 6-front panel; 7-drinking Column; 8-lighting ceiling.

2.7 Toilet facilities

The number of toilets depends on the number of passengers and the duration of theflight (table. 2.1).

If the flight duration is less than one hour and the number of passengers is up to 15people, the toilet on the plane can not be done.

Table 2.1

Number of toilet facilities

Flight duration, hour.	Less than 2	2…4	More 4
Number of passengers per toilet	60	50	40

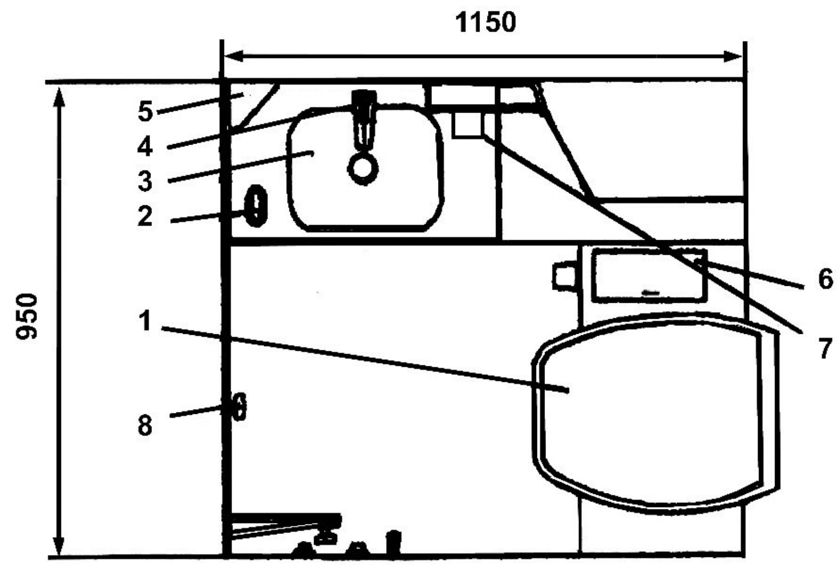


Figure 2.6. Type of toilet at the plan:

1 - unitaz; 2 - sink of the washbasin; 3 - dressing table; 4 - lampshade; 5 - nickname for small speeches; 6 - tank for a vikoristany toilet paper; 7 - milnitsya; 8 -door handle.

When calculating the mass and alignment options of the aircraft, it is necessary to take into account the mass of water reserves and, depending on the type of waste disposal system, chemical reagents. When performing CP, you can follow the datain Table. 2.1, and the total supply of water and chemical reagents is defined as:

$$\sum m_p = q_p N_{\text{A=B}}$$

Table 2.2.

Reserves of water and chemical reagents per person

Flight duration, hour.	Quantity per person q_r, kg
Up to 2	0,7
2…4	1,0
Above 4	2,0

2.8 Calculation of basic parameters and chassis layout

At the initial design stage, when centering has not yet been completed and there areno drawings of the general appearance of the aircraft, only a part of the landing gear parameters is determined.

Removal of the main chassis supports (fig.2.7):

e=(0.15 ..0.20) b_A.

If the extension is too large, it is difficult to separate the front support during takeoff, and if it is too small, it is possible to roll the aircraft over on the tail whenthe rear interiors and trunks are loaded first. In addition, the load on the front support will be too small and the aircraft will wobble when driving on a slippery runway and crosswind.

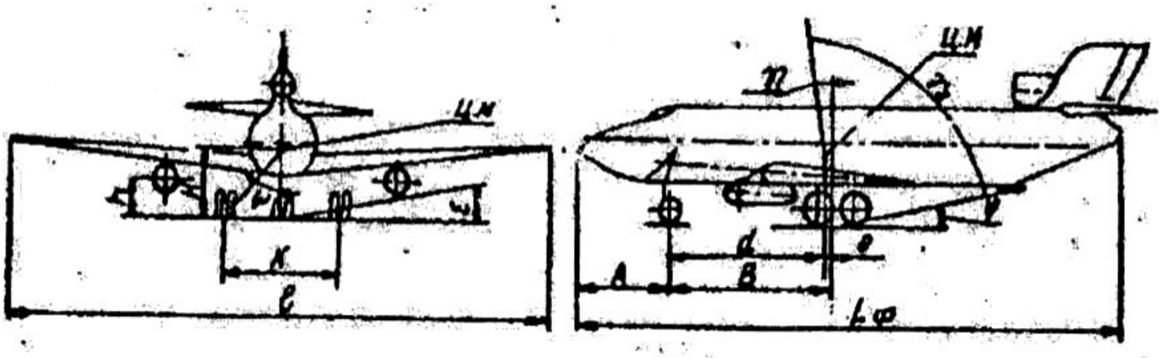


Fig.2.7.

The chassis base is from the expression:
$B=(0,3...0,4)L_f=(6...10)$ e=10,74 m.

Large values belong to aircraft with engines on the wing. The last equality meansthat the front support has 6... 10% of the aircraft's weight.

The removal of the front support will be equal to:
$d = B - e = (0,94...0,9)B$=7,17 m.

The chassis track is calculated using the formula: К=(0,7…1,2)B≤ 12 m.К=3,86 m.

Provided that the side hood is prevented, K>2H. here H is the distance from therunway to the center of mass (CM) of the aircraft. The position I and,M can be taken in height.

The landing gear wheels are selected from the take-off weight of the aircraft according to the amount of load in the parking lot; when selecting the front supportwheels, dynamic loads are taken into account. The type of pneumatics (balloon, semi-cylinder, arched) and the pressure in them are determined by the runway coating for which the aircraft is intended to be operated. Brake wheels are installedon the main and sometimes front supports. Wheel loads are determined by:

- main support wheel $P_{wh}=9,81(B - e)т_o/Bпz$=93029,05 (H);
- front support wheel $P_{sw}=9,81K_d\, e\, т_o/Bпz$=35114,87 (H),

where n i z - the number of supports and wheels on one support, respectively; K_d=1,5...2,0 - dynamic coefficient.

According to the calculated value of the load on the wheels P_{ma} and P_{fr} and thevalue of take-off V_{to} and landing V_{la} speeds are selected according to the pneumatics catalog.

According to the calculated value of the load on the wheels P_{main} and P_{nose} and the magnitude of the take-off $V_{takeoff}$ and landing $V_{landing}$ speeds are selected from the catalog of pneumatics fulfilling the conditions:

$$P^к > P_{main}\,;\; P^к > P_{nose}\,;\; V^к_{landing} > V_{landing};\; V^к_{takeoff} > V_{takeoff}$$

Table 2.3

Select the following wheel parameters:

Main supports(brake): (mm)	1325X430A
Front support: (mm)	840x300A

If the parking load specified in the catalog for the selected wheel P^K

and it is more than the calculated one by 5% or more, then for the coordinated operation of the liquid-gas shock absorber and pneumatics, it is necessary to reduce the pressure in the pneumatics to the value of:

$$P = P_0 \frac{P_{CT}}{P^0_{CT}}, \text{(Pa)}$$

To ensure the Cross-Country ability of aircraft operating on unpaved airfields, thepressure in the landing gear pneumatics must be within the limits of p =(3...5)10^5 Pa.

2.9 Layout and calculation of the main Tail parameters

One of the most important tasks of an aerodynamic layout is to choose the locationof the horizontal tail. To ensure the longitudinal static stability of the aircraft relative to overload, its CM must be in front of the focus of the aircraft and the distance between these points, attributed to the value of the average aerodynamic chord (CAC) of the wing, determines the degree of longitudinal stability:

$$m_Z^{Cy} = \overline{X}_T - \overline{X}_F < 0$$

Where e m^{Cy} - moment coefficientthe $\overline{X}T$ and $\overline{X}F$ respectively, the relative coordinate of CM and focus.

If m^{Cy}=0, then the aircraft has a neutral longitudinal static stability.

If m^{Cy}>0, then the plane is statically wobbly. In the normal scheme of the aircraft (tail behind the wing), the focus of the "wing-fuselage" combination is shifted backwhen installing horizontal tail, in the "duck" scheme (tail in front of the wing) - forward. Statistical ranges of values of the coefficients of static moments of horizontal $A_{ГО}$ and vertical A_{BO} Tail are given in Table. 9, where $L_{ГО}/b_A$ i L_{BO}/b_A are characteristic relations of the side and side to the wing. Using Table. 2.4, it is possible to determine in the first approximation the geometric parameters of the Tail.

Table 2.4.

Ranges of values of static tail moments

Types of aircraft	$A_{ГО}$	A_{BO}	$\frac{L_{ГО}}{b_A} = \frac{L_{BO}}{b_A}$
Mainline passenger cars with TVD	0,8...1,1	0,05...0,08	2,0…3,0
Main passenger lines with turbofan turbofan turbofan turbofan turbofan	0,65...0,8	0,08...0.12	2,5…3,5
Heavy non maneuverable with a swept wing	0,5...0,6	0,06...0,1	2,5...3,5
Heavy non maneuverable with a straight wing	0,45...0,55	0,05…0,09	2,0...3,0
High-speed maneuverable vehicles	0,4...0,5	0,05-0,08	1,5...2,0

Determining the geometric parameters of the tail

Usually the areas of the vertical S_{BO} and horizontal

S_{VT} Tail are:S_{GT} = (0,18…0,25)·S ;

S_{HT} = (0,12…0,20)·S

You can define it more accurately:

$S_{GT} = \frac{b121 \times S}{HF} \times A_{HF}$=20,00 m^2;

$S_{VT} = \frac{l \times S}{5F} \times A_{VF}$=10,44 m^2,

where L_{VF}, L_{HF} – horizontal and vertical tail shoulders;l and S – wingspan and wing area;

A_{GO}, A_{BO} – coefficients of static moments, the value of which can be taken fromtable.2.4.

The values of LVF and LHF depend on a number of factors. First of all their size isaffected by:

- length of the nose and tail parts of the fuselage;
- sweep and wing placement, as well as conditions for ensuring stability and controllability of the aircraft. In the first approximation, we can assume that LHF* LVF=14,00 m depending on the design features, you can find from the relations:
-with the normal scheme of the aircraft and the trapezoidal shape of the wing in theplan LГO = (0,2…3,5)×bCAC
- for duck scheme aircraft LHF = bCAC;
- for light aircraft LHF = (0,2…2,3) ×bCAC;
- for heavy aircraft LHF = (3,2…3,3) ×bCAC

Determination of rudder area, height and direction

The height of the steering wheel is usually taken: S_{PB} = (0,3…0,4)S_{HF}=6,00 m^2.The direction area is usually taken: S_{PH} = (0,35…0,45)S_{VF}=4,18 m^2.

Selection of the aerodynamic compensation area

The area of aerodynamic compensation is advisable to take (when 0,3≤M≤0,6)$S_{AK.PB}$ = (0,22…0,25) ×S_{PB}=1,30 m^2.

$S_{AK.PH}$ = (0,2…0,22) ×S_{PH}=0,90 m^2.

If the flight speed is M × 0,75, to $S_{AK.PB}$ × $S_{AK.PH}$ = (0,18…0,23) ×S_P.

In order to prevent overcompensation of steering wheels, the following requirements must be met:

$$\frac{S_{AK.PB}}{S_{PB}} = \frac{S_{AK.PH}}{S_{PH}} \leq 0,3$$

Height trimmer area: $S_{TP.PB}$ = (0,08…0,12)·S_{PB},
and for the rudder of an airplane with two engines: $S_{TP.PH}$ = (0,04…0,06)·S_{PH},for an aircraft with four engines $S_{TP.PH}$ = (0,06…0,10)·S_{PH}.

Determination of the horizontal tail span

The wingspan and Tail of the aircraft.l_{GO} = =(0,32…0,5)·l_W=10,00 m.

In this dependence, the low limits correspond to a turbojet-powered aircraftequipped with a return stabilizer.

The height of the vertical tail of the h_{BO} is determined depending on the placementof the wing on the fuselage and the placement of engines on the aircraft. So, in thebill, they take:

-for low-wing aircraft with engines placed on the wing (when M×1):h_{BO} = (0,14…0,2) ×l_W;

- when placing the engines in the root part of the wing h_{BO} = (0,13…0,165) ×l_W;
- when removing the engines to the rear of the fuselage: h_{BO} = (0,13…0,14) ×l_W. With the upper position of the wing relative to the fuselage in the recommendedranges, the upper limit should be taken.h_{BO} =4,00 m;
- The narrowing of the horizontal and vertical tail should be chosen:
- η_{HF} = 2…3 i η_{VF} = 1…1,33 – for aircrafts with M<1
- η_{HF} = 2…4 i η_{VF} = 2…5 – for aircrafts with M>1
- η_{HF} =3 , η_{VF} =1;

Lengthening of the Tail

You can recommend it:

- for aircraft whose speed is less than the speed of sound;

λ_{VF}=0,8…1,5; λ_{TF}=3,5...4,5

- for aircraft whose speed is greater than the speed of sound

λ_{VF} =1,5…2,5; λ_{TF}=2,5...3,5

Determination of the Tail chords $b_{КОНЦ}$, $b_{САХ}$, $b_{КОРН}$ is performed according to theformulas:

Tail chords HT:

$b_{end} = \frac{2 \times S_{HT}}{(\eta_{HT}+1) \times l_{HT}}$ =1,00 m

$b_{CAC} = 0.66 \frac{\eta_{HT}^2+\eta_{HT}+1}{\eta_{HT}+1} b_{HT\ TIP}$ = 2,14 m

$b_{root} = b_{tip} \times \eta_{HT}$ =3,00 m

Tail chords VT:

$b_{end} = \frac{2 \times S_{VT}}{(\eta_{VT}+1) \times l_{VT}}$ =2,61 m $b_{CAC} = 0.66 \frac{\eta_{VT}^2+\eta_{VT}+1}{\eta_{VT}+1} b_{VT\ TIP}$ =2,58 m

$b_{root} = b_{tip} \times \eta_{VT}$ =2,61 m

Relative profile thickness

For horizontal or vertical tail in the first approximation

$C_{op} \approx 0.8 \times C_{cp}$

More precisely taking into account the characteristics of aircraft:

- for aircraft whose speed is less than the speed of sound

$$\bar{C}_{Op} = 0,08…0,10;$$

-for transonic aircraft

$$C_{Op} = 0,06...0,09;$$

- for supersonic aircraft of the normal scheme

$$C_{Op} = 0,03...0,04;$$

- for supersonic aircraft of the "duck" scheme

$$C_{Op} = 0,02.$$

If the stabilizer is attached to the keel, the required value is C_{Op} take on the upper edge to provide the base for fixing the stabilizer on the keel.

Sweep of the Tail

The sweep of the Tail is assumed to be 3 ... 5^0 more than the sweep of the wing.This is done to ensure the controllability of the aircraft with the occurrence of awave crisis on the wing.

2.10 Selection and linking of power circuits of aggregates

The power scheme of the unit is understood as the articulation of structural elements that ensure the perception of loads and their transfer to the balancing points in the form of transverse force, bending and torsional moments. The mainelements of the power circuit are the spars, wing and tail panels, reinforced ribs,reinforced frames. During the layout process, it is necessary to link the power circuits, which consists in the fact that:

the wing wall elements (spars and beams) and the tail should be connected to thereinforced fuselage frames;

a place must be provided for the passage of the center section caisson through thefuselage;

the landing gear niches should not intersect the power set of the wing;
the mounting points of the chassis racks should be supported by reinforcedelements (ribs, frames, walls of the chassis niche);
the power elements of the tail should be supported by reinforced fuselage frames;the handlebar mounting brackets are performed as a continuation of reinforced ribs.
The alignment of the power circuit is reflected in a general drawing, where the axes of the spars, reinforced ribs and frames are applied with dashed lines with twodots.

3. AIRCRAFT ALLIGMENT

General provisions

When performing the volumetric-mass layout, calculations of the aircraft alignment are performed, i.e. finding such a position of the center of mass (CM) ofthe aircraft relative to the average geometric chord of the wing (CAC), in which: in the variant with the most backward position of the CM, the minimum allowablemargin of static stability of the aircraft is provided; in the variant with the most forward position of the CM, conditions are providedfor sufficient deflection of the elevator or stabilizer for longitudinal balancing ofthe aircraft in all flight modes.
The more effective the longitudinal controls and balancing of the aircraft, the morethe maximum forward alignment can be permissible and, accordingly, the wider the permissible operational range of alignment.

During the operation of the aircraft, the position of its CM changes both as fuel isproduced in flight, and as a result of various loading options and flight weights.
Therefore, in CM, it is necessary to calculate the alignment ranges of the aircraftfor the most typical cases of its operation:
take-off weight with the landing gear released;take-off weight with the landing gear retracted; landing weight with the landing gear released;
distillation version (without commercial load with maximum amount of fuel) withthe chassis removed;
parking option (without commercial loading, fuel, crew) with the chassis released.The calculation of aircraft alignment is usually an iterative process, which is performed by the method of successive approximation to the desired result, eitherby changing the layout, or by rearranging mass groups, or using both options simultaneously.
When performing CP, the alignment is determined along the x-axis, along the fuselage (Fig. 9.).

The initial data for calculating the alignment are the mass statement, theoretical drawing and preliminary layout of the fuselage, wing, tail, chassis. The drawing must be carried out according to one of the scales in accordance with current standards: 1:10; 1:15; 1:20; 1:25; 1:40; 1:50; 1:75; 1:100; 1:200.

