

# Extending the Aircraft Conceptual Design Workflow

## A Methodology for the Architecture Exploration and Optimization of Next Generation Multi-Role Seaplanes

Developments of geometric modeling tools at Federico II

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EUROAVIA / UNINAST Event

“Dual Horizons: Where Sea and Sky Collide”

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Università degli Studi di Napoli Federico II

Scuola Politecnica e delle Scienze di base



# Agenda

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- The EU-funded COLOSSUS project (HORIZON Europe)
- The COLOSSUS Use Cases
- Geometric modeling tools & automatic generation of full A/C configurations
  - SmartUp Engineering (Spinoff Federico II) - JPAD
  - JPAD & JPAD Modeller
  - JPAD-NX



## COLLABORATIVE SYSTEM OF SYSTEMS EXPLORATION OF AVIATION PRODUCTS, SERVICES & BUSINESS MODELS

The COLOSSUS consortium develops a system-of-systems design methodology, which for the first time enables the combined optimization of aircraft, operations, and business models.

The results are specific solutions for **intermodal transport** and **wildfire-fighting**, as well as open methods and tools made available to research and industry.

Read More on

[colossus-sos-project.eu/](http://colossus-sos-project.eu/)

# International Context

## The «EUROPEAN» International Context

- The research activity fits in the context of the EU-funded COLOSSUS project.
- The COLOSSUS project is aligned with the current research priorities of the Climate, Energy and Mobility cluster promoted under the Horizon Europe Programme.
- It addresses two major challenges:
  - I. accelerating the reduction of aviation-related impacts and emissions, and
  - II. contributing to the preservation of the European aviation industry's global leadership by fostering digital transformation and disruptive technologies.

## Main Technical Objective relevant for the research activity

- Execution of conceptual design studies of a **multi-role seaplane** equipped with **hybrid-electric propulsion** to serve the passenger transport market, as well as the niche of aerial firefight platforms.

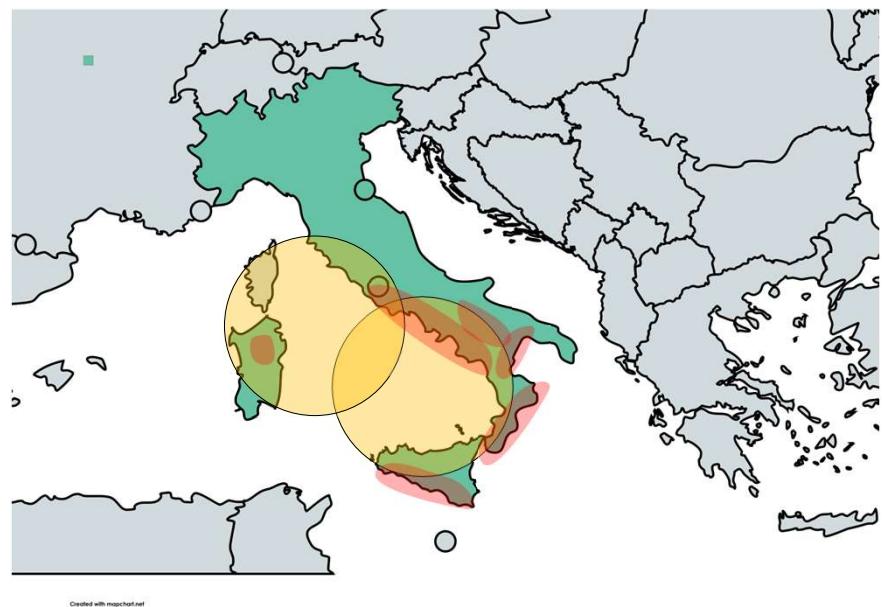


# Introduction to Use Cases

## Purpose of Multi-Role Seaplane

- The aviation transport sector recorded, in 2023, a 19.3% increase in total flight demand compared to 2021, with national and intra-EU flights accounting for 15.0% and 35.9% of total passenger volumes.
- Routes within the 300–499 km range, which have experienced the most significant decline in demand, has encouraged the exploration of novel products and services aimed at reducing environmental impact while maintaining competitive, cost-efficient performance.
- According to the Joint Research Centre of the European Commission, by early 2025 wildfires had affected more than one million hectares of land, with over 1800 individual events releasing approximately 38.68 million tonnes of CO<sub>2</sub> into the atmosphere.
- This dual-use, passenger transport and wildfire fighter, potential strengthens the economic viability of such platforms, while also improving fleet adaptability to fluctuating market demands or seasonal emergency needs.

Map Credits: <https://www.mapchart.net/europe.html>



Created with mapchart.net

Radius: 350 km



Wildfire Map in 2025



# Introduction to Use Cases

## Top-Level Aircraft Requirements (Pax Transport)

- Analysis of competitors
- Seaplanes providing passenger transport services are mostly operated in:
  - Asia
  - United States
  - Canada
- The main competitors are:
  - Cessna Caravan
  - Cessna Grand Caravan EX
  - DHC-6 Twin Otter



Parameter	Value	Req. Type	Source	Note(s)
MTOM	19 000.0 lb	Maximum	CS-23	Certification limit.
Payload	3 510.0 lb	Maximum	Benchmark	18 Pax. at 175.0 lb per pax plus 20.0 lb luggage.
Take-Off Distance	1 850.0 ft	Maximum	-	At MTOM, ISA Sea Level. From complete stop to 35.0 ft obstacle.
Landing Distance	1 850.0 ft	Maximum	-	ISA Sea Level. From 50.0 ft obstacle to complete stop.
Max. Cruise Speed	160.0 KTAS	Minimum	Benchmark	At 10 000.0 ft (FL100).
Cruise Altitude	10 000.0 ft	Fixed	Benchmark	Typical for the Caravan series [96].
Absolute Ceiling	25 000.0 ft	Minimum	Benchmark	-
Block Range	189.0 nm	Fixed	Benchmark	Design Point. At maximum payload. FL100.
Wingspan	78.74 ft	Maximum	Benchmark	ICAO B category.
Entry Into Service	2035	Fixed	COLOSSUS	-
Fuel Saving	-30.0%	Minimum	COLOSSUS	With respect to existing seaplanes operating in the same certification category.

TLARs have been derived from the comparative analysis of benchmarked aircraft, complemented by needs and specifications identified within the international context of the COLOSSUS project, as well as by rules established by regulatory authorities.

# Introduction to Use Cases

## Top-Level Aircraft Requirements (Aerial Firefight)

- Aerial Firefight aircraft are typically retired pax transport aircraft retrofitted with tanks, probes and doors to conduct firefight operations.
- There are a lot of old projects.
- Only few aircraft have been specifically designed to conduct firefighting tasks.
- The main competitors are:
  - AT-802 FireBoss (3 000 kg P/L)
  - De Havilland CL-415 (6 000 kg P/L)



Parameter	Value	Req. Type	Source	Note(s)
MTOM	19 000.0 lb	Maximum	CS-23	Certification limit.
Take-Off Distance	1 850.0 ft	Maximum	Pax Transport TLAR	-
Landing Distance	1 850.0 ft	Maximum	Pax Transport TLAR	-
Max. Cruise Speed	160.0 KTAS	Minimum	Pax Transport TLAR	-
Cruise Altitude	10 000.0 ft	Fixed	Pax Transport TLAR	-
Absolute Ceiling	25 000.0 ft	Minimum	Pax Transport TLAR	-
Wingspan	78.74 ft	Maximum	Pax Transport TLAR	ICAO B category.
Block Range	189.0 nm	Fixed	Pax Transport TLAR	Design Point. At design payload. FL100.
Design Payload	540.0 US Gal.	Fixed	Benchmark	73.5% of Max. Payload
Max. Payload	735.0 US Gal.	Fixed	Benchmark	-
Distance Ops.	3.7 nmi	Fixed	Benchmark	Sizing Point
Entry Into Service	2035	Fixed	COLOSSUS	-
Fuel Saving	-30.0%	Minimum	COLOSSUS	-

To ensure certification commonality and streamline the overall design process some requirements have been inherited from the passenger transport configuration.

Firefighting-specific requirements have been derived from the benchmarking analysis, ensuring that the aircraft is appropriately tailored to the operational and performance demands of aerial firefighting missions.

COLOSSUS approach works enabling the combined optimization of aircraft, operations and business models.

The project develops

## TWO USE CASES

01

### Sustainable Intermodal Mobility

Evaluating the concept for performance, competitiveness, environmental impact and life cycle footprint.



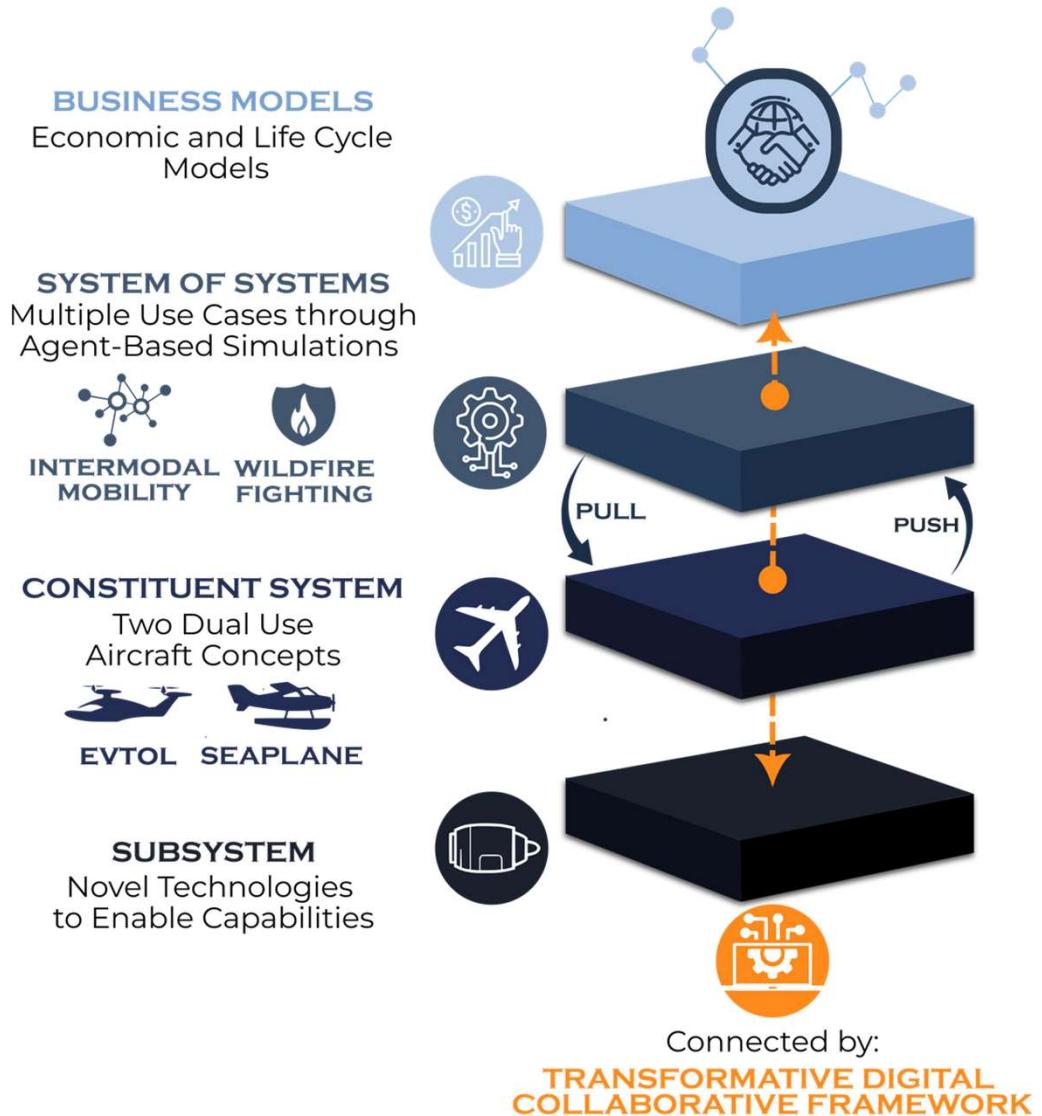
02

### Aerial Wildfire Fighting

Detecting and fighting wild-fires by combining latest developments in the fields of aircraft design and technology, automation, AI and digitalization.



COLOSSUS employs a 4-level approach to identify needs, capabilities, and system requirements in the initial phases of the holistic product development process and to cover them appropriately throughout the development cycle.



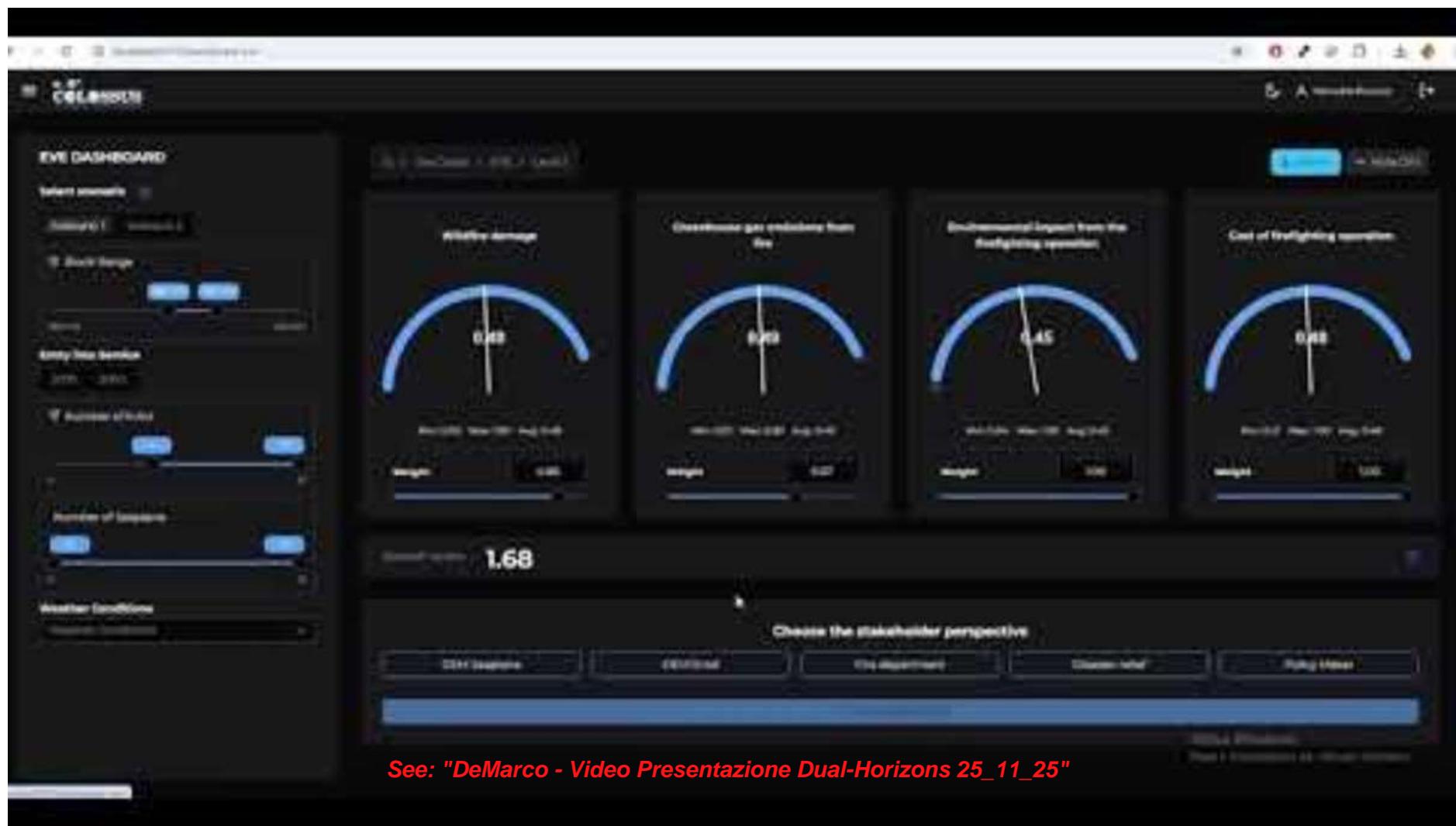
The project employs this approach to design two disparate multi-role aircraft of Seaplane and eVTOL configurations for two use cases posing contrasting requirements: Advanced Air Mobility and Aerial Wildfire Fighting

## eVTOL



## MULTIROLE SEAPLANE





See: "DeMarco - Video Presentazione Dual-Horizons 25\_11\_25"

# Preliminary Design and Performance Assessment

- The aircraft preliminary design stage is typically characterized by a large number of degrees of freedom, encompassing architectural features, geometrical parameters and mission-related variables.

Variable	Symbol	Type
Power-to-Weight Ratio	P/W	Continuous
Wing Loading	W/S	Continuous
Wing Aspect Ratio	AR <sub>w</sub>	Continuous
Wing Taper Ratio	$\lambda_w$	Continuous
Airfoil Mean Thickness Ratio	t/c	Continuous
Wing Apex	X <sub>LE,w</sub>	Continuous
Horizontal Tail Volumetric Coef.	V <sub>H</sub>	Continuous
Horizontal Tail Thickness Ratio	(t/c) <sub>H</sub>	Continuous
Horizontal Tail Sweep Angle	$\Lambda_H$	Continuous
Vertical Tail Volumetric Coef.	V <sub>V</sub>	Continuous
Vertical Tail Thickness Ratio	(t/c) <sub>V</sub>	Continuous
Vertical Tail Sweep Angle	$\Lambda_V$	Continuous
Cruise Mach Number	M <sub>CR</sub>	Continuous
Climb Speed	V <sub>CL</sub>	Continuous
Powertrain Architecture	-	Mixed-Discrete

*Hierarchical Dependencies*

Powertrain	Variable	Type	Options
Turboprop	Rated Power	Continuous	-
Reciprocating	Rated Power	Continuous	-
	Fuel Type	Categorical	Jet-A1, Diesel
	Energy Carrier	Categorical	Battery, Hydrogen
	Energy Supplier	Categorical	Battery, Fuel-Cell
	Thermal Engine	Categorical	Reciprocating, Turboprop
Hybrid-Electric	Take-Off Hybrid Ratio	Continuous	-
	Climb Hybrid Ratio	Continuous	-
	Cruise Hybrid Ratio	Continuous	-
	Descent Hybrid Ratio	Continuous	-

- The design of a seaplane requires adding specific set of architectural features necessary to size and shape the hull.

# Preliminary Design and Performance Assessment



How can we describe what features to consider and what's the necessary effort in integrating them into the design process ?

- Hull architectural features shall have an impact on the typical aircraft KPIs.
  - Take-Off performance from water surfaces represent a KPIs that's typically optimized for this class of aircraft.
- A parametric model shall be required to enable fast adaptability into an optimization problem.
  - The hull is often deeply integrated into the fuselage shape parametrization, reducing the number of models to include into the optimization problem.
  - Hull Parametric Model: *Hydrodynamic Investigation of a Series of Hull Models Suitable for Small Flying Boats and Amphibians*. NACA Technical Note 2503. J. Hugli W. C. and W. C. Axt (See Pictures)
- The number of features to consider shall enable the integration of hydrodynamic performance models suitable for the early design stage.

Description	Symbol	Type
Step Height (as percentage of beam)	$h_{\%B}$	Design Variable
Afterbody Length	$L_a$	Design Variable
Forebody Deadrise Angle (at the step)	$\beta_1$	Design Variable
Afterbody Deadrise Angle	$\beta_2$	Design Variable
Maximum Beam	B	Constant
Sternpost Angle	$\varphi$	Constant

A Total of 6 Independent Parameters

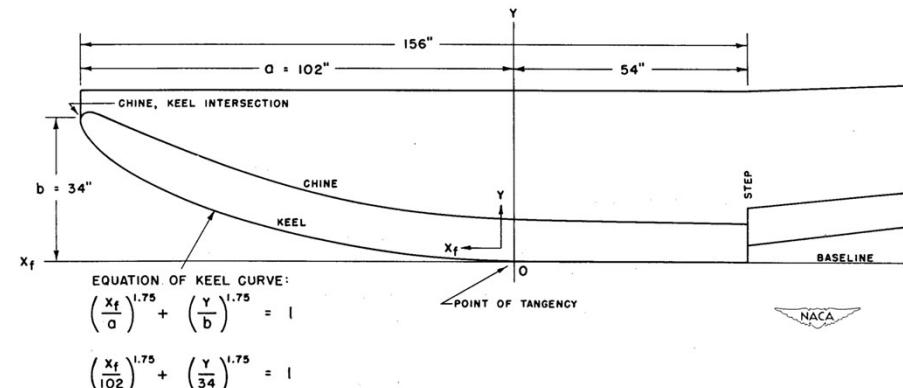
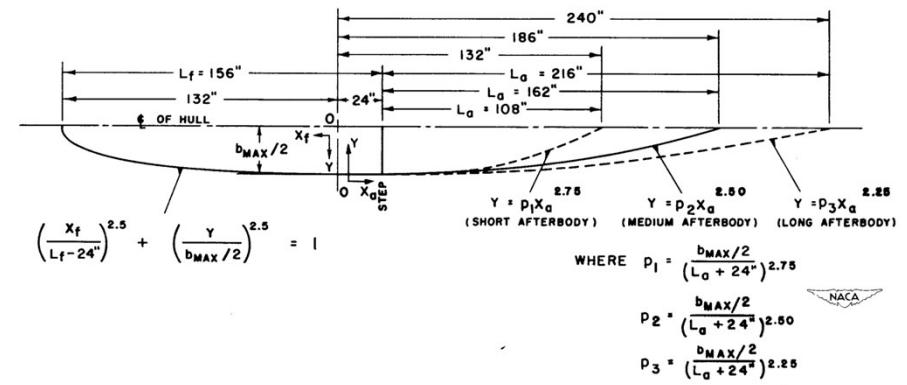


Figure 2.- Full-scale forebody keel curve equation.

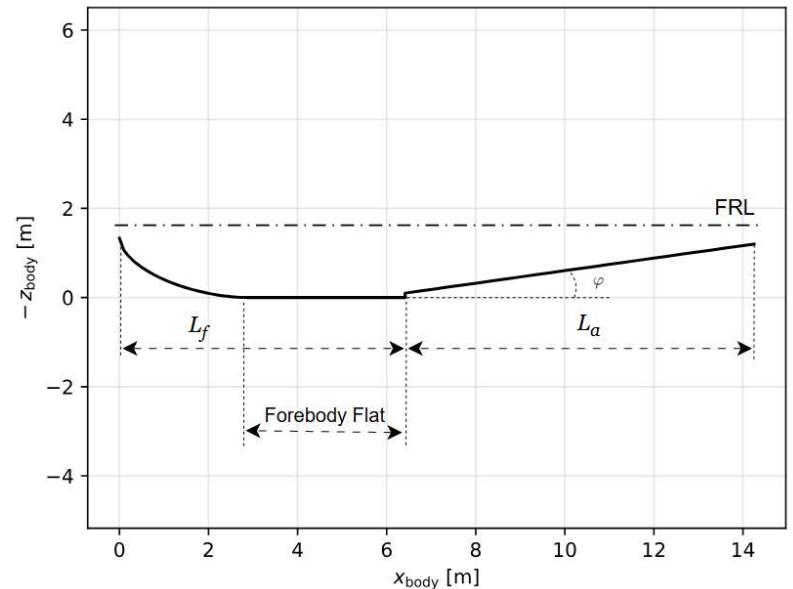


# Preliminary Design and Performance Assessment

## Advantages of the Hugli and Axt Model

- It enables a parametric description of the keel curve of the hull and of the seaplane planform.
- Controls the forebody and the afterbody in an independent way.
- Requires a limited number of shape parameters:
  - The seaplane length.
  - The step height (absolute or percentage of the beam).
  - The deadrise angle variation along the forebody.
  - The deadrise angle variation along the afterbody.
  - The height of hull apex (constant in our study).
  - The fraction of forebody to afterbody length (constant, depending on payload arrangement).
  - The maximum beam (constant in our study because dictated by payload requirements)
  - The sternpost angle (constant in our study due to limitations of performance models adopted in the preliminary stage)

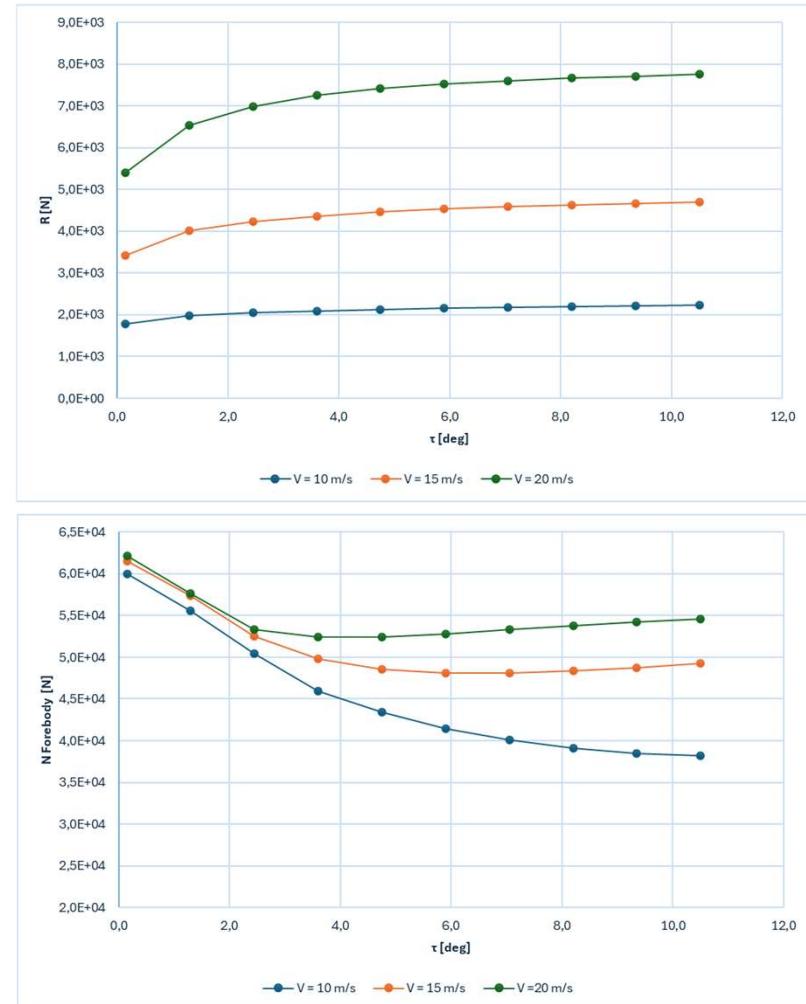
Keel Curve visualization (take-off driven optimized parameters).



# Preliminary Design and Performance Assessment

## The Hydrodynamic Performance Model

- Hydrodynamic performance studies have been carried out using the model proposed by **David Svahn**: «**Performance Prediction of Hulls with Transverse Steps**».
- The model is based on a modified version of the semiempirical model proposed by **Savitsky and Brown** in 1964 and in 1976.
- It accounts for the presence of a transverse step in the hull (typical of seaplanes).
- Enable the determination of:
  - Friction Resistance of both the forebody and afterbody (*R* in the figure)
  - Pressure Resistance
  - Normal forces acting on the forebody and afterbody (*N* in the figure)
  - Pitching moment
- A MATLAB class has been created to enable the analysis of hydrodynamic performance in fixed trim conditions and in free-to-trim conditions.
  - The latter are essential for the analysis of the take-off run from water surfaces, to avoid any pitch motion.



# Preliminary Design and Performance Assessment

## The Take-Off Optimization Problem

- For a fixed airframe and powertrain, the optimization of the take-off run from water surfaces requires the optimization of the hull shape.
- The objective is to minimize, in free-to-trim conditions, the resistance coefficient in the entire speed envelope of the take-off run.

$$f_{\text{obj}} = \int_0^{V_{\text{LO}}} C_R dV = \int_0^{V_{\text{LO}}} \frac{R_{\text{hydro}}}{\rho_w B^3} dV \quad (5.9)$$

- Design variables have been selected to be those necessary to the selected parametric model.
- Optimization constraints allow the seaplane to trim during the run and to avoid unstable solutions.
  - Eq.(5.12) has been proposed by **Morabito** in: "A Review of Hydrodynamic Design Methods for Seaplanes". In: *Journal of Ship Production and Design* 37.03 (Aug. 2021).

$$h_{\%B} \geq 0.59 \frac{L_a}{B} \varphi \quad (5.12)$$

	Function/Variable	Nature	Quantity	Note(s)
minimize	$f_{\text{obj}}$	cont.	1	From Eq. (5.9)
				<b>1 Total Objectives</b>
with respect to	$h_{\%B}$	cont.	1	5% to 8% [103]
	$\beta_1$	cont.	1	-
	$\beta_2$	cont.	1	-
	$L_a$	cont.	1	50% to 70% of the fuselage length [106]
				<b>4 Total variables</b>
subject to	Eq. (5.12)	cont.	1	-
	$M_{\text{hydro}} + M_{\text{aero}} = 0$	cont.	1	-
				<b>2 Total constraints</b>

Parameter	Value	Unit	Note(s)
$B$	1.90	m	Seaplane width.
$\varphi$	8.0	deg	Average value.
$\beta_1$	14.5	deg	-
$\beta_2$	19.0	deg	-
$L_a$	7.83	m	55% of the fuselage length.
$h_{\text{step}}$	0.1	m	5.26% of the Beam.

