Aero Sekur

Floatability: The use of simulation for the helicopter seaworthiness (Case study)

Summary

- Scope of presentation
- The case study
- Validation protocol
  - Generalities
  - Validation of the model
  - Verification of the helicopter stability
  - Verification of the helicopter stability (with kit “underbelly fuel tanks”)
- Why simulation?

Scope of presentation

The presentation describes the approach and the activities performed to remove limitations on the AW189 helicopter relevant to the lateral CG position for operations in conditions more severe than sea state 4.

The case study

The case study was represented by a specific helicopter mass/CG, characterized by a significant lateral CG offset, position in “cabin flooded” condition.

The model capsized during tests in this configuration/condition at sea state 6. The way to achieve the cabin flooding (holes drilled on the helicopter model belly) was not fully representative of the real helicopter. This may have induced a non-realistic behavior, resulting in the capsizing.

It is worth noting that this was the only test failed during the campaign. In particular, the test in the same conditions and no water in cabin was passed.

The target was to substantiate that, under those conditions and in a more representative configuration, the helicopter is capable to stay upright.

Validation protocol

Aero Sekur and Leonardo Helicopters have proposed the use of an analytical simulation tool, with the intent to substantiate buoyancy of the rotorcraft for the case study.

EASA has agreed on use of simulation, in the specific case, as a complement to the results of the extensive scale model testing conducted for the type certification of the AW189.

Validation protocol - Generalities

Validation of the model through correlation with towing tank tests

Selection of significant configurations for correlation

Verification of the helicopter stability in the study case configuration

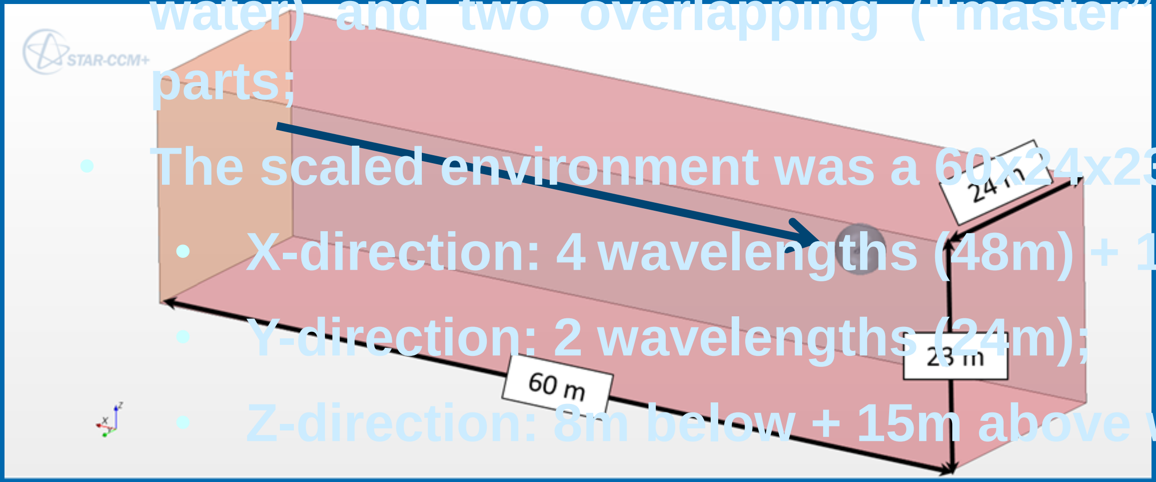
Verification of the helicopter stability in other variants ("underbelly fuel tanks")

On these models additional configurations (over the study case) have been simulated for stability verification

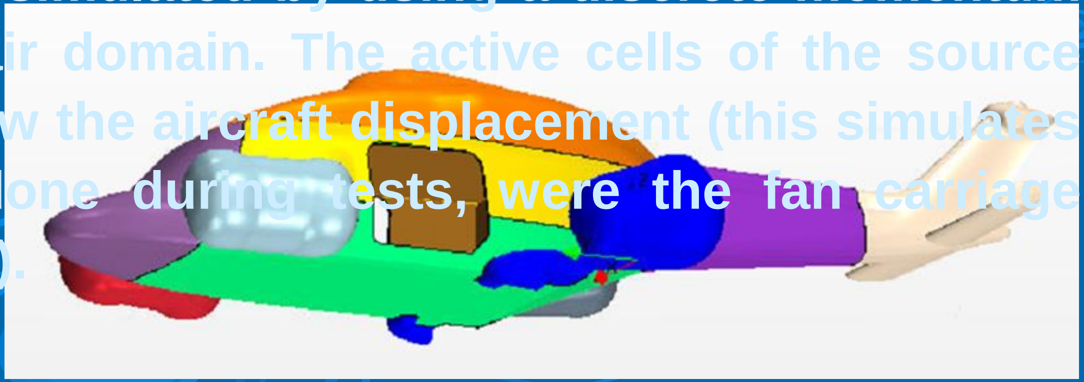
Substantiation of seaworthiness capability for the mass/CG configuration up to sea state 6 with cabin doors open