Before the direct determination of the alignment, an aircraft mass statement is compiled. It includes the mass of mi main parts and assemblies of the aircraft, including fuel and cargo. It should be remembered that on modern subsonic aircraft, fuel is placed in the wing caissons, sometimes on long-haul aircraft, additionaltanks are placed in vertical or horizontal tail.

The mass summary is drawn up in the form of a table - centering sheet, which includes the coordinates of the centers of mass of all components of the take-off mass of the aircraft relative to the nose of the fuselage xi, as well as static momentsof mass mihi (Tables 3.1, 3.2.). To determine the coordinates of the xi, a schematicdrawing of the previous version of the layout of the aircraft should be used.

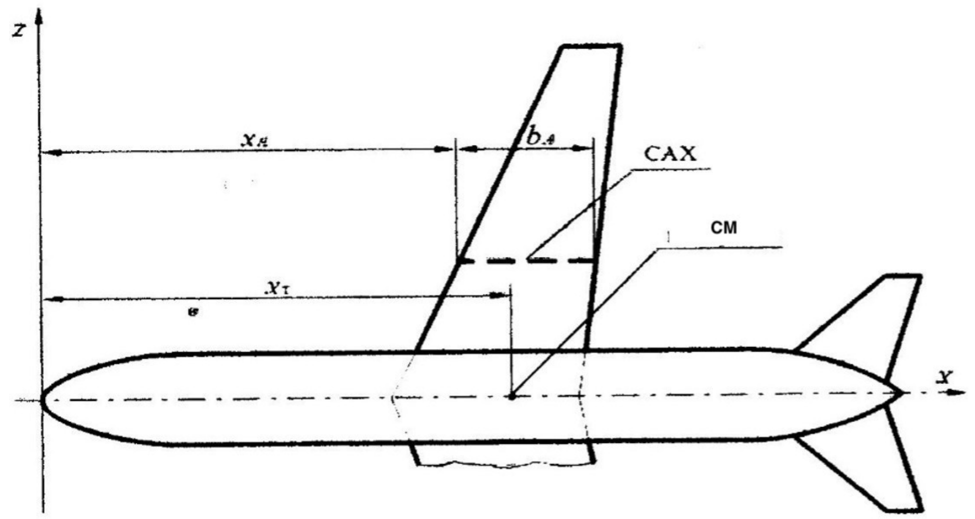


Fig. 3.1. Before determining the position of the center of mass of the aircraft inrelation to the CAC

In order to reduce the time when calculating the alignment of the aircraft and thelayout of the units, the following methodology is proposed.

Determination of the center of mass of the equipped wing

The mass of the equipped wing includes the mass of its structure, part of the mass of the equipment (placed in the wing), the chassis and the mass of fuel. Regardless of where the main landing gear supports are located (on the wing or fuselage), they, together with the front support, are included in the centering list of the masses of the equipped wing (Table 3.1.). The origin of the specified coordinates of the centers of gravity of the masses is selected in the projection of the point of origin of the CAX on the XOY plane.

The name of the object, their relative and absolute masses and the coordinates of the centers of mass are entered in the centering list. The coordinates of the fuel mass centers in each tank (group of tanks) are located (see appendix).

- behind the chord of the wings - in the middle of the caisson;
- by wingspan – at a distance z from the inner, relative to the plane of symmetry ofthe aircraft, the tank wall $z=0.45l_t$,

where l_t – the length of the fuel tank wall along the span of the spar.

The relative mass of fuel that can be placed in the fuselage (wing center section)

$$\bar{m}_{p\,f} = \bar{m}_{p} - \bar{m}_{p\ cp}\ ,$$

where m_f – total relative mass of fuel, $m_{п\ кр}$ - relative mass of fuel that can be placed in the wing consoles. Relative mass of fuel that can be placed in the wing

$$\bar{m}_{f\ cp} = \frac{\beta\ \bar{c}_{cp}}{\lambda_{cp}^{0,5}} \frac{m_0^{0,5}}{p_0^{0,5}}$$

where $\beta = 220+15\eta_w$ – coefficient that depends on the narrowing of the wing η_w λ_W – wing extension; p_0 – specific wing load during takeoff; c_{cp}– average relative wing thickness; m_0 – take off mass.

The coordinates of the center of mass of pylons, engines, and gondolas are determined graphically from the centering drawing of the wing.
In Table. 3.1.an approximate list of mass objects and recommendations fordetermining the coordinates of their centers of mass are given.

Table3.1

Centering mass sheet of the equipped wing

№ п/п	Name object	Mass m_i relative	Mass m_i absolute ,kg	The coordinate ofthe center of mass x_i, m	Static mass moment $m_i x_i$, kgm
1.	Wing (construction)	0,11722	5005,88	1,49	7475,86
2.	Fuel system (1,5%…2%) from $m_п$	0,0045632	194,87	1,49	291,02
3.	Aircraft control system(30%)	0,00337	98,65	1,99	196,43
4.	Electrical equipment (10%)	0,00337	143,92	0,33	47,76
5.	Anti -icing system (70%)	0,011123	475,01	0,33	157,64
6.	Hydraulic system (70%)	0,01393	594,88	2,32	1381,96
7.	Main enigines	0,05464	2333,40	-2,69	-6276,85
8.	Engine equipment, attachment points	0,0284128	1213,37	-0,71	-855,92
9.	Fire protection system	0,0185776	793,36	-0,71	-559,64
Equipped wing (without fuel and chassis)			10853,33	0,17	1858,26
10.	Equipped wing (without fuel and chassis)	0,032632	1393,55	2,17	3019,68
11.	Fuel (including aero-navigation reserve):	0,22816	9743,57	1,49	14551,20
Total			21990,45	0,88	19429,14

The coordinate of the center of mass of the equipped wing is determined by theformula

$$x_{cr} = \frac{\sum m_i x_i}{\sum m_i}$$

Determination of the center of mass of the loaded fuselage

The origin of coordinates is chosen in the projection of the nose of the fuselage on the horizontalaxis (see appendices). The construction axis of the fuselage is taken as the x-axis. An approximate list of mass objects and recommendations for determining the coordinates of their centers of mass are given in Table 3.2.

Table 3.2.

Centering mass sheet of the loaded fuselage

№	Name object	Mass m_i		The coordinate of the center of mass x_i, m	Static moment of mass x_i, кгm
		relative	absolute kg		
1	2	3	4	5	6
GLIDER					
1.	Fuselage (construction)	0,11992	5121,18	13,99	71627,24
2.	Horizontal Tail	0,01287	549,61	26,14	14369,21
3.	Vertical Tail	0,01474	629,47	26,14	16457,04
EQUIPMENT AND MANAGEMENT					
4.	High-rise equipment	0,00681	290,82	13,13	3818,2
5.	Anti-icing system (30%)	0,004767	203,57	13,70	2789,8
6.	Passenger equipment	0,0165	704,63	2,85	2011,9
7.	Decorative cladding	0,0094	401,43	13,99	5614,4
8.	Household equipment	0,0067	286,12	14,27	4083,3
9.	Hydraulic system(30%)	0,00597	254,95	14,27	3638,0
10.	Electrical equipment (90%)	0,03033	1295,24	11,42	14788,6
11.	Location equipment	0,0035	149,47	2,28	341,31
12.	Navigation equipment	0,0052	222,07	1,43	316,93
13.	Radio communication equipment	0,0026	111,03	1,43	158,47
14.	Instrumentation	0,0061	260,50	1,14	297,43
15.	Aircraft control systems (70%)	0,00539	230,18	14,27	3285,1

Table 3.2.

1	2	3	4	5	6
16.	APU	0,0076496	326,68	14,83	4844,38
Empty fuselage			11036,96	13,45	148441,24
EQUIPMENT					
17.	Crew		190,00	2,85	542,33
18.	Flight attendants		150,00	2,85	428,16
19.	Documentation and tools	0,0055	234,88	2,00	469,30
20.	Water (chemical genus.)		180,00	13,70	2466,18
21.	Additional equipment	0	0,00	11,42	0,00
Empty equipped fuselage			11791,84	12,92	152347,21
22.	Front chassis support	0,008158	348,39	3,55	1236,78
Total			12140,23	12,65	153583,98
COMMERCIAL LOAD					
23.	Passengers		6450,00	14,56	93894,83
24.	Baggage		2064,00	15,70	32402,92
25.	Products power supply		342,44	14,84	5082,74
Total			20996,67	13,57	284964,48

The coordinate of the center of mass of the loaded fuselage is determined by the formula

$$x_i = \frac{\sum m_i x_i}{\sum m_i}$$

Determined the centers of mass of the equipped wing and fuselage, the equation of equilibrium of moments relative to the nose of the fuselage is compiled

$$M_f x_f + m_w(x_a + x_w) = m_0(x_a + x_c)$$

where x_a - the position of the beginning of the CAX wing relative to the nose of the fuselage. c is the distance from the beginning of the Saha to the center of mass of theaircraft. As reported, the alignment of the aircraft.

$x_T = x_a + c$ – this is the coordinate of the position of its center of mass in the projection on the CAX of the wing, it can be determined from the previous formula

$$x_T = \frac{m_* x_* + m_{cp}(x_a + x_{cp})}{m_0}$$

In practice, the alignment of the aircraft is determined, as a rule, in relative coordinates x_T, i.e. the position of the CM of the aircraft from the beginning ofthe CAX, expressed as a percentage (or fractions) of the CAX

$$\bar{x}_T = \frac{x_T - x_A}{b_A} 100\%$$

Thus, to calculate the alignment of the aircraft x_T, it is necessary to know the position of the beginning of the wing CAX relative to the nose of the fuselage x_a. The initial value of x_a can be determined through the appropriate scale according tothe scheme of the prototype aircraft, having previously determined the value of theCAX and drawing it on the wing

As a result of the calculations carried out, the values of the aircraft alignmentsgiven in Table 3.3 should be obtained.

Table 3.3.

The value of aircraft centering according to statistics

Straight wing		Sweepback wing	
Low wing	High wing	Low wing	High wing
13…32	15…33	18…38	20…42

If these values cannot be obtained, it is recommended to use the following alignment adjustment tools:

change the location of the heaviest loads in the fuselage;

move the wing along the fuselage (in this case, not only the center of mass of theaircraft will move, but also the CAX of the wing).

In order to determine how far l you need to move, for example, the wing of an airplane as the largest aircraft unit by weight, you first need to decide how much you need to change the alignment. ΔX_tin order to get the specified recommended values ΔX_t.Value ΔX_t in defined as the difference between the calculated and recommended values xA_T. The distance l is as follows

$$l = \frac{\Delta \bar{x}_T b_a m_0}{m_{cp}}$$

To increase x_T it is necessary from the initial value x_a subtract the value of l,then you need to recalculate the plane's alignment with the new x_a value.

In order to facilitate the calculation of alignment options, it is recommended to combine the masses and the corresponding mass coordinates in the table table. 3.4.Mandatory variants of aircraft alignment calculations for the most typical cases of aircraft operation are summarized in Table. 3.5.
When performing alignment calculations you must check that the following requirements are met: $\sum m_o = m_{cp.\ w.} + m_{cp.\ ф.}$;
$L_{ro} \geq 3b_a$

For the landing version, the mass of fuel can be taken approximately 15%...20% (depending on the type of aircraft) of the mass of fuel at take–off, and for distillation - the mass of fuel is the maximum possible (due to the absence of) commercial load) and is determined by the capacity of the fuel tanks of the aircraft. The centering process is considered completed only after the centering values for the most typical aircraft operation options fall within the recommended ranges.

Table 3.4.

Consolidated centering statement

№	Name object	Mass m_i, kg	Mass coordinate mac x_i, m	Mass static moment $m_i x_i$, kgm
1.	Equipped wing (without fuel and chassis)	10853,33	0,17	1858,26
2.	Front chassis support (released)	348,39	3,55	1236,78
3.	Main chassis supports (released)	1393,55	2,17	3019,68
4.	Fuel	9743,57	1,49	14551,20
5.	Empty equipped fuselage	11791,84	12,92	152347,21
6.	Passengers	6450,00	14,56	93894,83
7.	Baggage	2064,00	15,70	32402,92
8.	Food	342,44	14,84	5082,74
9.	Front chassis support (collected)	348,39	3,05	1062,58
10.	The main supports of the chassis (removed)	1393,55	2,17	3019,68

Table 3.5.

Options for centering the aircraft

№	Name option	Mass m_i, kg	Mass static moment m_i x_i, kgm	CM $x_{cml\ i}$, m	Centering n
1.	Takeoff mass (chassis released)	42987, 11861	304393,62	13,38	37,35
2.	Takeoff mass (chassis removed)	42987, 11861	304219,43	13,37	37,23
3.	Landing mass (chassis released)	34736, 2	292492,97	13,32	35,59
4.	Distillatory (without commercial load, chassis removed)	34130, 7	172838,93	12,89	22,48
5.	Parking (without commercial load, fuel, crew, water, chassis released)	23632, 2	154555,9549	12,83	**20,84**

SPECIAL PART

INTRODUCTION:

The AN-158 is a short-range passenger aircraft carrying from 0 to 99 passengers (depending on the configuration of the aircraft) at a distance of up to 3100km. This aircraft is an elongated version and was originally called the AN 148-200.
Presented on April 21, 2010 in Kyiv. The first flight of the AN-158 took place on April 28, 2010 from the Antonov GP airfield. Certification was completed on February 28, 2011 [36].
The aircraft is equipped with two dual-circuit D-436-148 engines, manufactured by Motor Sich (other engine options are also possible), with a specific fuel consumption of 1,458 kg/hour.
In the structural part, the aircraft has a number of advantages compared to the previous model (AN-148). Among such advantages we can include:

• Maximum increase in the number of seats to 99 units (compared to 89 seats of the aircraft described above).
• Lengthening of the cabin by more than 1.7 meters, which in turn increases passenger capacity.
• Reduction of parameters such as fuel consumption (3%) and various operating costs (12%).
• Increased wing efficiency due to end aerodynamic surfaces

At the same time, the maximum take-off weight of the aircraft has not changed and is equal to 43.7 tons. Consequently, the chassis has not suffered any reinforcements.

Regarding the special part of my diploma work, I needed to create a mount for a passenger aircraft seat to the floor of the aircraft, and also compare this option with a modified seat assembly. Describe their characteristics, advantages and make a strength calculation, while showing this in a note of a special part of my work.
Throughout the history of aviation, designers have tried to reduce the weight of the aircraft without damaging the structure, to increase the performance of the aircraft while reducing its costs. Improvements in the design of the seat attachment in my work, as well as a reduction in its weight, have a positive definite impact on the take-off and technical characteristics of a passenger vessel.

4. Fixing the aviation passenger seat

In this part, we will consider two types of mounting: modular and lightweight assembly.

4.1 Lightweight seat assembly

It consists of the seat itself and the component that supports it. Strictly speaking, the seat body is an inseparable structure consisting of a part of the seat and a part to support the back of the passenger of the aircraft. The back of the chair is connected to the supporting part of the chair with the possibility of sliding along this part. Often the chair assembly contains a load-bearing structure with two transverse beams that go the width of the chair and are supported by racks. The main parts, such as the bearing part, beams and various fasteners are made of metals that have a large mass. In turn, this affects the weight of the aircraft, and consequently, the technical characteristics and commercial profitability are reduced. Therefore, the main task is to improve the passenger seat by reducing its weight, changing the geometric dimensions, simplifying the design, as well as selecting more durable and at the same time lightweight materials.

Thus, this seat can be characterized as a device with a simple design, which in turn limits its configuration. This can be manifested as a restriction in the deviation of the back of the chair or the chair to the side, and so on. This disadvantage can be neglected, since this version of the chair is suitable for a short-range aircraft, and as you know, the AN-158 aircraft is such.

In addition, the seat body and its supporting part can be connected to each other to give it the characteristics of plastic deformation, flexibility, as well as shape changes in exceptional operating conditions. The last aspect is particularly necessary from the point of view of the proposed seat assembly for use in civil aviation according to the SAE AS 8049B-2005 standard [38], which also provides loads of 14G down and 16G forward.

We will consider the preferred sides for this seat, each of which relates to the passenger seat component as a whole and is disclosed in the description.

Separate features that are open for the sake of a general type of component of a lightweight passenger flight seat assembly (for example, the second aspect: a lightweight passenger aviation seat assembly) can be analysed as open in the context of any type of component of a lightweight passenger seat assembly.