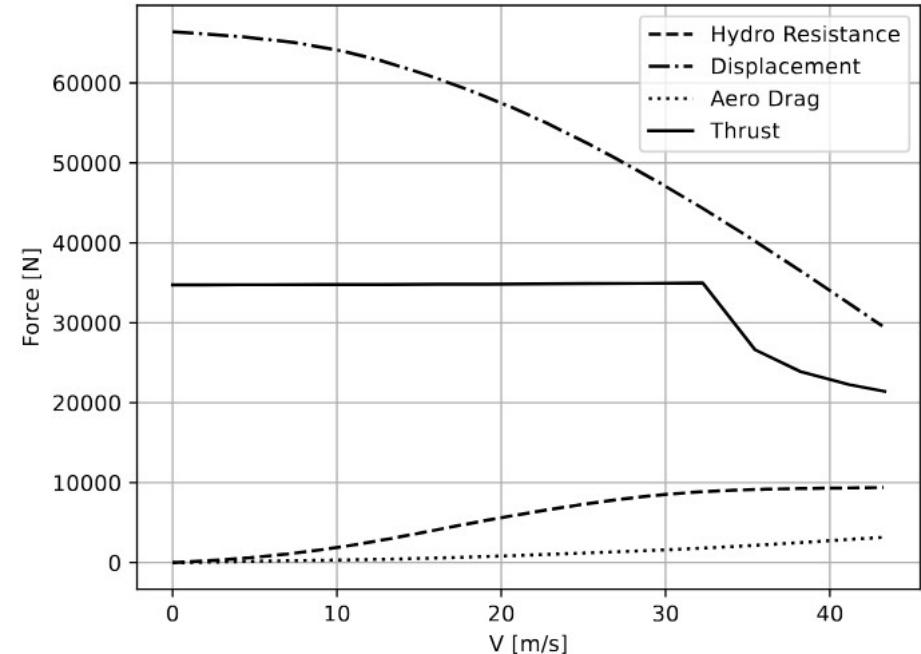
# Preliminary Design and Performance Assessment

## Take-Off Analysis

- The analysis of the take-off run has been conducted under simplified assumptions leading to Eq.(5.16) expressing the system of ODEs to solve to determine the «water» distance.

$$\begin{cases} \dot{V} = \frac{g}{W} \left[ -D - \frac{\Delta(C_V)}{W} R - N_1 \sin \tau_1 - N_2 \sin \tau_2 + T \right] \\ \dot{x}_{CG} = V \end{cases} \quad (5.16)$$

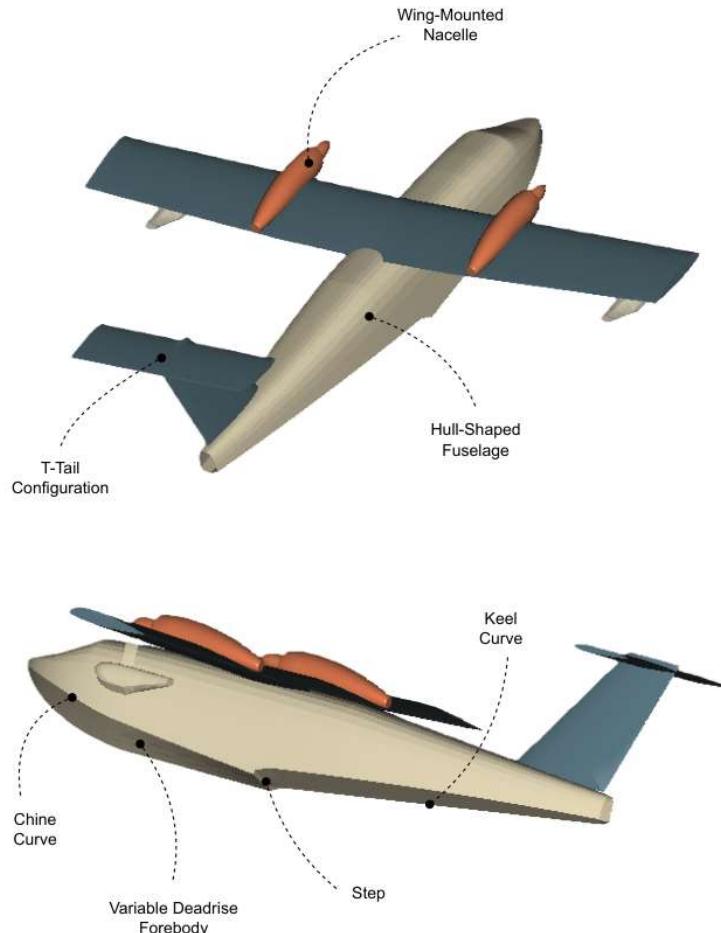
- Analysis have been conducted on two seaplane configurations.
  - Passenger Transport version.
  - Aerial Firefight version.



Forces acting on the seaplane during the water run.

Use Case	Water Run	Ground Run	$\Delta$
Passenger Transport	338.2 m	234.9 m	+44.0%
Aerial Firefight	431.0 m	279.9 m	+54.0%

# Preliminary Design and Performance Assessment

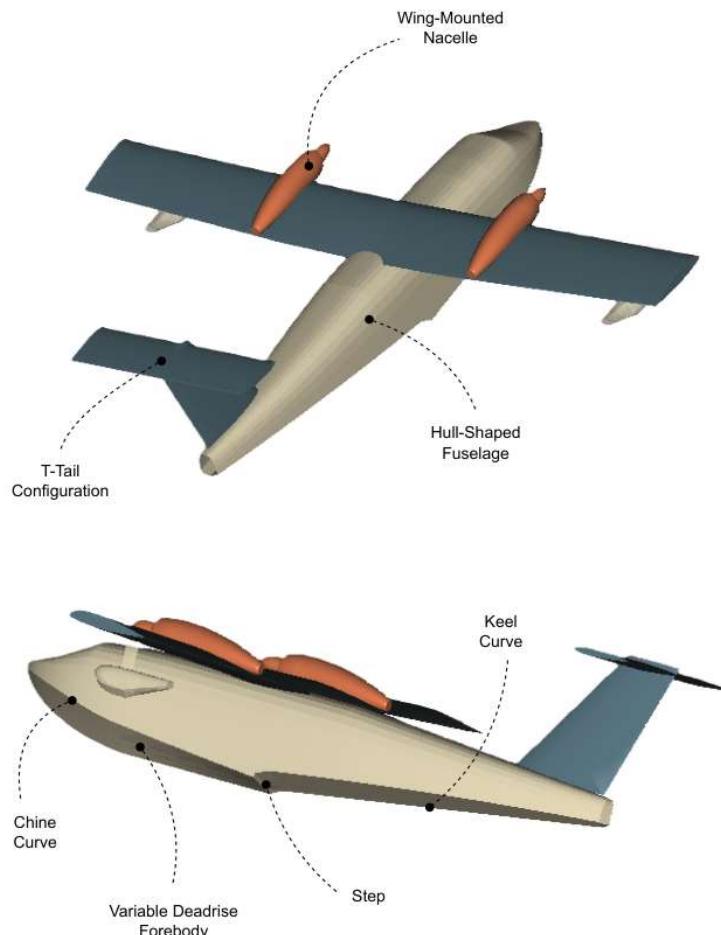


Hybrid-Electric Seaplane					
Item	Unit	Twin Otter	$\phi_{BAT}: 37.5\%$	$\phi_{BAT}: 50.0\%$	$\phi_{BAT}: 90.0\%$
<i>Capital Costs</i>					
Insurance	USD/hr	62.21	70.42	70.42	70.42
Depreciation	USD/hr	234.28	264.74	264.74	264.74
Interests	USD/hr	275.93	311.80	311.80	311.80
<i>Operational Costs</i>					
Jet-A1 Fuel	USD/hr	317.85	211.36	203.42	201.88
Electricity	USD/hr	-	36.62	47.06	50.12
Cockpit Crew	USD/hr	240.0	240.0	240.0	240.0
Airframe Maintenance	USD/hr	220.27	240.27	240.27	240.27
Turboprop Maintenance	USD/hr	170.44	171.90	171.90	171.90
EM Maintenance	USD/hr	-	20.38	20.38	20.38
Battery Maintenance	USD/hr	-	41.27	53.02	56.48
<i>Charges</i>					
Take-Off & Landing	USD/hr	28.35	32.89	32.89	32.89
Navigation	USD/hr	70.53	74.75	74.75	74.75
Ground Handling	USD/hr	307.80	297.97	297.97	297.97
CO <sub>2</sub> EU ETS	USD/hr	30.25	20.12	19.36	19.21
<b>DOC</b>	USD/hr	1 957.91	2 034.49	2 048.0	2 052.82
<b>IOC</b>	USD/hr	900.57	901.89	910.67	913.81
<b>DOC</b>	USD	1 957.91	2 101.63	2 115.57	2 120.57
<b>IOC</b>	USD	900.57	931.66	940.72	943.97
			USD/hr	2 133.27	2 147.23
			USD/hr	966.11	975.18
			USD	1 987.50	2 000.51
			USD	900.09	908.54
<i>Performance</i>					
Take-Off Ground Roll		1 843.0 ft		1 420.0 ft	-22.9%
Take-Off Water Run		1 965.0 ft		1 539.0 ft	-21.7%
Landing Distance		1 450.0 ft		1 817.0 ft	+23.3%
Max Cruise Speed		162.0 KTAS		214.0 KTAS	+32.1%
Ferry Range		705.0 nm		750.0 nm <sup>a</sup>	+6.4%

+7.3% in Off-Design Condition

+1.51% in Design Condition

# Preliminary Design and Performance Assessment



Item	Unit	Constant Payload	Variable Payload
<i>Scenario 1</i>			
Jet-A1 Mass	lb	1 153.7	1 158.7
Battery Energy	kWh	204.35	204.35
Aircraft WTO	lb	10 730.0	10 735.1
Maximum Aircraft Mass	lb	14 848.0	15 876.0
Total Mission Time	min	112.0	112.3
Firefight Mission Time	min	41.0	41.2
Number of Drops	-	5	5
Total Mission Range	nm	310.0	310.0
Operational Efficiency	lb/min	249.0	280.0
DOC	US Gal./min	65.76	73.15
	USD	5 900.0	5 953.0
DOC	USD/hr	3 161.0	3 181.0
	USD/US Gal. hr	1.17	1.06
<i>Scenario 4</i>			
Jet-A1 Mass	lb	754.4	766.6
Battery Energy	kWh	131.5	131.5
Aircraft WTO	lb	10 309.5	10 322.4
Maximum Aircraft Mass	lb	14 753.8	15 225.8
Total Mission Time	min	90.2	90.5
Firefight Mission Time	min	74.7	75.0
Number of Drops	-	12	12
Total Mission Range	nm	181.5	181.5
Operational Efficiency	lb/min	328.7	374.75
DOC	US Gal./min	86.8	99.0
	USD	4 730.2	4 785.9
DOC	USD/hr	3 145.4	3 171.9
	USD/US Gal. hr	0.49	0.43

110.0 nm      Airport to fire loc.

10.0 nm      Fire loc. to water

+11.2%      Efficiency

-9.4%      DOC

16.6 nm

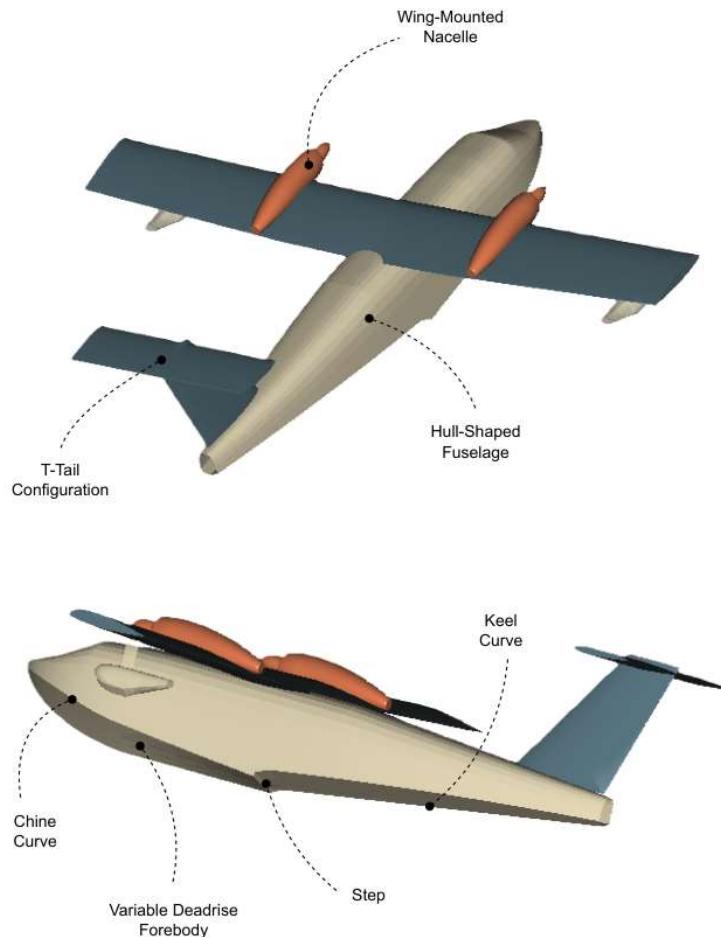
6.4 nm

+14.0%      Efficiency

-12.2%      DOC

2-hour mission for both scenarios.

# Preliminary Design and Performance Assessment



Drop ID	Unit	Constant Payload	Variable Payload	Note(s)	
<b>Scenario 1</b>					
1	US Gal.	540.0	540.0	-	
2	US Gal.	540.0	555.0	-	110.0 nm
3	US Gal.	540.0	581.2	-	
4	US Gal.	540.0	634.0	-	10.0 nm
5	US Gal.	540.0	700.0	-	
	US Gal.	2 160.0	3 010.2	Total Payload	+39.0% Payload
<b>Scenario 4</b>					
1	US Gal.	540.0	540.0	-	
2	US Gal.	540.0	568.0	-	
3	US Gal.	540.0	594.4	-	
4	US Gal.	540.0	594.4	-	
5	US Gal.	540.0	620.8	-	
6	US Gal.	540.0	620.8	-	
7	US Gal.	540.0	634.0	-	
8	US Gal.	540.0	634.0	-	
9	US Gal.	540.0	647.2	-	16.6 nm
10	US Gal.	540.0	647.2	-	
11	US Gal.	540.0	660.4	-	6.4 nm
12	US Gal.	540.0	660.4	-	
	US Gal.	6 480.0	7 421.6	Total Payload	+14.5% Payload

# Technologies supporting this study...

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# SmartUp Engineering



[www.smartup-engineering.com](http://www.smartup-engineering.com)

A Spinoff of  
Federico II  
(2020-2025)



**Fabrizio Nicolosi**  
CEO



**Agostino De Marco**  
CCO



**Pierluigi Della Vecchia**  
CTO



**Salvatore**  
Engineering Services Manager  
**Corcione**



**Danilo Ciliberti**  
R&D Engineer



**Vincenzo Cusati**  
R&D Engineer



**Vittorio Trifari**  
Software Development Manager



**Manuela Ruocco**  
R&D Engineer

# SmartUp Engineering

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SmartUp Engineering is an innovative SME founded by young aerospace engineers and researchers from the University of Naples Federico II, Italy.

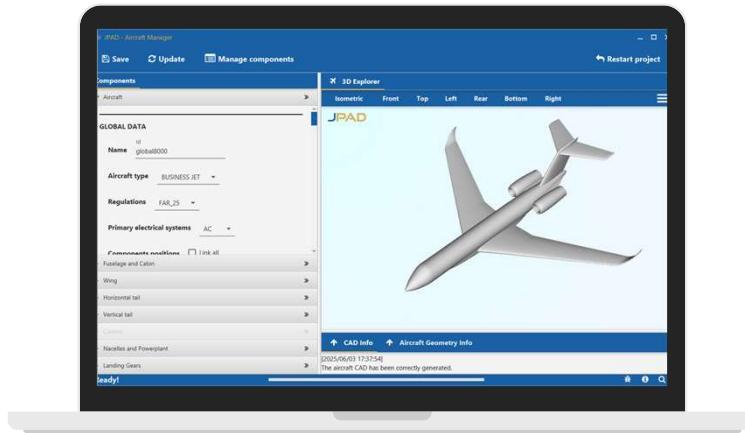
The company specializes in:

- Software development for industrial and scientific aerospace applications.
- Design, development, and testing of innovative aerial platforms for air, sea, and land use.
- Implementing cutting-edge technologies in aerospace, mechanical, and energy industries.



The team, brings over 50 years of combined experience, offering expertise in aircraft design, aerodynamic analysis, aerospace software development, flight simulation, and experimental testing.

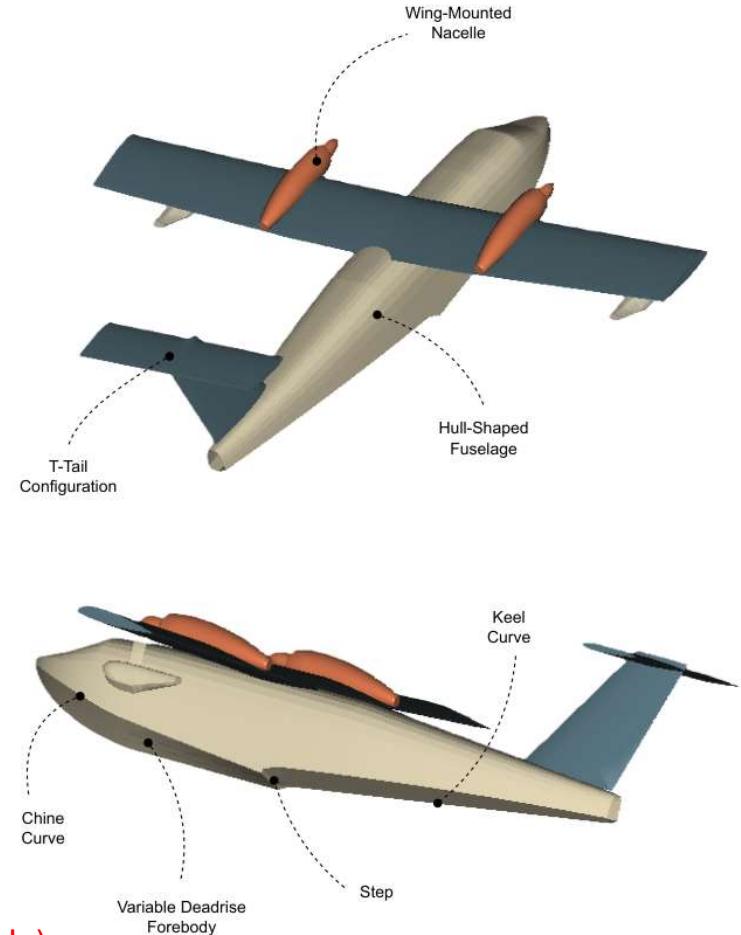
# Geometric Modeling of Complex Shapes



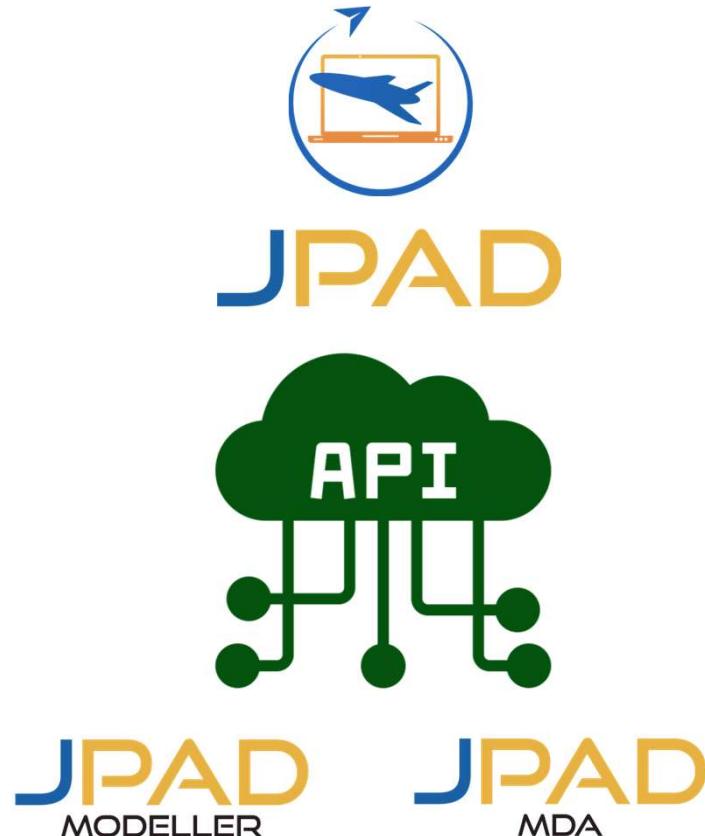
<http://www.smartup-engineering.com/jpad-modeller>

<https://altair.com/blog/articles/altair-partner-alliance-smartup-jpad-modeller>

<https://www.youtube.com/@smartupengineering6505/playlists> (YouTube Tutorials)

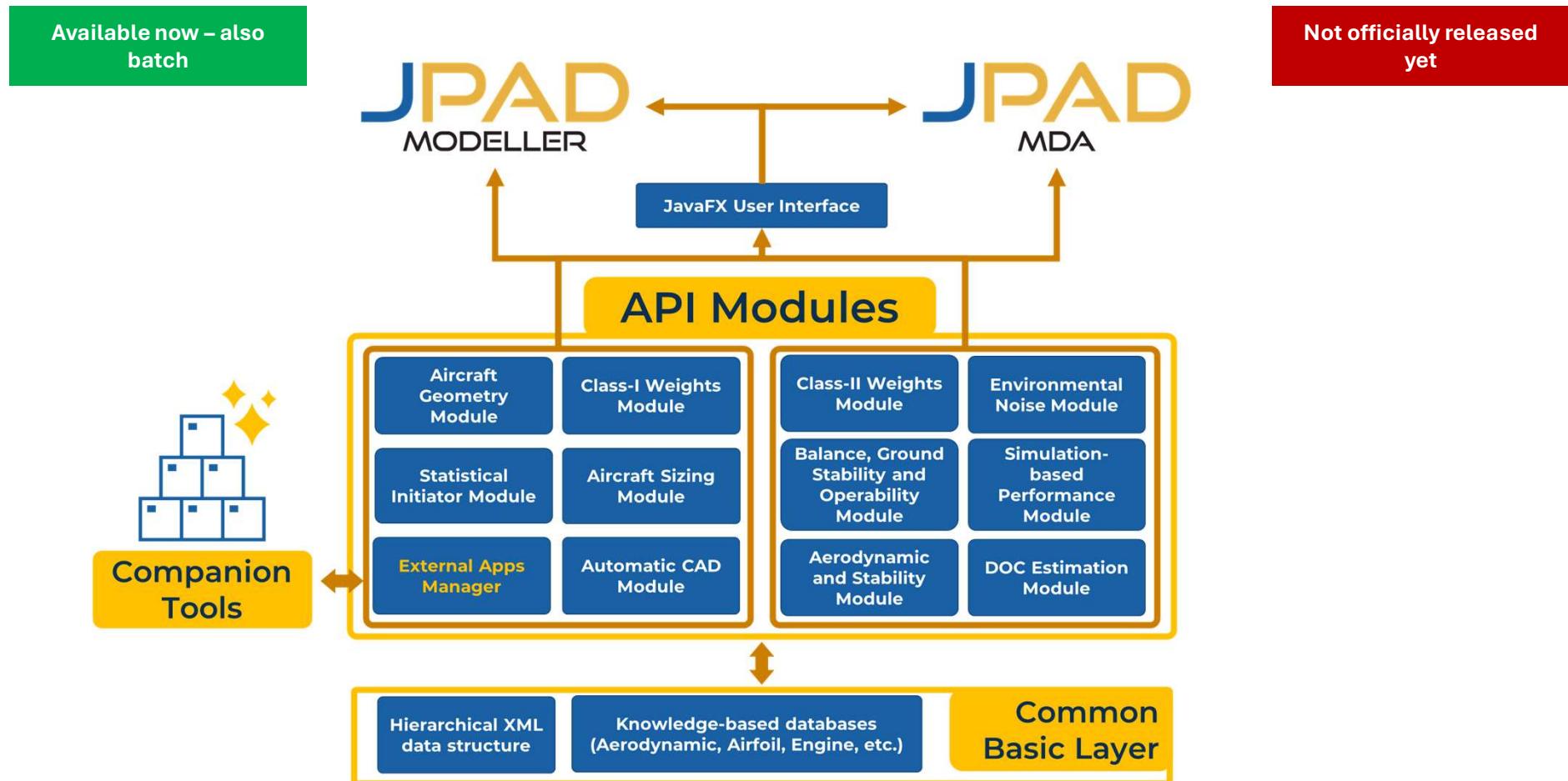


# JPAD – Java API for Aircraft Design



- Modular computational library, structured as an API (Application Programming Interface)
- Interface to many third-party tools
  - DATCOM
  - AVL
  - OpenVSP
  - FlightStream (ALTAIR / SIEMENS)
  - STAR-CCM+ (SIEMENS)
  - XROTOR
- On-demand new modules, based on users' needs
  - Hybrid-Electric Pre-Design
  - Detailed mission simulation module
  - Non-conventional aircraft modelling
  - Airfoil and wing optimization
- On-demand products derived from the API

# JPAD – Java API for Aircraft Design

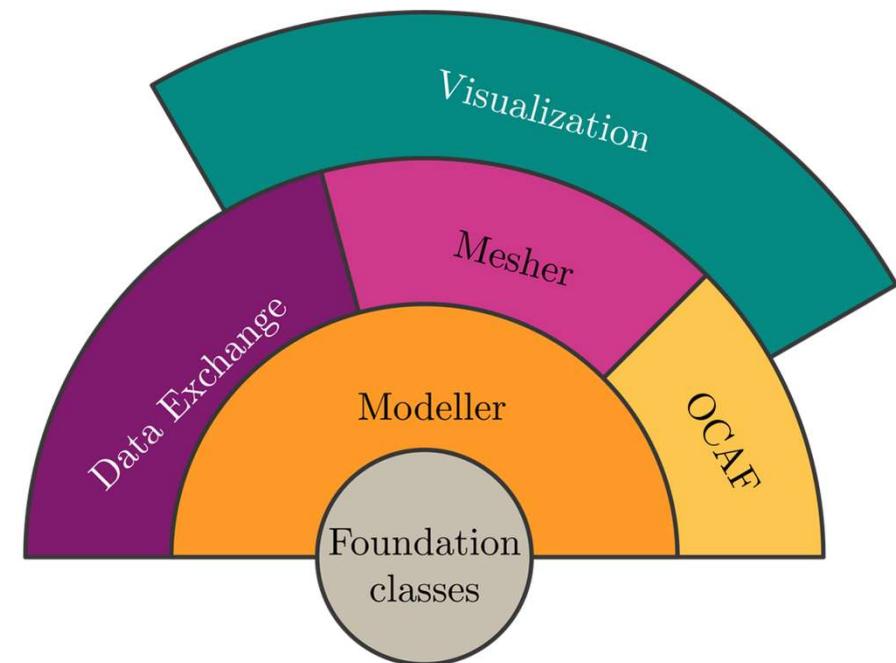


# JPAD-CAD & OpenCASCADE Technology (OCCT)



Open CASCADE (Computer Aided Software for Computer Aided Design and Engineering) is the only open-source CAD kernel in the market. It consists of a library of several modules written in C++.

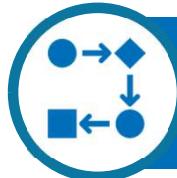
The JPAD-CAD module makes use of a C++ to Java binding that amalgamates both OCCT functionality and functions developed ad hoc by DLR researchers for their TiGL library, which implements Gordon Surfaces.



# JPAD Modeller Features



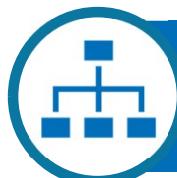
JPAD Modeller allows you to generate high-definition and fully parametric aircraft models, as well as their highly detailed parametric CAD solid, IN SECONDS!



JPAD Modeller aims at supporting designers in conceptual and preliminary aircraft design task, providing a useful pre-processor for your typical workflows

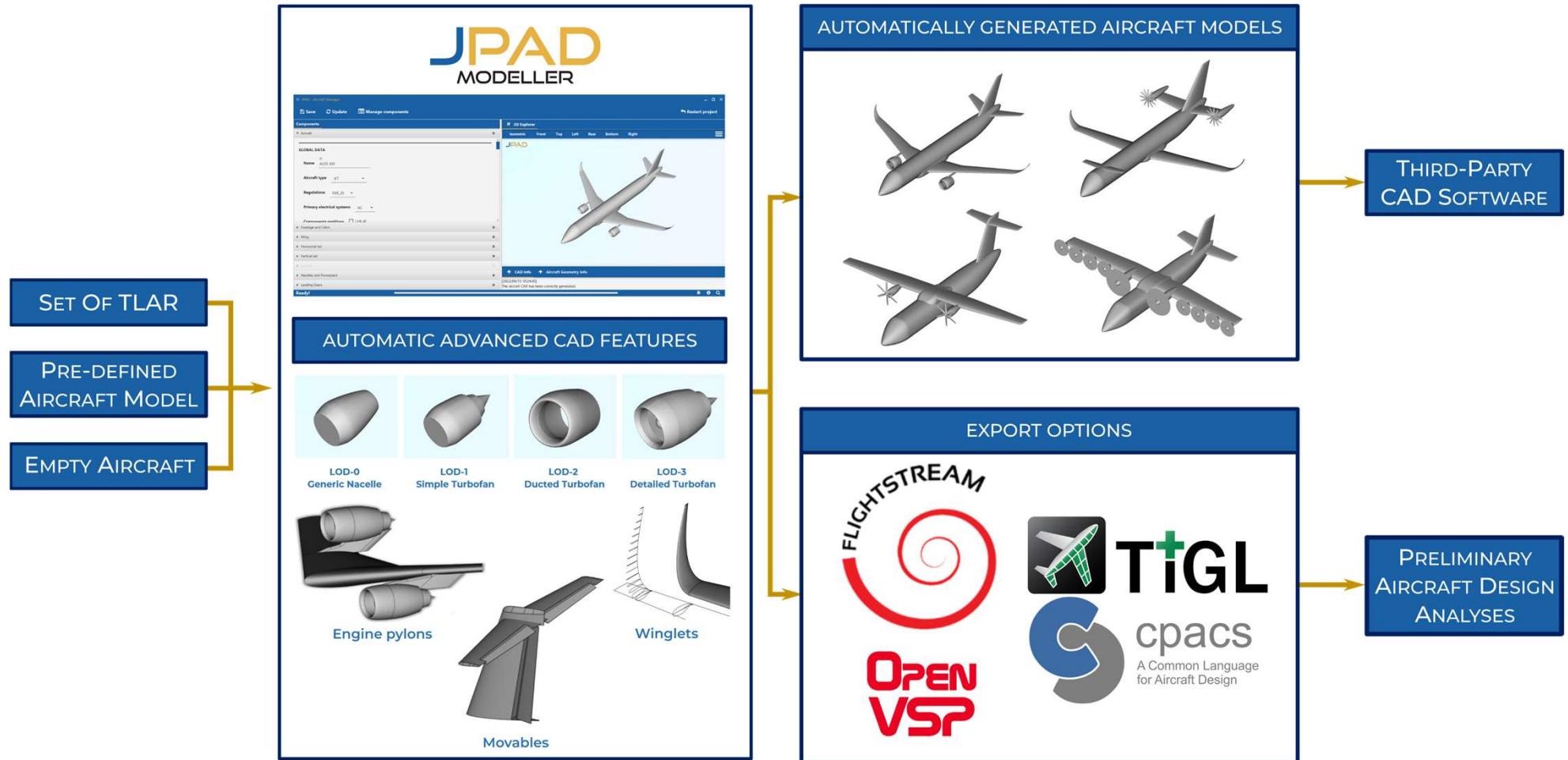


JPAD Modeller provides you with the possibility to automatically generate high-definition and fully parametric aircraft models, as well as detailed parametric CAD solids, that you can export to various file formats, including STEP, BREP, IGES, STL



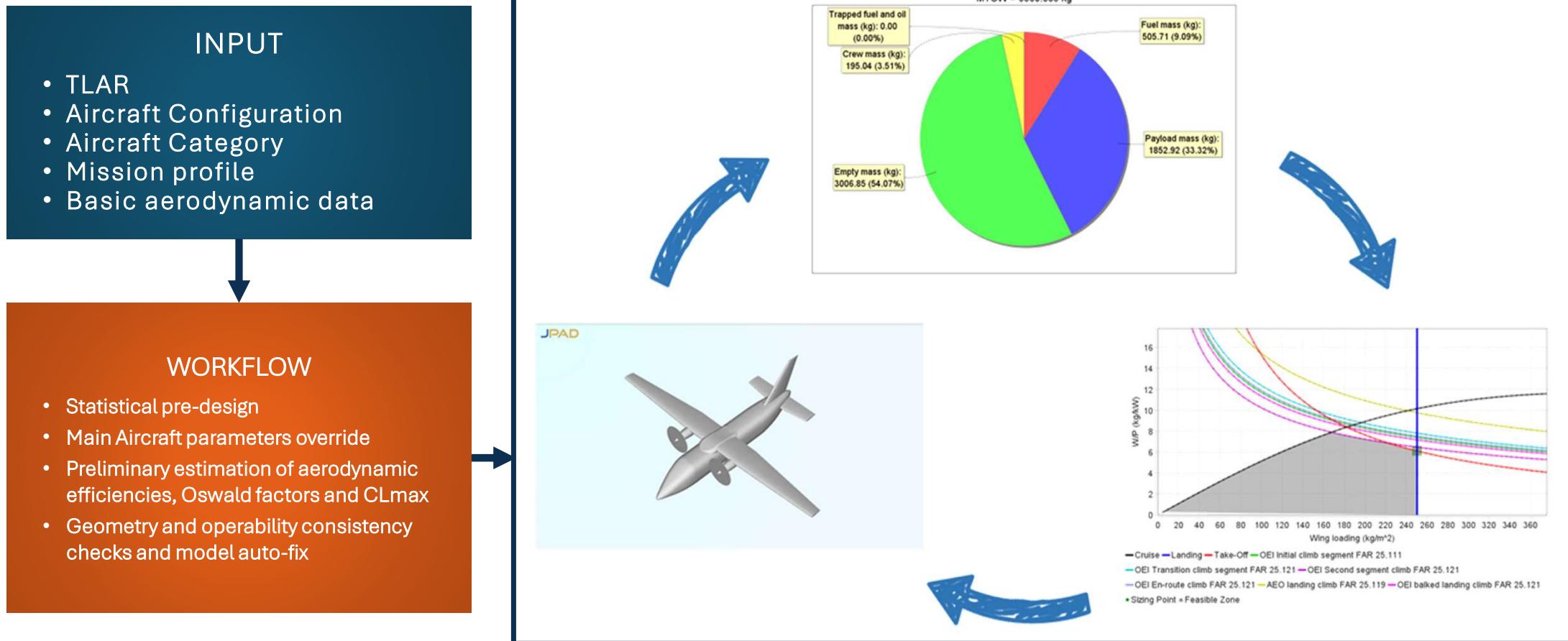
JPAD Modeller can natively export aircraft models toward the following external companion tools and file formats: CPACS, OpenVSP, FlightStream®

# JPAD Modeller Features



# Pre-Design Module

Automatic aircraft definition from a set of Top Level Aircraft Requirements. Class-I weights estimation and Sizing Plot.