Model description

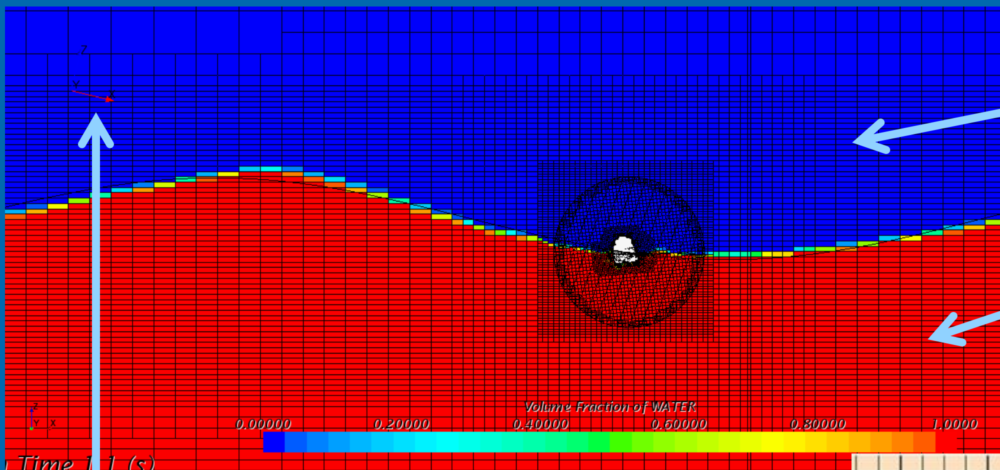
- The fluid domain consisted in two immiscible phases (air and water) and two overlapping (“master” and “slave” meshes) parts;



- The scaled environment was a 60x24x23 meters box:
  - X-direction: 4 wavelengths (48m) + 12 meters for damping;
  - Y-direction: 2 wavelengths (24m);
  - Z-direction: 8m below + 15m above water free surface.
- The wind has been simulated by using a discrete momentum source within the air domain. The active cells of the source were moved to follow the aircraft displacement (this simulates what is normally done during tests, were the fan carriage “follows” the model).



Model description



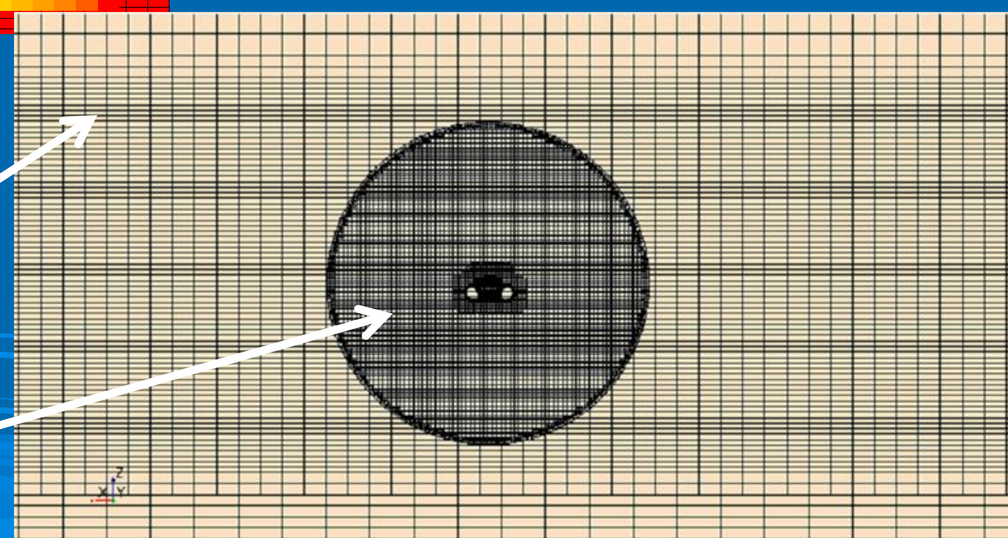
Air

Water

Fan (wind source)

