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Undersea Defence Technology
13-15 May 2019
Stockholmsmässan, Sweden

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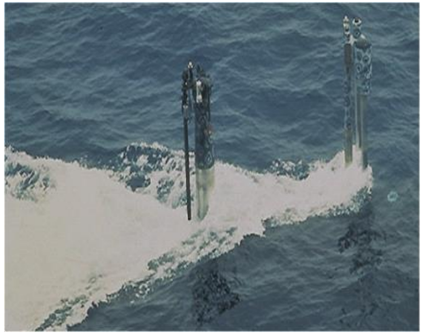
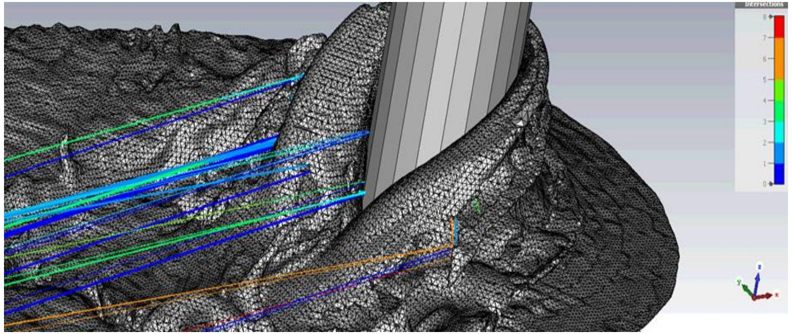
Simulation of radar cross section (RCS) of the wake of a submarine at periscope depth

Eric Letouzé, Naval Group





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Summary

- Introduction
- CFD computation of the wake
- RCS computation
- Influence of several parameters on the RCS of the wake

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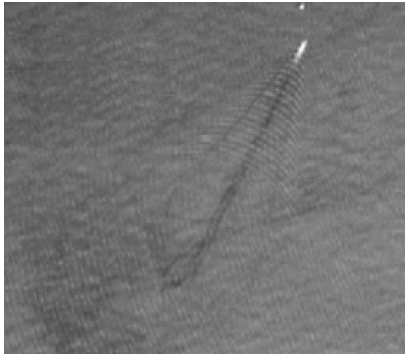
Introduction

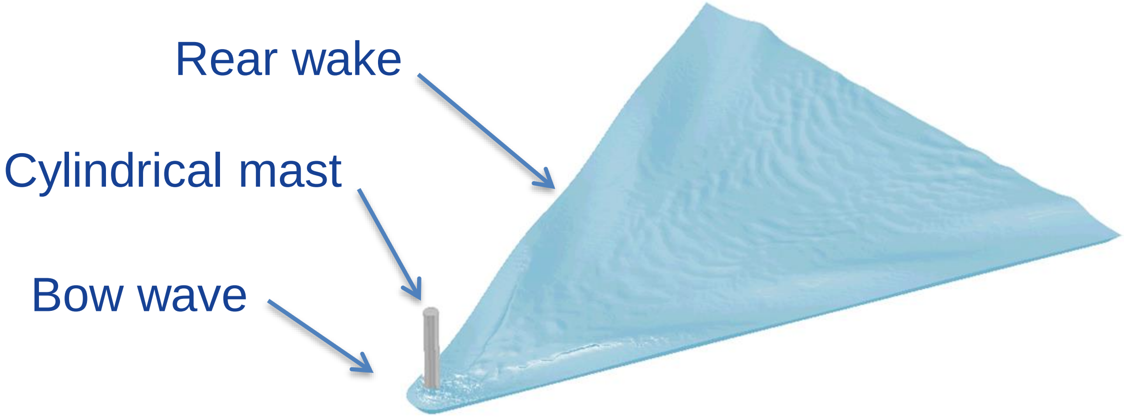
The evaluation of the radar signature of a submarine at periscope depth must consider not only the RCS of the mast and the sensor but also the RCS of the wake.



Introduction

This presentation focus on the evaluation of the RCS of the wake generated by a cylinder moving on a linear trajectory with a certain speed.