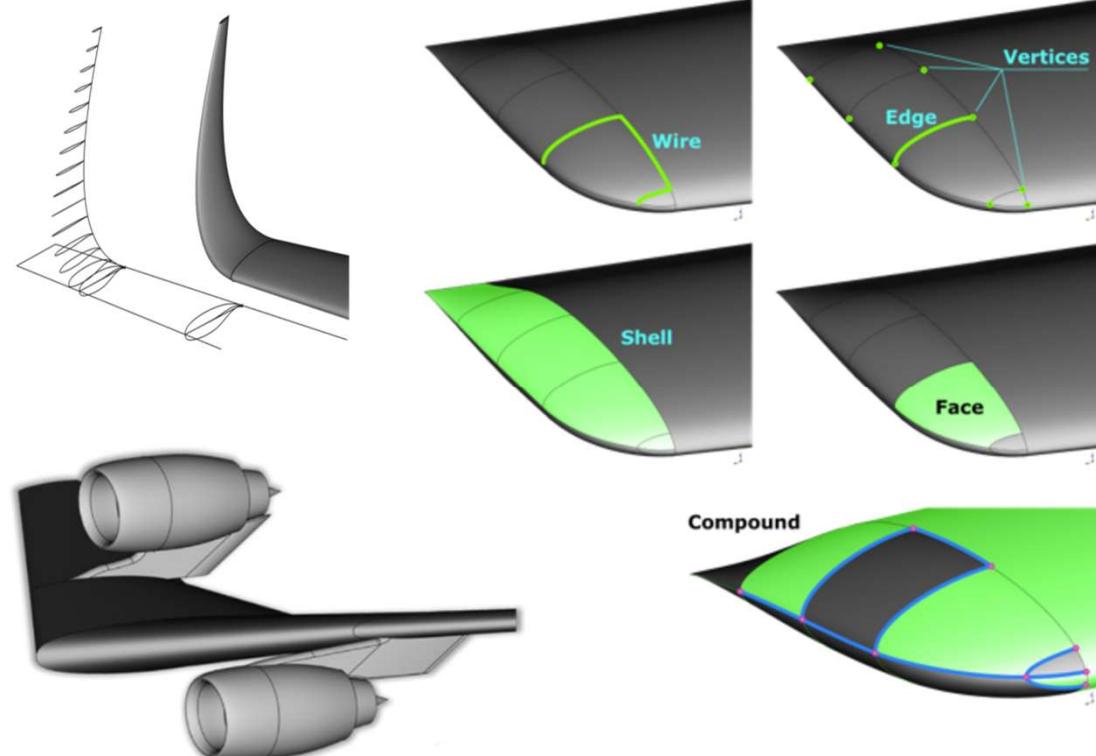
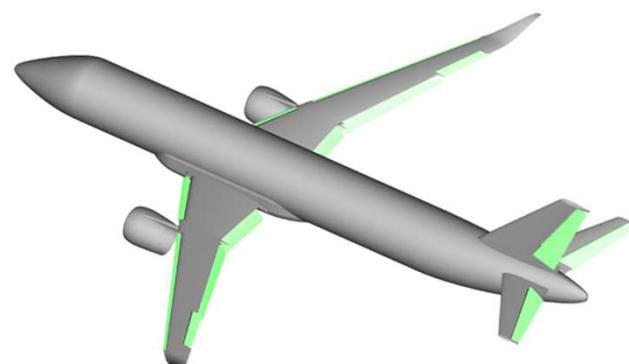




## Automatic CAD generation

JPAD Modeller can automatically generate the following CAD components:

- ❖ LIFTING SURFACES TIPS
- ❖ WINGLETS
- ❖ WING-FUSELAGE FAIRINGS
- ❖ CANARD-FUSELAGE FAIRINGS
- ❖ ENGINE PYLONS
- ❖ PROPELLER DISKS WITH SPINNERS
- ❖ NACELLES (with different Levels of Detail - LOD)
- ❖ DETAILED MOVABLES AND CONTROL SURFACES



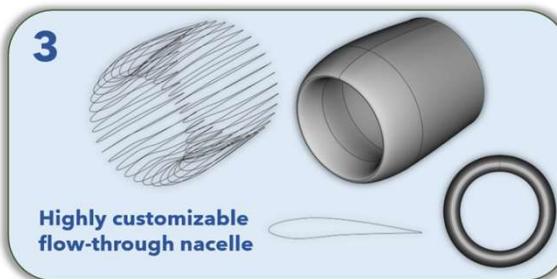
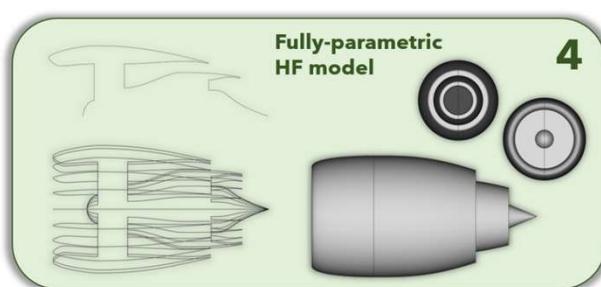
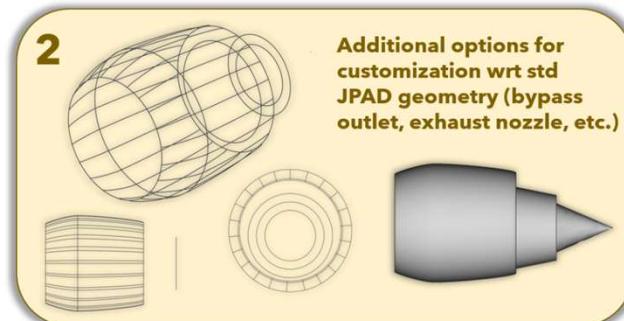
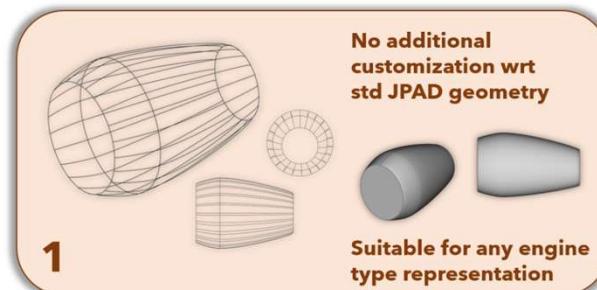
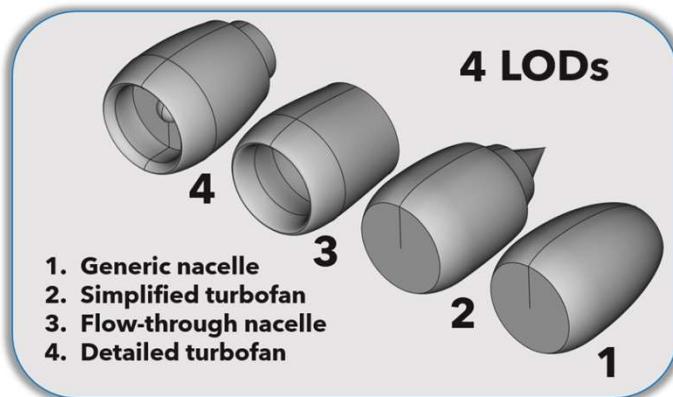
## ADVANCED CAD FEATURES

# ADVANCED CAD FEATURES

## Engine Levels Of Details (LOD)



LOD: Level Of Detail

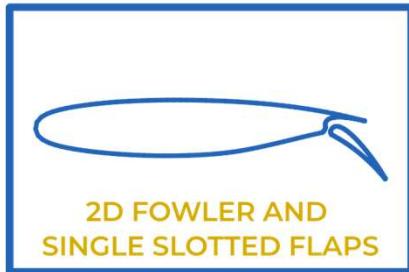


## MOVABLES CONTROL SURFACES

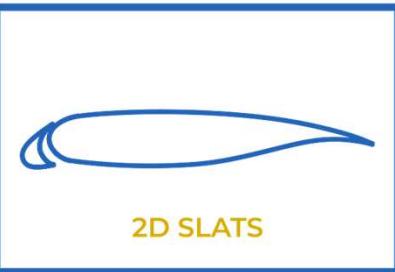
Detailed modelling and automatic generation of movable surfaces in seconds starting from 2D inner and outer section parameters.



### From 2D sections geometrical parameters



2D FOWLER AND  
SINGLE SLOTTED FLAPS



2D SLATS



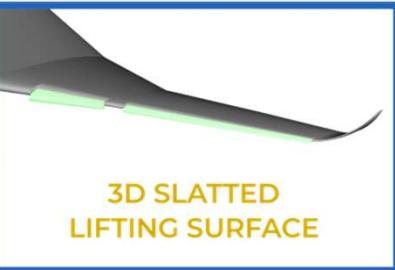
2D AILERONS AND  
CONTROL SURFACES



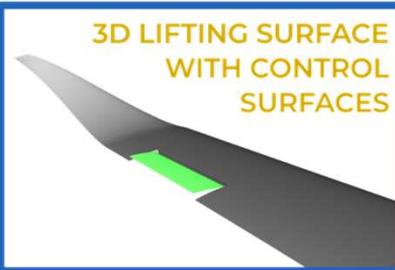
### To the movable 3D model



3D FLAPPED  
LIFTING SURFACE



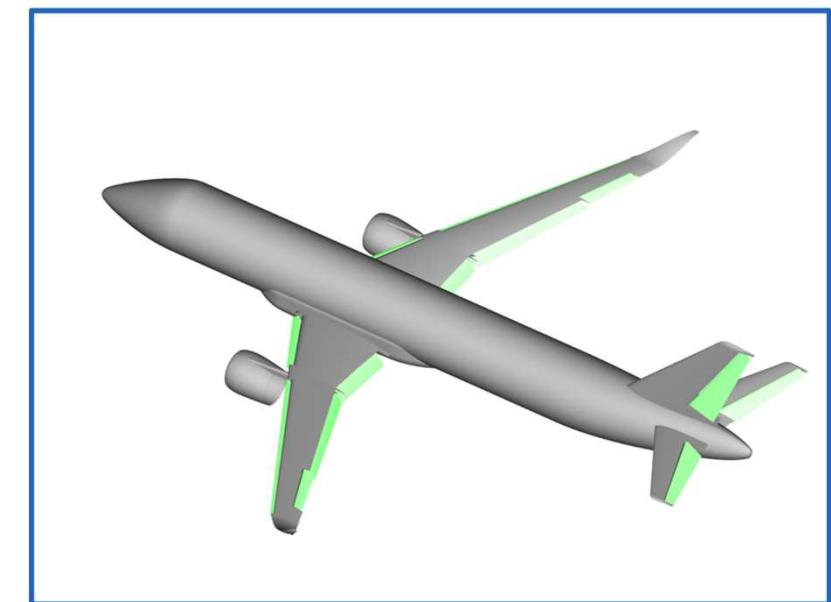
3D SLOTTED  
LIFTING SURFACE



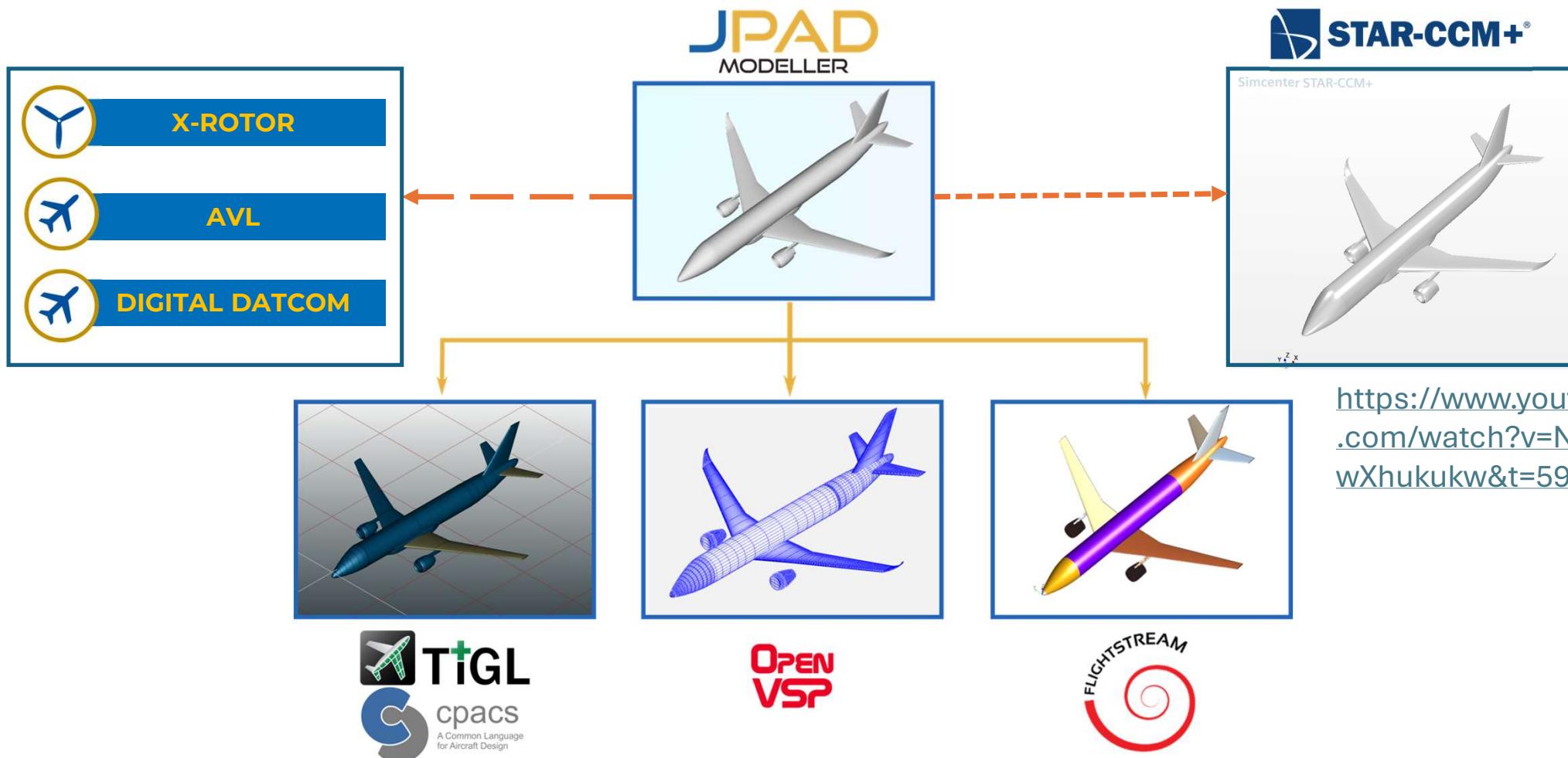
3D LIFTING SURFACE  
WITH CONTROL  
SURFACES



### Up to the full aircraft CAD model



## Export Options toward many companion tools



- NX OPEN: API FRAMEWORK OF SIEMENS NX



- **Programming interface** for **Siemens NX CAD**
- Supports multiple languages (C++, **Java**, Python, VB)
- Enables **automation** of modeling and design tasks
- Basis for building **custom applications**



```
Session theSession = (Session) SessionFactory.get("Session");
UI theUI = (UI) SessionFactory.get("UI");
ListingWindow theLW = theSession.listingWindow();
Part theWorkPart = theSession.parts().work();
Point3d p3d = new Point3d(1000.0, 0.0, 500.0);
String pointName = "testPoint";
Point p = createPoint(theLW, pointName, theWorkPart,
```

## • NX OPEN: GEOMETRY BUILDING BLOCKS



### Splines

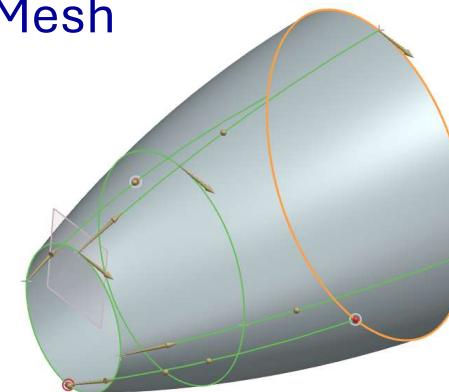
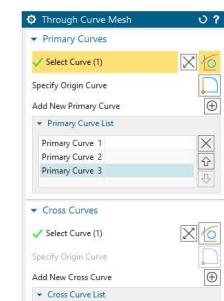
- 3D Spline
- Spline on datum plane
- Assign tangent to spline

```
ThroughCurveMesh surf = NXSurfaces.createSurfaceThroughCurveMesh(  
    lw, "WingSkin",  
    primarySplines, // spanwise curves  
    crossSplines, // section curves  
    theWorkPart, theUI  
)
```

NX Open  
API

### Surfaces

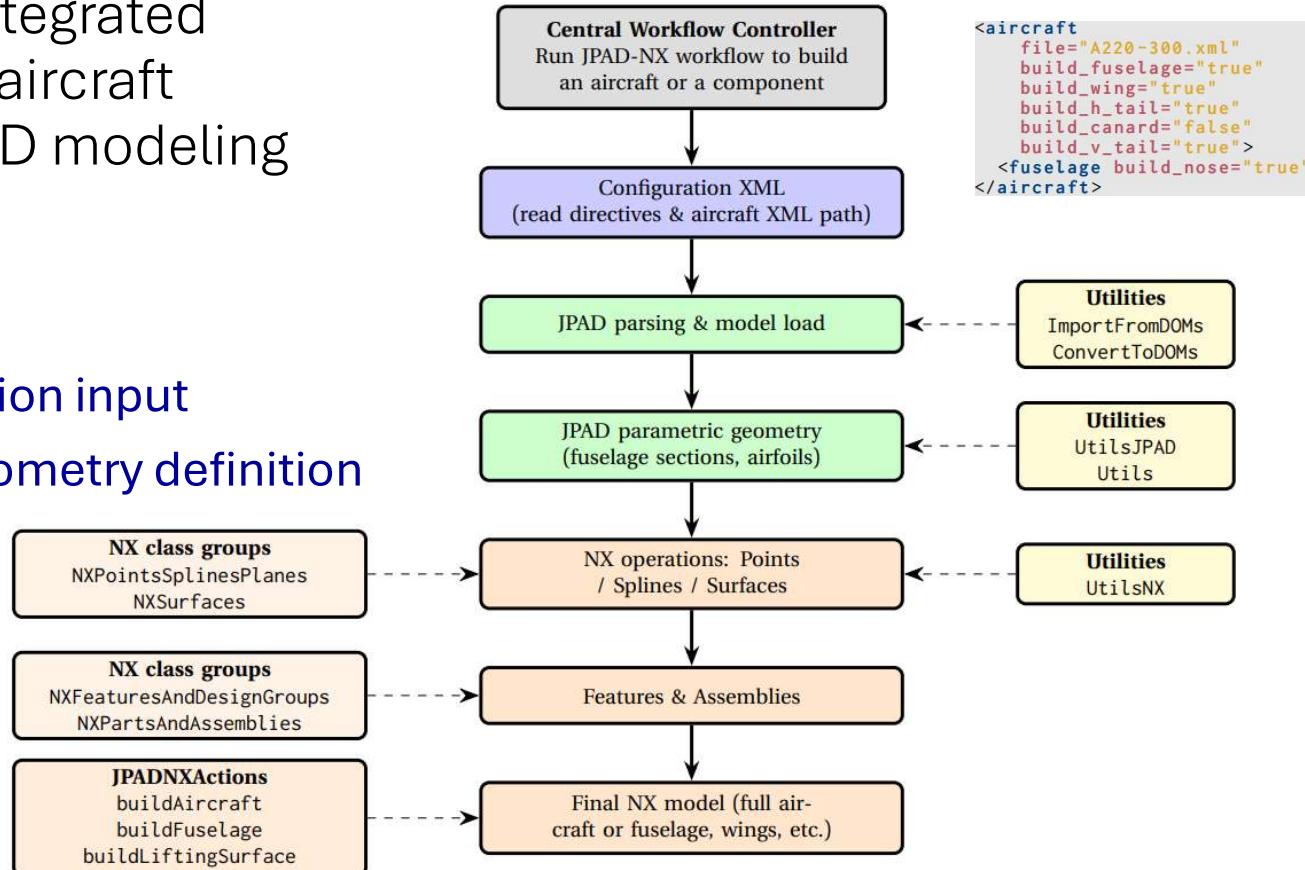
- Through Curve Mesh
- Through Curve



- **JPAD-NX** an integrated framework for aircraft parametric CAD modeling

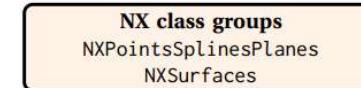
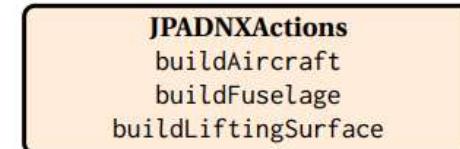
## Workflow:

- XML configuration input
- Parsing and geometry definition
- NX operations
- CAD model
- Model modifications

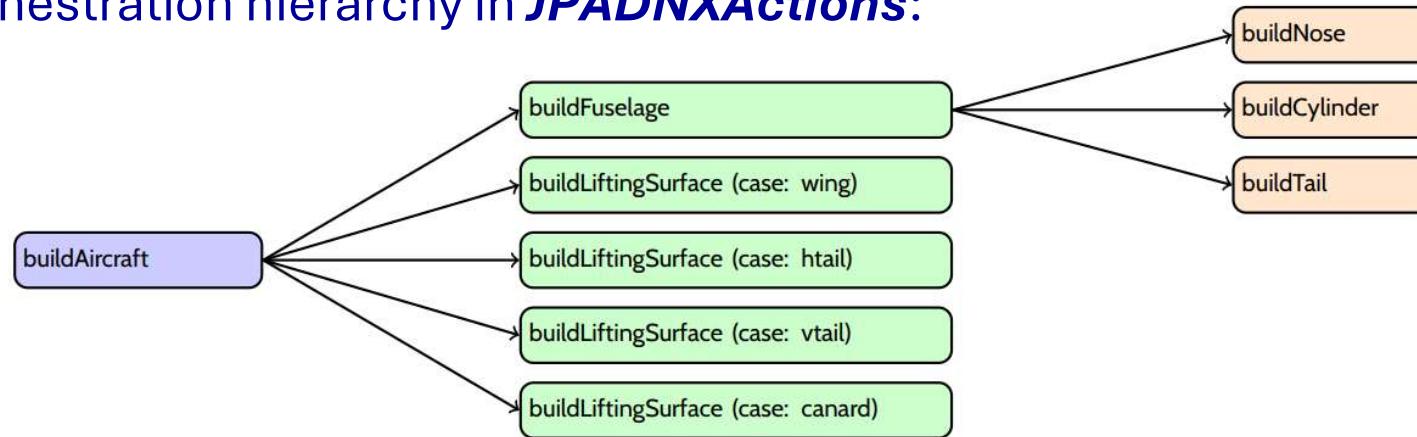


## • GEOMETRY GENERATION

- High level methods: *JPADNXActions*
- Underlying classes for geometric operations:  
*NXPointsSplinesPlanes, NXSurfaces*



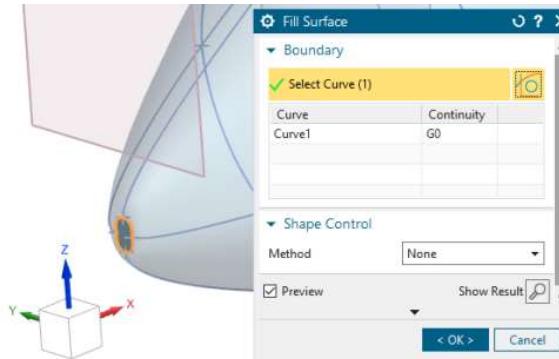
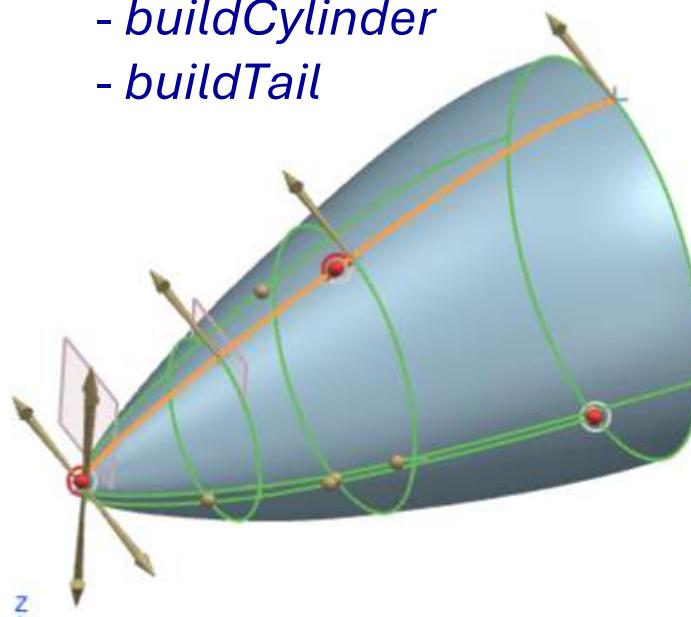
Orchestration hierarchy in ***JPADNXActions***:



- **FUSELAGE** (*buildFuselage*)

Divided into three trunks:

- *buildNose*
- *buildCylinder*
- *buildTail*

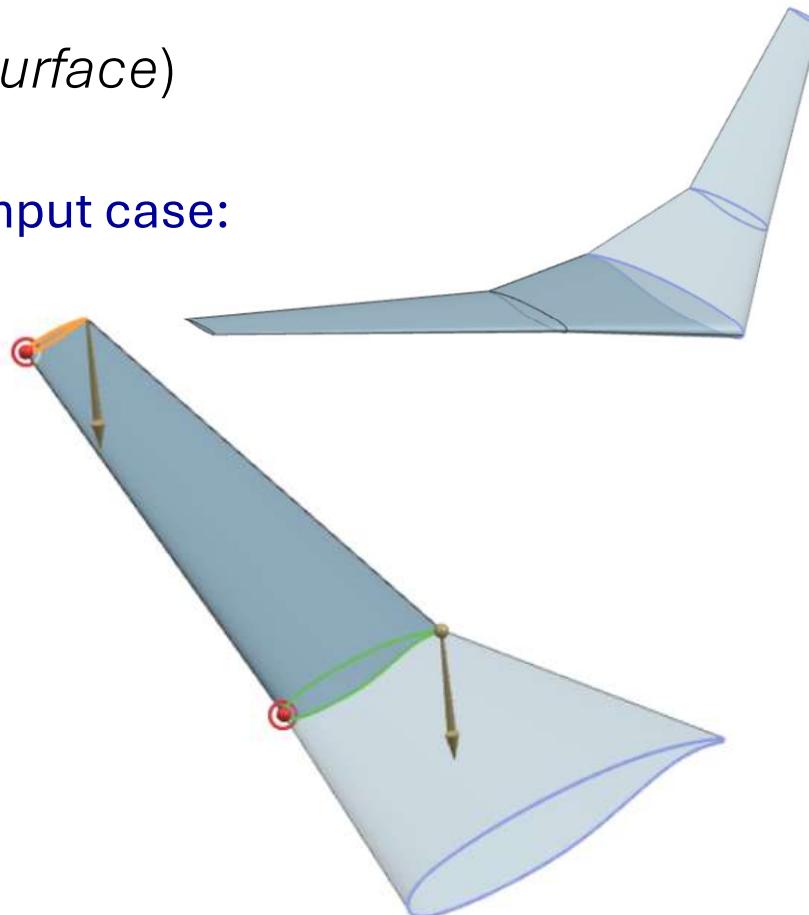
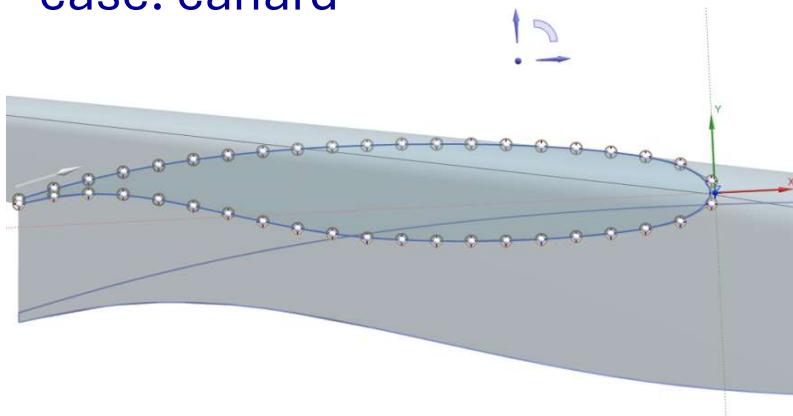


Directive(s)	Geometric effect in NX
xNoseSectionsRatio	Places axial stations in $[x_{nose\_start}, x_{nose\_end}]$ used for datum planes and cross-section splines.
startSectionTypeNose	Defines the tip footprint (assigned shape) on the first datum plane; avoids a cap-type surface. Sizes are ratios of nose length / cylinder width / cylinder height.
radiusNoseStartRatio	Vertical tip tangents (upper/lower), scaled by cylinder height.
widthNoseStartRatio	Vertical tip tangents (upper/lower), scaled by cylinder height.
heightNoseStartRatio	Vertical tip tangents (upper/lower), scaled by cylinder height.
tzNoseTipUp	Vertical tip tangents (upper/lower), scaled by cylinder height.
tzNoseTipDown	Vertical tip tangents (upper/lower), scaled by cylinder height.
tyNoseTip	Lateral tip tangent (sides), scaled by cylinder width.
txNoseEndUp	Axial end tangents at $x_{nose\_end}$ (upper/lower/sides), scaled by nose length.
txNoseEndDown	Axial end tangents at $x_{nose\_end}$ (upper/lower/sides), scaled by nose length.
txNoseEnd	Axial end tangents at $x_{nose\_end}$ (upper/lower/sides), scaled by nose length.
nUpperLeftPoints	Per-section spline fidelity on the upper/lower arcs of each cross section.
nLowerLeftPoints	Per-section spline fidelity on the upper/lower arcs of each cross section.

