Tokyo 2015 – Vortex core analysis for the JBC
Test case 1.3a

Objectives

During the previous editions of the Gothenburg and Tokyo workshops, the local flow analysis was uniquely based on the inspection of the flow characteristics at specific cross-sections where experiments were available. Although this procedure is still useful and necessary, it only provides a global picture of the flow for each experimental cross-section. In the present edition of the workshop, we would like to enrich this cross-section based analysis by a more detailed and local vortex flow analysis in order to draw more elaborate conclusions about the generation and evolution of the longitudinal vortices. Although we do not have everywhere experimental data, we believe that it might be interesting to compare our respective computations in terms of ability to predict the onset and progression of the main vortices which compose the JBC stern flow. It is hoped that, from these local comparisons, may stem some common features which will help establishing better diagnosis and future recommendations concerning the local accuracy and turbulence modelling to capture accurately the onset and progression of the predominant vortical structures influencing the flow in the wake of a ship.

Procedure in general terms

In order to check the feasability of this procedure, it has been decided to apply it only to the free-surface flow around the JBC with no propeller and no ESD (experiments from NMRI, test case 1.3a). Moreover, based on preliminary computations, several vortices present in the stern flow have been identified. These vortices are shown in the figures 1, 2 and 3. For the sake of simplicity, the local vortex core analysis will be performed only on the main vortex called here Vortex1.

The local analysis of the vortex flow will be based on two different local inspections :

<u>1- A longitudinal vortex core analysis</u>

Here, after having defined the streamline corresponding to the core center, we will draw the evolution of some specific flow characteristics along this line from the onset of the vortex to the near wake of the JBC. This analysis will be conducted for the main vortex.

<u>2- A transversal vortex core analysis</u>

In this second study, at three specific cross-sections (i.e. X/Lpp=0.9625, X/Lpp=0.9843 and X/Lpp=1.0000), we will draw the evolution of some flow characteristics along two lines y=cst. and z=cst., for a range such that one stays inside the main vortical structure. In this part, we will also provide figures showing the local grid density to try to correlate the computational results with the local grid density.

In the next section, we will describe the procedures and will provide instructions, Tecplot formats and styles to help every contributor generating the same standardized outputs.

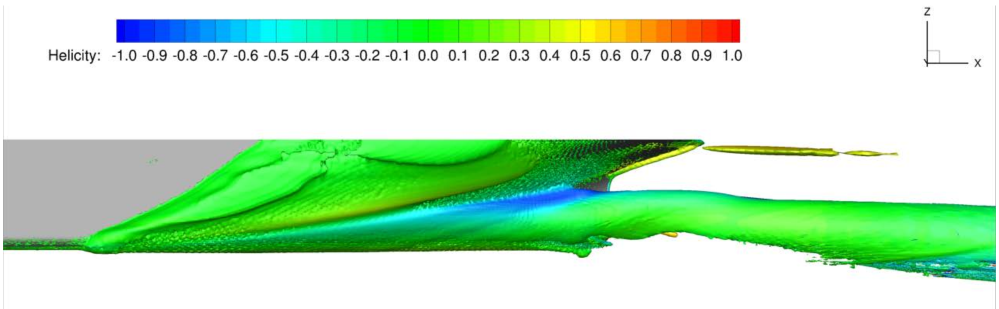

Figure 1- JBC – Side view of the vortical structures identified as iso-surfaces Q*=25

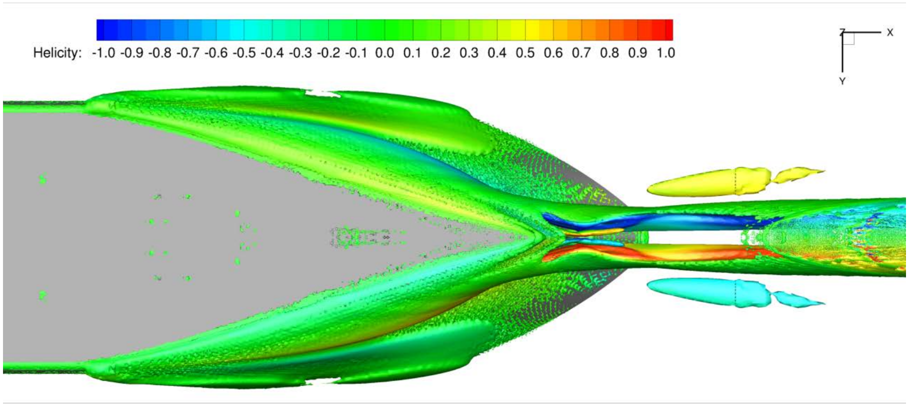

Figure 2- JBC – Bottom view of the vortical structures identified as iso-surfaces Q*=25