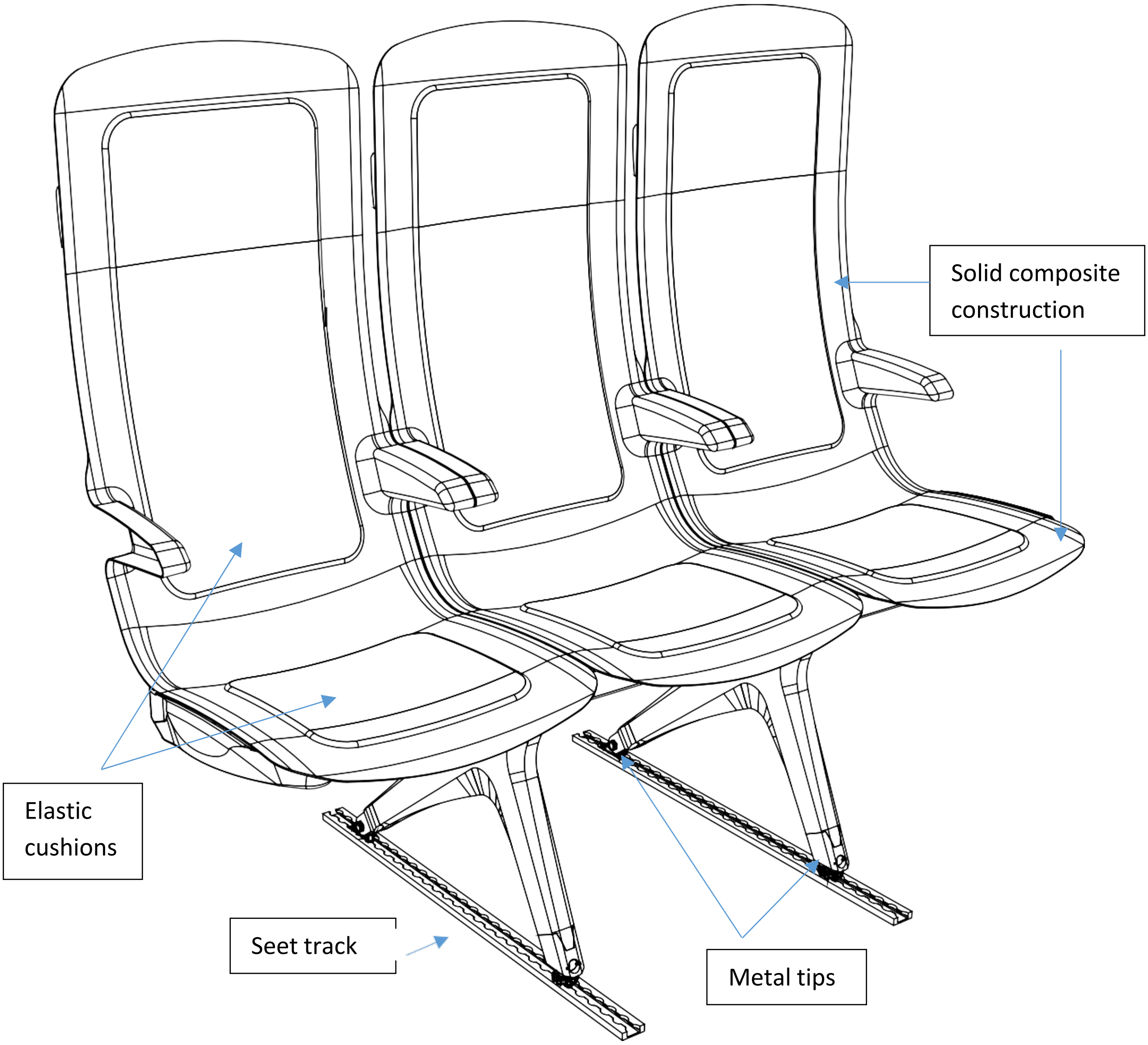
The second moment is attributed to the component of the passenger aviation seat assembly, moreover, the lightweight element meets at least one of the following requirements:

• The component forms a monolithic or whole-body part.
• The component is an inseparable construction.
• The component is made of reinforced fibber composite.

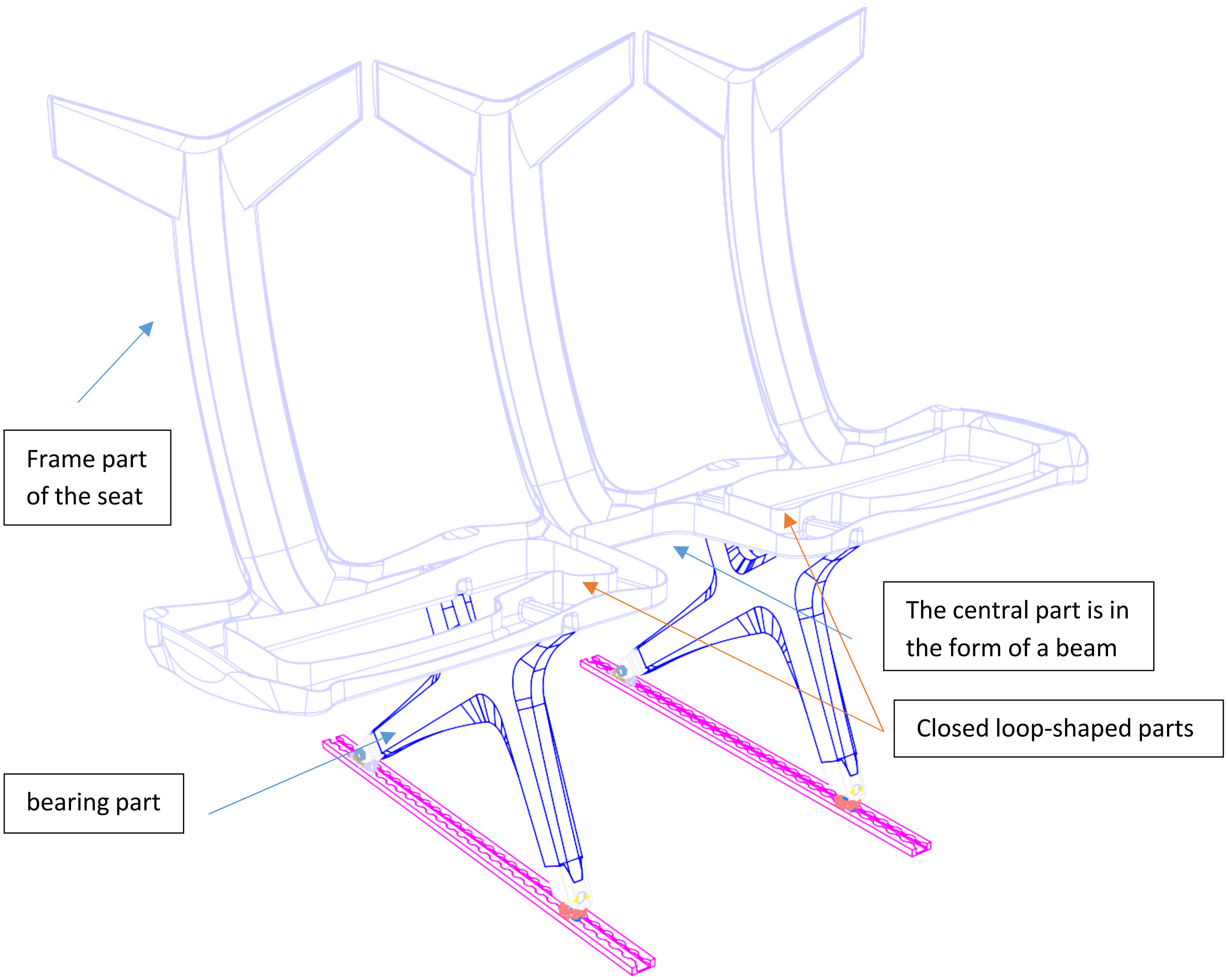
• The component contains carbon, ceramic, boron and steel fibbers.
• Contains fibrous layers that are located next to each other, while the fibers of the main cover are oriented at an angle 30 ,45 ,60 ,75 ,105, 120, 135, 150 degrees relative to the fibbers of the second cover. The permissible deviation is 5 degrees (preferably 2 degrees).

The third point is attributed to the bearing portion of the passenger seat assembly while the bearing portion covers at least one section in the form of a rack that meets at least one of the following requirements:
• The rack forms a monolithic or whole body part.
• The riser is an undivided structure.
• Contains one, two, three (preferably 2 racks, but even more preferably 4) racks.
• Part of the rack contains at least one empty rack inside.
• The part in the rack variant covers the inner body part and two symmetrical halves, mainly distributed by a rod plane, which are fastened to each other, mainly bolted or welded, moreover, the inner body part or symmetrical halves are mainly single structures.
• The part in the rack variant covers four racks, moreover, the first rack branches off from the third rack, and the longitudinal axis of the first rack and the longitudinal axis of the third rack are placed at an angle forming an angle greater than 90°, preferably greater than 100° and preferably less than 120°, more preferably less than 110°.

The fourth point refers to the bearing part of the seat assembly, mainly in synthesis with at least one of the previous points mentioned above, while the bearing part covers at least one frame part that meets at least one of the following requirements:
• The frame part forms an integral or single body part.
• The frame part is a single structure.
• The frame part is configured to support at least one lobe in the form of a seat, preferably exactly three parts in the form of a seat.
• The frame part is configured for connection with at least one seat body, preferably with a part to the seat or partially in the form of a backrest, or partially in the form of a headrest, or partially in the form of an armrest of at least one seat body.
• The frame part covers at least one device for articulation with a rack, which is attached, mainly by rivets or bolts, to a part of something like a beam or a loop-shaped part.



On the picture we can see the side view of the seat



On the picture we can see the rerspective component-by-component view of the front pillar of the seat.

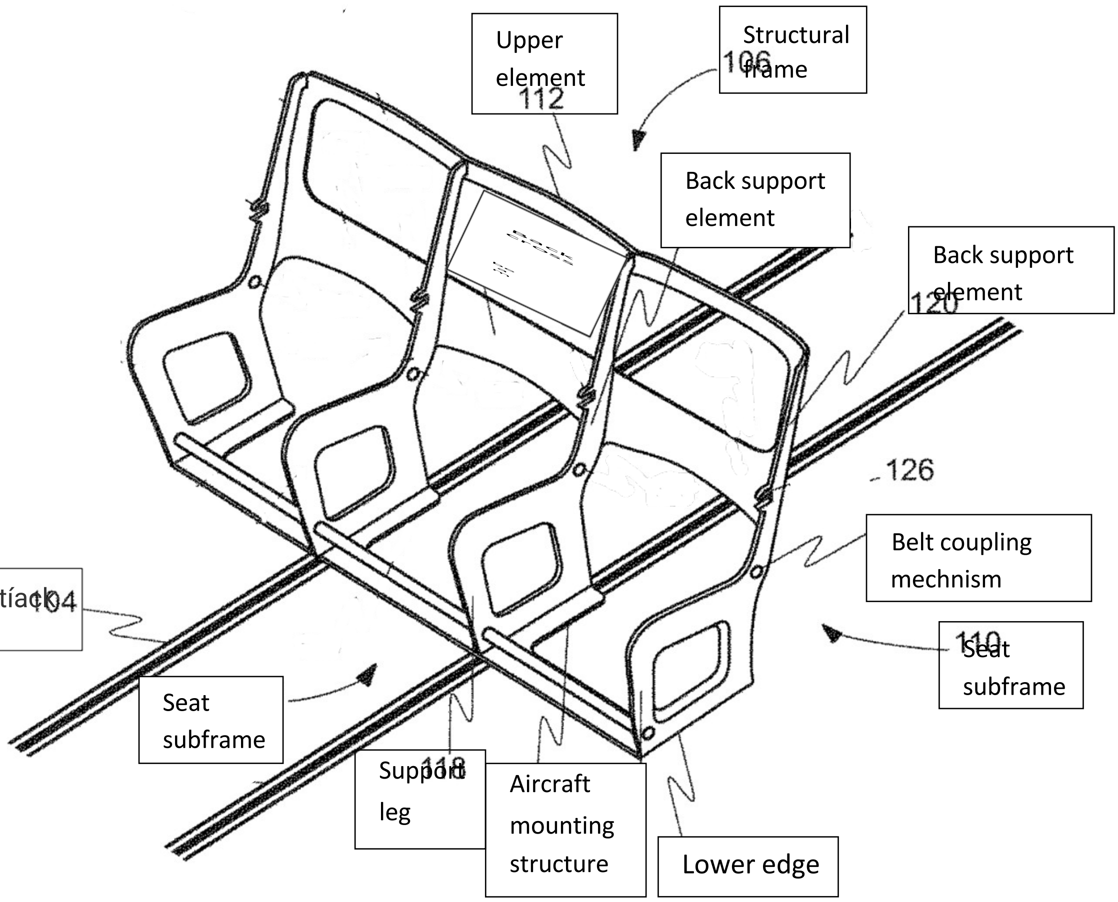
4.2 Modular passenger seat

Historically, the passenger seats of airplanes were made of heavy and bulky materials that meet the set conditions for the design and comfort of passengers. Because of this, the average passenger seats of aircraft store a number of relatively heavy metal components. Such components can dramatically affect the total weight of the aircraft, especially if the aircraft covers hundreds of passenger seats.
Take for example the 777, where its payload is about 6 percent of the total weight of the aircraft.
In the aircraft industry, weight reduction has always been important. If it is possible to achieve a reduction in the weight of the aircraft structure, the amount of fuel that the aircraft can transport increases, and, similarly, the flight range can be increased.
However, in the field of civil aviation, fresh solutions were reluctantly used to reduce the weight in the design of seats, often due to problems with cost and obtaining a license. In addition, there is no emphasis on weight loss approval in the business relationship between seat manufacturers and airlines. As a rule, the airline that buys the plane independently determines and acquires passenger seats. subsequently, the seats are sent to the aircraft manufacturer and installed in the aircraft. As a result, aircraft manufacturers do not so often regulate the weight of passenger seats, since the priorities of price and functionality are immeasurably higher, airlines rarely encourage seat manufacturers to produce light products.
The passenger seat depicted has a lightweight modular design that can reduce weight compared to conventional seats. In view of the implementation of the seat, a whole composite load-bearing frame and a set of convenient frame nodes (one for each passenger) combined with the load-bearing frame are used. due to the combined design, the passenger seat will be able to meet the design requirements for a small and lightweight structure with a much smaller number of parts compared to ordinary seat designs. In addition, the modular design of the seat simplifies the installation operation.
The above-mentioned nuances are implemented in the form of an embodiment of the passenger seat assembly of the aircraft. The seat assembly is combined with a monolithic frame, and the monolithic frame is designed to support at least one passenger and transfer loads combined by at least one passenger to the aircraft fuselage structure. A convenient frame node implemented with the possibility of interacting with the whole structural frame in order to adapt to the movement of the convenient frame node of a relatively integral structural frame.
Such and other nuances are implemented in the form of the embodiment of the manufacturing technology of the passenger seat assembly of the aircraft.

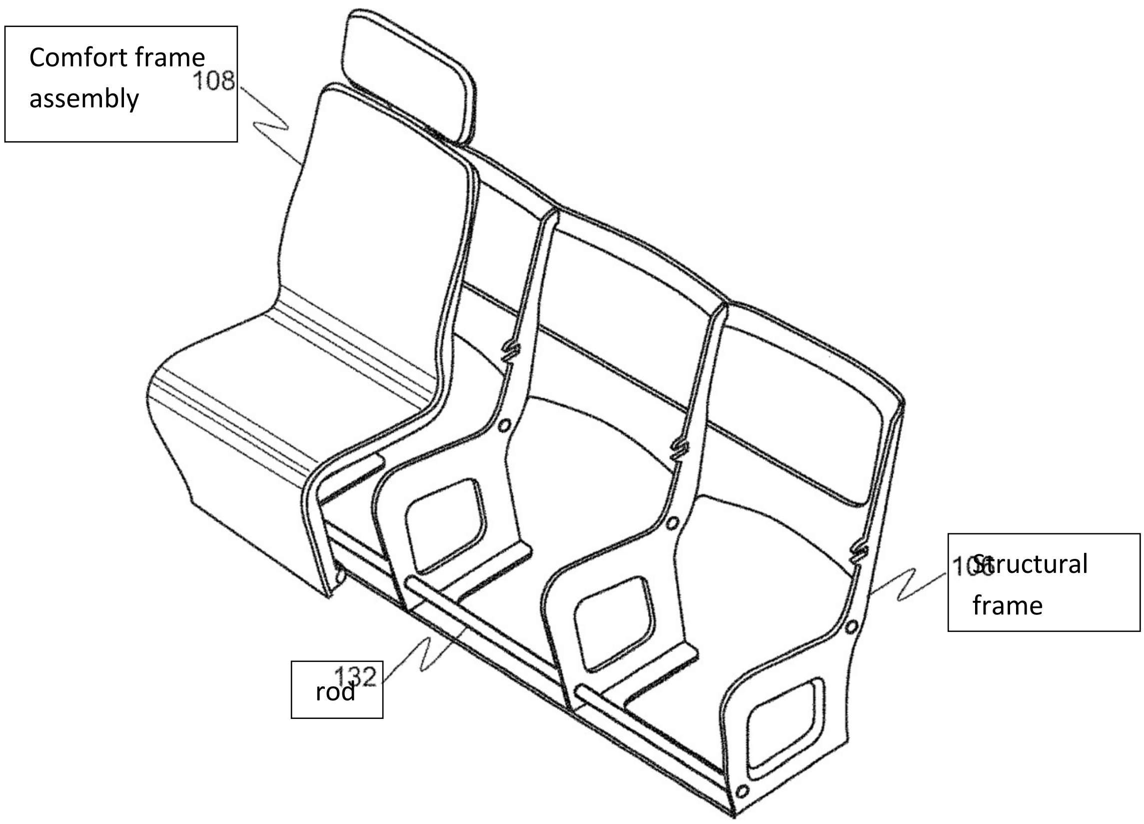
The method covers the planning of a frame with an integrated composite structure suitable for the design of the aircraft fuselage, and the frame with an integrated composite structure includes N seat subframes corresponding to the positions of N passenger seats. creating a frame, creating N nodes of a convenient frame for a passenger seat node, each of which contains a main frame and a fabric support combined with a suitable support frame for the sake of finding the seat plane.