- LIFTING SURFACES (*buildLiftingSurface*)

One method varying depending on input case:

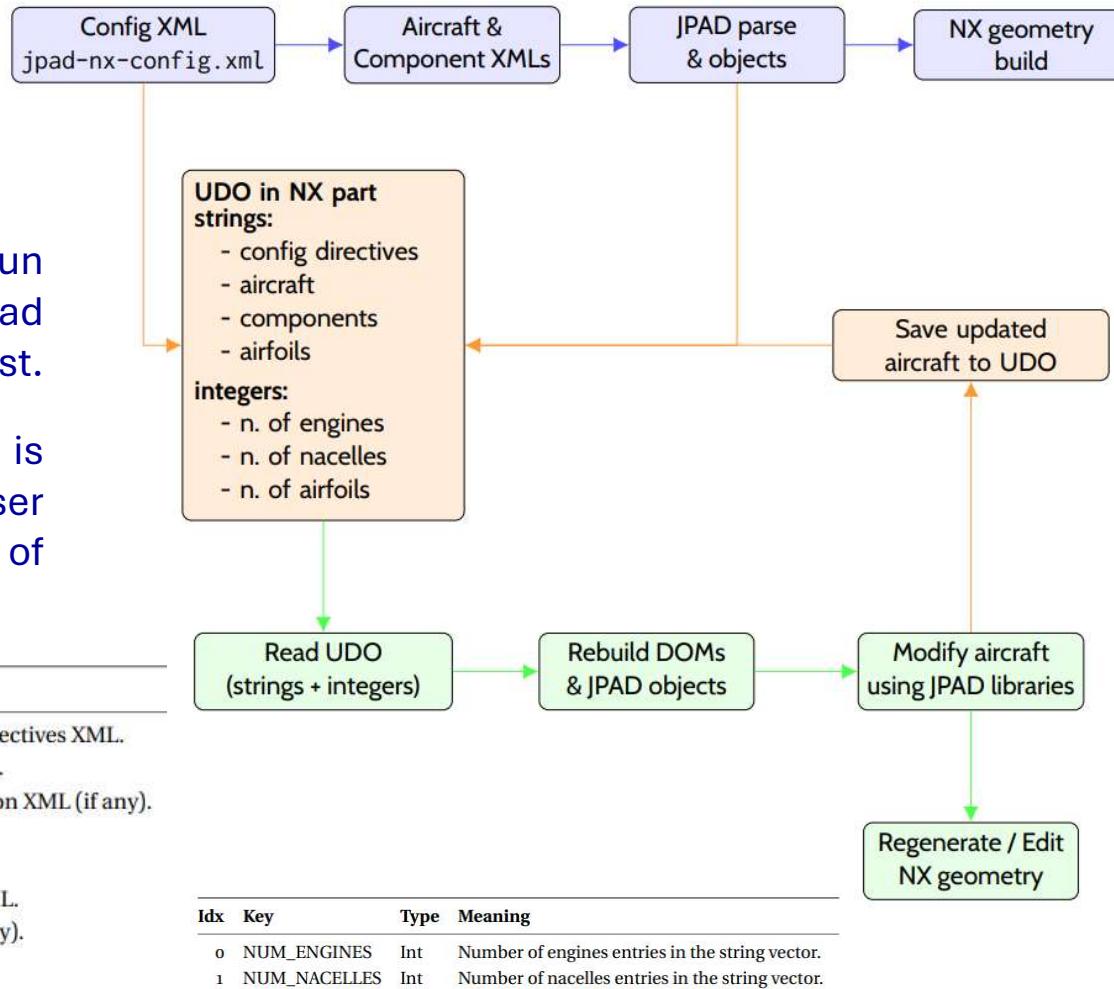
- case: wing
- case: horizontal tail
- case: vertical tail
- case: canard



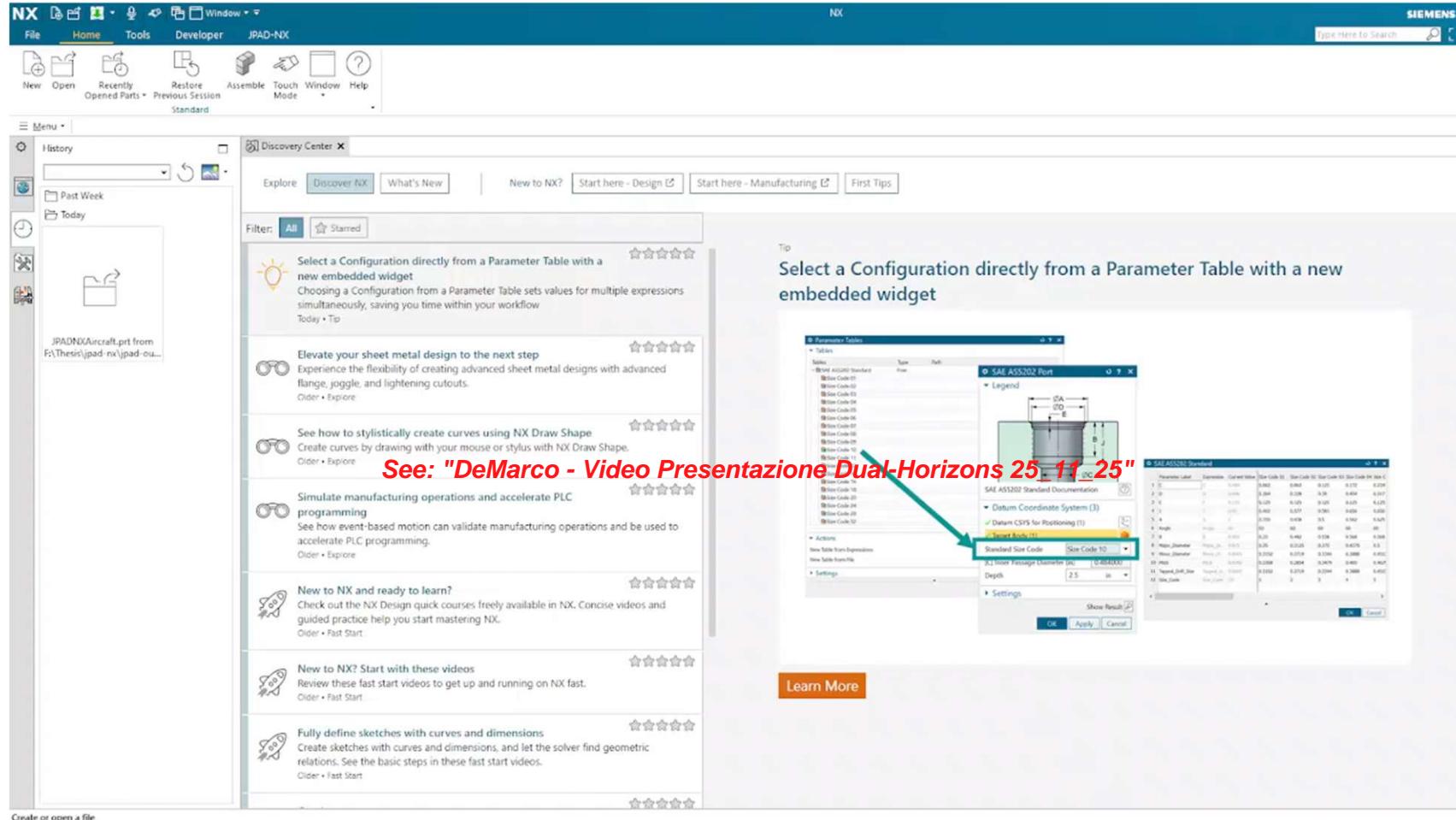
- PERSISTENCE OF INFORMATION

- After the NX Program run ends, the information read from the XMLs would be lost.
- To make it persistent, it is saved inside NX **UDOs** (User Defined Objects) as vectors of strings and integers:

Idx	Key	Type	Content / Notes
0	NX_CONFIG	String	JPAD-NX build directives XML.
1	AIRCRAFT	String	Main aircraft XML.
2	CABIN_CONFIGURATION	String	Cabin configuration XML (if any).
3	FUSELAGE	String	Fuselage XML.
4	WING	String	Wing XML.
5	H_TAIL	String	Horizontal tail XML.
6	CANARD	String	Canard XML (if any).
7	V_TAIL	String	Vertical tail XML.



# JPAD-NX: Short Demo

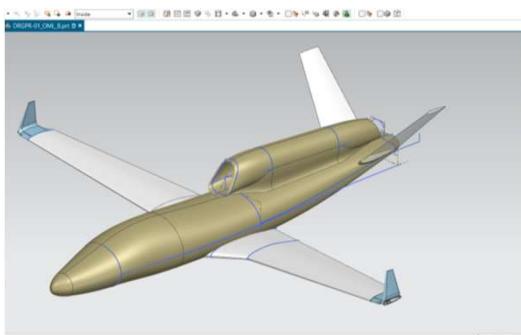


The screenshot shows the NX 10.0 interface with the Discovery Center open. The interface includes a top menu bar with File, Home, Tools, Developer, and JPAD-NX, and a toolbar with various icons for file operations. The main area features the Discovery Center, which displays a list of tips and tutorials. One tip is highlighted in red with the text: "See: *"DeMarco - Video Presentazione Dual Horizons 25. 11. 25"*". A detailed view of a parameter table dialog is overlaid on the Discovery Center. The dialog shows a table for "SAE ASS202 Standard Documentation" with columns for Parameter Label, Expression, Current Value, and Standard Value. A red arrow points to the "Standard Value" column header. The dialog also includes a preview image of a mechanical part and a "Parameter Table" section with a table of values.

# JPAD - SIEMENS Co-dev. PIPELINE

SIEMENS

SMARTUP  
ENGINEERING



01

JPAD – NX

Modeler integration in NX CAD

JPAD  
MODELLER



02

JPAD-STAR

Export JPAD model and execute analysis

JPAD  
MODELLER

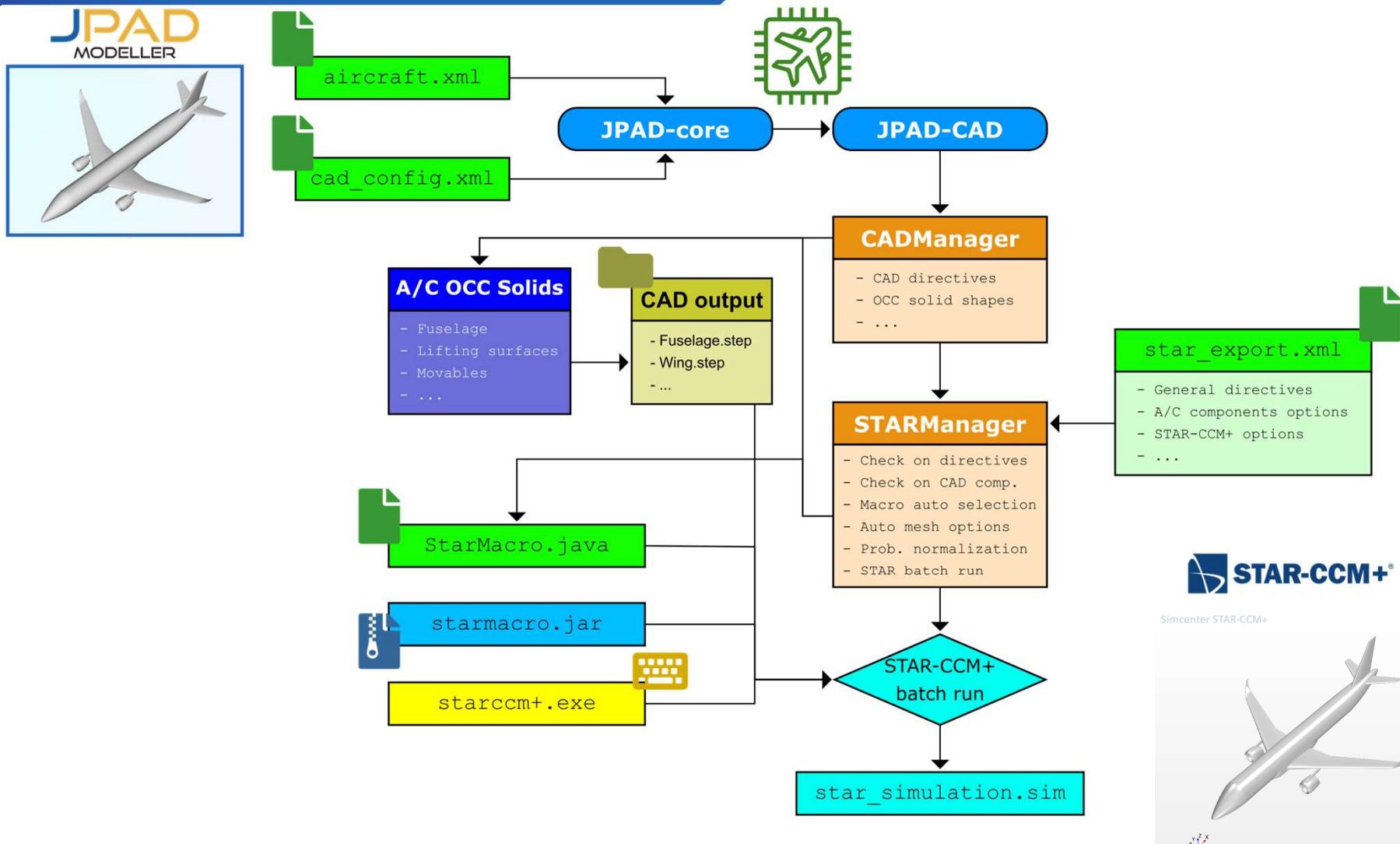


03

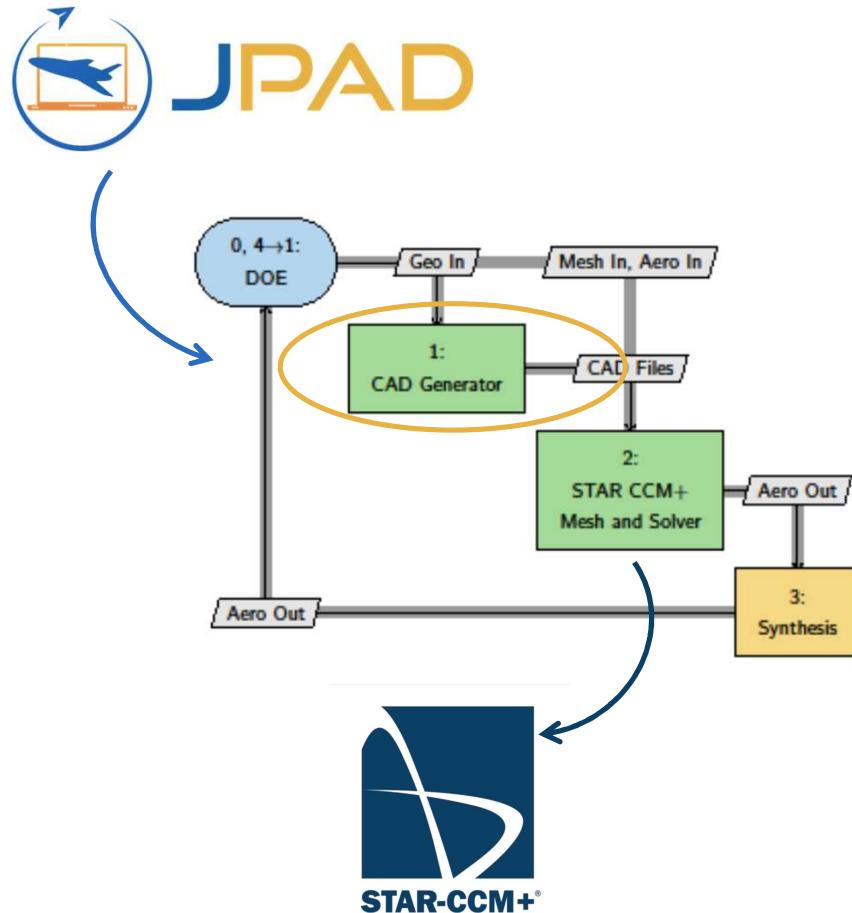
JPAD-FEM analysis

(In development)

# JPAD - SIEMENS Co-dev. PIPELINE

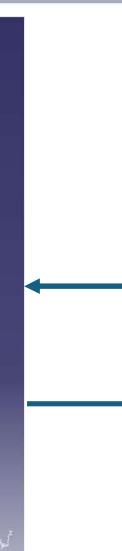
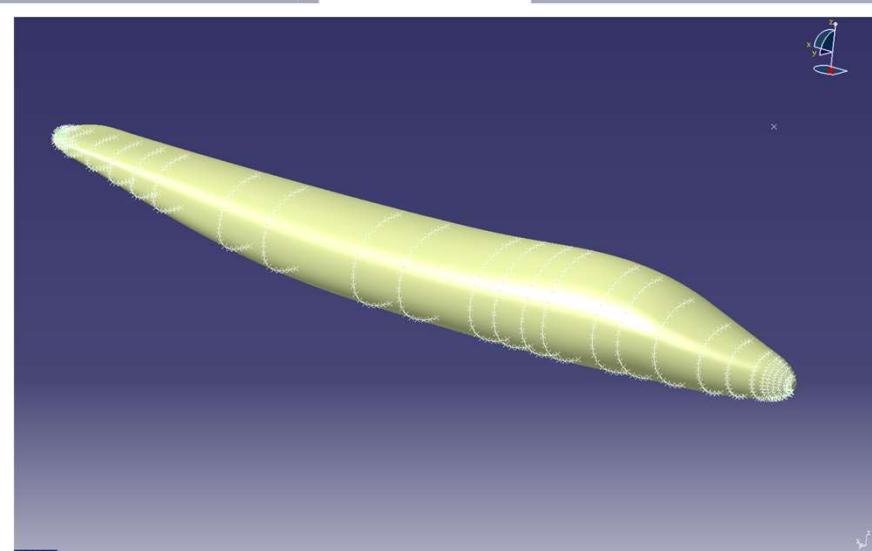
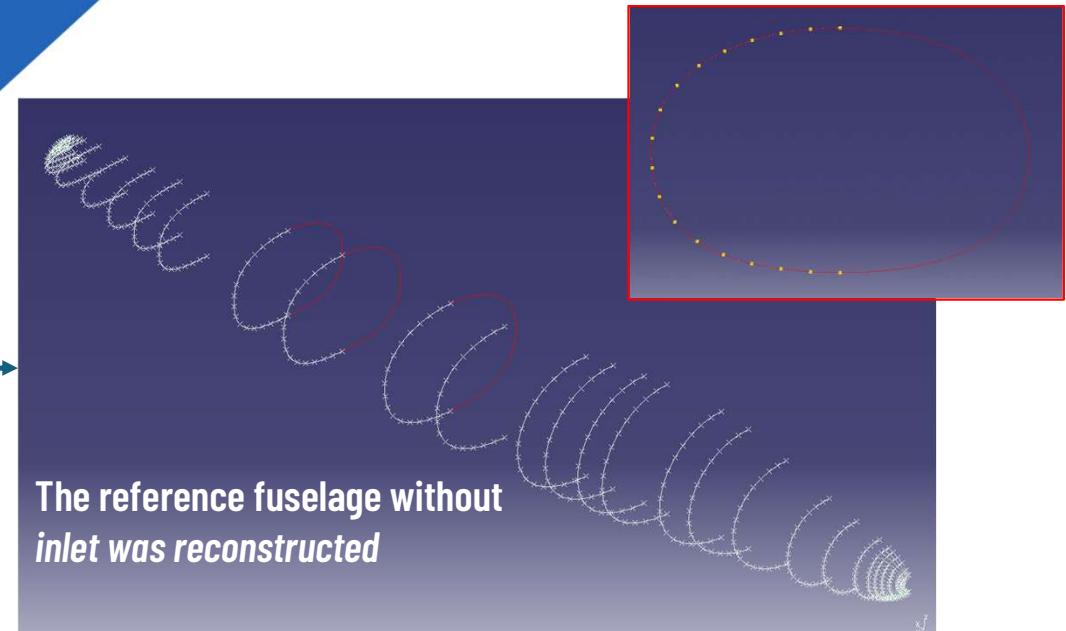
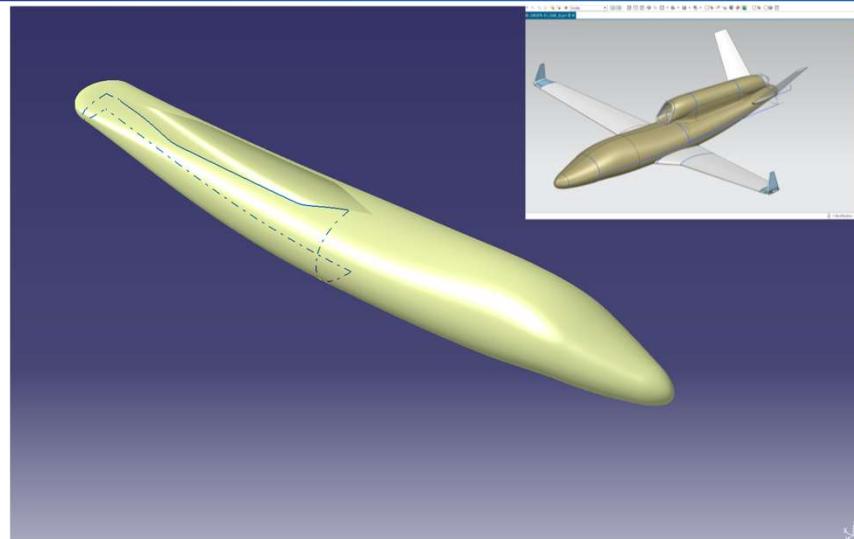


## JPAD – SIEMENS Use-case



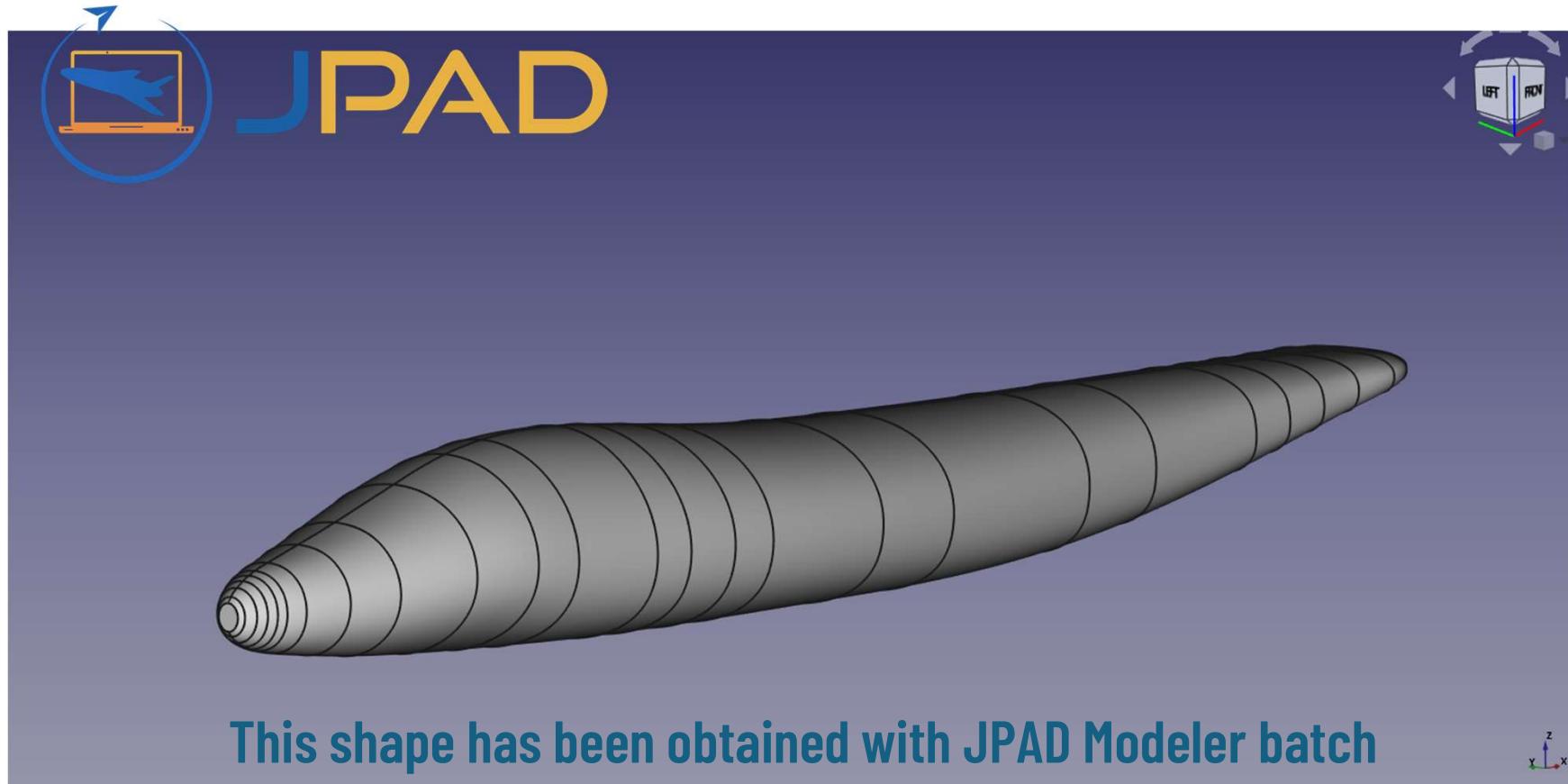
# JPAD → STAR-CCM+

## Angel Owl – Geometry

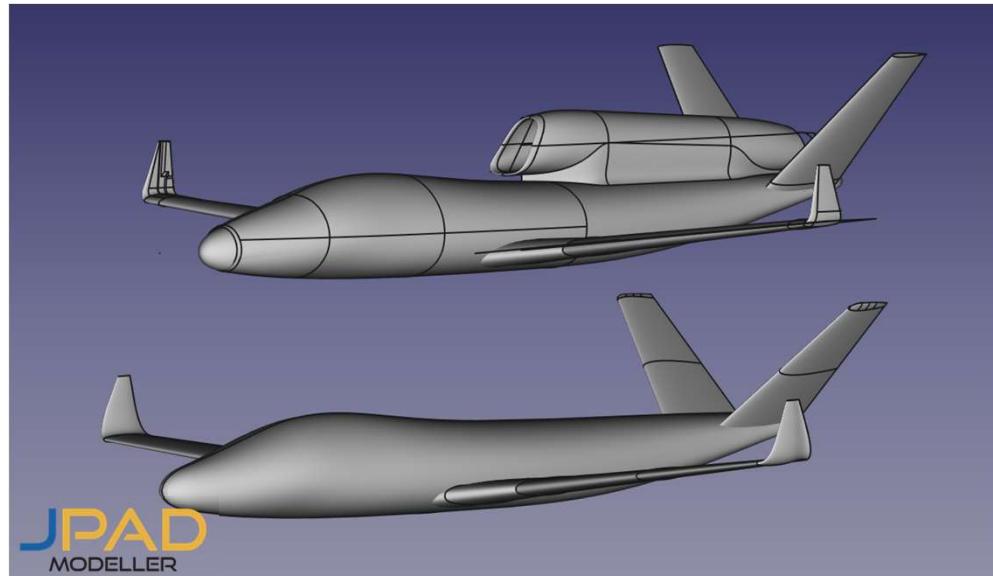


**Points have been imported in JPAD for building a *body* object**

## Angel Owl – Geometry

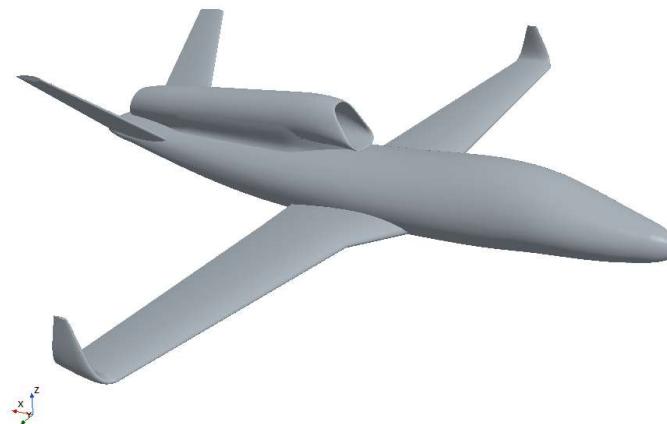


# Angel Owl – Geometry

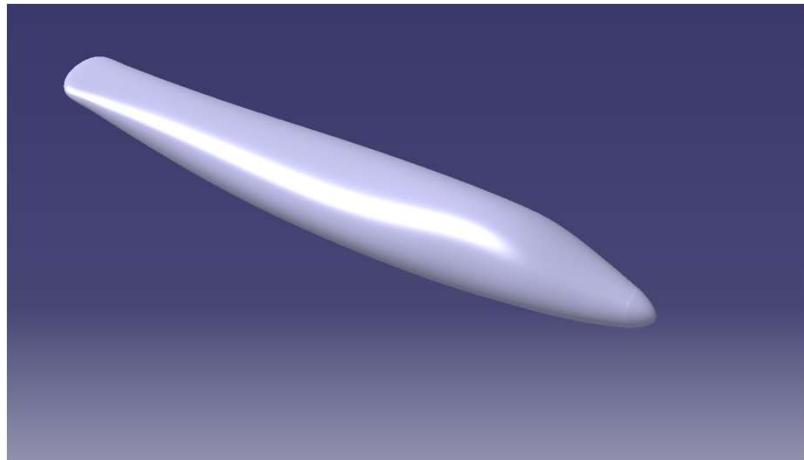


Simcenter STAR-CCM+

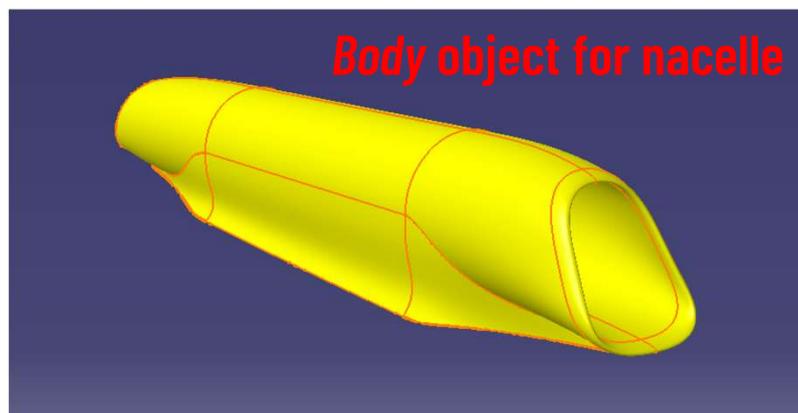
**STAR-CCM+**



# Angel Owl – Geometry



```
<kimpact_config>
  <sections>
    <section id="1" num="0">
      <x_coord unit="m">0.0000</x_coord>
      <y_coord unit="m">0.0000</y_coord>
      <z_coord unit="m">0.0000</z_coord>
    </section>
    <section id="1" num="1">
      <x_coord unit="m">0.025000</x_coord>
      <y_coord unit="m">0.00000000000000, 0.01380450700000, 0.02696226100000, 0.0389345
      <z_coord unit="m">0.06831974000000, 0.06682743100000, 0.06238314800000, 0.0553391
    </section>
    <section id="1" num="2">
      <x_coord unit="m">0.050000</x_coord>
      <y_coord unit="m">0.00000000000000, 0.01947540300000, 0.03811947600000, 0.0552058
      <z_coord unit="m">0.10098256700000, 0.09896993300000, 0.09298106400000, 0.0834091
    </section>
    <section id="1" num="3">
      <x_coord unit="m">0.100000</x_coord>
      <y_coord unit="m">0.00000000000000, 0.02755533000000, 0.05411864500000, 0.0787249
      <z_coord unit="m">0.14608461000000, 0.14349414100000, 0.13571815500000, 0.1230468
    </section>
    <section id="1" num="4">
      <x_coord unit="m">0.150000</x_coord>
```