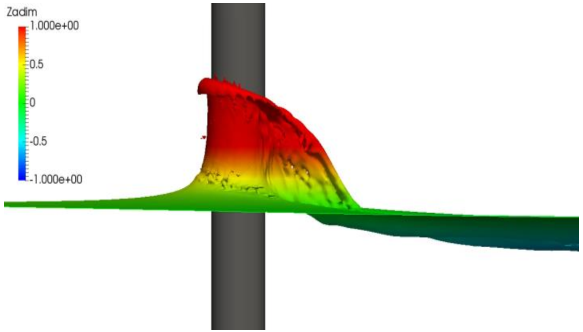
The optimization of the mast shape and the reduction of the wake are out of the scope of the presentation.

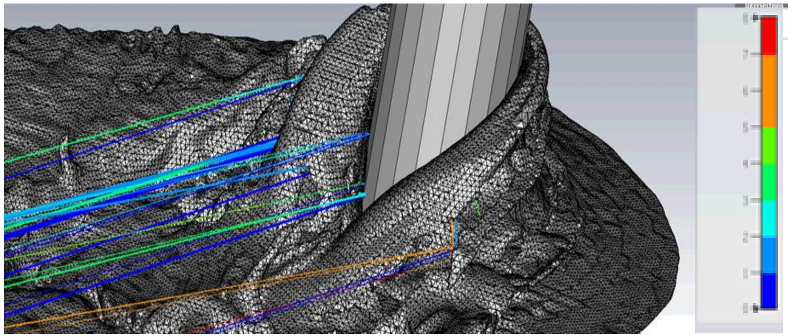


Introduction

RCS calculation of the wake is a challenging activity

- Intensive in terms of calculations
- The wake is not static
- Many parameters to take into account





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Summary

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- **CFD computation of the wake**
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CFD computation of the wake

Flow around a cylinder : a complex free-surface deformations calculation

- Typical Re number 10^5 to 10^6 : critical to supercritical regions

→ Difficulty to predict the correct drag coefficient

- Typical Froude number : 1 to 4

→ unsteady wake and long time for convergence of calculations

Modelling of such flows is challenging

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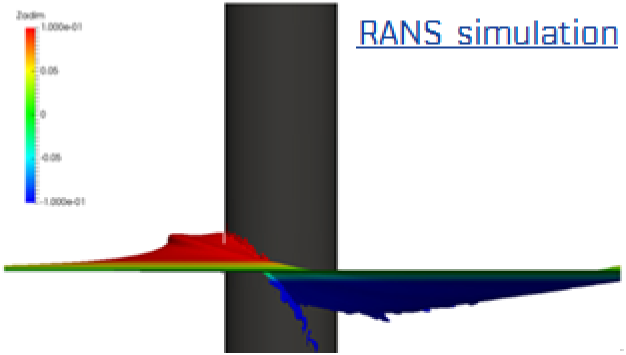
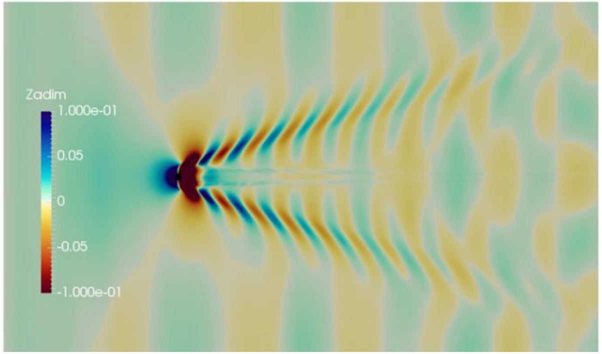
CFD computation of the wake

Speed 2,3 kts (RE=234000 FR=0.84)