The above-mentioned nuances can be embodied in one of the variants of the execution of the passenger seat assembly. The passenger seat assembly has an integral structural frame designed to support at least one passenger, the first seat subframe, the second seat subframe and the aircraft made in it as a whole. The integrated load-bearing frame has a prefabricated installation and the first convenient frame assembly combined with the first seat subframe, the first integrated main frame and the first single main frame combined with the first. The first node of the comfort frame accommodating the second fabric support and the second Node of the comfort frame, combined with the second seat subframe, while the second node of the comfort frame is connected to the second integral main frame and the second integral main frame. And the second assembly of the comfortable frame includes a second fabric support. [43]

The above-mentioned nuances are implemented by the type of execution of the technology of attaching the seat section to the aircraft. This method covers the connection of the supporting frame, which includes a seat subframe, a suitable passenger seat placement to the aircraft fuselage structure, and then to the structural frame, the main frame and the fabric support that characterizes the seat surface. The unification of the convenient frame section consists of the above summary, which was presented to familiarize with the choice of concepts in a simple form, which was indicated below in the description.



ľhe fíont peíspective view of the stíuctuíal fíame attached to the seat tíack



Partial side view of one passenger seat assembly option.

4.3 The comparison of the seats

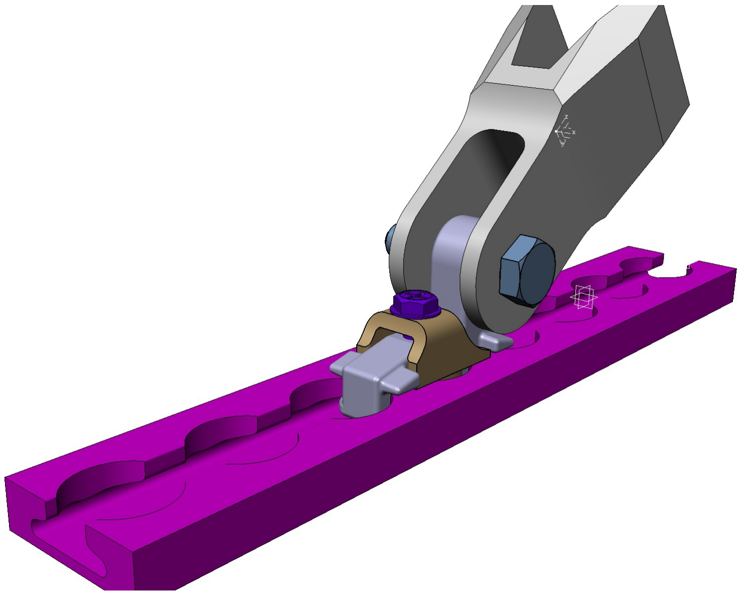
There is an obvious sign in the claimed seat variants, this is the desire to reduce weight and simplify the design in relation to previous versions of seats.
Next, we will make an amendment to the fact that the lightweight chair will be called "The First prototype", and the modular chair "The Second prototype".
Both prototypes are suitable for aircraft with a short range (say, up to 700 miles (or up to 1100 km) of flight range), since their adjustment in the mode of reclining the seat back at a certain angle in a given direction or shifting the seat towards the aisle and back is impossible.
The first prototype contains a load-bearing structure with cross beams, and this power structure consists of various power structures, the crown of the armrest is made of lightweight material, as well as the fastening of the fitting to the fitting itself (moreover, this fastening itself is attached to the chair stand with an adhesive substance). This innovation made it possible to protect this node from additional weight (drilling a hole with a further fixing of the bracket, as an example).However, it should be noted that such a solution has its drawbacks. Non-adhesive material, like any other material, is subjected to "fatigue". In our case, this is the cracking of the attached layer between the two parts, which can be critically unsafe for passengers. I would like to add that an increase in temperature, its difference, as well as humidity can also shorten the service life of this adhesive material.
The second prototype has a unique solution in its own way, namely, the seats are designed and installed by the manufacturer himself. This allows us to optimize the costs of its production as much as possible, as well as to take into account the exact weight of the seats in the aircraft when designing it. Another solution is a modular design: a one-piece composite load-bearing frame and a set of various nodes (an attachment pattern to the floor of the aircraft, or a seat upholstery attachment unit). Such a modular solution will meet the design requirements of a small and lightweight structure with a much smaller number of parts compared to conventional seat designs. In addition, the modular design of the seat simplifies the installation and disassembly operation in case of necessary maintenance of the aircraft floor. The entire frame of the chair is made of composite materials, which has a very large advantage in weight over "traditional" chairs. In addition, the modular design can be attached directly from the seat track (without the need to use fittings) to the floor of the aircraft, which further facilitates the installation.

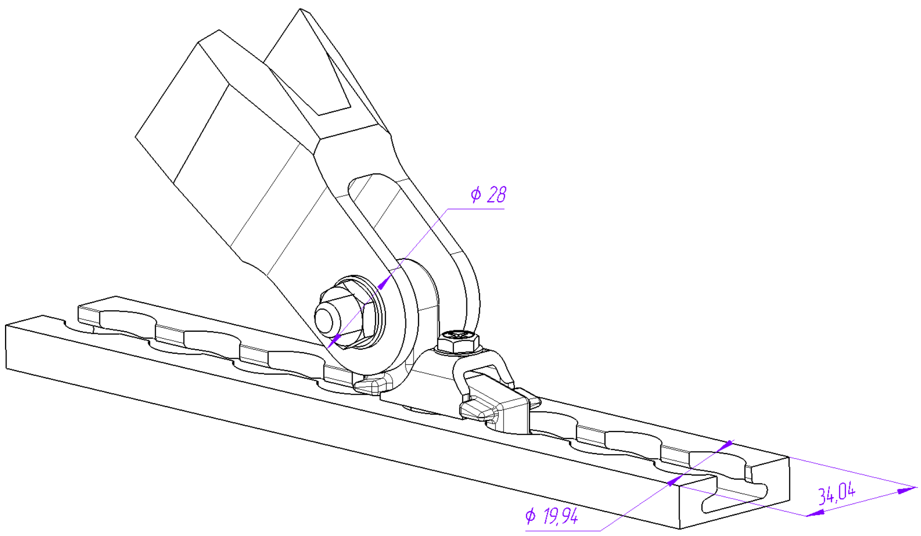
Seat track is installed on the floor of the aircraft allowing passenger seats to be attached to the seat track rather than directly to the floor. This allows for secure attachment of the seats, but with the option of moving or removing the seats quickly simply by removing them from the seat tracks as needed. Available common aircraft seat track and high strength alloy tracks. Also known as L-Track and cargo track. Seat tracks are Manufactured from high tensile aircraft 7075-T6511 Aluminum and optionally 6AL4V Titanium [45]

However, the composite, like other materials, is not without drawbacks. In particular, its main disadvantage is polymerization shrinkage, due to which the concentration of internal pressure changes, as well as the dimensions. It should be noted its toxicity to workers producing it. The fact is that during production, the composite is ready to emit vapors harmful to humans, as well as microscopic dust that can settle in human lungs and is not excreted. But the most important drawback is the price. This is explained by the fact that their production requires high-precision, and therefore expensive equipment, which certainly affects the price of the final product.

4.4. Strength calculation

We will calculate the tension part of the chair rack that it exerts on the fitting and seat track.





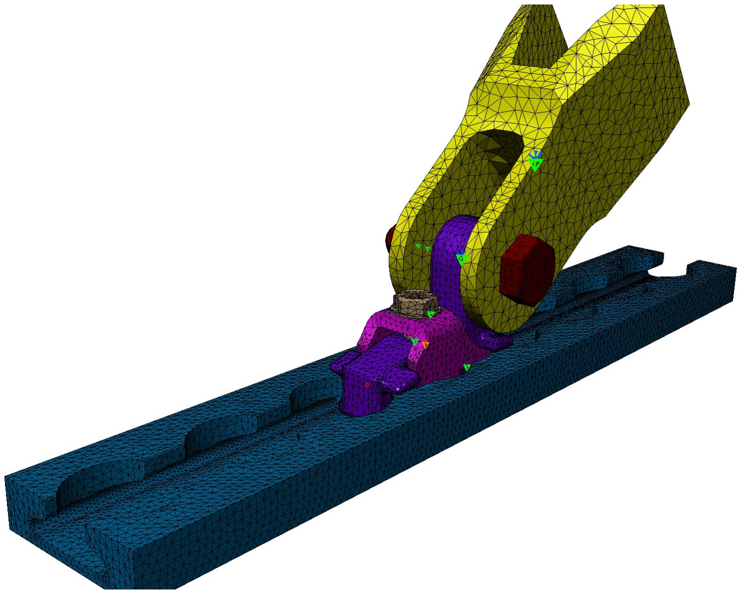
Isometric view

CATIA SYSTEM uses the finite element method, that is, the construction is considered as consisting of many parts. In this case, these are rectangles in an approximate number of 90,000 units. 4 different equations are made for each of them.

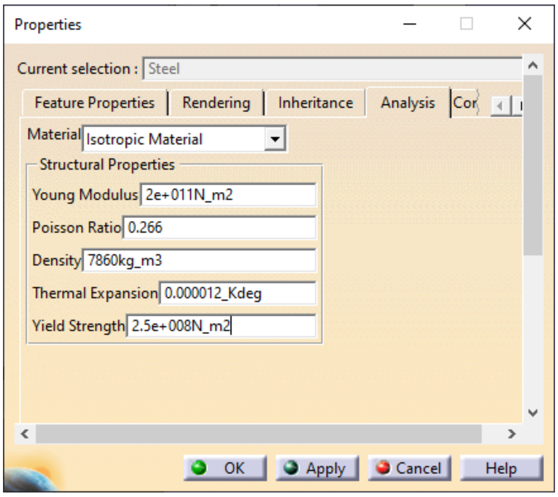
The sequence includes a calculation scheme, a generated grid and an explanation to the system of which parts are movable and which are fixed, where the force should be directed, and so on.

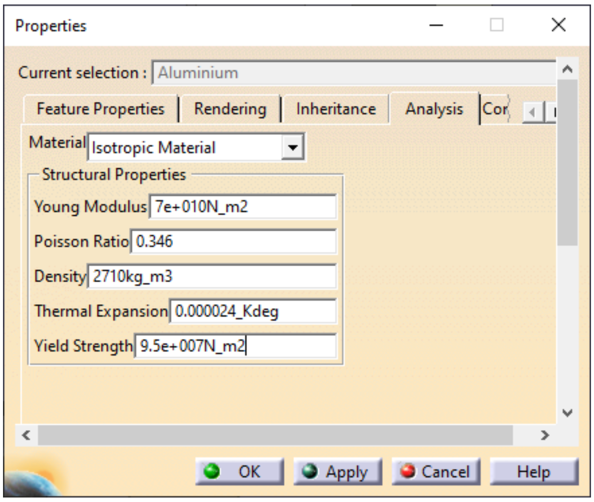
As a result, we will get this:

This unit consists of triangles, the rack and the sieve track are made of aluminum, the fitting is made of zinc-nickel alloy, and the bolt is made of steel.

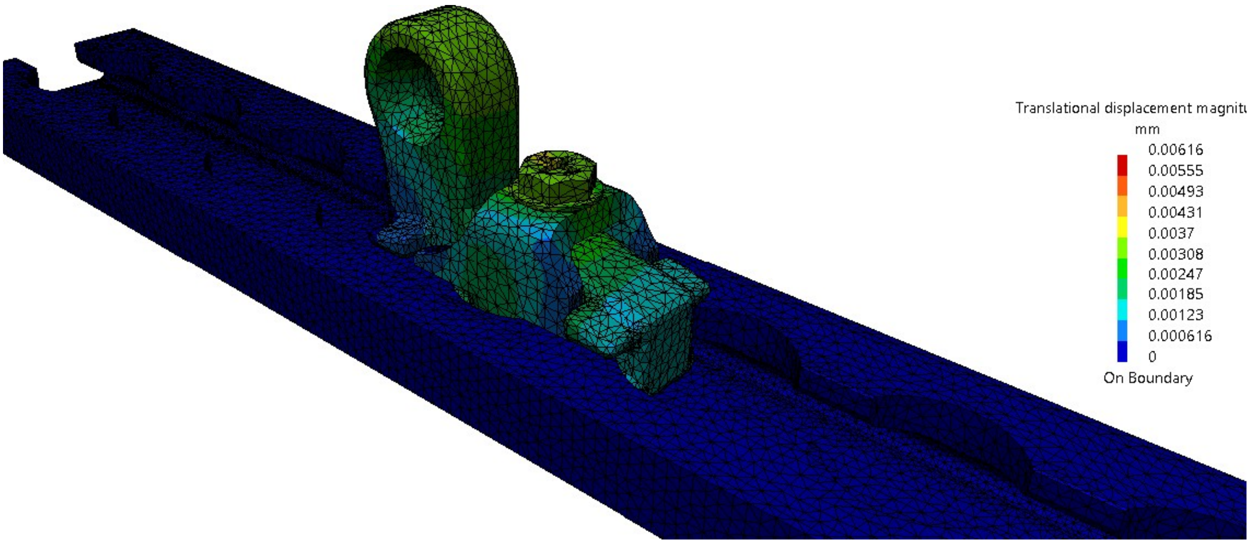


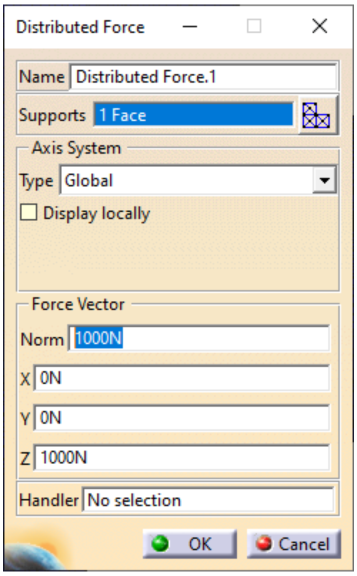
Properties of materials:

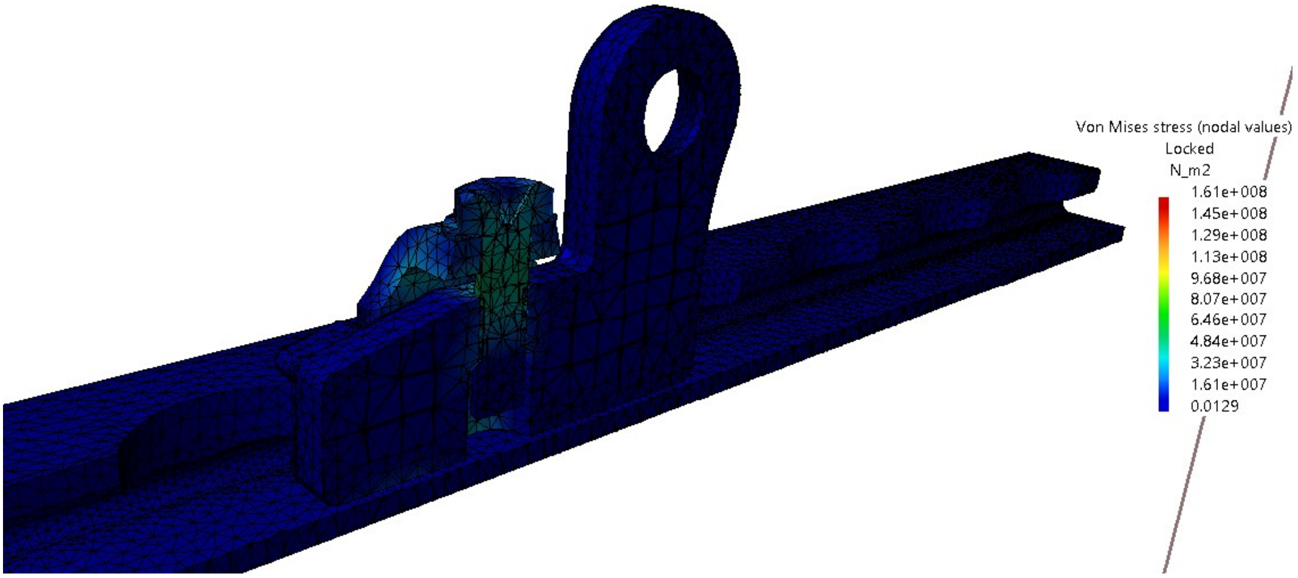




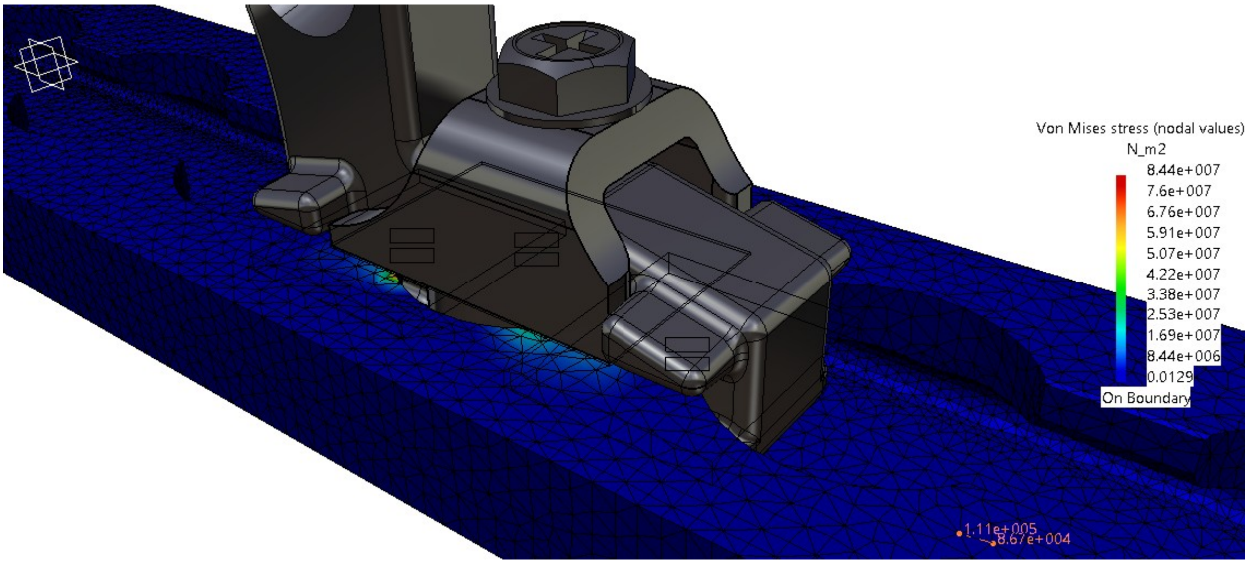
If we apply a force of 1000 Newtons to the fitting and the seat track, we get:


Translational displacement magnitu
mm
0.00616
0.00555
0.00493
0.00431
0.0037
0.00308
0.00247
0.00185
0.00123
0.000616
0
On Boundary

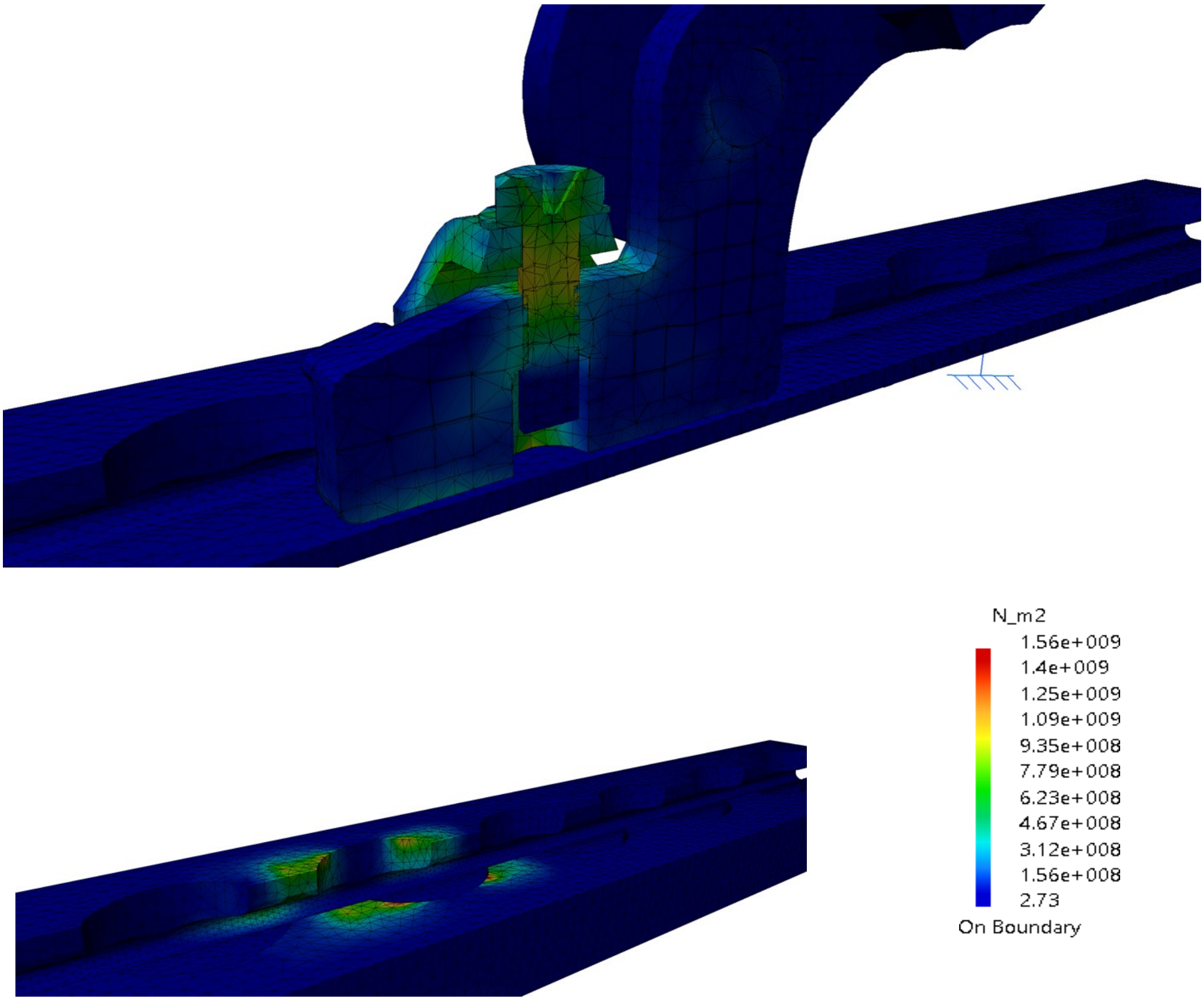

Distributed Force
Name Distributed Force.1
Supports 1 Face
Axis System
Type Global
Display locally
Force Vector
Norm 1000N
X 0N
Y 0N
Z 1000N
Handler No selection
OK
Cancel


Von Mises stress (nodal values)
Locked
N_m2
1.61e+008
1.45e+008
1.29e+008
1.13e+008
9.68e+007
8.07e+007
6.46e+007
4.84e+007
3.23e+007
1.61e+007
0.0129

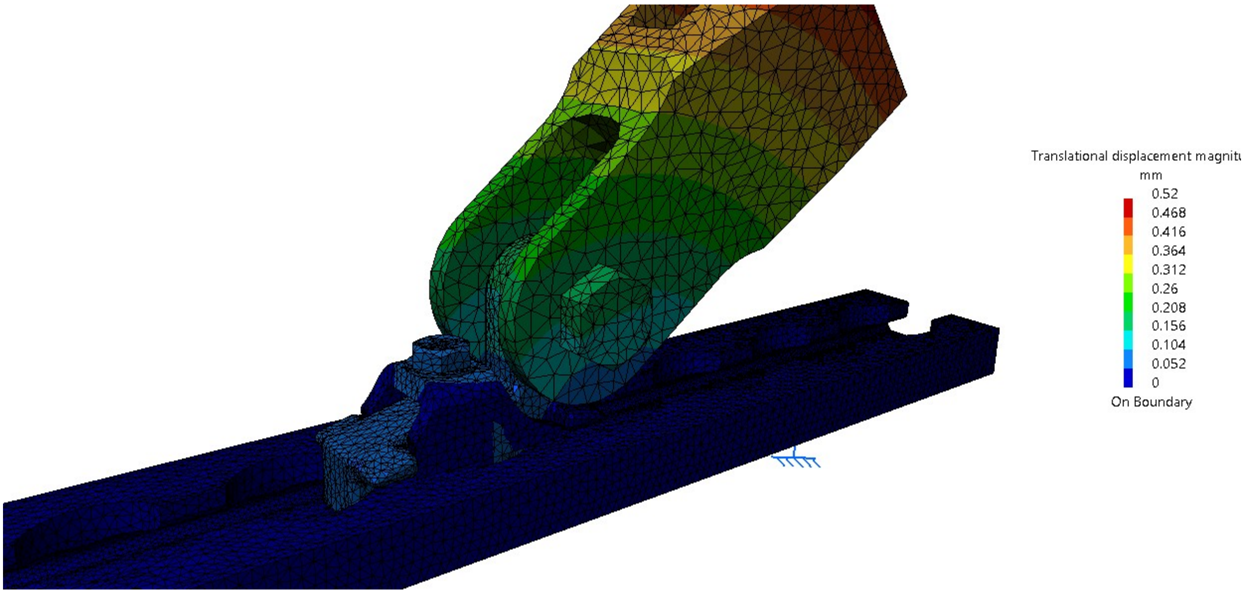
The result of the applied force on the seat track:



Tension from longitudinal load:

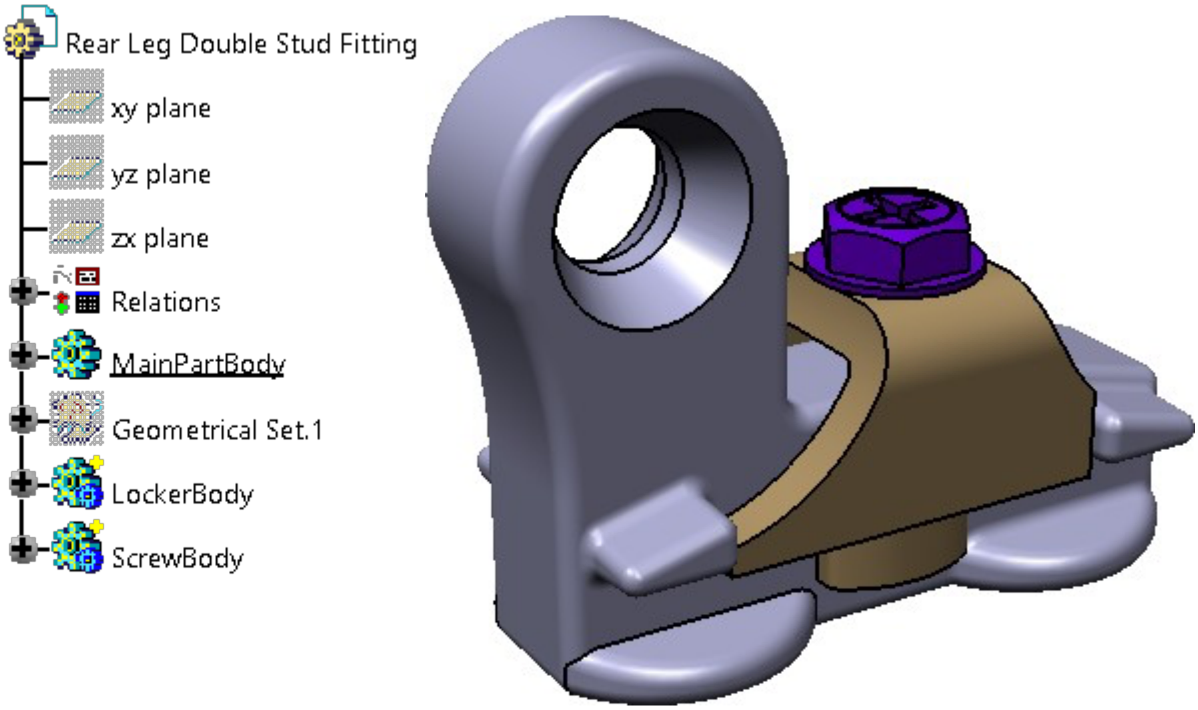


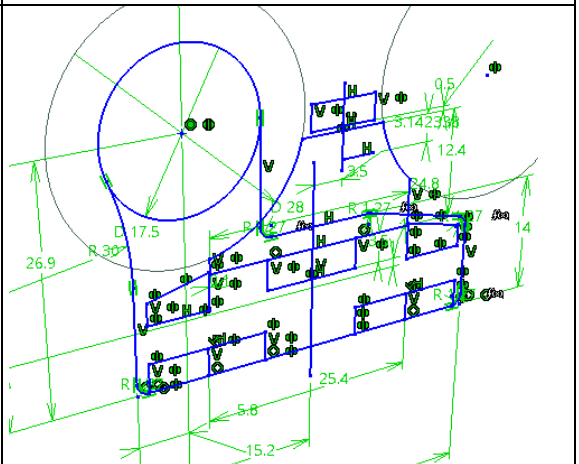
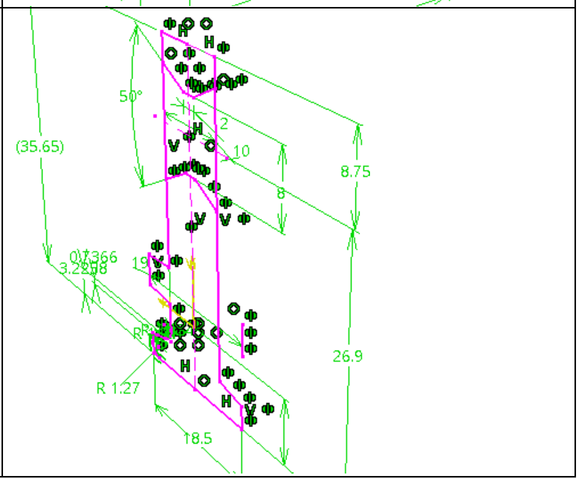
Thus, this node can withstand a load of 1000 newtons, the component is within its strength. No plasticity or deformation was detected.

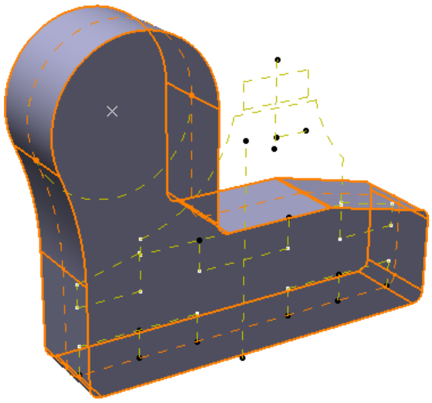
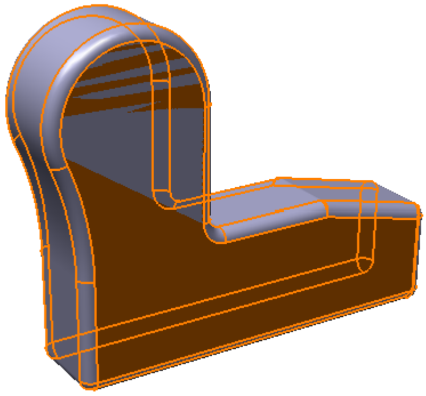
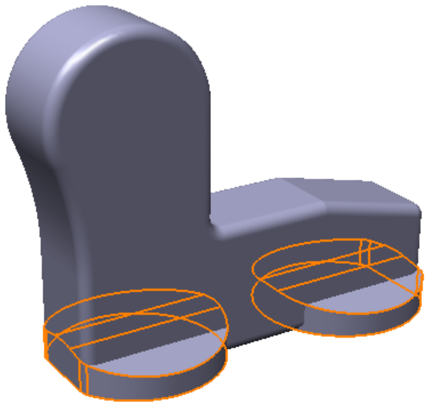
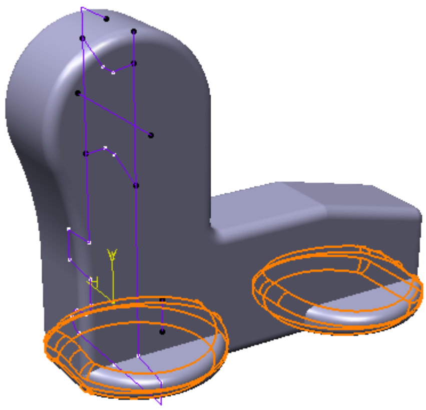


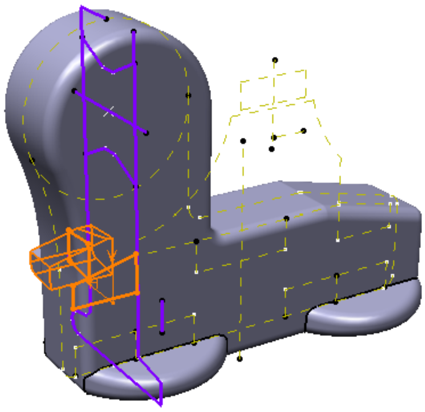
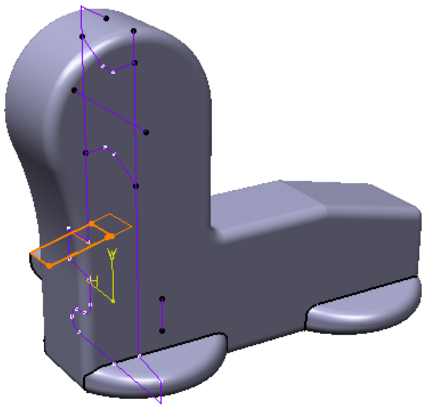
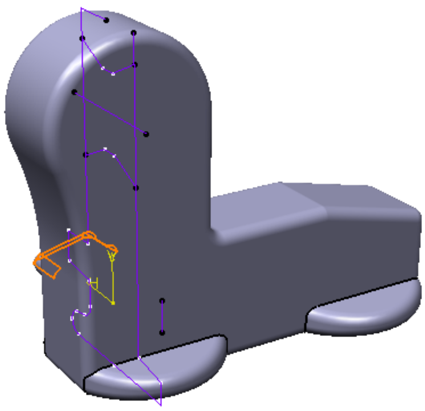
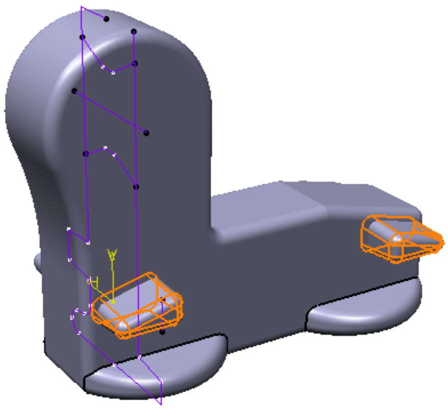

```
Von_Mises_stress_(nodal_values).1

  Display
    On deformed mesh
    On boundary
    Over all the model

  Value Type: Von Mises stress

  Extrema Values
    Min: 2.73317  N_m2
    Max: 1.55756e+009  N_m2
  Filters
    1D elements:
      Components: All
    3D elements:
      Components: All
```

