

1. Executive Summary

The EU-funded ESTOLAS (Extremely Short Take Off and Landing on Any Surface) project aimed to create an aircraft combining the best features of an airship, a plane, a helicopter and a hovercraft. The ESTOLAS hybrid aircraft would be able to carry much heavier payloads than a helicopter and to use much smaller airports and runways than a conventional plane, or even to land and take off from water.

ESTOLAS team examined the potential of four different sizes of hybrid aircraft – small, medium, heavy and super-heavy. The smaller models could be used to replace helicopters, providing a longer range and a greater payload capacity than a helicopter provides. The larger use, or even using open areas of land or water closer to the places of origin or ESTOLAS models could be able to transport cargos using smaller airports than conventional planes can destination.

The project main scientific work packages included: Computer simulation, calculation, and formulation of the ESTOLAS characteristics, Estimation and choice of optimal Engine Concept for the hybrid aircraft, Development and testing of a physical and radio-controlled models of the ESTOLAS aircraft.

During the project implementation main parameters and characteristics of the ESTOLAS prototype were defined. Possible operating restrictions for small, medium and large ESTOLAS concepts were formulated, operating characteristics were calculated for each prototype - the approximate flying range, payload capacity, time of flight. On the basic parameters ESTOLAS prototypes do not exceed the corresponding take-off weight of classical prototypes of aircraft and helicopter, other than providing partial off-airfield operation.

Proposed propulsion system structure on board of ESTOLAS opens new strategy for flight control during at flight, which enables the VTOL-operations for the flight vehicles with high payload. In the frame of performed investigations an optimal architecture for electric ESTOLAS was proposed.

The aerodynamic experiments on the ESTOLAS hybrid aircraft provided an opportunity to adequately evaluate the given design. Additional lift force created by the central propeller was calculated and taken into consideration while processing the aerodynamic data in the process of calculating the take-off and landing performance of ESTOLAS hybrid aircraft.

All ESTOLAS prototypes elaboration resulted in ambiguous advantages over traditional hovercraft as helicopters or convertiplane except short take-off and landing distance and all-surface operations. Principles of ESTOLAS aircraft design, construction, operation philosophy, performance need further research as a new concept.

The key technological approaches for further research of ESTOLAS aircraft concept are:

- blended-Wing-Body configuration offering large internal volume and providing about half its maximum lift requirements at all phases of flight;
- helium gas-based buoyancy lift providing a about half of its maximum lift requirements at all phases of flight;
- novel hybrid electric power generation system: solar panel on upper fuselage and wing surfaces, advanced fuel cells and high-efficiency gas-turbine electric power generator;
- Rotatable electrically powered propulsion modules for cruise, vertical take-off and landing, and for manoeuvring close to ground during cargo loading/unloading operations;
- Slide-folding wings for operations within the urban environment or confined spaces.

2. Project context and main objectives

The concept of the project was to develop and validate the conceptual design for a hybrid aircraft – an air vehicle that combines the best qualities of an airship, a plane, a helicopter and a hovercraft. Such a hybrid aircraft constitutes a completely novel type of an aircraft with an extremely short take-off and landing on any surface (ESTOLAS). ESTOLAS aircraft concept has got the following major advantages compared to the existing air vehicles:

(A1) Extremely short take-off and landing roll (0 – 170 m) with a possibility of vertical take-off and landing (VTOL);

(A2) Take-off and landing from any natural terrestrial surface: runway, field, marsh, sea, lake, river, snow etc.;

(A3) High load ratio: 1.5 – 2.0 times higher if compared to the turbojet transport planes and turbo-propeller aircraft;

(A4) The empty design has a 20 - 70 % aerostatic unloading depending on type/size;

(A5) Global flight range with an opportunity for cargo delivery to anywhere on earth without **needing to refuel**;

(A6) Lower fuel consumption;

(A7) Cost of transportation will be similar to that of the railway transport;

(A8) The payload ratio of ESTOLAS is much higher than other aircraft types at shortest take off/landing distances.

(A9) Much higher values of the cruise speed in comparison to an airship.

The main ideas underlying the proposed project emerged from both partners' estimation of the needs in the results of the project and partners' background. **The needs in the results** of the project are:

(N1) A small (payload 1-2 tonnes) ESTOLAS hybrid aircraft is needed for use where light helicopters are currently used but a longer range is required;

(N2) A medium (payload 40-60 tonnes) ESTOLAS hybrid aircraft is needed for use where heavy helicopters are currently used but heavier payload is required to carry to perform relevant tasks;

(N3) A large (payload 100-200 tonnes) ESTOLAS hybrid aircraft is needed for transportation of cargo, including heavy cargo, using small airports or open areas of land or water close to places of origin and destinations of the cargo;

(N4) A super-large (payload 200-400+ tonnes) ESTOLAS hybrid aircraft is needed for special purposes of transportation very heavy cargo using small airports or open areas of land or water close to places of origin and destinations of the cargo.

(N5) Reducing land areas needed for air transport infrastructure and of the fuel consumption per load weight per delivery distance is an important ecological, economic, and societal problem, which is expected to grow in the future.

The background of the project was partners' previous experience in theoretical and experimental design of such air vehicles. By the beginning of the project a working full-size prototype (a manned

light ESTOLAS hybrid aircraft) had been developed and it took a flight (Filimonov, 2003). The prototype had at least one drawback - low stability in some particular flight conditions. A theoretical solution for the problem above had been found. The basic concept of the proposed ESTOLAS aircraft is the following. This aircraft is a mixed type "flying wing", the basic part of which is the disk-shaped centerplane. In general, it serves as a receptacle for elevating gas (helium). In the channel of its centre, there are a jacking system and a cargo cabin and, at the edges, there are a pilot-passenger cabin, cantilevered wings and a tail. The combined take-off and landing device is placed underneath: wheels, ski bearers and air cushioned landing gear.

The disk shape of this aircraft makes it possible to reduce the overall dimensions of the gas tankage body by 3.0 to 3.5 times in comparison with the classical cigar-shaped form of an airship and, at the same time, to reduce considerably the lateral air blown surface.

The presence of plane elements such as the cantilevered wing and tail provides the necessary stability and controllability during horizontal flight and, due to load-bearing properties of the cantilevered wing and disk-shaped body together with aerostatic unloading of the design, a high transport efficiency with regard to weight feedback and specific productivity is achieved.

Positioning the propeller in the central channel of the disk allows the properties of vertical take-off aircrafts, including helicopters, to be realized.

The presence of the elements of an air cushioned plane, air cushioned landing gear along with a supercharger activated by the propeller facilitate off-airfield operations and the basing of the aircrafts, i.e. movement, landing and take-off from water, marshes, any flat ground, snow covered surface, etc.

The absence of a regular airfield and presence on-board of the technological self-servicing block-module placed in a cargo cabin ensures the autonomy of operation: docking facilities and tie-down devices, take-off and landing runways, platforms and other elements of the infrastructure, typical of regular airships, planes and helicopters become unnecessary.

The positioning of the elevating power plant in the channel of the disk and the cruise engine on the back part of the disk-centerplane makes it possible to create the most successful configuration of the power plant as a whole, providing all of the necessary thrust characteristics during all of the flight regimes with the simultaneous support of stabilization and control.

Three principles for creating the lifting force (aerostatic, aerodynamic and jet) used on this aircraft, the possibility of landing on an all-terrain flat surface, the airflow over the systems of control and stabilization generated by the power plant's propellers, the relatively low specific loading on bearing surfaces with the simultaneous use of modern aviation control systems and navigation make it possible to achieve high reliability and safety of operation.

However, by the beginning of the project there were still important technical problems to be resolved: (1) the optimal sizes and shapes of the aerodynamic flanges had to be determined for the ESTOLAS aircraft of various sizes, and (2) the concept of the ESTOLAS aircraft of various sizes had to be assessed not only with the modern currently available engines, but also with the engine concepts planned for the future. Following the successful resolution of these problems, the given concept of a heavy load carrier, being built on the basis of modern achievements in aviation engine building, control systems, constructional materials and technologies, could be realized in the near future.

The project objectives were:

(O1) To verify the calculations of the shape and location of the aerodynamic flanges needed to resolve the low stability problem.

(O2) To create demonstration models of the aircraft and test them in the wind tube and in radio-controlled flight in order to verify the calculated characteristics of the ESTOLAS aircraft and validate experimentally the view that the addition of aerodynamic flanges indeed resolved the low stability problem.

(O3) To calculate and formulate the characteristics of a) small [< 3 tonnes maximal payload], b) medium [between 10 and 80 tonnes maximal payload], and c) large [> 80 tonnes maximal payload] hybrid aircraft, such as flight parameters, the optimal engine type, power and weight parameters, thermal efficiency, specific fuel consumption (SFC), emissions in general and for cargo transportation (kg of fuel per ton of cargo per km), safety, noise level e. t. c. and to denote a perspective propulsion concepts.

(O4) To study the dimensions of the runways, taxiways and parking spaces in the small and medium European airports and estimate how many of them (in percentages and absolute figures) will be able to accept small and medium hybrid aircraft.

(O5) To compare the ESTOLAS small, medium and large versions with competing air vehicles in terms of the exploitation benefits (i.e. longer range, better fuel economy) versus the drawbacks, and to identify the potential market demand by the European and world markets.

(O6) To provide safety assessments, risk analysis and JAR/CS Certification support.

(O7) To draw a conclusion about whether the concept of ESTOLAS in its small, medium or large version is feasible for further development, and, if so, to prepare a business plan for the further development of the hybrid aircraft and to submit it to the investor who has expressed interest in building such aircraft.

The project's progress was planned to be estimated using specific measures of success:

(MeS1) Objective (O1) was planned to be considered successfully achieved if the results of theoretical modelling and calculations would allow evaluating the effect of the shape and location of the aerodynamic aerodynamic flanges on the stability and steer ability of the ESTOLAS aircraft.

Objective (O2) were planned to be considered successfully achieved if:

(MeS2) Virtual model of the ESTOLAS aircraft designed using computer modelling software and computer-aided design (CAD / CAE / CAM);

(MeS3) Demonstration model of the ESTOLAS aircraft for wind tunnel tests (the working area of the wind tunnel is of 8 m² or 16 m²) was planned to be designed;

(MeS4) Radio controlled (RC) aircraft model of the ESTOLAS aircraft designed. Radio equipment of the RC model should have at least 9 control channels, including: control of elevator, ailerons and mechanization, engines, rudders, stabilization systems or automation. As the power plant of the RC model it was assumed to use electric brushless motors, powered by Li-Po battery power. Expected duration of the flight - 10 ... 15 minutes, the largest wingspan - 800 mm. Modes of RC model's flight were planned to reflect the most realistic flight modes of the prototype.

(MeS5) Results of the study of aerodynamic characteristics on the demonstration model of the ESTOLAS aircraft in a wide range of angles of attack and slip in modelling unsteady flow and performance of power plants. Range of flow rates from 20 to 100 m/s;

(MeS6) The results of flight tests of a RC model of the ESTOLAS aircraft, including the evaluation of RC model prototype flight characteristics: stability and steer ability in all modes of flight - from take-off to landing and cruising, the influence of aerodynamic flanges prototype "ESTOLAS" on the side stability and balancing.

(MeS7) Objective (O3) was planned to be considered successfully achieved if the calculated characteristics of the small, medium and heavy versions of the ESTOLAS aircraft would correspond to the parameters of ESTOLAS aircraft proposed in the Description of Works with not more than 15% deviation. Concerning the engine estimation, there were no quantifiable verifiable measures. Qualitative measures of success for objective (O3) include:

- Determination of engine systems with technical parameters of the best modern aircraft
- Suggestion of a perspective propulsion concepts which can achieve the ACARE 2020 targets (a 50% cut in CO₂ emissions per passenger kilometre, which means a 50% in fuel consumption, and an 80% cut in nitrogen oxide emissions)

Objective (O4) was planned to be considered successfully achieved if:

(MeS8) Statistical data obtained by analyzing the following parameters of European small and medium sized airports: the characteristics of the runways (length, width, type of surface, allowable loads, etc.) and taxiways (width, angles, etc.); the presence of means for precise landing of the aircraft, the presence and types of obstacles, the transmitting antennas etc.; the type and size of parking place and platforms for maintenance, restrictions of power plant noise level and pollution level relating environment etc., would demonstrate the applicability and market value of the proposed ESTOLAS aircraft;

(MeS9) The results of flight tests of a radio-controlled model of the ESTOLAS aircraft, including the evaluation of: the possibility of aircraft on small aerodromes, the effectiveness of manoeuvring before landing, course and glide path keeping, the ability of the aircraft to go around for a second landing approach, taxing characteristics of prototype for manoeuvres on the aerodrome; ability of prototype to withstand the direction of take-off and it's behaviour during the procedure of an aborted take-off, **would demonstrate the applicability of the ESTOLAS aircraft for small airports.**

(MeS10) Objective (O5) was planned to be considered successfully achieved if the comparison of the ESTOLAS small, medium and large versions with competing air vehicles in terms of the exploitation benefits (i.e. longer range, better fuel economy) versus the drawbacks would allow the identification of potential market demand at the European and world markets.

