THE USE OF CO-SIMULATION METHODOLOGY IN THE PROJECT OF PZL SW-4 HELICOPTER ADAPTATION TO MARITIME VERSION.

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Abstract

The article will present issues related to the implementation of the HELIMARIS project that assume modernization of PZL SW-4 to maritime mission and landing on vessel. The project encompasses issues related with helicopter adaptation (passive and active elements increase crew safety) to maritime version, basing on the context of the multidisciplinary analysis philosophy. The CO-SIMULATION calculation methodology involves the use of CFD analyzes for calculations of helicopter aerodynamic characteristics, both during flight and landing approach to vessel deck. The calculation model is a mapping of the CAD geometry of the helicopter model with the built-in RR 250 C20R engine, taking into account simplifications aimed at limiting the number of elements. The issues presented in the article will focus on the aerodynamic analysis of the helicopter in the case of unintentional activation of the floats and the assessment of the impact on the helicopter static and dynamic stability depending on the flight phase and on the current configuration, as well as the problem of turbulence interference between vessel and the helicopter during the approach to landing. The use of CFD (figure 1) analyzes includes hydrodynamic aspect of helicopter buoyancy and vessel motion on waves and allows to describe the dynamics of phenomena occurring during flight of helicopter conducting operations in cooperation with vessels. The collected information will help to develop procedures for safe and optimal landing approaches on the vessel deck. The article also presents exemplary results of analyzes and attempts carried out so far as part of the implementation of the Helimaris project, as well as an approximation of issues related to the verification of tasks set based on real objects, adapted to perform maritime missions.

The main aspect of modeling focuses on the assessment of aerodynamic characteristics of a helicopter equipped with an flotation system from point of view failure that can occur during flight and as result flotation system can be symmetric or antisymmetric activate. Maritime modification and nonintentional flotation system activation cause modification of aerodynamic characteristics that have influence on flight mechanics aspect of the static and dynamic stability of the helicopter, as well as to determine the swash plate control margin. The CFD analysis methodology with additional rotor model defined by VBM(Virtual Blade Model) User Define Function algorithms, will allow to determine the impact of disturbances of the active float system on the rotor performance and the possibility to trimming the rotor, also in the vicinity of the vessels deck. Another aspect analyzed based on the Co-Simulation philosophy is the use of CFD algorithms and equations describing helicopter flight mechanics, to assess the impact of aerodynamic disturbances generated by the vessel superstructures on the helicopter rotor during landing approach, including the case of symmetry and asymmetry inflow on to the rotor (taking into account the influence of vessel exhaust gases), as well as describe power and thrust fluctuation related with partially presence of the helicopter rotor above the vessel helideck. Analysis also including different environmental conditions depend on operation zone (for example Baltic Sea, Mediterranean Sea), that define boundary conditions velocity fluctuation. Definition of Turbulence (especially in the landing zone) related to the presence of a vessels that were determined based on tunnel tests and CFD analyzes, has been calculating by the CTO (Ship Design and Research Center), for sea states in accordance with the definition presented in Advisory Circular AC 27.801 (figure 2).

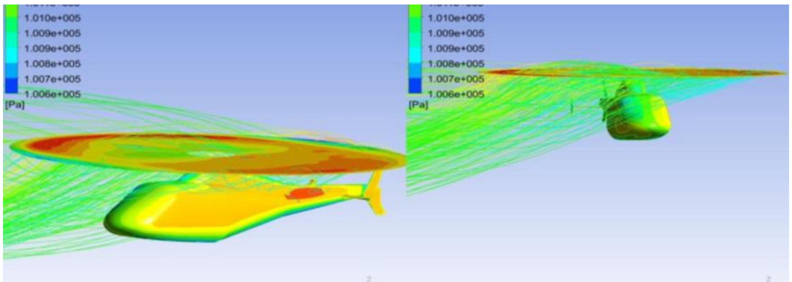

Figure -1 Visualization of SW-4 helicopter CFD model with VBM rotor model

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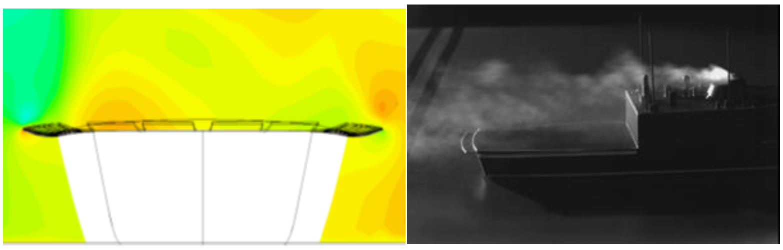

Figure -2 Visualization of the vessel numerical and wind tunnel model

Data collected based on Co-Simulation strategy will be used for optimization process of helicopter landing approach procedure on vessel deck, and used as a input data for the helicopter mathematical model used in the real time simulation described in FlightLab environmental. As part of the implementation of the Co-Simulation strategy, hydrodynamic stability analyzes of the helicopter were made, aimed at confirming the safety requirements of the crew during ditching when the floats are in good working order and when one section of float is damaged.

Areas of research in which the CAE engineering support tools were used in:

• The numerical model of an isolated helicopter rotor in the ANSYS Fluent system using the user functions defined in the Virtual Blade Model (VBM) used in the validation process on the basis of available data from the helicopter tests. The analysis assumed the implementation of a preliminary computational model of the isolated helicopter rotor and its validation. The geometric model of the rotor was constructed in accordance with the geometric CAD model of the blade and the numerical geometry of the hub. The calculation method is based on VBM (Virtual Blade Model) UDF code algorithms. Calculation assumption include the polar characteristics determined do not contain the effect of the air cushion (Out of the Ground Effect). The rotor distance from the base of the calculation grid is above 2 diameters of the rotor.

• Helicopter numerical model in the ANSYS Fluent system used for validation based on available aerodynamic characteristics.

• Numerical model of the helicopter with the rotor used to determine the helicopter's aerodynamic characteristics necessary to build the mathematical model of helicopter flight mechanics in the FLIGHTLAB system used for flight real time simulator software (developed by Warsaw University of Technology).

