Shape3d to Xflr5 tutorial

<complex-block>

Once the foil has been drawn in Shape3d, click on the Component -> Slices -> NACA profile generator menu:

This function allows you to adjust a slice on a NACA profile (or another profile imported from a .dat file), but also to export the foil so that it is easy to analyze in Xflr5.

4-digit NACA Genera	tor		×
Chord (c): 24.99		Exp	ort Import
Thickness 13	% of c (3.25)		Export cross sections in
Camber (m): 6	% of c (1.50)	Max at (p):	40 % of c
Tilt (t): 4	% of c (1.00)		
NACA6413			
	ОК	Cancel]

Note that the foil must be drawn as in the screenshot above: with the leading edge to the right, and the trailing edge to the left.

Xflr5 is open source software that can be downloaded from http://www.xflr5.tech/xflr5.htm

The export consists of 20 .dat profiles and an xml file.

Open Xflr5 and click on the File -> New Project menu:

XII XI	IID V0.35		
File	Module Options ?	?	
	New Project		Ctrl+N
	Open		Ctrl+0
	Load Last Project		Ctrl+Shift+O
	Insert Project		Ctrl+Shift+I
	Close the Project		Ctrl+F4
B	Save		Ctrl+S
	Save Project As		Ctrl+Shift+S
	1 C:/Users/thoma/Dowr	nloads/Foil Jet 1650_xflr5/Jet 1650.xfl	Ctrl+7
	2 C:/Users/thoma/Dowr	nloads/Go Foil Decath_xflr5/Go Foil.xfl	
	3 C:/Users/thoma/Dowr	nloads/test5.xfl	
	4 C:/Users/thoma/Dowr	nloads/Go Foil Decath_xflr5/Go Foil 2.xfl	
	5 C:/Users/thoma/Dowr	nloads/ /Go Foil HA.xfl	
	6 C:/Users/thoma/Dowr	nloads/Go Foil Thin.xfl	
	7 C:/Users/thoma/Dowr	nloads/foil decathlon.xfl	
	Exit		

5 Open File					×
\leftrightarrow \rightarrow \checkmark \uparrow \square \rightarrow Ce PC	> Téléchargements > Foil Jet 1650_xflr5			5 v	
Organiser 👻 Nouveau doss	III - III ()				
🕂 Téléchargemei 🖈 🐴 🛛	Nom	Modifié le	Туре	Taille	
🗎 Documents 🖈 🔤	Foil Jet 1650_profile_0_x44.25.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
🔤 Shape3dX 🖈 🛛 🚺	Foil Jet 1650_profile_1_x41.79.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Shape3dWeb 🖈 🛛	Foil Jet 1650_profile_2_x39.34.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Sh3dX 🖈 🚺	Foil Jet 1650_profile_3_x36.88.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Cvcpp *	Foil Jet 1650_profile_4_x34.43.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
C# *	Foil Jet 1650_profile_5_x31.97.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Kerallan	Foil Jet 1650_profile_6_x29.51.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
	Foil Jet 1650_profile_7_x27.06.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Close up AKI	Foil Jet 1650_profile_8_x24.60.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
InstallX	Foil Jet 1650_profile_9_x22.15.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Production	Foil Jet 1650_profile_10_x19.69.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
SamplesX	Foil Jet 1650_profile_11_x17.24.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
OpeDrive - Percon:	Foil Jet 1650_profile_12_x14.78.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Chebrive - Persona	Foil Jet 1650_profile_13_x12.32.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Ce PC	Foil Jet 1650_profile_14_x9.87.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
E Bureau	Foil Jet 1650_profile_15_x7.41.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Documents	Foil Jet 1650_profile_16_x4.96.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Images	Foil Jet 1650_profile_17_x2.50.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
h Musique	Foil Jet 1650_profile_18_x1.27.dat	14/12/2021 10:07	Fichier DAT	3 Ko	
Chists 2D	Foil Jet 1650_profile_19_x0.044.dat	14/12/2021 10:07	Fichier DAI	3 KO	
Ielechargements					
Close up ART					
Disk motor					
flow5_v7.19_wir					
📙 Foil Jet 1650_xfli 🗸					
Nom du fie	chier : "Foil Jet 1650_profile_0_x44.25.dat" "I	Foil Jet 1650_profile_1_x41.7	9.dat" "Foil Jet 1650_pr	ofile_2_x39.34.da ~	XFLR5 file (*.dat *.plr *.wpa *.xfl $ \smallsetminus $
					Ouvrir Annuler

