PyNAT - User Guide

Python based Naval Architecture Tools

GitHub Repository Link

https://github.com/praveen-kch/Py-NAT.git

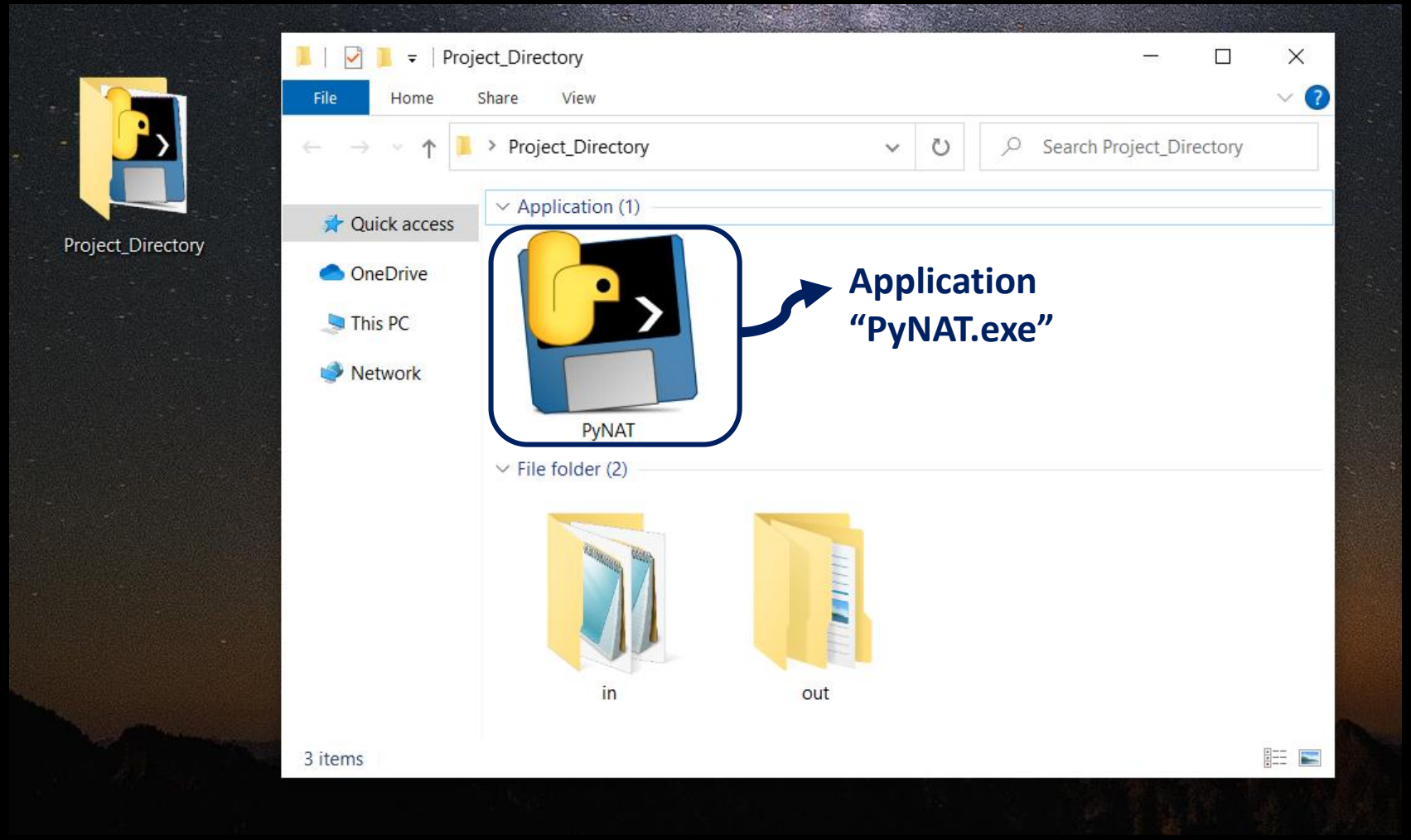
Contains:

- Python Source Scripts
- CUI Application : PyNAT.exe
- Docs
- Sample Test Case & Templates for input preparation

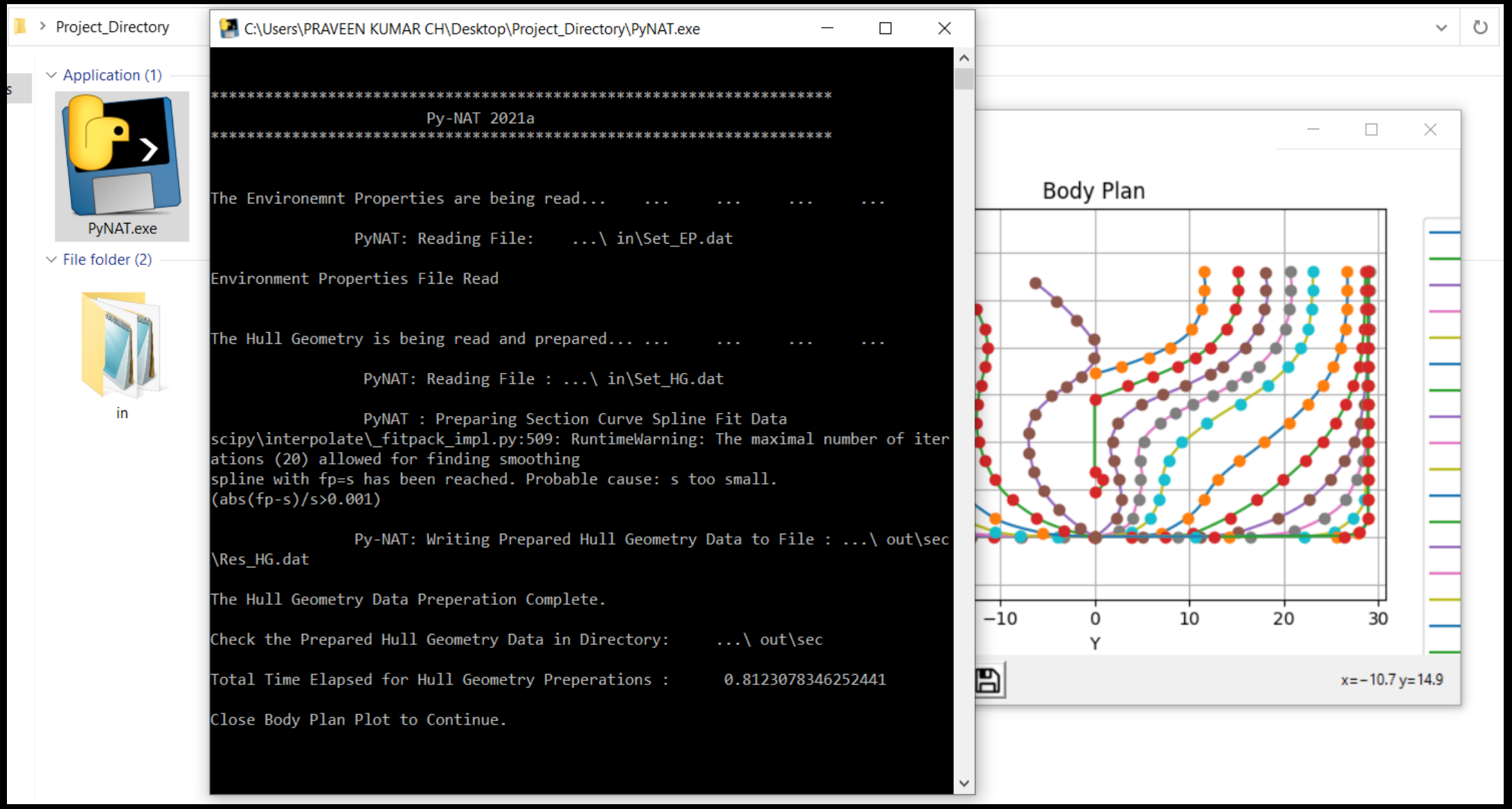
Program and Directory Structure

Section 1

The Application



“PyNAT.exe” is the executable file which starts the Application



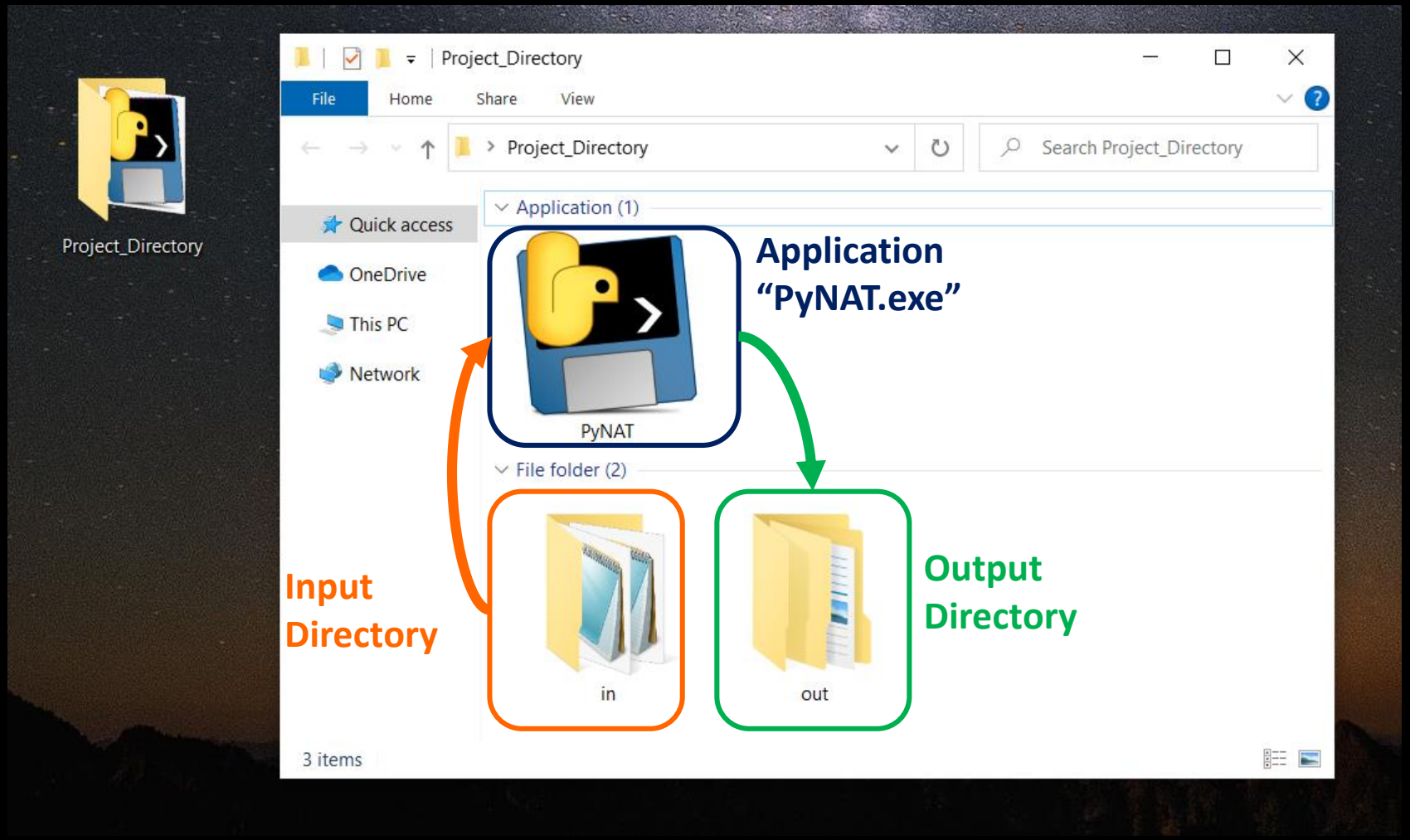
“PyNAT” runs in shell / command prompt

Upon starting “PyNAT.exe” …

It Reads Files from the Directory “in”

Runs the chosen Analysis

Writes results to the Directory “out”



- The “out” directory, its sub directories and files are created by the PyNAT program.
- User need not to create “out” folders or its files.
- PyNAT overwrites any existing files with the same name.

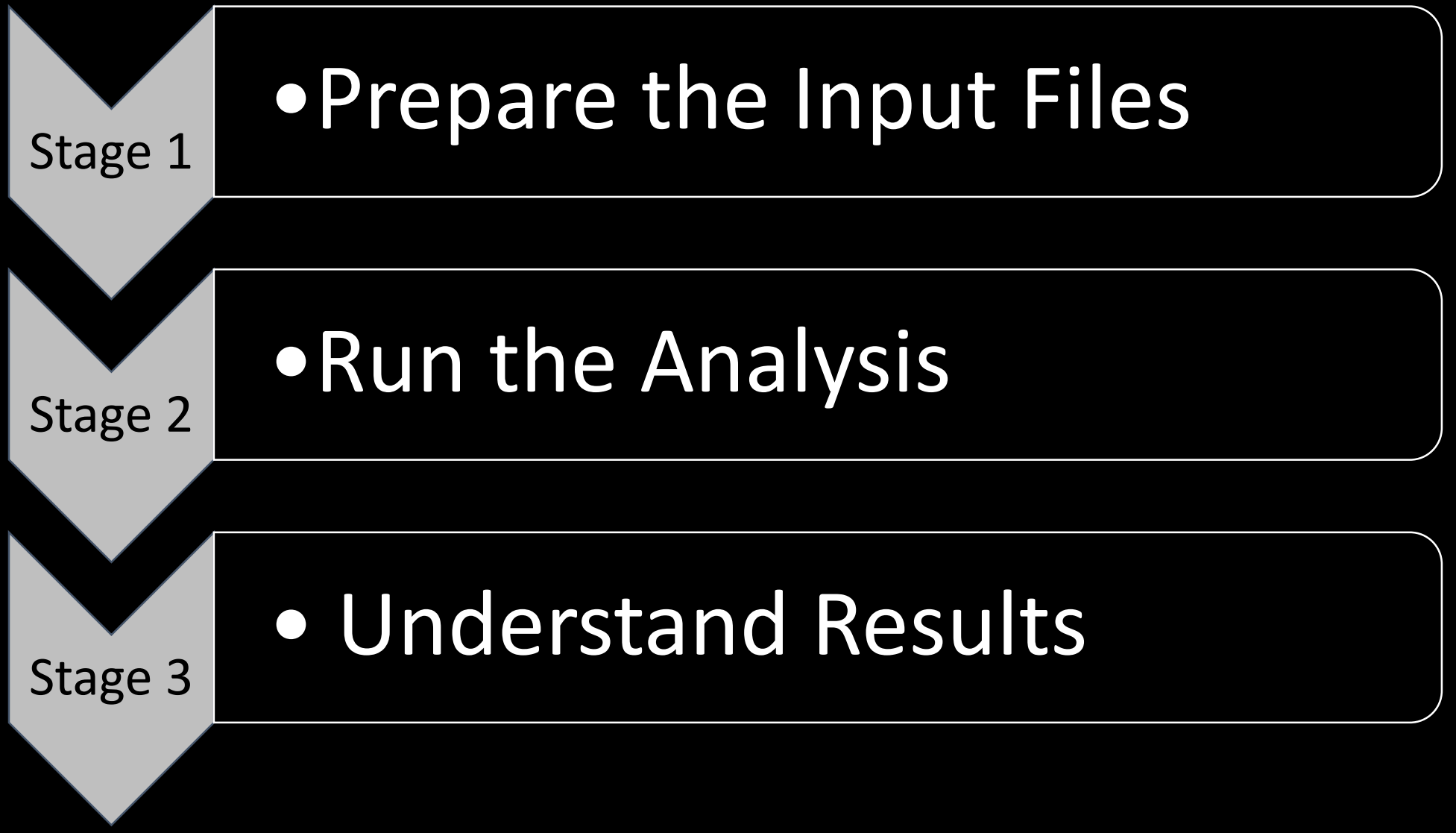
A Note on Unit System

- All Angles should be given only in degrees. Internally the program converts them to radians for calculations.
- For the rest of the input quantities, User should maintain the consistency of units while preparing the input files
- If input parameters (except angles) are given in SI units then the resultant outputs would also be produced in SI units.
- If input parameters are given in Foot – Pound- Seconds Unit System then the resultant outputs would also be in FPS System.