• The numerical model of a vessel used for both buoyancy analysis in the ANSYS AQWA system and for aerodynamic analysis in the STAR CCM + system. In order to minimize the risk of damage to the helicopter during the approach to the landing on the ship, it is necessary to pre-numerically analyze the dynamics of the floating object depending on the environmental (operational) conditions. For this purpose, the ANSYS AQWA simulation package was used. The following figure 3, shows the visualization of the surface domain of the surface zone of the vessel helideck. Numerical calculations and model validation were performed by the CTO and implemented in wind tunnel and laboratory basins. The CFD numerical analyzes of the vessel superstructure part use the STAR-CCM+ calculation solver.

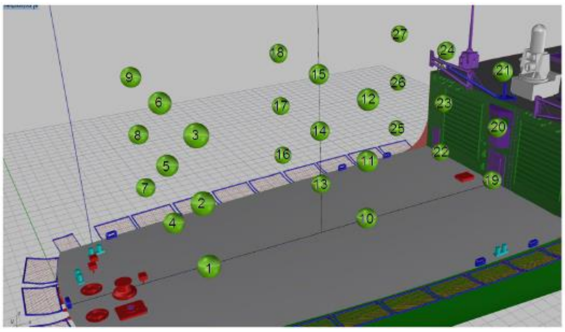

Figure-3 Visualization of vessel helideck measure matrix

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1. SYMBOLS AND ABBREVIATIONS

AoA	Angle of Attack
CAD	Computer Aided Design
CFD	Computational Fluid Dynamics
CoG	Center of Gravity
CTO	Ship Design and Research Center
EFS	Emergency Flotation System
h/c	helicopter
IAS	Indicated Airspeed
ISA	International Standard Atmosphere
IGE	In-Ground Effect
OGE	Out of Ground Effect
IMU	Inertial Measurement Unit
MR	Main Rotor
MTOW	Maximum Take-Off Weight
OAT	Outside Air Temperature
SL	Sea Level
TET	Tetrahedral element
TOT	Turbine Outlet Temperature
TOW	Take-Off Weight
TR	Tail Rotor
UDF	User Defined Function
VBM	Virtual Blade Model

2. INTRODUCTION .

The application of the Co-Simulation methodology requires the integration of various numerical environments characterized by a different model of algorithms allowing for the solution of differential equations among others Euler, Lagrange'a [6]. Characteristic feature of integration based on the Co-Simulation method is the possibility of continuous data exchange between objects having a different definition of boundary conditions and another description of the discretized object. Application of the Co-Simulation methodology it enables complex analyzes of the PZL SW-4 helicopter necessary in the designed process of modification structure to perform operational maritime missions and cooperation with vessels.

2.1. Definition of the test object

The object of research is the PZL SW-4 helicopter (Fig. 1) adapted to perform maritime operational and cooperation with vessels (Fig. 2, 3). Increasing the operational capabilities of the helicopter requires the introduction of design changes that have a significant impact on the aerodynamic and aeromechanics characteristics of the helicopter, and thus on static, directional, dynamic stability and helicopter performance. Changing the operational conditions of the helicopter (operations in the vicinity of the vessel) requires additional numerical validation confirming the capacity and confirming safety during the mission. The main areas to be modified include:

- Active safety system based on the EFS floatation system, activated automatically (by indicators deployed on helicopter structure/ manually (activated by pilot) in the case of contact between the helicopter and the water surface.
- Passive safety system based on life rafts, activated together with flotation system in the case of contact between the helicopter and the water surface.
- anchoring system support landing and allows to safety fix helicopter to vessel deck.

Fig. 1 PZL SW-4 maritime version.

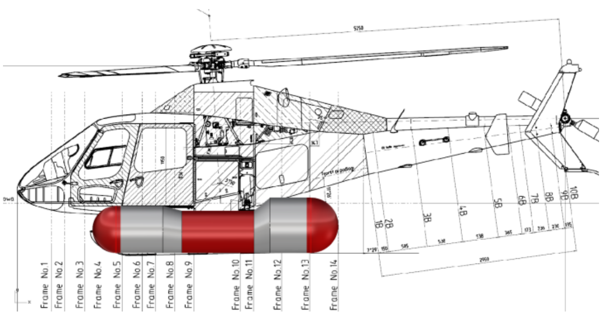

Fig. 2 Visualization of EFS in active mode.

An important area of issues requiring the use of the Co-Simulation methodology is the problem of interference disturbances generated by vessel (class T-23 frigate)

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(Fig. 3) and their impact on rotor performance during approach to landing on a vessel deck. The the landing procedure will be assessed when:

- general assessment of the impact of disturbances depending on the position of the helicopter relative to the vessel deck and EFS configuration(active rolled),
- general assessment impact on the helicopter rotor the turbulence generated by superstructure and exhaust gas generated by the vessel.
- general assessment impact on the helicopter rotor the turbulence generated by superstructure and exhaust gas the exhaust gas generated by the vessel in case of unintentional activation of the EFS system.

The Co-Simulation method takes into account the coupling of CFD analyzes with the numerical model of the rotor with the described VBM UDF algorithm, as well as the coupling of the result data with the internal software developed by PZL-Świdnik.

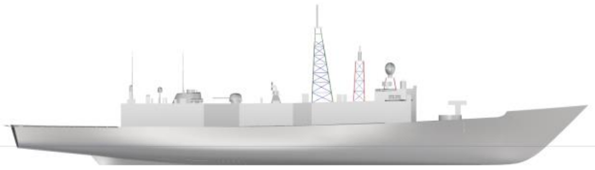

Fig. 3 Visualization of vessel[1].

2.2. Numerical description of helicopter

For evaluation of the impact changes in aerodynamic characteristics, is required comparative CFD analysis of the reference helicopter model and helicopter model with maritime modification. In case of reference numerical model that include main part of structure that is fuselage and vertical stabilizer, in case of maritime version model additionally include flotation system in different configuration. The predicted areas of analysis include aspect of helicopter performance, static and dynamic stability. The shape and external dimensions of the swimmers system were selected based on numerical analyzes and tank tests conducted by the CTO, in such a way as to ensure the sufficient helicopter buoyancy in accordance the definition presented in Advisory Circular AC 27.801.