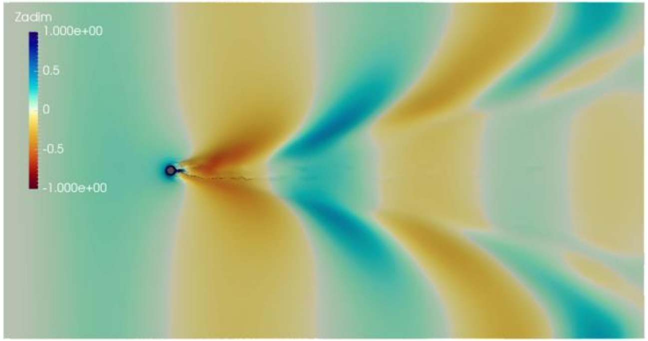


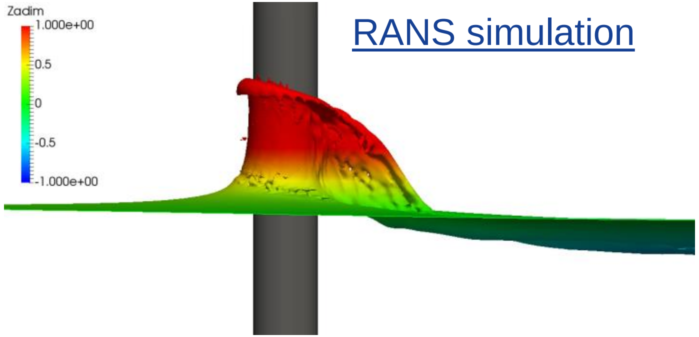


	RANS simulations
Bow wave height (/ D)	0,34
Trough depth (/ D)	0,28
Kelvin wake angle (°)	18-19

CFD computation of the wake

Speed 6 KTS (RE=614000 FR=2.21)





RANS simulation

	RANS simulations
Bow wave height (/ D)	2,06
Trough depth (/ D)	0,55
Kelvin wake angle (°)	16

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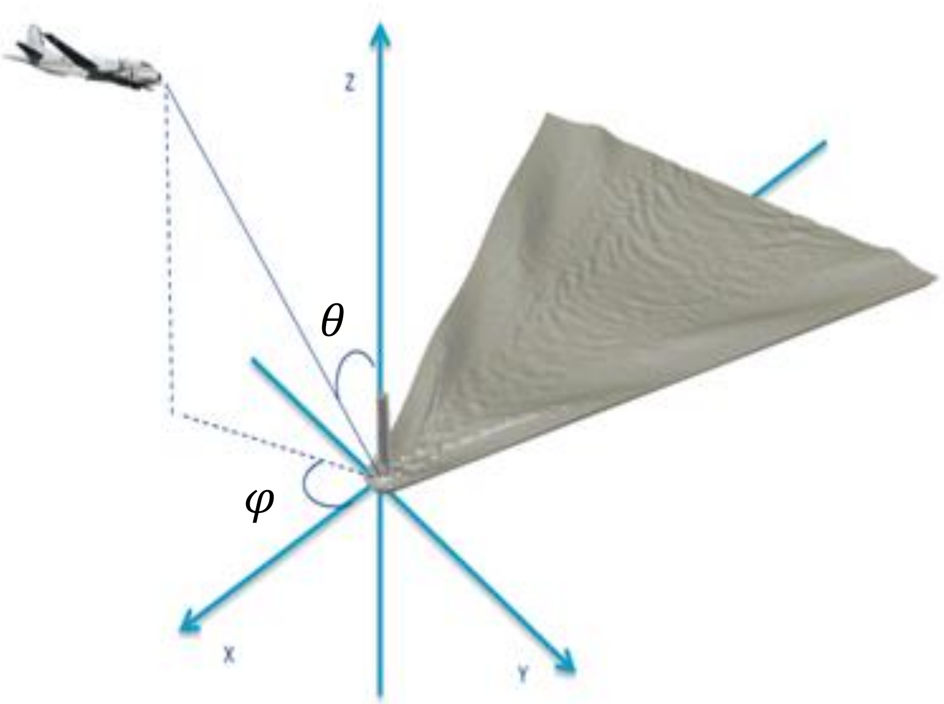
RCS Computation

Computation
- Asymptotic solver
- CST Microwave Studio (MWS)

The target
- Typical cylindrical cylinder and its
- Speed of 2.3 knots, 4 knots, and 6

Geometry of the problem
- The far-field theory
- Monostatic case
- X band (10 GHz)
- The free-space
- The grazing angle (théta = 89 °)
- Angular range in azimuth from 0 °



