Università degli Studi di Padova – Dipartimento di Ingegneria Industriale

Corso di Laurea in Ingegneria Aerospaziale

Confronto di strutture interne di ali per droni

Tutor universitario: Prof. Ugo Galvanetto

Laureando*: Casarotto Simone*

Padova,14/03/2024

INTRODUZIONE

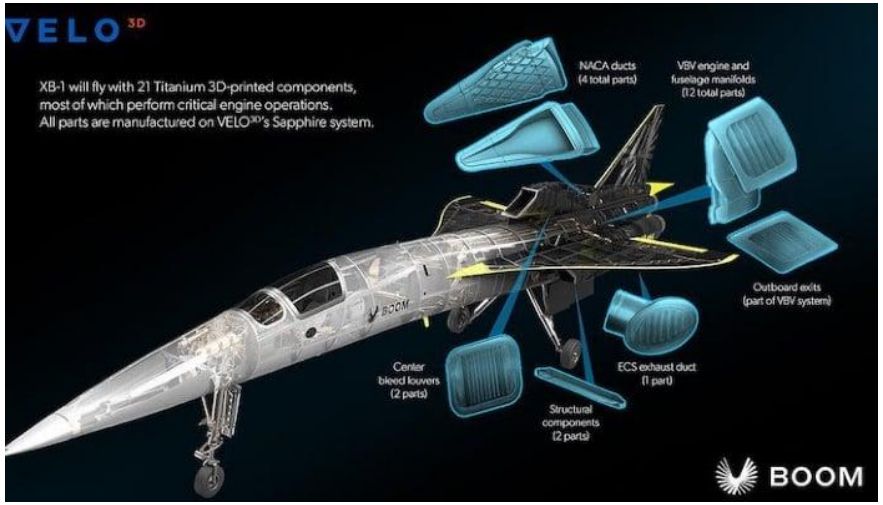
Stampa 3D in ambito aerospaziale:

- Qualsiasi complessità realizzabile
- Consolidazioni di più parti in una unica
- Accelerazione del time to market
- Ottimizzazione dell'inventario e della logistica
- Riduzione dello spreco di materie prime

Credit: University of Sheffield

Mercato in espansione nella mobilità elettrica e nel volo autonomo.

Una sfida futura: ali stampate in 3D



Credit:Velo3d

OBIETTIVI DEL LAVORO

- Trovare la struttura più resistente e performante a parità di peso
- Analisi di tipo statico strutturale

Programmi utilizzati:
Autodesk Fusion,
Ansys Discovery

AUTODESK Fusion 360

Credit: Autodesk

Ansys

Credit: Ansys

SEMPLIFICAZIONI E ASSUNZIONI

- Problema statico
- Materiale scelto
- Materiale isotropico
- Carico distribuito uniformemente

Material	Plastic, HDPE
State	Solid
Density	959 kg/m³
Young's modulus	1,08e9 Pa
Poisson's ratio	0,418
Shear modulus	3,81e8 Pa
Bulk modulus	2,2e9 Pa
Tensile yield strength	2,84e7 Pa
Tensile ultimate strength	2,84e7 Pa
Thermal expansion coefficient	0,000145 1/°C
Thermal conductivity	0,481 W/m·K
Specific heat	1,78 kJ/kg.C
Embodied energy	7,52e7 J/kg
CO2 footprint	2,06 kg/kg
Potential to recycle	True
Description	High density polyethylene / HDPE / PE-HD (homopolymer, general purpose, molding & extrusion) Data compiled by Ansys Granta, incorporating various sources including JAHM and MagWeb. ANSYS, Inc. provides no warranty for this data.
Class	Polymers
Subclass	Thermoplastics

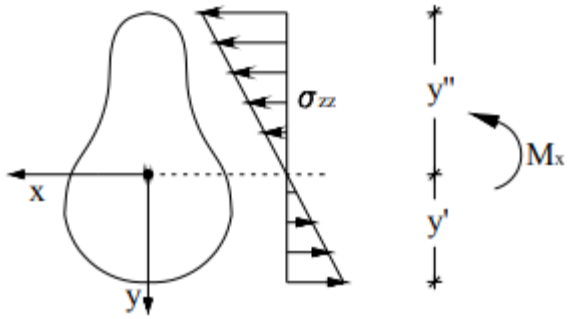
FONDAMENTI TEORICI

Trave incastrata alle estremità, con carico distribuito.

Applico l'ipotesi di De Saint Venant.