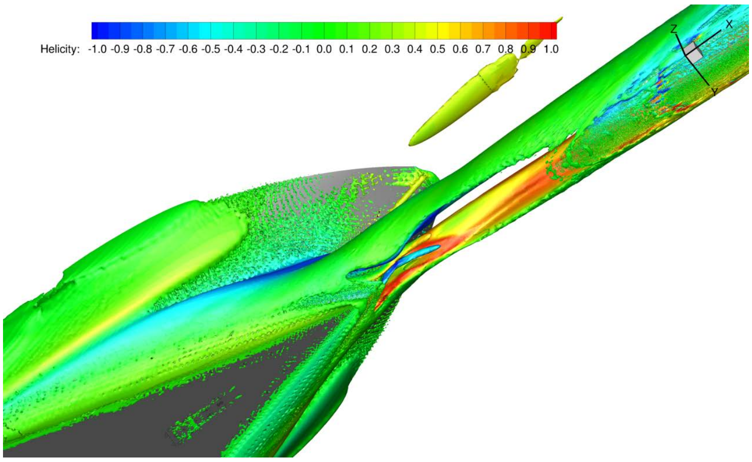

Figure 3- JBC – Perspective view of the vortical structures identified as iso-surfaces Q*=25

Comprehensive description of the vortex flow analysis procedures

1- Visualization of the selected vortical structure

Three standardized views (side, bottom, perspective) have been chosen to provide a common and unified visualisation of the flow. They will be generated by each contributor based on the following information .

Tecplot files :

Tecplot files associated to these styles should contain the adimensional volumic grid coordinates (X/Lpp, Y/Lpp, Z/Lpp) and the helicity defined on the surfaces corresponding to the adimensional Q criterion Q*=25. The Q* criterion is colored by the adimensional Helicity. Here are the definitions of the adimensional Q criterion and helicity.

Definition of the second invariant Q :

$$Q=\frac{1}{2}\left(\Omega_{ij}\Omega_{ij}-S_{ij}S_{ij}\right)$$

and Q* is obtained by multiplying Q by L_{pp}^2/U_{ref}^2

Definition of the helicity :

$$He=\frac{\vec{U}\cdot\vec{\Omega}}{|\vec{U}|\cdot|\vec{\Omega}|}$$

which is by definition non-dimensional.

First lines of the Tecplot files in directory ***Tecplot_Files_Headers*** : hull.dat and isoq.dat

Tecplot styles in directory ***Tecplot_Style***s :
To each view corresponds a different Tecplot style, i.e. side_view.sty, bottom_view.sty, perspective_view.sty. We have noticed that these views may be polluted by vortices present in the air close to the free-surface. You are free to apply a blanking to suppress these unwanted vortices.

Figures :
As soon as the tecplot files are written in agreement with the conventions described above, the use of the provided Tecplot styles will automatically lead to the same standardized figures.
Each contributor will generate the following figures based on the workshop conventions.

[Contributor_Name]-[Code_Name]_side_view_vortex1.png,
[Contributor_Name]-[Code_Name]_bottom_view_vortex1.png,
[Contributor_Name]-[Code_Name]_perpective_view_vortex1.png

Examples are given in the directory ***Figures***.

Total number of figures : 3

2. Longitudinal vortex core analysis

To find the center of the main vortex, one first looks for the maximum value of the longitudinal vorticity omega_x in the center of each identified vortex at cross-section S4, X/Lpp=0.9843. Then using Tecplot, for instance, one draws a streamline upstream and downstream from this point and stores its location. Finally, one has to extract along this curve the requested physical quantities i.e. Y/Lpp, Z/Lpp, ω_x, u/U, TKE and Q. It is very difficult (almost impossible) to determine precisely the real onset point of the vortex using this procedure, but this should produce consistent results which will be used to compare the evolution of the respective computational and experimental results along this three-dimensional line.

Tecplot Files :
The Tecplot file should contain the 3D coordinates of the vortex center line and the following extracted physical non-dimensional quantities i.e. X/Lpp, Y/Lpp, Z/Lpp, ω_x /(U/Lpp), u/U, TKE/(U**2) and Q*. The first lines of this Tecplot file to be generated by each participant can be found in an example put in directory ***Tecplot_Files_Headers*** under the name « longit_vortex.dat ».
This Tecplot file should be uploaded to the T2015 ftp site to enable comparisons on pictures which will be common to all the participants performing this local analysis. The name of this final Tecplot file will be :

[Contributor_Name]-[Code_Name]_longit_vortex1.dat

Tecplot styles in directory ***Tecplot_Style***s :
Various styles are provided for both vortex and all physical quantities. Here is the complete list:

ycore_vortex1.sty
zcore_vortex1.sty
uxcore_vortex1.sty
wxcore_vortex1.sty
tkecore_vortex1.sty
qcore_vortex1.sty

Figures :
Each contributor will generate the following figures based on the workshop conventions.

- [Contributor_Name]-[Code_Name]_ycore_longit_vortex1.png,
- [Contributor_Name]-[Code_Name]_zcore_longit_vortex1.png,
- [Contributor_Name]-[Code_Name]_wxcore_longit_vortex1.png,
- [Contributor_Name]-[Code_Name]_uxcore_longit_vortex1.png,
- [Contributor_Name]-[Code_Name]_tkecore_longit_vortex1.png,
- [Contributor_Name]-[Code_Name]_qcore_longit_vortex1.png

The figures will be used to check the consistency of the results but the final analysis will be performed on figures gathering all the results of the participants for the sake of conciseness and clarity.