(MeS11) Concerning the safety certification analyses, there were no quantifiable verifiable measures. Qualitative measures of success for objective (O6) include:

The qualitative measures of success for objective (O6) include:

- Validation of the global feasibility of the ESTOLAS concept regarding certification and safety;
- Obtaining a clear view of the driving relevant safety and certification factors and limits for the further development of ESTOLAS.

(MeS12) Objective (O7) was planned to be considered successfully achieved if the investor accepts the elaborated business plan.

3. Main Scientific & Technological results / foregrounds

3.1. S/T methodology and associated work plan

The **S/T methodology** for the project is essentially based on the enhancement and further theoretical and experimental development of a previously designed working full-size prototype of a manned light ESTOLAS hybrid aircraft (Filimonov, 2003). Within the project computer modeling of the shape and location of the aerodynamic flanges needed to resolve the low stability problem under certain flight regimes was performed, using the following means: a wind tunnel small subsonic speeds with two working parts; a complex of experimental installations for research of aerodynamic characteristics (stationary and non-stationary AC on models methods of the compelled and free fluctuations; stationary and non-stationary AC on large-scale semi models and compartments of bearing surfaces FM; the device for imitation of harmonious flaws; the device for imitation of influence of the screen of the earth; the device for maintenance with the compressed air for modeling of work of power-plants and other researches; the device for research of characteristics of wind turbines; water-pulverize installation for modeling of an artificial cloud in a working part of a wind tunnel; the automated control system of experiment, including gathering and processing of experimental data; special software in the field of CAD/CAM/CAE technology (designing computer program Solid Works, Pro Engineer, Unigraphics NX, technological computer program Master Cam, etc.), in the field of engineering calculations (MathCad), in the field of computer design (GPSS), in the field of statistical data processing and transport system optimization (QSB, SPSS, etc.), in the field of geographical information systems (ArcGIS) etc.).

This methodology was used in order to calculate and formulate the characteristics of a small, a medium, a large and a superlarge ESTOLAS aircraft.

To verify the calculations experimentally, a demonstration models of the aircraft were produced and tested in the wind tube and in the radio-controlled flight. Radio-controlled model will was manufactured in three stages according to a previously designed in CAD / CAM environment drawings. The first stage can be divided in two parts. Both parts were supported by quantitative methods – calculations and manufacturing. Second stage included complete manufacturing of glider parts and structural components. After second stage bench testing of the aircraft all devices was made, then assembly and finishing was completed. Third stage included flight test with the following evaluations.

Methodology of all stages included:

- A. Calculation of RC model characteristics and selection of and manufacturing.
 - Calculations of the maximum take-off weight of the model parameters;
 - Selection of parameters of the power plant;
 - Calculation of the parameters of the power battery for electric motors and controllers;
 - Designing of the radio system based on the required number of control channels - control surfaces, propulsion and equipment.
- B. Material selection and manufacturing
 - Selection of the necessary materials and aggregates based on their weight characteristics;
 - Selection of the material for the glider taking into account the necessary strength and stiffness;
- C. Manufacturing parts and structural components of glider.

- Production of parts and structural components using high-precision machine tools by means CAD / CAM technology.
- Production of the precise form and geometry of the prototype model.

D. Flight test of ESTOLAS aircraft model

- Evaluation of evaluate the performance characteristics of prototype model;
- Evaluation of the stability and steerability in all modes of flight - from takeoff to landing and cruising;
- Investigation of the influence of "ESTOLAS" prototype with aerodynamic flanges on the side stability and balance
- Simulation of the possible failures and emergency situations, to evaluate the appropriate response to possible failures and emergency situations of prototype model.

In order to study the dimensions of the runways, taxiways and parking spaces of small and medium European airports with respect to the possibility of accepting small and medium ESTOLAS hybrid aircrafts, the project partners considered statistical data obtained by analyzing the following parameters of European small and medium sized airports: the characteristics of the runways (length, width, type of surface, allowable loads, etc.) and taxiways (width, angles, etc.); the presence of means for precise landing of the aircraft, the presence and types of obstacles, the transmitting antennas etc.; the type and size of parking place and platforms for maintenance, restrictions of power plant noise level and pollution level relating environment etc.

Flight tests of a radio-controlled model of the ESTOLAS aircraft, including the evaluation of: the possibility of aircraft on small airdromes, the effectiveness of maneuvers before landing, course and glide path keeping, the ability of the aircraft to go around in case of need, taxing characteristics of prototype for maneuvers on the airdrome; ability of prototype to withstand the direction of take-off and it's behavior during the procedure of aborted take-off, allowed conclusions and offers regarding aerodromes characteristics which is necessary for basing, reception and service of the hybrid aircraft "ESTOLAS", as well as the possibility of operating this type of aircraft.

To provide JAR/CS Certification support, in compliance with JAR/CS 23 and /or 25, essential systems for the ESTOLAS aircraft were analysed, including the safety assessments and risk analysis.

The small, medium and large versions of ESTOLAS with competing air vehicles in terms of the exploitation benefits (i.e. longer range, better fuel economy) vs the drawbacks, and identify the potential market demand for the different versions of ESTOLAS in the European and world markets were compared with competing air vehicles (present in the market and announced by other developers) in terms of their exploitation benefits, as well as through the estimation of the market needs in the short, medium, and long-term perspective. This lead to a conclusion about whether the concept of ESTOLAS in its small, medium or large version is feasible for further development.

The methodology of the project took into account its **multidisciplinary** nature. The project's objectives, in order to be achieved, demanded the involvement of the holders of the core technology and experts from different fields (the modeling of aerodynamics of the aircrafts, computer simulation, the development and testing of aircraft physical models, land facilities for air transport, and market analysis). The scope of the project implied its **international** character, due to the necessity to involve the most appropriate experts who happened to be from different countries and because the outcome of the project targets users worldwide.

3.2. Computer simulation, calculation, and formulation of the ESTOLAS characteristics

The work in these tasks was aimed at calculating and formulating characteristics for small / medium / large versions of ESTOLAS hybrid aircraft prototypes, such as flight parameters and performance, general fuel consumption, flying range with estimated payload, cruising speed, operations specifics using previous CAD modelling, Safety analysis, Airport study.

During implementation of tasks main parameters and characteristics of the ESTOLAS prototype were defined. Possible restrictions for concepts, operating parameters calculated for each prototype were formulated such as: payload capacity, time and range of flight. On the basic parameters, ESTOLAS prototypes do not exceed corresponding take-off weight of classical prototypes of aircraft and helicopter, other than providing partial off-airfield operation. The efficiency of aerostatic unloading for a large ESTOLAS prototype has been also calculated. With helium gas costs 1 m³ = 23.11 Euro, and the need of 700 m³ the total cost appears to be 16,180 Euro only for helium. Mass of helium conduct only 9 % of all large ESTOLAS mass, which clearly does not provide effective aerostatic unloading. Lifting rotor in fuselage central-section does not provide vertical take-off and landing for all prototypes.

Small ESTOLAS prototype is intended for carrying up to 600 kg of cargo or 4 - 5 passengers with luggage. The parameters of the prototype suggest achieving basic operating efficiency by integration into general aviation. General Aviation (GA) is all civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire. General Aviation covers a large range of activities, both commercial and non-commercial, including private flying, air ambulance, police aviation, aerial firefighting, air charter, bush flying and many others. The main advantage of the prototype over the traditional GA class aircraft is the possibility of off-airfield location and the possibility of take-off and landing from/on unprepared surface as well as the possibility of operating in hard-to-reach areas.

Basic performance predictions for the prototype:

- when two Teledyne Continental 10-360-ES engines with the fuel consumption of ~58 kg/h are used as a basic propulsion system, estimated time of flight in cruising regime with payload capacity is 5 hours;
- estimated flight range in cruising regime is ~1200 km taking into consideration the operation of takeoff and landing device engine;
- maximum flight height of 3000 meters can be an obstacle when operating in mountainous terrain.

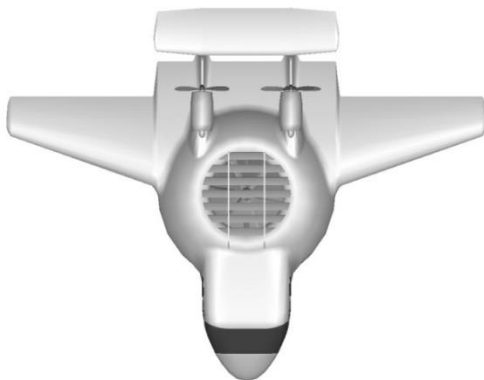


Fig. 1. Small-ESTOLAS, top view

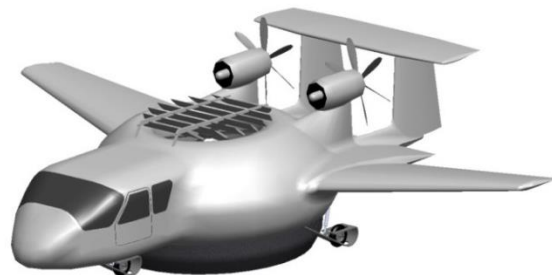


Fig.2. Small-ESTOLAS, isometric view

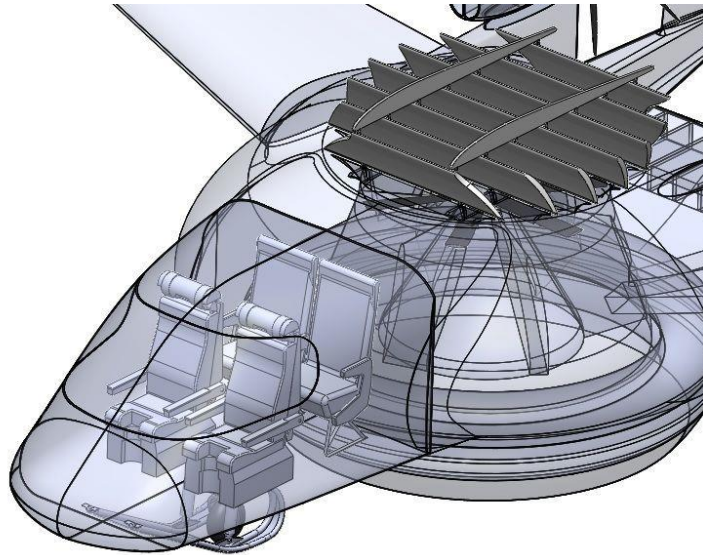


Fig. 3. Small-ESTOLAS, prototype layout

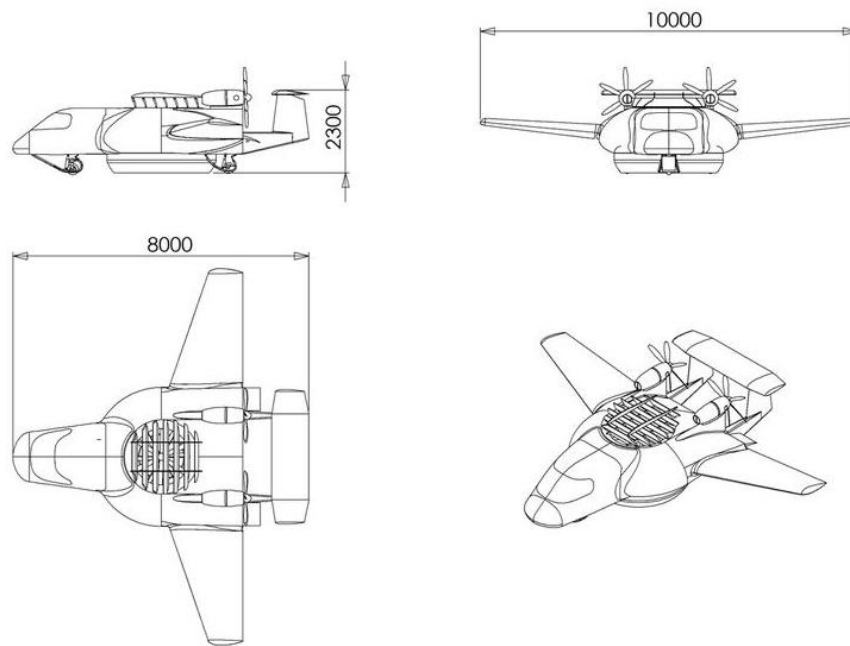


Fig. 4. General layout of the Small-ESTOLAS

Medium ESTOLAS prototype is intended for the needs of national economy; the main advantage of the prototype is the possibility of off-airfield location and the possibility of take-off and landing from/on unprepared surface.

Basic performance predictions for the prototype:

- when two PT6A engines with fuel the consumption of ~ 200 kg/h are used as a basic propulsion system, estimated time of flight in cruising regime with payload capacity is 3 hours;
- flight range in cruising regime is 750 km;
- maximum flight height of 3000 meters can be an obstacle when operating in mountainous terrain.