Steps to perform an Analysis using PyNAT

Section 2

Analysis Stages

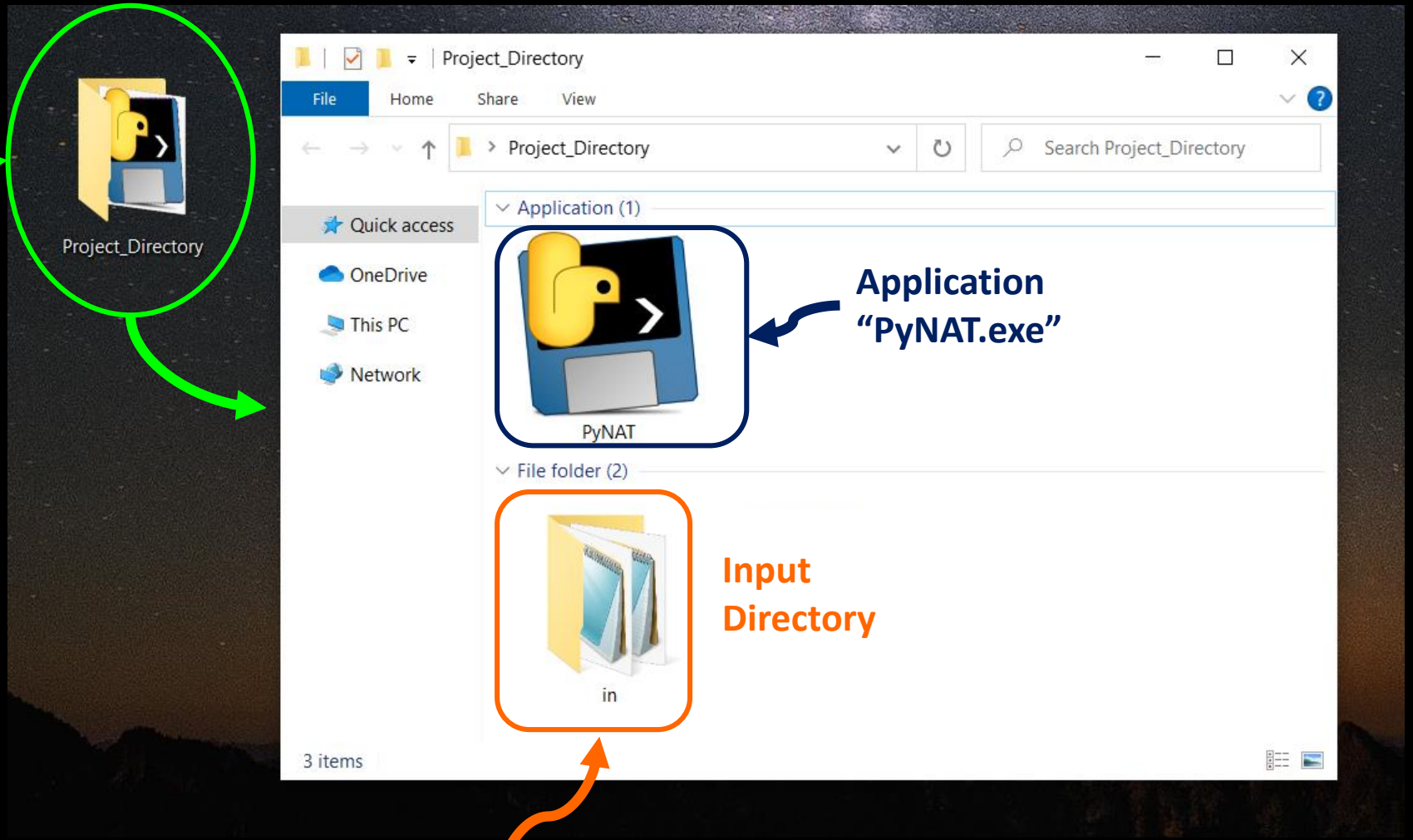


Stage 1 : Preparation of Inputs

Step 0	• Create the Project Working Directory
Step 1	• Hull Geometry Definition file
Step 2	• Environment properties
Step 3	• Hydrostatic Analysis Settings
Step 4	• KN Curve analysis settings
Step 5	• Load Case Definition for GZ curve

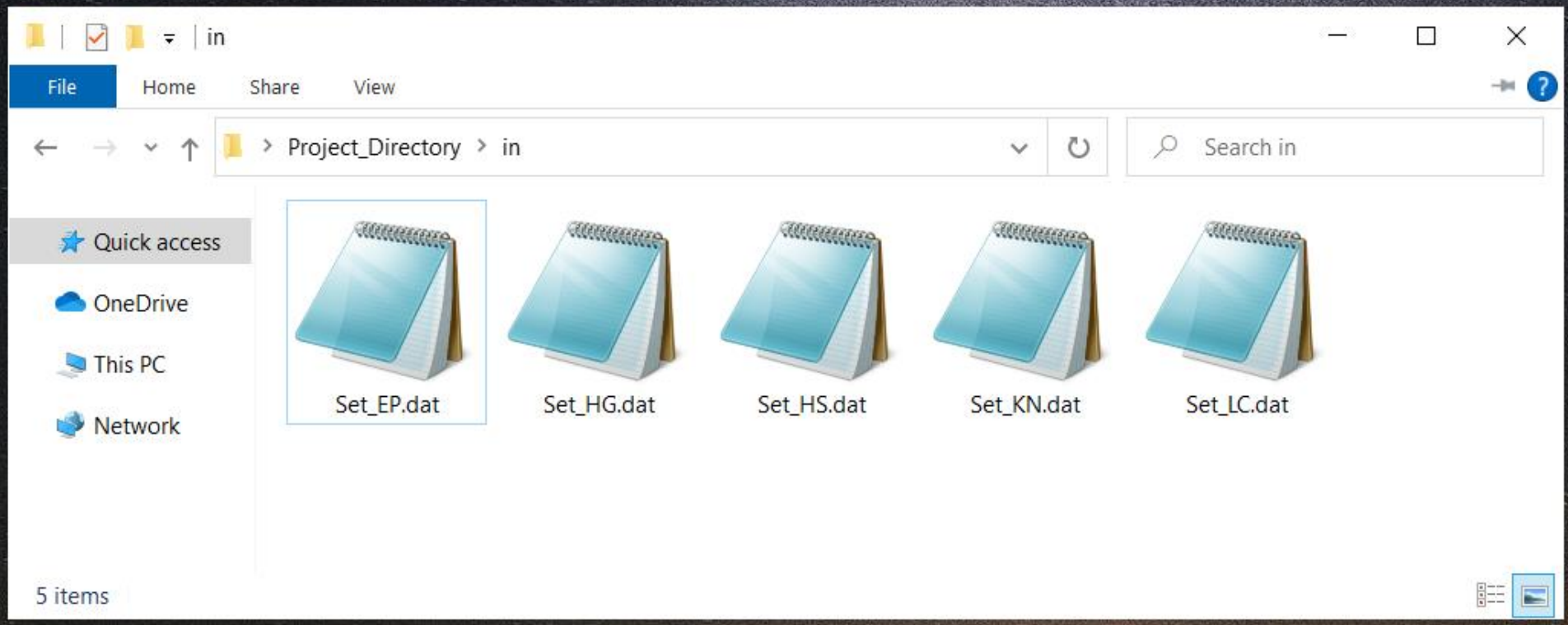
Step 0: The Working Directory

Create a Project / Working Directory and copy PyNAT.exe into it



Inside the Working Directory Create a sub directory named "in"

The Input Directory



“in” folder Should Contain Five Input files as shown

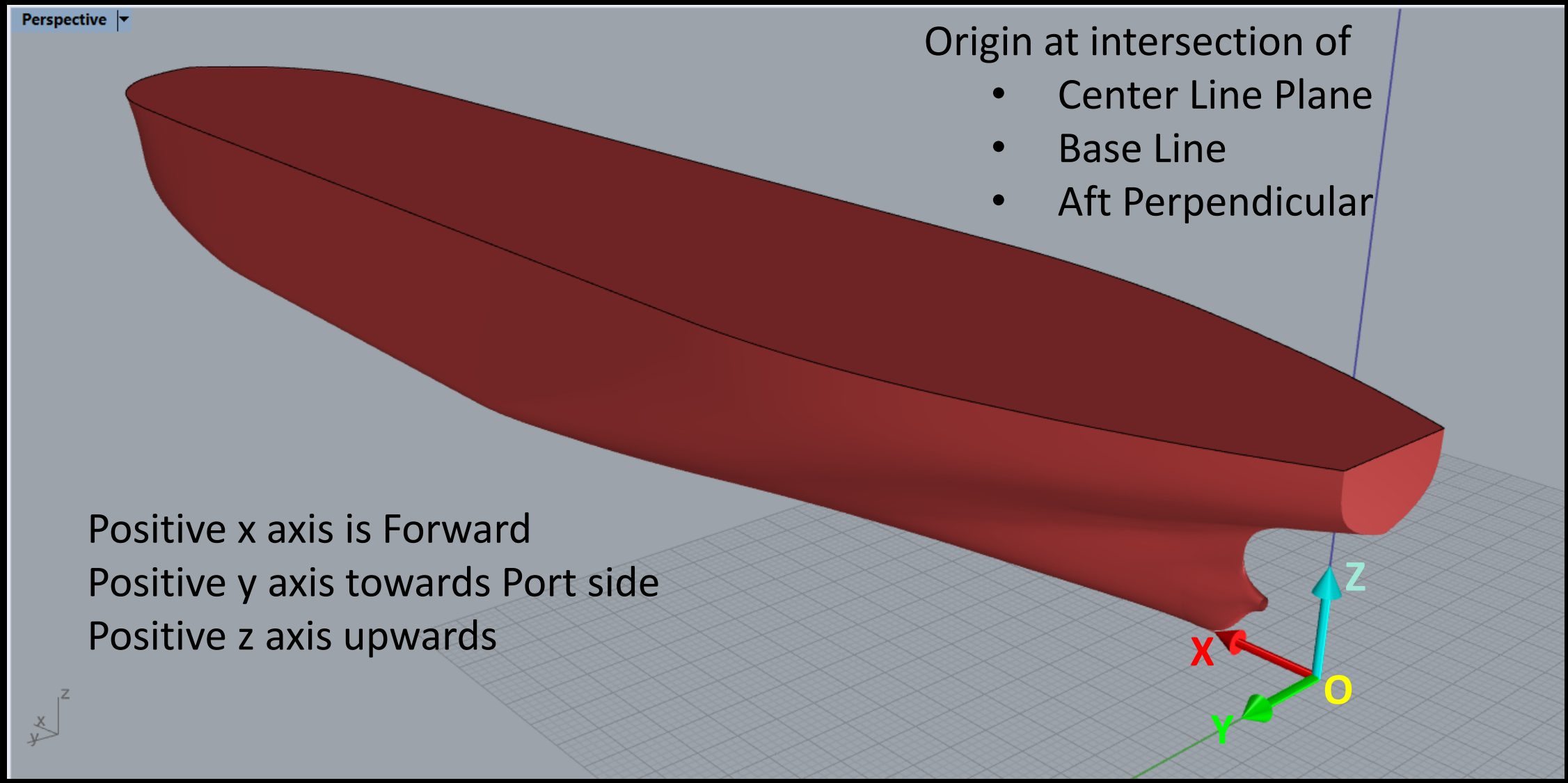
These Files are to be created by the user, with required data for analysis.

See example test case directory in GitHub Repository.

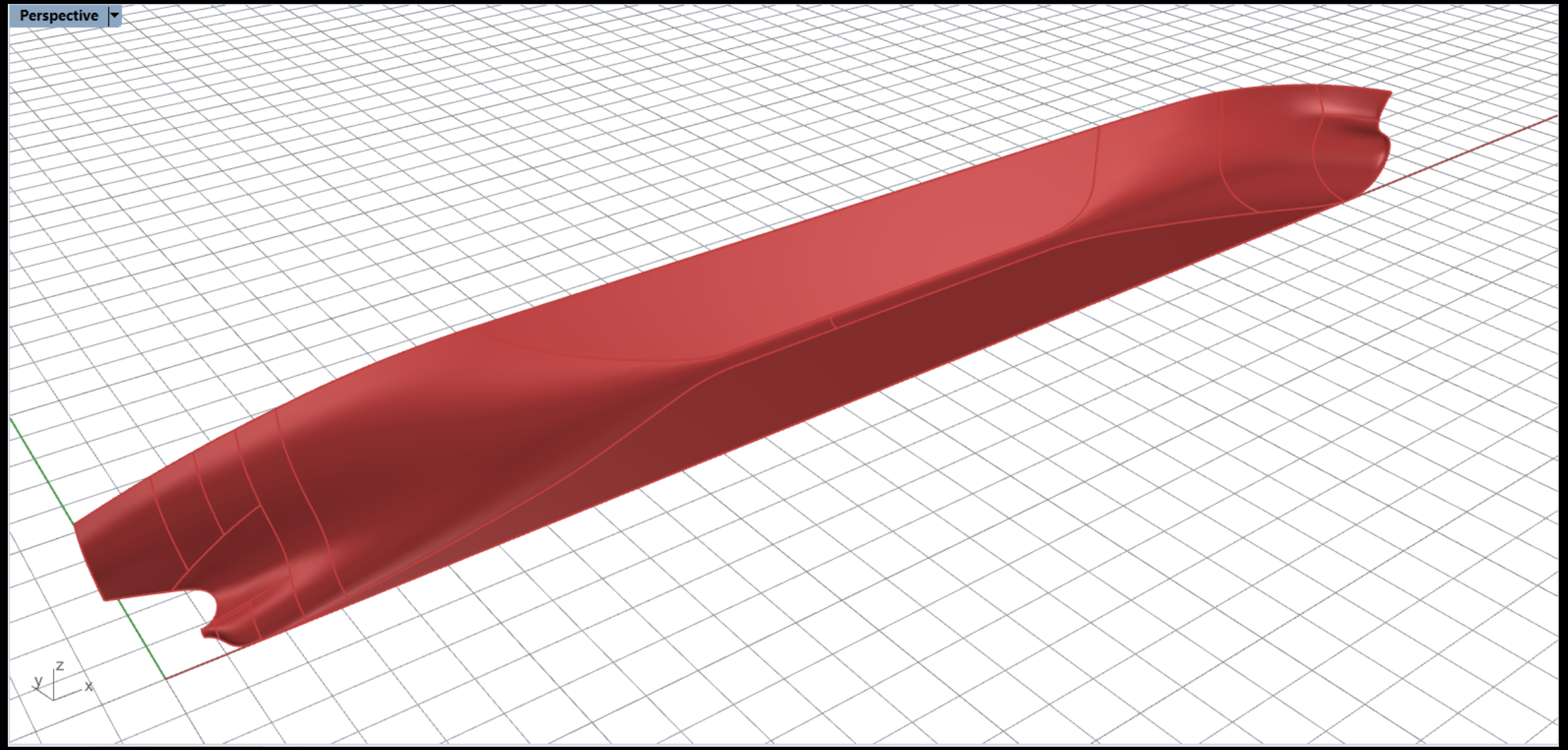
Overview of Input Files

File Name	Input Data	Purpose
Set_EP.dat	Environment Property, Water Density	Read immediately after Application is started
Set_HG.dat	Data that Defines the Hull Geometry	
Set_HS.dat	Range of Drafts and Trim angles at which the Hydrostatics are to be Computed	Read when user chooses to perform hydrostatic analysis
Set_KN.dat	Range of Heel Angles to compute Cross Curves of Stability	Read when the user chooses to perform Large angle stability analysis
Set_LC.dat	Load Cases defined by Mass displacement and VCG	