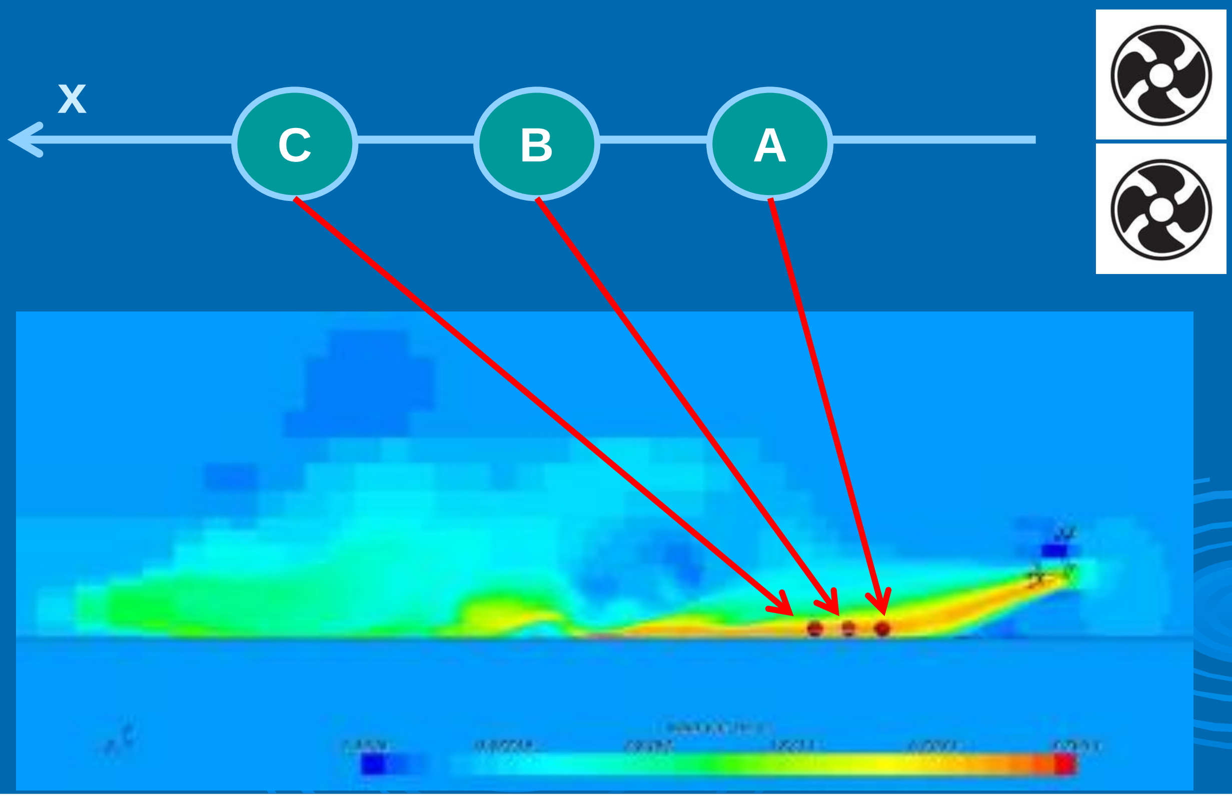
Master mesh

Slave mesh



Model description

The “wind fan” has been tuned to verify the consistency of the simulated condition with the test setup (which was verified using three anemometers).



Model description

Possible causes of mismatch between simulation and tested model have been preliminarily investigated.

	TOWING TANK TEST	SIMULATION	MISMATCH
Initial condition	Vehicle is placed in calm sea, then waves gradually increase and wind is applied after the first nominal wave	Vehicle gradually dropped in fully developed sea and nominal wind	Higher roll oscillation in the simulations during the first seconds of analysis
Fan position & orientation	Manual control on the wave tank carriage	Numerically controlled, in relation with the H/C velocity to keep a fixed distance	Vehicle dynamics (especially yaw rotation)
Water tank side walls	H/C approaching side walls after a certain number of waves	Side walls are not represented	Vehicle dynamics (reduced displacement and rotations)