Fig.5. Medium-ESTOLAS, isometric view

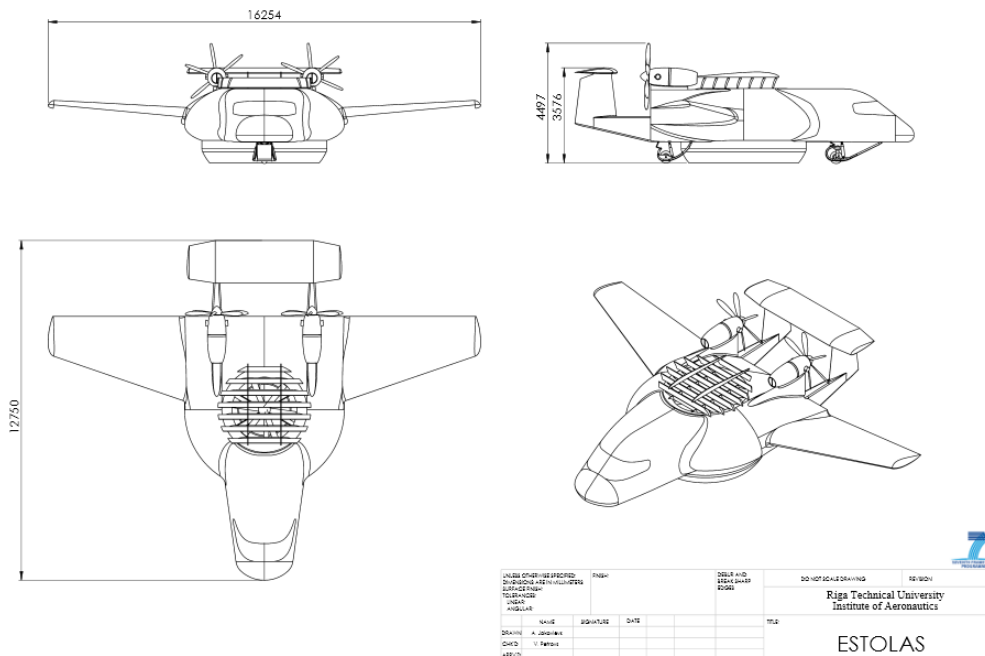


Fig. 6. Medium-ESTOLAS, basic geometric parameters.

Large ESTOLAS prototype is intended for carrying from 45 to 60 tons of cargo. The experimental aircraft uses several principles of lift generation, which sets additional requirements for its operation. First of all, it is related to the necessity of using helium gas as well as to the general layout of the prototype.

Basic performance predictions for the prototype:

- when two TVD AI-20k engines with fuel the consumption of ~2000 kg/h are used as a basic propulsion system, estimated time of flight in cruising regime with the payload capacity of 45 tones is 7 hours;
- estimated flight range in cruising regime is ~1100 km taking into consideration the operation of takeoff and landing device engine;
- the maximum flight height of 500 meters can be a serious obstacle when operating both in mountainous terrains and places that have average factors for relative height.

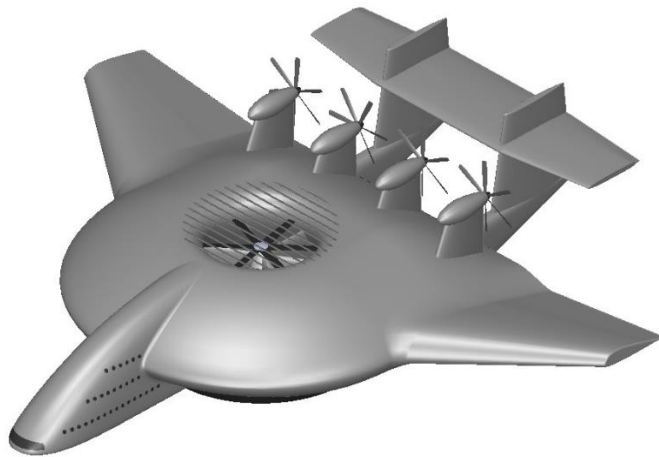


Fig. 7. Large-ESTOLAS, isometric view

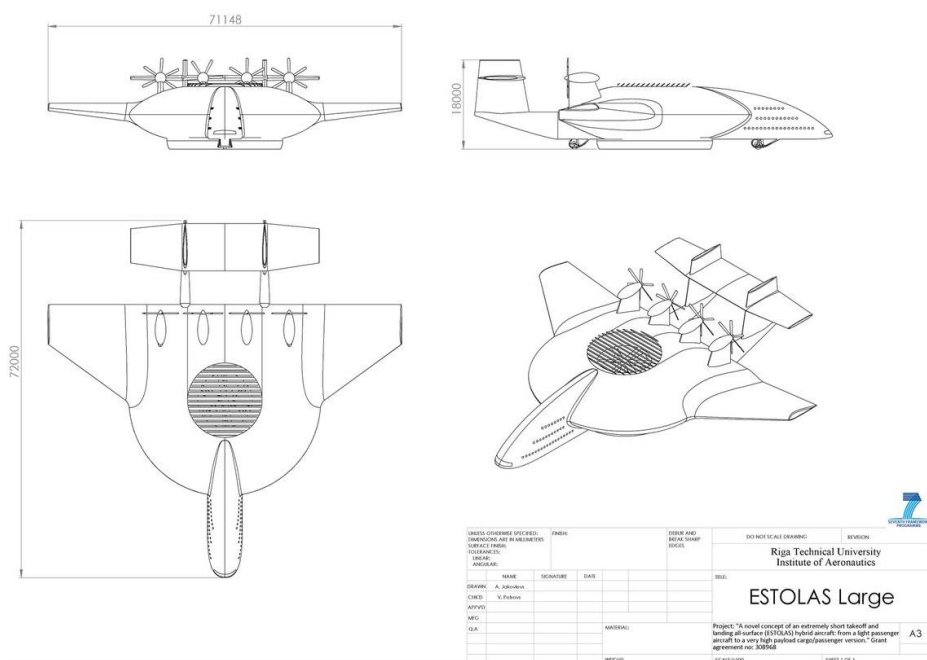
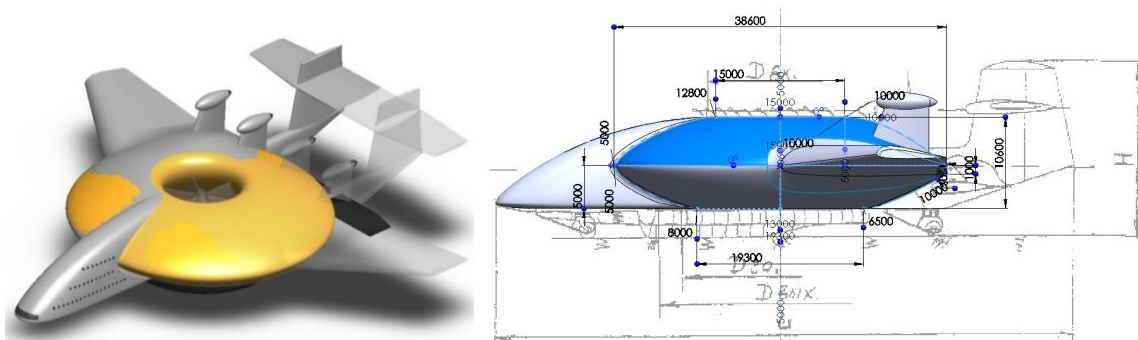


Fig.8. General layout for Large-ESTOLAS



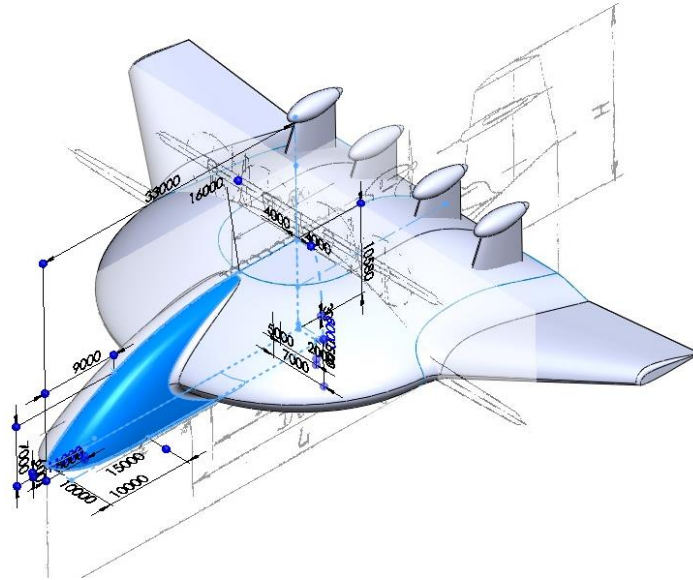


Fig. 9. Defining geometrical parameters and calculating the volume for gas on the CAD model.

Large ESTOLAS aircraft is able to hold in its aerostatic unloading tank up to 6600 m³ of helium. The calculation of aerostatic lift is made according to the formula:

$$F_A = \rho g V,$$

where ρ – liquid (gas) density, kg/m³; g – free fall acceleration 9.8 m/s²; V – submerged body volume m³.

Air density ρ_{air} under the temperature of 15 C is equal to 1.226 kg/m³, helium density $\rho_{hel} = 0.169$ kg/m³. The lift force created by the helium tank is equal to:

$$F_A = (\rho_{air} - \rho_{hel}) * g * V = (1.226 - 0.169) * 9.8 * 6600 = 68366.76 \text{ N, or } 6976.2 \text{ kg of aerostatic unloading.}$$

As the center section airfoil has to remain unchanged, the skin of the tank should be rigid. It may entail the necessity of discharging helium during flight in order to reduce excessive pressure on the skin and the construction inside the tank, because air pressure falls as the altitude increases. In such a case, helium supplies should be replenished during descent to compensate the lift force. For this purpose, some cylinders with compressed helium should be carried on board. Taking into consideration the soft flow of helium the given cylinders will be required in any case in order to permanently control the necessary volume of helium.

Conclusions for Chapter 3.2

During the tasks performing main parameters and characteristics of the ESTOLAS prototype were defined. Possible operations restrictions for small, medium and large ESTOLAS concepts were formulated, operating parameters were calculated for each prototype - the approximate flying range, payload capacity, time of flight. On the basic parameters ESTOLAS prototypes do not exceed the corresponding take-off weight of classical prototypes of aircraft and helicopter, other than providing partial off-airfield operation. The efficiency of aerostatic unloading was calculated for a large ESTOLAS prototype. With helium gas costs 1 m³ = 23, 11 Euro, and the need of 700 m³, total cost is 16,180 Euro only for helium. Mass of helium conduct only 9 % of all large ESTOLAS mass, which clearly does not provide effective aerostatic unloading. Lifting rotor in fuselage central-section does not provide vertical takeoff and landing not for one of the prototypes.

3.3. Estimation and choice of optimal Engine Concept for the hybrid aircraft

Optimal engine integration into novel aircraft concept requires an acceptable weight at higher power. The definition of engine weight parameters was detailed described in WP3.1. In the next steps the values of weight to power ratio and Power to weight ratio of chosen engine types will be compared.

As it was mentioned above, for some versions of ESTOLAS is recommended a gas turbine engine of type GTD 350. This engine was used in helicopters Mil Mi 2 and can achieve the maximum start power of about 300 kW.

Based on the performed calculation of the engine power for central rotor and horizontal flight, the main engine parameters were estimated within this deliverable.

The analysis of engine parameters was performed using the matrix of proposed optimal engine concept for the future airplane design, which was originally mentioned in Del. 3.4.

This mentioned in Del. 3.4 matrix describes engines of different manufactures. The engine data were taken from the manufacturer information sheets. The calculations of these data were performed taking into account the ESTOLAS operation conditions.

As it was mentioned in deliverable 3.1, the specific power is one of the most important parameters describing the engine perfection. In previous chapters, the characteristic of all possible engine types considering defined power ranges was given. In this deliverable was necessary to compare all chosen engines regarding the specific power. It was shown that the specific power of chosen piston engines achieves acceptable value (around 1). The weight to power ratio of chosen gas turbine is even lower.

The performed analysis of fuel consumption values makes it sure that the central rotor propulsion consumes much more fuel comparing to cruise engines. As a rule, the central rotor power drive consumes during the take-off phase at least 2 times more fuel compared to the cruise engine. Hence, considering the engine type for the central rotor drive the specific fuel consumption has to be taken in account.

Although the gas turbine technology allows a much higher power to weight ratio than the piston engine, the piston engine consumes less fuel.

This fact can be explained by a lower efficiency of turbo engine on the one hand and by older development technology and manufacturing technology of considered gas turbine GTD 350.

Obliviously, from point of view of efficiency, it makes sense to apply the multi-engine power system, based on numerous of piston engines.

Next possible solution would be an application of more powerful gas turbine as a central power generator in combination with various electric engines, driving propellers and central rotor (Del. 3.4).

The possible engine emissions levels in the aircraft were investigated. The proposed piston engine application in the ESTOLAS aircraft causes exhaust emissions depending on the lambda value. Because the lambda value is changing during the flight, the estimation of emission level during the flight regimes is difficult.

However, the performed development of engine systems in the last years allowed to achieve a significant reduction of exhaust gas emissions of piston engines. This reduction was shown in example of the Rotax engine improvement. Very important is the achieved decrease of CO₂ emissions.

The chosen optimal engine concepts demands high efficiency propellers. For the planed ESTOLAS application the use of high performance propellers with variable pitch is recommended. The biggest advantage of the variable-pitch propeller is the possibility of adapting the propeller pitch to the actual aircraft speed.

The estimated engine parameters are given considering the propeller gear. All mentioned engines are equipped with high efficiency gears.

It makes sense to develop a special high performance gear to drive the central rotor with increased diameter. This new gear will allow the high torque at lower RPM.

Furthermore, an advanced gear system is required in case of the use of a multi-rotor system to achieve an acceptable support for vertical force.