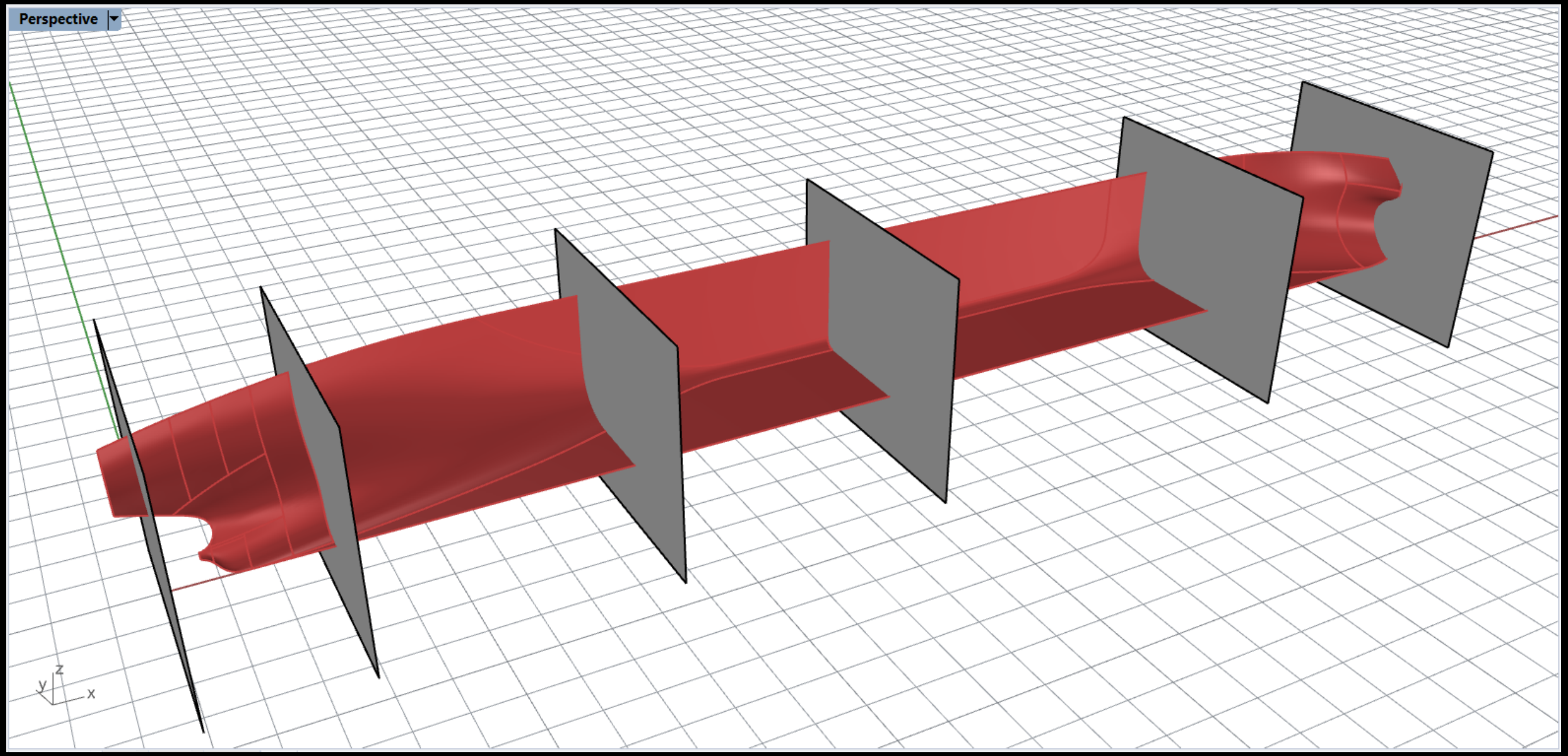
Step 1: The Hull Geometry Definition



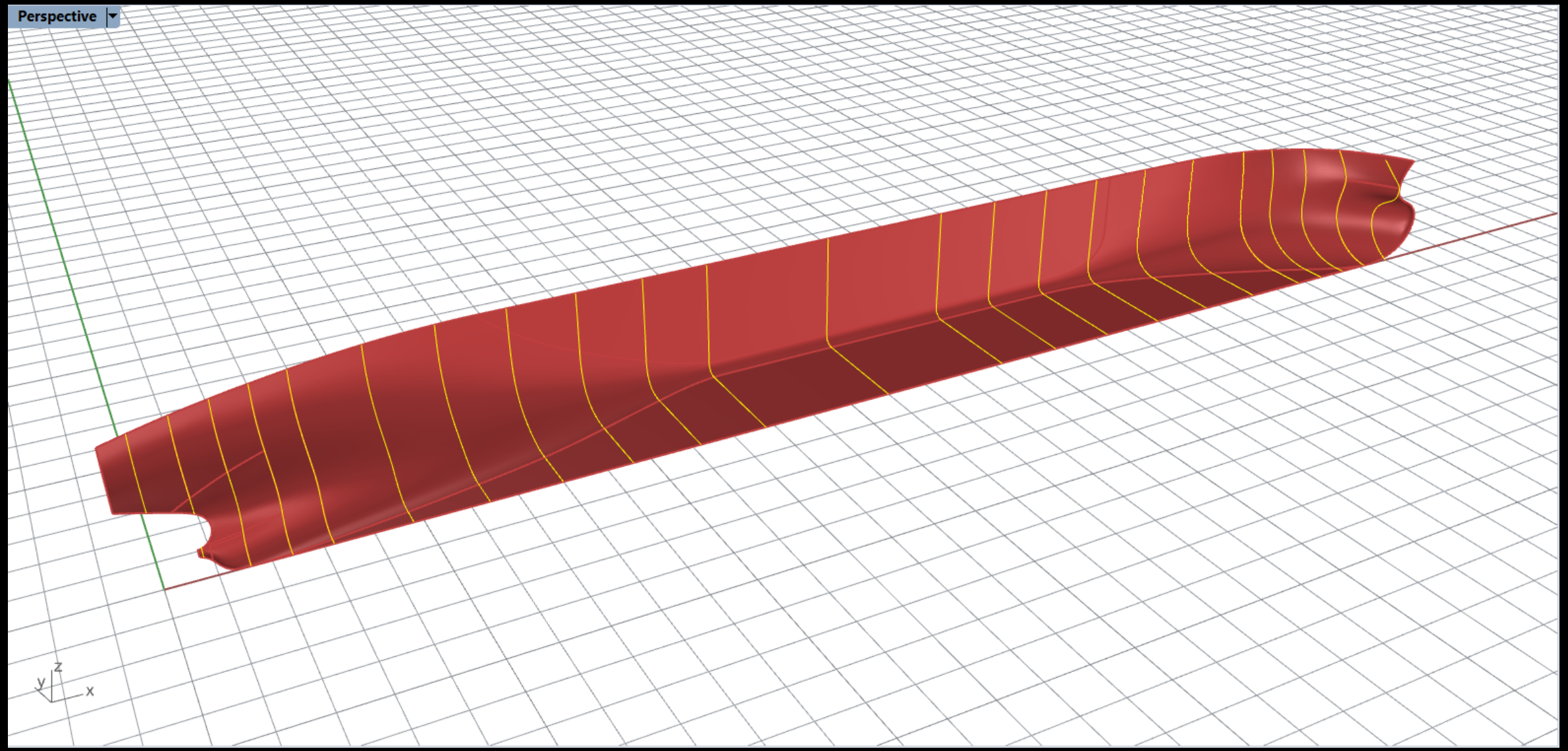
Ship Reference Frame



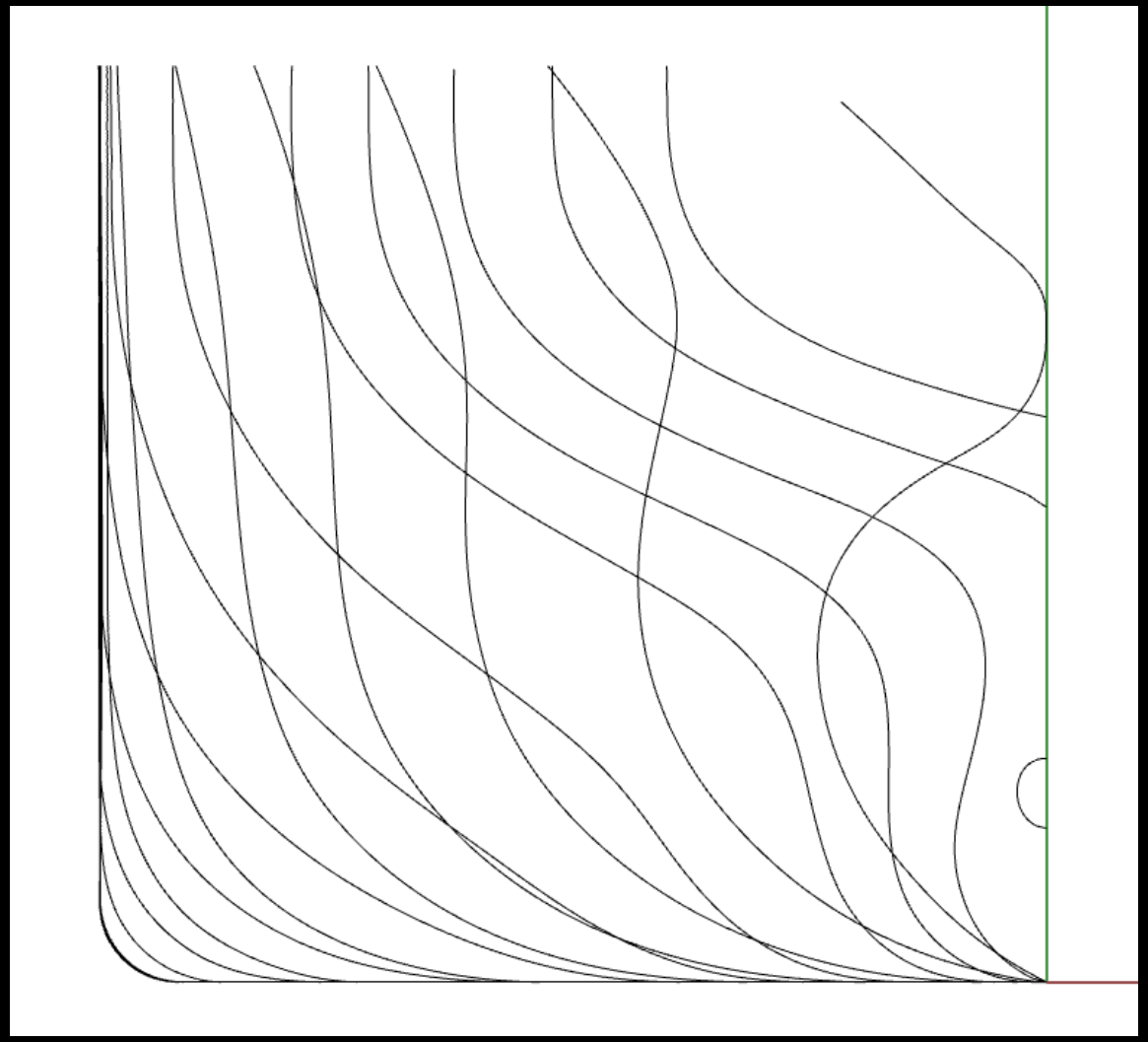
Consider only the port side half of the hull
(both Y and Z are positive this side)

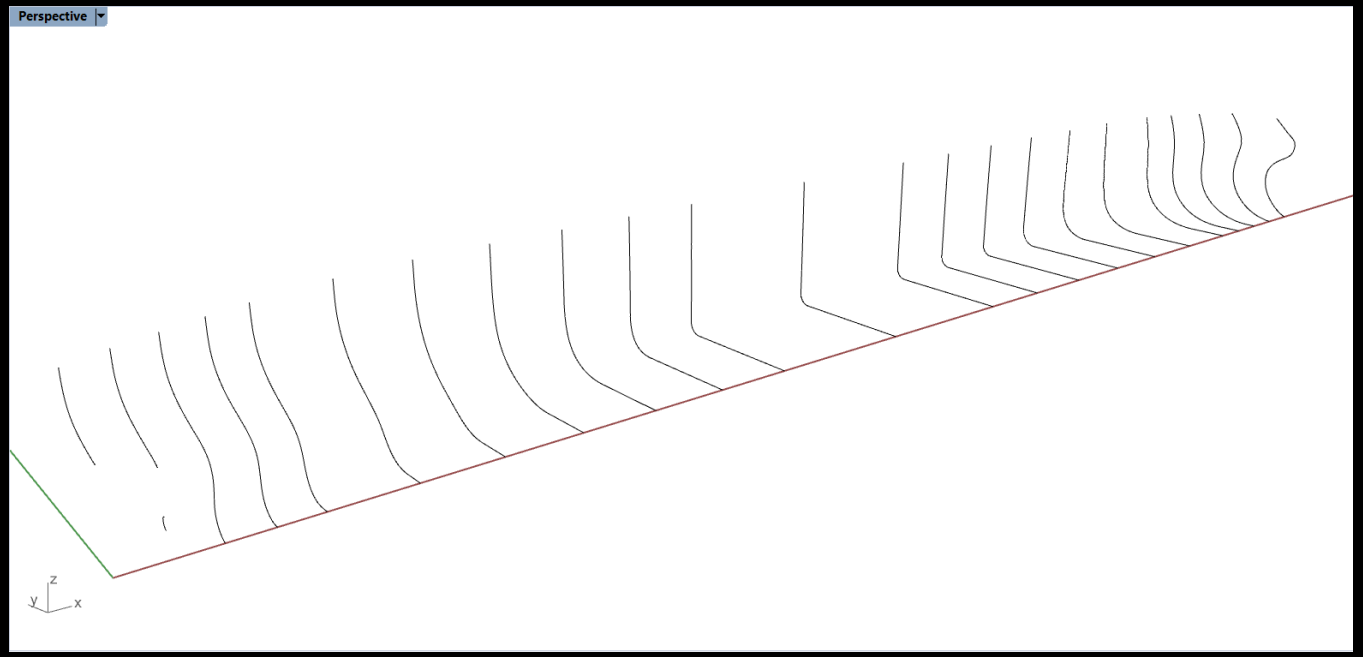


Create Cutting Planes parallel to YZ plan at various station locations along the length of the ship