Examples are given in the directory ***Figures***.

Total number of figures : 6

3. Transversal vortex core analysis

For the three experimental cross-sections and for vortex1, we would like to analyze the flow distribution along the transversal directions Y/Lpp and Z/Lpp=cste. We will produce figures for each aforementioned physical quantities and additional figures showing the local grid density. Characteristic physical quantities will be extracted in the vortex core along these transversal directions by using 100 points in a normalised range defined by (-0.005< (Y-Ycore)/Lpp < +0.005 ; Z=Zcore) and (Y=Ycore ; -0.005< (Z-Zcore)/Lpp < +0.005).

Tecplot Files :
The Tecplot files should contain the 3D coordinates of the vortex center line and the following extracted physical non-dimensional quantities i.e. (Y-Ycore)/Lpp, (Z-Zcore)/Lpp, ω_x /(U/Lpp), u/U, TKE/(U**2) and Q*.

First lines of Tecplot files in directory ***Tecplot_Files_Headers*** :
For the local grid visualisation : mesh_cross_sections.dat
For the visualisation of the transverse evolution of physical quantities of interest : transvyz_vortex.dat.

The Tecplot file describing the transverse evolutions should be generated by each particpant and uploaded to the T2015 ftp site in order to enable comparison on the same picture as done for the longitudinal analysis. The name of this final tecplot file will be :

[Contributor_Name]-[Code_Name]_transv_vortex1.dat

Tecplot styles in directory ***Tecplot_Style***s :
A unique style is provided for the visualisation of the local grid density in the region where the main vortex is present : mesh_cross_sections.sty

Styles are also provided for the visualisation of the tranverse evolution of physical quantities in the core of both vortices of interest. Here is the complete list:

wxcore_transvy.sty
uxcore_transvy.sty
tkecore_transvy.sty
qcore_transvy.sty

wxcore_transvz.sty
uxcore_transvz.sty
tkecore_transvz.sty
qcore_transvz.sty

Figures :
Each contributor will also generate the following figures based on the workshop conventions.

Section S2 :X/Lpp=0.9625
[Contributor_Name]-[Code_Name]_mesh_S2.png
[Contributor_Name]-[Code_Name]_wxcore_transvy_S2_vortex1.png
[Contributor_Name]-[Code_Name]_uxcore_transvy_S2_vortex1.png
[Contributor_Name]-[Code_Name]_tkecore_transvy_S2_vortex1.png
[Contributor_Name]-[Code_Name]_qcore_transvy_S2_vortex1.png
[Contributor_Name]-[Code_Name]_wxcore_transvz_S2_vortex1.png
[Contributor_Name]-[Code_Name]_uxcore_transvz_S2_vortex1.png
[Contributor_Name]-[Code_Name]_tkecore_transvz_S2_vortex1.png
[Contributor_Name]-[Code_Name]_qcore_transvz_S2_vortex1.png

Section S4 :X/Lpp=0.9843
[Contributor_Name]-[Code_Name]_mesh_S4.png
[Contributor_Name]-[Code_Name]_wxcore_transvy_S4_vortex1.png
[Contributor_Name]-[Code_Name]_uxcore_transvy_S4_vortex1.png
[Contributor_Name]-[Code_Name]_tkecore_transvy_S4_vortex1.png
[Contributor_Name]-[Code_Name]_qcore_transvy_S4_vortex1.png
[Contributor_Name]-[Code_Name]_wxcore_transvz_S4_vortex1.png
[Contributor_Name]-[Code_Name]_uxcore_transvz_S4_vortex1.png
[Contributor_Name]-[Code_Name]_tkecore_transvz_S4_vortex1.png
[Contributor_Name]-[Code_Name]_qcore_transvz_S4_vortex1.png

Section S7 :X/Lpp=1.0000
[Contributor_Name]-[Code_Name]_mesh_S7.png
[Contributor_Name]-[Code_Name]_wxcore_transvy_S7_vortex1.png
[Contributor_Name]-[Code_Name]_uxcore_transvy_S7_vortex1.png
[Contributor_Name]-[Code_Name]_tkecore_transvy_S7_vortex1.png
[Contributor_Name]-[Code_Name]_qcore_transvy_S7_vortex1.png
[Contributor_Name]-[Code_Name]_wxcore_transvz_S7_vortex1.png

[Contributor_Name]-[Code_Name]_uxcore_transvz_S7_vortex1.png
[Contributor_Name]-[Code_Name]_tkecore_transvz_S7_vortex1.png
[Contributor_Name]-[Code_Name]_qcore_transvz_S7_vortex1.png

Examples are given in the directory ***Figures***.

Total number of figures : = 27

The figures will be used to check the consistency of the results but the final analysis will be performed on figures gathering all the results of the participants for the sake of conciseness and clarity, as previously mentionned.