Then File -> Open, and select all the .dat:

Then go to the menu Module -> Wing and Plane Design:

5 xflr5 v6.53

File	Module	View	Foil	Design	Analysis	Polars
Ĉ	Clos	e all			Ctrl+0	
Objec	Dire	ct Foil D	esign		Ctrl+1	8
	XFoi	il Inverse	e Desigr	n	Ctrl+3	
1	XFoi	I Direct	Analysi	s	Ctrl+5	×
	Win	g and Pl	ane De	sign	Ctrl+6	-
	Exec	ute scri	pt		Ctrl+X	È .
	Foil Jet	1650 1650	profil profil	e 12 e 13	x1 x1	_

Then Plane -> Import plane(s) from xml file(s):

ភ 🔊 🔊	r5 v6.53							
File	Module	View	Plane	Polars	OpPoint	Analysis	Graphs	Ol
			D	efine a Ne	ew Plane	i	F3	1
Ohiec	t explorer		D	efine (Ad	vanced user	rs) (s	Shift+F3	
objec	explorer		М	lanage ob	jects	I	F 7	
1	2 3		C	urrent Pla	ne		E.	ph
			In	nport plar	ne(s) from x	ml file(s)		

And select the xml file exported by Shape3d:

🔚 Open XML File				×
← → · · ↑	PC > Téléchargements > Foil Jet 1650_xflr5		ٽ ~	
Organiser 👻 Nouveau	dossier			EE - 🔟 📀
🖊 Téléchargemei 🖈 🐴	Nom	Modifié le	Туре	Taille
🔮 Documents 🖈	Foil Jet 1650_profile_xflr.xml	14/12/2021 10:07	Fichier XML	14 Ko
Shape3dX 🖈				
Shape3dWeb 🖈				
Sh3dX 🖈				
🔤 Cvcpp 🛛 🖈 💙				
Nom	du fichier : Foil Jet 1650_profile_xflr.xml		~	Plane XML file(*.xml) $~~$
				Ouvrir Annuler

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We can then directly launch a lift analysis from the Analysis -> Define an Analysis menu:

Analysis Graphs Options ?	
Define an Analysis	F6
Define an Analysis (advanced users) Define a Stability Analysis Import analysis from xml file	Ctrl+F6 Shift+F6
View Log File Advanced Settings	L
	Analysis Graphs Options ? Define an Analysis Define an Analysis (advanced users) Define a Stability Analysis Import analysis from xml file View Log File Advanced Settings

You can do an analysis at a given speed (Type 1), or at a given lift (Type 2). The Type 2 analysis is very interesting to see how a foil will behave with a given user:

👼 Analysis D	efinition - xf	lr5 v6.53						?	\times
Auto Analys	sis Name T2	-LLT							
Polar Type	Analysis	Inertia	Ref. dimensions	Aero data	Extra	Irag			
O Type 1 (F	ixed Speed)			٧œ	=	36	km/h		
Type 2 (F	ixed Lift))=	0.00	•		
Type 4 (F	ixed aoa))=	0.00	•		
O Type 5 (E	leta range)								
						Wing	Loading =	6.100 kg	2/m²
						1	Tip Re.sqrt((Cl) = 12	000
						Ro	ot Re.sqrt(Cl) = 164	000
							Vinf.sqrt(Cl) = 9.88	m/h
						_			
							Save	Disc	ard

You must then choose the method in the Analysis tab. Ring vortex works well. We're not going to check Viscous just yet, which will allow us to get lift faster.