From the point of view of flight safety, there is a risk of a failure EFS, during mission which a symmetrical or single float activated. As a result of activation, there is a sudden change in the current balance of the moment forces acting on the helicopter affecting on stability and basic performance.

From the point of view of completing the mathematical model of the helicopter [3], as well as calculation and analyzes aeromechanical problems. In this case is required to determine the aerodynamic characteristics for the configuration shown in figure below (Fig. 4)

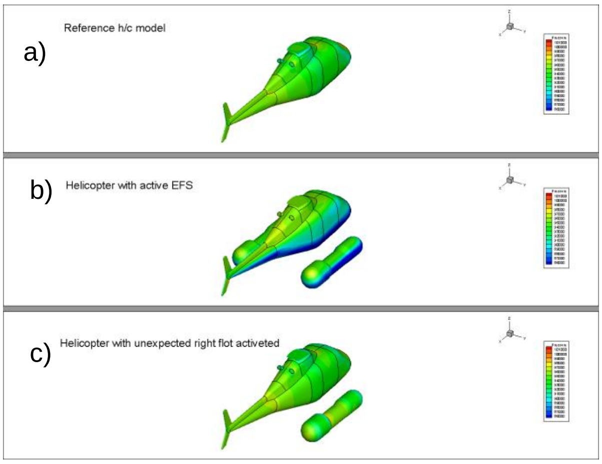

Fig. 4 Comparison h/c numerical model a) reference h/c model, b) helicopter with activwe EFS, c) helicopter with active right floats.

The above numerical models corresponding to the helicopter's configuration were used to assess the impact of marine equipment fitting on aerodynamic characteristics:

- Helicopter reference model including vertical stabilizer and engine exhaust collectors RR 250 C20R engine (Fig. 4a)
- Helicopter model with active EFS float system vertical stabilizer and engine exhaust collectors RR 250 C20R engine (Fig. 4b),
- Helicopter model with an active right float, vertical stabilizer and engine exhaust collector RR 250 C20R engine (Fig. 4c).

The numerical model is based on a triangular volume grid using a TET element and in the case of a boundary layer PRISM type elements were used. The discretization of the geometric model is based on the T-Grid solver. The generated elements are evaluated based on the SKEWNESS quality control factor of no more than 0.85 (Fig. 5). Each of the numerical models is in a similar computing space divided into zones:

- internal directly surrounding the helicopter model,
- external that is representation of environment are identical for each computational model.

Additionally, each of the above numerical models is equipped with a rotor represented by the VBM User Define Function, placed in the internal zone of the computing space (Fig. 6).

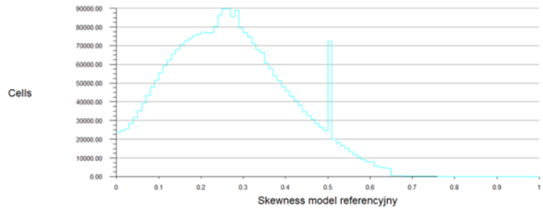

Fig. 5 Histogram of reference model skewness quality.

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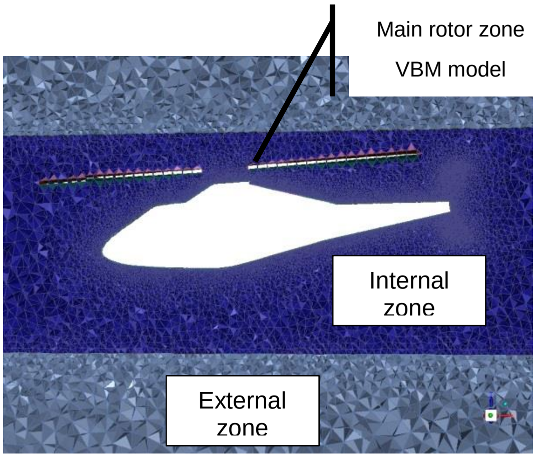

Fig. 6 Visualization of compiuting envirmoent.

2.3. Definition of numerical problem

The CFD numerical analyzes were divided into three groups:

- 1st, aimed at assessing the impact of the change in the value of aerodynamic coefficients Cl, Cd, Cm, as a resulting of installed on the helicopter EFS maritime equipment and its intended or unintentional activation. The values obtained during calculation, will be used to determine the basic properties of the helicopter's stability, and performance characteristics. Based on the reference values presented in table 1, aerodynamic characteristics for all calculation models were determined and the values will be used for modify mathematical helicopter model of SW-4 helicopter developed by PZL Świdnik and build a mathematical model, based on the FlightLab system[3].

- 2nd, aimed at assessing the impact of disturbances generated by the watercraft on the value and nature of the induced velocity distribution depending on the position relative to the vessel. Helicopter configuration used for calculations assumes the use of the rotor model described by VBM algorithms. The reference values of the rotor parameters are shown in table 2.

- 3th, analysis of aerodynamic characteristics of an isolated EFS system, for determine helicopter's fuselage turbulence influence.

Table 1 Reference value used for calculated aerodynamic characteristic.

nb	Name of parameters	Value/units
1	Main rotor Area	63.61 [m^2]
2	Density (ISA)	1.171[kg/m^3]
3	Enthalpy	289933.8[J/kg]
4	Length	1[m]
5	Pressure	95192 [Pa]
6	Temperature (ISA)	283[K]
7	Velocity	101[m/s](0.3 Ma)
8	Specific heat coefficient	1.4[-]
9	Viscosity	1.789E-05[kg/ms]

Table 2 Reference value used for calculated rotor interference.

nb	Name of parameters	Value/units
1	Main rotor Area	63.61[m^2]
2	Density (ISA)	1.209[kg/m^3]
3	Enthalpy	289994.5[J/kg]
4	Length	1[m]
5	Pressure	99992.27[Pa]
6	Temperature (ISA)	287[K]
7	Velocity	55.8[m/s]
8	Specific heat coefficient	1.4[-]
9	Viscosity	1.789E-05[kg/ms]
10	Rotor radius	4.5[m]
11	Rotor nominal speed	437 [rpm]