# Automatic Pyshics settings



Angel Owl results						
LC	description	Mach	Speed (KTAS)	Nz	Weight	Altitude (ft)
1	Pull up	0.24	157	2.5	DTOW	Sea level
2	Push over	0.24	157	-1	DTOW	Sea level
3	Pull up	0.17	290	2.5	DTOW	Sea level
4	Pull up	0.72	412	2.5	DTOW2	37300
5	Push over	0.72	412	-1	DTOW2	37300
6	Pull up	0.50	371	2.5	DTOW	37300
7	Pull up	0.24	157	2.5	ZFW	Sea level
8	Push over	0.24	157	-1	ZFW	Sea level
9	Pull up	0.72	412	2.5	ZFW	37300
10	Push over	0.72	412	-1	ZFW	37300
11	Steady roll (30°/s)	0.17	114	0	DTOW	Sea level
12	Abrupt roll (30°/s <sup>2</sup> )	0.17	114	0	DTOW	Sea level
13	Steady roll (30°/s)	0.17	114	1.67	DTOW	Sea level
14	Abrupt roll (30°/s <sup>2</sup> )	0.17	114	1.67	DTOW	Sea level
15	Landing 1g	0.08 0.12	60 80	1	DTOW	Sea level
16	Cruise 1g	0.64	370	1	DTOW	41000

```

<?xml version="1.0" encoding="utf-8"?>
<jpad_star_directives>
  <general>
    <star_exe_path value="C:\Program Files\Siemens\18.06.006-R8\STAR-CCM+18.06.006-R8\star\lib\win64\clang15.0vc14.2-r8\l
    znTVLyA/mVtU8v0fF/oqA -licpath 1999@flex.cd-adapco.com -->
    <star_options value="-np 8 -power -podkey 90+bwmwGsrYxoT/l5F6y -licpath 1999@flex.cd-adapco.com"/> <!---> -cpubind -rs
    <case_id value="AngelOwl_test"/>
    <task value="SET_SOLVERS"/> <!-- Available enumerators: IMPORT_SHAPES, CREATE_DOMAIN, CREATE_MESH, SETUP_PHYSICS, CRE
    GENERATE_MESH, RUN_SIMULATION. If left empty or not recognized, IMPORT_SHAPES is automatically selected -->
    <macro_filename value="StarGeneralMacro.java"/>
    <destination_folder value="C:/Users/Vincenzo-PC/Desktop/AngelOwl"/> <!-- If left empty, it is assumed it is the defau
    "d:\SIEMENS_LULA\CFD_analyses\AngelOwl"-->
  </general>
  <shapes>
    <simulation sim_type="VISCOUS"> <!-- Available enumerators: EULER, VISCOUS. If left empty or not recognized, EULER is aut
    <operating_conditions>
      <mach_number>0.64</mach_number> <!-- More than one value can be provided. Different values should be separated by
      <angle_of_attack unit="deg">0.0</angle_of_attack> <!-- More than one value can be provided. Different values shou
      <sideslip_angle unit="deg">0.0</sideslip_angle> <!-- More than one value can be provided. Different values should
      <altitude unit="m">41000.0</altitude> <!-- More than one value can be provided. Different values should be separa
      <isa_deviation unit="K">0.0</isa_deviation> <!-- More than one value can be provided. Different values should be
      <derived isa_model="TRUE"> <!-- If set to TRUE, all conditions are derived from JPAD-implemented ISA model, using
    </operating_conditions>
    <fluid_domain_parameters symmetry="TRUE">
      <longitudinal_front_factor>20</longitudinal_front_factor> <!-- Sets the Longitudinal extension of the fluid domai
      <overall_length, the wing span, etc.) -->
      <longitudinal_rear_factor>50</longitudinal_rear_factor> <!-- Sets the Longitudinal extension of the fluid domain,
      <overall_length, the wing span, etc.) -->
      <vertical_factor>15</vertical_factor> <!-- Sets the vertical extension of the fluid domain, based on the maximum
      wing span, etc.) -->
      <transversal_factor>15</transversal_factor> <!-- Sets the lateral extension of the fluid domain, based on the max
      the wing span, etc.) -->
    </fluid_domain_parameters>
    <custom_parts>
      <mesh>
        </mesh>
    </simulation>
  </jpad_star_directives>

```

**JPAD**  
MODELLER



## Operating conditions

- M=0.15 (Low speed), FL=0 → AoA 0° up to stall
- M=0.64 (High speed), FL=41000 → AoA -4° up to 4°

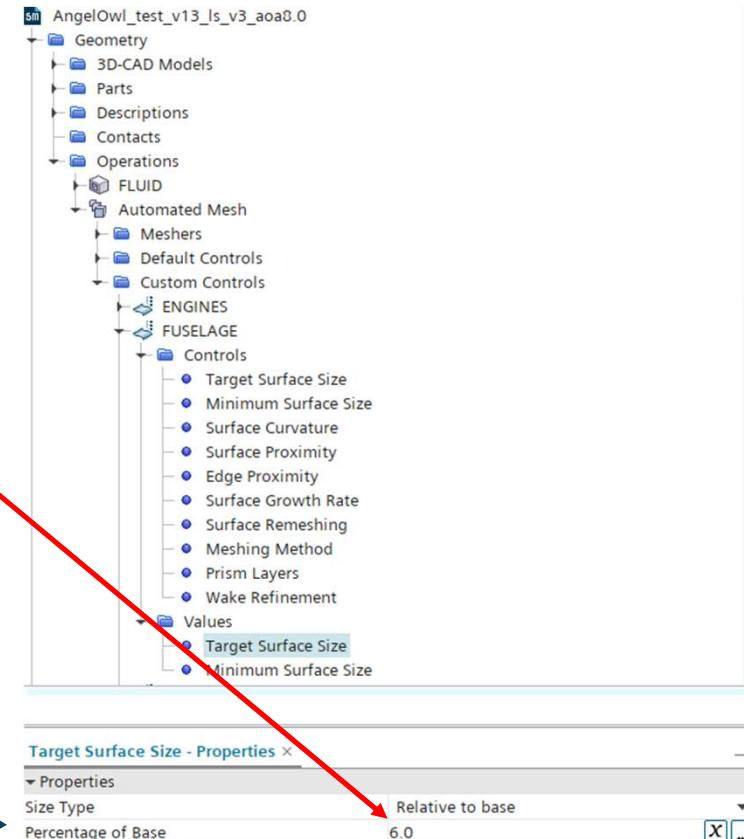
**JPAD Input file for**  
**STAR-CCM+**

# Angel Owl – Mesh Parameters



```
<fluid_domain_parameters symmetry="TRUE">
<custom_parts>
<mesh>
  <general>
    <num_prism_layers>20</num_prism_layers> <!-- Only applicable for
  </general>
  <shapes_specific> <!-- A/C components can be arbitrarily added
  <mesh_control -->
    <fuselage>
      <target_surface_relative_size apply="TRUE">6.0</target_
      <minimum_surface_relative_size apply="TRUE">6.0</mini_
      <surface_growth_rate apply="FALSE">1.2</surface_growt
    </fuselage>
    <wing>
      <target_surface_relative_size apply="TRUE">4.0</target_
      <minimum_surface_relative_size apply="TRUE">0.1</mini_
      <surface_growth_rate apply="TRUE">1.2</surface_growt
    </wing>
    <htail>
      <target_surface_relative_size apply="TRUE">0.5</target_
      <minimum_surface_relative_size apply="TRUE">0.01</mini_
      <surface_growth_rate apply="TRUE">1.2</surface_growt
    </htail>
</mesh>
</custom_parts>
</fluid_domain_parameters>
```

**JPAD Input file for  
STAR-CCM+  
(mesh section)**



The screenshot shows the JPAD software interface with the following details:

- Project Structure:** AngelOwl\_test\_v13\_ls\_v3\_aoa0.0 > Geometry > 3D-CAD Models, Parts, Descriptions, Contacts, Operations, FLUID, Automated Mesh, Meshers, Default Controls, Custom Controls, ENGINES, FUSELAGE, Controls, Values.
- Custom Controls - FUSELAGE:** Target Surface Size, Minimum Surface Size, Surface Curvature, Surface Proximity, Edge Proximity, Surface Growth Rate, Surface Remeshing, Meshing Method, Prism Layers, Wake Refinement.
- Target Surface Size - Properties:**

Size Type	Relative to base
Percentage of Base	6.0
Absolute Size	0.006996526680799 m

## **Mesh Configuration**

### **Meshing Models:**

- Surface Wrapper
- Surface Remesher
- Polyhedral Mesher
- Prism Layer Mesher

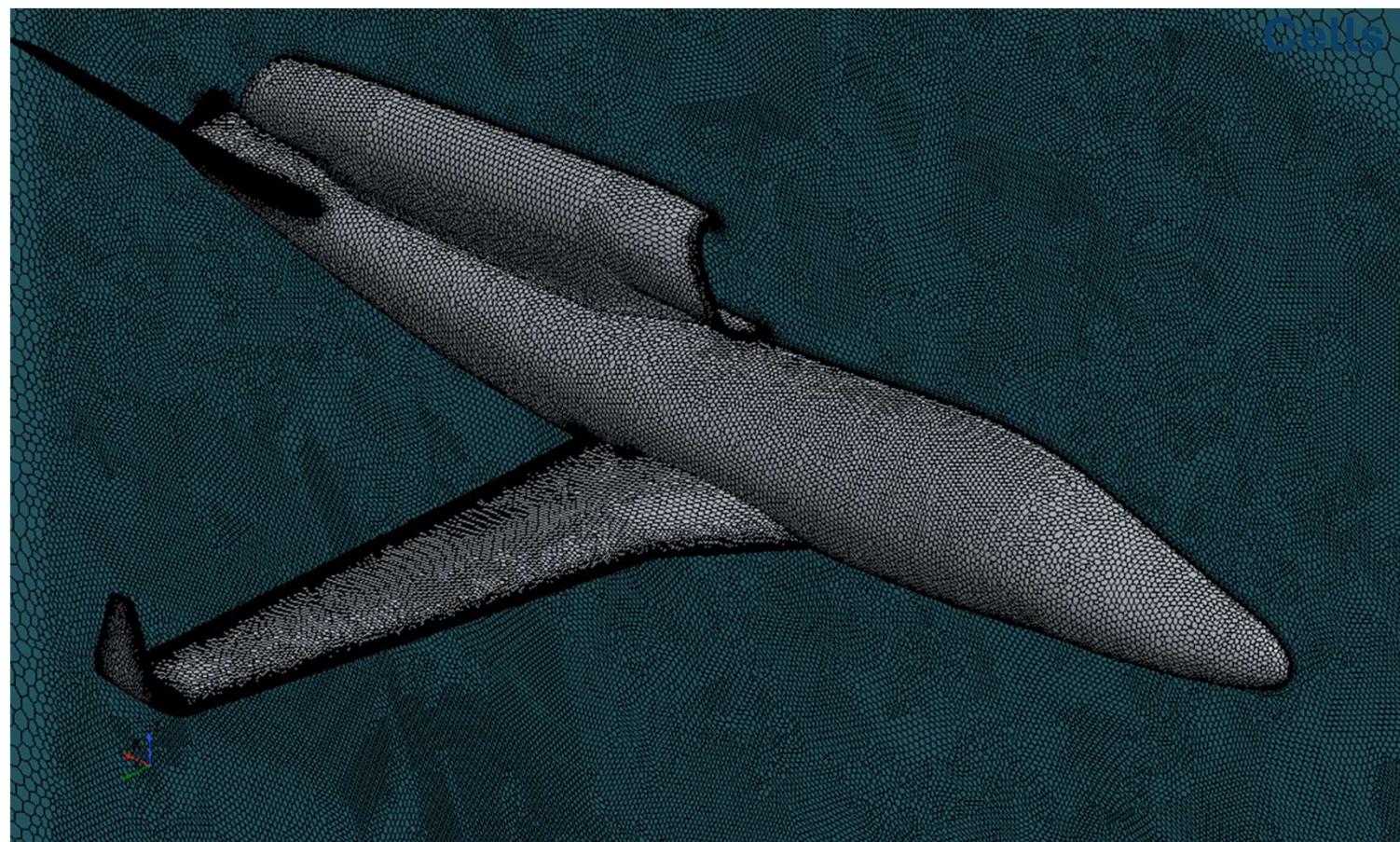
**Base Size:** 0.01

### **Surface Controls:**

- Growth Rate: 1.5
- Min Size: 0.001
- Target Size: 0.005

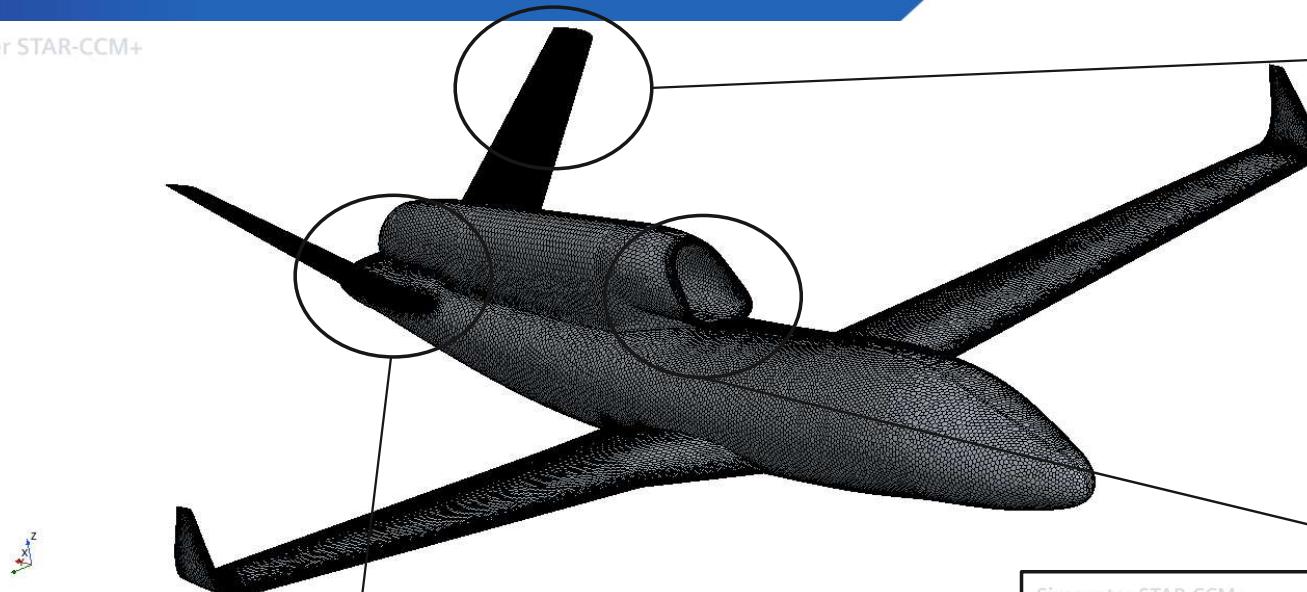
### **Prism Layer Settings:**

- Layers: 20
- Stretching: 1.2
- Relative Thickness: 20%

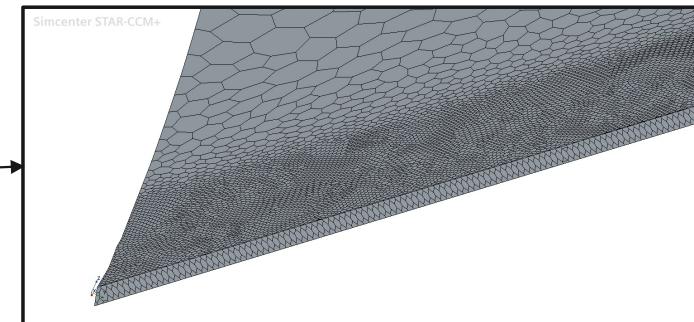


# Angel Owl - Mesh Details

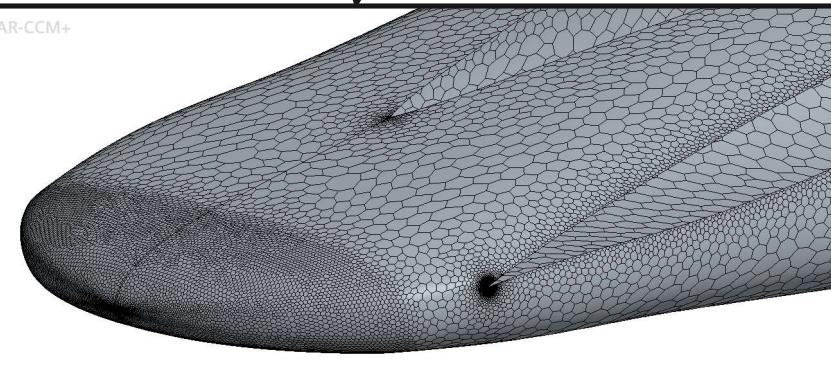
Simcenter STAR-CCM+



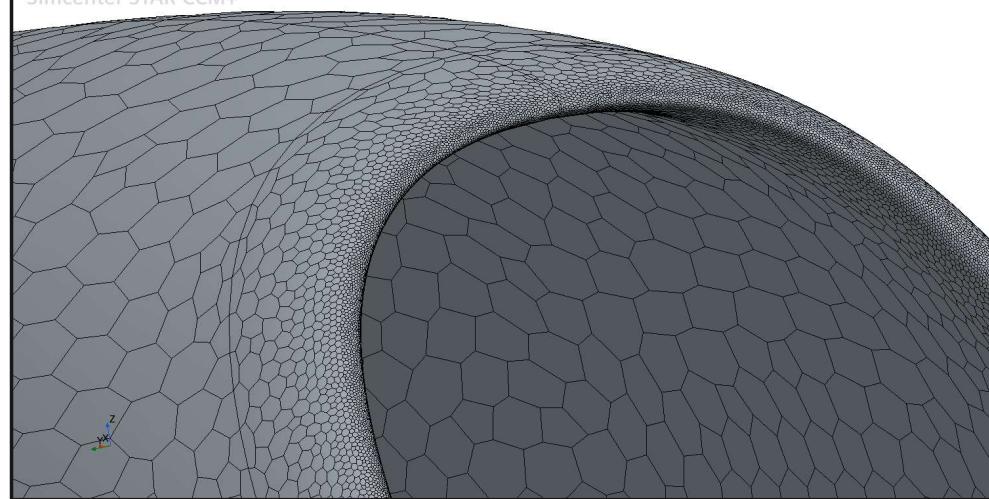
Simcenter STAR-CCM+



Simcenter STAR-CCM+

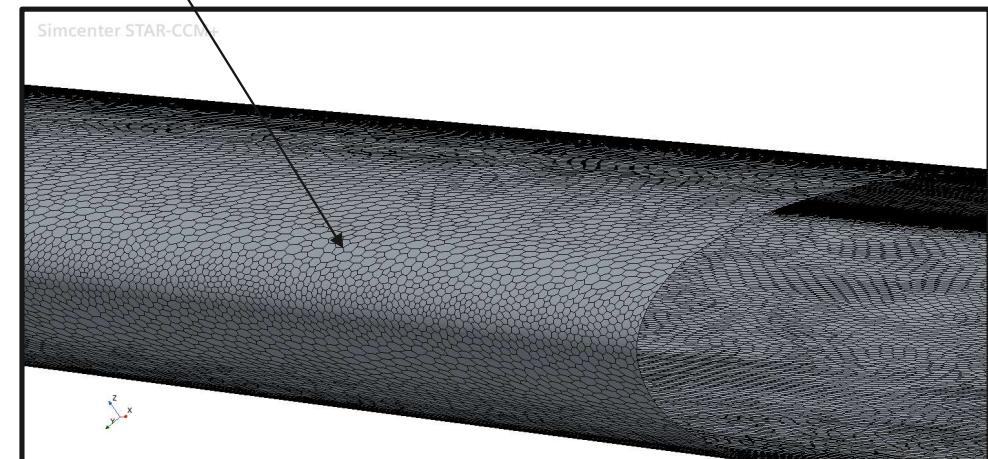
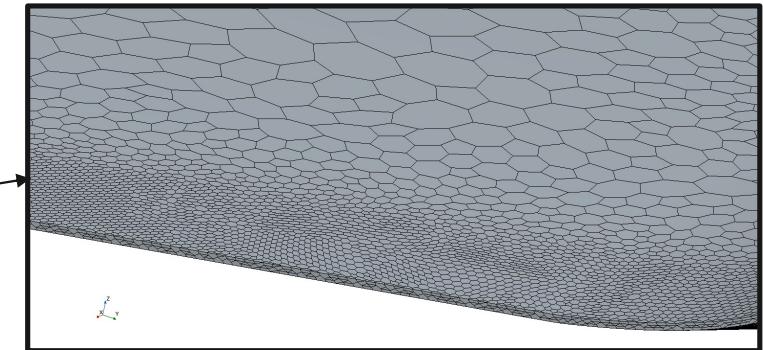
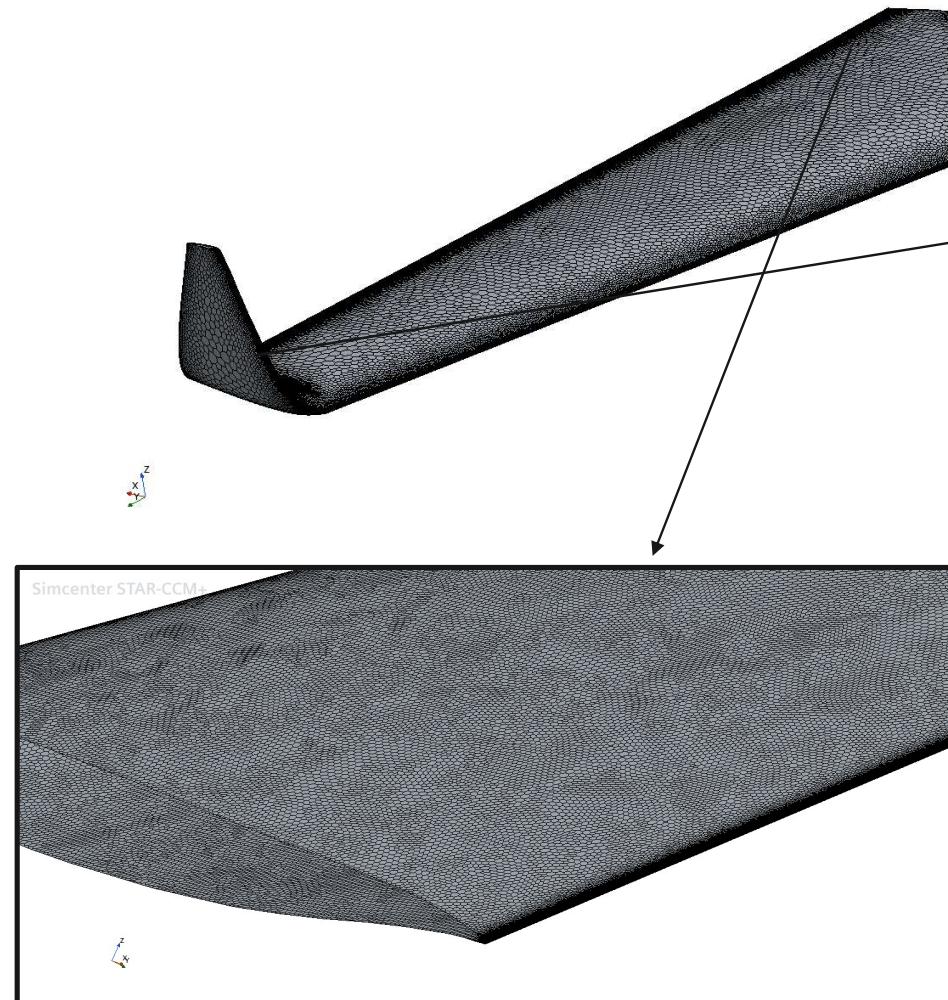


Simcenter STAR-CCM+



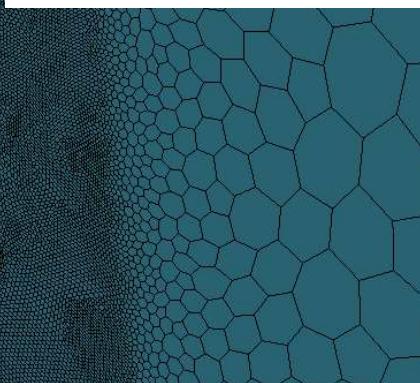
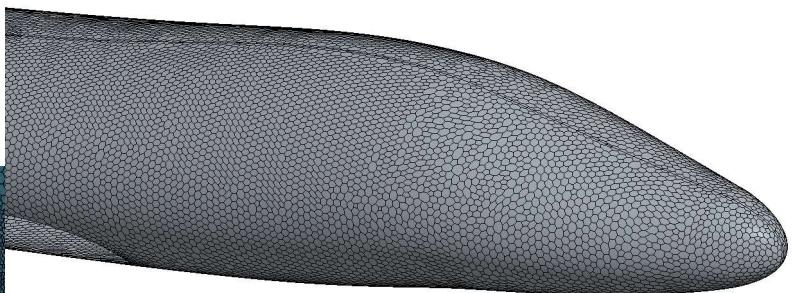
# Angel Owl - Mesh Details

Simcenter STAR-CCM+

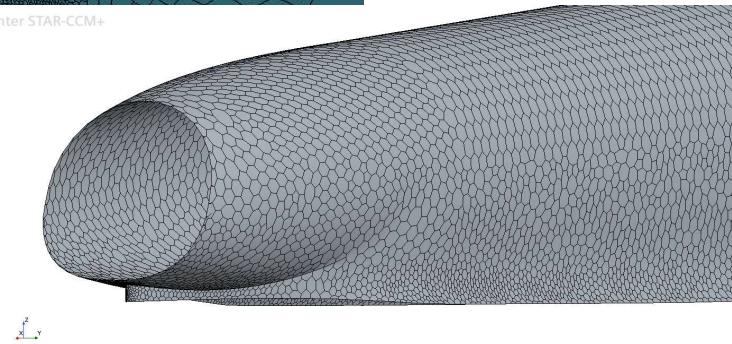


# Angel Owl – Mesh Details

Simcenter STAR-CCM+



Simcenter STAR-CCM+

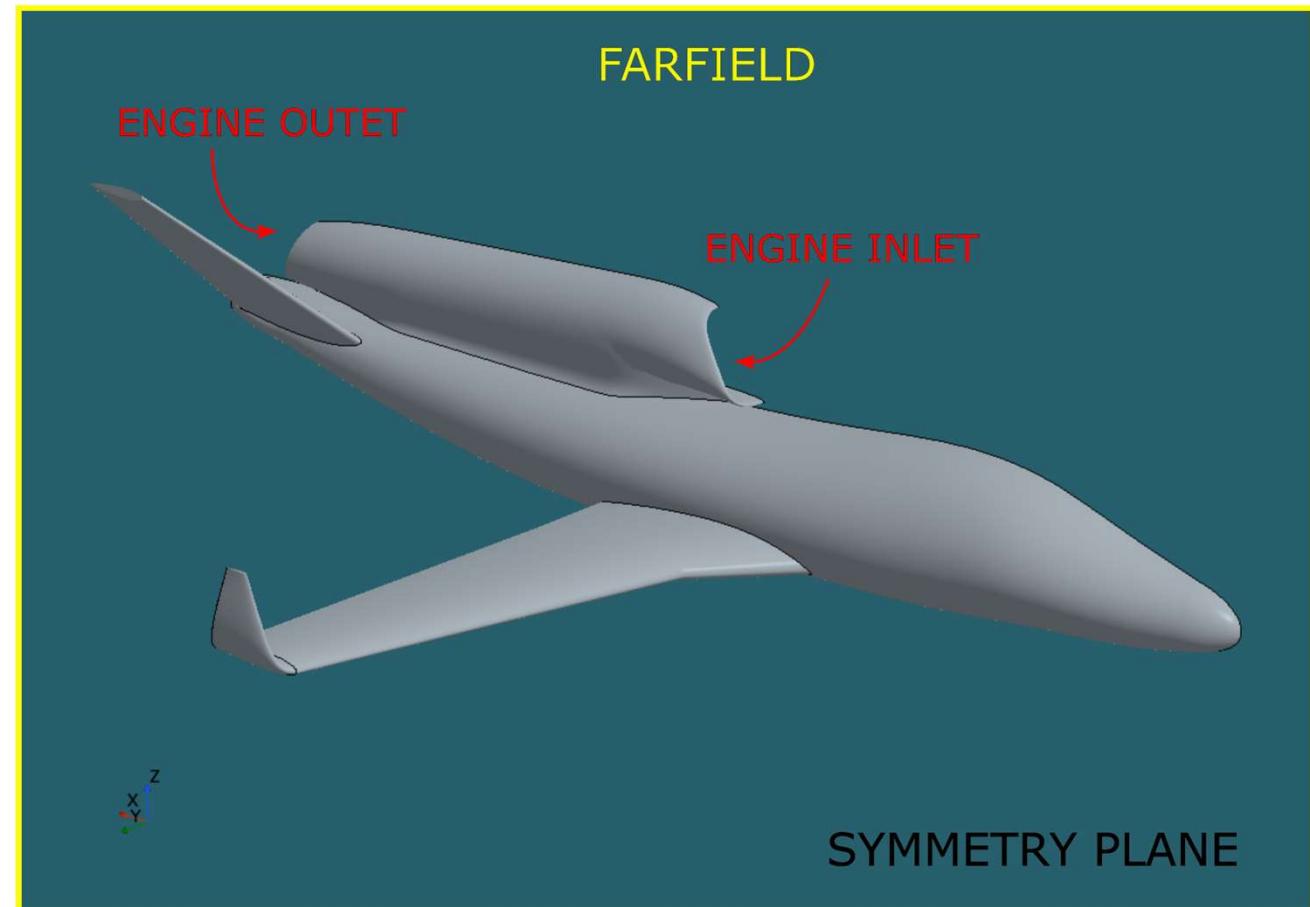


## Physics Models

- **Solver:** 3D, Steady, Segregated Flow
- **Turbulence:** k- $\omega$  SST
- **Energy Equation:** ~~X~~  
(Isothermal)
- **Gas Model:** Ideal Gas (Air)