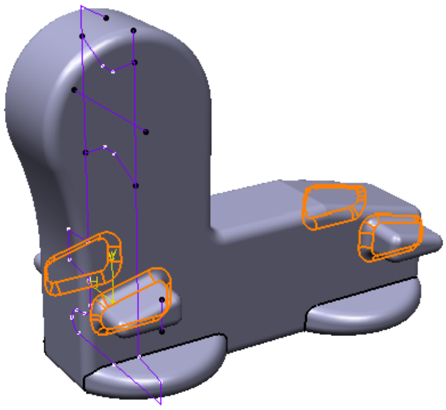
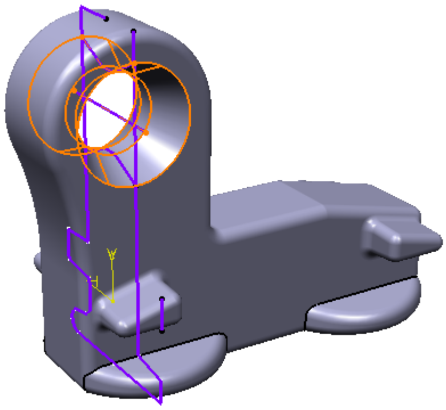
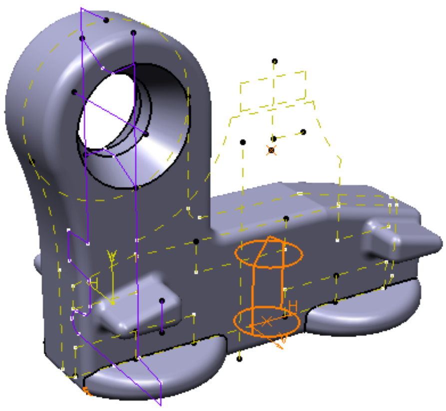
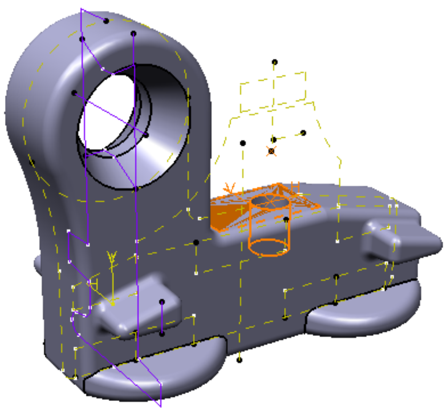
4.5 Step-by-step construction of the fitting

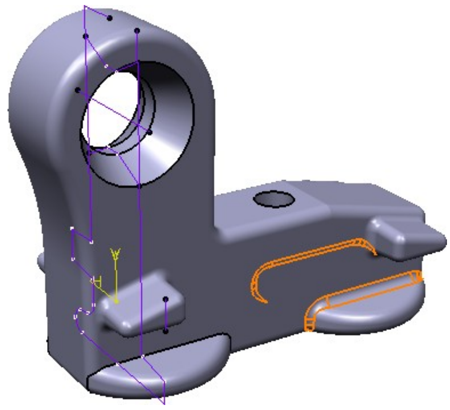


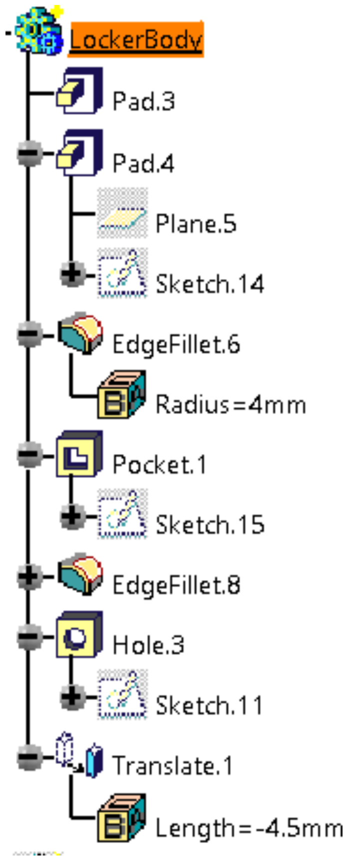
№	Description of the operation	Illustration
1.	We are building all the lines of the main view in Sketch.1 with dimensions. Sizes from the catalog [5]	
2.	We are building all the lines of the side view in the Sketch Sketch.2 with dimensions.	

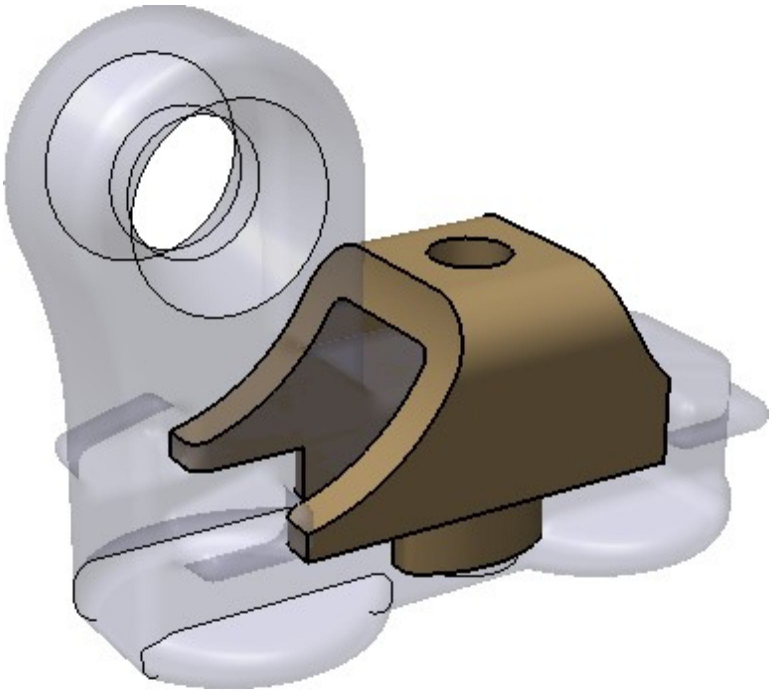
3.	We are building all the lines of the side view in the Sketch Sketch.2 with dimensions.	
4.	Building the EdgeFillet fillets.2	
5.	Perform the construction of fillets	
6.	Perform the construction of R1.27 fillets with the EdgeFillet.1 command	

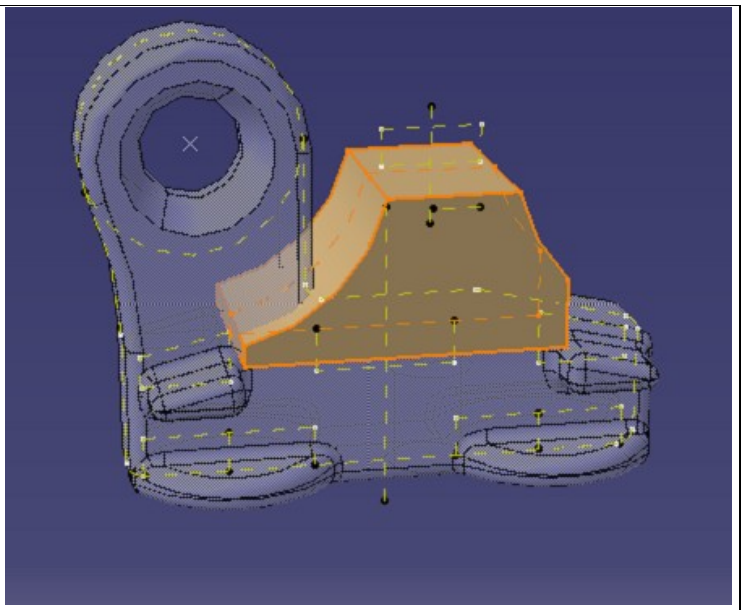
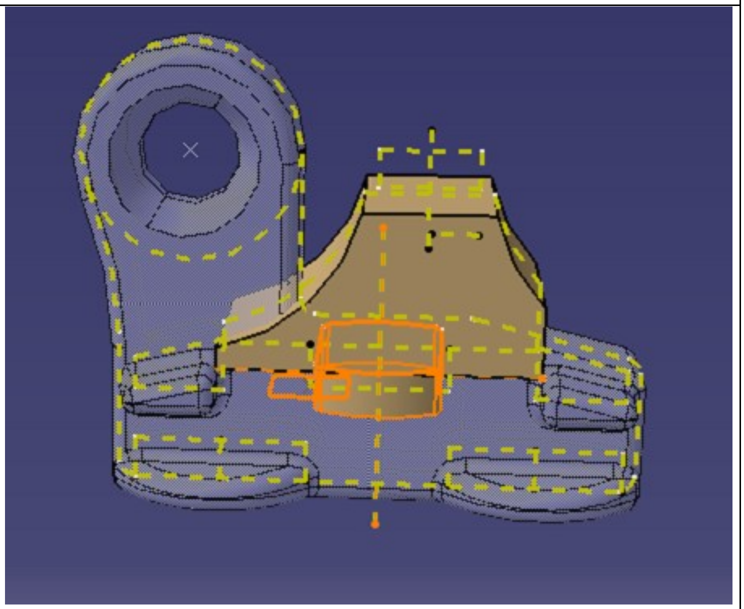
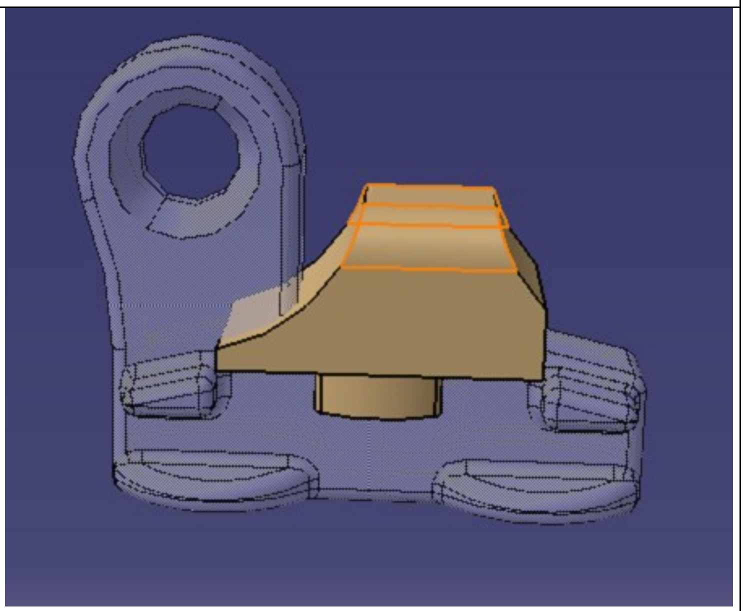
8.	Perform the construction of a protrusion on the surface of the part with the Combine command.1. We use two sketches.	
9.	Cut off the upper edge of the ledge.	
10.	Build external fillets	
11.	Build mirror reflections of the ledge.	

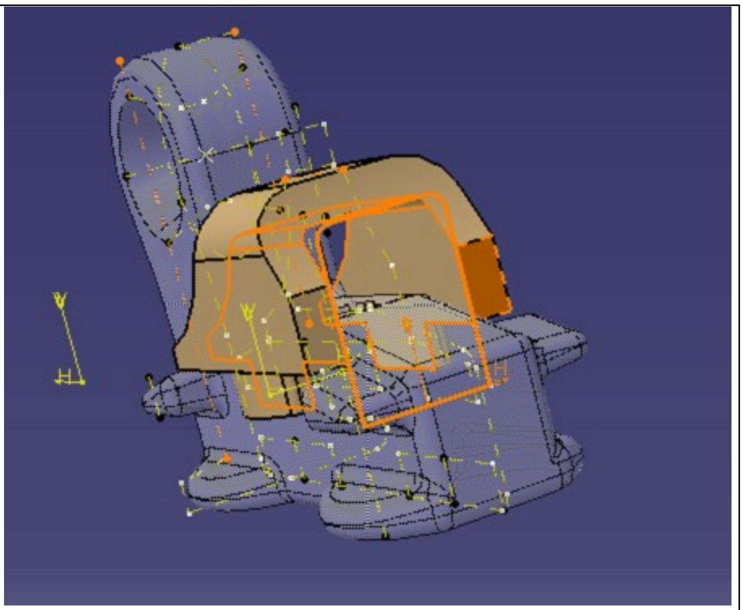
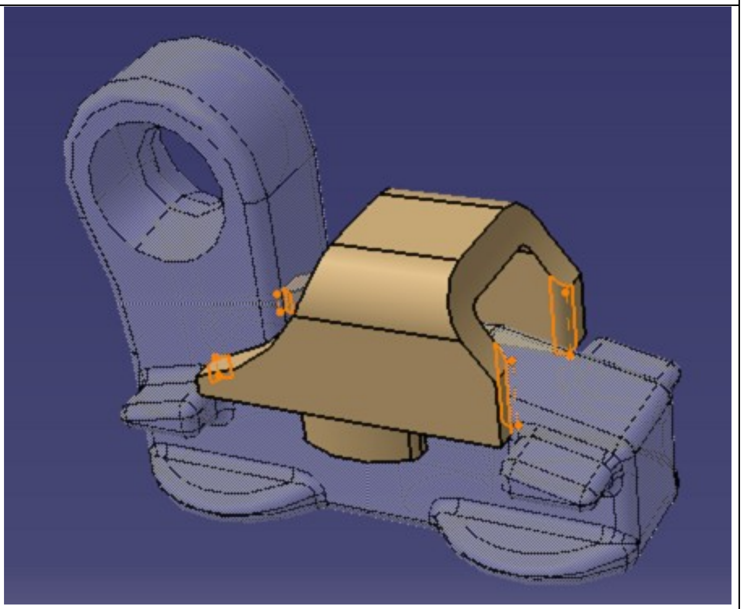
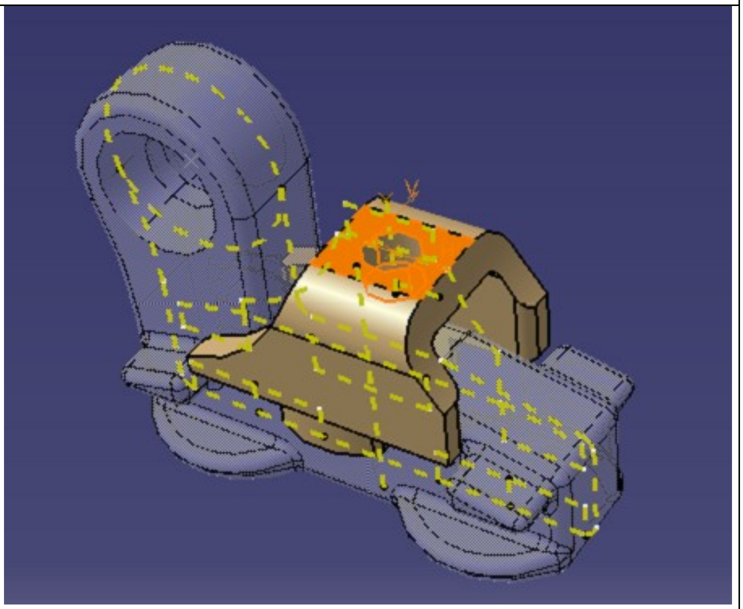
12.	Built the fillets	
13.	The hole is made by rotating the profile	
14.	Hole at the bottom for easier detailing	
15.	M5 thread hole	

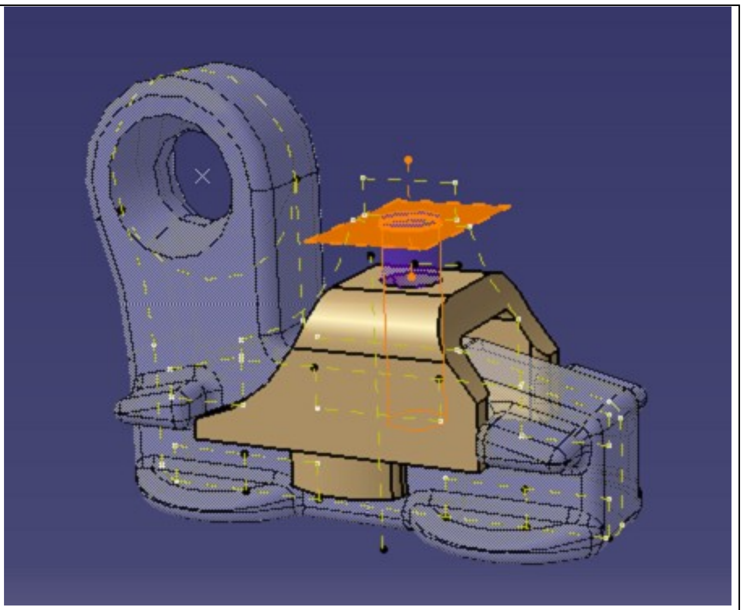
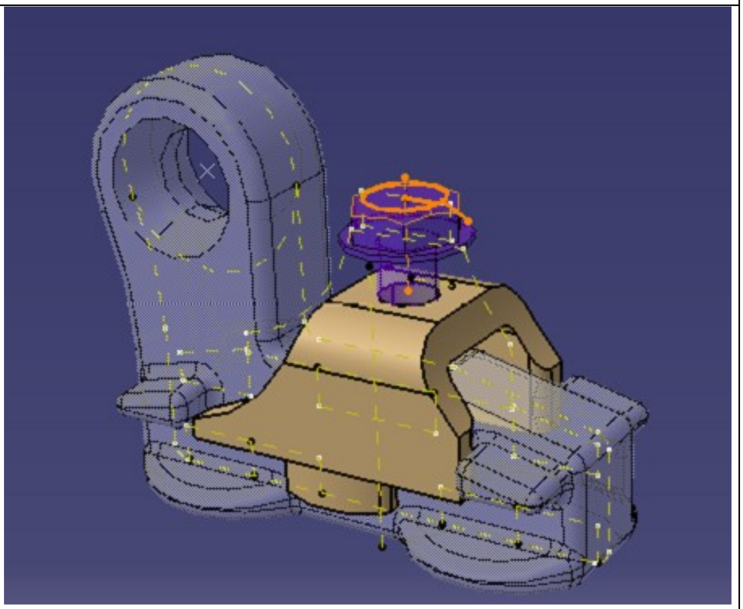
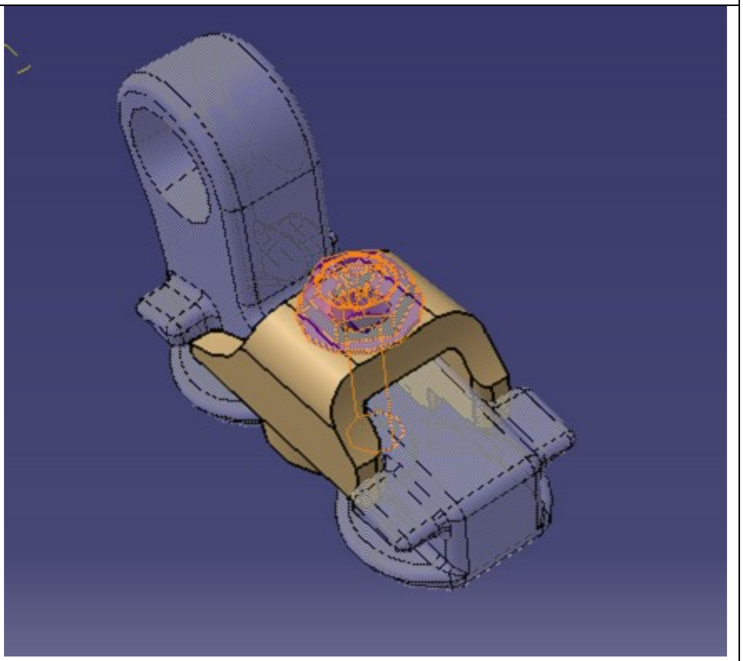
16.	Rounding of sharp edges with a radius of 1mm	