Validation protocol

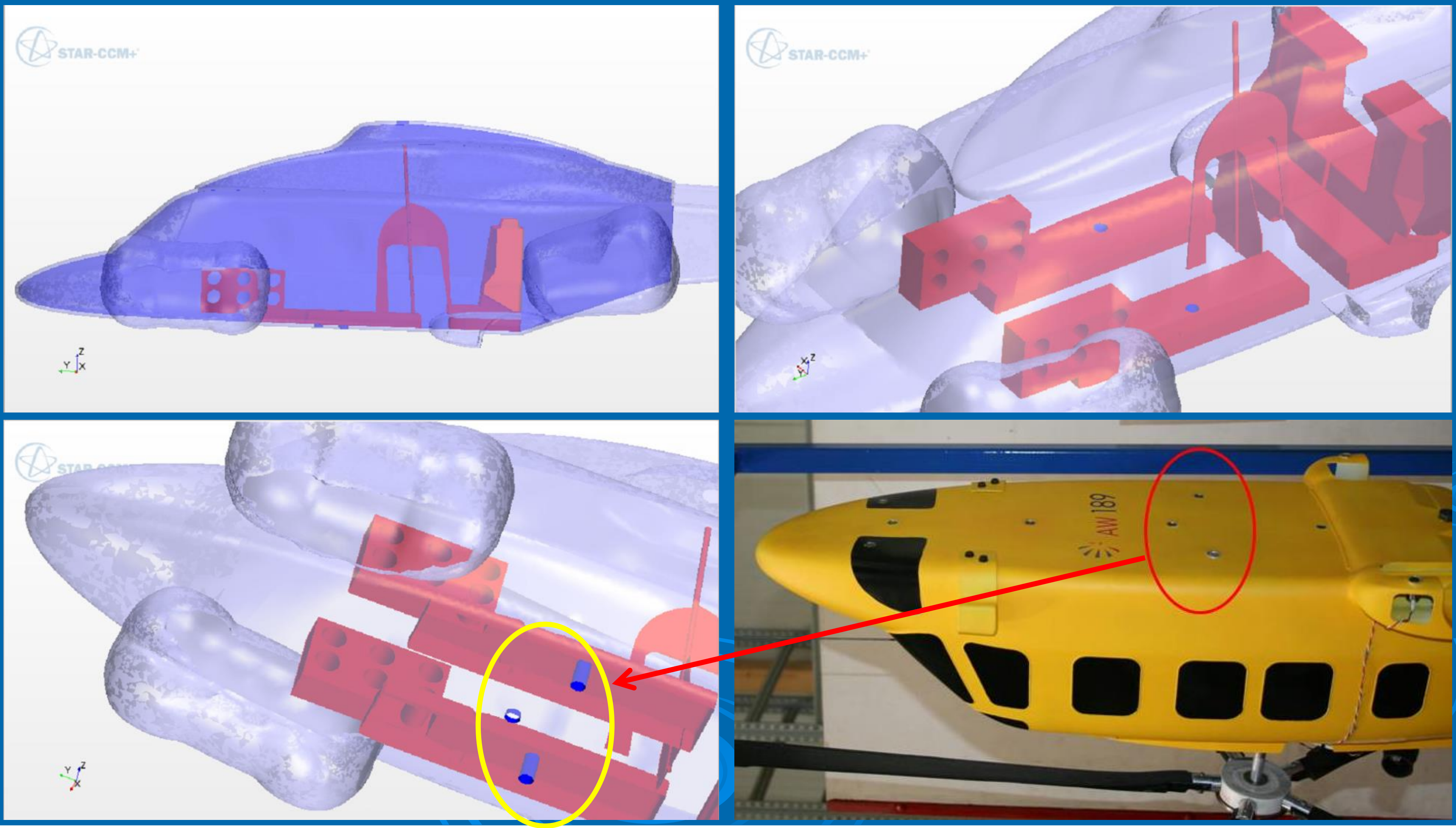
Validation of the model

This phase consisted in:

- **building a FEM model <u>corresponding to the scaled helicopter mock-up</u>, including internal volumes and holes drilled to achieve flooding during tests;**
- **selection of a number of significant test cases to be simulated (5 different mass/CG configurations);**
- **analysis run and correlation between the movies kept during towing tank tests and simulation.**

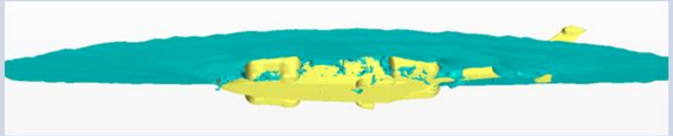
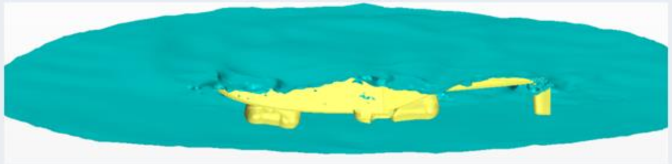
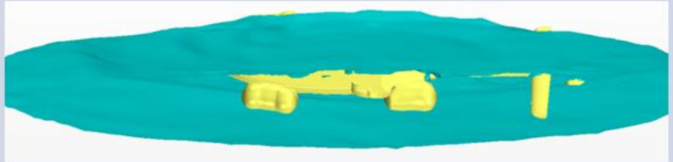
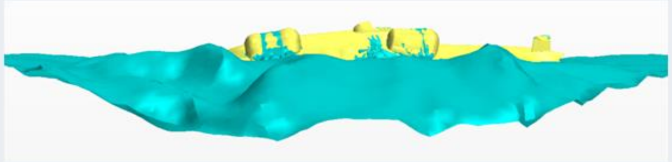
Validation protocol