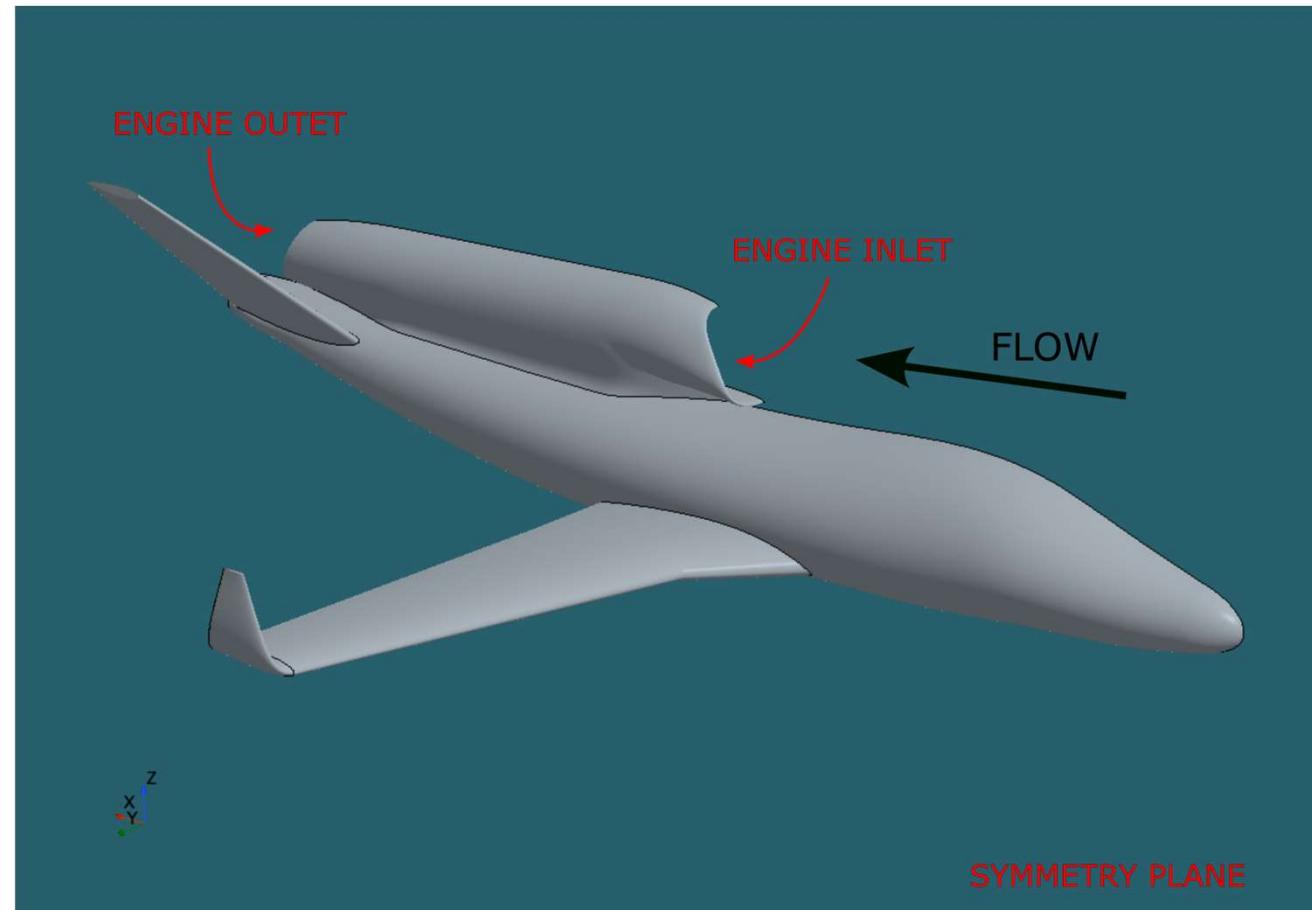
## Boundary Conditions & Domain

- **Inlet/Outlet:** Free-stream (custom magnitude/direction)
- **Geometry Input:** JPAD-based surfaces
- **Domains:** Regions auto-generated via surface wrapping and meshing



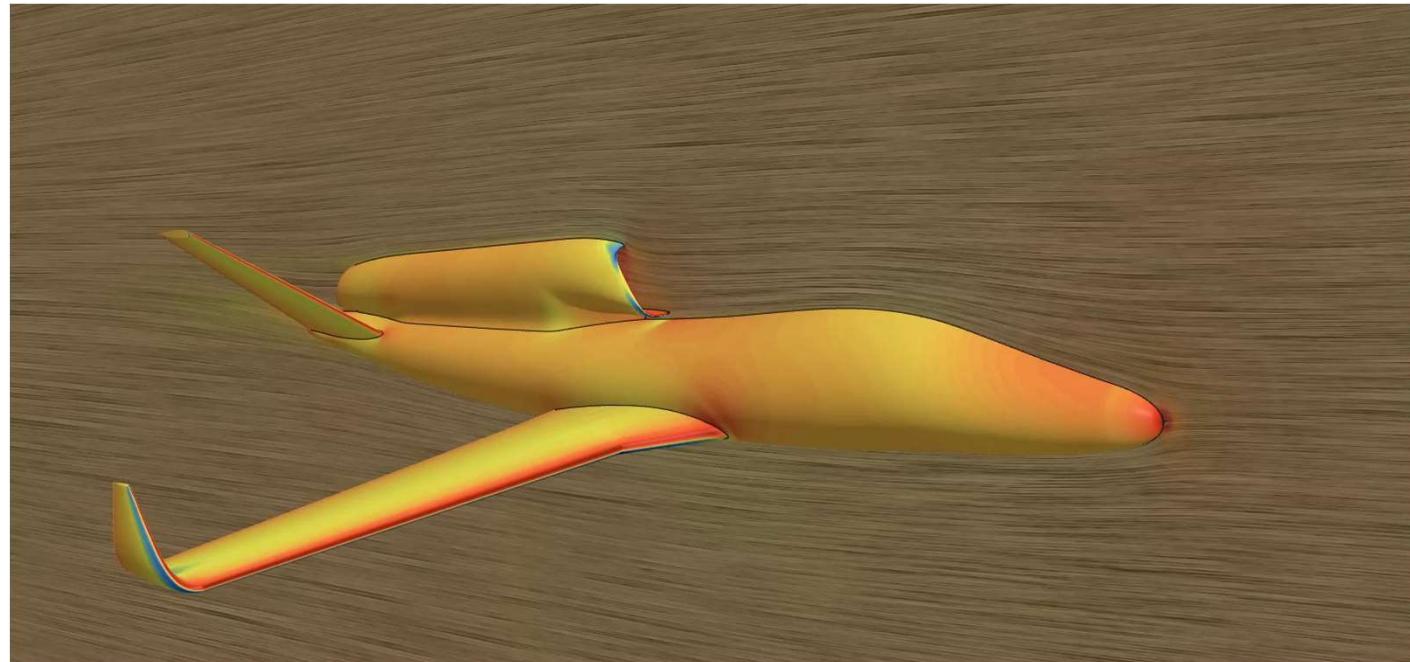
## Engine Inlet and Outlet conditions

- Due to numerical convergence issues, **no specific boundary conditions** have been defined for the **engine inlet and outlet**.
- As a result, the **flow passes through the engine domain freely**, without additional constraints or imposed flow properties.



## Engine Inlet and Outlet conditions

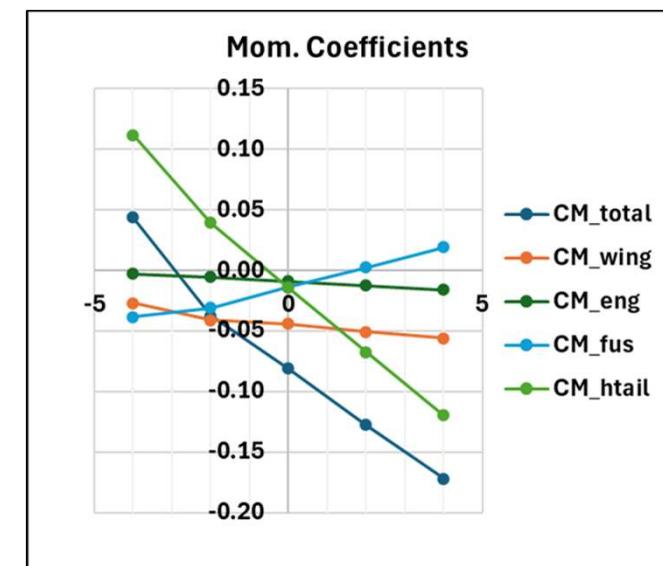
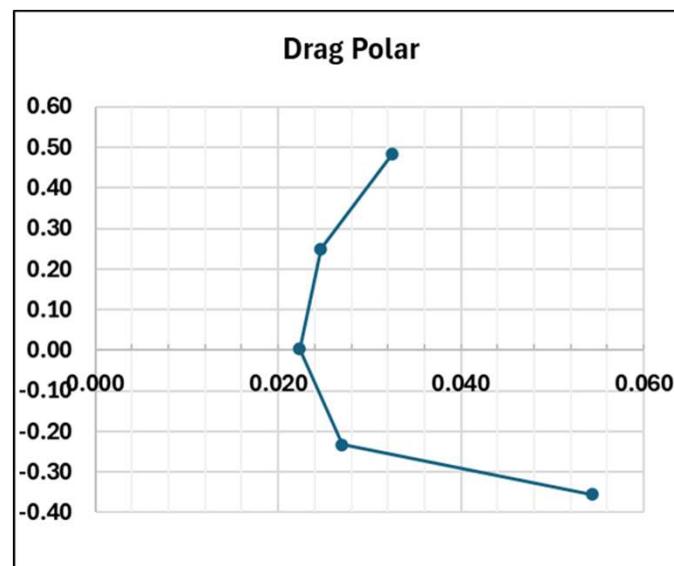
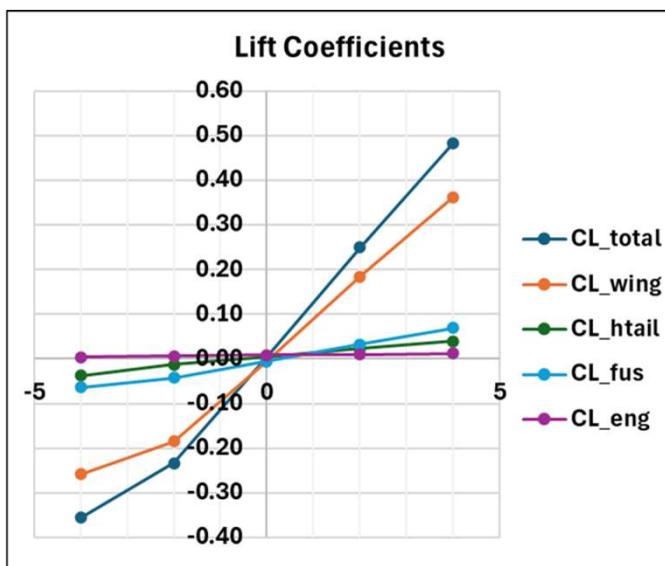
- Due to numerical convergence issues, **no specific boundary conditions** have been defined for the **engine inlet and outlet**.
- As a result, the **flow passes through the engine domain freely**, without additional constraints or imposed flow properties.



# Angel Owl – Numerical Results

High Speed conditions:  
**M=0.64, Re=14.8 Mil.**

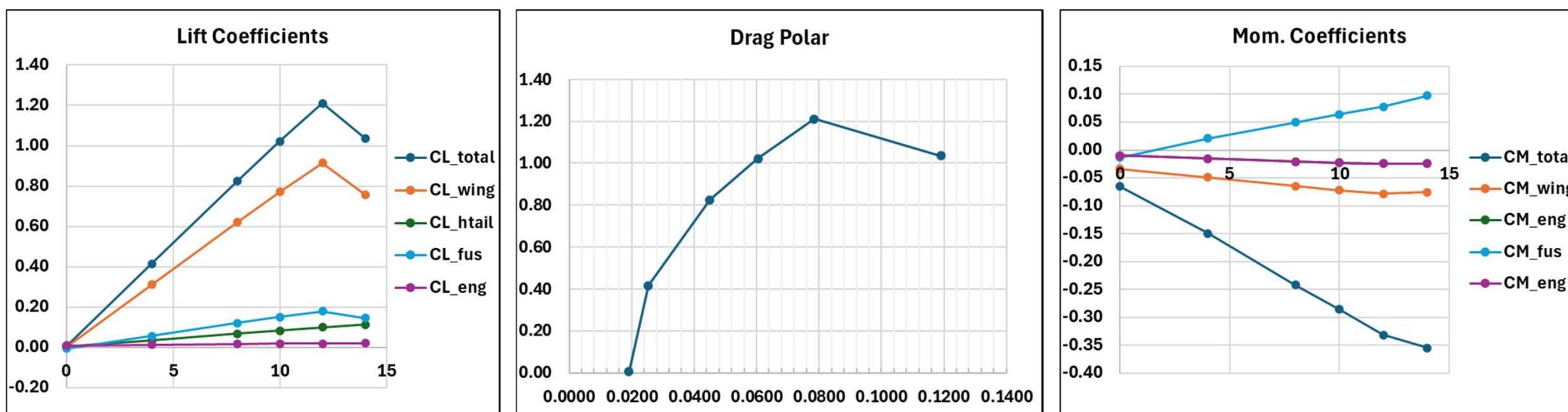
AoA	CD_fus	CD_eng	CD_htail	CD_wing	CD_total	CL_fus	CL_eng	CL_htail	CL_wing	CL_total	CM_fus	CM_eng	CM_htail	CM_wing	CM_total
-4	0.012	0.002	0.002	0.038	0.054	-0.064	0.004	-0.037	-0.259	-0.356	-0.038	-0.003	0.112	-0.027	0.044
-2	0.008	0.002	0.002	0.015	0.027	-0.042	0.006	-0.013	-0.185	-0.233	-0.031	-0.005	0.039	-0.041	-0.038
0	0.007	0.003	0.002	0.011	0.022	-0.006	0.008	0.005	-0.004	0.004	-0.014	-0.009	-0.014	-0.044	-0.081
2	0.008	0.003	0.002	0.012	0.025	0.032	0.011	0.023	0.185	0.250	0.003	-0.012	-0.067	-0.051	-0.127
4	0.011	0.003	0.003	0.015	0.032	0.070	0.013	0.040	0.362	0.484	0.019	-0.016	-0.120	-0.056	-0.172



# Angel Owl – Numerical Results

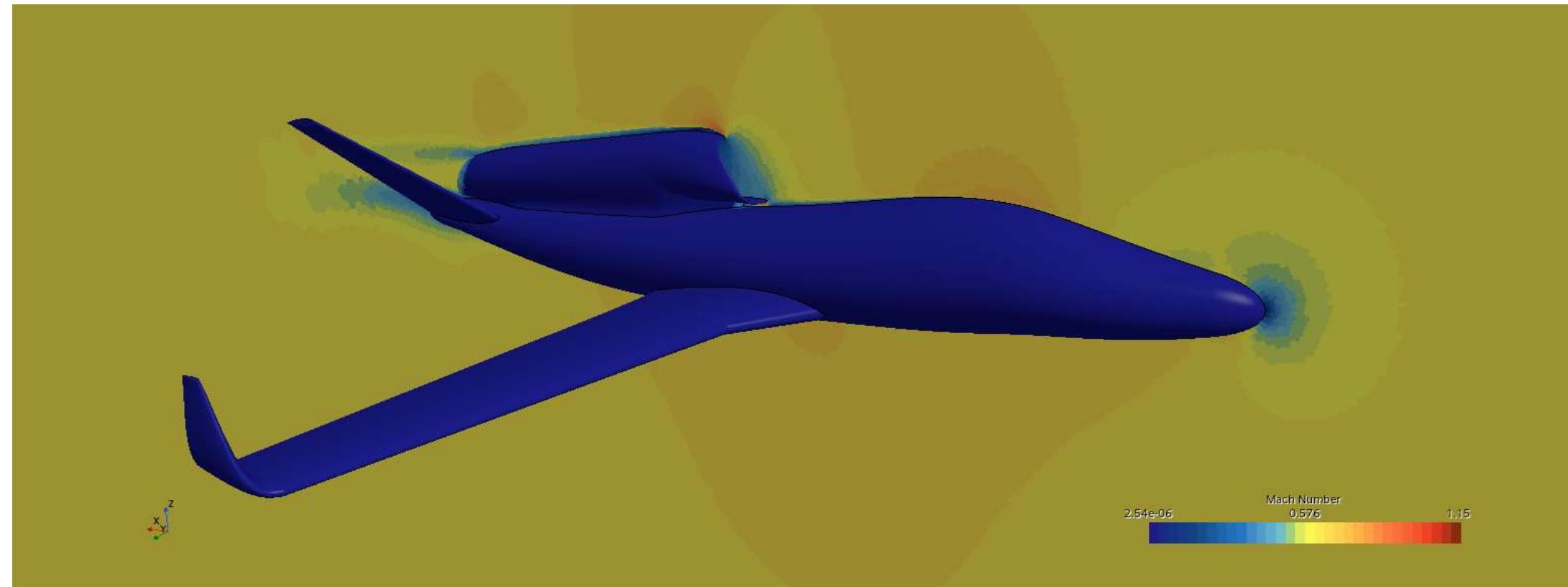
Low Speed conditions:  
**M=0.19, Re=5.85 Mil.**

AoA	CD_fus	CD_eng	CD_htail	CD_wing	CD_total	CL_fus	CL_eng	CL_htail	CL_wing	CL_total	CM_fus	CM_eng	CM_htail	CM_wing	CM_total
0	0.0062	0.0021	0.0015	0.0092	<b>0.0191</b>	-0.0060	0.0088	0.0033	-0.0006	<b>0.0055</b>	-0.0134	-0.0096	-0.0086	-0.0340	<b>-0.0655</b>
4	0.0088	0.0029	0.0026	0.0109	<b>0.0253</b>	0.0571	0.0129	0.0351	0.3104	<b>0.4155</b>	0.0207	-0.0155	-0.1058	-0.0489	<b>-0.1497</b>
8	0.0182	0.0044	0.0057	0.0168	<b>0.0451</b>	0.1204	0.0165	0.0670	0.6203	<b>0.8242</b>	0.0495	-0.0209	-0.2055	-0.0647	<b>-0.2416</b>
10	0.0254	0.0058	0.0081	0.0212	<b>0.0604</b>	0.1503	0.0179	0.0828	0.7702	<b>1.0212</b>	0.0641	-0.0226	-0.2555	-0.0719	<b>-0.2859</b>
12	0.0340	0.0069	0.0109	0.0266	<b>0.0784</b>	0.1791	0.0191	0.0989	0.9134	<b>1.2105</b>	0.0778	-0.0245	-0.3067	-0.0781	<b>-0.3316</b>
14	<b>0.0346</b>	<b>0.0080</b>	<b>0.0059</b>	<b>0.0705</b>	<b>0.1190</b>	<b>0.1458</b>	<b>0.0206</b>	<b>0.1120</b>	<b>0.7562</b>	<b>1.0345</b>	<b>0.0976</b>	<b>-0.0244</b>	<b>-0.3521</b>	<b>-0.0758</b>	<b>-0.3548</b>