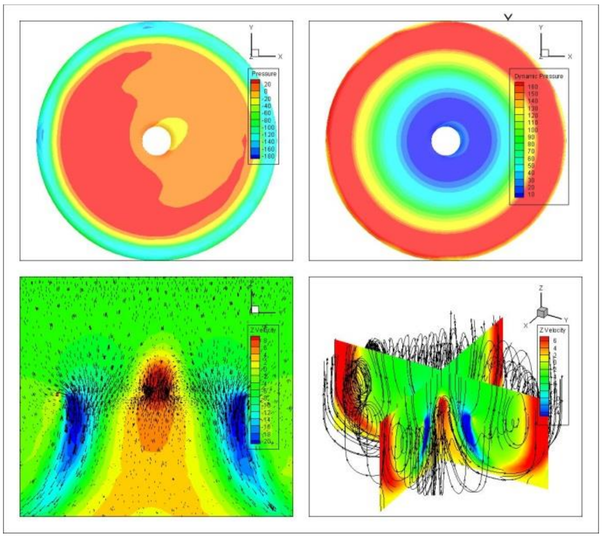

Fig. 7 Visualisation isolated Main Rotor describe by VBM UDF code.

2.3.1. Helicopter Aerodynamic characteristic

Based on the reference values adopted in Table 1 and the assumed boundary conditions values corresponding to the free-stream speed V_∞ = 0.3Ma, assumptions describing the characteristic cases of the β-side slip angles and α angles of attack the air flow relative to the fuselage, were defined and present on Fig. 10. The numerical analyzes of the characteristics and the tendency of change them relation to the base model take into account the case study of the isolated EFS

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system as well as the full helicopter's model. Comparative analysis of the above cases will allow to determine the impact of interference turbulence generated by EFS on the value of aerodynamic coefficients. The following figure shows a visualization of the computing environment (Fig. 8) an isolated EFS system Fig. 9 a helicopter fuselage with active EFS system.

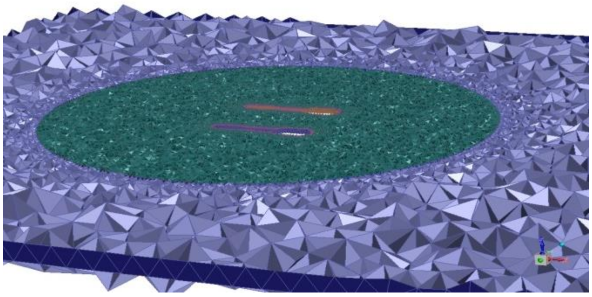

Fig. 8 Numerical model of isolated flotation system.

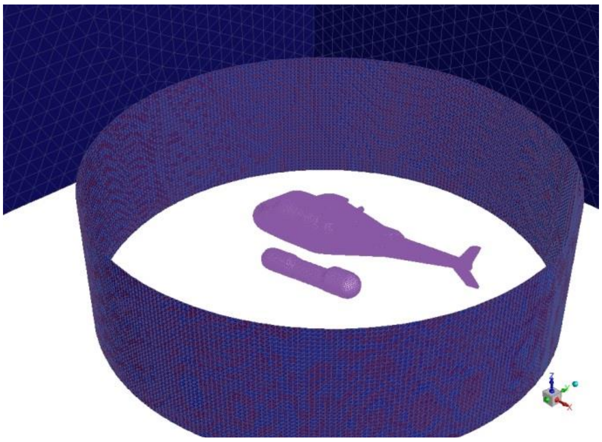

Fig. 9 Visualisation of grid mesh system helicopter fusilage with flotation system model.

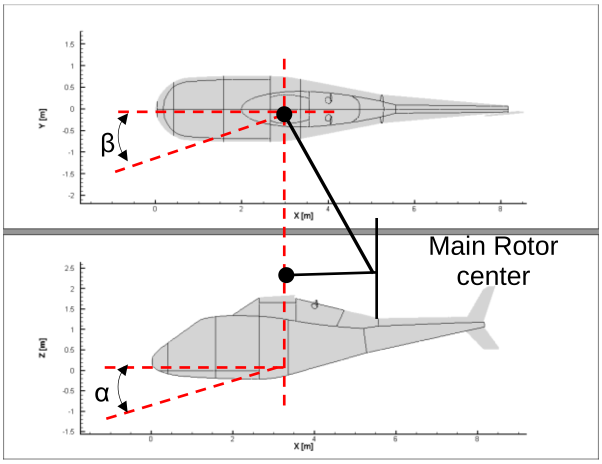

Fig. 10 Assumption parameters of CFD analysis.

For numerical analysis, CFD were used a Density-Based solver, computing governing equations of continuity, momentum. A standard SST K-ω type turbulence model with additional energy equations was used. The air model was described by the Ideal-Gas model with the Sutherland three-parameter model of viscosity.

The boundary conditions were defined by the Pressure Far-Field model, where parameters such as the speed of incoming air, inflow angle, static pressure (stagnation), ambient temperature parameters according to ISA atmosphere dependencies and in accordance with the following equations (1)(2) were determined. Values of carrier forces Cl and resistance forces Cd are determined for reference parameters values specified in table 1. The values of aerodynamic moments Cm-x, Cm-y, Cm-z are determined relative to the center of the hub (Fig. 10). The following equations describe the assumed relationship between the stagnation pressure and the ambient pressure of the tested object:

The following equations describe the assumed relationship between the stagnation pressure/temperature and the ambient pressure/temperature of the tested object:

$$\frac{p_o}{p} = \left[1 + \left(\frac{\gamma - 1}{2}\right) M^2\right]^{\frac{\gamma}{\gamma - 1}} \quad (1)$$

$$\frac{T_0}{T} = 1 + \left(\frac{\gamma - 1}{2}\right) M^2 \quad (2)$$

Where:

P_0 - reference pressure 101325[Pa]

T_0 – reference temperature 288[K]

γ- gas constant

M- Mach numer

The figures below present the results of analysis of aerodynamic characteristics of the entire helicopter as well as comparative results for the isolated EFS system.

