README for Data Files of :

‘Multi-objective Multi-point Aerodynamic Optimisation of a Hypersonic Waverider’

**Jade Nassif**

# Overview

In terms of the data files, the thesis can be divided into:

* Data files for the surrogate model:
* files with the subscript “min” refer to the M5 flow condition
* files with the subscript “max” refer to the M8 flow condition
* Data Files for the longitudinal analysis:
* files with the subscript “alpha\_0” refer to 0 angle of attack
* files with the subscript “alpha\_neg\_2\_5” refer to -2.5 degree angle of attack
* files with the subscript “alpha\_pos\_2\_5” refer to +2.5 degree angle of attack
* Data files for the test cases:
* Geometry files are labeled opt1, opt2 and opt3 – referring to the 3 optima found (see thesis)
* Data files for the multi-objective cases

Every section of this document will correspond to a folder in the “Thesis Files” folder.

# Databases

This folder contains mainly .xlsx (Excel) files. These contain some of the results of the thesis.

## Surrogate Database

The “database.xlsx” file contains the sample points and corresponding outputs used to build the surrogate models and perform the design space analysis. Note that the ith index in the left column corresponds to Waverider i and this notation is maintained in all other files regarding the Surrogate (see Appendix B).

* Aerodynamic quantities are either obtained at M5 or M8 and the subscript used reflects this.
* “CL” and “CD” refer to lift and drag coefficient, obtained with S\_ref=36 m^2.
* “LD” refers to the lift to drag ratio
* “Lift” and “Drag” are shown here in Newtons and correspond to half the geometry.
* “Delta\_L” and “Delta\_D” are the percentages of lift and drag decrease from M5 to M8.
* Whenever a “visc” subscript is included this refers to an estimate obtained via the viscous corrections applied to drag (see thesis in multi-objective cases section)

## Longitudinal Analysis

“optimisation\_results\_n10.xlsx” is the results obtained from the Case 1 Pareto Front after applying K-means with n=10 clusters. (see Thesis Longitudinal Analysis results section). The estimates shown here are from the surrogate.

“stability\_database.xlsx” contains the results shown in the longitudinal analysis results section. “cg” is the CG at centre of mass. “cp” is centre of pressure. “CM” is pitching moment about the centre of mass (Refer to thesis on how this is calculated). Lift and drag estimates at non zero angles of attack have been adjusted already (see Performance Estimation - Convergence section in thesis).

## Test Cases

“single\_obj\_solutions.xlsx” contains Table 18 shown in the test cases results section.

## Multi-objective Cases

Every case has a corresponding folder. Within each folder is a database for this case, which contains 10 sheets which correspond to each Pareto Front obtained from the ith run of the Genetic Algorithm.

# Geometries

## Surrogate Database

The 100 geometries corresponding the sample points (see Appendix B of thesis) are included in this folder.

## Longitudinal Analysis

The 10 geometries obtained from the case 1 pareto front are included in this folder. However, since waverider\_1 (minimum volume) was not used in the analysis, waverider 2 is technically the 1st waverider shown in Table 18.

## Test Cases

The three geometries shown here correspond to three optima reached (see thesis test cases results section)

# Macros

StarCCM+ Macros were used to automate the simulation setup process. These can be run in StarCCM+ and are .java files. Note that you will need to modify the last line of the java file which saves the document in a location of your choice.

## Surrogate Database

Each waverider from the database (Appendix B of thesis) has a corresponding .java file included here. These set-up the entire case and are run on the Base Files which contain only the waverider geometry and common things like the “RefineCriterionMachNumber” refinement criterion. Examples of the base files for waverider 1 and 16 are included.

## Longitudinal Analysis

The notation here for the ith waverider is the same as in 3.2.

# Python Scripts

## Surrogate Database

Apart from surrogate related files, this folder also contains more general files which have been used across many parts of the thesis. In this section, the files are summarised in the approximate order in which they were used:

1. “setup.py”

This file contains functions used all across the project related to the design space. It is imported in many of the other files, mainly to import the constant properties of the design space (w, beta etc).

1. “generate\_sample\_points.py”

This file generates the sample points (Appendix B of thesis) used to build the surrogate models. Its output is the first version of “database.xlsx” containing only the columns M\_design to X4.

1. “generate\_waverider\_geometries.py”

This generates the 100 geometries corresponding to the sample points and in the Geometries folder mentioned earlier

1. “get\_geometric\_properties.py” and “get\_projected\_surface.py”

This calculates the geometric properties of the geometries and returns and updated “database.xlsx” file with this new information.

1. “generate\_macros\_and\_sub.py”

This file creates the macros and sub files used to setup the cases for the 100 geometries and run them on HPC.

1. “rename\_logs.py”

After running the cases on HPC, the logs containing aerodynamic info like Lift, Drag, L/D were downloaded from HPC. These logs were renamed into a .txt format using this file.

1. “get\_coefficients.py” and “get\_lift\_drag.py”

These were used on the log files to extract the aerodynamic properties of lift drag and L/D, CL, CD. Also included in “get\_coefficients.py” is the function used to estimate the viscous contributions (courtesy of Dr Jimmy-John Hoste). Both return an updated “database.xlsx”.

1. “surrogate.py”

Was used to train the surrogate models, outputs “surrogate\_models.pkl” which contains the instances of the KRG class corresponding to each surrogate model.

Other general files:

* “plot\_design\_space” : was used to generate Figure 16a
* “random\_forests.py” : was used to train the random forest models for feature importances and generate Figure 21
* “height\_M\_design.py” : was used to generate Figure 10 through the theta Beta M relation
* “design\_space\_slices.py” : was used to generate all other figures in the “Design Space Analysis” results section.
* “generate\_a\_waverider.py” : self explanatory

## Longitudinal Analysis

* “get\_geometric\_properties.py” : equivalent to the above file with the same name but the longitudinal analysis waveriders
* “plot\_results.py” : all plots from the longitudinal analysis section were generated via this script

## Multi-objective Cases

Every case has a folder containing:

* A file in which the optimisation case is run.
* A file in which the post processing takes place (Pareto Front plots)

## Test Cases

* “generate\_test\_waveriders.py” : used to generate the geometries corresponding to the three optima reached
* “one\_obj\_optimisation.py” : given the low computational cost of the test cases, they were all run through this file, only ever changing the cost function if need be.

# Simulation files

All the simulation files included here are ready to be run (i.e the macros were already run).

For the Grid Convergence Study, n0 corresponds to no refinement, n1 a single refinement until n3.