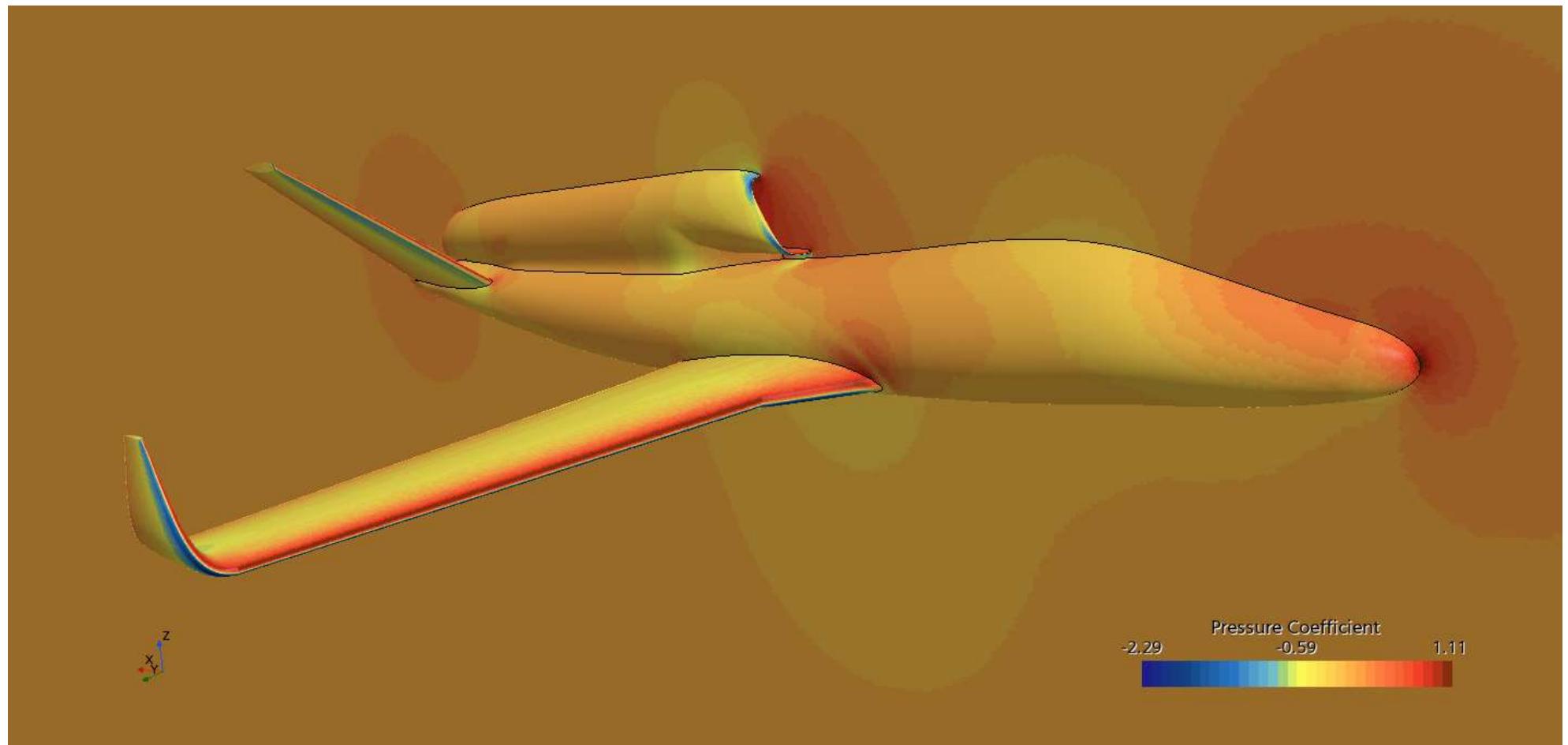
Angel Owl

**Mach Number contour**  
**AoA = 0 deg, M=0.64**



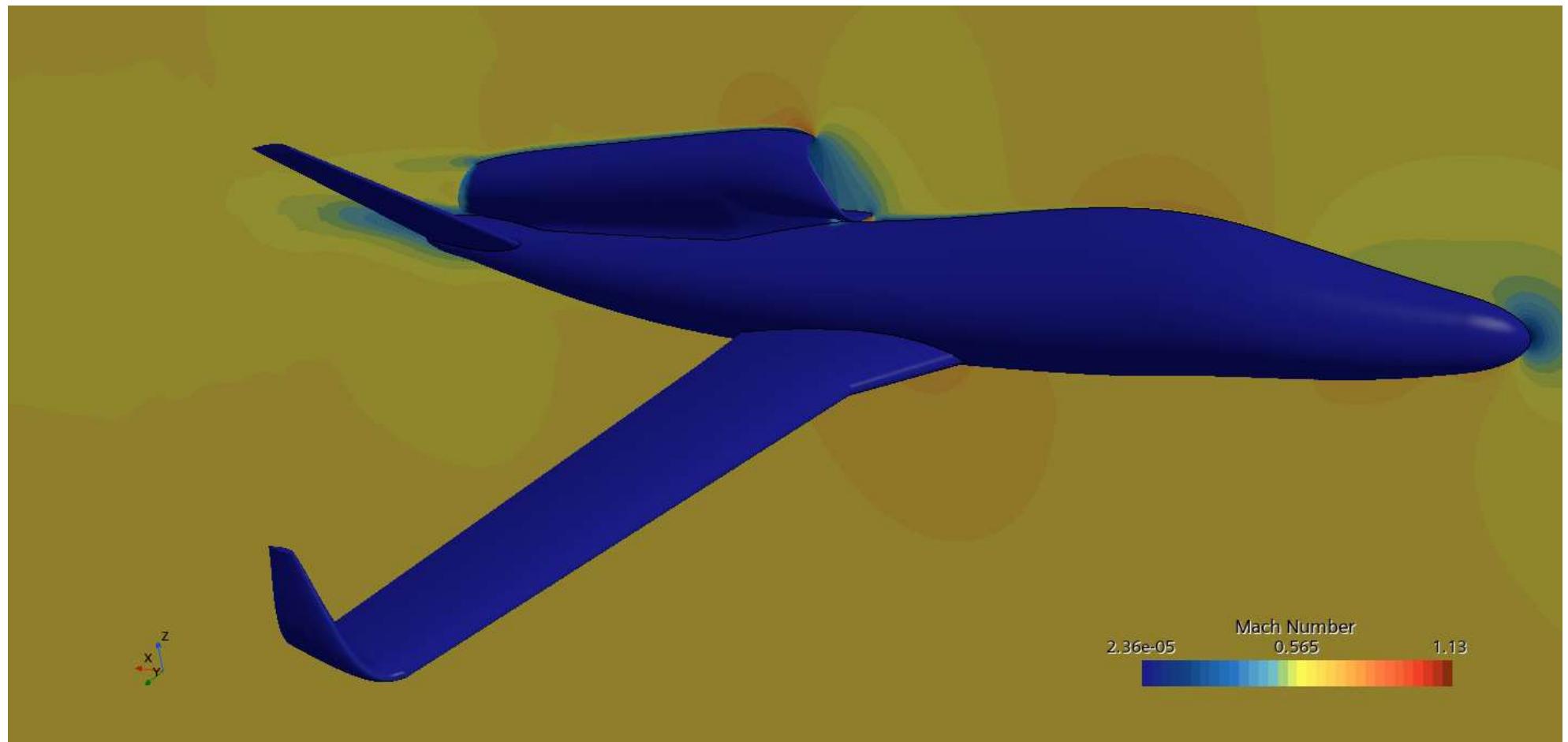
Angel Owl

Pressure Coeff. contour  
AoA = -4 deg, M=0.64



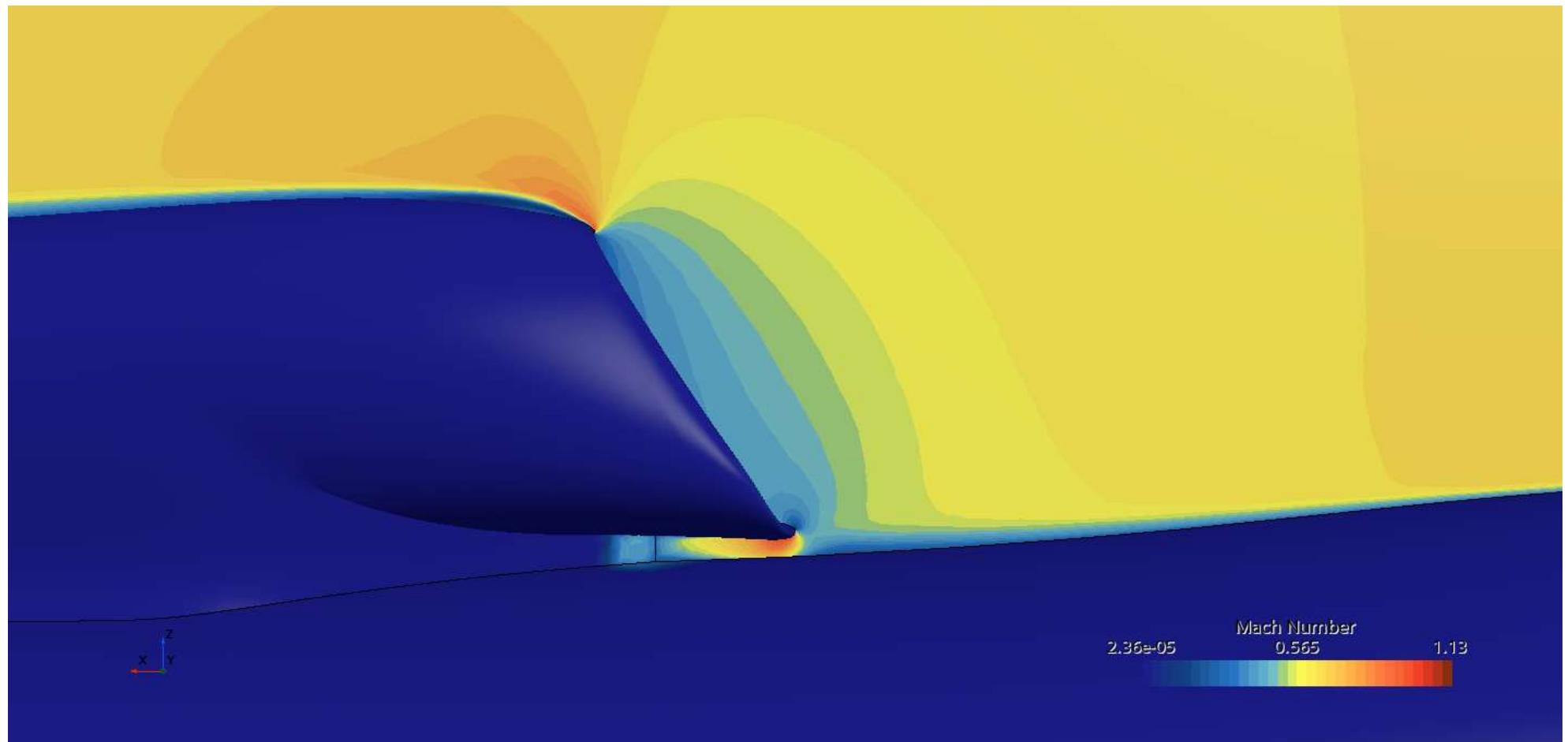
Angel Owl

Mach Number contour  
AoA = -4 deg, M=0.64



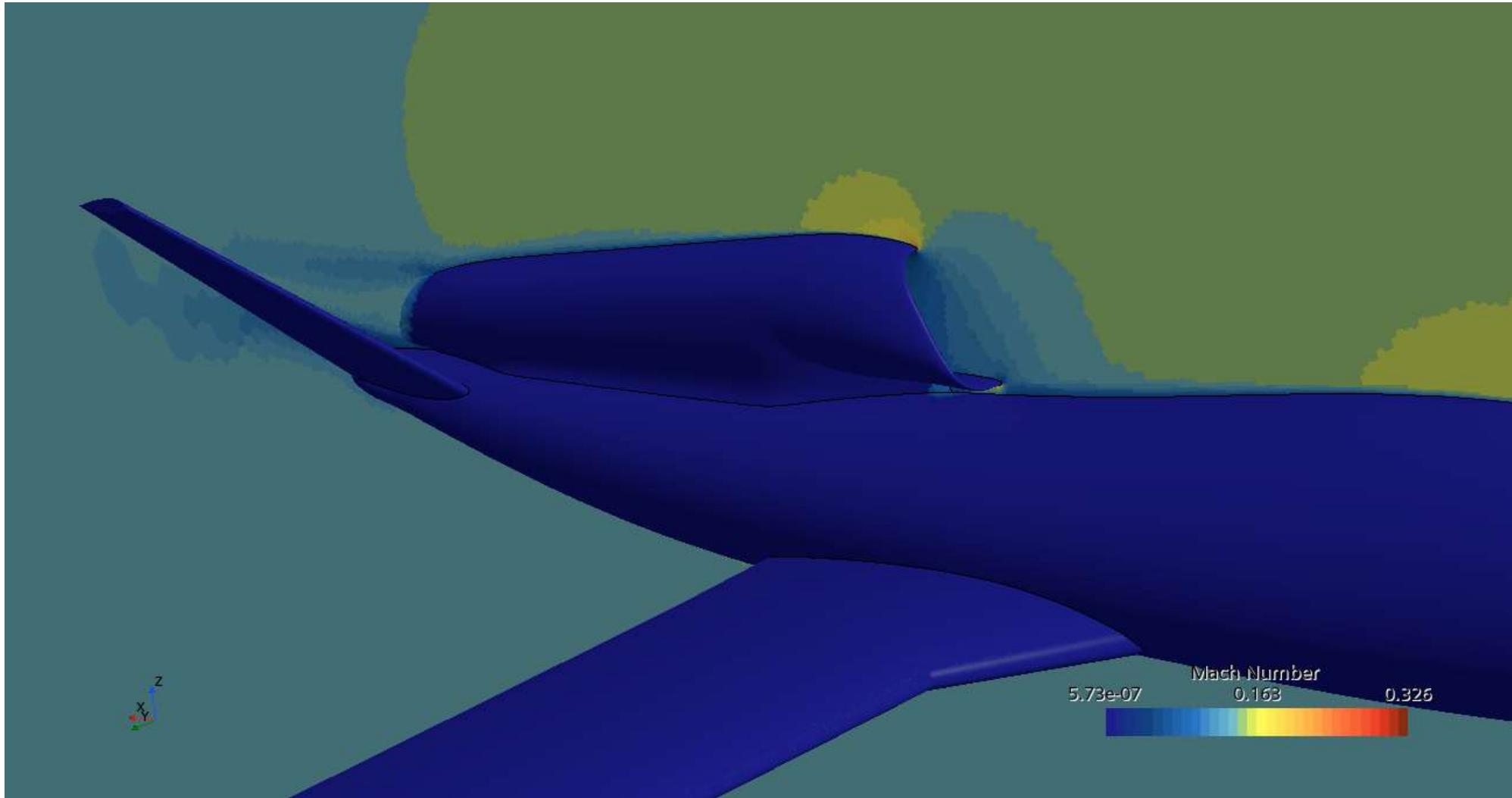
Angel Owl

Mach Number contour  
AoA = -4 deg, M=0.64



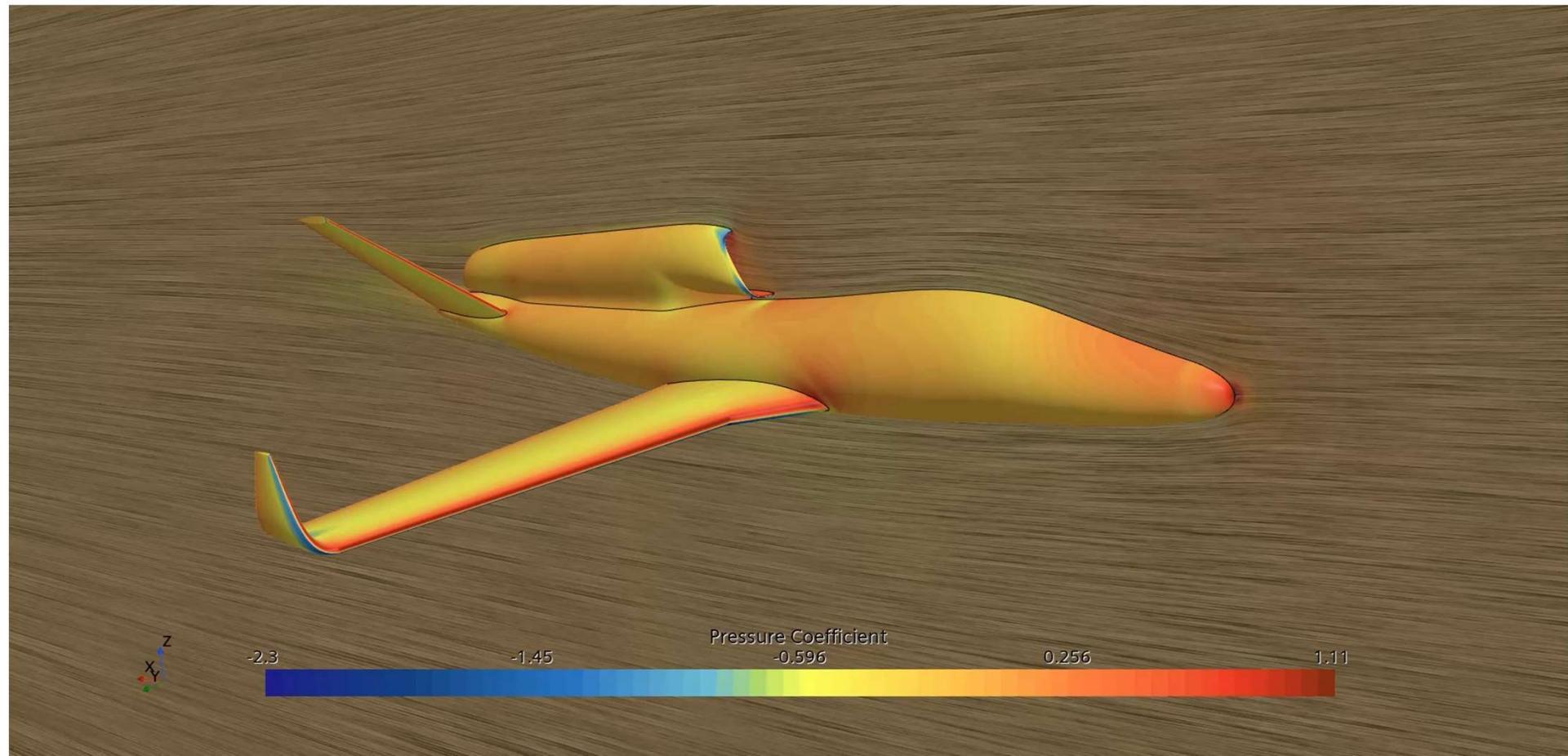
Angel Owl

Mach Number contour  
AoA = 8 deg, M=0.15

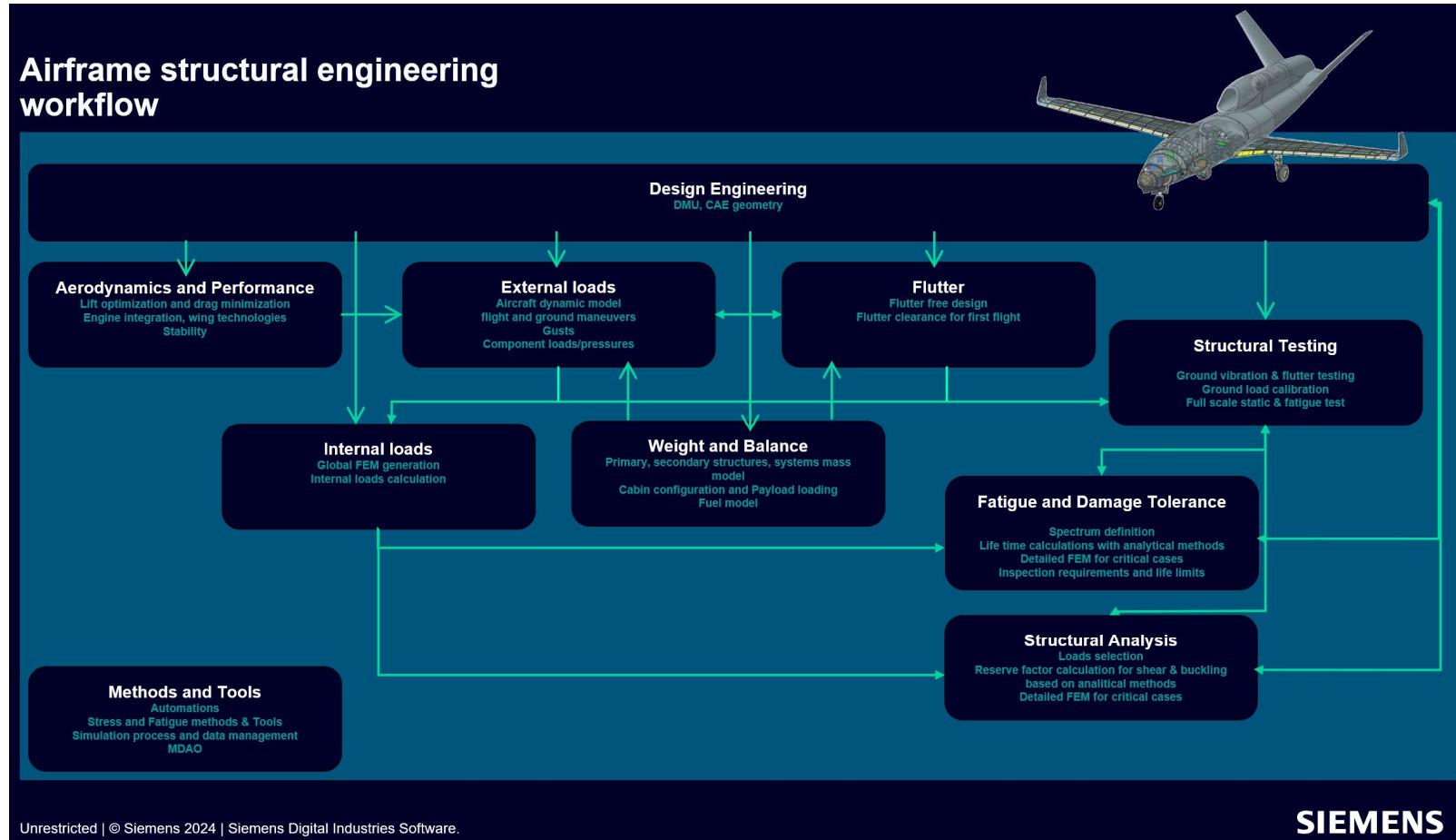


Angel Owl

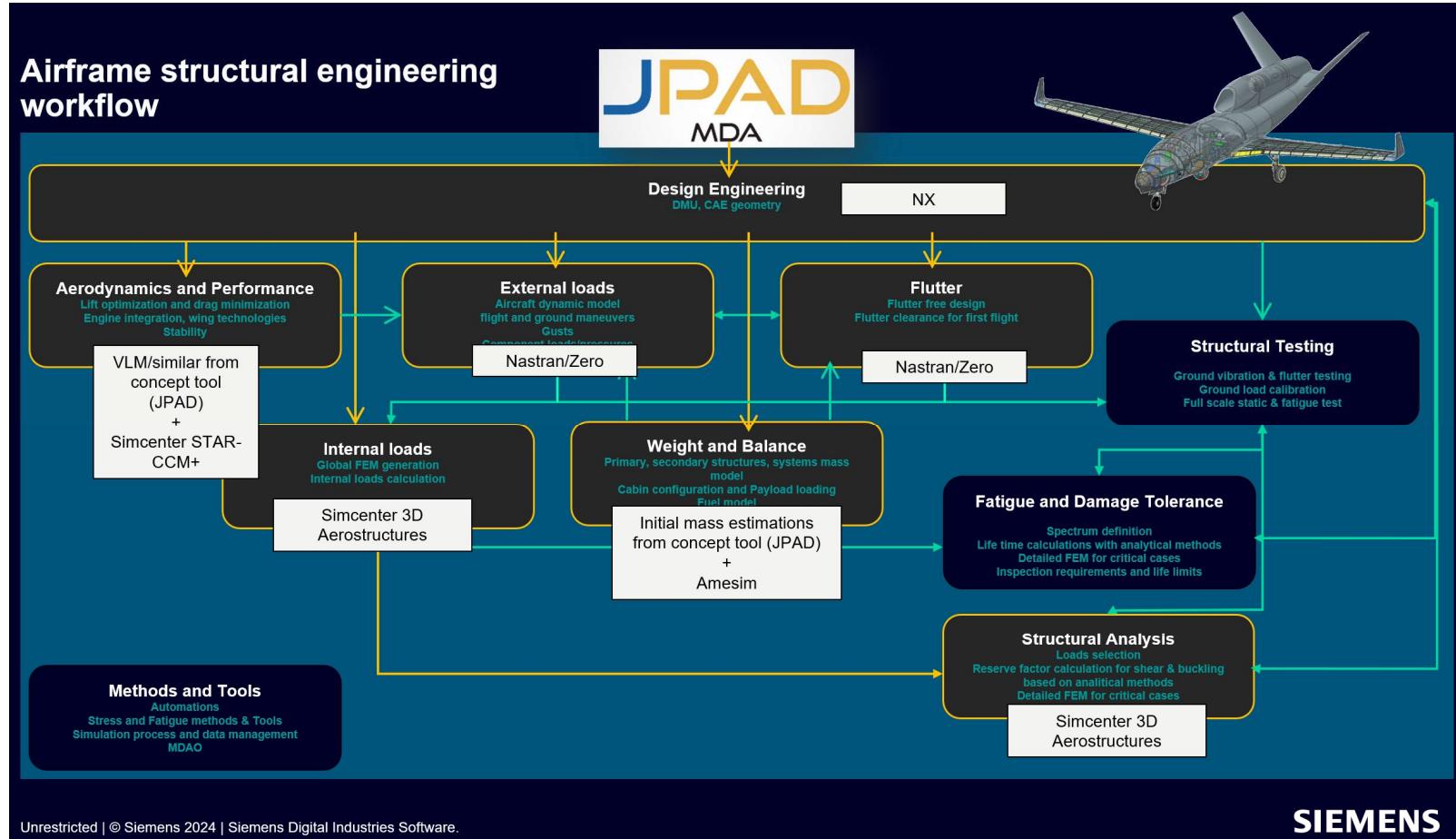
Mach Number contour  
AoA = -2 deg, M=0.64



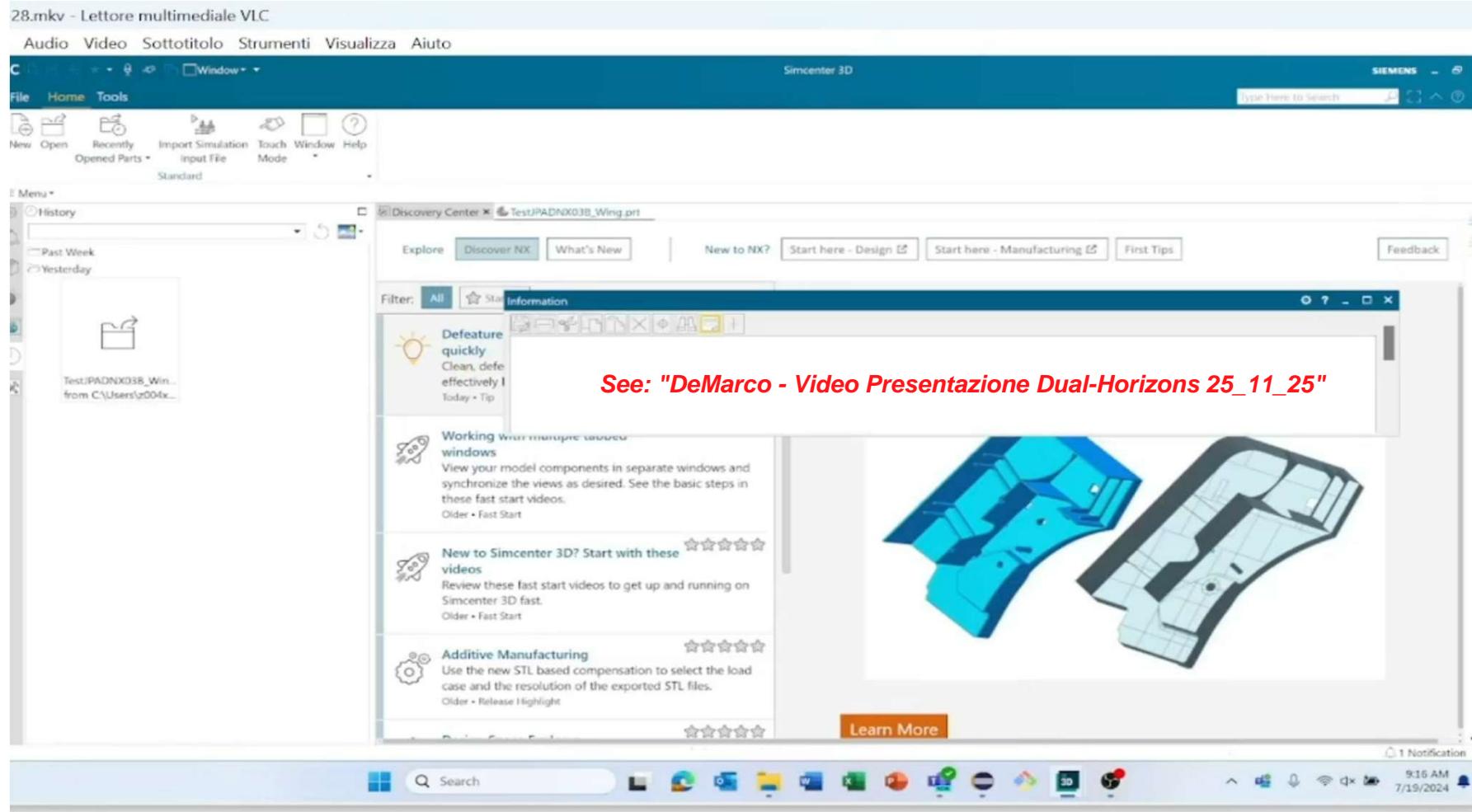
# JPAD-NX & Structural Engineering



# JPAD-NX & Structural Engineering



# JPAD-NX & Structural Engineering



Dassault Falcon10x  
Wing

Manual Modelling:  
**1 day**

With automation:  
**5 to 10 mins!**

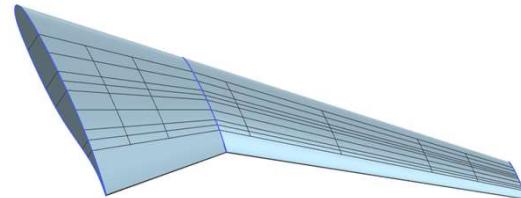
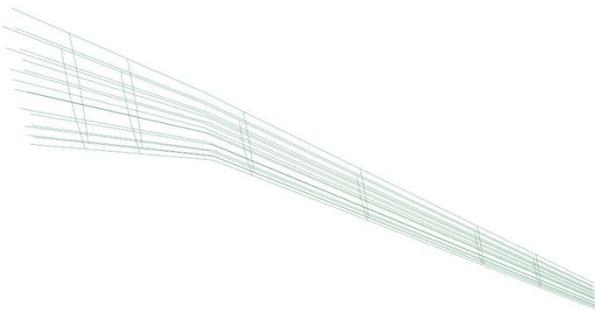
# JPAD-NX & Structural Engineering



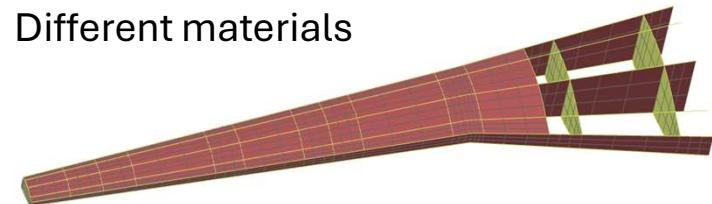
**Robust process:** can be applied to various aircraft models and different configurations

**Flexible:** inputs based on the XML format, can be adapted easily

## Airbus A220-300 Wing



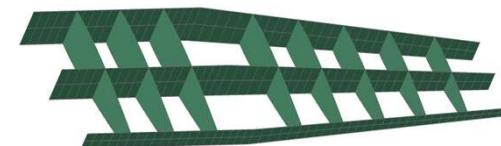
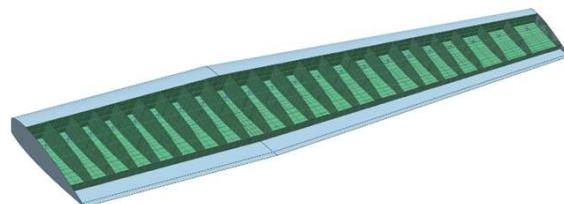
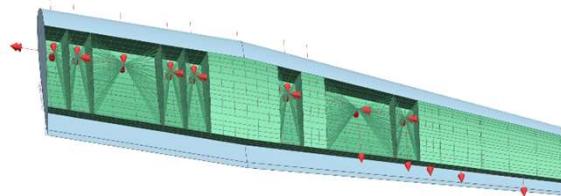
Different materials



Section customization



## ATR-42 Wing



# JPAD-NX & Structural Engineering

## Case study: ATR-42 Wing

### Number and Position of Stringers

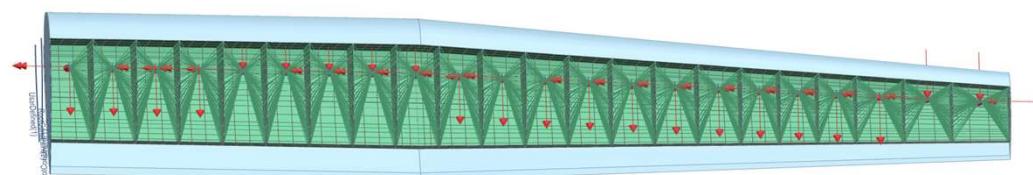
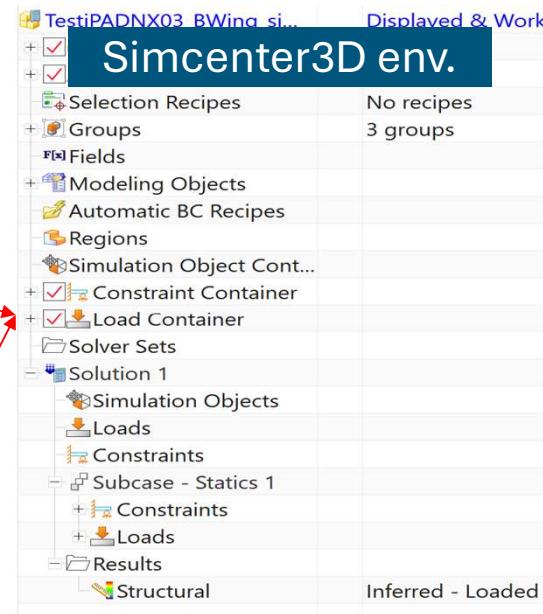
```
<stringers>
  <stringer id="stringer 1">
    <positioningLeadingEdgeToChord>
      <epsilon>0.3</epsilon>
    </positioningLeadingEdgeToChord>
  </stringer>
  <stringer id="stringer 2">
    <positioningLeadingEdgeToChord>
      <epsilon>0.55</epsilon>
    </positioningLeadingEdgeToChord>
  </stringer>
  <stringer id="stringer 3">
    <positioningLeadingEdgeToChord>
      <epsilon>0.7</epsilon>
    </positioningLeadingEdgeToChord>
  </stringer>
</stringers>
```

### Loads

```
<rib id="rib 1">
  <positioningRootPercentageWingSpan>
    <eta>0.045</eta>
  </positioningRootPercentageWingSpan>

  <thickness>1.5</thickness>

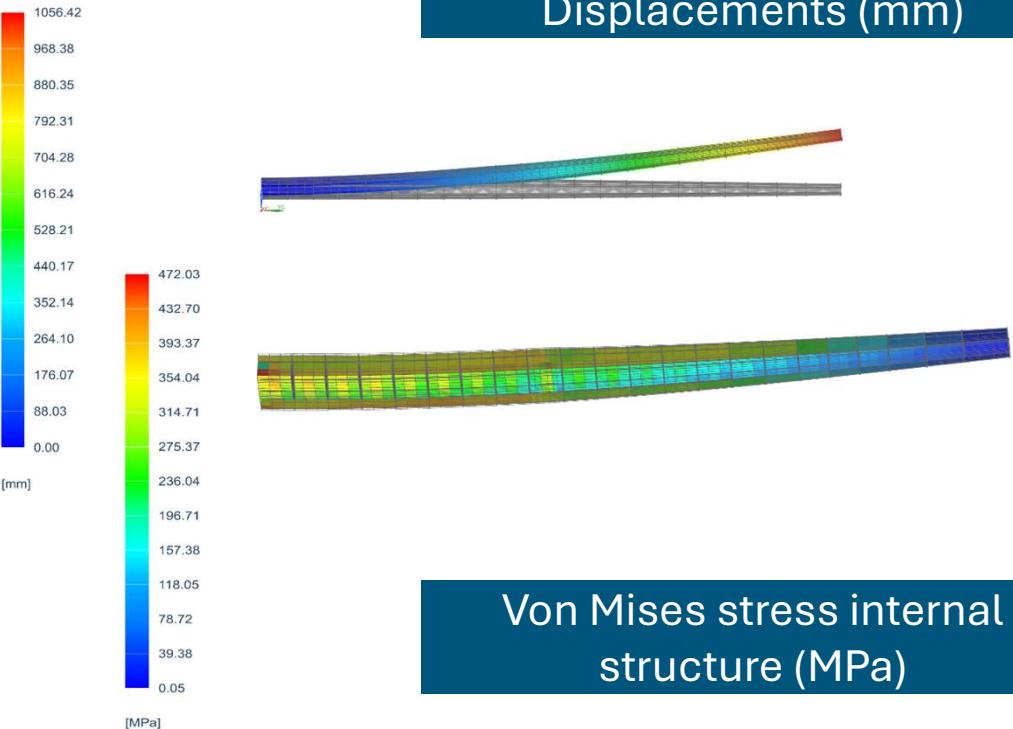
  <loadBeforeFx> -727.0 </loadBeforeFx>
  <loadBeforeFz> 10640.8 </loadBeforeFz>
  <loadBeforeMy> -165914.2 </loadBeforeMy>
```



# JPAD-NX & Structural Engineering

## Case study: ATR-42 Wing

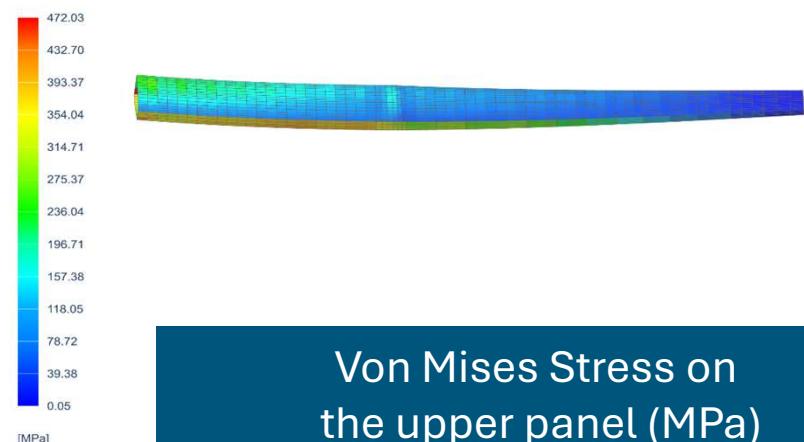
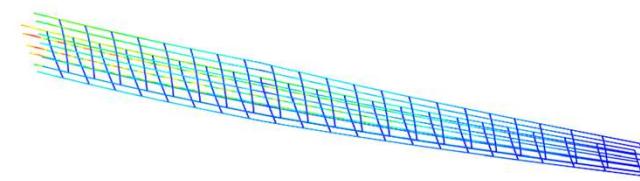
TestjPADNX03\_BWing\_sim : Solution 1 Result  
Subcase - Statics 1, Static Step 1  
Displacement - Nodal, Magnitude  
Min : 0.00, Max : 1056.42, Units = mm  
CSYS : Absolute Rectangular  
Deformation : Displacement - Nodal Magnitude



Von Mises stress internal structure (MPa)