The mentioned advantages and disadvantages of main parameters of the chosen engine concepts, described in this deliverable, have to be considered during the engine application into the ESTOLAS aircraft.

Diameter of ESTOLAS centerplane D influences the aerostatic lifting force. It was assumed that the ESTOLAS centerplane for is ideal torus. Fig. 10 shows a curve which describes the increase of aerostatic force with the centreplane diameter growth.

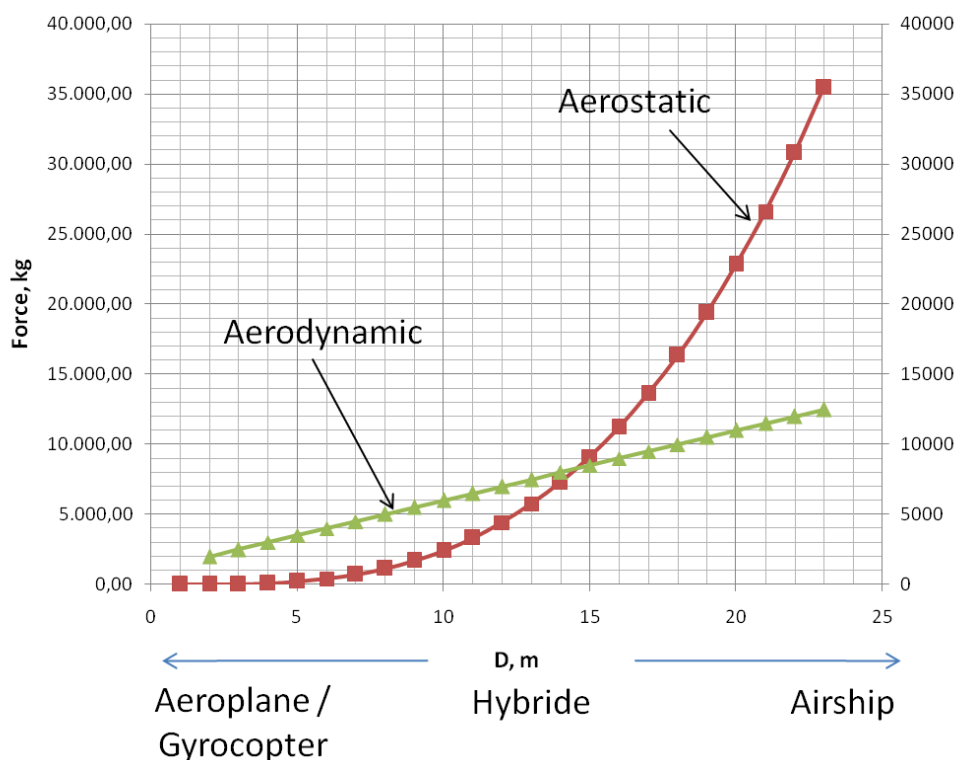


Fig. 10. Aerostatic force as function of ESTOLAS centerplane diameter

Fig. 10 makes it clear that the aerostatic force is not significant up to centerplane diameter of about 6 - 8 meter. ESTOLAS flight behaviour is similar to the aeroplane ones in the range up to 8 m centerplane diameter. The ESTOLAS achieves airship properties when the centerplane diameter is higher than 15 m. In the range between 8 and 15 m ESTOLAS can be considered as pure hybrid aircraft.

The green line in Fig. 10 representing the increasing aerodynamic forces is hypothetical because up to this point no exact relationships between the centerplane diameter and wing area are not known.

Wing area as function of the take-off mass is show in Fig. 11. These curves were created using the results of Filimonov's calculations.

The yellow vertical lines illustrate parameters of ESTOLAS-family of different weight categories (from Bella 1 up to Fialka F6) proposed by Filimonov.

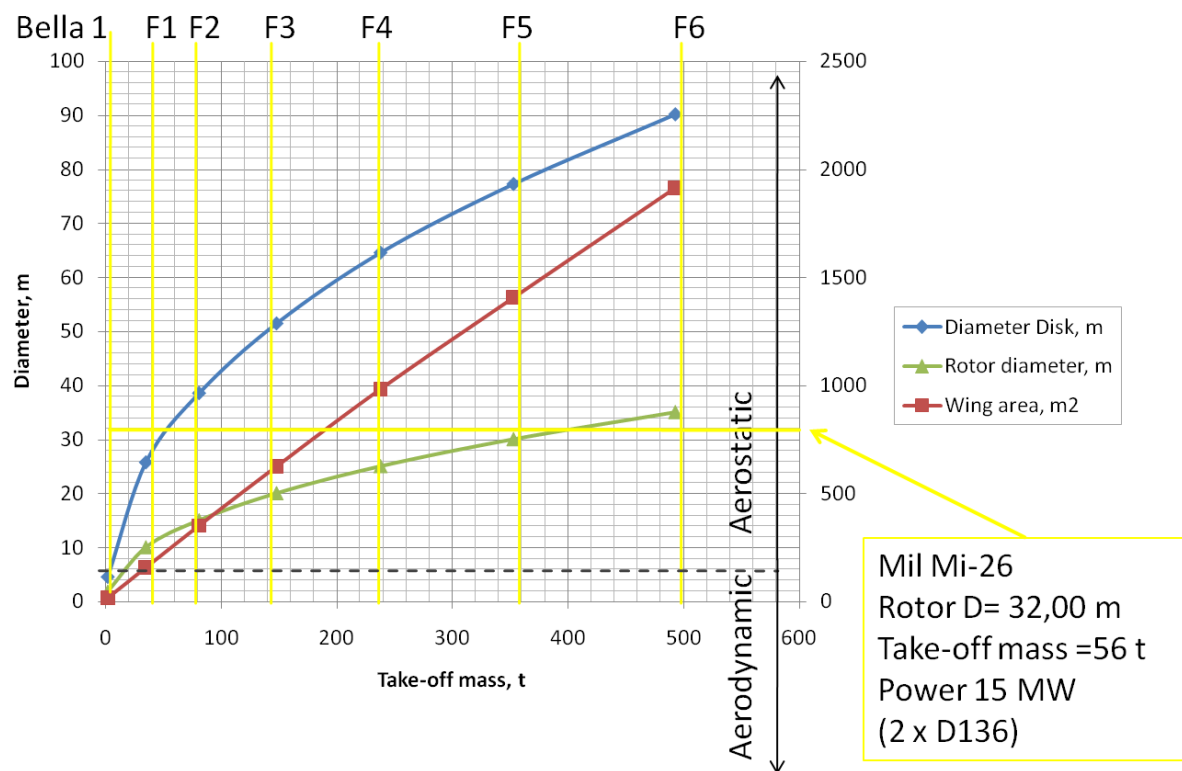


Fig. 11. Wing area and diameter of rotor and centerplane disk

According to calculations of Filimonov the wing area increases linearly (red line in Fig. 11) and the centerplane diameter (blue curve in Figure 3.8) with rotor diameter (green curve in Fig. 11) increase by a root function of take-off mass. The wing area is given in m² in the right ordinate axis.

This fact proves that Filimonov design ideas are based on basic torus geometry calculations. It has to be mentioned at this point that the maximal rotor diameter of Fialka 6 (yellow line F6) reached diameter of 32 m. Although a rotor of this diameter is difficult to manufacture, this rotor size corresponds with the rotor diameter of Mil Mi-25. This helicopter is powered by 2 x 7460 kW D136 power units of Motor Sich and can carry the take-off mass of 56 t. However, the mass of 56 t which

can take the rotor of 32 m diameter is planned (according Filimonov) to be installed in ESTOLAS of 400 t take-off mass. This would mean that the central rotor can cover only 14% of all lifting forces in case of 400 take-off mass ESTOLAS. The manufacturing of bigger rotors would mean a new development challenge because of higher blade velocities and strength problems,

Analysing information, described above, can be concluded that up to take-off mass of 12 ton only Aeroplane / Gyrocopter hybrid version makes sense!

To achieve the best centerplane rotor performance for each ESTOLAS type an analysis of the rotor number, rotor diameter and rotor rotation speed has to be performed. The engines power characteristic can be estimated on the base of achieved calculation results. Results of calculation are shown in Fig. 12. The red curves illustrates the function of rotation speed (left ordinate axis) and the blue curves represents the rotor diameter for different rotor numbers. The more rotors are used, the smaller rotor diameter has to be chosen. The rotor rotation speed can be increased by the higher rotor number. However, Fig. 12 shows that one rotor system has twice bigger rotor diameter compared with 2 rotors systems.

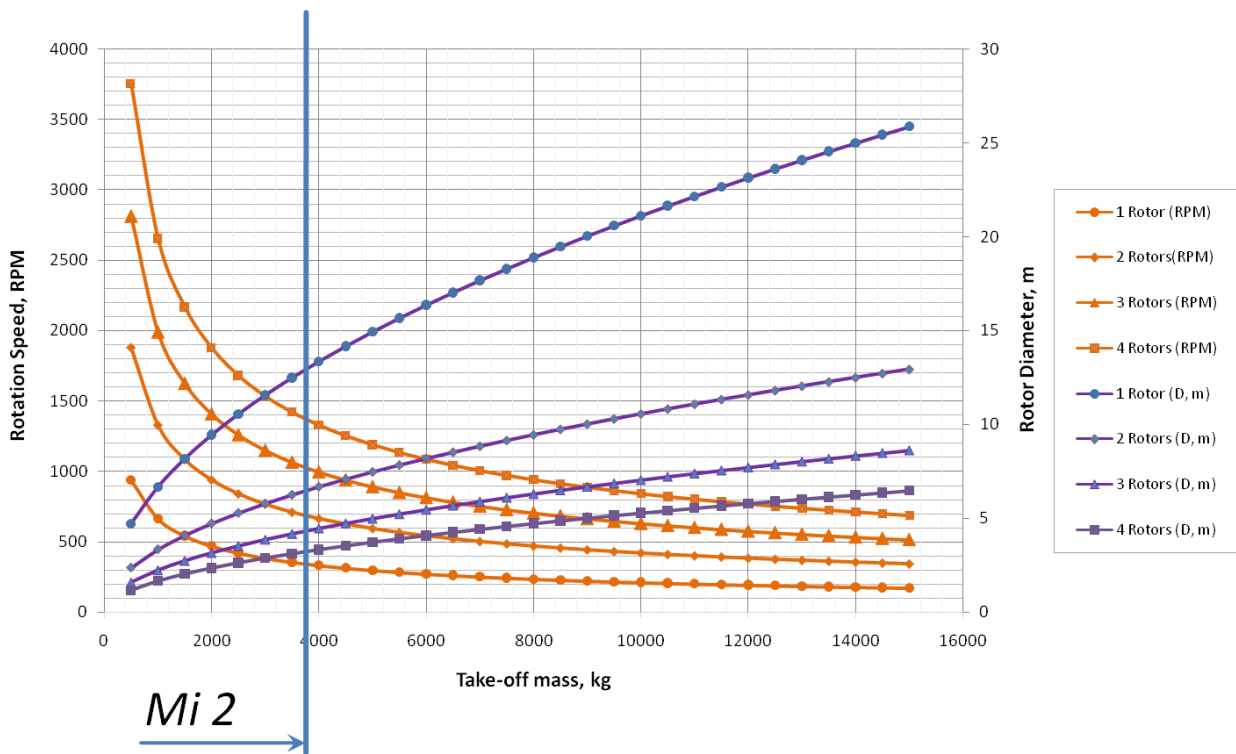


Fig. 12. Centerplane rotor diameter and rotation speed

Results of calculations were verified using the date of existing Mil Mi 2 helicopter. According to the diagram on the Fig. 12 for the take-off mass of 3700 kg is a rotor of 13 m required. Existing helicopter Mi 2 with take-off mass 1400 kg has a rotor diameter 14,50 m what is not far away from calculated in Fig. 12 values. Hence, the curves of Figure 4.1 can be used for further rotor optimization.

Another possibility to increase the lifting force at given rotor diameter can be achieved by adding of new rotors in the aircraft, however this case a design change is necessary. This point will be discussed in the next chapter.

For a sufficient engine integration into the ESTOLAS aircraft different engine mounting points has to be considered. As it was mentioned above, for the horizontal flight of ESTOLAS at least 2 engines are required. These engines can be applied at ESTOLAS within 3 possible concepts. These 3 concepts of engine integration are shown in Fig. 12.

In case of concept A the engines are integrated in the aircraft wings offers the best options for safety. However, the air flow created by the propeller has not to affect the vertical air jet, causing by two rotors. Both engines should be placed on the wing in acceptable distance from each other to avoid the flow interactions.

In case of concept B the probability of interactions of both air flows is lower compared to concept A. This concept has to be checked regarding the safety, because both engines are situated to close together.

Using version C (Fig. 13) the best air flow behaviour and safety can be expected, however, the place for cargo loading is limited and loading is much difficult.