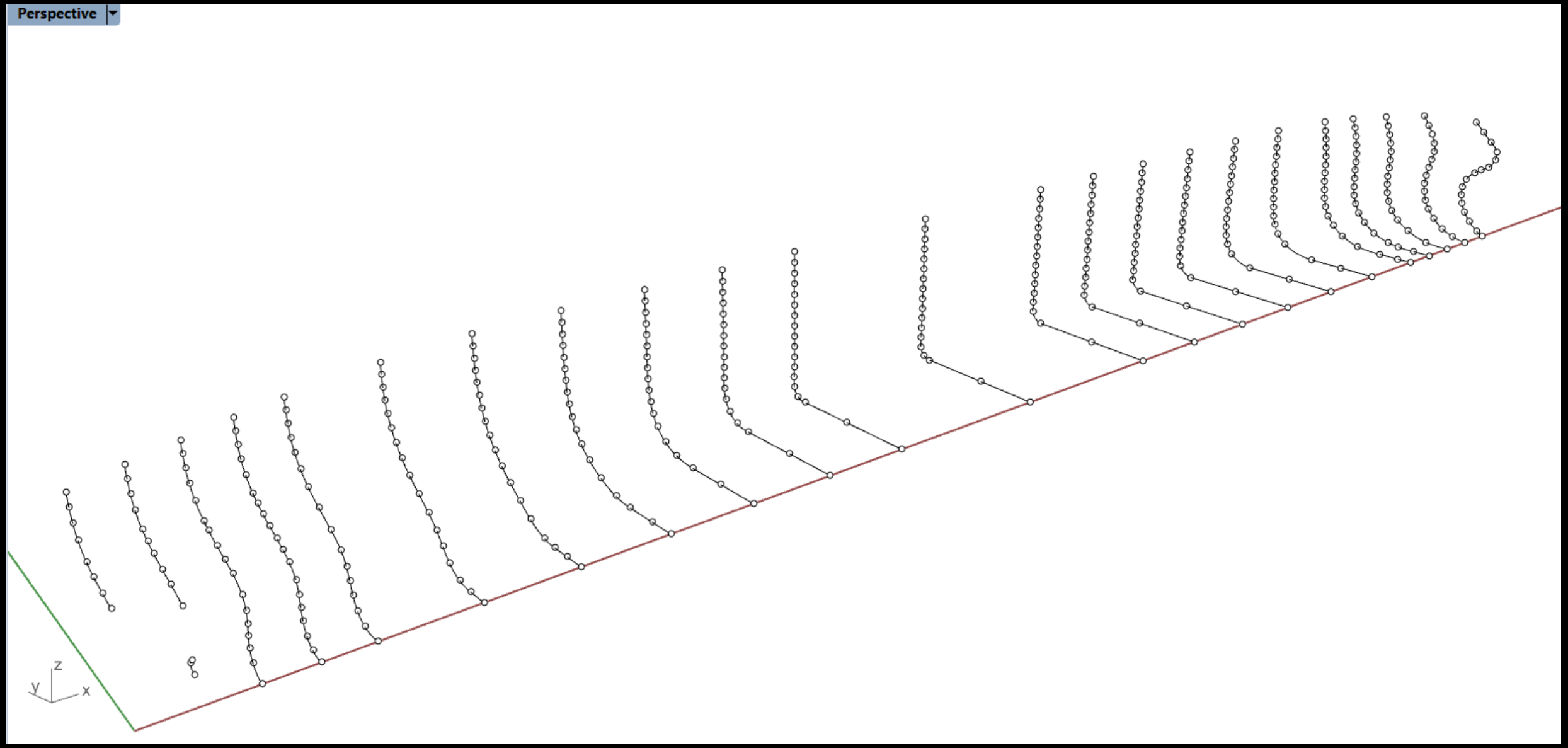


Obtain the intersection curves of each section plane with the hull surface

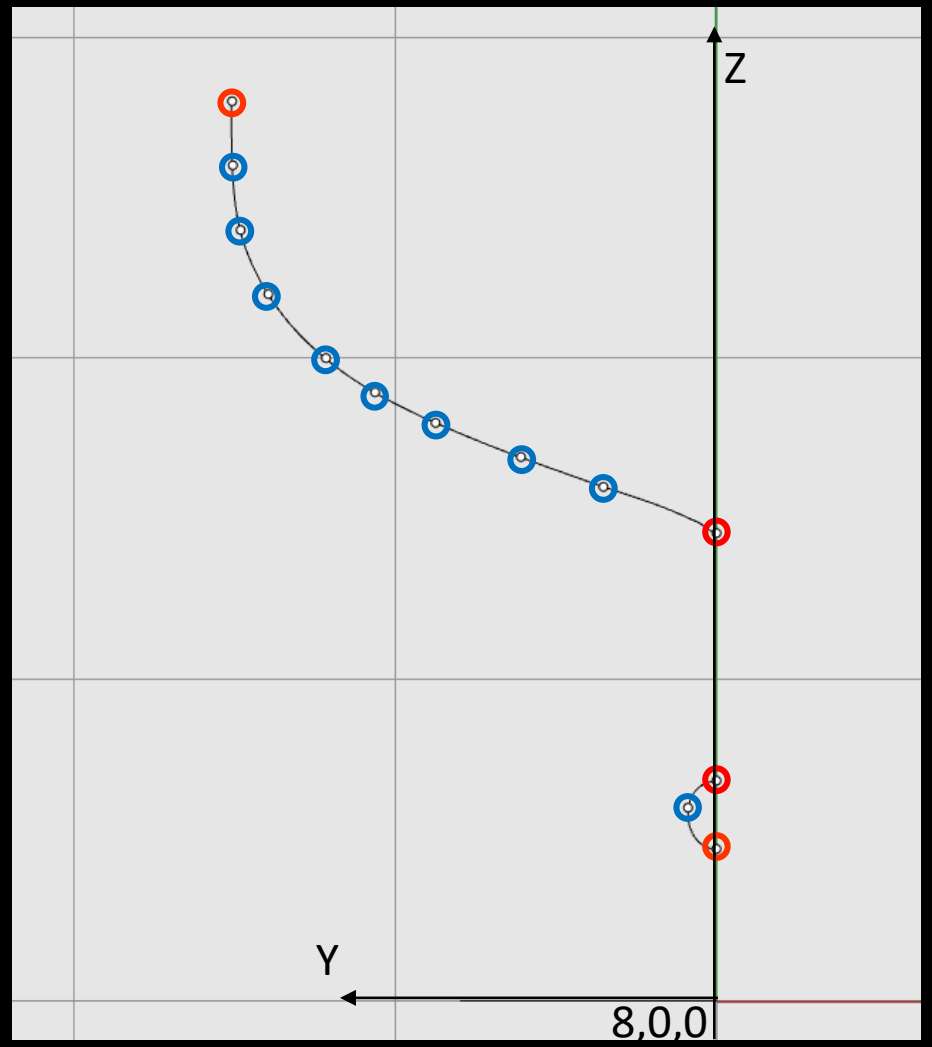




The Obtained Section curves
Used to define the Hull geometry



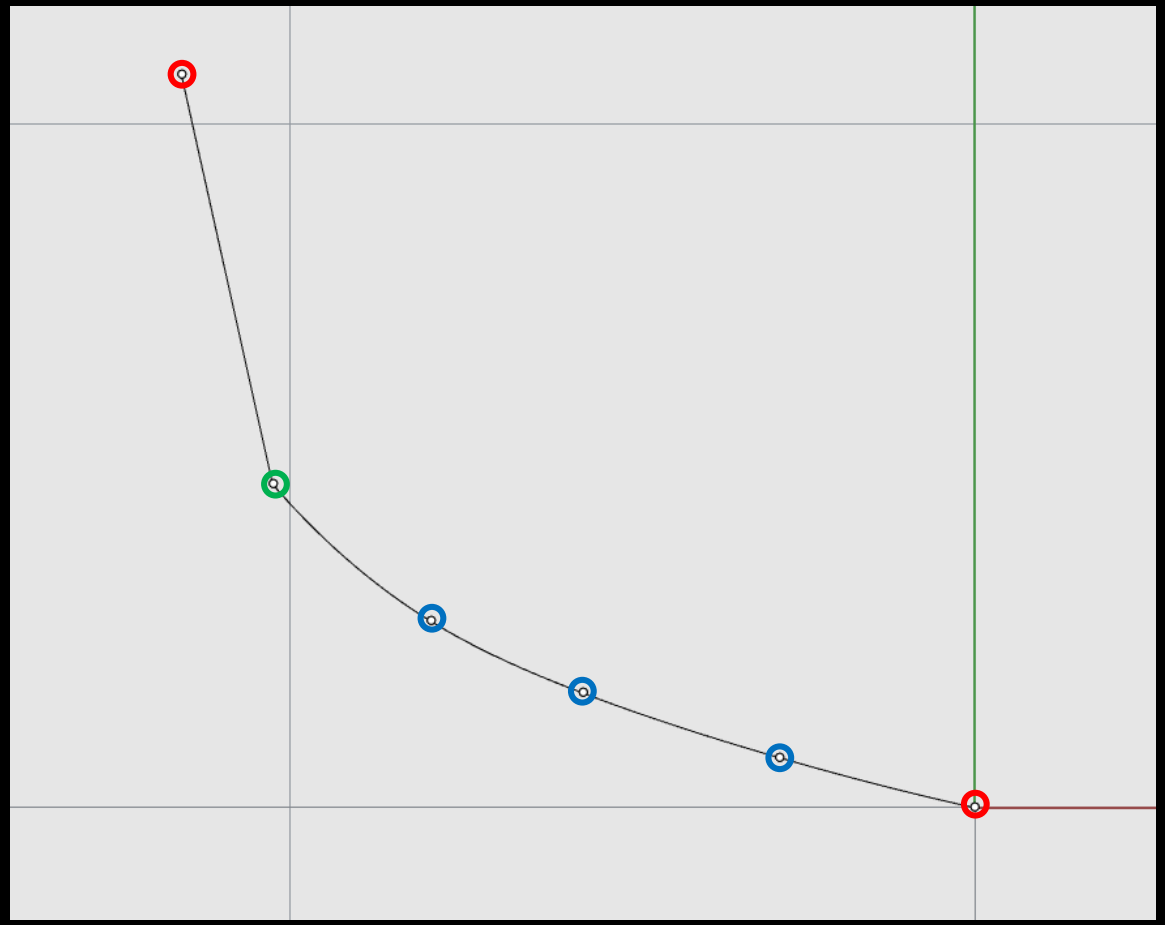
On each of the curves identify the key points required to define the section accurately



Example : Curve Points defining Section at X = 8

X	Y	Z	b/k
8	0.000	4.71	b
8	0.884	6.00	
8	0.000	6.834	b
8	0.000	14.529	b
8	3.538	16.00	
8	6.116	16.924	
8	8.776	18.00	
8	10.657	18.939	
8	12.186	20.00	
8	13.971	22.00	
8	14.839	24.00	
8	15.08	26.00	
8	15.106	28.00	b

The points in red circle are the ends of curves defining the section ,
Hence those points coordinates are followed by a tab and letter ‘b’
The program identifies them as break points



Example 2: A section with a Knuckle point

X	Y	Z	b/k
0	0.000	0	b
0	2.847	0.73	
0	5.73	1.678	
0	7.951	2.73	
0	10.256	4.73	k
0	11.59	10.73	b

The point in the Green circle is a knuckle point, with C0 Continuity
Hence those points coordinates are followed by a tab and letter ‘k’
The program identifies them and splits curve at that point

Make “Set_HG.dat” using the obtained Curve points

Length

Breadth

Location of AP along x axis

Curve Points of Station at x=0

Set_HG.dat - Notepad

File Edit Format View Help

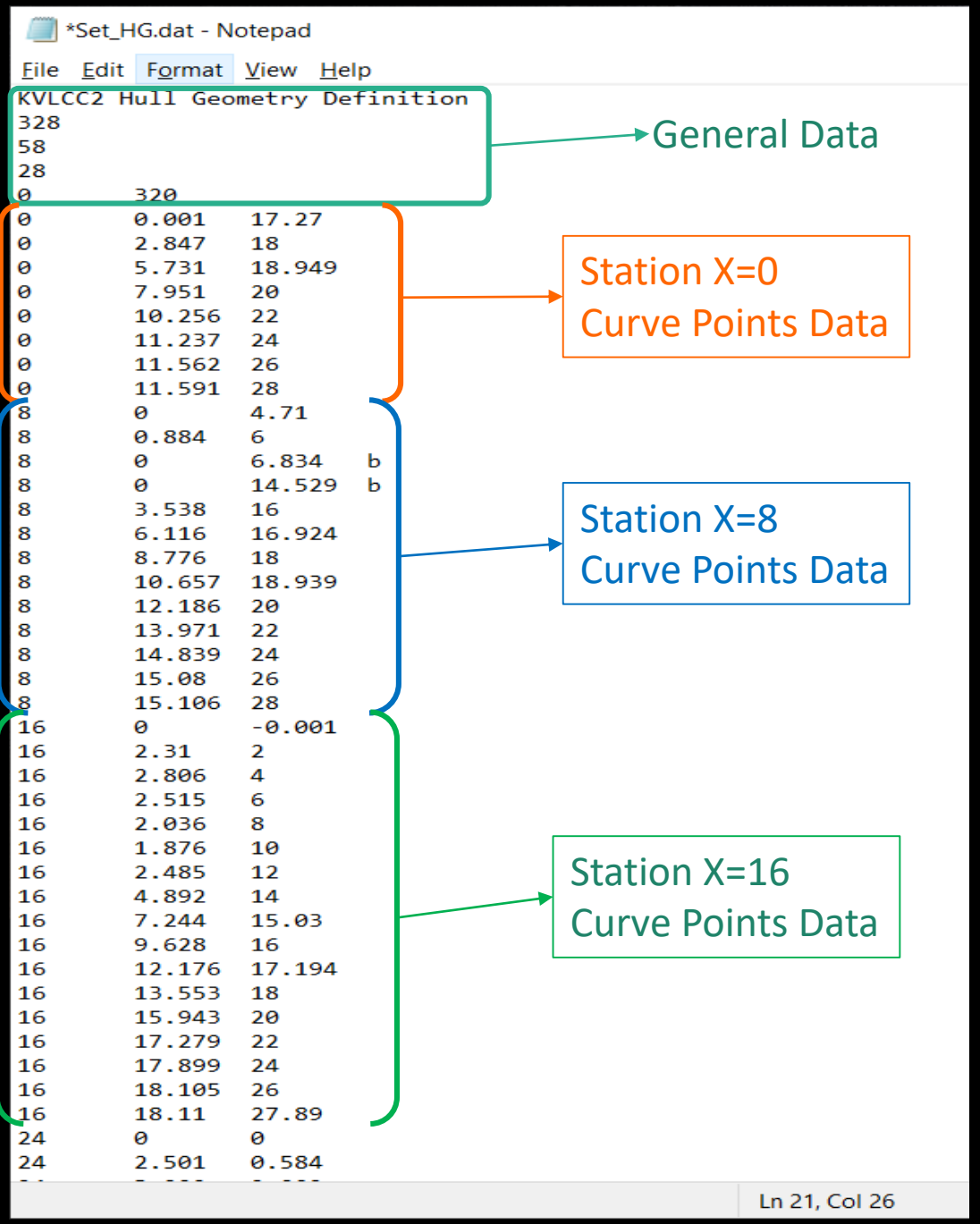
Name Tag

```
KVLCC2 Hull Geometry Definition
328
58
28
0          320
0          0.001    17.27
0          2.847    18
0          5.731    18.949
0          7.951    20
0          10.256   22
0          11.237   24
0          11.562   26
0          11.591   28
8          0        4.71
8          0.884    6
8          0        6.834    b
```

Depth

Location of FP along x axis

“Set_HG.dat” should contain data in the format shown here.
‘tab’ should be used to separate data values in a line.
Empty/stray lines not allowed.



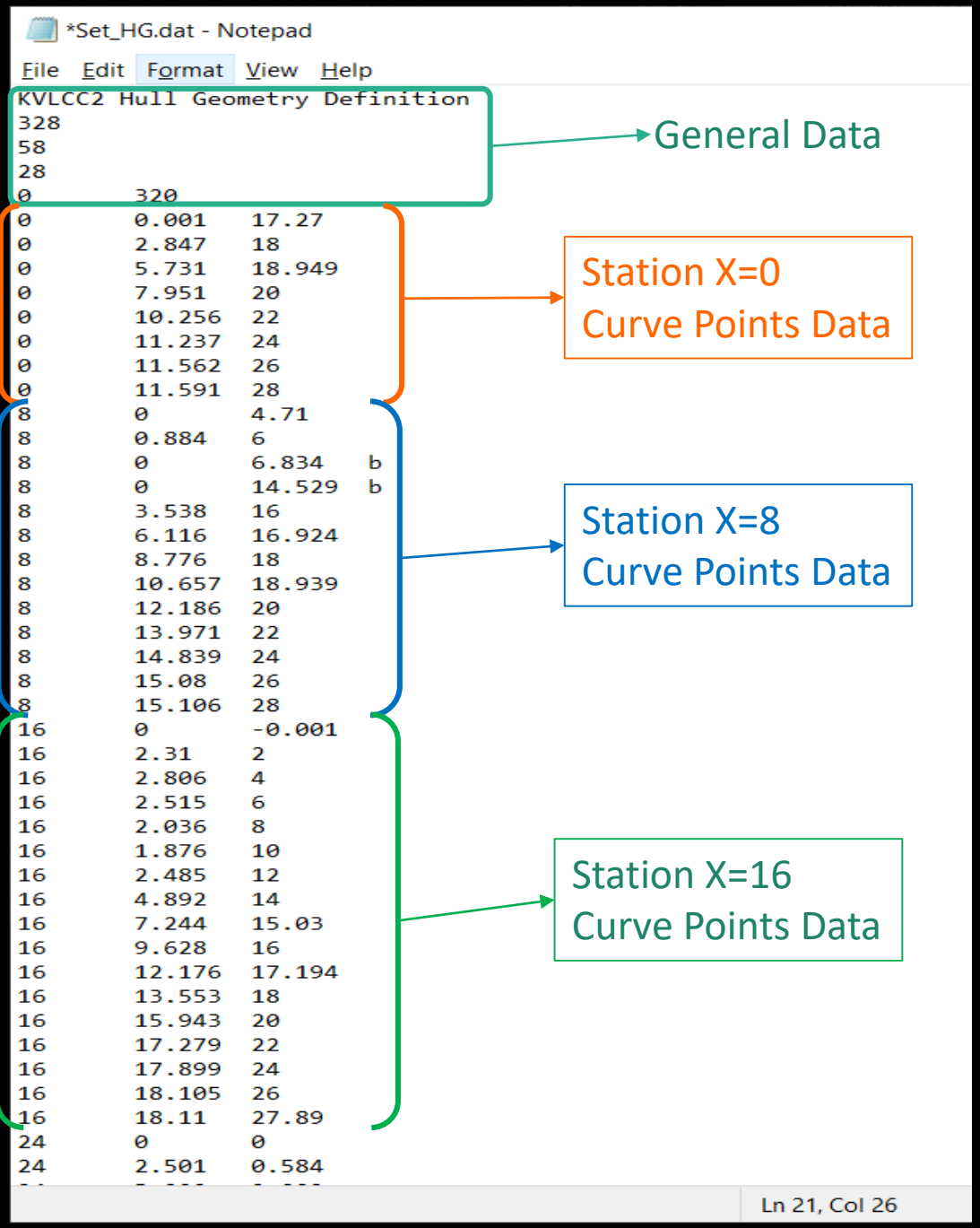
First 5 lines contain General data

From the sixth line , Station wise curve points data is entered.

If 'N_{st}' Stations are used to define the hull geometry

Then N_{st} blocks of station data should be included in the "Set_HG.dat"

'tab' should be used to separate data values in a line. Empty stray lines not allowed.



Each Block Contains N_{pt} rows

Each row contains one curve point data
First three columns of data include X,Y,Z coordinate values separated by tab and an optional fourth column value which can be the letter “b/k”

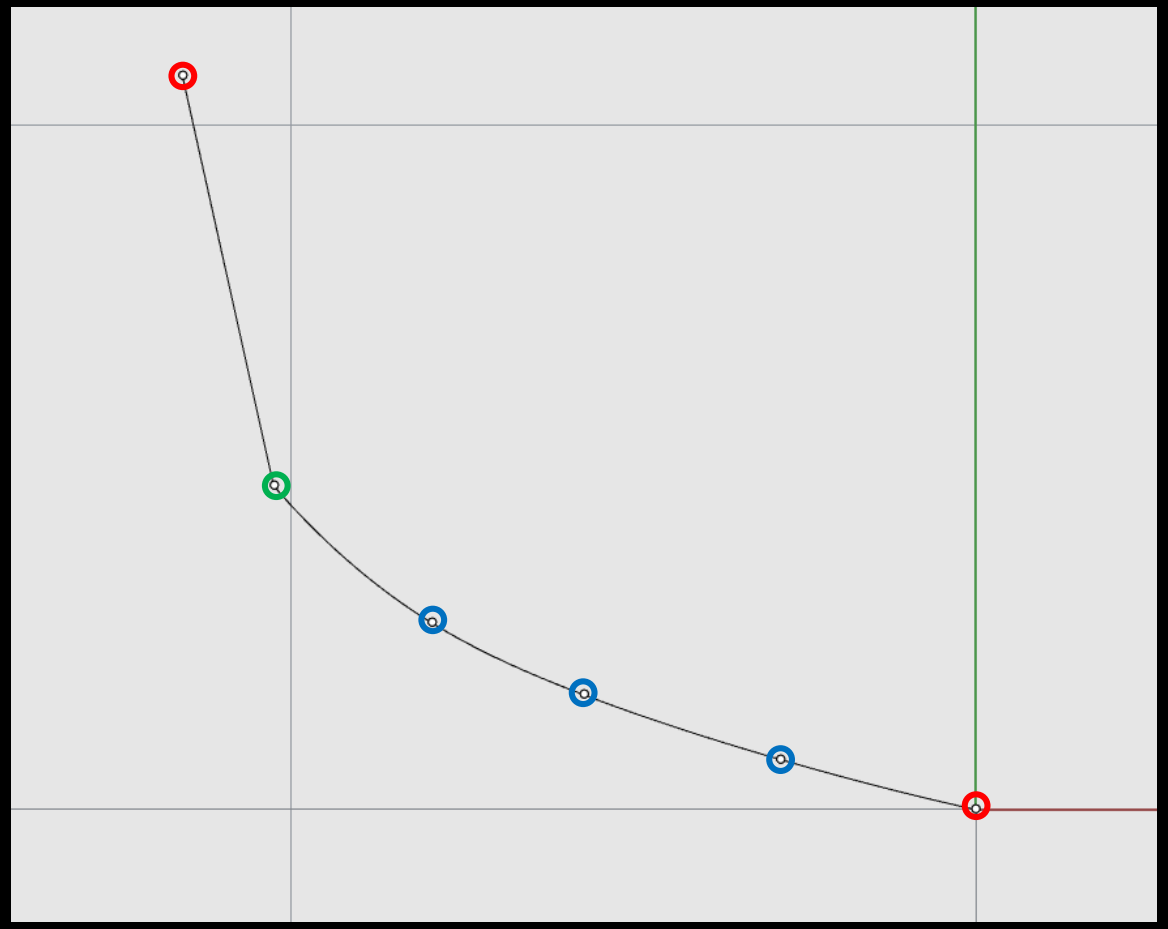
N_{pt} , No. of Points, can be different for each station

‘tab’ should be used to separate data values in a line.
Empty stray lines not allowed.