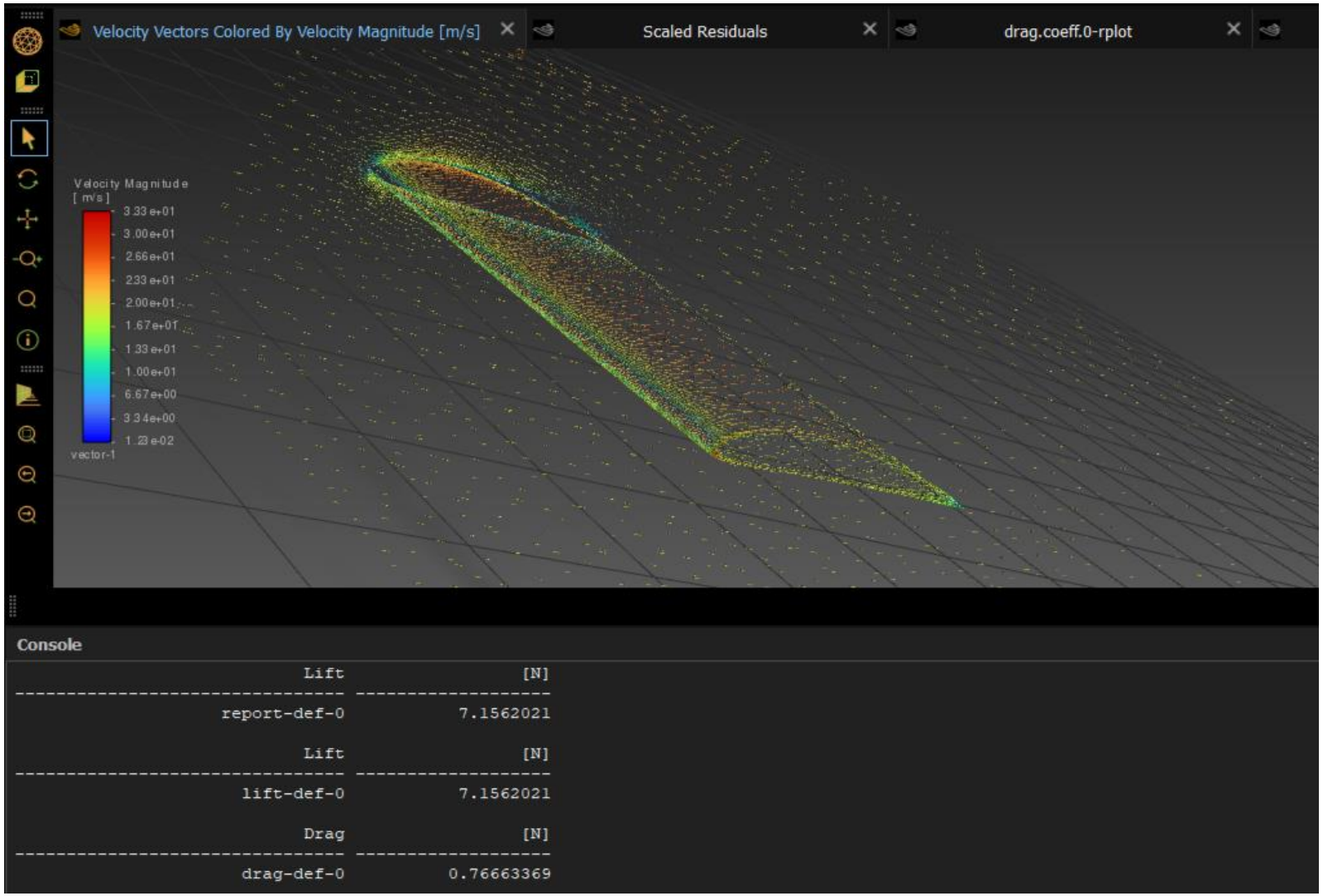
Analizzo la Formula di Navier $\sigma_z = \frac{M_x}{I_{xx}} y$

L'obiettivo è Massimizzare il momento d'inerzia



DATI GENERALI DELLA SIMULAZIONE

- Lunghezza ala 500 mm
- Corda 200 mm
- Massa 280g
- Airfoil Naca 2412
- Lift 20N
- Drag 2N