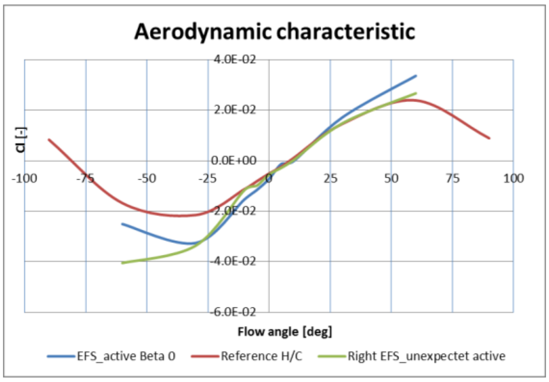

Fig. 11 Characteristik of lift coficient Cl.

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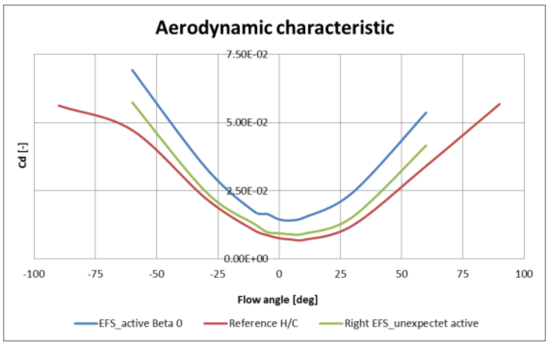

Fig. 12 Drag coficient characteristic Cd.

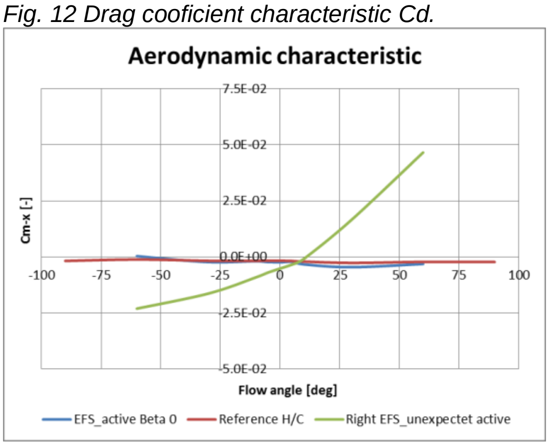

Fig. 13 Characteristic moment coefcient along X axis.

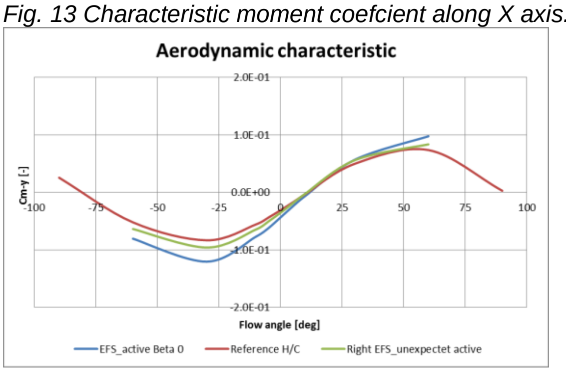

Fig. 14 Characteristic moment coefcient along Y axis.

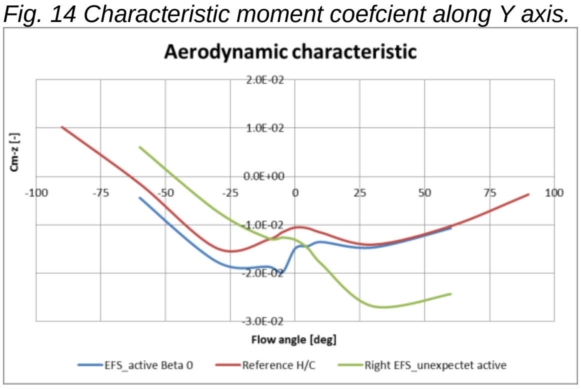

Fig. 15 Characteristic moment coefcient along Z axis.

The determined aerodynamic characteristics will be used to supplement the FlightLab mathematical model of the PZL SW-4 helicopter [3], as well as for internal programs describing the helicopter's flight mechanics and performances aspect.

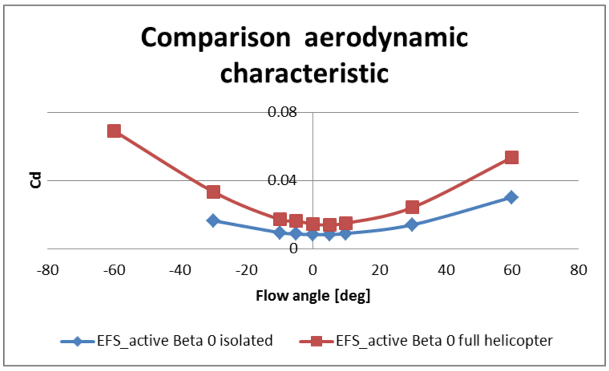

Fig. 16 Comparison aerodynamic characteristic between full helicopter model and isolated EFS model.

2.3.2. CFD analysis of helicopter rotor vs vessel interaction

The cooperation of the light helicopter, which is PZL SW-4 with a vessel class T23 frigate with an helideck located at the stern of the ship, requires the assessment of the impact of disturbances generated by the ship and interaction with the rotor. An important element of the analysis is the assessment is impact of turbulence on size and character rotor induced velocity, depending on the position relative to the helideck, as well as the value of requirement power and thrust in the case of trimmed and untrimmed rotor (longitudinal and lateral moment).

As a calculation model use vessel, with the shapes of superstructures and main dimensions similar to the frigates T23, with a draught T=4.5m was selected. The main dimensions of the watercraft are shown in the following table 3.