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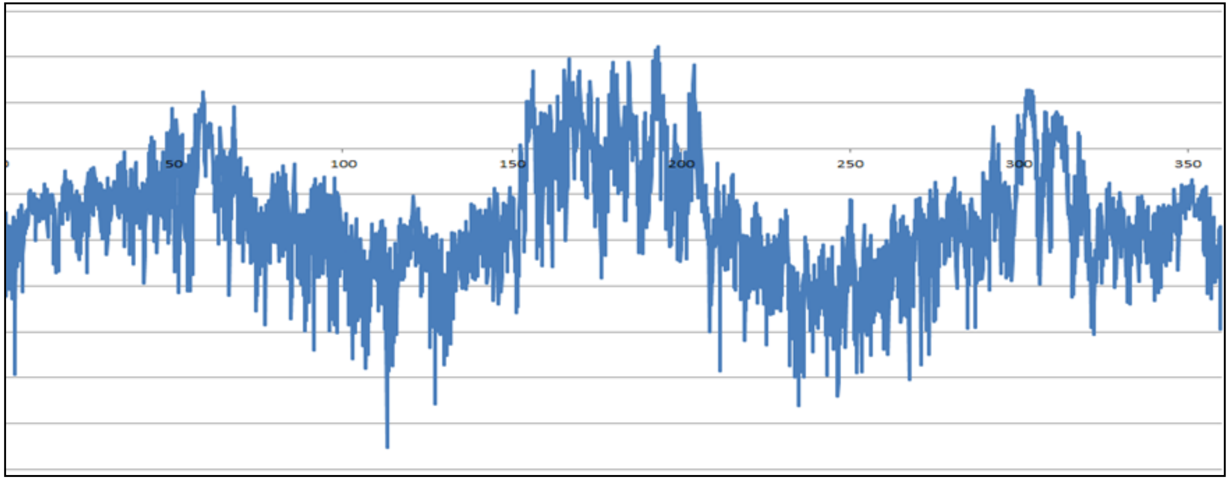
RCS Computation

RCS computation of the whole target



Speed 4 kts – PEC Material

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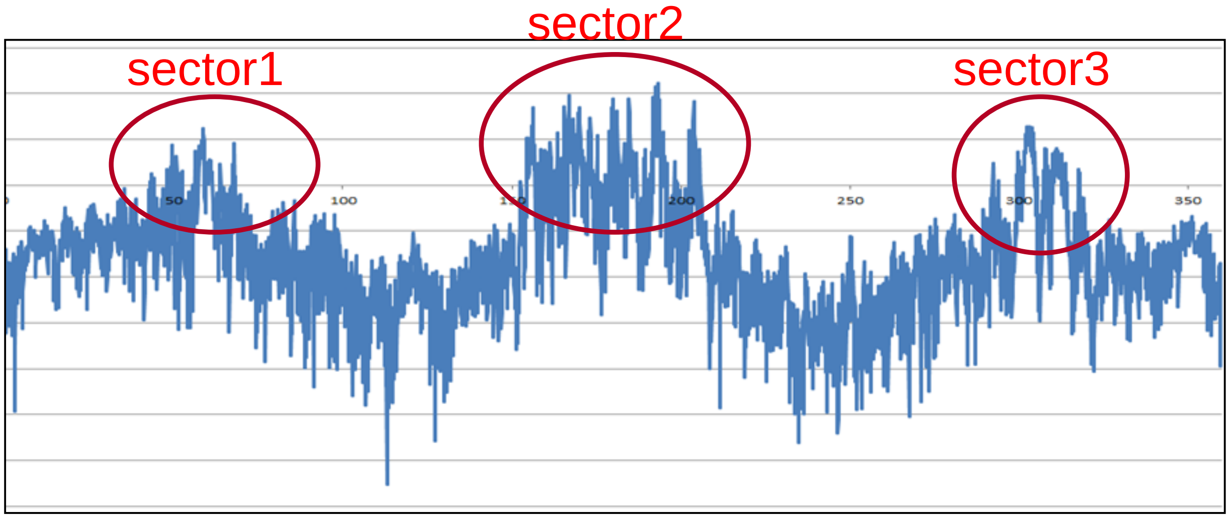
RCS Computation