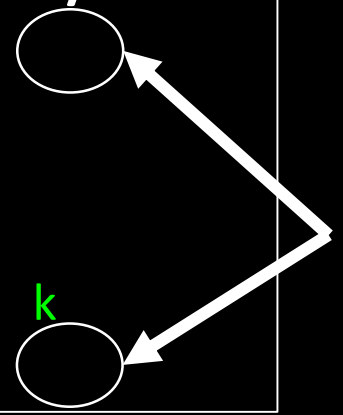
Note

It is not necessary to give ‘b’ for bottom most and top most points of the section.

Even if ‘b’ is not mentioned the program considers them as curve ends



X	Y	Z	b/k
0	0.000	0	
0	2.847	0.73	
0	5.73	1.678	
0	7.951	2.73	
0	10.256	4.73	k
0	11.59	10.73	



Leaving Empty is okay at top and bottom most points along “Z”

Each Row contains one curve point Data , The X, Y, Z coordinates are measured in Ship Reference Frame

The fourth column is optional parameter ‘c’ defining the nature of curve / continuity at that curve point.

Give ‘b’ if the curve is discontinuous at this point i.e., the curve breaks here and a new curve starts from next point

Give ‘k’ if there is a knuckle at this point i.e., only C0 continuity is enforced

Curve Point Coordinates

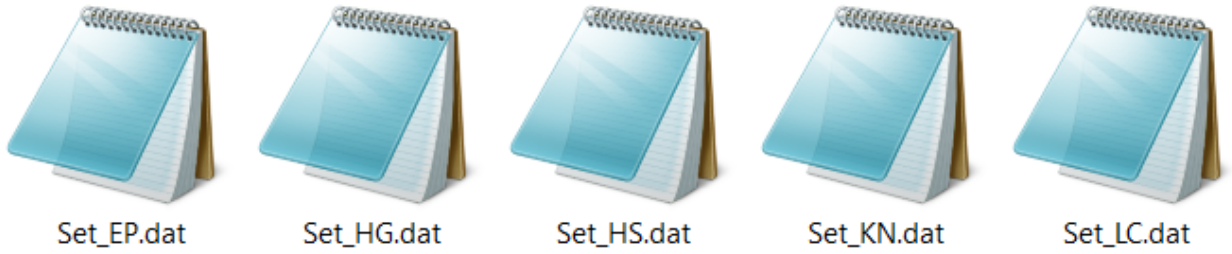
X Y Z b/k

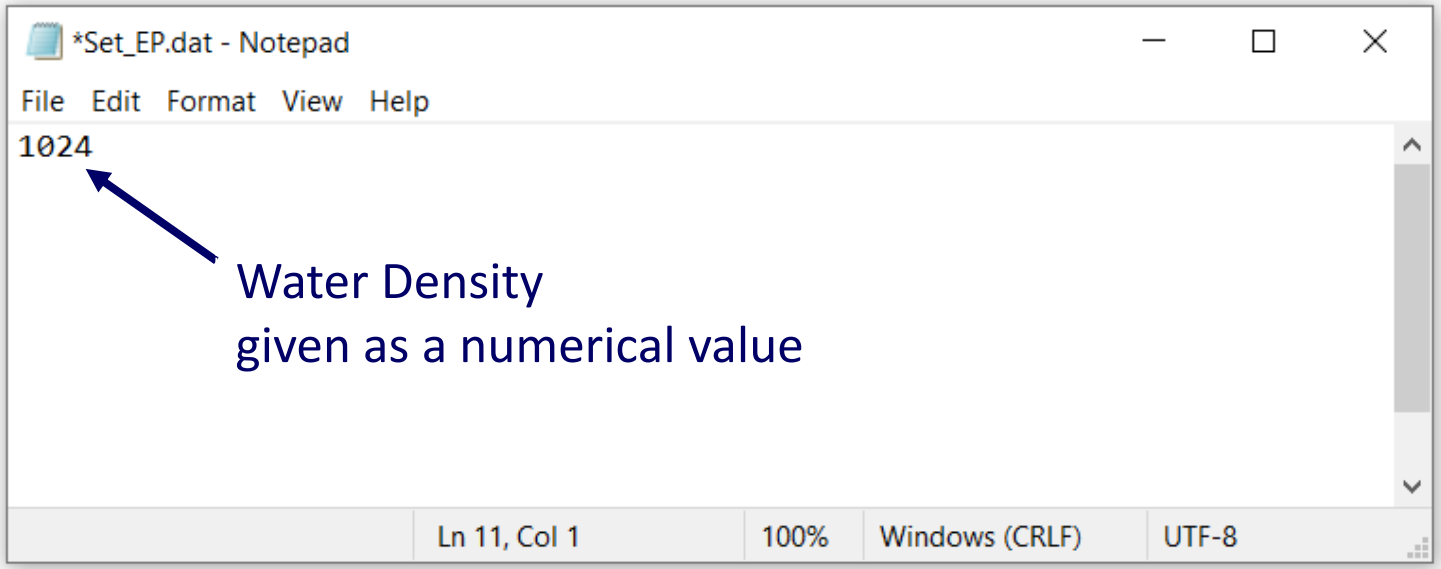
Set_HG.dat - Notepad

File Edit Format View Help

```
KVLCC2 Hull Geometry Definition
328
58
28
0        320
0        0.001    17.27
0        2.847    18
0        5.731    18.949
0        7.951    20
0        10.256   22
0        11.237   24
0        11.562   26
0        11.591   28
8        0        4.71
8        0.884    6
8        0        6.834    b
```

Step 3: Create “Set_EP.dat”





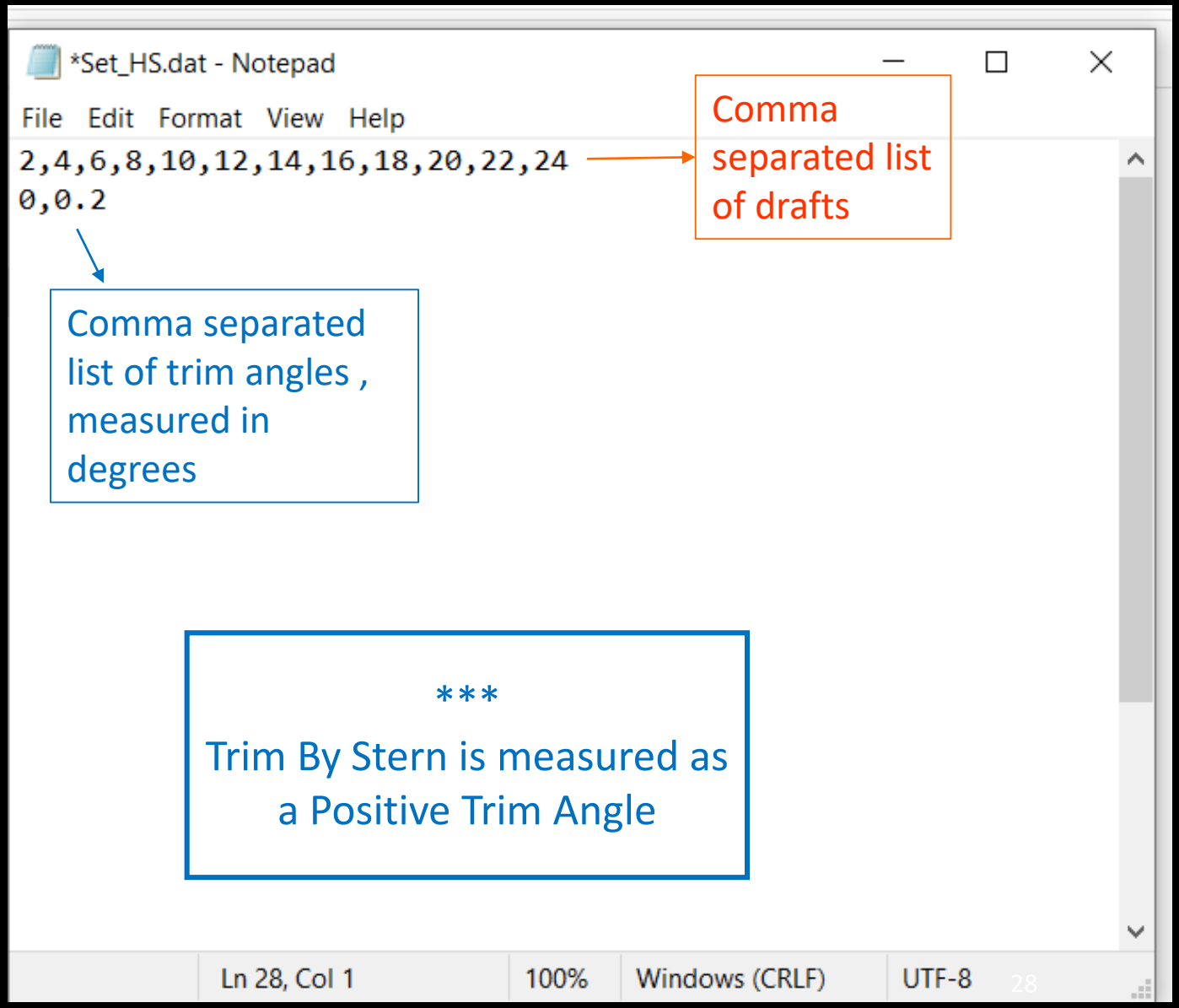
File contains only one numerical values of water density

Step 3: Make “Set_HS.dat” file

PyNAT reads the drafts and trim angles for hydrostatic analysis from this file

Program computes Hydrostatics for all possible combinations of draft and trim

If N drafts and M trim angles are given,
Hydrostatics are computed for a total of N*M floating cases

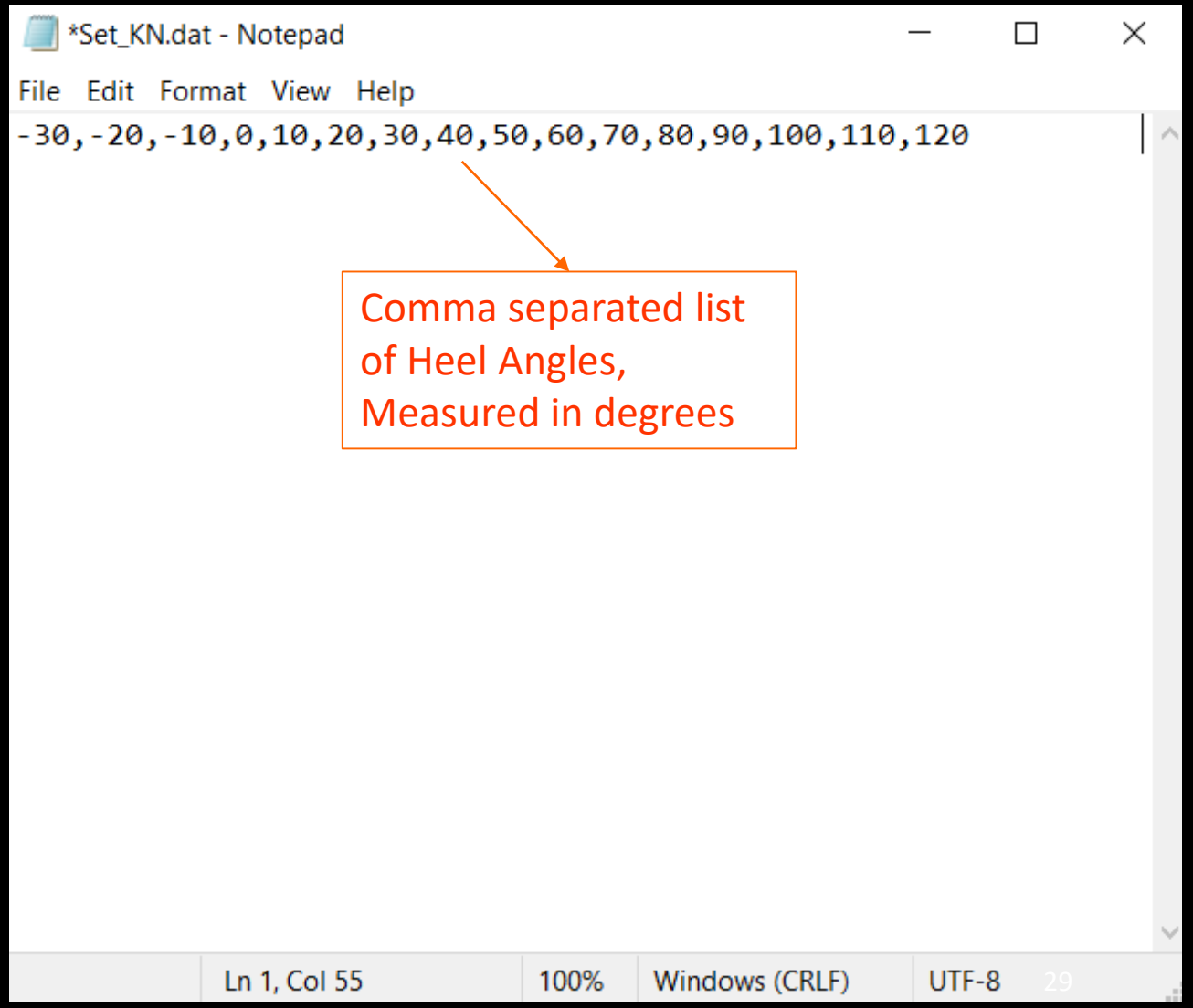


Step 4: Make “Set_KN.dat” file

PyNAT reads the heel angles from this file, for computing KN curve data.

At each heel angle , a range of 11 displacements in between almost zero and maximum are considered

At each combination of heel and displacement the KN value is computed.



Step 5: Make “Set_LC.dat” file

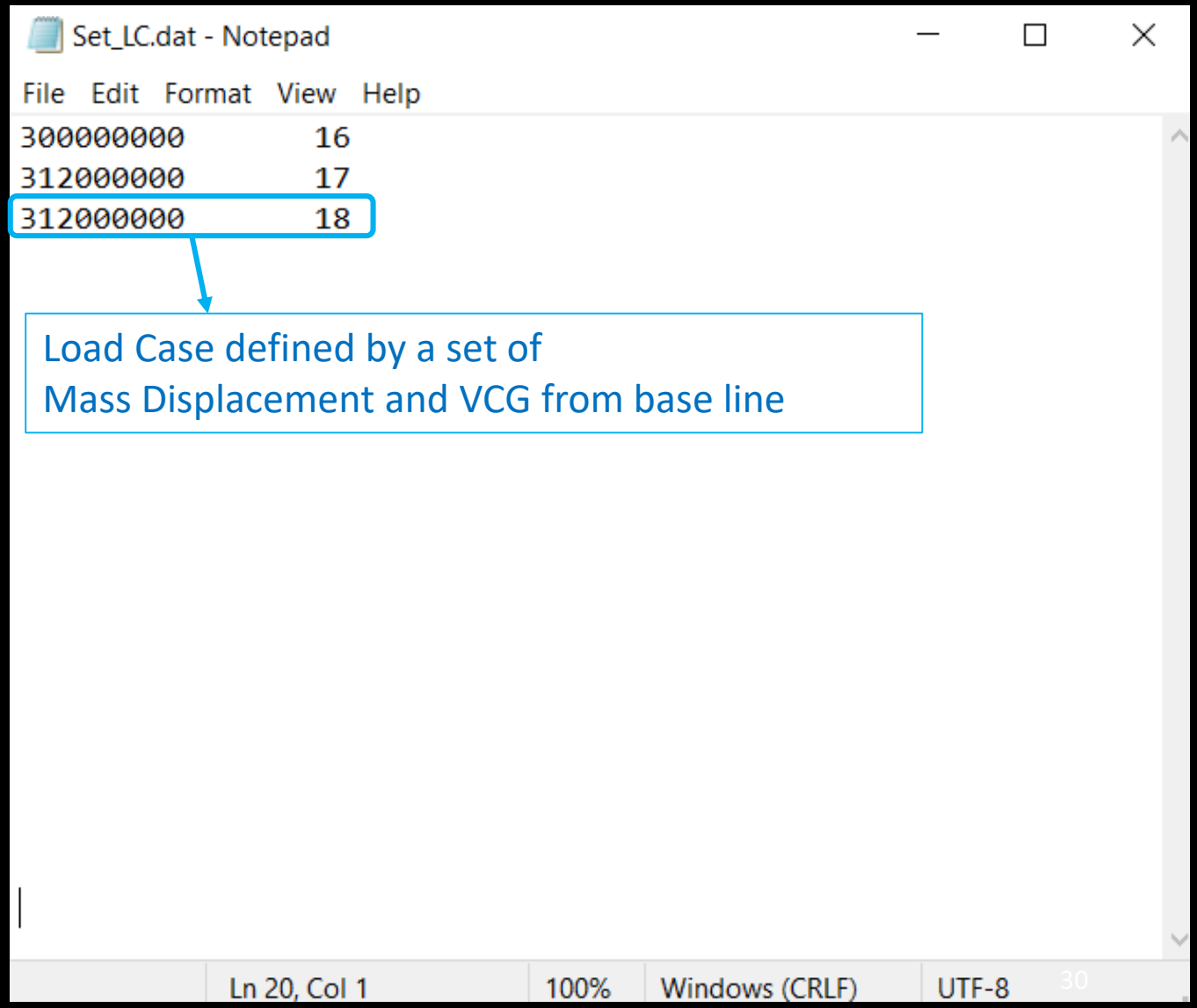
Each Row / Line defines a Load case

Each Load case is defined by A Mass Displacement and the VCG from Base line.

