Short Manual for the Nacra 17 VPP

1 Introduction

The Nacra17 VPP has been developed for the German Olympic Nacra crew of the Olympic games 2020/1 and 2024, namely team *Kohlhoff/Stuhlemmer.* It has been used to support the team in finding a proper foil/rudder/rig setup/trim by means of a VPP. Two publications accompany the development, which describe theory and results in detail:

- Graf, K. and Freiheit, O. (2020). VPP-driven sail and foil trim optimization for the Olympic Nacra-17 foiling catamaran. Proc. 5th InnovSail, Ecole Naval de France / Brest.
- K. Graf (2026): VPP-Driven Sail and Foil Trim Optimization for the Olympic NACRA 17 Foiling Catamaran, 7th International Conference on Innovation in High Performance Sailing Yachts and Wind-Assisted Ships, InnovSail 2026, Gothenburg, Sweden.

The Nacra 17 VPP is available to the public without any guaranty. It is provided as a folder containing the Matlab© source code. Beside these brief user hints, no manual is provided and it is up to a user, to study the source code if she/he wants to make proper use of it.

Consequently, the VPP requires a solid understanding of how VPPs work and a basic understanding of numerical algorithms. For your own research, it is almost always necessary to study the source code and, if necessary, modify it.

2 Files

The provided folder contains a couple of matlab-files and no sub-directory:

- Files, starting with letter C and having an extension .m are matlab class files. The file name will suggest the particular purpose of the class.
- Files with the extension. mlx are so called live-skripts. These are the driver routines for particular computations or postprocessing.
    - optimizeVelocityGivenTWS_TWARange.mlx is the script, which actually does the VPP calculation. It allows to calculate a full polar or a subset of it. The user can change the upper part of the file to describe his setup (the TWS/TWA range to compute and other setup variables). The script writes a result file resultTablePOLAR.mat. It can be renamed to whatever reasonable file name
    - processVelocityPolar.mlx generates graphical output of a polar file which has been created using the above script. The name of the result file can be choosen. Default is resultTablePOLAR.mat.
    - processVMGfromPOLAR.mlx generates VMG results from a polar result file. The output of this script shows the foil settings for maximizing VMG, based on an existing polar file (f.x. resultTablePOLAR.mat).
    - processResultTable.mlx is a convenience script, allowing to choose a particular TWS/TWA-combination from a polar result file and list the state variables and the forces as tables.
    - The .mat-files contain some example results.
    - The JSON-files contain wind tunnel test results which are used by the VPP. Do not change them, however you may generate your own wind tunnel test result file if you want.

3 Global versus local optimization

The Nacra 17 VPP solution procedure is based on optimization. An iterative numerical procedure is used to find the settings of the foils, rudders and rig, for which the boat speed achieves a maximum. The equilibrium condition of the flow forces is established as constraints for the numerical optimization method. For all the forces and the yawing moment an equilibrium constraint is used, which a non-equilibrium constraint is used for the heeling and pitching moment. See the theoretical papers above for details.

Local and global solution procedures can be chosen in the first section of the file: optimizeVelocityGivenTWS_TWARange.mlx (and of course the user may change the source code).

The optimizer relies on the definition of initial values and upper and lower bounds. If you use a wide range of TWSs and TWAs, it is hard to guess proper initial values, so global optimization has to be used, which is computationally demanding (may take hours depending on your computer). For a small TWS/TWA range and proper initial values, local optimization may work well and takes only seconds. Initial values have a strong impact on the solution for local optimization. Reasonable bounds help to ensure numerical stability. For global optimization, proper initial values are of less importance, however proper bounds may narrow the design frame and thus accelerate the computation and increase stability.

4 Flow force prediction

The aerodynamic model for the flow force prediction is based on wind tunnel test and the wind tunnel test results are processed with a proprietary method, developed by the Yacht Research Unit Kiel at the University of Applied Sciences Kiel. The test results of the Nacra wind tunnel tests are given in the JSON-files: Y_NacraUP.json and Y_NacraDOWN.json for upwind and downwind courses respectively. Note that the apparend wind angle always is close 30-40°, regardless of the actual course with respect to true wind. Also note, that the flow force coefficients a built with a reference sail area (P*E+I*J)/2.

The hydrodynamic flow forces are derived from URANS free surface CFD investigations. Response surfaces for the hull and regression formulas for the rudders and daggerboards are used. Consult the above mentioned publications for details. The coefficients for the hydrodynamic forces are hard coded in the respective classes and do not depend on external files.

5 No guarantee

The VPP provided here has been validated to some extend and used successfully. However, no guarantee is given. It is 100% the user's responsibility to generate accurate results.

Kiel, August 2026, K. Graf