RCS computation of the whole target



Speed 4 kts – PEC Material

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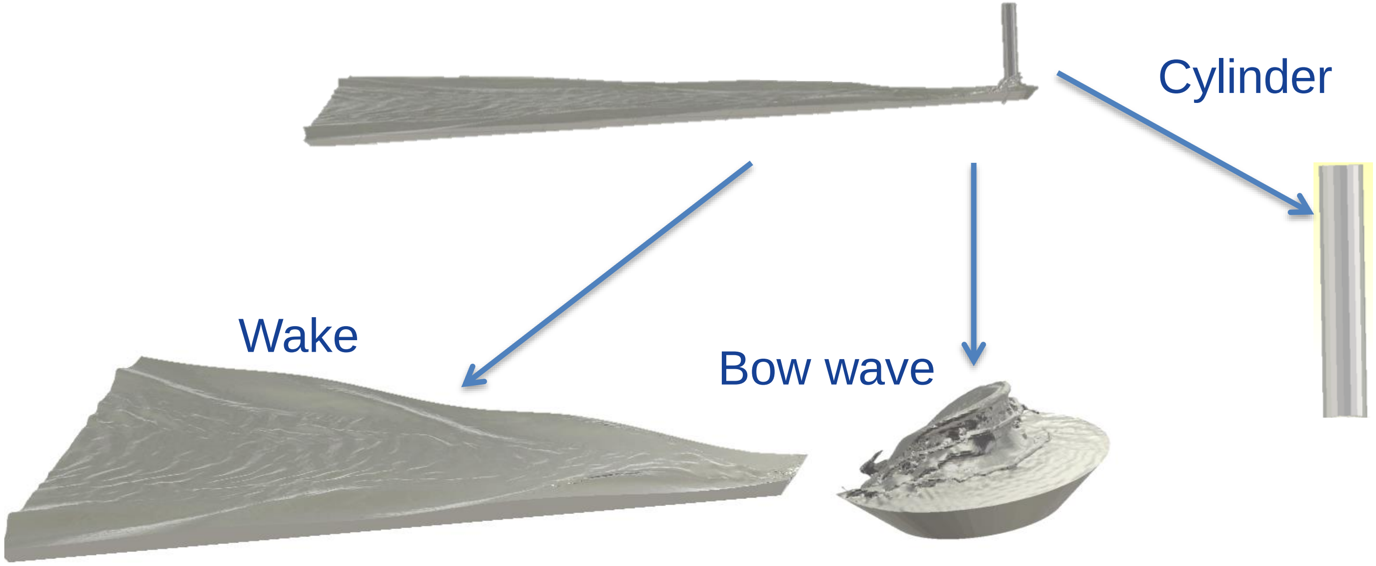
RCS Computation

Study of individual sources of indiscretion :

- The target is separated in 3 different parts
- RCS computation of individual parts