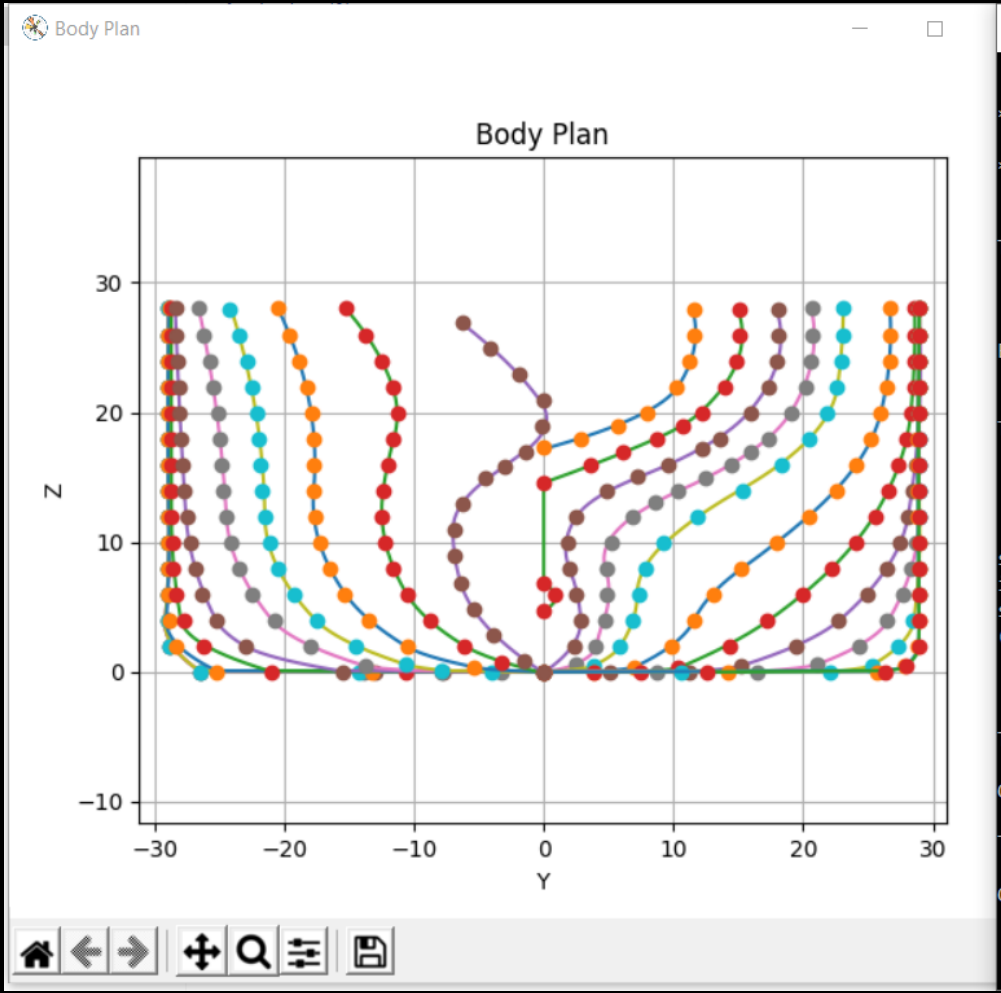
Program computes GZ curve for each load case

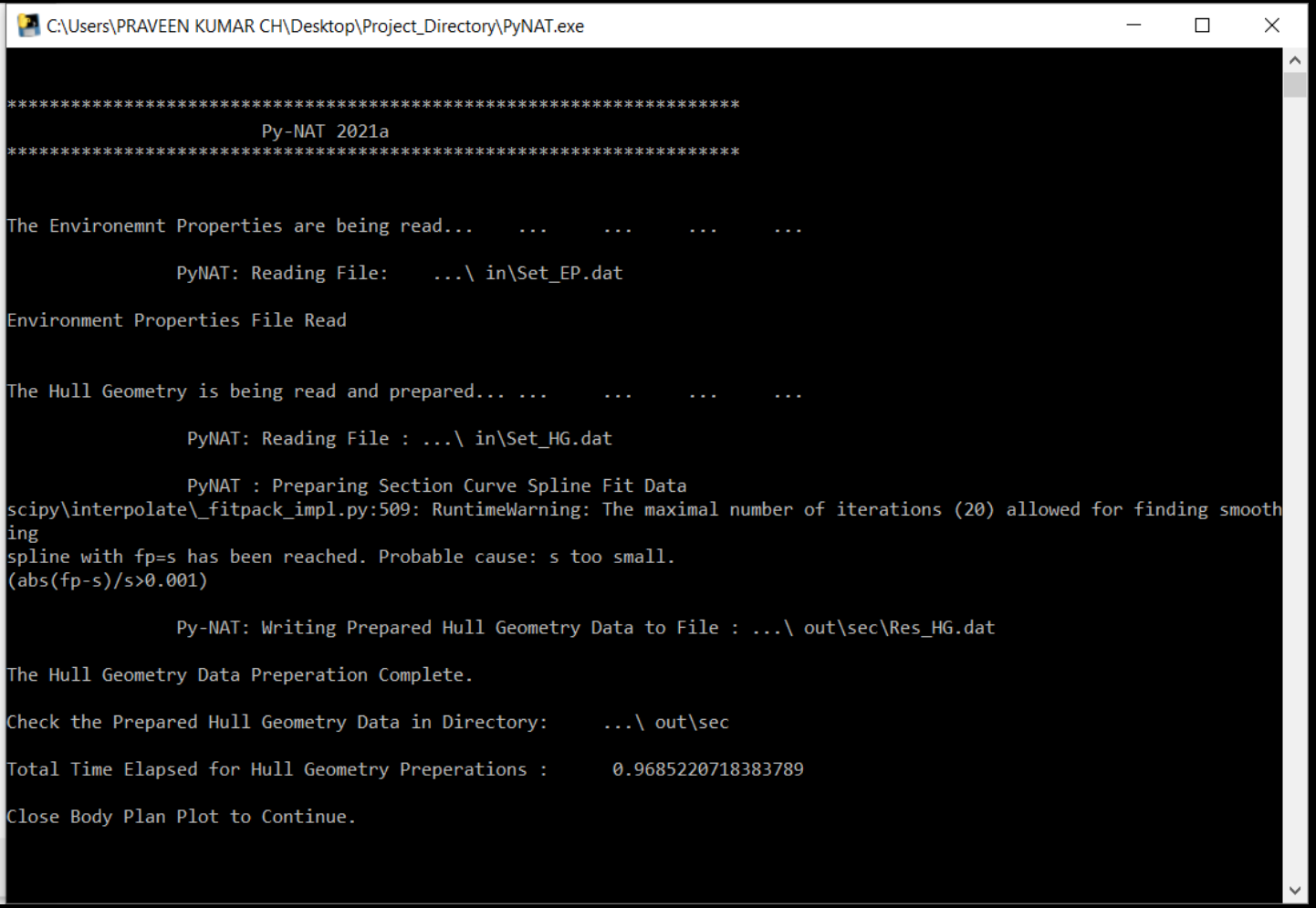
The File should contain only Numerical values separated by tabs and new lines

An extra empty line may throw an error



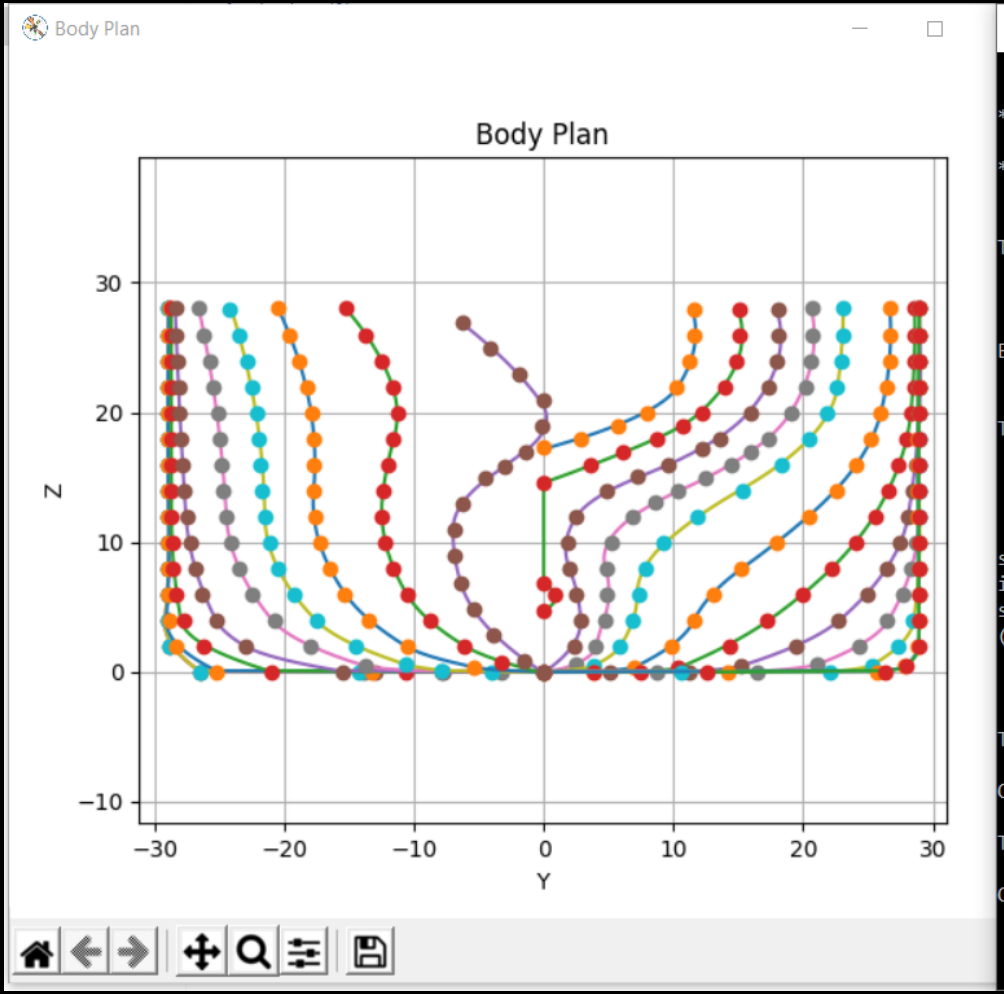
Stage 2: Running the Analysis





Up on running the PyNAT.exe it would take about a minute to start the application

Stage 2: Running the Analysis

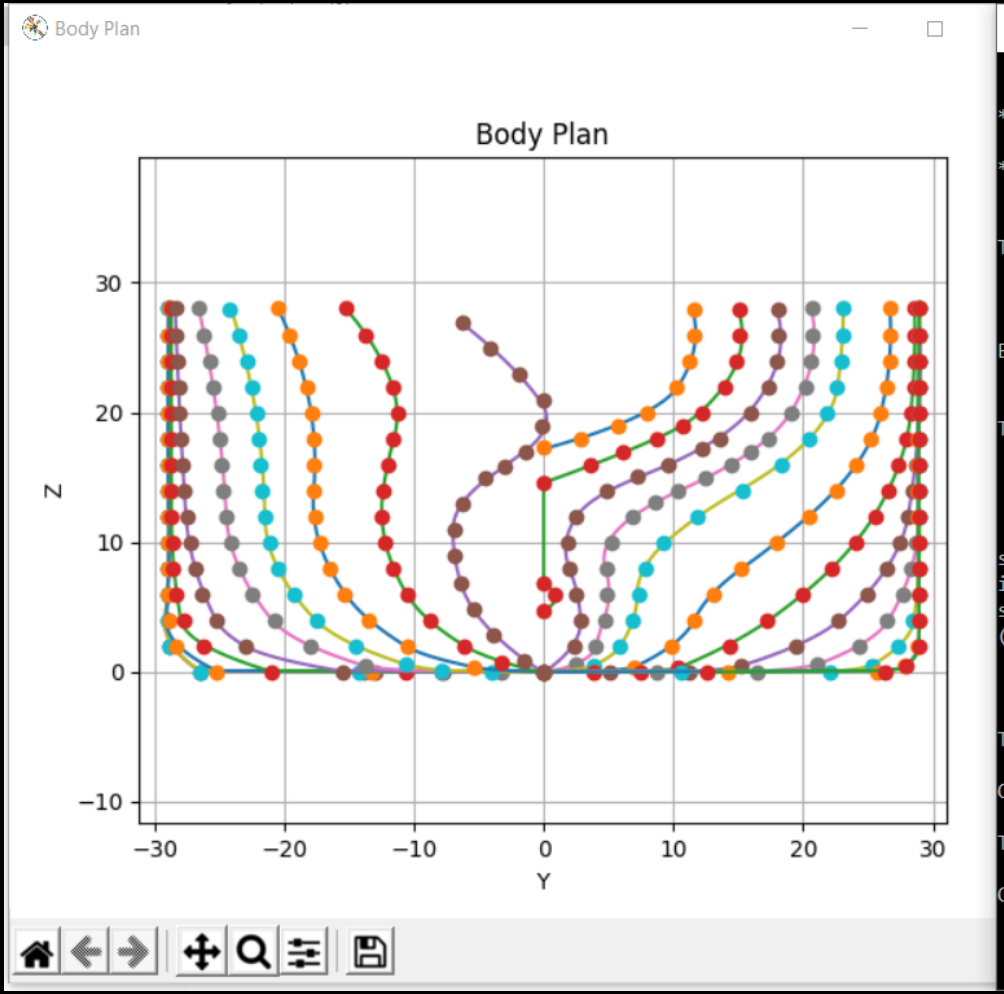


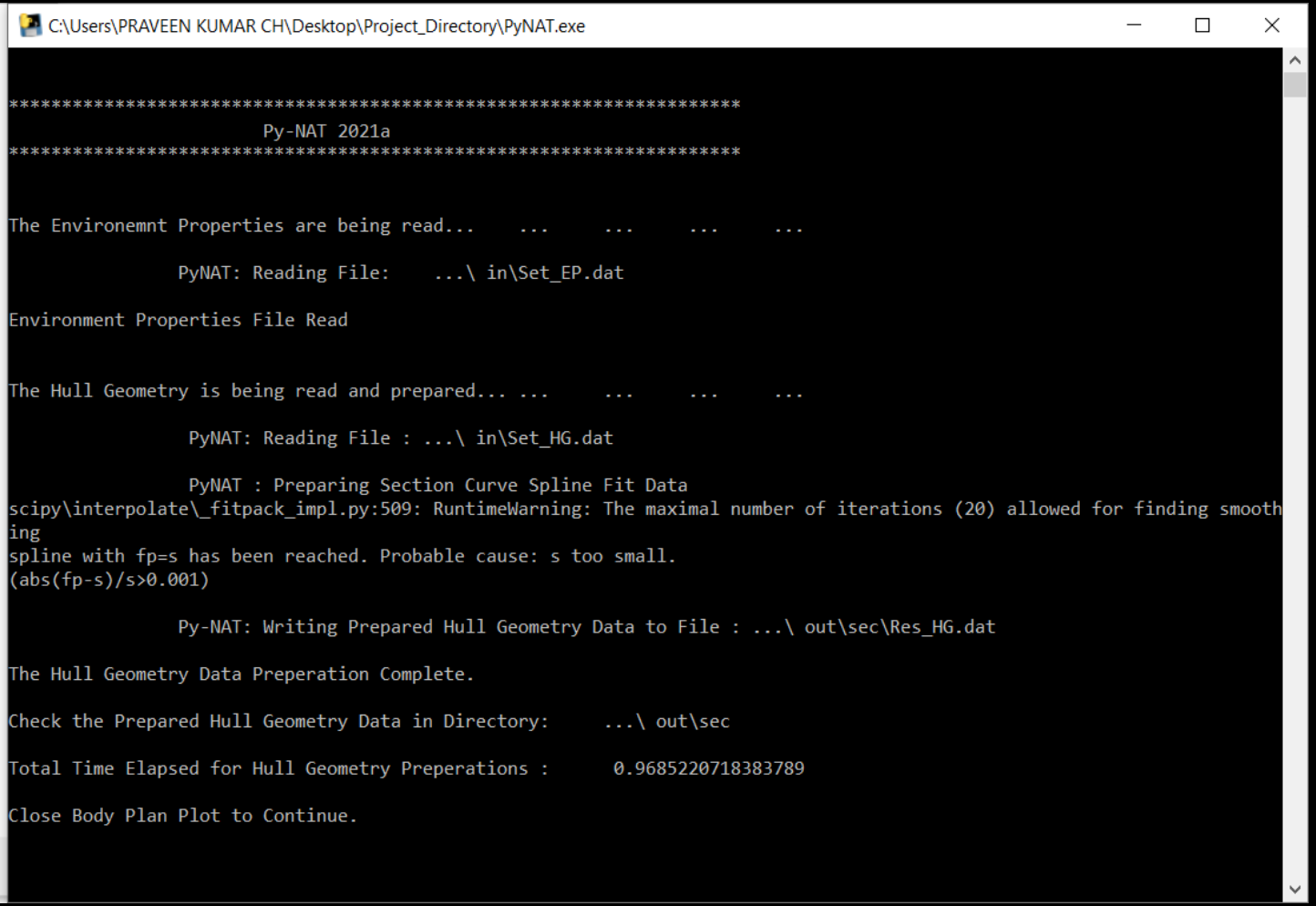
C:\Users\PRAVEEN KUMAR CH\Desktop\Project_Directory\PyNAT.exe

```
**********************************************************************
                        Py-NAT 2021a
**********************************************************************


The Environemnt Properties are being read...    ...     ...     ...     ...

               PyNAT: Reading File:    ...\ in\Set_EP.dat

Environment Properties File Read


The Hull Geometry is being read and prepared... ...     ...     ...     ...

                PyNAT: Reading File : ...\ in\Set_HG.dat

                PyNAT : Preparing Section Curve Spline Fit Data
scipy\interpolate\_fitpack_impl.py:509: RuntimeWarning: The maximal number of iterations (20) allowed for finding smooth
ing
spline with fp=s has been reached. Probable cause: s too small.
(abs(fp-s)/s>0.001)

               Py-NAT: Writing Prepared Hull Geometry Data to File : ...\ out\sec\Res_HG.dat

The Hull Geometry Data Preperation Complete.

Check the Prepared Hull Geometry Data in Directory:     ...\ out\sec

Total Time Elapsed for Hull Geometry Preperations :      0.9685220718383789

Close Body Plan Plot to Continue.
```

Up on initialization the program loads and prepare the Hull Geometry data for calculations. A plot of the Body Plan view of read sections is shown.