Validation of the model



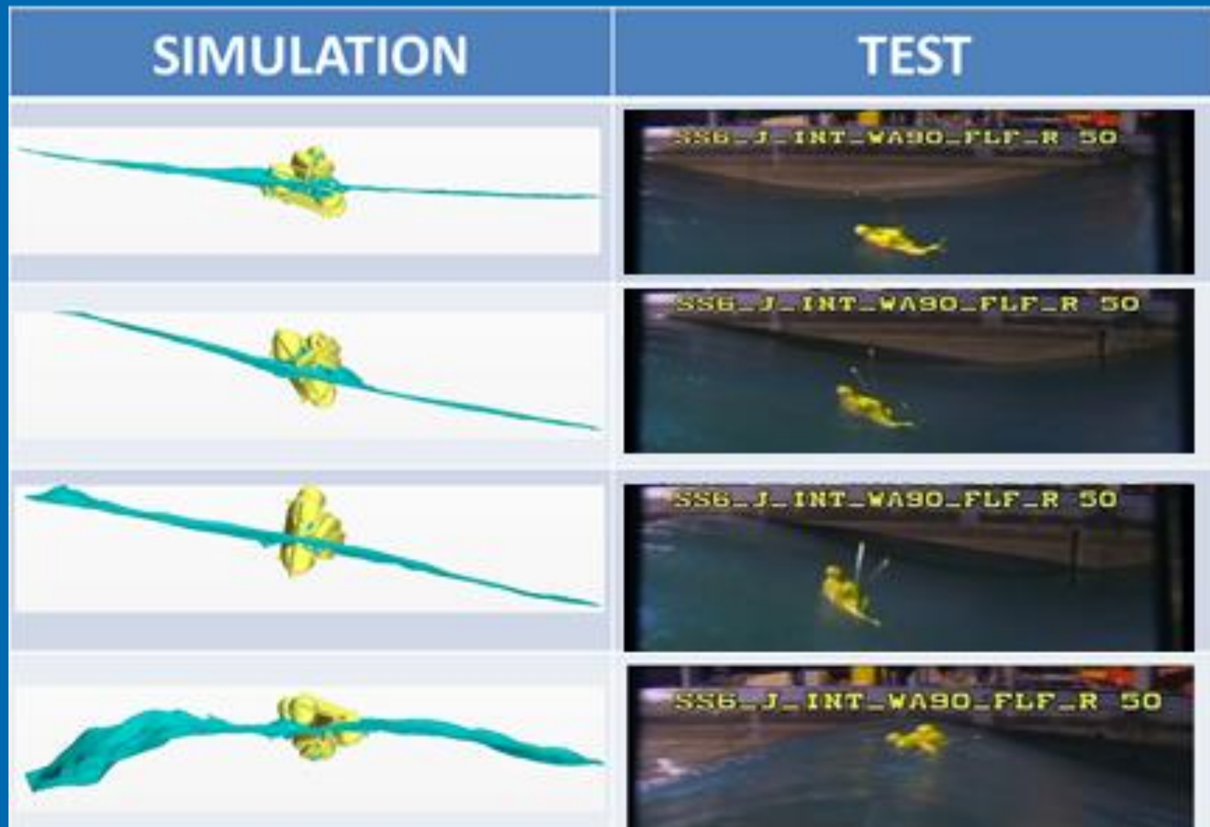
Validation protocol

Validation of the model

SIMULATION	TEST
	
	
	
	

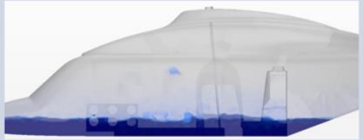
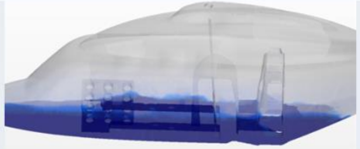
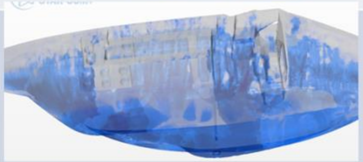
Validation protocol

Validation of the model



Validation protocol

Validation of the model

SIMULATION	NOTES
	Initial condition – water inside cabin
	
	
	
	

SIMULATION	NOTES
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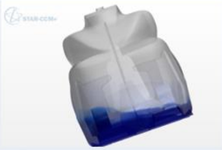
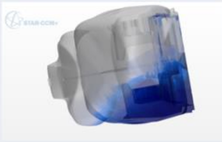
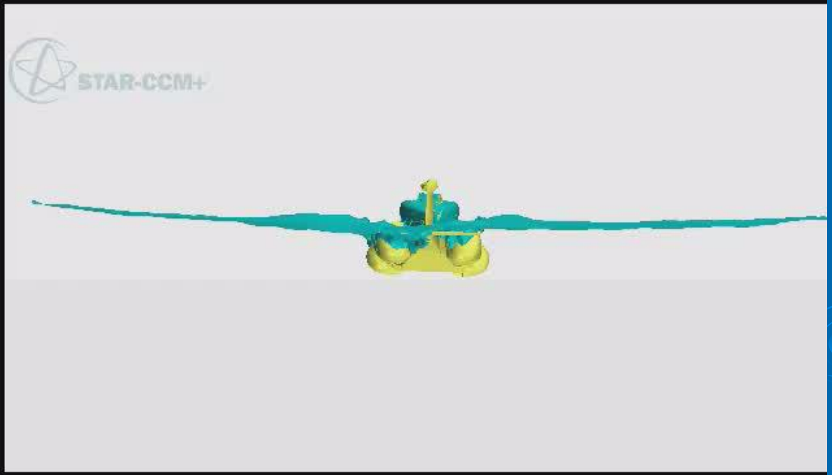
	
	
	
	