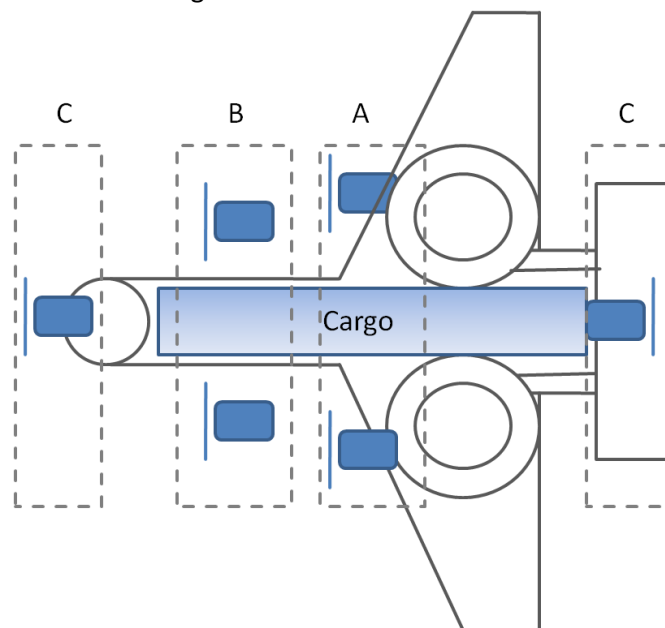


Fig. 13. Concepts of horizontal flight engine integration of ESTOLAS

A combination of two concepts of engine integration can be used. For example, in case of a 3-rotor system 2 engines can be mounted in the wings (concept A) and the third engine can be integrated on front of the aircraft as it is shown in case of concept C.

For an optimal engine integration into a novel aircraft main knowledge about the lifting forces are required. Furthermore, analysis these forces during the start and horizontal flight regimes has to be performed.

Performed above analysis shows that the application of electric components (electric engines, generators and batteries) can improve the flight properties of planed ESTOLAS in the future. Therefore is necessary to find optimal architecture for future more-electric or all-electric ESTOLAS now, during the concept phase.

Electric engines powered by solar energy are environmental friendly and can ensure a largely carbon-neutral energy supply for aviation.

For example, an aircraft needs 25 kW power at 100 mph. Hence, 300 minutes of flight requires 75 kWh of energy. The expected system weight for 75 kWh can be calculated as follows [20]:

- Lead Acid Batteries - 3000 kg
- NiMH Batteries - 1500 kg
- Li-Ion Batteries- 600 kg
- Fuel Cell System (including 3 kg of H₂) - 165 kg
- Gasoline equivalent is 100 kg!

Conclusions for Chapter 3.3

In the frame of performed investigations an optimal architecture for electric ESTOLAS was proposed. It was shown that this perspective architecture allows to reach a significant weight and costs reduction at minimized emissions level.

Proposed propulsion system structure on board of ESTOLAS opens new strategy for flight control during at flight, which enables the VTOL-operations for the flight vehicles with high payload.

The further calculations of main energetic parameters of ESTOLAS on the base of geometric data is required.

3.4. Creating physical model of the ESTOLAS aircraft and testing them in the wind tube

Tasks performed during the implementation of this package of works:

- Developing the methodology of the experiment. Creating a programme for processing the obtained data.
- Creating a model for testing taking into account the geometry of T4 wind tunnel, which was installed in the aerodynamic laboratory of the Institute of Aeronautics.
- Working out a complex consisting of devices and software required for the experiment.
- Carrying out a complete complex of static tests and obtaining six aerodynamic coefficients as well as providing a description of stability and steerability. The experiment was carried out for the model without using the central lift unit.
- Drawing conclusions and providing recommendations regarding the design of the ESTOLAS hybrid aircraft.
- The most important points – studying the bottlenecks and improving the flight characteristics without changing the conception. The work on optimization should be better carried out in an experimental way. (fillets, fences, liquidation of local separations, etc.)

The main method of research, which determines the success of aerodynamics as a science and its wide application in many fields of technology, is the testing in wind tunnels. The wind tunnel is a physical instrument, which makes it possible to obtain in one of its elements, i.e., in the test section where the body under test is placed, uniform rectilinear steady air flow at a given velocity. There are two main types of low-speed wind tunnels: direct impact wind tunnels and closed-return type wind tunnels.

Construction and measurement complex of aerodynamic wind tunnel meets specific requirements that provide precise results of research. The model positioning mechanism (alpha mechanism) construction has to take into account objectives, including precise manufacturing, minimal flow influence, ergonomic and as much as possible simple design etc.

T-4 tunnel poses an aerodynamic wind tunnel with open work area. The basic diagram with main part definition of the T-4 wind tunnel is given on Fig.14.

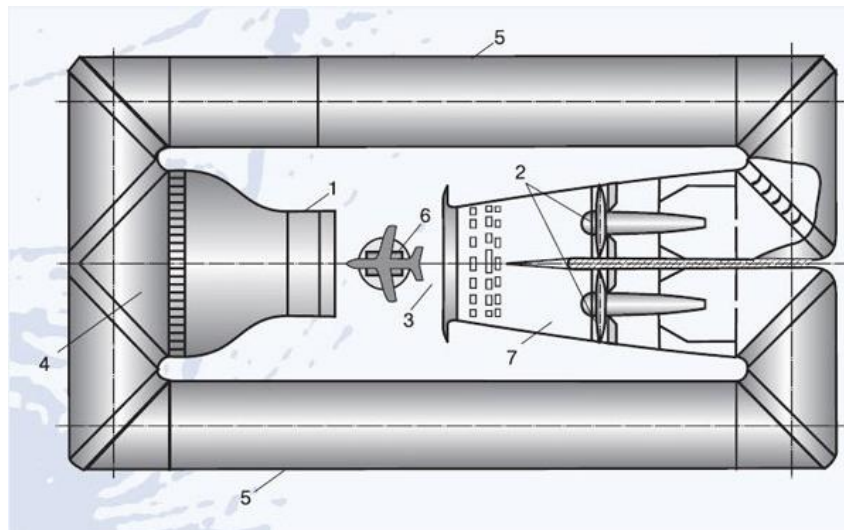


Fig. 14. T-4 wind tunnel basic diagram: 1- nozzle; 2- fans; 3- open work area; 4- prechamber; 5- return passage; 6- research model with alpha mechanism; 7- diffuser

For successful investigation of different experimental ESTOLAS aircraft prototypes it was important at first to design an accurate 3D prototype models using CAD (*Computer-aided design*) systems. Using these models it was possible to determine and investigate many parameters such as aerodynamic characteristics, arrangement features, weight and dimensions; it was also possible to evaluate the strength of the structure and investigate static and dynamic loads. The 3D model was created using SolidWorks software that allowed to implement all the above mentioned actions. Along with it, the scaled model for aerodynamic researches was designed. This model repeated the form of the original prototype and had scaled dimensions in about 22 times. (Fig.15.)



Fig. 15. ESTOLAS CAD model, for aerodynamic experiment

Creation of the scaled CAD model was the first step in implementing the model for tests. Taking the second step in implementing the model, the project expert group resolved the following problems:

- The way how the model will be manufactured;
- What kind of materials will be used;
- How to fix the model in the wind tunnel during tests;
- How to put all the required hardware inside the model.

In particular, it became possible to manufacture main parts and units using a high-precision 3D milling machine; the designed model was also provided for the opportunity to use additive manufacturing also known as "3D printing" technology for manufacturing complex geometry parts and small size parts. An additional model was designed for the investigation of possibility and efficiency of operating at standard airports. In such a model, the outer body (which completely copies the prototype geometry) was created, the parameters of weight were specified and several versions of undercarriage were designed with high precision. With the help of further computer simulation it was possible to determine minimum dimensions of taxiways during the prototype maneuvering. In all the designed models, the program allowed to promptly change basic values such as weight, dimensions or changes to the arrangement by using previously designed parts and assemblies. The main advantage of that model was a modular design. The fuselage consisted of 4 independent layers that were assembled into solid sandwich-type part.

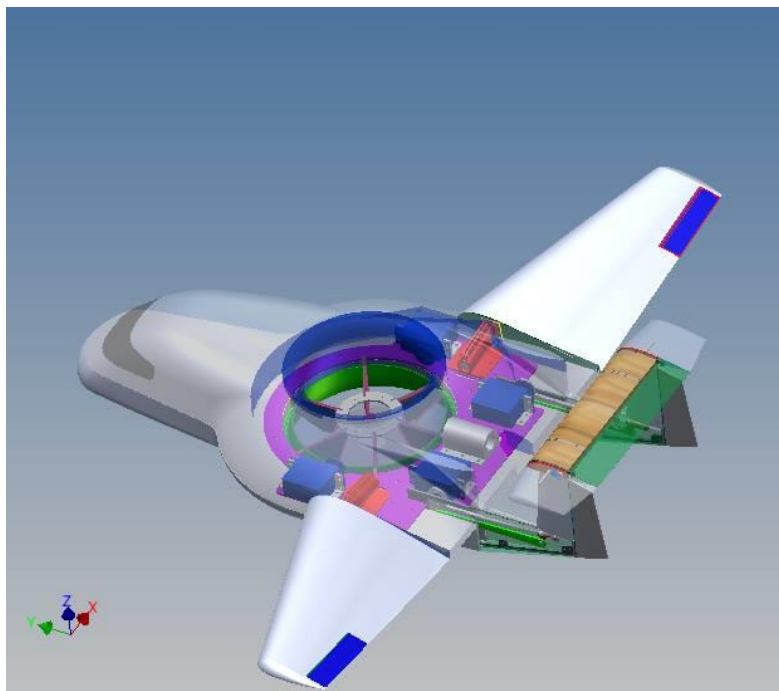


Fig. 16. ESTOLAS CAD model for aerodynamic test, configuration.

Results of ESTOLAS physical model testing in a wind tube:

- The stalling angle – 7° (relative to the aircraft construction line). Early stall occurs on wing panels, which caused by high lift TsAGI P3 airfoil with the relative thickness of 18% and the wing-setting angle of 5° .
- A very abrupt stall the pilot will be unable to respond if he has reached the stalling angle.
- High aerodynamic drag determined by the stall in the back part of the fuselage, the same as for a bluff body.
- The given structure of horizontal tail does not provide the aircraft with a positive lift coefficient. Zero pitching moment has a large negative value caused by the lift airfoil of TsAGI P-II horizontal stabilizer. To change the value of zero pitching moment, it is necessary to use a reverse convex or a symmetrical airfoil with a negative setting angle.

- Relative to the chosen aircraft center of gravity, the lateral position of the aerodynamic center up to the stalling angle remains behind the center of gravity relative to the flight direction, which is an evidence of stability of the given aircraft.
- Relative to the chosen aircraft center of gravity, the position of the side aerodynamic center up to the stalling angle remains behind the center of gravity relative to the flight direction, which is an evidence of static yaw stability of ESTOLAS hybrid aircraft.
- The analysis of the obtained data – taking into account the deflection of the diving rudder, rudders and ailerons - allows to make a the following conclusion. The performance of steering surfaces practically does not depend on the angle of attack, which means that the complete control over the flight can retained within the flight range of angles of attack.

Conclusions for Chapter 3.4

The aerodynamic experiments on the ESTOLAS hybrid aircraft provided an opportunity to adequately evaluate the given design. The aerodynamic design of ESTOLAS aircraft is very much different from the traditional aircraft that operate in the world's airspace. The ESTOLAS is a concept combining the capabilities of a plane, a helicopter, an air-cushioned aircraft and an airship.

If we consider the concept from the point of view of classical plane and helicopter designs the engineers marked the trouble spots related to aerodynamics at the stage of designing and manufacturing the model intended for aerodynamic tests. It should be taken into account that the given aircraft is equipped with a central lift unit which has to reduce the take-off run and landing run as well as the take-off and landing speeds; however, the experiment in the wind tunnel was carried out for the flight configuration of ESTOLAS hybrid aircraft. The reason for choosing this particular mode of operation is related to the fact that the lift propulsion system operates only during takeoff and landing and the time of its operation is strongly limited.

Additional lift force created by the central propeller was calculated and taken into consideration while processing the aerodynamic data in the process of calculating the take-off and landing performance of ESTOLAS hybrid aircraft. During horizontal flight, the grid of the input device is closed and the flow between the upper (low pressure) and the lower (high pressure) center section surfaces does not occur. This particular configuration was tested in the process of aerodynamic experiments. The examination related to the influence on and dependence of aircraft stability and steerability, wing flap system – slotted flaps, ailerons was carried out. It included also the checking of: the diving rudder and all-moving horizontal tail of a console type, rudders and jet flaps. Jet flaps were deflected in combination with slotted flaps in the "no jet" mode because designing a jet flow is rather a difficult task which would change the internal structure of the model itself with subsequent increase of the model weight and in excess of technical limits inside the model strain-gauge balance.

3.5. Test flight of the radio-controlled demonstration model of ESTOLAS prototype

The following methodology was used to carry out the test flight of the radio-controlled ESTOLAS model:

- Taxiing along the runway to check the aircraft controllability in taxiing modes, to determine the correctness of propeller balancing and aircraft response to the throttle control knob.
- Acceleration up to a speed close to the takeoff speed for determining the stability and controllability of the aircraft during acceleration followed by stop.