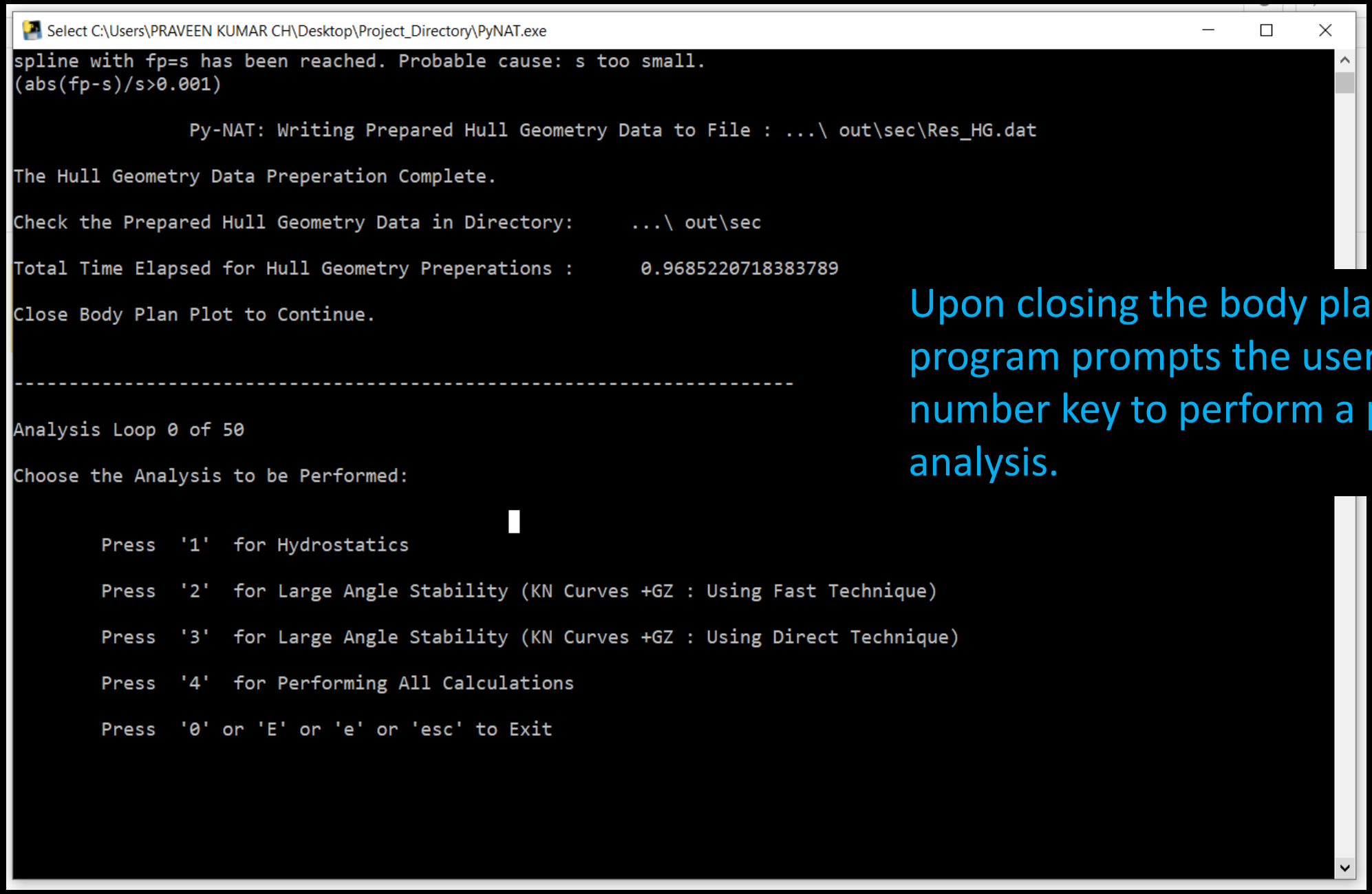
Stage 2: Running the Analysis



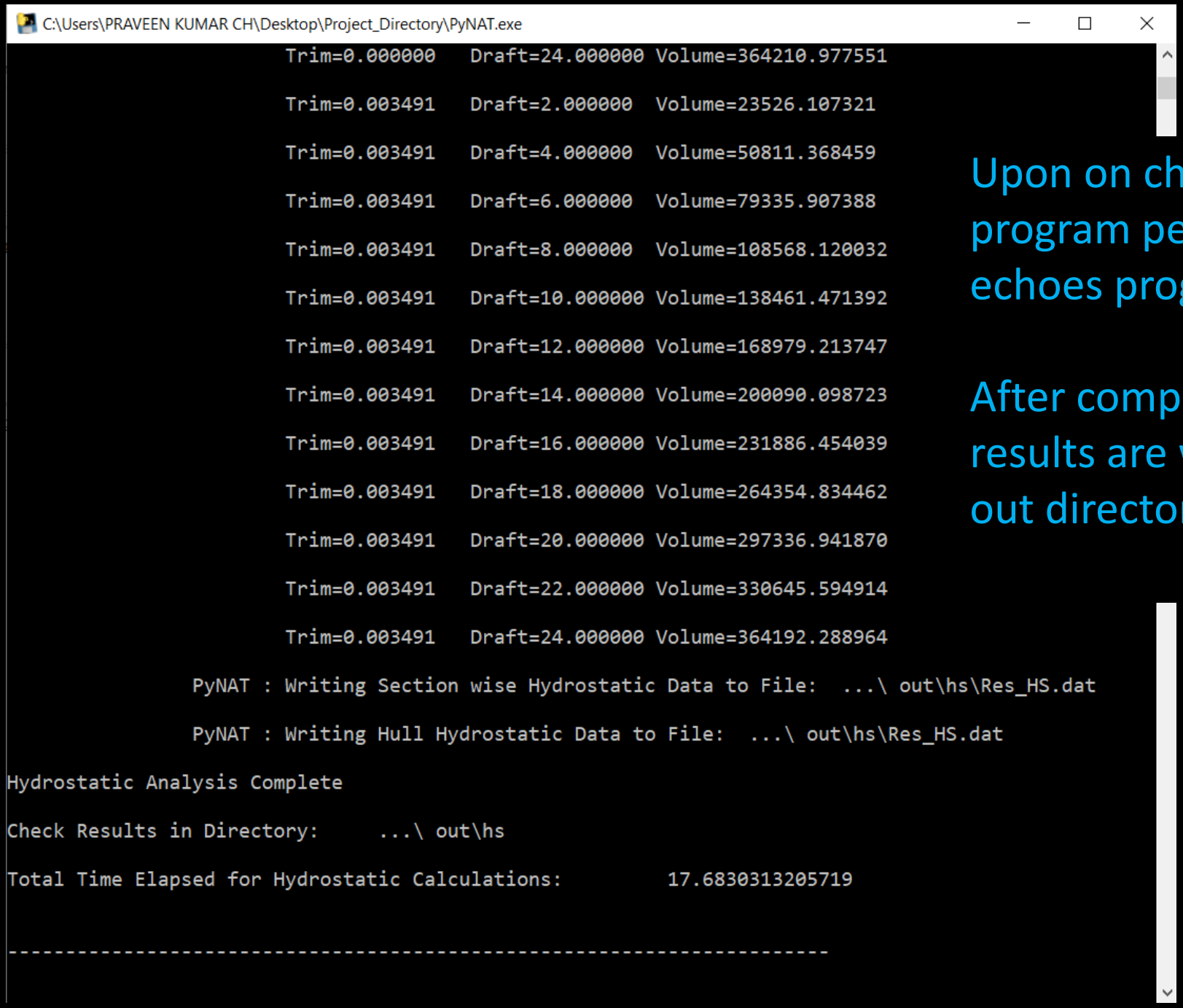


The user can inspect the curves fitted.

The body plan plot must be closed to continue with further analysis.

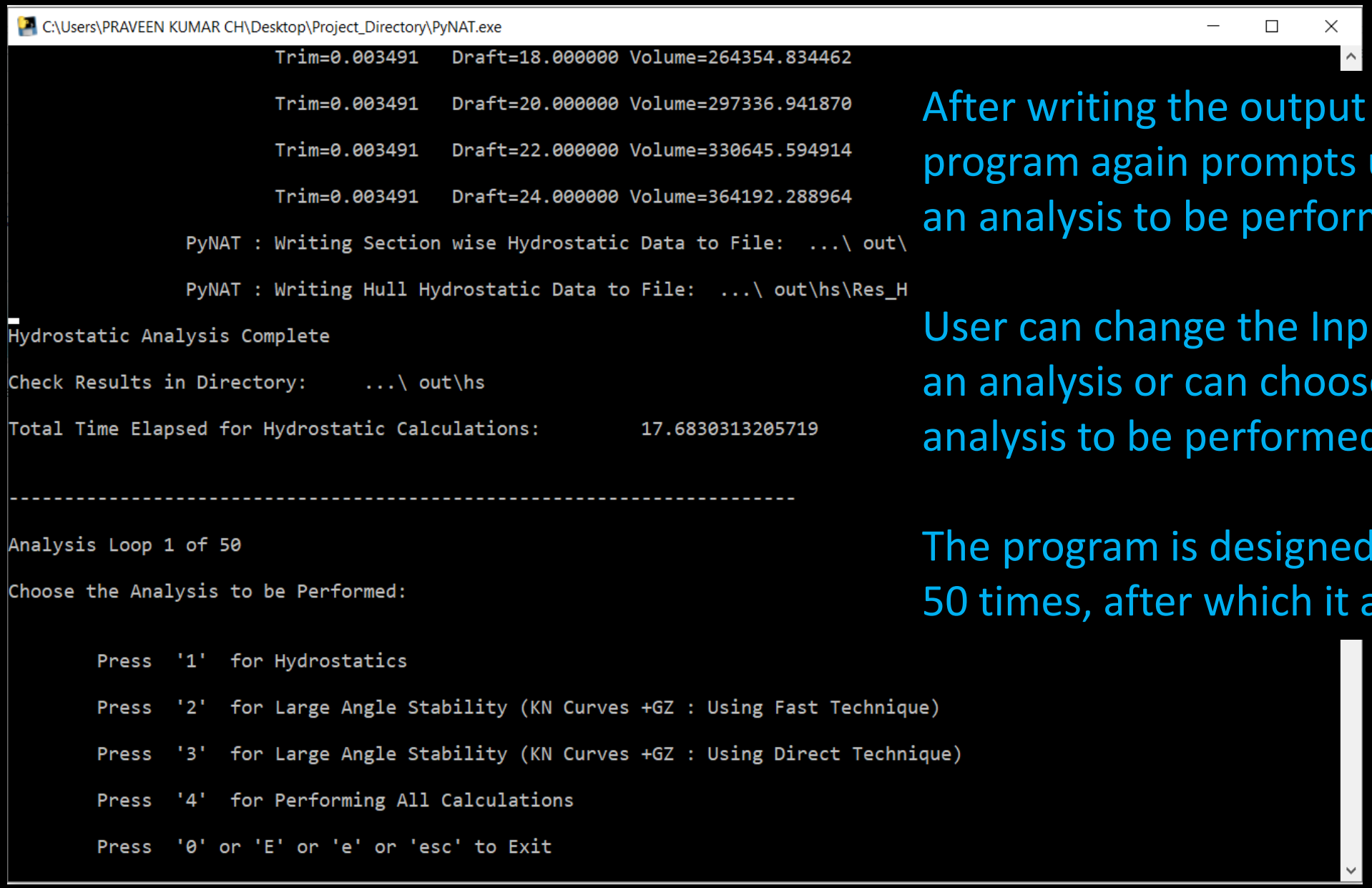


Upon closing the body plan plot, the program prompts the user to press a number key to perform a particular analysis.



Upon on choosing an analysis the program performs the analysis and echoes progress on to the terminal…

After completion of the Analysis the results are written to the output files in out directory.



After writing the output files, the program again prompts user to choose an analysis to be performed.

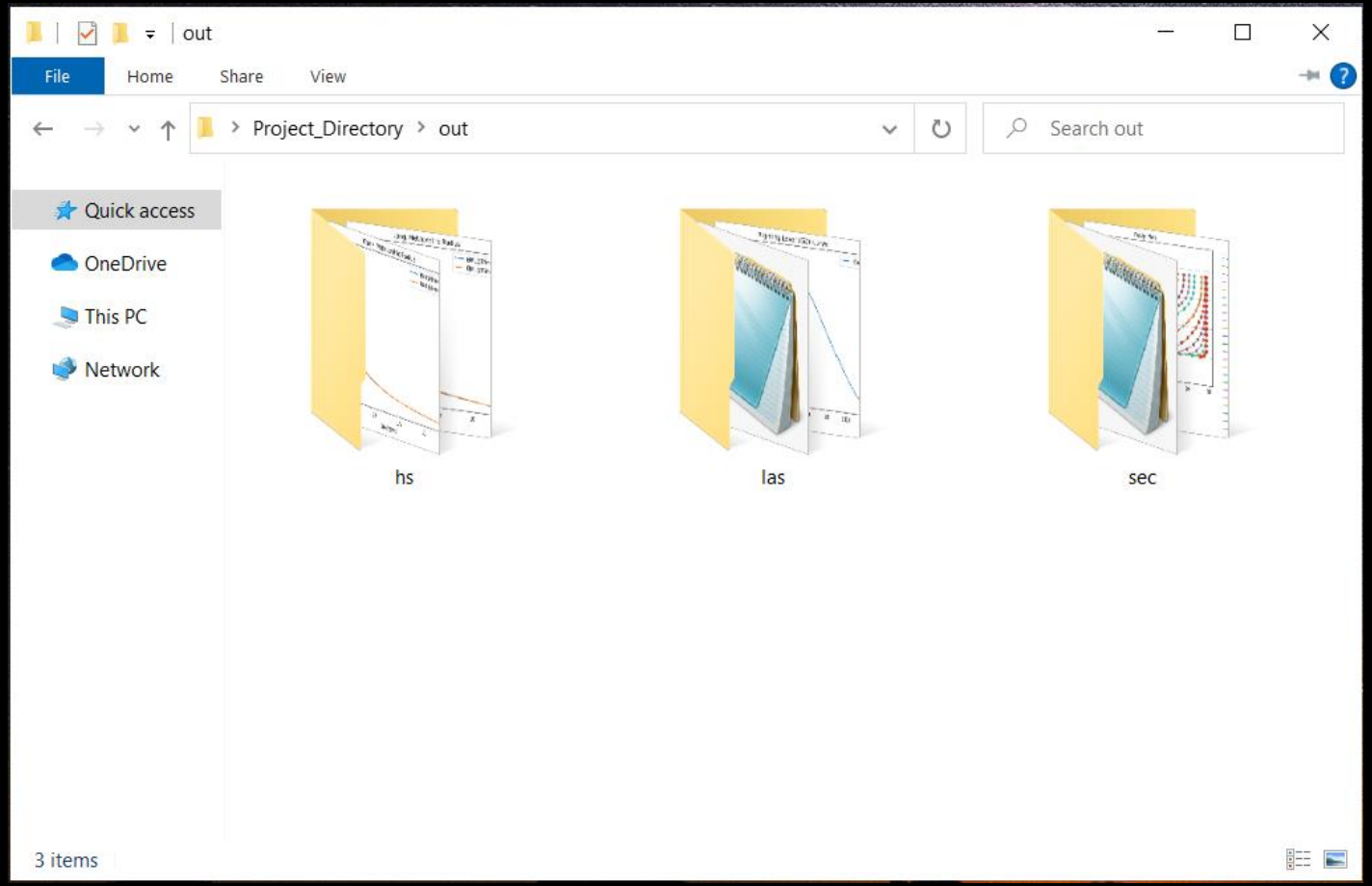
User can change the Input files and redo an analysis or can choose a different analysis to be performed.