ALA 1: STRUTTURA TRADIZIONALE

Monitors

Max. Displacement

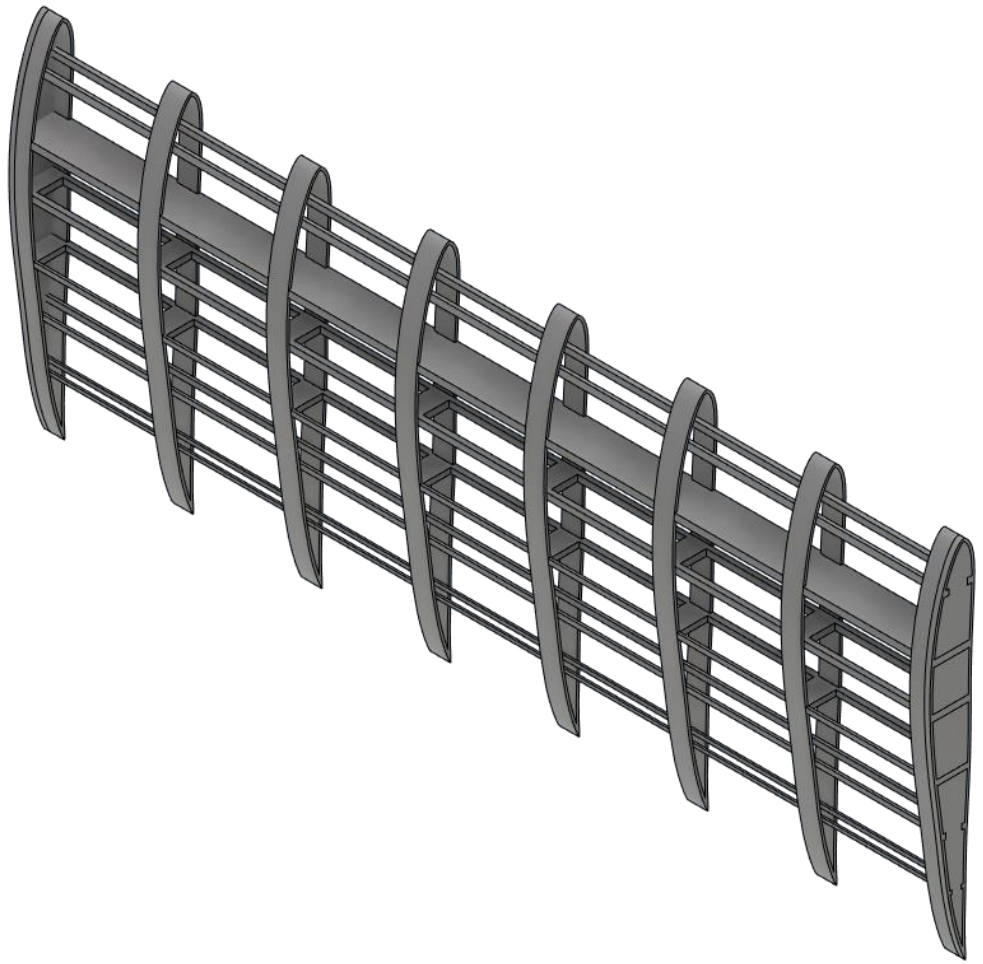
Design	Refine
1	0,00982 m

Max. Von Mises Stress

Design	Refine
1	2,39e6 Pa

Factor of Safety

Design	Refine
1	11,9



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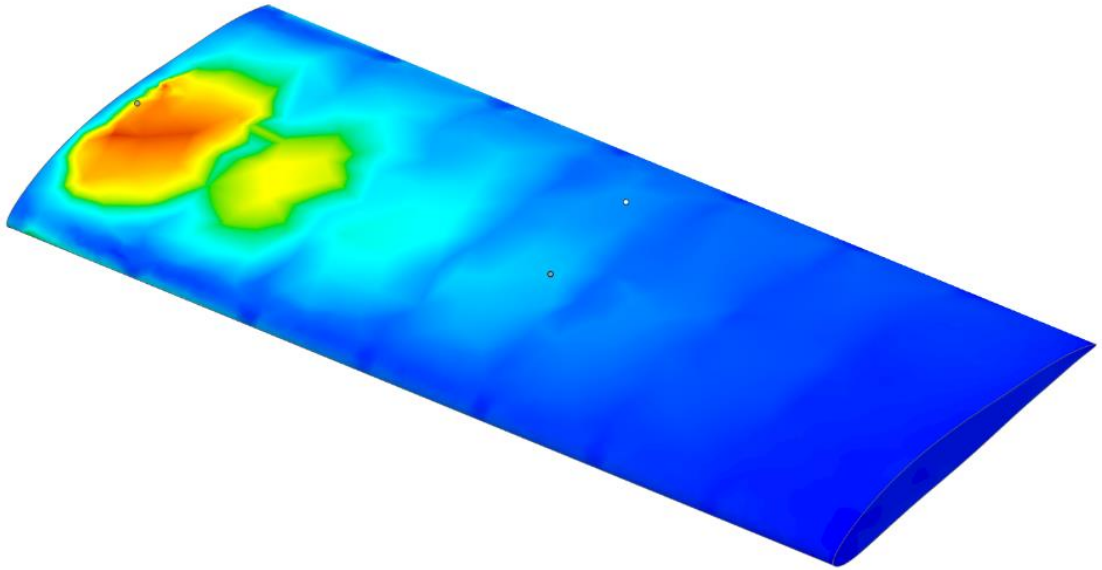
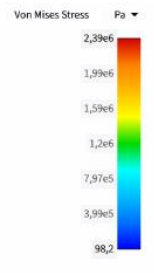
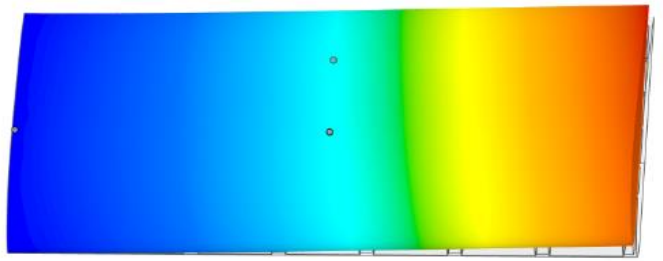
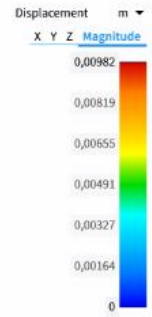
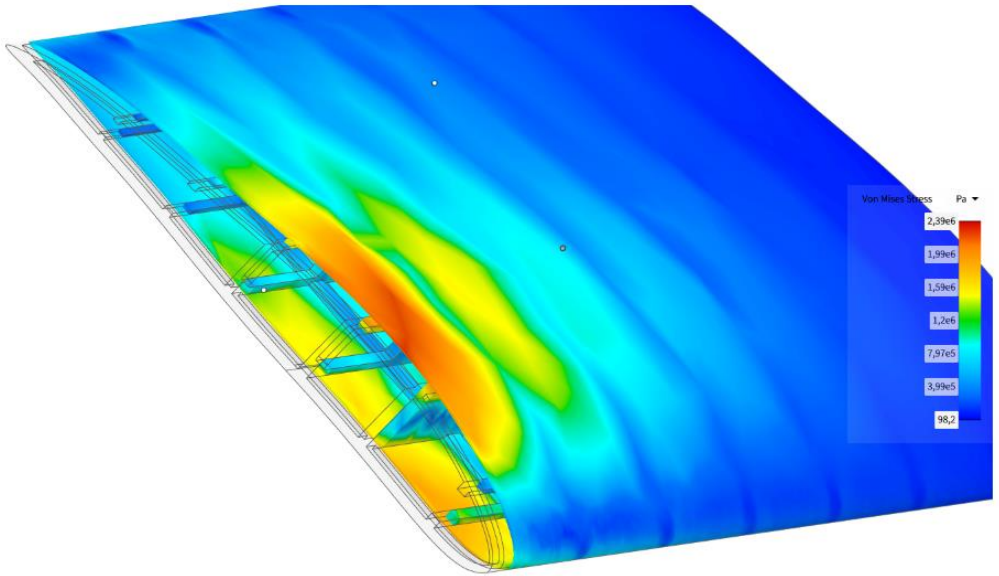