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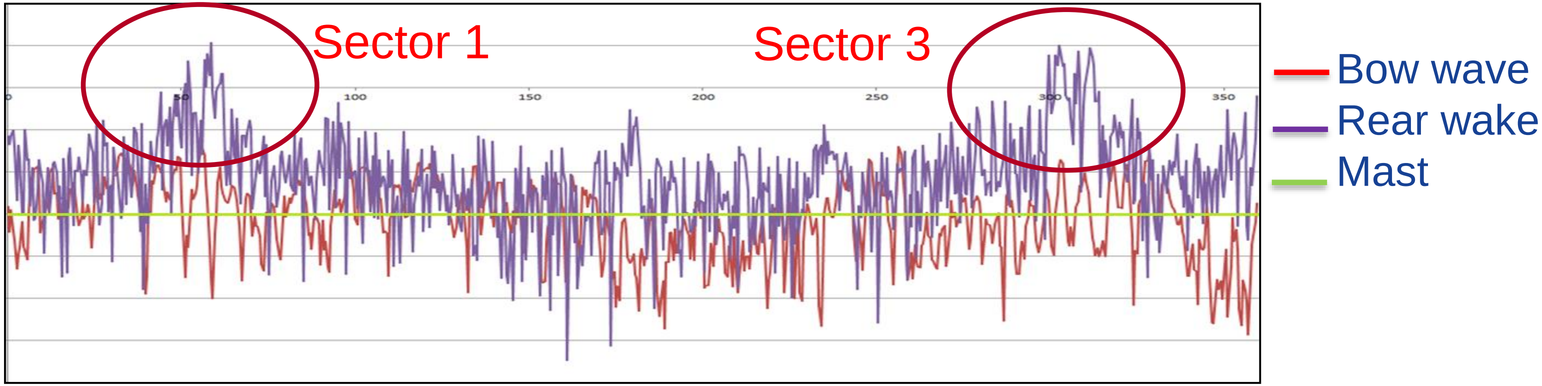
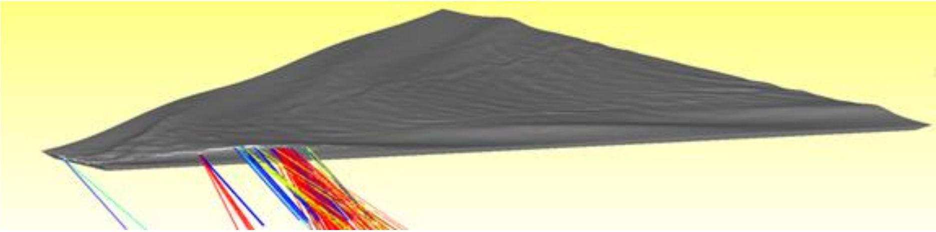
RCS Computation

In the angular sectors 1 and 3, the high RCS level is due to reflections on the rear wake

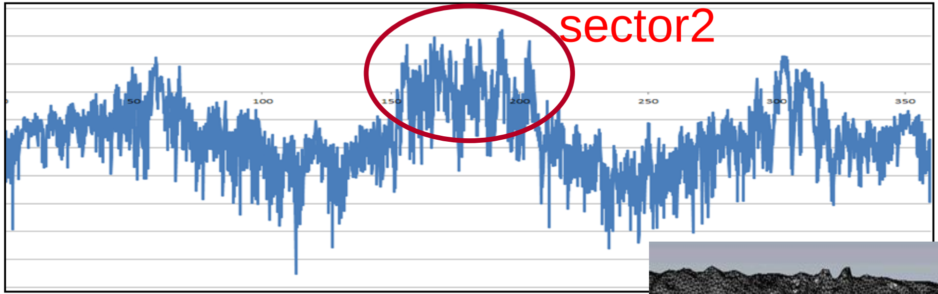


Speed 4 kts – PEC Material

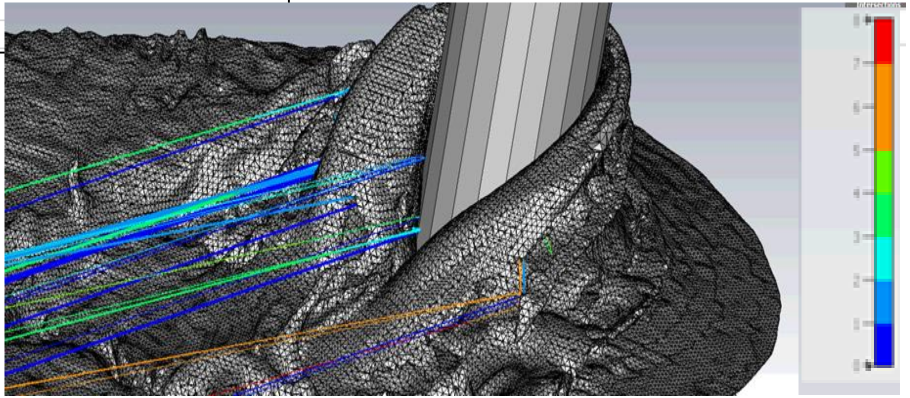


RCS Computation

In the angular sector 2, the high RCS level is due to the multipath effect between the mast and the wake