The program is designed to prompt for 50 times, after which it auto terminates.

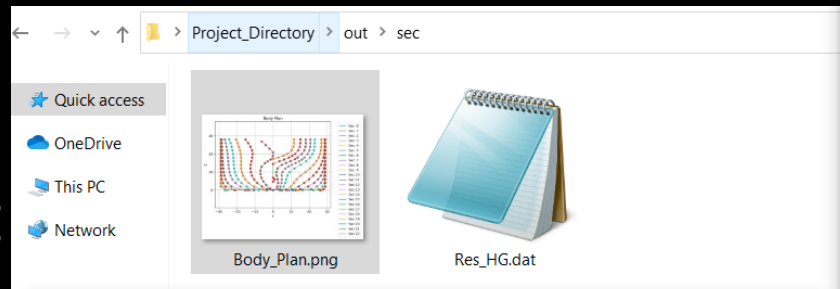
Stage 3: Understanding the Results

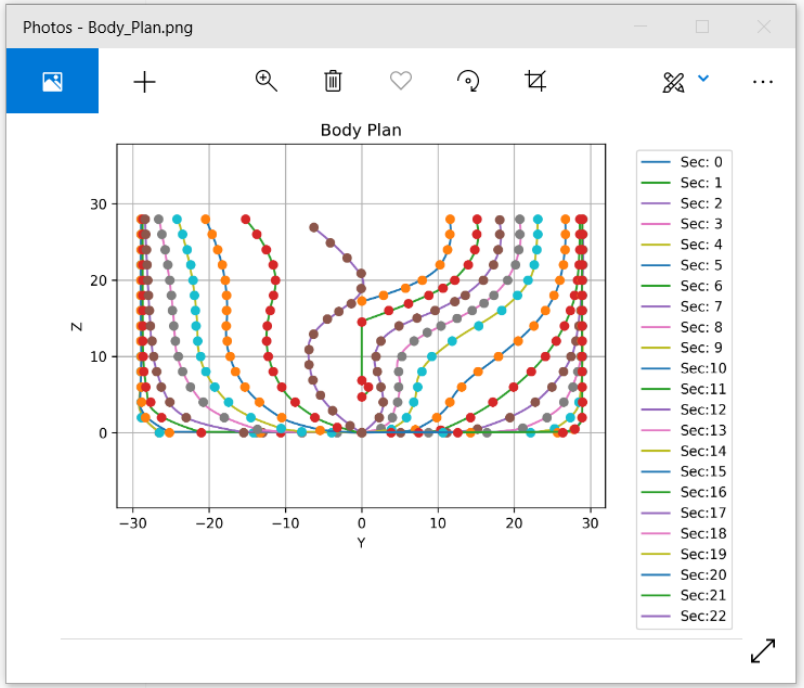
The “out” directory contains three sub directories…

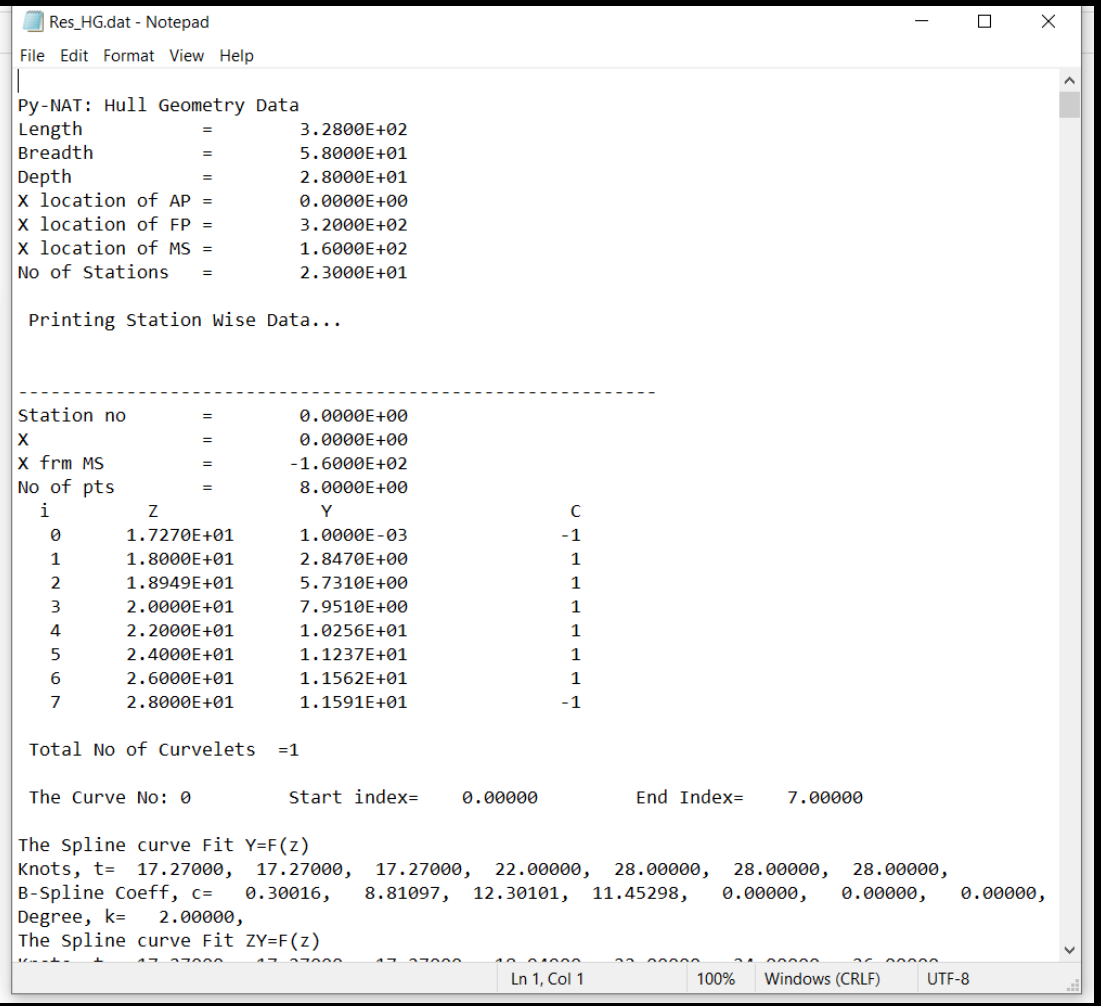
sec	Contains the prepared hull geometry data
hs	Contains the results from hydrostatic analysis
las	Contains the results from large angle stability analysis



Output files in Directory “sec” :

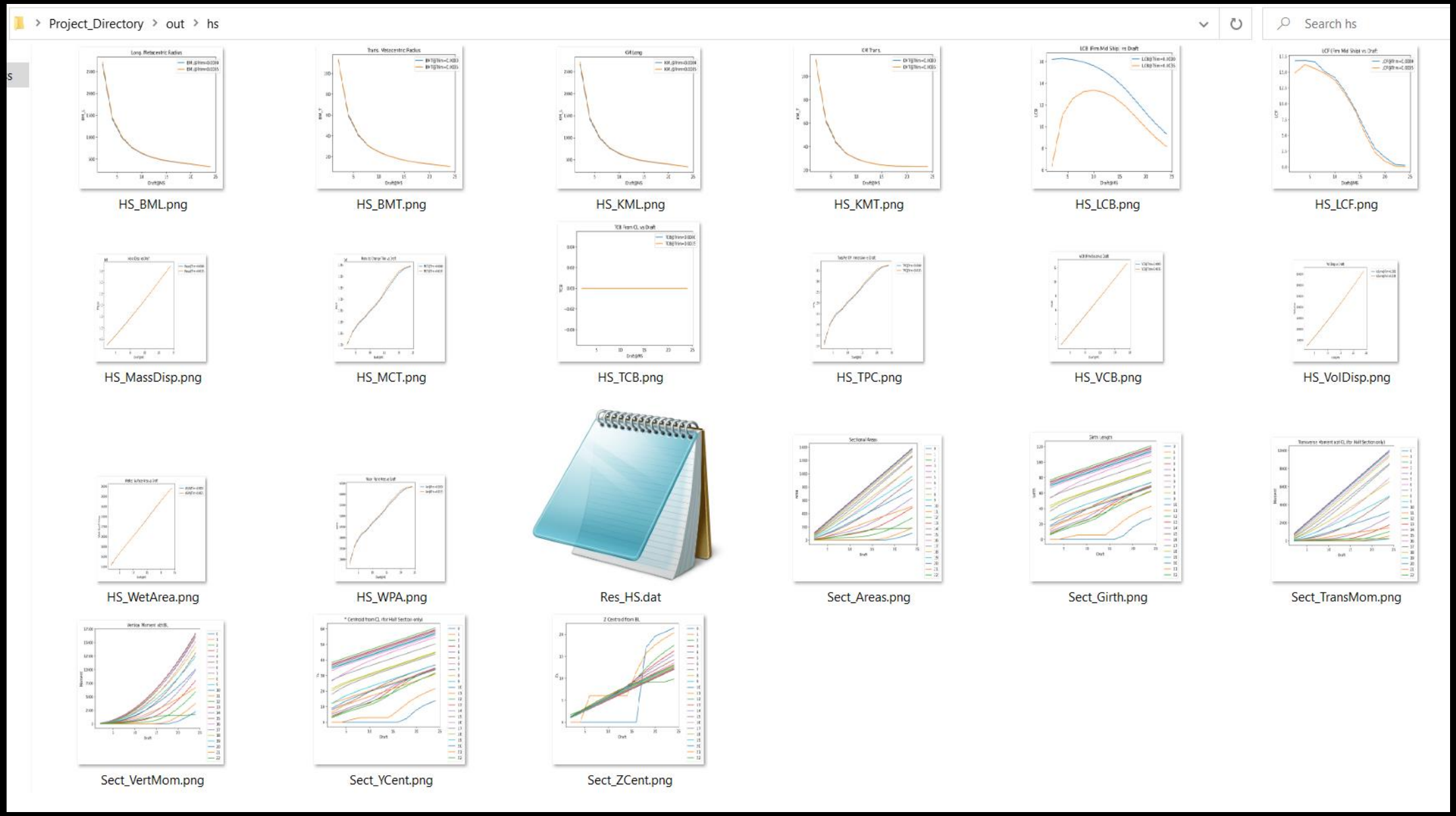






Body_Plan.png	The body plan view of section curve points and fitted curves
Res_HG.dat	The prepared hull geometry data. Includes station wise spline curve fit data

Output files in Directory “out/hs” :



Output files in Directory “out/hs” :

HS_VolDisp.png	Volumetric Displacement vs Draft
HS_MassDisp.png	Mass Displacement vs Draft
HS_WetArea.png	Wetted Hull Surface Area vs Draft
HS_LCB.png	Longitudinal Center of buoyancy from amidships (Positive forward) vs draft
HS_TCB.png	Transverse Center of buoyancy from Center Plane vs draft
HS_VCB.png	Vertical Center of Buoyancy from Base Line vs draft
HS_WPA.png	Water Plane Area vs Draft
HS_LCF.png	Longitudinal Center of Flotation vs draft

Output files in Directory “out/hs” :

HS_BML.png	Longitudinal Metacentric Radius vs Draft
HS_BMT.png	Transverse Metacentric Radius vs Draft
HS_KML.png	Long. Metacenter height from Keel vs Draft
HS_KMT.png	Trans. Metacenter height from Keel vs Draft
HS_TPC.png	Tons per CM immersion vs draft

Res_HS.dat	The results of Hydrostatic Analysis Section wise followed by Volumetric Properties

Output files in Directory “out/hs” :

Sect_Areas.png	Sectional Area vs Draft
Sect_Girth.png	Section Girth vs Draft
Sect_TransMom.png	Half Section Transverse moment vs Draft
Sect_VertMom.png	Section Vertical moment vs Draft
Sect_YCent.png	Y ordinate of centroid of half section from Center Line vs draft
Sect_ZCent.png	Z ordinate of centroid of section from Base Line vs draft

Output files in Directory “out/las”

Project_Directory › out › las

DAT File (4)

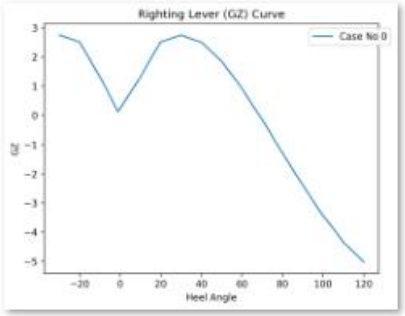
Res_GZ.dat

Res_GZ_FAST.dat

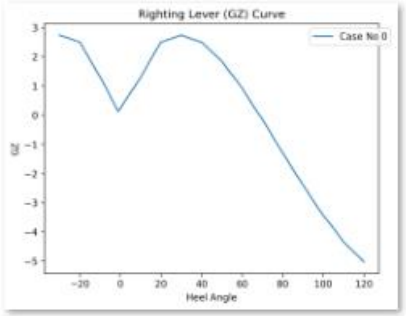
Res_KN.dat

Res_KN_FAST.dat

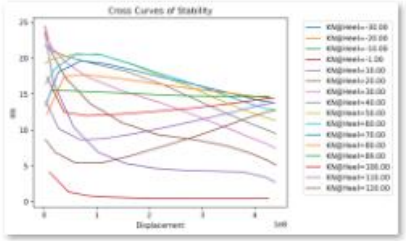
PNG File (4)



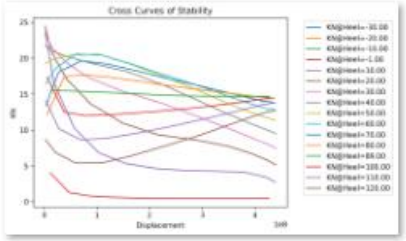
LAS_GZ.png



LAS_GZ_FAST.png



LAS_KN.png



LAS_KN_FAST.png

Output files in Directory “out/las”

Project_Directory › out › las

DAT File (4)

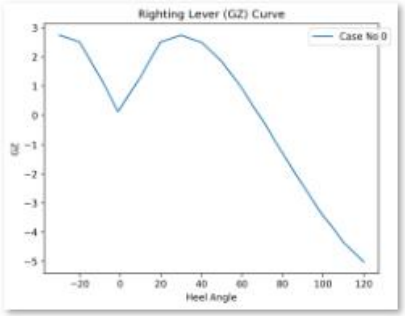
Res_GZ.dat

Res_GZ_FAST.dat

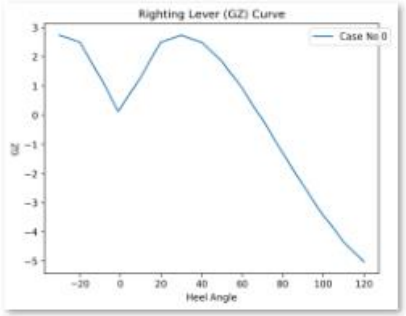
Res_KN.dat

Res_KN_FAST.dat

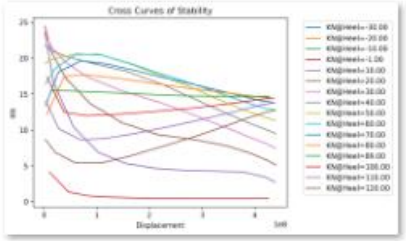
PNG File (4)



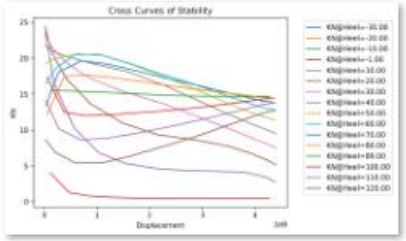
LAS_GZ.png



LAS_GZ_FAST.png



LAS_KN.png



LAS_KN_FAST.png

Output files in Directory “out/las”

Res_KN.dat	The KN Curve Calculation Data (from Direct Method)
Res_GZ.dat	The GZ Curve Calculation Data (Direct Method)
Res_KN_FAST.dat	The KN Curve Calculation Data (Fast Method)
Res_GZ_FAST.dat	The GZ Curve Calculation Data (Fast Method)

Examples

The Distribution in the GitHub repository includes the Test Case on a KVLCC2 hull form.

The templets and input files can serve as tools to prepare inputs for other vessels

Note that program writes the Heel and trim angles in radians in some files and in degrees in another. The user have to interpret accordingly.

Suggestion and Feedback will be appreciated

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