ALA 2: LONGHERONI INCLINATI

Monitors

Factor of Safety

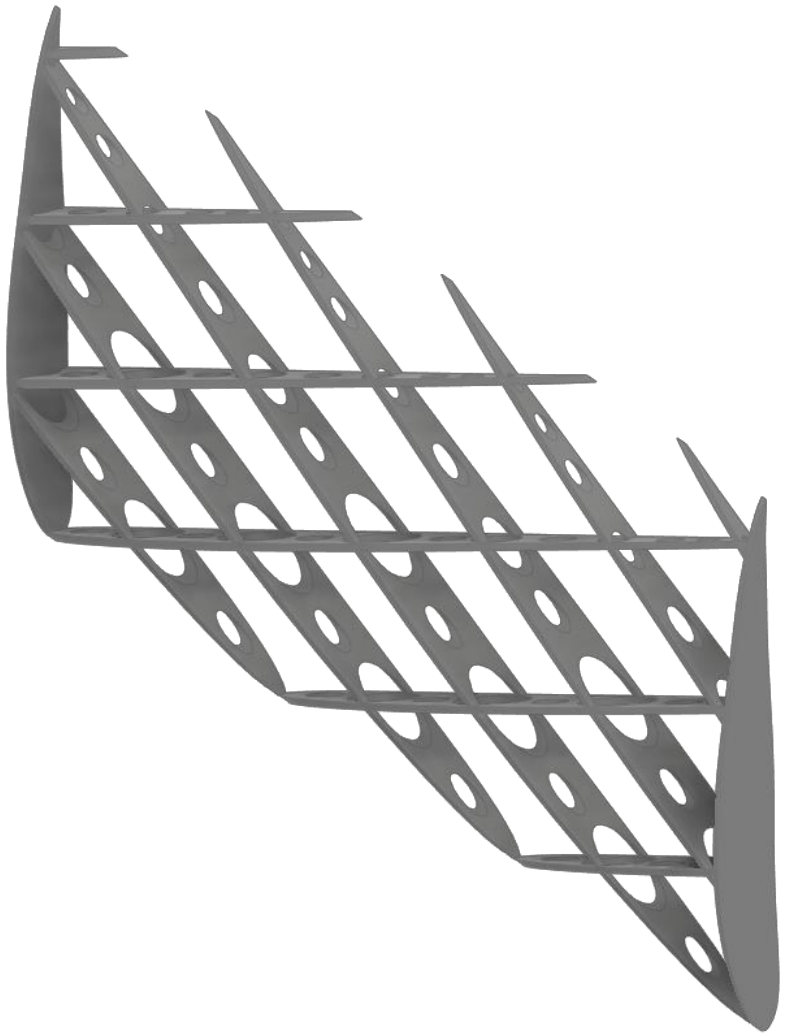
Design	Refine
1	9,41
2	9,33

Max. Displacement

Design	Refine
1	0,00935 m
2	0,00943 m

Max. Von Mises Stress

Design	Refine
1	3,02e6 Pa
2	3,04e6 Pa



DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