17	Create a polygon according to a given drawing, then use the Pad command.	
18.	We create an additional attachment to the seat track from the fitting side	
19.	Creating a rounding of the upper edge	

20.	We create a cutout of this part of the part with the command (Cavity), since it is removable.	
21.	Creating fillets of the selected parts of the part.	
22.	Building a threaded hole	

23.	Creating a bolt by creating a cylinder in the area of the threaded hole, the rectangle will serve as the future cap of the bolt.	
24.	We use the Pad function for the bolt.	
25.	We build a recess for servicing the bolt with a screwdriver.	

CONCLUSION

The purpose of my work was to calculate the aircraft according to the specified parameters of the wing, alignment, fuselage, center of mass, layout and many other aspects.

Also, my work included the selection of chair options that were ahead of traditional seats in their merits. They are lighter, made of composite materials. In total, two options were presented. According to one of them, a 3D model was created, a scheme for the phased construction of the selected seat node, as well as a calculation for various forces that act on it.

The appendix contains drawings, according to which some nodes were created in a special part of the course work, as well as their primary sources. Also in the application, images of drawings of the aircraft of the aircraft and the additional components attached to it are added.

I believe that such developments are a necessity, since each element in the aircraft must have characteristics that put it at an advantage over the aircraft of the previous generation. Aviation seats are no exception.

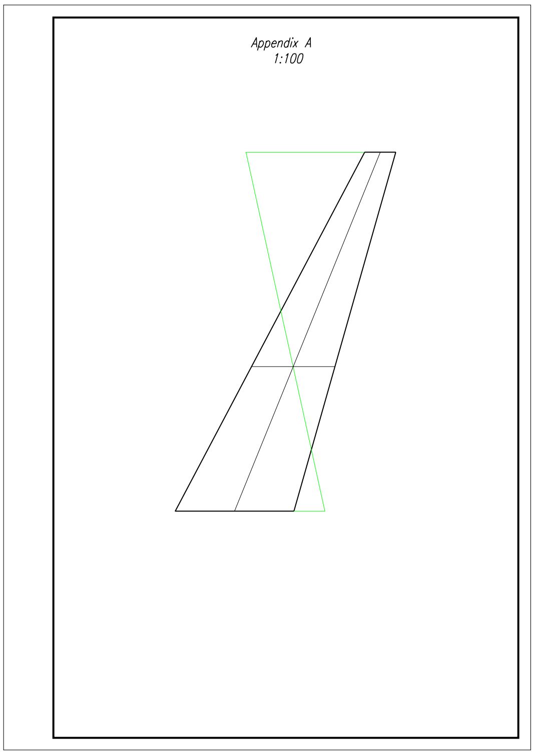
Literature:

1. Regulations on diploma theses (projects) of graduates of the National Aviation University: approved by the order of the rector from 03.11.2006, №178 / unit. - К.: Вид-во НАУ, 2011. - 72 с.
2. Documentation. Reports in the field of science and technology. Structure and rules of registration: DSTU 3008-95.– To replace GOST 7.32-91; [Effective 1996-01-01]. - Kyiv: State Standard of Ukraine, 1995. - 38 p.
3. Vanin VV Registration of design documentation: textbook. way. / VV Vanin, AV Bliok, GO Gnitskaya; Ministry of Education and Science of Ukraine. - 3rd ed.– K .: Karavela, 2004. - 160 p.
4. Isaenko VM Ecology and environmental protection. Diploma design: textbook. way. / VM Isaenko, VM Krivorotko, GM Franchuk. - К.: НАУ, 2005. - 192 с.
5. Chelyukanov IP Methodical instructions for course design for students majoring in 1303 "Technical operation of aircraft and engines" / [comp. : IP Chelyukanov, PF Maksyutinsky, VI Lukin, etc.]; KIIGA. - К.: КИИГА, 1989. - 44 с.
6. ESKD. General provisions: DSTU GOST 2.001: 2006. - In place of GOST 2.001-70; [Effective from 01.01.2007]. - К.: Gosstandart Ukrainy, 2007. - 16 с.
7.ESKD. General requirements for text documents: GOST 2.105-95. - Replaced GOST 2.105-79; GOST 2.906-71; [Introduced 1997.07.01]. - К.: Gosstandart Ukrainy, 1996. - 45 с.
8. ESKD. Text documents: GOST 2.106-96. - Replaced GOST 2.106-68, GOST 2.108-68; GOST 2.112-70; [Introduced 1998.29.05]. - К.: Gosstandart Ukrainy, 1998. - 58 с.
9. ESKD. Basic requirements for drawings: GOST 2.109-73. - Replaced GOST 2.107-68 in part chap. VIII; GOST 2.109-68 in part chap. VIII; GOST 5292-60 in part chap. VIII; [Introduced 01/07/1974]. - M.: Gosstandart Soyuz SSR, 1974. - 50 s.
10. ESKD. Normokontrol: GOST 2.111-68. [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSSR, 1971. - 12 s.
11. ESKD. Formats: GOST 2.301-68. - Replaced GOST 3450-60; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 4 s.
12. ESKD. Scales: GOST 2.302-68. - Replaced GOST 3451-59; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 3 s.
13. ESKD. Lines: GOST 2.303-68. - Replaced GOST 3459-59; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 8 s.
14. ESKD. Drawing fonts: GOST 2.304-81. - Replaced GOST 2.304-68; [Introduced 1982.01.01]. - M.: Gosstandart Soyuz SSR, 1982. - 30 s.
15. ESKD. Images - views, sections, sections: GOST 2.305-68. - Replaced GOST 2.317-69 in parts of the application; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 24 s.
16. ESKD. Designations of graphic materials, rules of their drawing on drawings: GOST 2.306-68. - Replaced GOST 3455-59; GOST 11633-65; [Introduced. 1971.01.01]. - M.: Gosstandart Soyuz SSR, 1971. - 9 s.

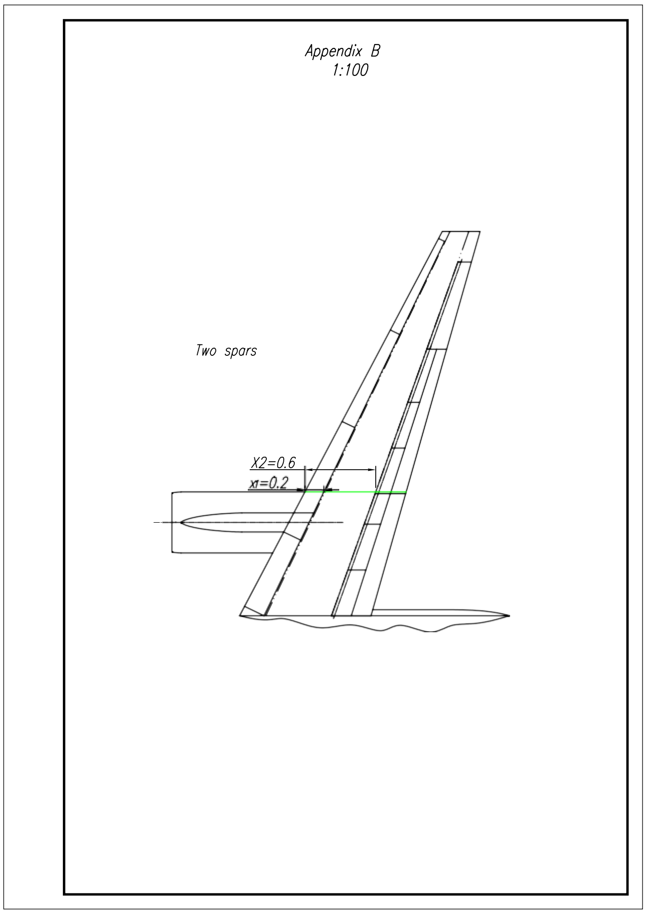
17.ESKD. Drawing of the sizes and maximum deviations: GOST 2.307-68. - Replaced GOST 3458-59; GOST 9171-59; GOST 5292-60 - in part chap. III; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 35 s.
18.ESKD. Designation of surface roughness: GOST 2.309-73. - Replaced GOST 2.309-68; [Introduced 1975.01.01]. - M.: Gosstandart Soyuz SSR, 1975. - 14 s.
19.ESKD. Drawing on drawings of designations of coverings, thermal and other types of processing: GOST 2.310-68. - Replaced GOST 2940-63 - c parts of paragraphs 15–17; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 8 s.
20.ESKD. Thread images: GOST 2.311-68. - Replaced GOST 3459-59; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR. - 7 p.
21.ESKD. Conventional images and designations of welded joints: GOST 2.312-72. - Replaced GOST 2.312-68; [Entered January 1, 1973]. - M.: Gosstandart Soyuz SSR, 1973. - 16 s.
22.ESKD. Simplified and conditional images of fasteners: GOST 2.315-68. - Replaced GOST 3465-52; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 16 s.
23.ESKD. Rules of drawing on drawings of inscriptions, technical requirements and tables: GOST 2.316-68. - Replaced GOST 5292-60 - in part chap. VI and annexes; GOST 3453-59 - in part chap. VI; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 16 s.
24.ESKD. Rules of execution of drawings of springs: GOST 2.401-68. - Replaced GOST 3461-59; GOST 4444-60; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 29 s.
25.ESKD. Rules of execution of gear (slotted) connections: GOST 2.409-74. - Replaced GOST 2.409-68; [Introduced 1975.01.01]. - M.: Gosstandart Soyuz SSR, 1975. - 5 s.
26.ESKD. Simplified images of rolling bearings on assembly drawings: GOST 2.420-69; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 11 s.
27.ESKD. Schemes. Types and types. General requirements for implementation: GOST 2.701-84. - Replaced GOST 2.701-76; [Introduced 01/05/1985]. - M.: Gosstandart Soyuz SSR, 1985. - 17 s.
28.ESKD. Rules of execution of kinematic schemes: GOST 2.703-68; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSSR, 1971. - 7 s.
29.ESKD. Rules of execution of hydraulic and pneumatic schemes: GOST 2.704-76. - Replaced GOST 2.704-68; [Entered January 1, 1978]. - M.: Gosstandart Soyuz SSR, 1978. - 17 s.
30.ESKD. Symbols are graphic in schemes. Elements of cinemaattics: GOST 2.770-68. - Replaced GOST 3462-61; [Introduced January 1, 1971]. - M.: Gosstandart Soyuz SSR, 1971. - 27 s.
31. Metrology. Units of physical quantities. Physical steels and characteristic numbers. Main provisions, designations, names and meanings: DSTU 3651.2-97.– To replace GOST 8.417-81; [Effective January 1, 1999]. - Kyiv: State Standard of Ukraine, 1998. - 35 p.

32. Electrical engineering. Letter designations of basic values: GOST 1494-77 .; [Entered January 1, 1978]. - M.: Gosstandart Soyuz SSR, 1979. - 39 s.
33. ESCD. Main inscriptions: DSTU GOST 2.104: 2006. - To replace GOST 2.104-68; [Effective from 2007.01.07]. - К.: Derzhspozhyvstandart Uktainy, 2008. - 25 с.
34. System of standards for information, library and publishing. Bibliographic record. Bibliographic description. General requirements and rules of compilation: DSTU GOST 7.1: 2006. - In place of GOST 7.1-84; GOST 7.16-79; GOST 7.18-79; GOST 7.34-81; GOST 7.40-82; [Effective from 2008.01.04]. - К. Derzhspozhyvstandart Uktainy: 2008. - 57 с.
35. System of design documentation. Terms and definitions of basic concepts: DSTU 3321: 2003; [Effective from 01.01.2004]. - К.: Derzhspozhyvstandart Uktainy, 2004. - 55 с.
36. https://www.aviaport.ru/photos/121/
37.https://ru.wikipedia.org/wiki/Ан-158
38.https://patentimages.storage.googleapis.com/2c/e6/a4/799f5b8e23722b/RU2565433C1.pdf
39.https://patents.google.com/patent/JP5296779B2/en?q=aviation+passenger+seat&oq=aviation+passenger+seat&page=1
40.https://www.aeroexpo.online/prod/ancra-international/product-171598-59365.html
41.https://futuremetals.com/wp-content/uploads/2015/12/Future%20Metals%20-%20MRO%20Brochure.pdf
42.https://www.attax.com/wp-content/uploads/2020/01/ATTAX_Track_Fittings.pdf
43. https://www.aeroexpo.online/cat/interior-equipment/cargo-tracks-restraint-fittings-J-658.html
44. https://www.allsafe-group.com/aerospace/seat-track-fittings/information-panel-and-stanchion-fittings/
45. Aerospace Seat Track [Electronic resource] // Aircraft Extrusion. – Access mode: URL: https://aircraftextrusion.com/aircraft_extrusion/seat-track/ (viewed on May 10, 2022)