- Acceleration up to a speed close to the takeoff speed with nosewheel lift – for determining the most accurate takeoff speed.
- Acceleration up to the takeoff speed, nosewheel lift, takeoff, flap retraction at a height of 30 metres, climb up to 70 metres, levelling off.
- Horizontal circle-wise flight at a height of 70 metres, checking controllability during the horizontal flight – roll, pitch, yaw.
- Box-pattern flight with successive flap extension for determining the parameters of landing configuration, determining the minimum speed without the flaps and with fully retracted flaps.
- Climb up to 200 metres, switching the engines to "idle power", gliding with descent up to 70 metres – to check the gliding properties of the aircraft.
- Circling with flaps and engine revolutions in landing configuration – to check controllability in landing flight mode.
- Simulated approach by flying over the runway at a height of 5 metres in landing configuration, switching the engines to maximum mode at the runway threshold, switching the aircraft to the climb mode – to determine the flight characteristics when performing an emergency go-around flight manoeuvre ("TOGA" mode – Take-Off / Go Around).
- Landing approach (box-pattern) from a height of 50 metres by observing the sequence of landing – "descent, flareout, holding-off, touchdown", aircraft landing within the limits of runway touchdown zone, switching the engines to "idle" mode, landing run, taxiing, stop.

Evaluation of ESTOLAS prototype resulting from demonstration model flight-test

The process of testing and the results obtained during the test flight of the radio-controlled demonstration model of ESTOLAS prototype allowed to make the following conclusions:

Erroneous position of main landing gears. The main landing gears are too far from the area of aircraft centre-of-gravity limits (shifted to the tail unit), which considerably complicates the nose-wheel lift off during the aircraft takeoff by requiring the increase of take-off speed, takeoff run and practically maximum rudder deflection.

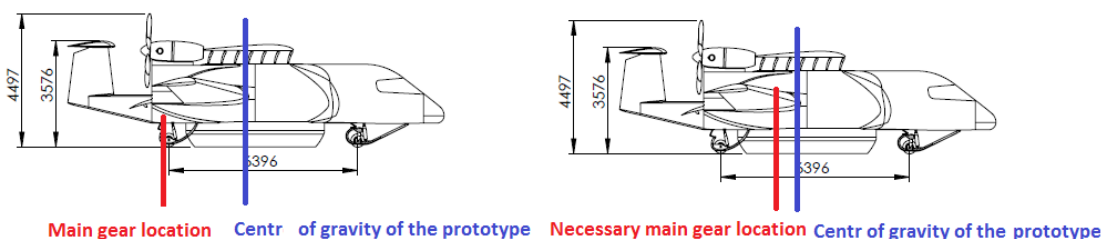


Fig. 17. Erroneous position of main landing gears

Conclusions for Chapter 3.5

According to the results of testing in a wind tunnel – the stalling angle is 7° (along the aircraft construction line). The early stall occurs on the wing panels, which is caused by the high lift airfoil TsAGI R3 with a relative thickness of 18%, and wing setting angle of 5° . The test flight completely confirmed the results of the aircraft aerodynamic study: during the take-off and at a climb gradient of more than 10 degrees there instantaneously occurred a stall from planes that caused the loss of control and crash.

As regards the results of testing in a wind tunnel – there occurs a very sharp stall the pilot will be unable to respond if he reaches the stalling angle. The stall occurred practically right after the lift off from the runway, and despite the instantaneous attempts to compensate aircraft evolutions in the air it appeared to be impossible to level off the aircraft.

3.6. Safety assessments, risk analysis and JAR/CS Certification support

3.6.1. Certification requirements

This package of works dealt with the investigation of a system hybrid aircraft “ESTOLAS” – the fuel storage tank. The investigation was based on the Certification Specifications (construction and licensing requirements) of the EASA and also encloses a complete Particular Risk Analysis according to ARP 4754-Directive.

A new hybrid aircraft series was analysed and evaluated basing on the construction and licensing requirements of the EASA. The hybrid aircraft "ESTOLAS" is a new Air Vehicle of a special class. The aircraft combines the properties of helicopters, winged airplanes, airships and hovercrafts (air cushion vehicle) comprising all the advantages and features of these aircraft.

The aim of this work was the identification of the certification requirements of the fuel tank for the ESTOLAS small and very heavy variants. In addition, a comprehensive Particular Risk Analysis (PRA) carried out according to ARP 4754 guideline to determine the effects of the tank system failure on the aircraft and the passengers.

The study was performed by a thorough investigation of the composition and structure of the licensing requirements, the properties of the hybrid "ESTOLAS" aircraft and the properties of the fuel. LPG (mixture of Propane and Butane) and Hydrogen are being used as fuel for the aircraft. In Europe some standards for the application of LPG and Hydrogen exist. The relevant requirements for the application were presented.

Particular risks are events or influences which are damage from outside the system(s). Within ESTOLAS project the main focus lied on the fuel tank. The Particular Risk Analysis was performed for the following Risks:

- Leakage of Fluids and Gases
- High Energy Rotating Fragments
- Overpressure / Rupture
- Fire

The consequences of the risks are major, hazardous or catastrophic. To avoid the influence on the aircraft, the passengers and the environment, requirements outlined in various norms and standards are adhered to. The requirement to be met can be found in the respective analysis. A certification can only be done by proving compliance with the requirements.

Table I: Overview of EASA Certification Specification (CS)

Section	Title/Contents
CS-22	Gliders and motorized gliders
CS-23	Normal, utility, commuter & aerobatic planes
CS-25	
CS-27	Small rotorcraft
CS-29	Large rotorcraft
CS-34	Aircraft engine emission and fuel venting
CS-36	
CS-APU	Auxiliary power units
CS-AWO	All weather operations
CS-E	Engines
CS-ETSO	European technical standard orders
CS-Definition	Definitions & abbreviations
CS-P	Propellers
CS-VLA	Very light aero planes
CS-VLR	Very light rotorcraft
AMC-20	General AMC for air worthiness of products, parts and appliances

Result for the classification of ESTOLAS series

All Certification Specifications of EASA certification are examined. The aim of the study was the determination of the codes that are required for certification of ESTOLAS series. These codes were developed by analyzing the provisions in "Applicability" with respect to the defined designed specification. The codes include the requirements for systems and engines of the aircraft.

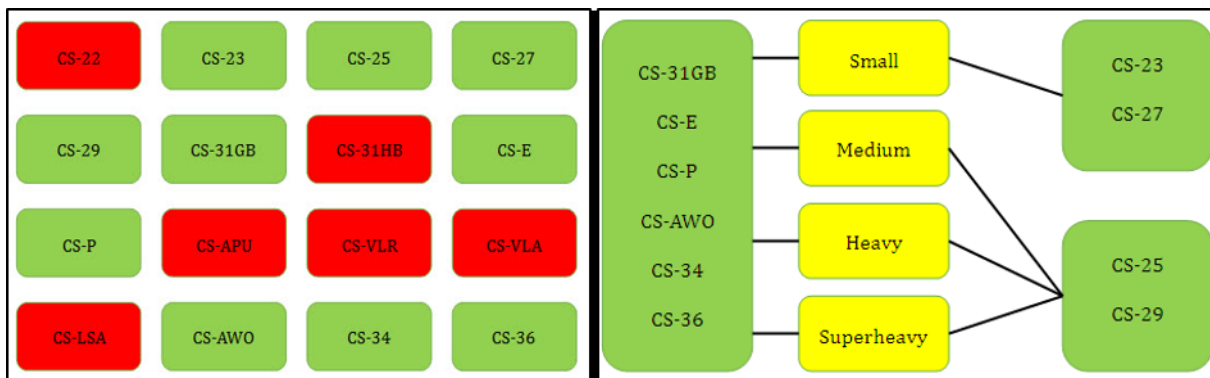


Figure 18. Applicable CS regulations to the ESTOLAS variants.

Figure 18 left includes all of the examined CS regulations. The red background describes CS regulations containing provisions irrelevant to ESTOLAS aircraft. The green-background indicates CS regulations which are relevant. Each ESTOLAS variant will be covered by a sub-set of the applicable CS regulations identified, as shown in Figure 18 right.

3.6.2. Safety Assessment

An important requirement for the certification of an aircraft is to demonstrate airworthiness. For this purpose, different methods are used. Failures, hazards and the effects as well as the links between them have to be identified. This analysis allows the qualitative and quantitative evaluation of the system.

The selection of appropriate detection techniques is dependent on the objectives, the scope of the system and the areas considered. The methods can be found in different phases of the application

lifecycle. The sooner problems are identified, the easier and cheaper it can be fixed. The compilation of the methods described in this section is due to their performance in the specifications for the safety case in ARP 4754 and ARP 4761 respectively.

The following methods were considered to provide safety analysis for ESTOLAS aircraft:

- Functional Hazard Assessments
- Preliminary System Safety Assessment
- Common Cause Analysis
- Zonal Safety Analysis
- Particular Risk Analysis
- Common Mode Analysis
- System safety assessment

Conclusions for 3.6.2

In assigning the CS regulations to the different variants of the ESTOLAS series special design, numerous provisions in the licensing examination and compliance with these requirements for the approval of the aircraft must be demonstrated. To achieve this goal, the different methods used - loosely clubbed under the keywords “system safety” – are outlined. The standard practices recommended and used for a qualitative and quantitative analysis are described in greater detail.

3.6.3. Functional Hazard Assessments (FHA)

The Functional Hazard Assessment (FHA) is a qualitative method and is used to identify functional failures. Failures are classified according to their severity. In addition, the hazards are classified according to their modes of failure. The FHA is already used in the development phase. In the search for new features or modes of failure, the FHA must be updated. FHA is performed the plane level as well as the subordinate system level. The study is similar at both the levels. Table 5.1 includes the categories of failures depending on the maximum probabilities of occurrence.

1. First Identification of the functions,
2. Second Determination of the failure modes,
3. Determine the impact,
4. Classification of the failure modes,
5. Determination of the DAL.

The identification of the failure modes and their effects is done by experts in the respective areas. The classification of the failure modes is carried out based on the impact on the aircraft, the passengers and the flight crew. The operating phases and the evaluations are taken into account in which the failure occurs.

Table II: Failure modes, probabilities of occurrence and DAL values according to ARP 4754 (source: EASA CS-25 and ARP 4754)

Classification of failure	Probability of occurrence (per flight hour)	Development Assurance Level (DAL)
Catastrophic	$<10^{-9}$	A
Hazardous	$<10^{-7}$	B
Major	$<10^{-5}$	C
Minor	$<10^{-4}$	D
No special effect	-	E

3.6.4. Risk assessment summary.

This report deals with the investigation of a hybrid aircraft “ESTOLAS”. The investigation is based on the Certification Specifications (construction and licensing requirements) of the EASA and also encloses a complete Particular Risk Analysis according to ARP 4754-Directive. For the analysis, an

Uncontained Engine Rotor Failure (UERF) is adopted to simulate the effects of the bursting of a propeller blade.

Conclusions for Chapter 3.6

Using DMU models of Small & Medium ESTOLAS aircraft, UERF analyses were done and the trajectory of the small and large fragments' resulting impacts were found. The study was done especially for the passenger cabin, the fuel tank, the helium tank and the system configuration. First, the effects of an impact to the aircraft component and the occupants were analysed.

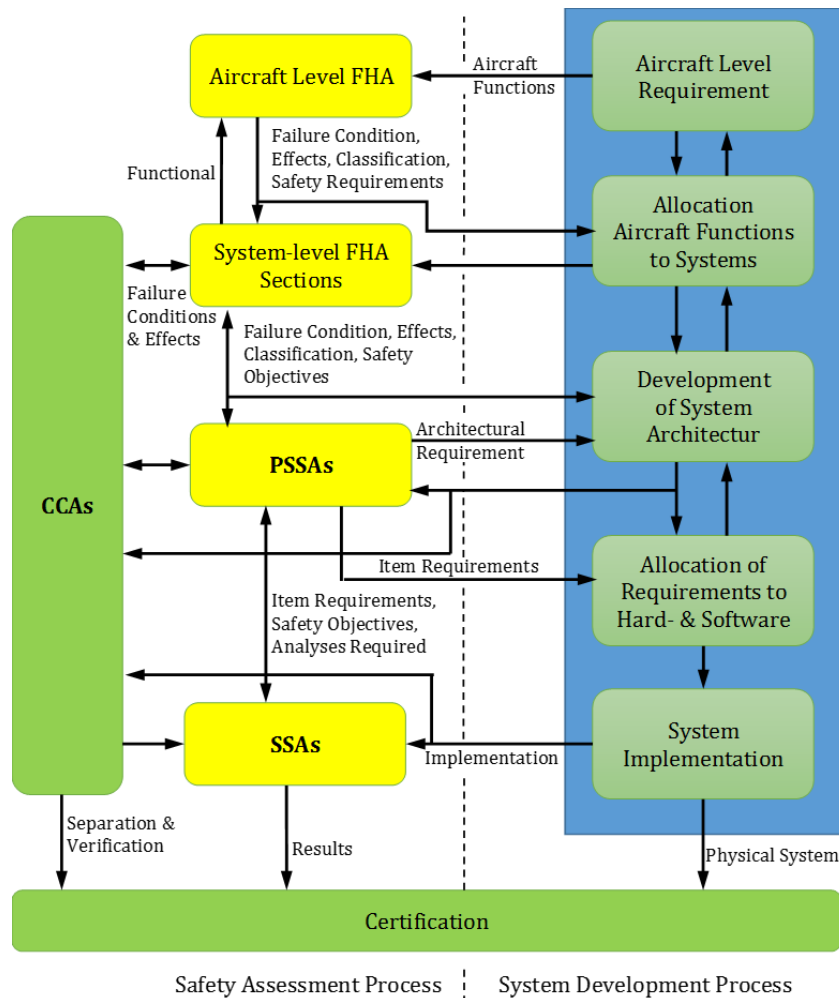


Fig. 19. Safety Assessment and System Development Process Model

The effects are:

- The propeller guard is not sufficient to prevent a possible collision.
- The helium tank is in the danger zone, but has no threat to the passengers and the aircraft.
- The pilot and passenger cabins are exposed to high risks which leaves a possible threat to human life.
- The fuel tank can cause an explosion due to an impact, thus leading to the crash of the plane.
- Other positions for the main propeller shall be investigated.