ALA 2: LONGHERONI INCLINATI

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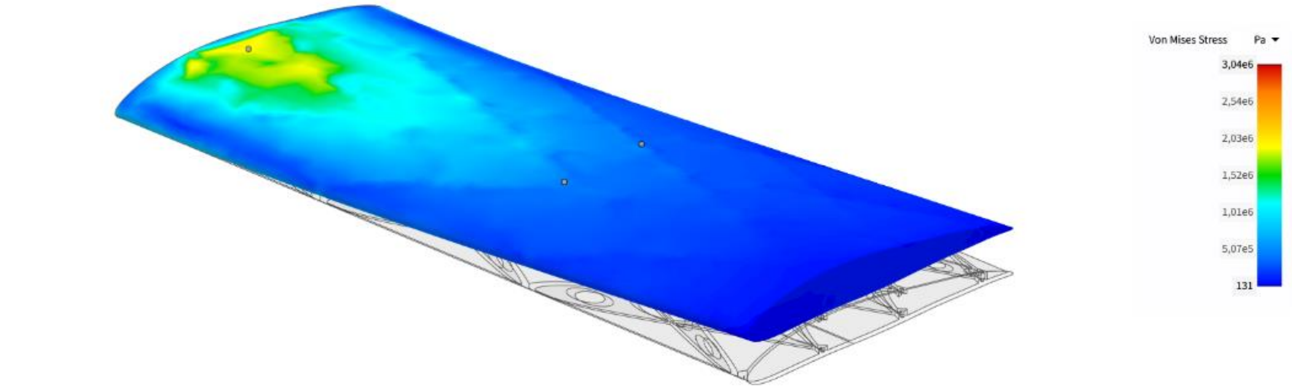
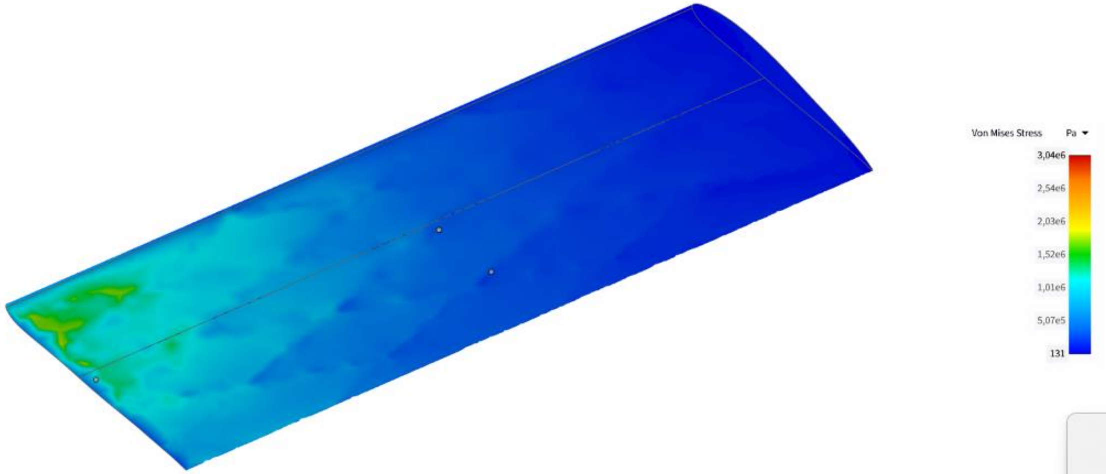
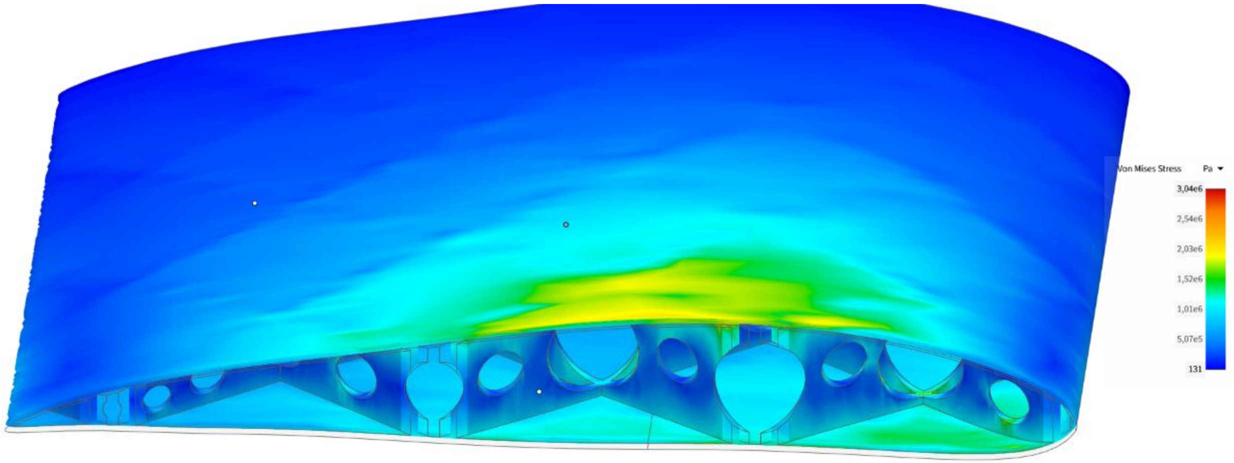
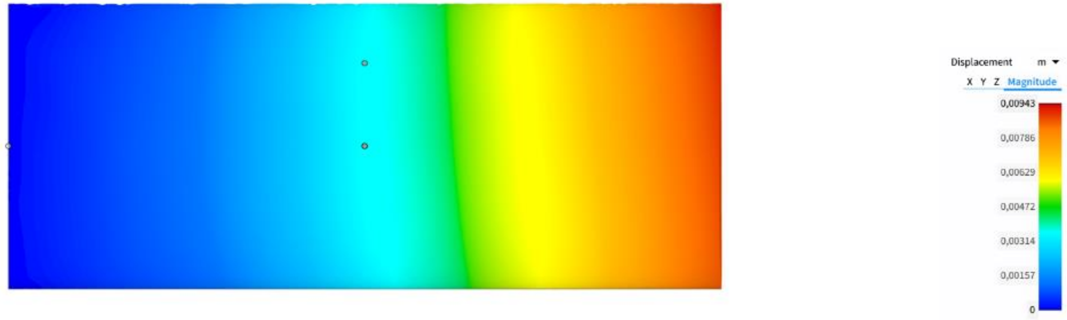