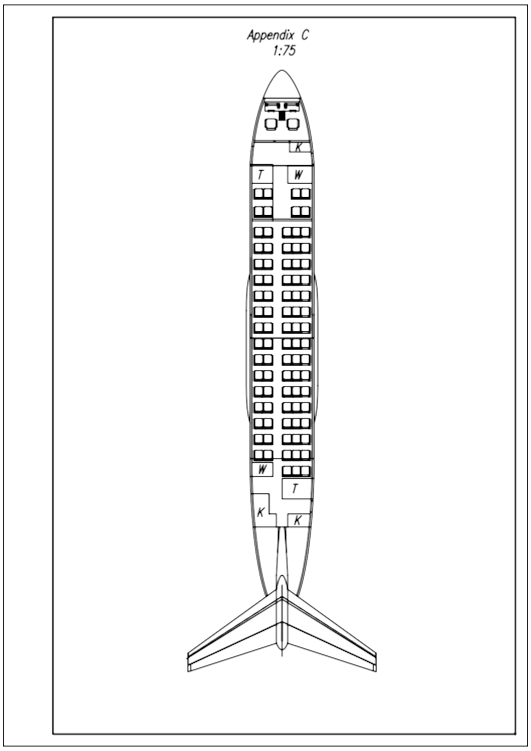
APPENDIX A



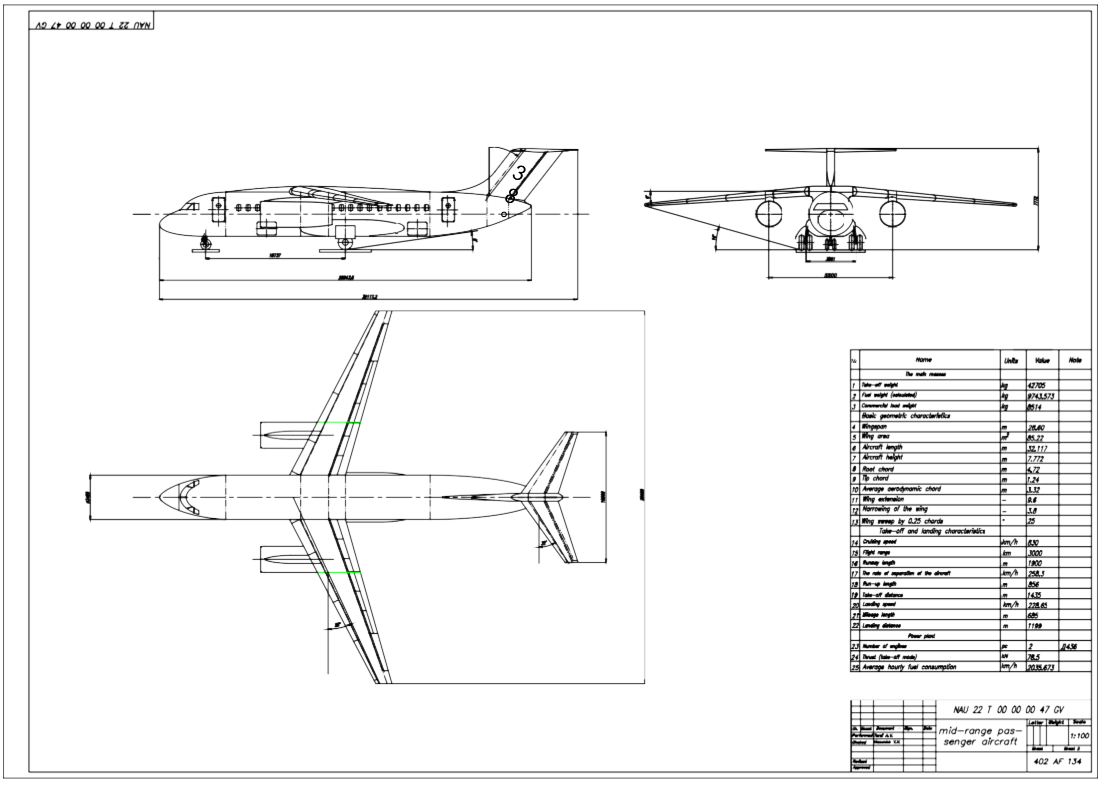
APPENDIX B



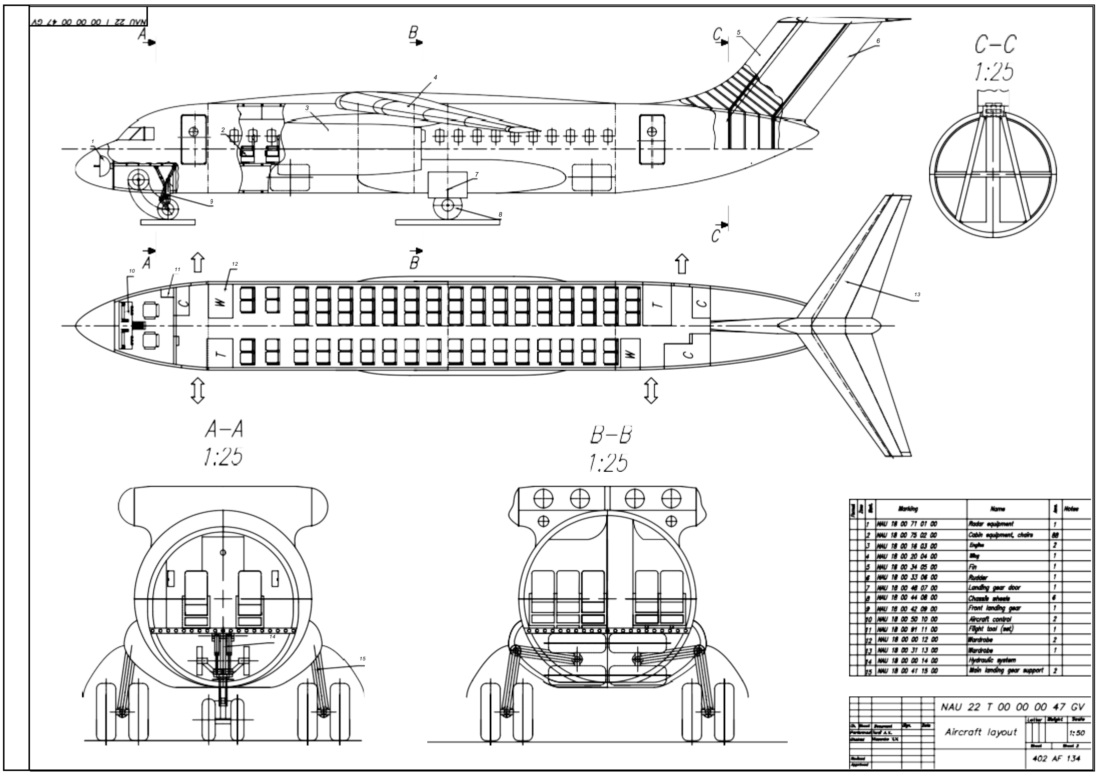
APPENDIX C



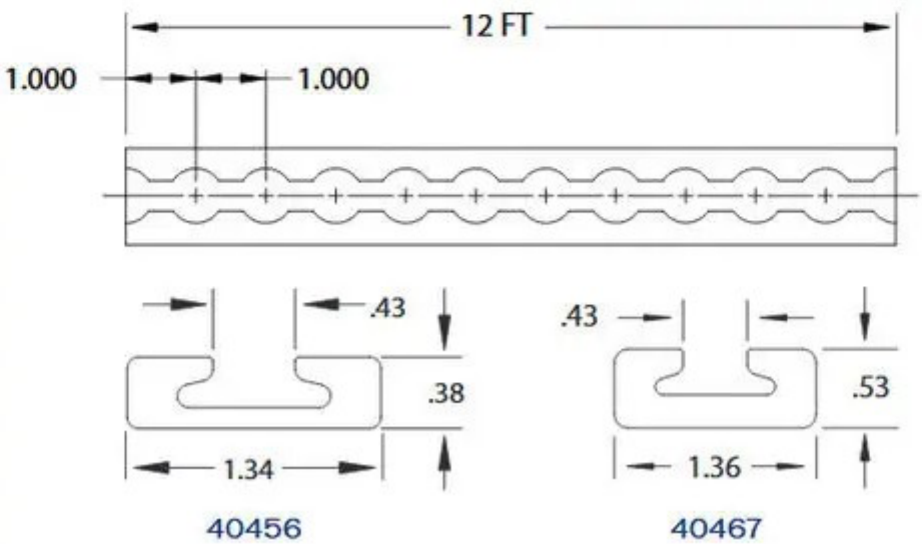
APPENDIX D



APPENDIX E



APPENDIX F

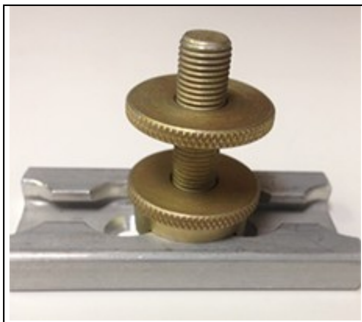


CHARACTERISTICS
Application: for air cargo
Installation: surface mounted
Other characteristics: aluminum
DESCRIPTION

Aircraft Seat Track — Standard aircraft track is used in the securement of cargo and interior assemblies. Made from 7075-T6 aluminum alloy extrusion to meet specification MS 33601 and ISO 7166. Available in heavy and medium duty

40456-11-144 Medium Duty Aircraft Track
Finish: -10 Clear anodized per MIL-A-8625, Type II, Class 1
-11 Unanodized
Standard Length: 12'
Load Capacity: 4,500 lbs. vertical
Weight: .40 lb/ft.
40467-10-144 Heavy Duty Aircraft Track
40467-11-144 Heavy Duty Aircraft Track,
Finish: -10 Clear anodized per MIL-A-8625, Type II, Class 1
-11 Unanodized
Standard Length: 12'
Load Capacity: 6,000 lbs. vertical
Weight: .60 lbs/ft. [42]

APPENDIX G



40073-13Single Stud Fitting

$91.15 [

Panel/Stanchion Single Stud fitting, used with Standard 'brownline style' seat track or anchor plates. Break Strength rating of 4,000 lbs.

To use your own Freight Account, enter coupon code **customeraccount** on checkout. Please include FedEx or UPS account number in customer notes on checkout.

SKU: 00118

Category: Panel Stanchion Seat Fittings

Description

Single Stud Track Fitting

Panel/Stanchion Single Stud fitting, used with Standard 'brownline style' seat track.

The fitting is 1.25″ high, and has a 3/8″ Threaded stud

Comes with two round nuts for tightening

Break Strength Rating (lbs) of 4,000 Vertically and Horizontally

(Pictured in a piece of standard seat track. The track is not included)

IMPORTANT: If this part is intended for use on an aircraft, it is the responsibility of the owner or operator of the aricraft to ensure that a basis for FAA approval is obtained prior to installation.

All load ratings, breaking strengths and working load capacities are based on the manufacturer's published data. Cargo Systems, Inc. assumes no liability for misstated load values based on the manufacturer's published data.

It is important that all parts are used in the manner in which they are specified. Parts should be inspected prior to each use. It is important to determine if any possible damage or deterioration has occurred. Such damage or deterioration may include, but is not limited to, rust, broken springs, damaged 'gates' or keepers' on snap hooks, or cracking of the metal. If such discrepancies are determined, these items should be removed from service immediately.

eight	.2 lbs

	imensions × 3 × 3 in https://www.cargosystems.com/product/40073-13/#

APPENDIX G

	**40191-11Double Stud Fitting** $86.00 **Panel/Stanchion Double Stud fitting, used with Standard 'brownline style' seat track.Break Strength Rating (lbs) of 6,500 tension and shear** To use your own Freight Account, enter coupon code **customeraccount** on checkout. Please include FedEx or UPS account number in customer notes on checkout. SKU: **00117** **Category:** **Panel Stanchion Seat Fittings**
	Description **Double Stud Track Fitting** Panel/Stanchion Double Stud fitting, used with Standard 'brownline style' seat track. The fitting is 1.97″ high, and has a 3/8″ Threaded stud Break Strength Rating (lbs) of 6,500 tension and shear (this part does not come with nuts) **eight** .2 lbs **imensions** × 3 × 3 in

APPENDIX H

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                        П Р О Е К Т
                    С А М О Л Е Т А   С   Т В Д
                   НАУ,    кафедра  К Л А
 ПРОЕКТ    Дипломный          Расчет выполнен    22.09.2021
 Исполнитель Терзи Артем      Руководитель

        ИСХОДНЫЕ ДАННЫЕ И ВЫБРАННЫЕ ПАРАМЕТРЫ
Количество пассажиров                                      0.
Количество членов экипажа                                  2.
Количество бортпроводников или сопровождающих              2.
Масса снаряжения и служебного груза                     1208.53 кг.
Масса коммерческой нагрузки                            40000.00 кг.

Крейсерская скорость полета                              750. км/ч
Число "М" полета при крейсерской скорости                  0.6748
Расчетная высота начала реализации полетов с крейсерской
экономической скоростью                                    8.000 км
Дальность полета с максимальной коммерческой нагрузкой  2000. км.
Длина летной полосы аэродрома базирования                  1.90 км.

Количество двигателей                                      4.
Оценка по статистике энерговооруженности в квт/кг          0.3000
Степень повышения давления                                25.00
Относительная масса топлива по статистике                  0.3000

Удлинение крыла                                            9.50
Сужение крыла                                              3.00
Средняя относительная толщина крыла                        0.125
Стреловидность крыла по 0.25 хорд                       13.0  град.
Степень механизированности крыла                           1.050
Относительная площадь прикорневых наплывов                 0.000
Профиль крыла - Лапминизированный скоростной
Шайбы УИТКОМБА - установлены
Спойлеры - установлены

Диаметр фюзеляжа                                           5.60 м.
Удлинение фюзеляжа                                         7.27
Стреловидность горизонтального оперения                  20.0 град.
Стреловидность вертикального оперения                   30.0  град.


                 Р Е З У Л Ь Т А Т Ы   Р А С Ч Е Т А
                 К М У Г А,     КАФЕДРА   "К И П Л А"
 Значение  оптимального  коэффициента  под'емной силы в расчетной точке
 крейсерского режима полета      Су        0.43810

 Значение коэффициента           Сх.инд.   0.00943

     ОПРЕДЕЛЕНИЕ КОЭФФИЦИЕНТА  Dм = Мкрит - Мкрейс

 Число Маха крейсерское                Мкрейс  0.67479
 Число Маха волнового кризиса          Мкрит   0.70652
 Вычисленное значение                  Dm      0.03173

   Значения удельных нагрузок на крыло в кПА(по полной площади):
             при взлете                           5.438
             в середине крейсерского участка      4.994
             в начале крейсерского участка        5.298
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APPENDIX H

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  Значение коэффициента сопротивления фюзеляжа и гондол      0.01408
  Значение коэфф. профиль. сопротивления крыла и оперения    0.00944
  Значение коэффициента сопротивления самолета:
           в начале крейсерского режима                    0.03539
           в середине крейсерского режима                  0.03482
  Среднее значение Су при условном полете по потолкам      0.43810
  Среднее крейсерское качество самолета                   12.58295
Значение коэффициента Су.пос.                                   1.891
Значение коэффициента ( при скорости сваливания ) Су.пос.макс.  2.836
Значение коэффициента ( при скорости сваливания ) Су.взл.макс.  2.339
Значение коэффициента  Су.отр.                                  1.684
Энерговооруженность в начале крейсерского режима                0.191
Стартовая  энерговооруженн. по условиям крейс. режима No.кр.    0.306
Стартовая энерговоруж. по условиям безопасного взлета No.взл.   0.208
Расчетная энерговоруженность самолета   No   0.312
Отношение   Dn = No.кр / No.взл        Dn   1.468


        УДЕЛЬНЫЕ РАСХОДЫ ТОПЛИВА ( в кг/кВт*ч ):
  взлетный                                               0.2442
  крейсерский (характеристика двигателя)                 0.2105
  средний крейсерский при заданной дальности полета      0.2122


       ОТНОСИТЕЛЬНЫЕ МАССЫ ТОПЛИВА:
            аэронавигационный запас         0.04362
            расходуемая масса топлива       0.13349

                    ЗНАЧЕНИЯ ОТНОСИТЕЛЬНЫХ МАСС:
            крыла                         0.09891
            горизонтального оперения      0.01136
            вертикального оперения        0.01310
            шасси                         0.03947
            силовой установки             0.19972
            фюзеляжа                      0.09938
            оборудования и управления     0.10765
            дополнительного оснащения     0.00122
            служебной нагрузки            0.00739
            топлива при  Lрасч.           0.17711
            коммерческой нагрузки         0.24470

         Взлетная масса самолета "М.о" =  163466. кГ.
    Потребная взлетная мощность двигателя    12737.8 kВт

Относительная масса высотного оборудования и
противообледенительной системы самолета                      0.0122
Относительная масса пассажирского оборудования
(или оборудования кабин грузового самолета)                  0.0002
Относительная масса декоративной обшивки и ТЗИ               0.0051
Относительная масса бытового (или грузового) оборудования    0.0320
Относительная масса управления                               0.0041
Относительная масса гидросистем                              0.0121
Относительная масса электрооборудования                      0.0252
Относительная масса локационного оборудования                0.0033
Относительная масса навигационного оборудования              0.0049
Относительная масса радиосвязного оборудования               0.0024
Относительная масса приборного оборудования                  0.0057
Относительная масса топливной системы (входит в массу "СУ")  0.0053
    Дополнительное оснащение:
Относительная масса контейнерного оборудования               0.0000
Относительная масса нетипичного оборудования                 0.0012
[встроенные системы диагностики и контроля параметров,
  дополнительное оснащение салонов и пр.]
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APPENDIX H

ХАРАКТЕРИСТИКИ ВЗЛЕТНОЙ ДИСТАНЦИИ

Скорость отрыва самолета	256.84 км/ч
Ускорение при разбеге	4.09 м/с*с
Длина разбега самолета	621. м.
Дистанция набора безопасной высоты	472. м.
Взлетная дистанция	1093. м.

ХАРАКТЕРИСТИКИ ВЗЛЕТНОЙ ДИСТАНЦИИ
ПРОДОЛЖЕННОГО ВЗЛЕТА

Скорость принятия решения	231.16 км/ч
Среднее ускорение при продолженном взлете на мокрой ВПП	2.21 м/с*с
Длина разбега при продолженном взлете на мокрой ВПП	722.59 м.
Взлетная дистанция продолженного взлета	1194.84 м.
Потребная длина летной полосы по условиям прерванного взлета	1229.36 м.

ХАРАКТЕРИСТИКИ ПОСАДОЧНОЙ ДИСТАНЦИИ

Максимальная посадочная масса самолета	145953. кг.
Время снижения с высоты эшелона до высоты полета по кругу	15.3 мин.
Дистанция снижения	31.83 км.
Скорость захода на посадку	248.04 км/ч.
Средняя вертикальная скорость снижения	2.00 м/с
Дистанция воздушного участка	527. м.
Посадочная скорость	232.74 км/ч.
Длина пробега	646. м.
Посадочная дистанция	1173. м.
Потребная длина летной полосы (ВПП + КПБ) для основного аэродрома	1959. м.
Потребная длина летной полосы для запасного аэродрома	1666. м.

ПОКАЗАТЕЛИ ЭФФЕКТИВНОСТИ САМОЛЕТА

Отношение массы снаряженного самолета к массе коммерческой нагрузки	2.3579
Масса пустого снаряженного с-та приход. на 1 пассажира	0.00 кг/пас.
Относительная производительность по полной нагрузке	316.36 км/ч
Производительность с-та при макс. коммерч. нагрузке	26966.3 т*км/ч
Средний часовой расход топлива	7355.516 кг/ч
Средний километровый расход топлива	10.91 кг/км
Средний расход топлива на тоннокилометр	272.767 г/(т*км)
Средний расход топлива на пассажирокилометр	0.0000 г/(пас.*км)
Ориентировочная оценка приведен. затрат на тоннокилометр	0.5110 $/(т*км)