After the expiry of the impact analysis, appropriate measures for the vulnerable components and areas are considered. The following points are identified:

- To provide more space for other system components, the helium technique is removed.

- To intercept the flying fragments, a shield made of PTFE between the passenger cabin and the central propeller is used.
- To intercept flying fragments is a shield made of PTFE between the main propeller and the fuel tank can be used.
- To prevent a possible explosion, the fuel tank should be installed as far away as possible from the central propeller.
- Central propeller can be installed in the top mounting option to minimize danger
- Hydrogen can be used as a fuel to reduce the tank size.

3.7. Analysis of the small and medium European airports with respect to the applicability of the proposed ESTOLAS aircraft

Small ESTOLAS aircraft can be attributed to category 1A ICAO code because the required runway length is less than 800 meters, the width between the main gear tracks is 2.3 meters, and the wingspan is 10 meters.

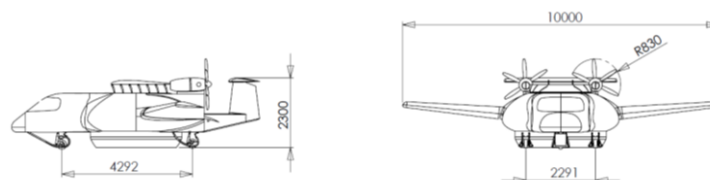


Fig. 20. Wheel base of the Small ESTOLAS aircraft

Medium ESTOLAS aircraft can be attributed to category 1B ICAO code because the required runway length is less than 800 meters, the width between the main gear tracks is 3.5 meters (4.7 meters according to tor dimensions), and the wingspan is 16.2 meters.

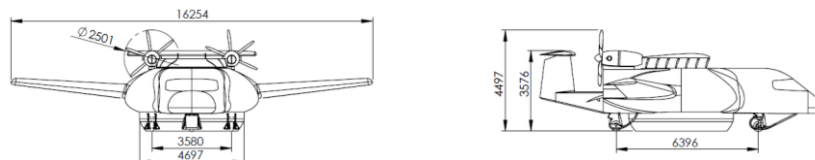


Fig. 21. Wheel base of the Medium ESTOLAS aircraft

Large ESTOLAS aircraft can attributed to category 1E ICAO code because the required runway length is less than 800 meters, the width between the main gear tracks is 16 meters, and the wingspan is 71.1 meters.

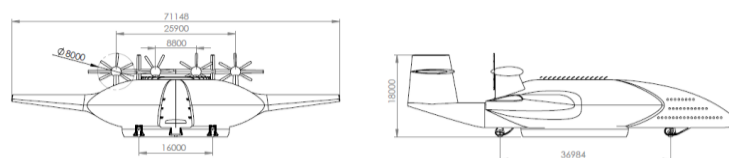


Fig. 22. Wheel base of the Large ESTOLAS aircraft

ESTOLAS aircraft (all versions – Small, Medium, Large) refer to landing category "A" as its landing speed is within the limits of 55 - 60 km/h and the range of final approach speed is approx. 70 km/h – estimated characteristics.

Medium ESTOLAS aircraft can be attributed to fire-fighting category 3 based on aircraft overall length and fuselage width (compartment) characteristics – 12 metres and 3 metres respectively. If we take into consideration not only the fuselage width, i.e. the width of the cargo-and-passenger compartment, but also the centre section width – 6 metres, which can also be considered as a part of the fuselage, it will be fire-fighting category 8, which can complicate the aircraft operation.

The Small ESTOLAS aircraft can be attributed to fire-fighting category 1 based on aircraft overall length and fuselage width (compartment) characteristics – 8 metres and 4 metres respectively.

The Large ESTOLAS aircraft can be attributed to fire-fighting category 9 on the basis of aircraft overall length and fuselage width (compartment) characteristics – 72 metres and more than 7 metres respectively.

The Small ESTOLAS aircraft is intended for carrying up to 600 kg of cargo or 4 - 5 passengers with luggage. The parameters of the aircraft suggest that basic operating efficiency can be achieved by integrating into General Aviation. General Aviation (GA) is all civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire. General Aviation covers a large range of activities, both commercial and non-commercial, including private flying, air ambulance, police aviation, aerial fire-fighting, air charter, bush flying and many others. The main advantage of the aircraft over the traditional GA class aircraft is the possibility of off-airfield location and the possibility of take-off and landing from/on unprepared surface as well as the possibility of operating in hard-to-reach areas.

Conclusions for Chapter 3.7

Design, categorization and performance data impose considerable limitations on the possibility of operating the Large ESTOLAS aircraft at European airports of any type. Operation of the Large ESTOLAS aircraft at small and medium airports practically excluded; operation of the aircraft at large airports and hub airports is also very challenging from the point of view of the required runway width. Considerable limitations appear when it is necessary to refill the aircraft with helium and carry out its maintenance – due to non-standard design and location of the lift engine with a rotor in the middle part of the fuselage the access to these units is limited.

3.8. Technical and economic aspects of operating the ESTOLAS aircraft at European airports

3.8.1. The necessity of using helium gas for the aerostatic unloading of the short take-off and landing aircraft.

The necessity of using helium gas for partial aerostatic unloading of the ESTOLAS aircraft can cause serious difficulties when introducing the aircraft into service at conventional European airfields.

First of all, it is related to the necessity of placing special tanks or a storage area for helium cylinders in the territory of an airport (Fig. 23). Another variant is the possibility of supplying helium upon request, which in its turn will require solving a logistic supply problem.



Fig. 23. Typical cylinder with helium gas

On the other hand, it is necessary to take into account the economic efficiency of aerostatic unloading. The cost of one filling with helium on the one hand and the efficiency of using aerostatic unloading of the aircraft on the other hand are the criteria for evaluation. According to preliminary calculations the use of helium on the ESTOLAS aircraft provides aerostatic unloading approximately at the level of 5 - 7 % from the short take-off and landing aircraft operating take-off weight. This circumstance allows to question the expediency of using aerostatic unloading for the ESTOLAS aircraft namely in such an embodiment.

It is also necessary to take into consideration some technical complexities that may arise while operating the aircraft with helium. Helium is a highly volatile gas, and timely detection of a slow leak of large volume of gas is rather a difficult task, while the absence of reliable control over gas consumption has a direct influence on the safety of flights. In particular, uncontrolled changes of helium volume on board due to leaks can alter take-off ability, flight and landing characteristics of the off-airfield aircraft. In this connection, it is necessary to equip the aircraft with additional special devices that will make it possible to accurately and reliably control gas consumption and detect leaks in proper time. The design of the aircraft also requires completion to provide reliable tightness of helium tanks.

3.8.2. Navigation equipment of the short take-off and landing aircraft

An aircraft that transports cargoes and passengers to European airports must be equipped with the required air navigation equipment to provide the possibility of landing and take-off in accordance with airfield category. An airfield category provides for restrictions related to meteorological minimum for an airfield.

Meteorological minimum in aviation means minimum values of cloud base height and horizontal visibility at which it is possible to carry out take-offs, landings and en-route flights. The meteorological minimum specified separately for an airfield, type of aircraft and pilots. For an airfield, the meteorological minimum can specified separately for different runways and for different approach patterns.

For an airfield and a certain type of aircraft, it is possible to specify different meteorological minima depending on the condition of flight operations systems being used (communication and signalling equipment, radio buoys, navigation equipment, etc.).

If an aircraft is not equipped with special air navigation equipment for landing according to the categories, it is possible to carry out landing according to a visual category, i.e. Visual Flight Rules (VFR), with the following typical minimum: visibility of 5000 meters and cloud base of 2000 feet; at the same time no hazardous weather conditions should be forecast within the 5 mile radius of the airfield.

The ESTOLAS aircraft is not equipped with instrument landing systems; therefore it can implement flights only according to Visual Flight Rules (VFR). To equip the aircraft with air navigation equipment, it may become necessary to make changes to its design, install additional instrumentation, etc.

Preliminary conclusion. The fact that the aircraft is not provided with modern air navigation equipment complying with international requirements will substantially limit its operating capacity at European airports because in this case only the flights according to Visual Flight Rules (VFR) are provided. In addition, average weather conditions often do not comply with the requirements for visual landing approach.

3.8.2. Certification of short take-off and landing aircraft design and operation

It is also necessary to evaluate the compliance of the aircraft during its operation with international ICAO / IATA standards and to evaluate the compliance with the requirements for noise and environmental compatibility. Apart from these aspects, it is also necessary to take into account aircraft operational safety parameters for operation in airports.

To ensure the compliance with the above listed requirements, it is necessary to certify the ESTOLAS aircraft according to international standards. The ESTOLAS aircraft is an experimental aircraft, the design and equipment of which presently hardly comply with international standards allowing operating an aircraft. First, this is related to the promotion of flight safety – availability of survival equipment for passengers and crew in case of emergency, on-board fire extinguishing equipment to extinguish engines during the flight, technical ability to continue the flight (takeoff, landing) in a case when one of the engines has failed, etc.

Preliminary conclusion. To certify the ESTOLAS aircraft, it is necessary to reconsider and update the design of the experimental short take-off and landing aircraft, to carry out a series of flight tests to evaluate all characteristics of the aircraft including the cases of emergency, to evaluate the compliance of the aircraft operating principle with flight safety standards.

3.8.4. Handling for ESTOLAS Prototypes

To ensure the possibility of operating the ESTOLAS aircraft for passengers and cargo transportation, the dimensions and arrangement of cargo doors and cabin doors must comply with technical standards accepted for standard maintenance of aircraft at an airfield. For example, it applies to the height of aircraft cabin doors for passengers and crew, arrangement and design type of the cargo hold, method of loading/unloading, etc.

In the case when the ESTOLAS aircraft is equipped with an internal combustion engine, it is necessary to provide the availability of filling with 100 Low Lead (LL) octane fuel at airfields. The aircraft design must also provide for the method of aircraft fuelling in accordance with the accepted limitations.

3.8.5. ESTOLAS maintenance requirements

To provide the possibility of operating the ESTOLAS aircraft at airports, it is necessary to take into consideration the requirements for typical maintenance of an aircraft – replacement of parts and units in case of failure, technical inspection of an aircraft before the flight, repair of damage and failures. Non-standard design and technical solutions of the ESTOLAS aircraft make it rather difficult to maintain the aircraft at any conventional European airfield. First of all, it is related to servicing the undercarriage of non-standard design, tanks to be filled with helium, etc.

Preliminary conclusion. In order to successfully put into operation the short take-off and landing aircraft on the basis of ESTOLAS aircraft design, it is necessary to substantially reconsider the design of the aircraft and provide the availability of maintenance of certain units and assemblies. It is also required to unify the maintenance procedures in order to attract existing certified technical personnel that will not need to be retrained.

Conclusions for Chapter 3.8

In order to operate at European airports of different classes it is necessary to have strict conformity with ICAO categories with regard to different requirements. These requirements should be taken into consideration already at the stage of designing non-standard aviation equipment. No fundamental limitations to the operation of the Small and Medium ESTOLAS aircraft have been detected except the presumably more complex maintenance due to non-standard design. For the Large ESTOLAS aircraft, the requirements for operation at European airports should be considered at the stage of designing and such important limitations as maximum wheelbase will become a serious obstacle for the operation at European airports of any type. At the design stage, taking into consideration aerostatic unloading with the help of helium gas, it is necessary to develop standard gas refilling procedures using maximally simplified refilling equipment which is supposed to be placed in the territory of an airport.

All ESTOLAS prototypes evaluations show that no clear advantage is detected except short take-off and landing distance and all-surface operations, these main ESTOLAS prototype advantages can be covered by traditional hovercraft as helicopters or convertiplane, in addition, helicopters or convertiplanes have an advantage as fully vertical take-off and landing. Main conclusions: ESTOLAS project principles of prototypes, construction, operation philosophy, performance need to be revised as a new concept.

4. Potential impact of ESTOLAS project

Expected impact, stated in the work programme for Area 7.1.6.3. (Promising pioneering breakthrough technologies and concepts for Aeronautics and air transport) was: *“Proposals should investigate breakthrough technologies and concepts that have the capacity to cause a step change in aeronautics and air transport in the second half of this century”*.

ESTOLAS project directly addressed this issue. Potential specific impacts of the project imposed by the advantages of ESTOLAS (A1) – (A7) listed above under Section of *Summary description of the project context and the main objectives* are the following:

(I1) Advantages (A1) and (A2) impose a possibility to exclude expensive and land-consuming infrastructure: service is carried out with the help of the mobile technological blocks - modules established in any part of the Earth. This meets the objective of *the bringing radical new approaches to the ground infrastructures for passengers and freights and the impact of the air transport on the environment*, stated in the Call.

(I2) Advantages (A2) – (A5) allow easy delivery to remote regions, which meets the objective of the *bringing radical new approaches to the vehicles and the propulsion technology*.