Monitors

Factor of Safety

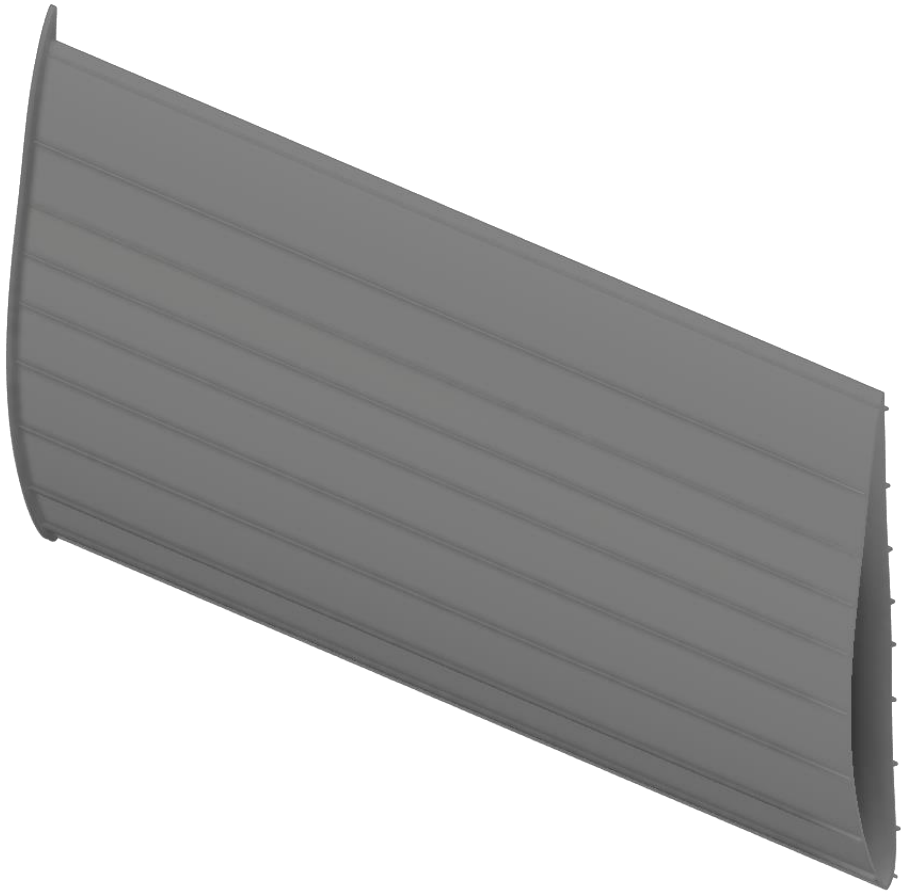
Design	Refine
1	14,3
2	14,1

Max. Displacement

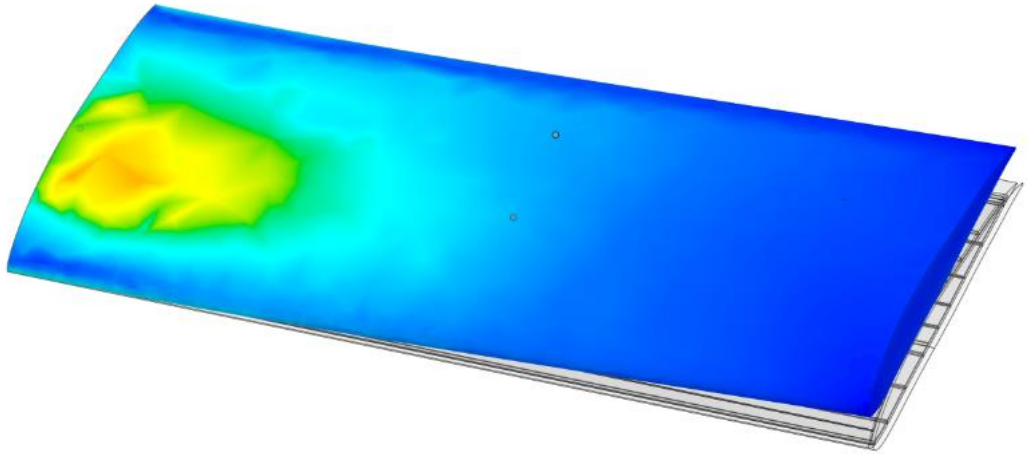
Design	Refine
1	0,00867 m
2	0,00875 m

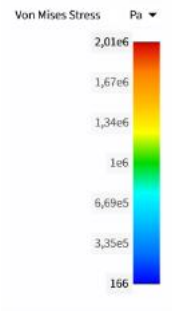
Max. Von Mises Stress

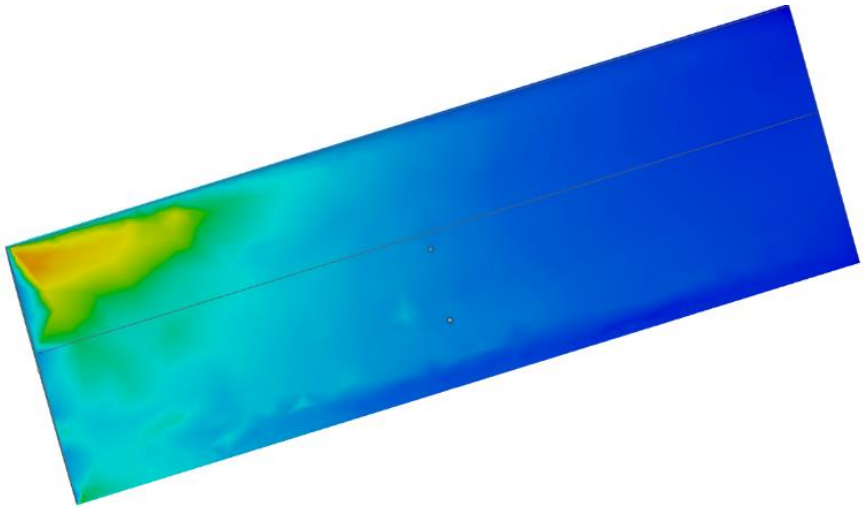
Design	Refine
1	1,99e6 Pa
2	2,01e6 Pa