5 Analysis Defi	nition - xfl	r5 v6.53					?	\times
Auto Analysis	Name T2	-VLM2-Invis	cid					
Polar Type	Analysis	Inertia	Ref. dimensions	Aero data	Extra drag			
Analysis Meth ULT (Wing Horseshoo Ring vorte	ods only) e vortex (V ex (VLM2)	LM1) (No sid	deslip)					
Options								
☐ Tilted geo	metry - NO dy Panels -	T RECOMME	INDED					
						Save	Disca	ard

튨 Analysis D	efinition - xf	lr5 v6.53					?
Auto Analys	sis Name T2	2-VLM2-1.0k	g-x10.0cm-Inviscid				
Polar Type	Analysis	Inertia	Ref. dimensions	Aero data	Extra drag		
-Inertia proj	perties me inertia						
					Plane Mas	ss =	80.000
					X_Co	G =	10.000

 \times

kg cm

0.000 cm

Discard

Z_CoG =

Save

In the Inertia tab we enter the weight of the rider + gear, 80kg for example:

s Analysis Definition - xflr5 v6.53			?	×
Auto Analysis Name T2-VLM2-80.0kg-x10.0cm-Invis	cid			
Polar Type Analysis Inertia Ref. dimension	s Aero data Ext	ra drag		
Air Data	Ground Effect			-1
Unit International Imperial	Ground Effect			
ρ = 1000.0 kg/m3		Height = 0.00	a	m
v = 1.3e-06 m²/s				
From Altitude and Temperature				
		Save	Discar	rd

Then in the Aero data if tab, enter the water density $1000 \text{kg} / \text{m}^3$ and its viscosity $1.3e-6 \text{ m}^2 / \text{s}$:

We click on the Save button, then in Polar View mode we click on the Analyze button to start the analysis:



This analysis calculates for each inclination of the foil (here between -5 ° and 20 °) the speed it takes for the foil to carry 80 kg (a lift of 784 N therefore). You can also display the drag Fx for each speed (with the inclination that corresponds to it).

Here we see that for this low aspect 1650cm² foil (rough copy of the Naish Jet 1650), at 5 m/s (~ 10 kt) you need an inclination of 2 °. Below 6 kt it takes more than 12 °... We can deduce that we can start pumping around 6 kt, but that normal navigation is only done from 10 kt roughly.

The drag Fx is here only the residual drag due to the vortices, and we see that it is greater the lower the speed and the large inclination. It only decreases as speed increases, which is unrealistic as there is no viscous drag.

To add the slimy drag it is a bit longer. You have to go to the menu Module -> XFoil Direct Analysis:



Then in the Analysis -> Batch Analysis menu:

5 xflr5 v6.53					
File Module View Foil Design	Analysis	Polars	Operating Po	oints	Graph
	Defir	ne an Ana	lysis	F6	
Object explorer	Batch	h Analysis	;	Ctrl	+ F6
	Impo	ort Analys	is from xml fil	e	
	XFoil	Advance	d Settings		
Foil Jet 1650 profile 0 x4	View	Log File		L	
TOUR CETO, AUTOTOLE TO A					

Then select all the profiles, and launch the Type 1 analyzes between -5 ° and 20 °:

쪐 Multi-threaded batch analysis - xflr5 v6.53

Foil Jet 16						
	650_profile_0	_x44.25				☑ Initialize BLs between polars
Foil Jet 16	650_profile_1	0_x19.69 dy7	.75 dihedral-	3.572		
foil Jet 16	650_profile_1	1_x17.24 dy	.13 dihedral-	4.512		Store operating points
oil Jet 16	650_profile_1	2_x14.78 dy1	0.66 dihedra	1-5.648		Update polar view
Foil Jet 16	650_profile_1	3_x12.32 dy1	2.35 dihedra	1-7.041		Max. Threads to use for the analysis: 1 /8
Foil Jet 10	650_profile_1	4_x9.87 dy14	.26 dihedral-	-8.952		
Foil Jet 10	b50_profile_1	5_x7.41 dy10	.42 dihedral-	11.937		
Foil Jet 10	b50_profile_1	6_x4.96 dy18	.92 dihedral-	15.461		
Foil Jet 10	b50_profile_1	7_x2.50 dy22	.03 dihedral-	20.003		
Foil Jet 10	650 profile_1	8_X1.27 dy24	0.05 diheden	24.703		
Coil Jet 1	650 profile_1	9_x0.044 dy2	15 dihadaal0	129.022		
Foil let 1	650 profile 7	x39 34 d-0	49 dihedral0.	035		
Foil let 1	650 profile 3	x36.88 dv0	98 dihedral-0	142		
Foil let 10	650 profile 4	x34.43 dv1.	61 dihedral-0	389		
Foil Jet 10	650 profile 5	x31.97 dv2	40 dihedral-0	0.705		
Foil Jet 1	650 profile 6	x29.51 dv3.	30 dihedral-1	.095		
oil Jet 1	650 profile 7	x27.06 dy4.	27 dihedral-1	.564		
oil Jet 1	650_profile 8	x24.60 dy5.	33 dihedral-2	.123		
oil Jet 1	650_profile 9	x22.15 dy6.	49 dihedral-2	.785		
		- /				
	Re	Mach	NCrit	Actions	^	
×	2750	0	0			
-	3750	0	9		- 11	
×	7500	0	9			
×	15000	0	9			
					-	
^	30000	0	9		_	
×	40000	0	9			
×	60000	0	9			
		-				
, ×	80000	0	9			
B X	100000	0	9			
×	130000	0	9			
	100000					
10 ×	160000	0	9		~	
Delas t -						
Polar typ	e					
	● T1	O T2	2 () T3		
Farred T						
Forced In	ansidoris					
		Top transiti	on location (x)	(c)	1	
	R	ottom transiti	on location (v	(c)	1	
	0	a com a anisia		~	-	
Analysis P	Range					
Cassific				Eren 7a		
		Min	Max	Increment	t	
		-5.000	20.000	0.5	00	
Alpha						
Alpha						

o x

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It takes several minutes, and at the end of it, the polars for all angles and Reynolds numbers between 4000 and 3e6 are displayed.



We can then return to the Module -> Wind and Plane Design menu, and define a new analysis, by checking the Viscous box this time:

5 Analysis Definition - xt		?	×									
Auto Analysis Name												
Polar Type Analysis	Inertia	Ref. dimensions	Aero data	Extra drag								
Analysis Methods	Analysis Methods											
ULT (Wing only)												
O Horseshoe vortex (VLM1) (No sideslip)												
Ring vortex (VLM2)	Ring vortex (VLM2)											
O 3D Panels	○ 3D Panels											
Q-Form	Ontions											
Options	Viscous Tilted geometry - NOT RECOMMENDED											
Viscous												
I lited geometry - NC												
Ignore Body Panels												
				E	Save	Disc	ard					

We obtain a lift identical to the previous analysis, but a higher drag which increases at high speed. There is therefore a minimum drag for a given inclination and speed:



There is therefore an optimum range of use between 9 kt and 12 kt.

Note that you can change the speed unit in the Options -> Preferences menu, but there is a small bug that causes the display to always revert to m/s with a scale that is not always good . You must then right click -> Current Graph -> Define Grapgh Settings, then Reset Graph Scales.



We can compare these results with a foil of 1040 cm² of higher aspect ratio (rough copy of the Naish Jet HA 1040):

We can see here that the bank at 10 kt is not 2 ° but 4 °. We descend to 2 ° around 12 kt. The minimum drag is around 14 kt, and the optimum range between 12 kt and 16 kt.

These results are not 100% reliable, but fairly true. We made a quantitative comparison with the results obtained with OpenFoam (a large simulation software, the analyzes are very long and require

large computers) by Decathlon and we were very close to the lift level for inclinations of up to 15°. The advantage here is that it takes less than 5 min in total to get an analysis.



You can also do Type 1 analyzes to obtain the optimum incline at a given speed (10-15-20 kt here):

It is also possible to load the stab to have lift and overall drag.

The Flow5 software is an advanced version of Xflr5, paid for, which allows you to do the same thing, with the addition of taking into account the foil / stab interaction (<u>https://flow5.tech/docs/flow5_doc/Analysis/VPW_.html</u>), and the possibility of optimizing (<u>https://flow5.tech/docs/flow5_doc/MOPSO.html</u>).