Speed 4 kts – PEC



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- **Influence of several parameters on the RCS of the wake**

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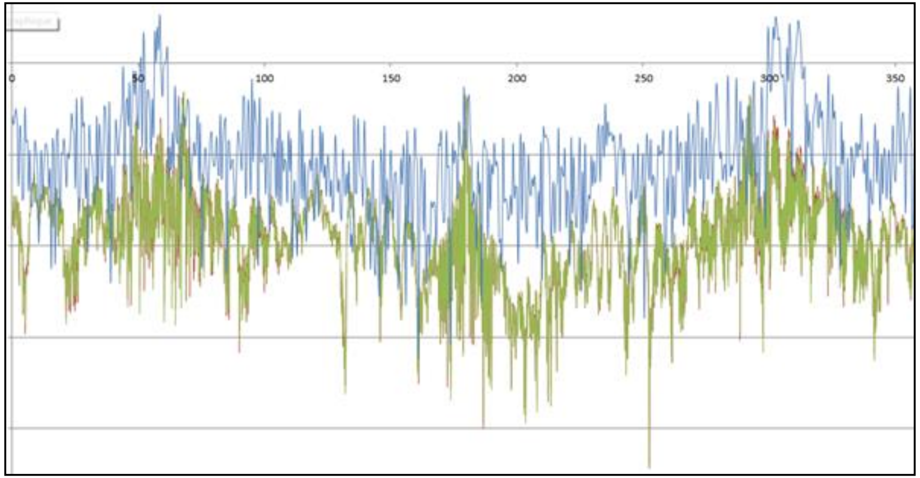
Influence of several parameters on the RCS of the wake

1-Influence of dielectric parameters of the sea water



PEC
Atlantic Ocean
Baltic Sea

Speed 4 kts – Wake only

Conclusion : The RCS level with effective dielectric parameters is approximately 10 dB less compared to the PEC. Moreover there is also a few dB difference, depending on the geographical area.

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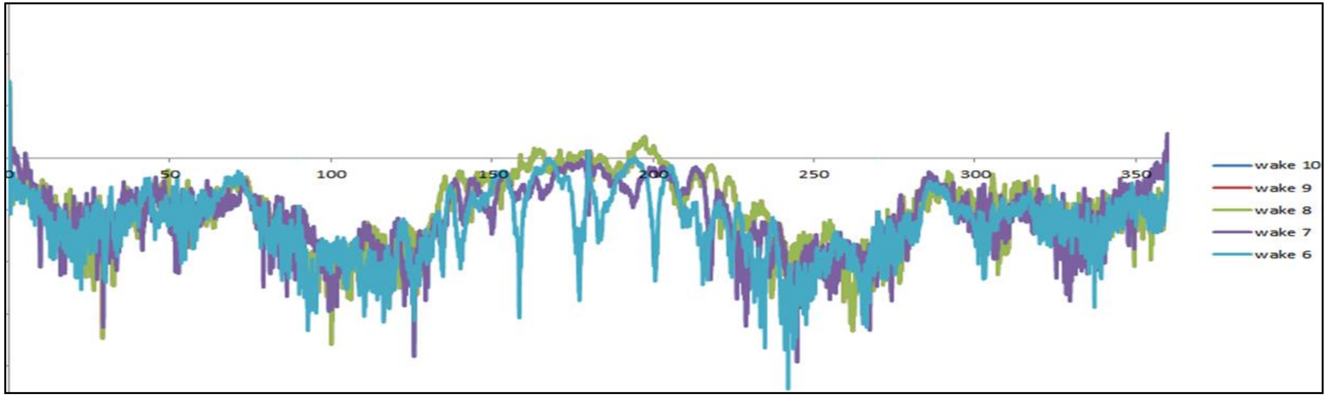
Influence of several parameters on the RCS of the wake

2-RCS of the wake as a function of time

The geometrical characteristics of the wake changes as a function of time.