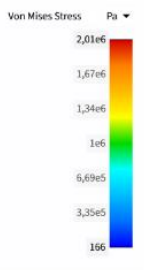


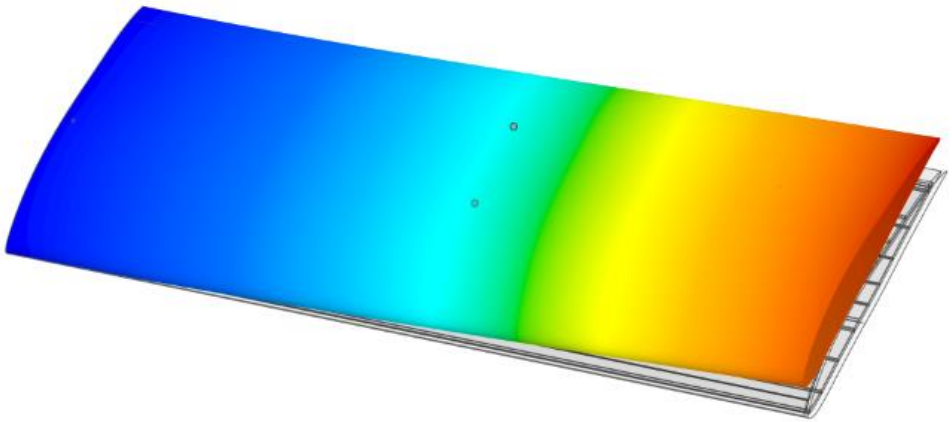
ALA 3











Monitors

Factor of Safety

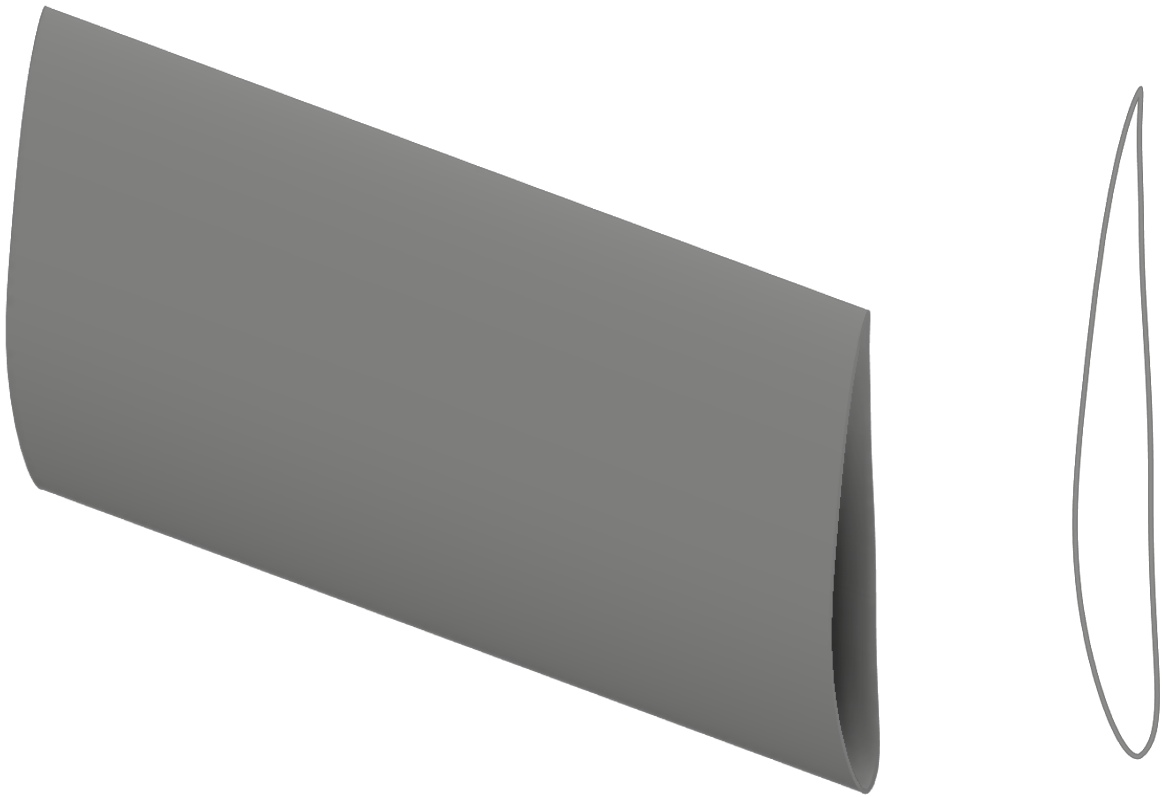
Design	Refine	Explore
1	13,8	2,15
2	14,7	

Max. Displacement

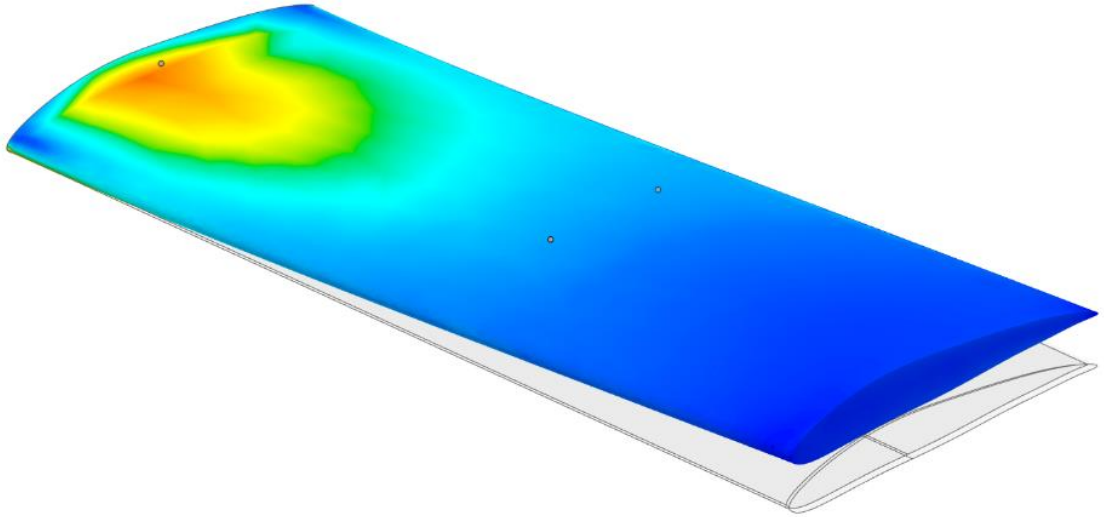
Design	Refine	Explore
1	0,00901 m	0,458 m
2	0,00902 m	