Table 3 Main data of the vessel[2]

	Symbol	Unit	T=4.5 m
Length, overall	L_{OA}	[m]	136.00
Length between perpendiculars	L_{PP}	[m]	121.00
Length of waterline	L_{WL}	[m]	124.75
Breadth at waterline	B	[m]	13.40
Draught: fore	T_F	[m]	4.50
Draught: aft	T_A	[m]	4.50
Displacement volume	V	[m^3]	3577
Area of wetted surface	S	[m^2]	1743

In the following figures (Figures 18 a), b), c))present helicopter position sequences relative to the vessel deck, for a non-slip flight on the azimuth that coincides with the vessel center of symmetry(ϑ=0[deg]). Three calculation positions were selected for the analysis; a) far away position with minimal effect of disturbances generated by the vessel and without influence of the ground effect, b) intermediate position where the helicopter is in the area of disturbances generated by the ship and minimal ground effect disturbances, c) position, where the object is in strong the field of disturbances generated by the ship, as well as located in the zone with the proximity of the ground effect. The speed of the vessel Vs=20kts(flow around hull) was adopted for the analysis, and for the average wind speed Vw1=12.55m/s [4].

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The main parameters of the vessel are shown in table 3. Diagram of the analyzed directions of inflow in relation to the landing area is presented on figure 17.

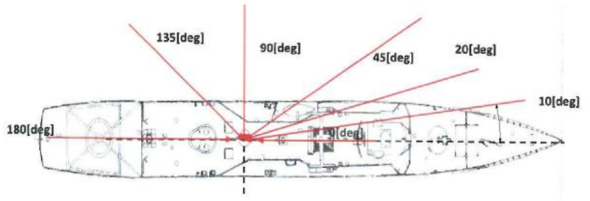


Fig. 17 Wind angles ϑ

On the basis of detailed numerical analyzes of the vessel carried out by the CTO [2], were defined a critical areas potentially dangerously for which the analysis of disturbance influence on rotor was carried out taking into account the helicopter EFS system configuration.

The analyzed inflow directions defined by the angle ϑ are shown in Figure 17,

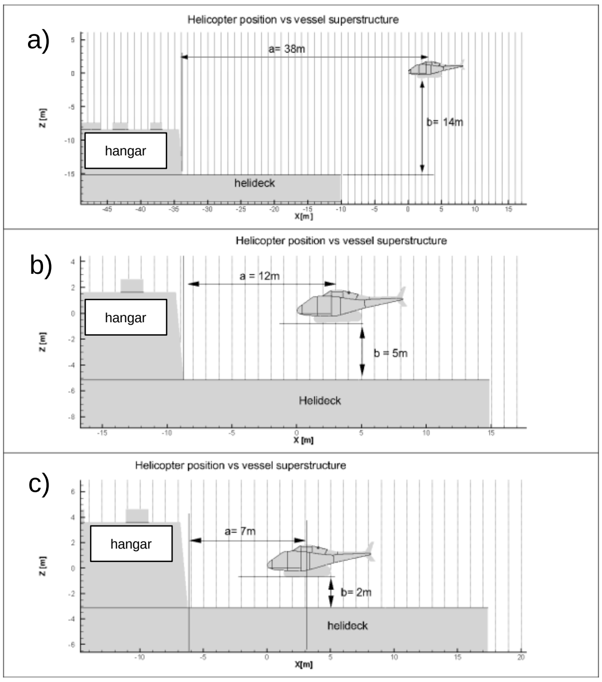


Fig. 18 Helicopter postion relative to vessel helideck.

For each calculation item show in figure above(Fig. 18) a), b), c) the induced velocity distribution is determined for the case when the helicopter rotor is trimmed and when computational analysis was carried out for a helicopter with an average take-off weight TOW=1650kg, at an ambient temperature of T = 288K (15°C). The figure below shows the trend of induced velocity measured in two measurement cross-sections, i.e. in close proximity to the rotor and a slight distance from ground level (landing zone). The analysis of the course of induced velocity values was carried out for cases in which the rotor remains in equilibrium as well as in the case when there is untrimmed in the range of pitch and roll moments.

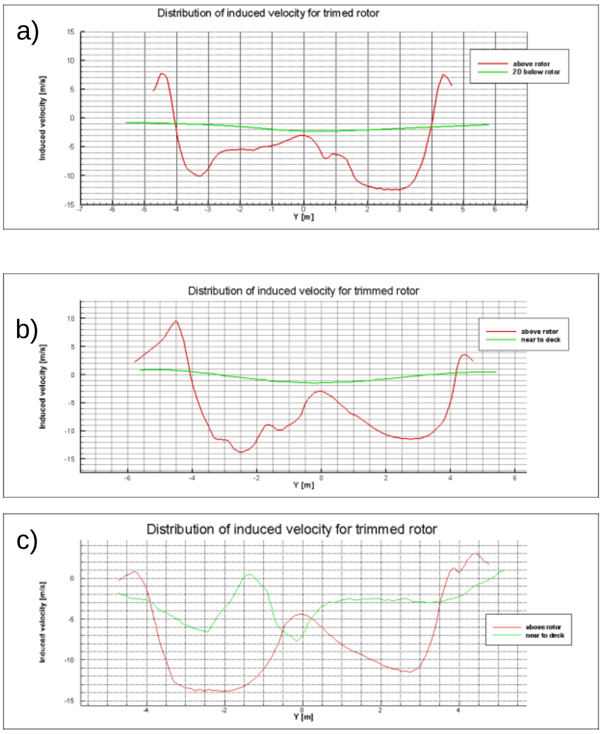
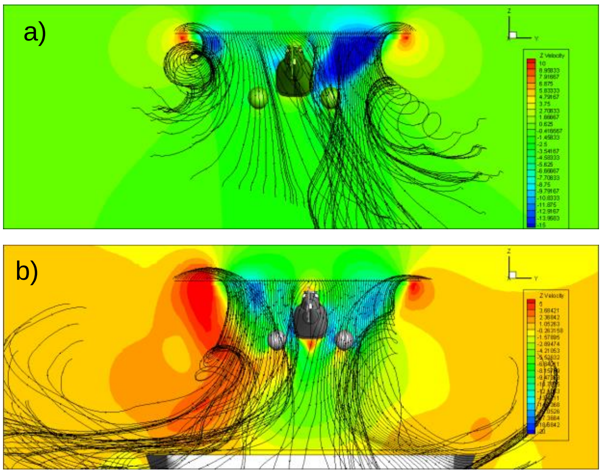


Fig. 19 Distribution of induced velocity terms of vessel position –trimmed rotor.