One RCS computation every 0,5 s



Speed 2,3 kts – Wake only - PEC Material

Conclusion : Important difference in dB due to the dynamic behaviour of the wake

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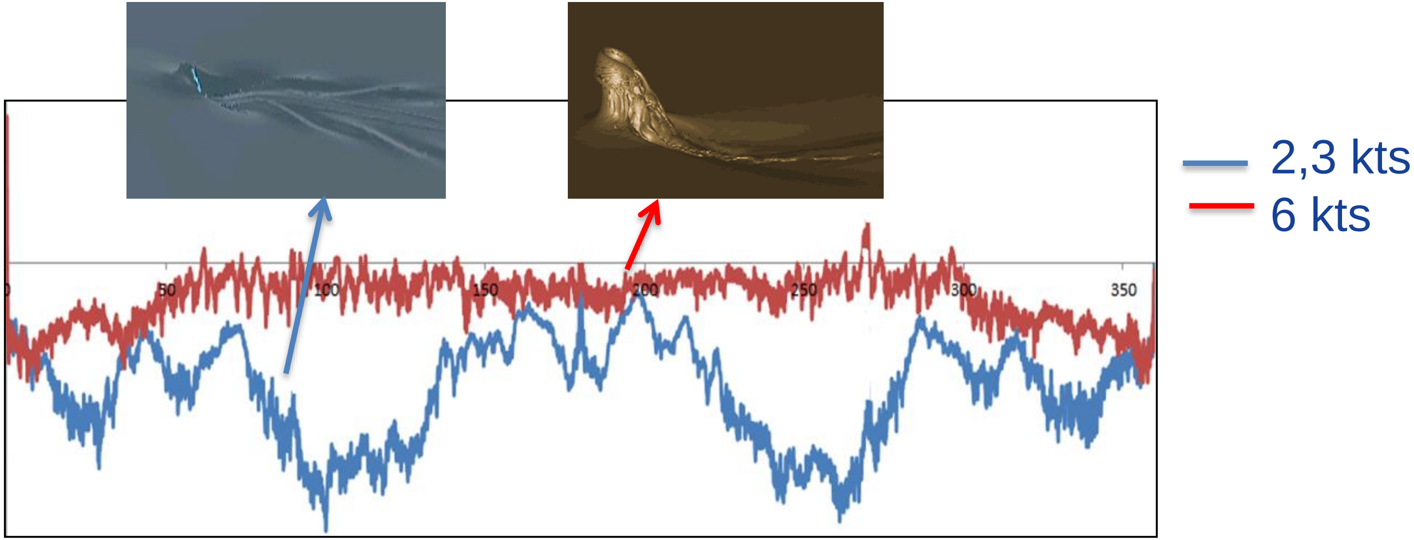
Influence of several parameters on the RCS of the wake

3-RCS of the wake function of the speed of the Submarine



PEC Material – Mean RCS

Conclusion : with a higher speed (6 kts), the bow wave has a “cylindrical” shape. The RCS increases on a wide sector, by 9 dB compared to 2,3 kts

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Conclusion

All these simulations made it possible to highlight the interacting parameters in the RCS results.

Evaluation of the RCS of a submarine at periscope depth :

1. Importance of taking into account the proper dielectric parameter of the sea area
2. The impact of the speed of the submarine
3. The impact of the “dynamic” geometry of the wake

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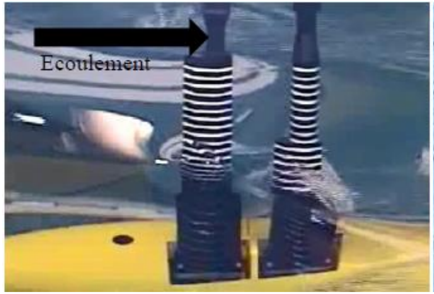
Conclusion

Many other tasks in the same field of activities will be performed :

1. Continue the numerical calculations with other methods (LES calculations, …)
2. Calculations with several masts hoisted
3. Calculations with the spray generated by diesel exhaust gas
4. Tests and measurements on scale models

The purpose is to master all the tools in order to optimize the mast shaping, to reduce the wake and to be able to precisely quantify the benefit on the radar signature.

These activities are part of a global and comprehensive approach to reduce the submarine indiscretions : “being able to see without being seen”



THANK YOU FOR YOUR ATTENTION