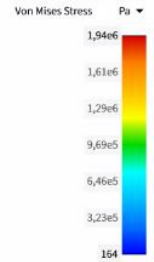
Max. Von Mises Stress

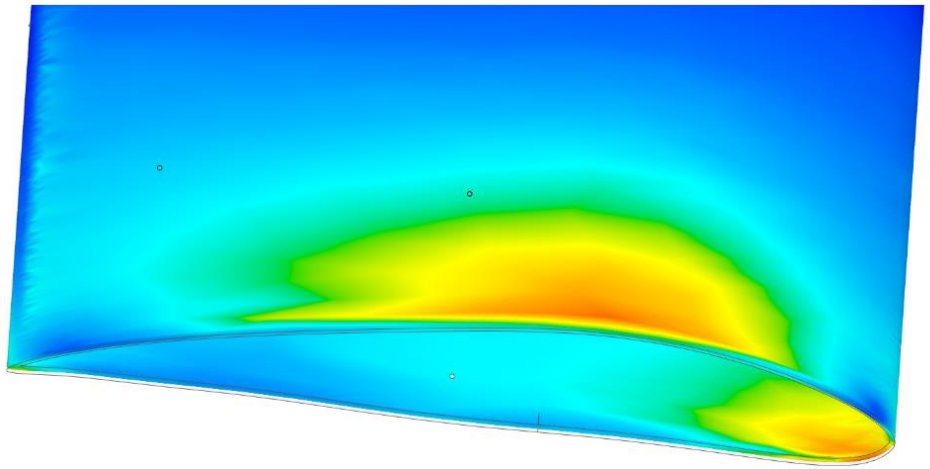
Design	Refine	Explore
1	2,06e6 Pa	1,32e7 Pa
2	1,94e6 Pa	

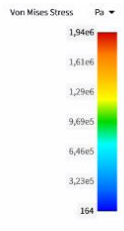


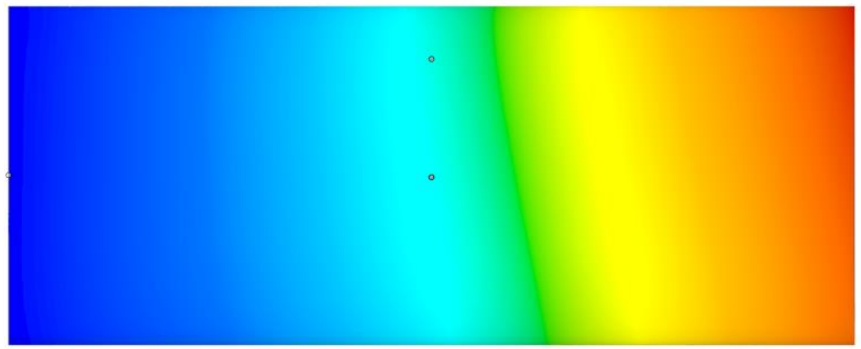
ALA 4

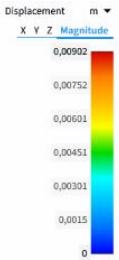








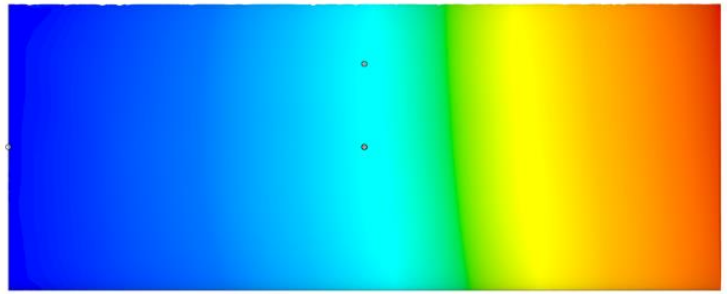




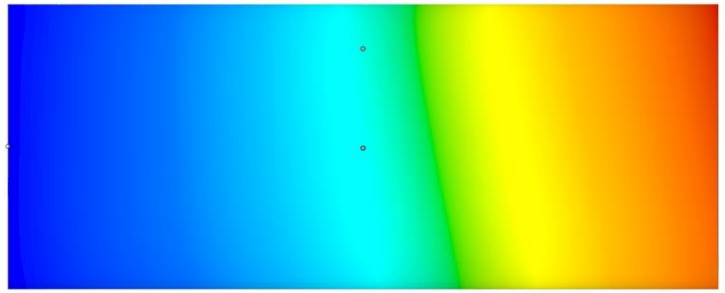
CONFRONTO

Ala	Factor of safety	Max Displacement [m]	Max Von Mises Stress [MPa]
Ala 1	11,9	0,00982	2,39
Ala 2	9,33	0,00943	3,04
Ala 3	14,1	0,00875	2,01
Ala 4	14,7	0,00902	1,94

E' necessario valutare anche i gradienti della deformazione: certe strutture mantengono una forma più fedele all'airfoil originale pur deformandosi nel complesso di più.



Ala 2



Ala 4

CONCLUSIONI

In conclusione, ritengo che la stampa 3d, sempre più utilizzata in tanti settori, possa essere vantaggiosa anche nell'ambito di progettazione delle ali di un velivolo: la possibilità di realizzare strutture molto complesse sfruttando un singolo processo può rappresentare a mio parere un grande passo avanti in questo campo.