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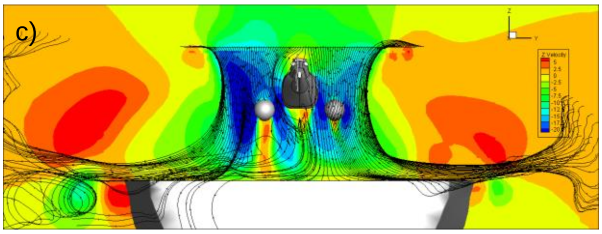

Fig. 20 Distribution strimlines generated by rotor during landing on vessel helideck-trimmed rotor

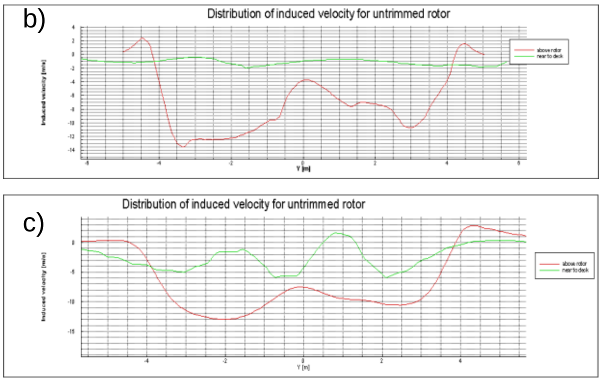

Fig. 21 Distribution of induced velocity terms of vessel position –untrimmed rotor

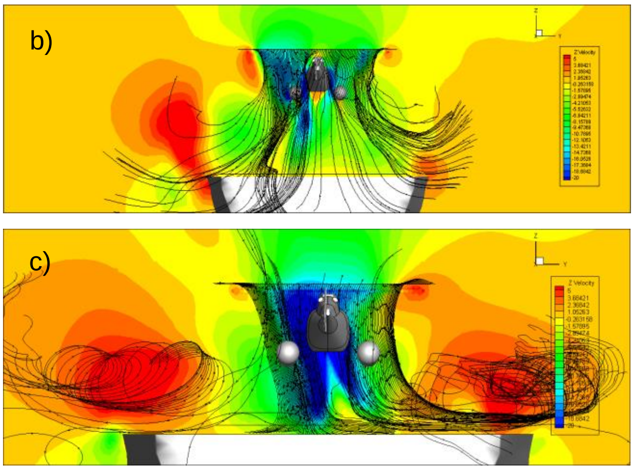

Fig. 22 Distribution strimlines generated by rotor during landing on vessel helideck-untrimmed rotor

On the basis of detailed numerical and laboratory analyzes of disturbances generated by the vessel [1][2], was determined the envelope of measurement cases for which was made detailed analysis of rotor response. The PZL SW-4 helicopter belongs to the class of light helicopters with the maximum take-off mass MTOW = 1800kg, therefore it is a susceptible object, more exposed to disturbances in the form of turbulence generated by superstructures and exhaust gases generated by the vessel (exhaust gas flow T- 23 class frigate ~ 39[kg/s], t=260°C [5]). The following figures 23, 24 show a visualization of a helicopter position in the area of vessel helideck being in the disturbances field generated by air flow around vessel superstructures and exhaust gases. The analyzes carried out are important from the point of view of the evaluation of distribution induced velocity as well as in case of changes in the require power demand.

Fig. 23 Exhoust gasses distribudion-flow angle ϑ= 0[deg] [2].

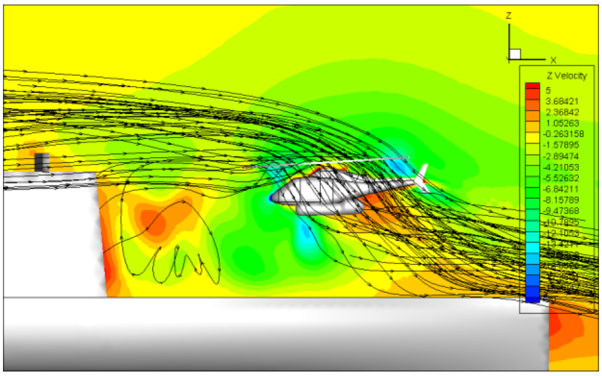

Fig. 24 Influence of Exhoust gasses on helicopter rotor - flow angle 0[deg].

2.4. Co-Simulation aspekt in performance analysis

Based on the numerical analyzes aerodynamic characteristics of the helicopter adapted to perform maritime missions, the basic performance characteristic were defined based on the Co-Simulation analysis methodology using coupling with internal flight mechanic software delivered by PZL-Świdnik, using the equations of the flight motion. The basic performance was determined depending on the type of performed mission. The following operations were considered in the:

Type of maritime mission:

- Patrol.
- Transport.

Ambient atmospheric conditions:

- temperature ISA-20, ISA, ISA +20,
- take-off and landing ceiling SL,
- flight altitude: 0-500 m,

- fuel reserve 30 min,
- helicopter mass configuration TOW=1800kg EFS rolled. The geometric parameters of the flotations system were adopted in according buoyancy test results in HELIMARIS project.

In below table 4 presents comparative performance results of a helicopter with rolled and active EFS in the case of maritime mission.

Table 4 Performance characteristic for helicopter equipet with flotation system.

Parameters definition	H/C + maritime equipment
IGE, OGE hover celling	Without change
Dynamic celling on MC power	Without change
Climb speed	Without change
Max speed on MC power, SL	Less ~ 5.5km/h
Range, SL	Less ~ 3.5%
Endurance	Without change

Comparative analysis of helicopter performance in the event of unintentional activation of floats is as follows:

- Analyzing the course of the required power in the function of speed, it is stated that in the case of a flight with open flotation and flights with complex, it increases for a speed of V_{IAS}= 100 km/h.
- The maximum speed for a helicopter with symmetrically flotation opened is reduced by 12 km/h.
- The flight endurance from speed V_{IAS}= 100 km/h is comparable for both swimmers configurations, the difference is not greater than 1%.
- Flight range for speed V_{IAS}= 180 km/h with activated flotation system is 8% smaller compare to flight with rolled EFS.