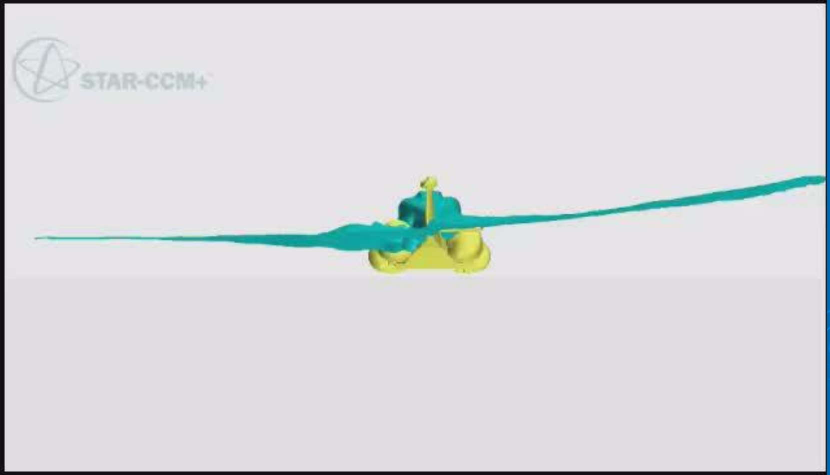
Validation protocol

Validation of the model



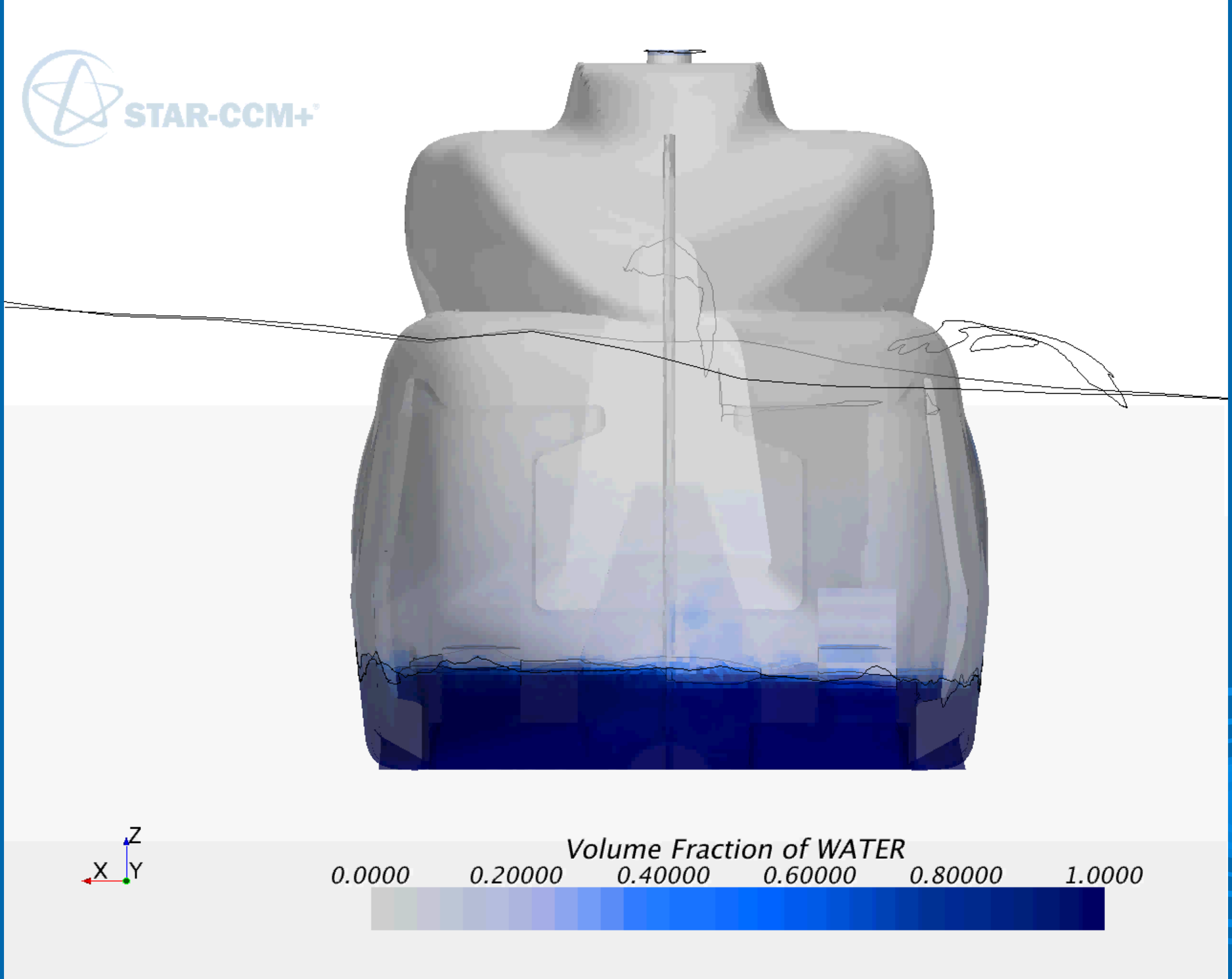
Validation protocol

Validation of the model



Validation protocol

Validation of the model



Validation protocol

Validation of the model

Two main results have been achieved:

- **a consistent correlation between tests and simulation, in terms of helicopter behavior in all the selected cases, including capsize dynamics of the case failed during tests;**
- **as the analysis allows to monitor the “internal” water domain, it has been recognized that the capsizing was induced by the swashing of the water entrapped inside the cabin.**

Validation protocol

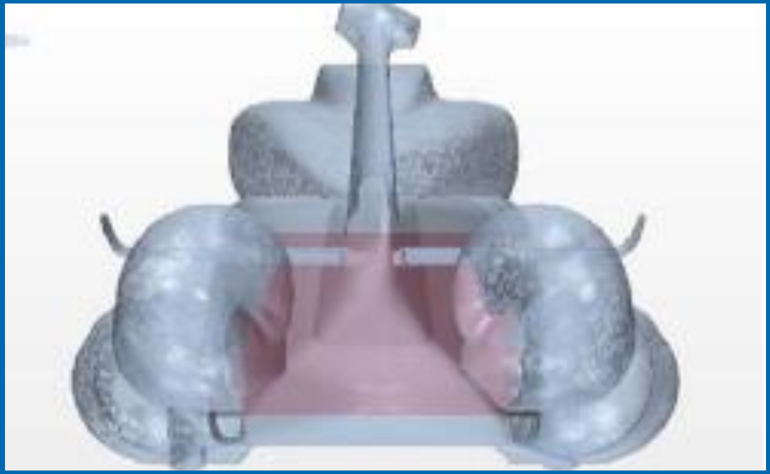
Verification of the helicopter stability