(I3) Advantages (A6) allows savings in fuel consumption and the diminishing of the air pollution, which directly contributes to the objective of the *bringing radical new approaches to the impact of the air transport on the environment*,

(I4) Advantages (A6) and (A7) contribute to the economic efficiency of the air transport, which meets the objective of the *bringing radical new approaches to the vehicles and the propulsion technology*.

(I5) Advantages (A2) and (A5) make the proposed ESTOLAS aircraft highly effective in preventing and liquidation of emergency situations of natural and technogenic character such as: industrial and forest fires, earthquakes and flooding, sea spills of petroleum and oil products, etc.

This meets the objective of the *bringing radical new approaches to the vehicles and the propulsion technology*.

(I6) Advantages (A1) and (A2) allow the development of a more dense network of dispersal fields, thus increasing the safety of air transportation and contributing to the objectives of the *bringing radical new approaches to the ground infrastructures for passengers and freights*.

All impacts (I1) – (I6) correspond to the expected impacts within the first topic addressed **AAT.2012.6.3-1** (Breakthrough and emerging technologies). Impacts (I1), (I2), and (I6) also correspond to the expected impacts of the topic **AAT.2012.6.3-2** (Radical new concepts for air transport), as they *propose and assess new approaches to the way passengers or freight access the vehicle, and the way air transport is connected with other modes*.

Additionally, development and production of the proposed air vehicles would create a new sub-sector of the European economics, facilitate research in the field, and create new jobs in Europe.

The impacts (I1) – (I6) contribute to two major objectives of the Framework Programmes – increasing the **quality of life of the European citizens** and increasing the **competitiveness of the European economics**.

Project partners foresee **the following steps that will be needed after ESTOLAS project completion to bring about these impacts**:

(S1) Targeted information dissemination and establishment of strong links with other key players in the field;

(S2) Continue the initial work on attraction of the investments for the further development of the advanced design and technology;

(S3) Further development of the design and technology and its adaptation to the market needs, using EU scientific programme opportunities (such as Horizon 2020 and others) and the attracted investments;

(S4) Addressing governmental and other decision-making bodies in the field of air transport with a detailed plan aimed in a broad exploitation of the proposed ESTOLAS technology at various environments in Europe and worldwide (within 3 - 5 years after the project's completion);

(S5) Continuous monitoring of the changing market needs, and of the developments in competing and supporting technologies;

(S6) Producing a pilot series of ESTOLAS aircrafts and its testing in real environments (within 6 – 9 years after the project);

(S7) Preparation for a serial production of the most appropriate versions of ESTOLAS aircraft (in medium perspective);

(S8) Mass production of ESTOLAS aircrafts and the corresponding development of the land airport facilities (in long-term perspective).

Further development of ESTOLAS concept requires a **European (rather than a national or local) approach** due to the two following factors:

- 1) the necessity to involve the most appropriate experts (developers of the core technology, holders of the corresponding patents, experts in aircraft design and production, experts in aerodynamics modeling, experts in market analysis, experts in business development of high risk innovative projects), who happen to be from different countries;
- 2) the outcome of the project targets users worldwide, thus stimulating the involvement of the partners from various business environments.

The **account of other national or international research activities** is taken in the following way.

Project partners will also monitor the research activities of the teams developing comparable concepts and other consortia within this EU Programme and other relevant national and international programmes.

Project partners assume that the main **external factor that may determine whether the impacts will be achieved** is possible arising of new more efficient technologies with the same or similar applications. The probability of this event(s) cannot be responsibly estimated now.

The foreseen **potential areas and markets of application of the project results** are determined by the advantages (A1) – (A9) and needs in the results of the project (N1) – (N5) described above under Section *Summary description of the project concept and main objectives*. Briefly, they are (for different versions of ESTOLAS aircraft):

- Areas where light helicopters are currently used but a longer range is required;
- Areas where heavy helicopters are currently used but heavier payload is required to carry to perform relevant tasks;
- Transportation of cargo, including heavy cargo, using small airports or open areas of land or water close to places of origin and destinations of the cargo;
- Transportation very heavy cargo using small airports or open areas of land or water close to places of origin and destinations of the cargo;
- Transportation to remote and underdeveloped regions;
- Development of a denser network of dispersal fields.

Main dissemination activities

The main dissemination activity of ESTOLAS project was a 2-day conference in Riga devoted to new concepts, future and emerging technologies for air transport. The key players in the field (researchers, aircraft developers, regulatory bodies in air transport) were specifically addressed. Identification of the key European and other players in the field and integration of the effort with them was the focus of this task.

The conference took place from the 10th to 11th of April in Riga and had very beneficial and relevant objectives for the project ESTOLAS. The project ESTOLAS was a key issue in the conference discussions. The questions that were in active deliberation dealt mainly with the most important tasks of the design and construction of future variations of ESTOLAS, as well as the main aspects of the integration of gas turbine-generators in electric aircrafts based on the example of ESTOLAS.

Information dissemination was successfully conducted through presentations, workshops, and discussions during the Conference, as well as through conference publications, seminars for students, media reports, articles, and the websites of the project partners.

The Conference enclosed two parts: business visits and speeches. In the framework of business visits the group of participants made calls upon Institute of Aeronautics RTU, Institute of Transport and Communication, and Aviatest.

During the visit at the Institute of Aeronautics RTU the radio-controlled model ESTOLAS was demonstrated to the Conference participants, media, and students.

The welcome speech of the Conference was made by the Director of Aviation Department of the Ministry of Transport of Latvia Arnis Muižnieks. Many representatives of public bodies and private companies made presentations about the current challenges and future developments of the industry. In the list of speakers were the Director of Institute of Aeronautics, ESTOLAS Project scientific leader at Riga Technical University Professor Aleksandrs Urbahs, the President of Transport and Telecommunication Institute of Latvia Igor Kabashkin, Vice President of SME's Business Development and International Cooperation Department of the Aerospace Cluster Pegase, in France Dr. Jean-Francois Boisson, Director of the Scientific Center for monitoring, analyzing and forecasting of the State Research Institute of Aviation of Russia Alexander Friedland, Network Manager at Networking Hub of the European Aerospace Cluster Partnership in Germany Nadine Sablotny, General Director of the Ulyanovsk Aerospace Cluster in Russia Vildan Zinnurov and many others.

In addition to the presentation of the speakers and workshops, the participation of students at the Conference allowed them to ask questions to well-known representatives of the aviation science and the aviation industry. As the aforementioned program description states media and students also participated in the visits and demonstration of the RC model ESTOLAS that also contributed to their engagement of the whole Conference. This successfully served the fulfilling of one of our most important objectives of the ESTOLAS project, namely increase the interest in aviation industry among students and young people.

Under ESTOLAS conference media had a high priority. Well-known media representatives from EU and CIS took part at the conference.

In addition to the ESTOLAS conference the ESTOLAS concept was introduced in the 3rd European Aeronautics Science Network (EASN) International Workshop on Aerostructures in Politecnico di Milano, Italy, which took place in from 9th to 11th of October, 2013.

A special session at the workshop was dedicated to ESTOLAS project. After the workshop ESTOLAS project partner organizations became full members of EASN (<http://www.estolas.eu/en/project-news-1>). The following presentations were made by ESTOLAS partners RTU, QPAC and AK:

1. *“Analysis of the design features and flying-technical characteristics of the ESTOLAS hybrid aircraft prototype”*
A. Urbahs, V. Petrovs, A. Jakovlevs
2. *“Aerodynamic research organization for a novel concept of an extremely short take-off and landing all-surface hybrid”*
A.Urbahs, D. Titovs, V. Petrovs, S. Luckinskis, A. Aleksandrovs, K. Eglitis
3. *“Assessment of possibility exploitation of short take-off and landing all-surface (ESTOLAS) hybrid aircraft at typical European aerodromes”*
A. Urbahs, V. Petrovs, M. Urbaha, K. Carjova
4. *“ACARE and Flightpath 2050 impacts on hybrid aircraft ESTOLAS development”*
V. Papkov
5. *“Certification Requirements for hybrid aircraft”*
W. Oomkens, O. Zysk, B. Kasiske
6. *“Particular Risk Analysis: Impact on Hybrid Aircraft Design”*
W. Oomkens, O. Zysk, B. Kasiske

Besides the presentations, the following scientific papers were published in the Workshop proceedings. The published papers are the following:

- *“Analysis of the design features and flying technical characteristics of the short take-off and all-surface landing hybrid aircraft prototype”*
Urbahs, V.Petrovs, A.Jakovlevs
- *“Aerodynamic research organization for a novel concept of extremely short take-off and landing all-surface hybrid”*
Urbahs, D.Titovs, V.Petrovs, S.Luckinskis, K.Eglitis, A.Aleksandrovs
- *“Assessment of possibility exploitation of short take-off and landing all-surface hybrid aircraft at typical European aerodromes”*
Urbahs, V.Petrovs, M.Urbaha, K.Carjova
- *“Certification Requirements for hybrid aircraft”*
W. Oomkens, O. Zysk, B. Kasiske
- *“Particular Risk Analysis: Impact on Hybrid Aircraft Design”*
W. Oomkens, O. Zysk, B. Kasiske

From the mentioned studies an upgraded version of the paper *“Particular Risk Analysis: Impact on Hybrid Aircraft Design”* is en-route to be published as a technical note in the **International Journal of Structural Integrity**. A paper on the ESTOLAS concept will be submitted to **The Aeronautical Journal of the Royal Aeronautical Society**.

ESTOLAS project was also presented in other scientific events such as LEMCOTEC Technology Transfer Workshop in Potsdam, scientific conference “Intelligent Transport Systems - 2012” in Riga, TIPS Public Workshop in Brussels and others.

Other important action in ESTOLAS project dissemination was working out of the project web-site: www.estolas.eu

ESTOLAS project aroused great interest from various media. Publications about the project were published both in scientific and popular press both in electronic and paper versions such as Focus, New Scientist, Gizmag, Mashable, The Baltic Course, Diena and others. The articles were published in 5 languages: English, German, Russian, Norwegian and Latvian.

ESTOLAS aircraft concept was presented at **Discovery Channel Canada** in daily Science and Technology show "Daily Planet". Information about ESTOLAS project was included in **iPad application "Stars of European Research & Innovation"**.

Exploitation of project results

Patent Application was initially to be prepared on the ESTOLAS technology and submitted within the project. However, in the course of the project it became clear that a patent application at this stage of development would not be reasonable. Consortium made a decision to prepare the Patent Application as planned, however beyond the project timeframe.

The Patent Application will be aimed to obtaining the grant of a patent of the ESTOLAS technology which combines the best characteristics of a plane, airship, helicopter and a hovercraft in a way that enables provision of a technological background for the development and construction of innovative hybrid aircrafts which meet tomorrow's challenges of not only European, but also Asian and American aviation.

This Patent Application will be intended to facilitate the work on the development and commercialization of the ESTOLAS technology. The importance of this Application is in describing the invention and the scope of the protection of the patent. It should contain details of the type of the application (national, regional or international), the background and overview of the ESTOLAS technology, as well as its embodiments and claims. In addition to the Patent Application abstract, several specifications of ESTOLAS will be included in the form of sketches, computer simulation results, models, etc.

Since the Patent Application description cannot generally be modified once it is filed, and the timing for it in the framework of the ESTOLAS project appeared to be too short to prepare a complete and detailed Application containing all the necessary information and results from various work packages, Consortium made a decision to prepare the Application beyond the project timeframe. However, the crucial factor for this decision became the results of the tasks of WP 4 "Development and testing of a demonstration model of the ESTOLAS aircraft". In particular the Report on the test of the physical models of the ESTOLAS aircraft in the wind tube, Report on the test of the radio-controlled model of the ESTOLAS aircraft and Report on the analysis of the experimental evaluation of the models of the ESTOLAS aircraft showed that several corrections should be made in the model to eliminate existing problems. Clearly for a patent application a proposed model must be complete and without any defects to make it reasonable to present to public and start looking for possible ways of commercialization. Hence, the Consortium partners agreed to postpone the preparation of the Application.

Nevertheless a number of **innovative methodologies** for design in CAD environment, aerodynamic research, evaluation for operational requirements, calculation and modelling for performance

parametres, design and construction of flying experimental models have been developed which contribute to general advancement of knowledge in the area:

- Development and implementation of design methodology in CAD-environment of complicated and non-standard geometry of experimental airborne devices with opportunity of virtual model scale-change without irregularities in outer geometry
- Development and implementation of aerodynamic research methodology of experimental airborne devices with non-standard geometry and partial aerostatic buoyancy
- Development and implementation of the evaluation methodology for operations requirements of hybrid airborne device. This methodology provides for evaluation of operations possibility at aerodromes, as well as running standartisation of experimental airborne device in accordance with ICAO and other norms. In the future this methodology allows to make evaluation of operations possibility of non-standard air vehicles of any type and design.
- Development of calculation and modelling methodology for performance parametres of hybrid airborne device. This methodology provides for forecasting performance parametres and efficiency of applying certain technology and innovation within small limits.
- Development of design and construction methodology of flying experimental models of hybrid airborne devices, as well as testing and sequence methodology taking into account a scale of model in relation to prototype. This methodology provides for evaluation and demonstration of experiments in accordance with aerodynamic researches and 3-D modelling.