The following figure 25 shows the visualization of the required power as a function of the flight speed for the EFS configuration (active, rolled)

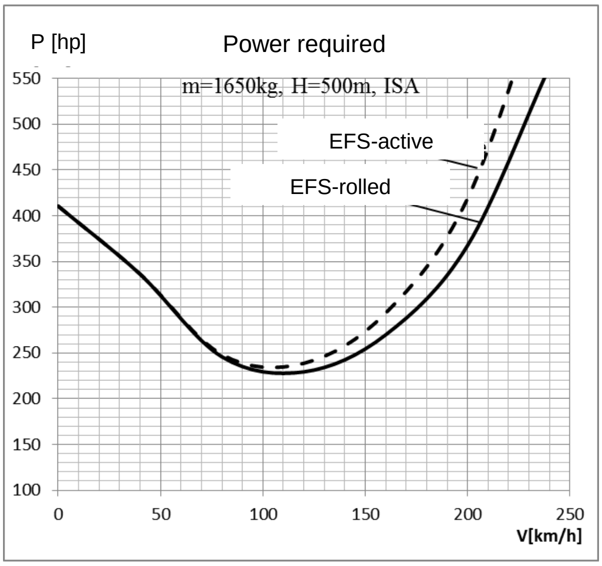

Fig. 25 Power required for horisontal flight.

2.5. Co-Simulation aspekt in helicopter stability

Another use of the Co-Simulation method is the coupling between CFD analyzes and algorithms related to static and dynamic stability of the helicopter. On the basis of aerodynamic data coupling resulting from CFD analysis, and algorithms responsible for the flight mechanics of the PZL SW-4 helicopter, equipped with basic equipment, required in maritime operations, after failure, consisting of unintentional filling of one or both floats, it is stated that the test object has a tendency to tilt and lower the flight, as well as to move sideways from the intended flight trajectory. Depending on the time of failure and consideration of the pilot's reaction:

In the case of pilot's delay of 1s, the control pilot's take-off allows to quickly extinguish the angular oscillation of the helicopter:

- yaw angles do not exceed 5deg,
- decrease of flight speed ~4m,
- deviation from the flight trajectory ~4-7m.

In the case of pilot's delay of 3s:

- yaw angles do not exceed 8deg,
- decrease of flight speed ~10m,
- deviation from the flight trajectory ~20m.

Inflate floats during the flight, without the pilot's reaction in the control causes:

- after 9s from the moment of failure, lowering the altitude ~ 50m,
- increase in flight speed by 5m/s,
- increase in descent speed by 8m/s,
- increase side speed up to 20m/s,
- deviation from the flight trajectory ~65m.

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Based on the numerical analyzes carried out, it is stated that the pilot having the entire control range at his disposal can minimize linear displacements and angular velocities resulting from unintentional inflate floats, as the simulation assumptions cover only 18% of the control range. The following figures 26-28, shows the visualization of the linear speed change in particular directions in the case of:

- All flotation inflate

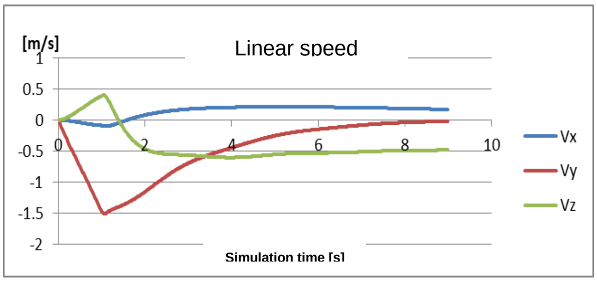

Fig. 26 Helicopter linear velocity after EFS activation

- Left flotation inflate

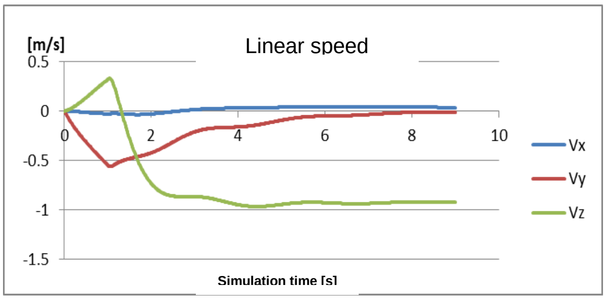

Fig. 27 Helicopter linear velocity after EFS activation

- Right flotation inflate

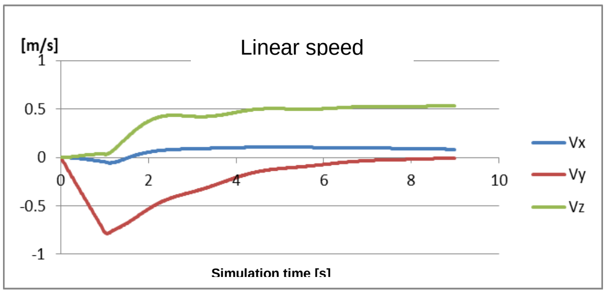

Fig. 28 Helicopter linear velocity after EFS activation.

3. SYNTHESIS OF RESULTS

The article presents a calculation based on Co-Simulation methodology enabling the implementation of tasks aimed at modernizing the PZL SW-4 helicopter allowing to perform maritime operational.

The presented analyzes were aimed at assessing the helicopter's capabilities to perform maritime mission and cooperation with vessels. An additional goal of the analytical work was to supplement the basic helicopter numerical models developed by PZL Świdnik, in the maritime version, as well as to supplement the data of the mathematical model in the FlightLab environment [3]. From the point of view of the parameters being evaluated, i.e. helicopter stability and basic performance, the modernization involving the installation of the EFS flotation system does not significantly affect the reduction of operational helicopter aspect, significantly increasing the security values. Obtained data of dynamic helicopter response can be used to pre-tune the autopilot executive system

The presented methodology of calculations also allows for validation of the landing approach procedure, enabling the assessment of the influence of turbulence generated by the vessel on the rotor, depending on the configuration of the helicopter equipment.

Further implementation of the tasks defined in the Helimaris project, thanks to the tank and tunnel tests performed by the CTO, as well as through tests on the real object during the flight trials, that will be conducted by PZL Świdnik, will allow to validate mathematical helicopter model. The data obtained in this way allows further modification of the interaction between numerical models.

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