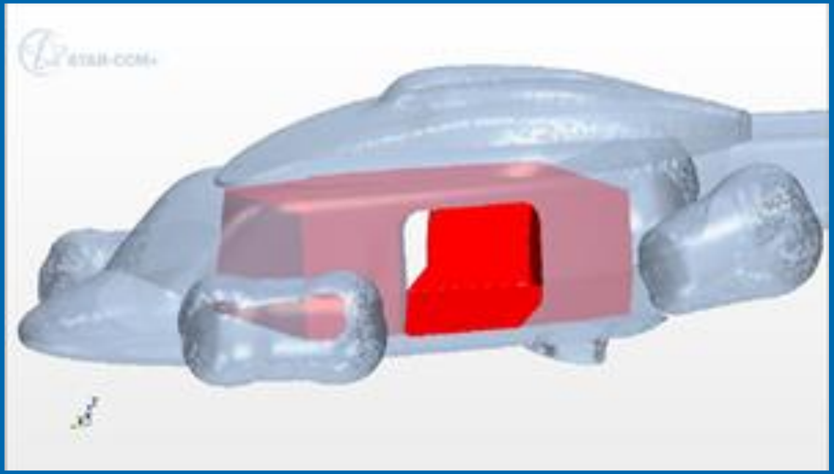
This phase consisted in:

- **building a FEM model corresponding to the helicopter with doors open, in order to represent the realistic scenario;**
- **selection of additional mass/CG configurations (over the case study) to verify the helicopter stability;**
- **analysis run and verification of the helicopter behavior.**

Validation protocol

Verification of the helicopter stability





Validation protocol

Verification of the helicopter stability

Validation protocol

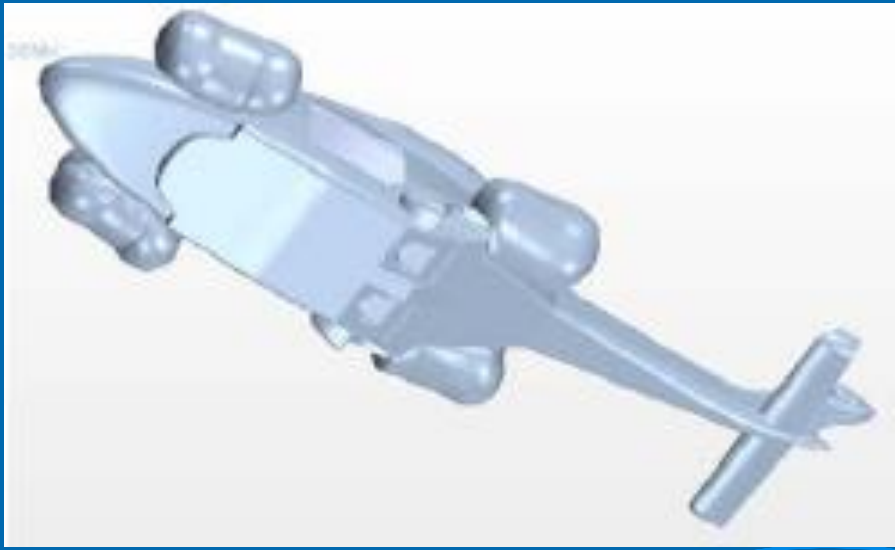
Verification of the helicopter stability with kit “underbelly fuel tanks”

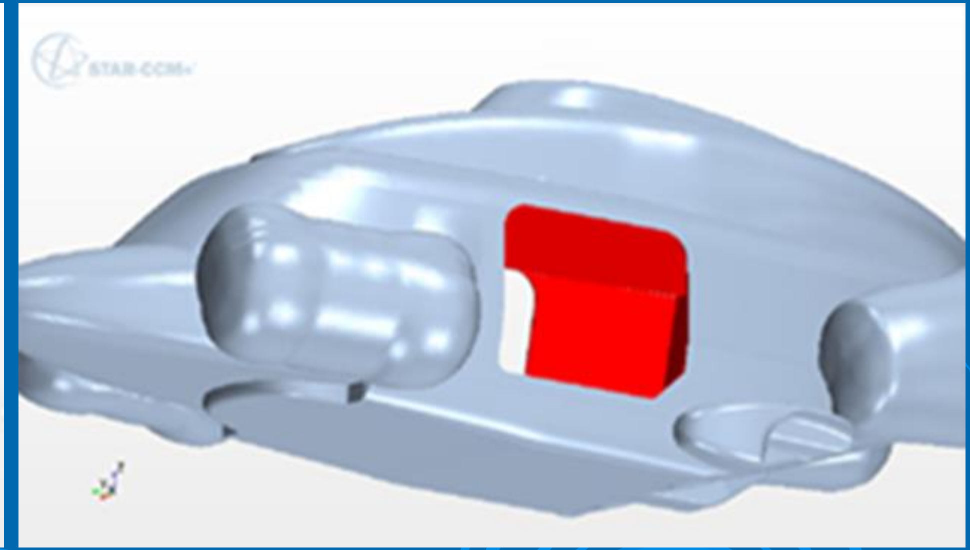
This phase consisted in:

- **building a FEM model corresponding to the helicopter “underbelly fuel tanks” variant with doors open;**
- **analysis run and verification of the helicopter behavior.**

Validation protocol

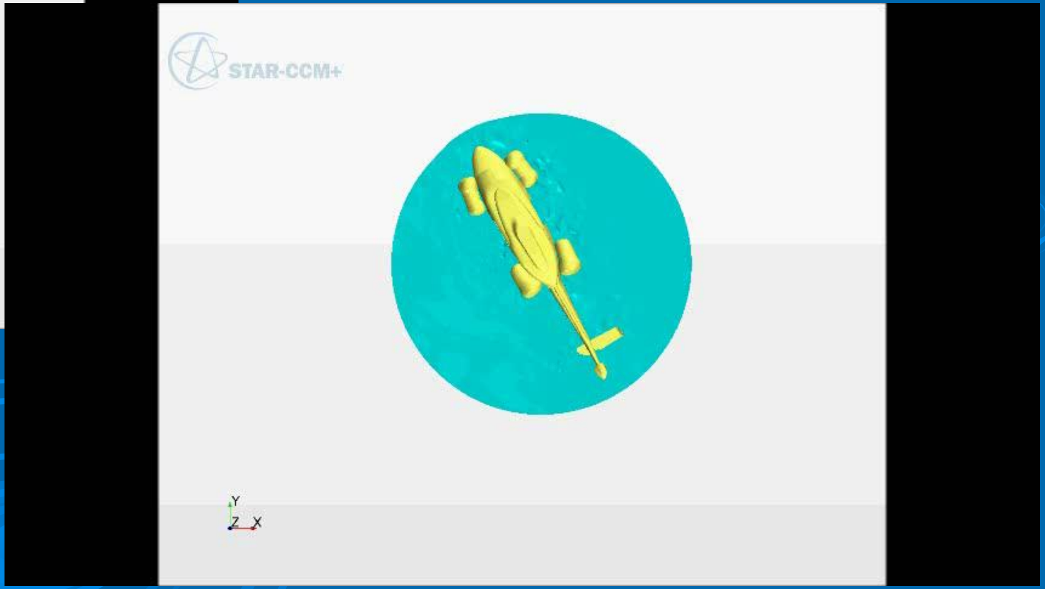
Verification of the helicopter stability with kit “underbelly fuel tanks”





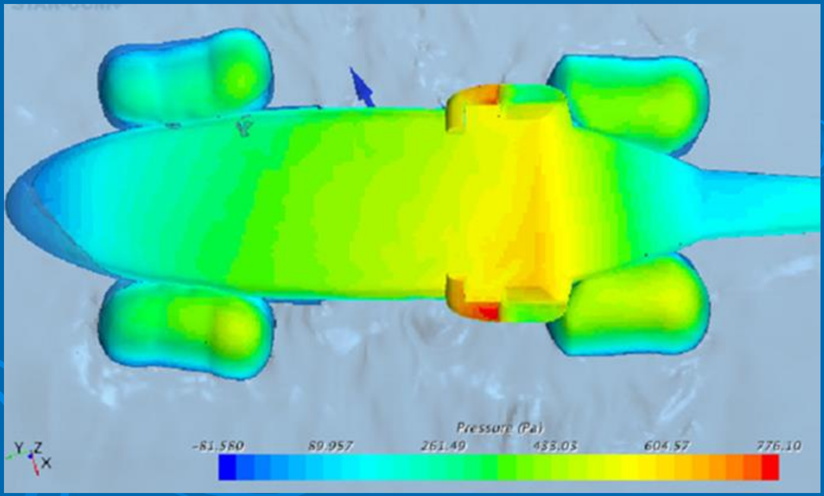
Validation protocol

Verification of the helicopter stability with kit “underbelly fuel tanks”



Why simulation?

- **No limits in the environment definition (irregular, crossed waves, wind, ...;**
- **Possibility to simulate full scale phenomena;**
- **Possibility to evaluate the marginality of the certification limits;**
- **Possibility to monitor and record a wide set of physical variables (pressure on fuselage, cinematic and dynamic characteristics, …);**
- **Possibility to optimize the design;**
- **Possibility to extend certification to aircraft variants without additional test campaigns.**



Why simulation?

Evolutions:

- **Methodology can be validated. Tests should be “think correlation”;**
- **More realistic floats simulation: “hinged” to the helicopter, flexible;**
- **Study of ditching phase.**

Why simulation?

A more extensive use of simulation, in correlation with tests, may:

- **provide the Industry with a flexible and reliable tool to design and optimize the safety equipment;**
- **provide the Agency with a new/alternative certification approach, with a wider number of fully recordable information, remarkably improved adherence to the real event and capability to represent all the parameters without any physical or geometrical limitation.**

Thanks for your attention