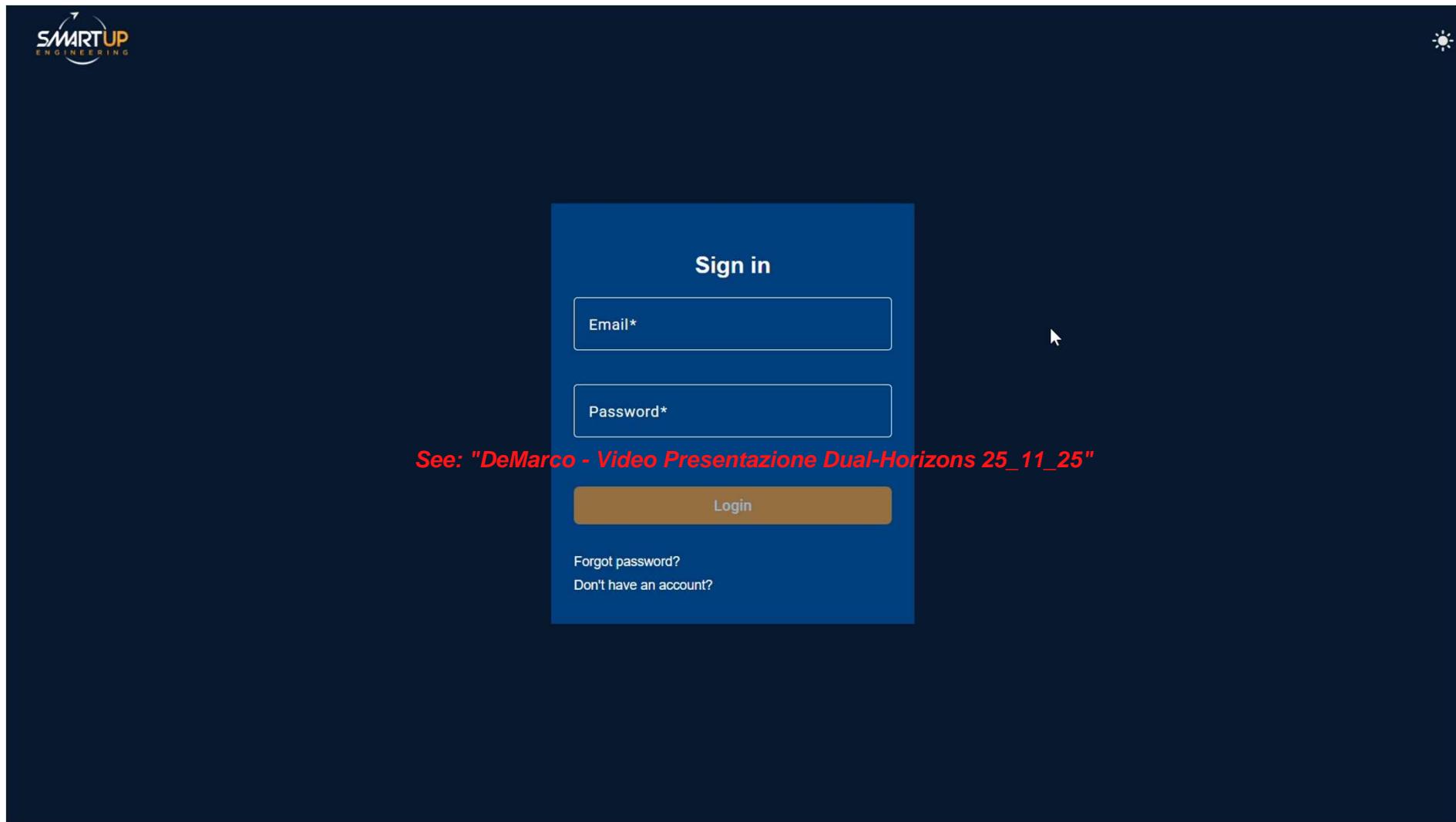


Von Mises stress on 1D elements (MPa)



Von Mises Stress on the upper panel (MPa)

# JPAD Modeller Web App – Release 2026



# JPAD Modeller Web App – Advanced Section Editing



JPAD

localhost:4316/modeller

Google ChatGPT SmartUpEngineering... Codewith.it - Code... front end back end jdk21 OneDrive Tech webmail Material Design Ico... siemens Components | Angu... Altri preferiti

Back File Hangar Update Components CAD Directives

Landing Gears Body

ID Body 1 +

ID

Sections

test Section 1 Section 2

Edit Nodes

Choose a section to copy f

ID

X Station 0

Offset X Y Z Unit

LOG PROBLEMS

**Section 1 EDITOR**

Global Data Nodes

Create new section Import Export

Background Symmetrize Auto-Scroll

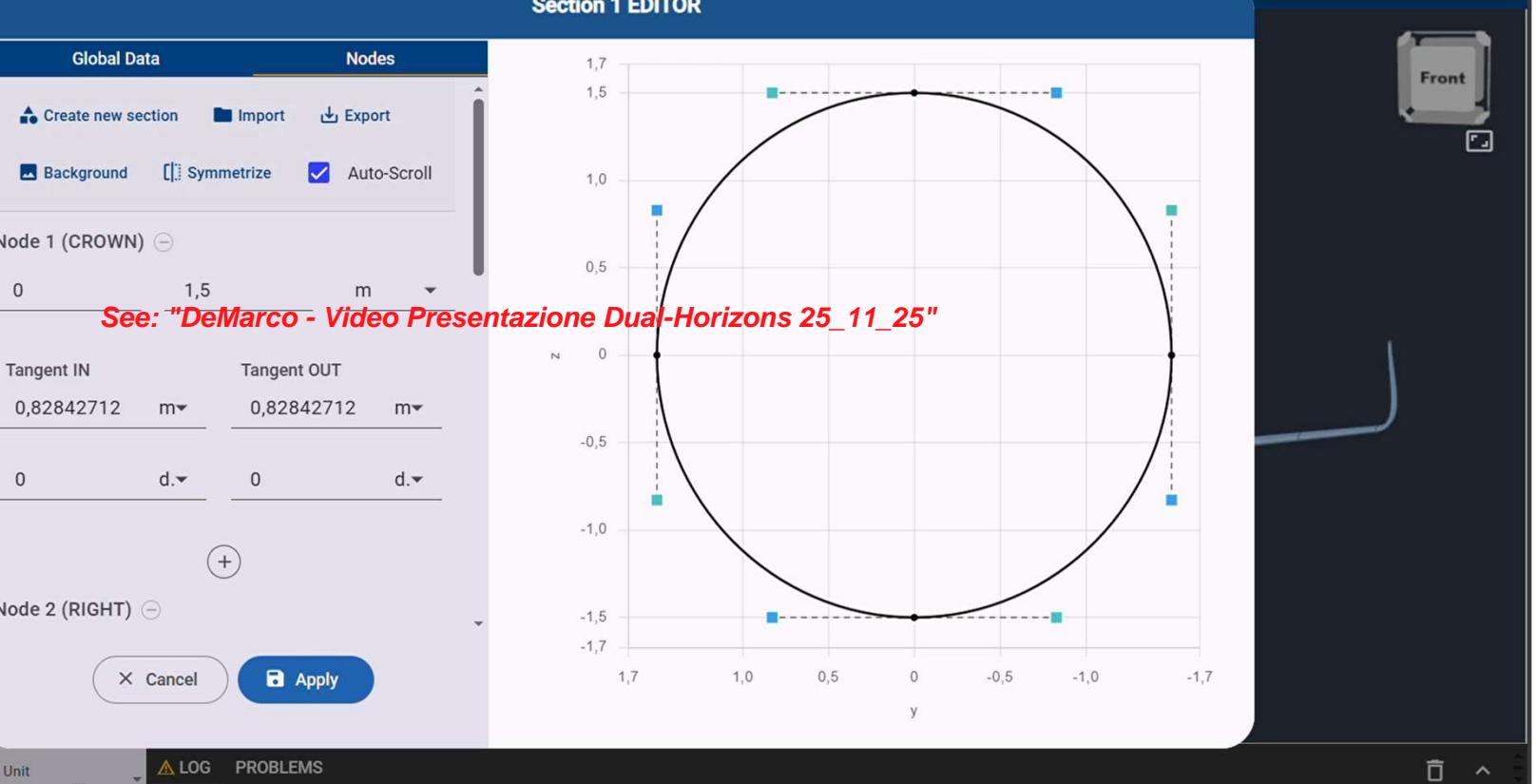
Node 1 (CROWN) 0 1,5 m

Tangent IN 0,82842712 m Tangent OUT 0,82842712 m

0 d. 0 d.

Node 2 (RIGHT) 0

**See: "DeMarco - Video Presentazione Dual-Horizons 25\_11\_25"**



# Fuselage Design

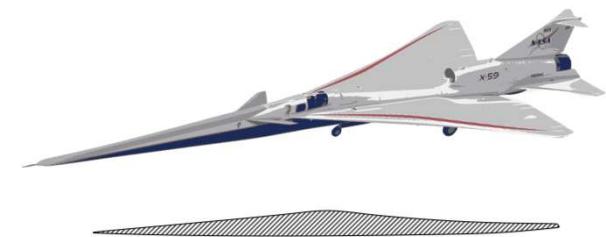
Fuselages vary significantly in shape between aircraft categories.

JPAD v2026 can generate fuselage shapes other than the so-called *tube fuselage*, common in modern airliners.

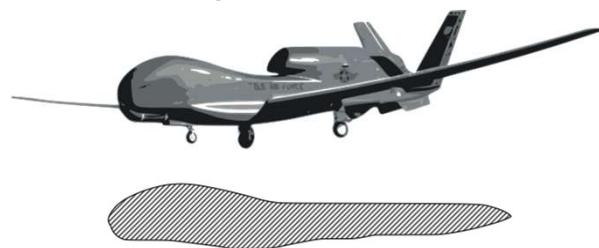
The AEVUM **Ravn X**



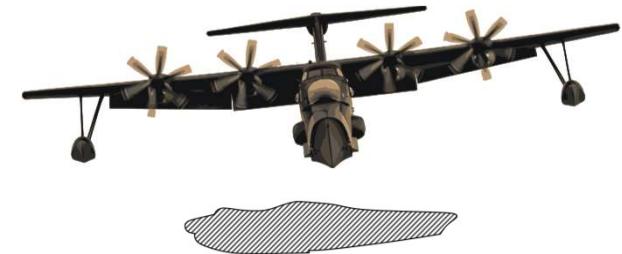
The NASA **X-59**



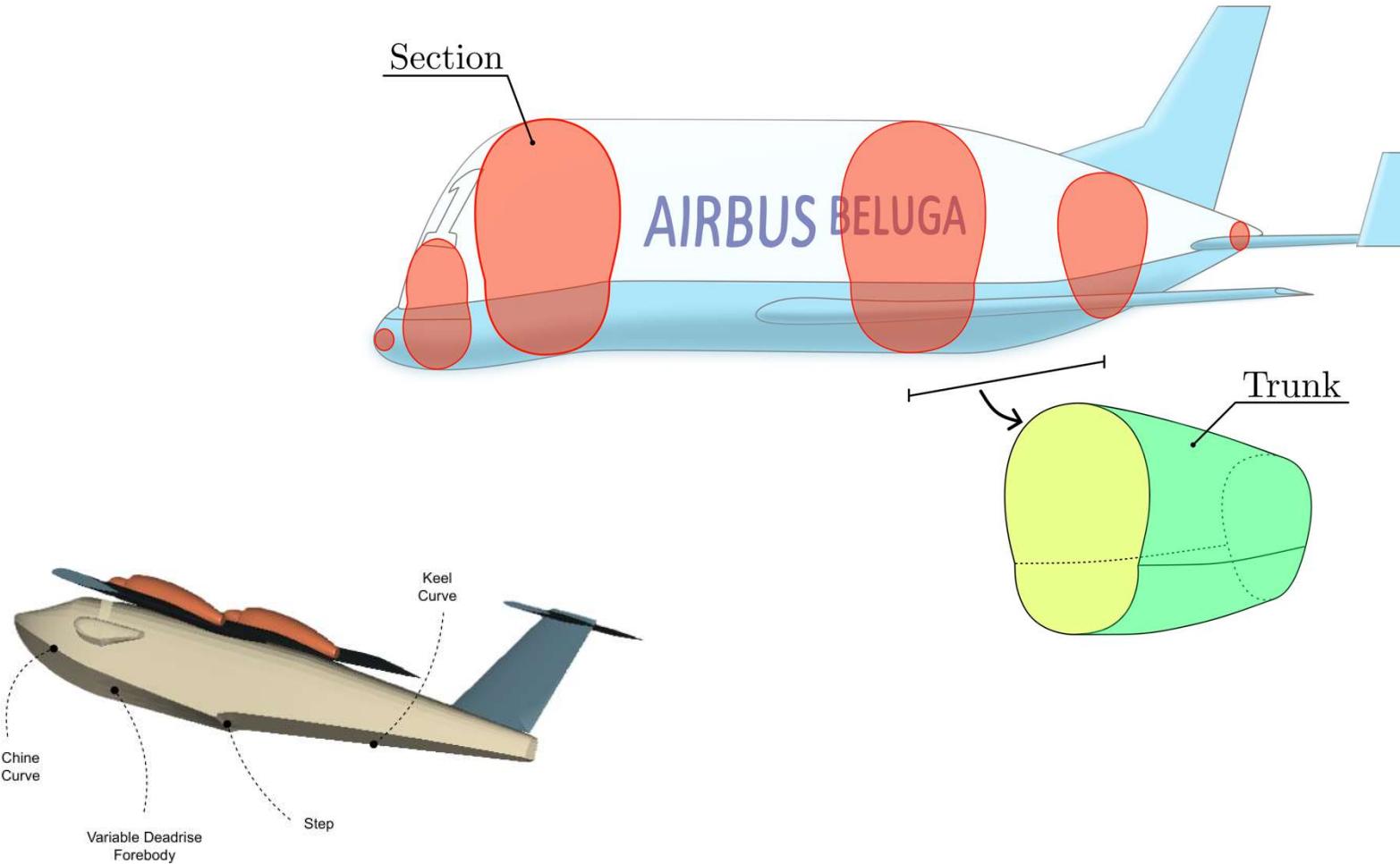
The Northrop Grumman **RQ4 Global Hawk**



The ShinMaywa **US-2**

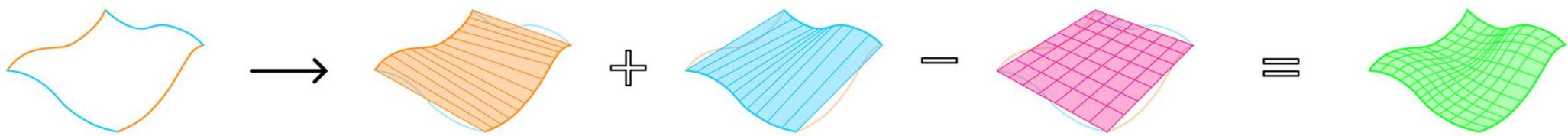


# Geometric Modeling of Complex Shapes

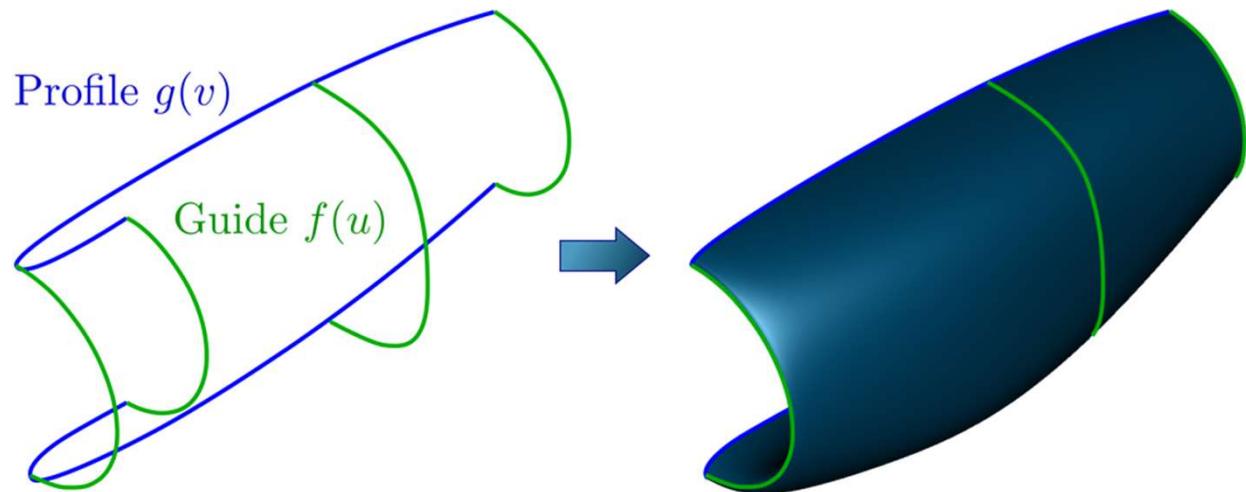


# Geometrical Modeling: Gordon Surfaces

A Gordon surface describes a surface as the result of an interpolation process involving a grid of curves. The grid consists of two groups of mutually orthogonal curves, called *guidelines* and *profiles* respectively.

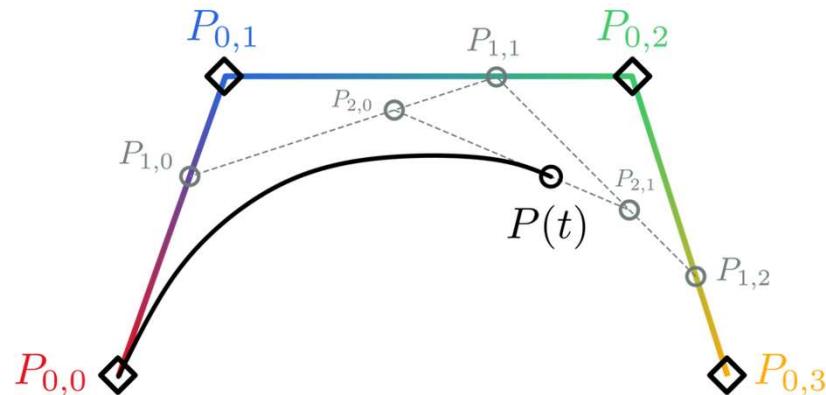


Gordon surfaces can manage high levels of geometrical complexity as long as the network of curves is consistent and well-structured.

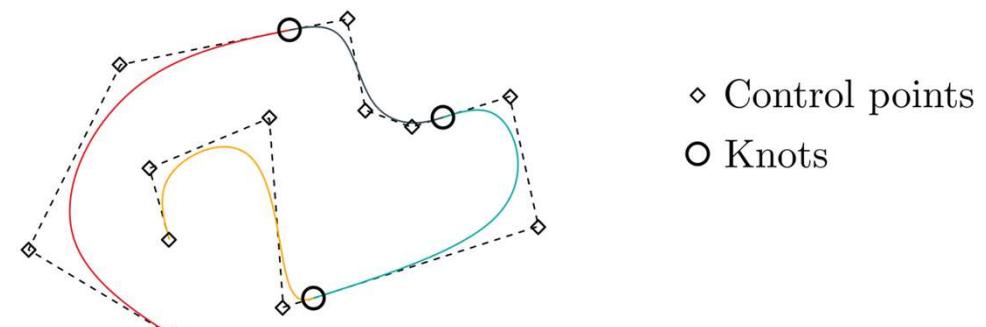


# Geometric Modeling: Curves

An effective way to model smooth curves is through grafted linear interpolation. This is the case with Bézier curves. A concatenation of Bézier curves forms a Basis spline, which allows local control and facilitates obtaining different levels of mathematical and geometric continuity on the curve.



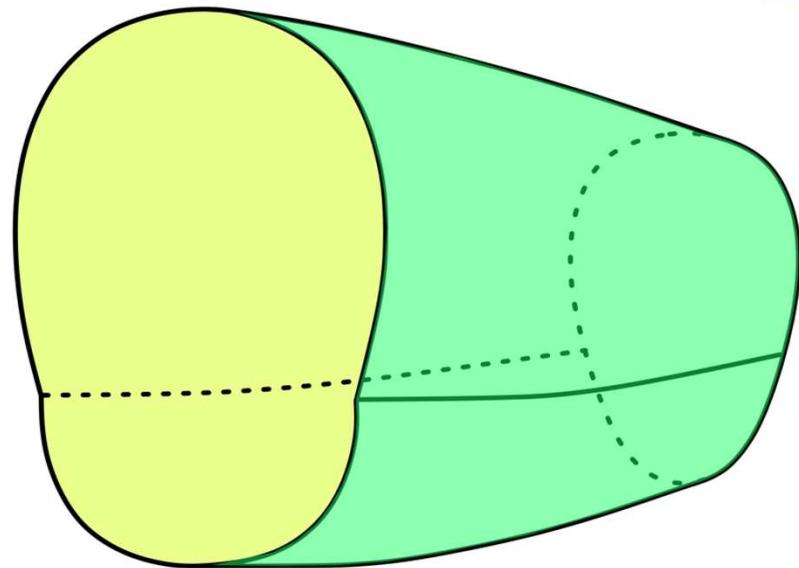
Construction of a Bézier curve



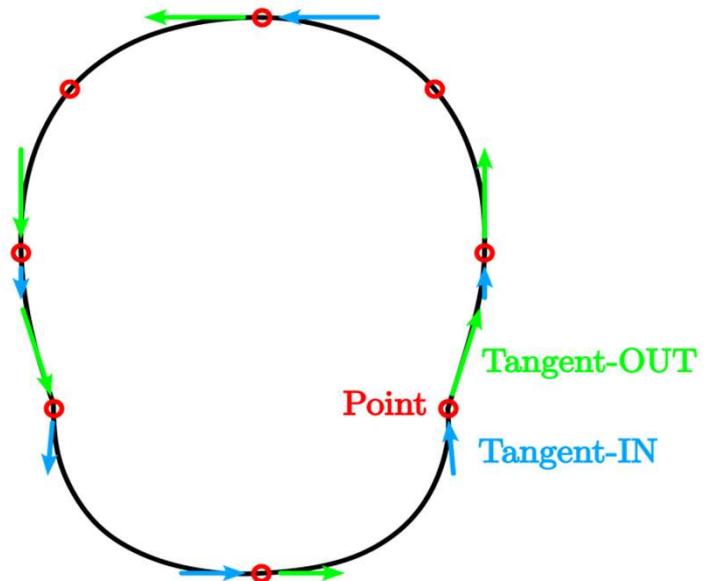
Construction of a B-Spline curve

# Geometric Modeling: Complex Sections

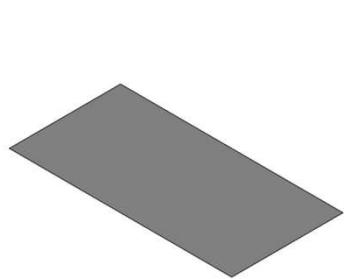
At the end of this process, we have the desired elementary information: a triplet of a point and two vectors, which describe the tangency condition of the curve when it passes through that point and when it leaves it.



**JPAD**  
MODELLER



# Geometric Modeling: Complex Surface Patches



A plane made of 2 profiles and 2 guides.



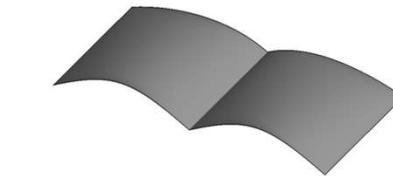
A curved surface made of 2 profiles and 2 guides.



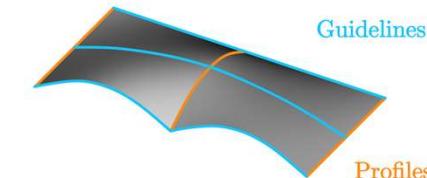
A Gordon surface made of 2 profiles and 2 guides.



A Gordon surface made of 3 profiles and 2 guides.



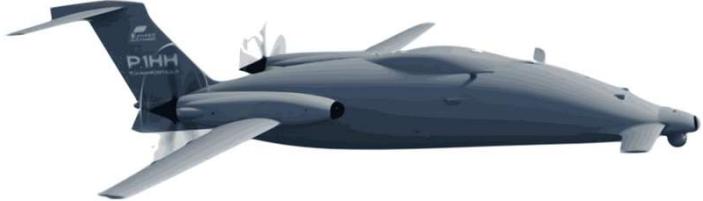
A Gordon surface made of 3 profiles and 2 guides.



A Gordon surface made of 3 profiles and 3 guides.

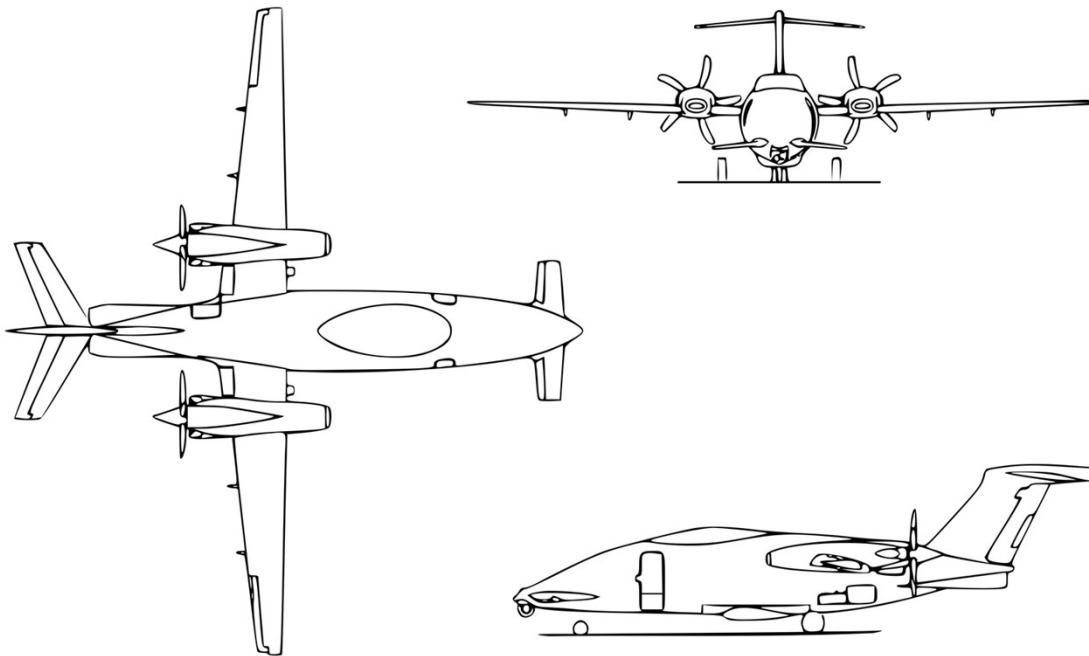


# A Case Study (1/3)



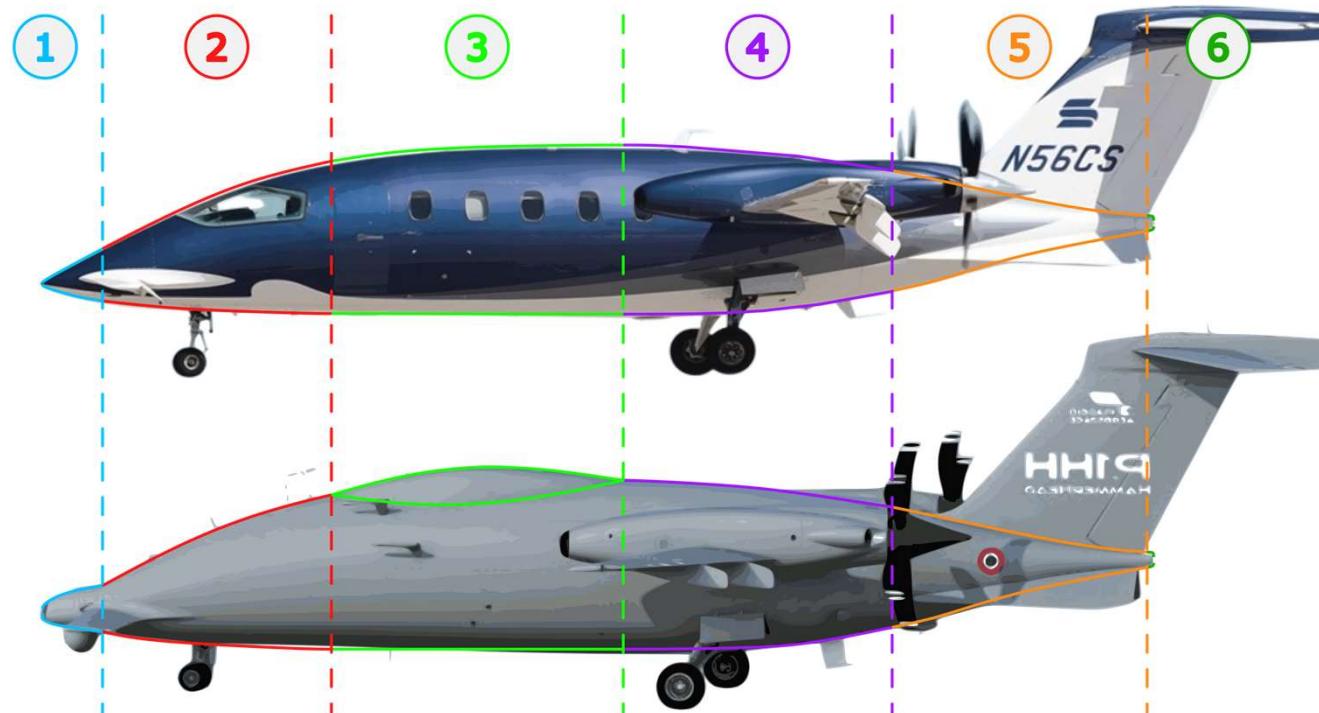
To highlight the software's capabilities in terms of local CAD modifications, an aircraft that lends itself well is the **Piaggio P-1.HH HammerHead**, a UAV version of the P-180.

The fuselage inherits the same airframe from the P-180, with some modifications on the nose and central region of the fuselage, where additional avionics required a dome.



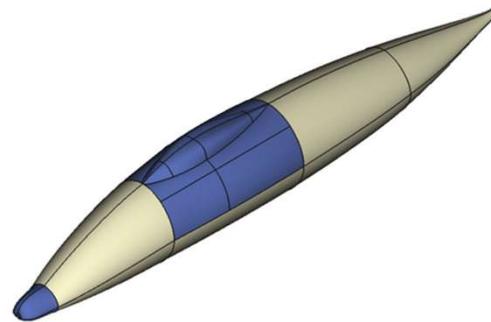
# A Case Study (2/3)

Differences between the two models: P-180 & P-1.HH

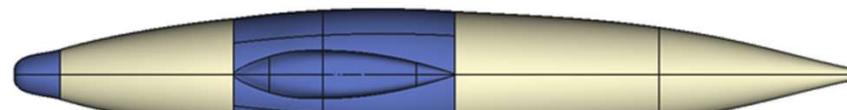


Trunks n. 2, 4, 5, and 6 can be assumed in first approximation to be the same of the P-180.

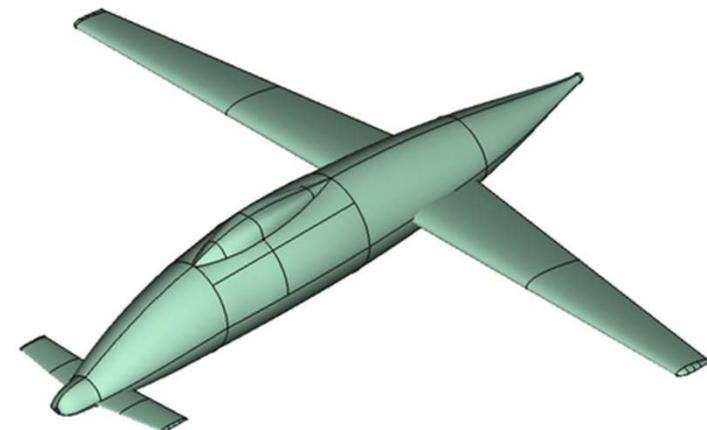
# A Case Study (3/3)



P-1HH CAD fuselage



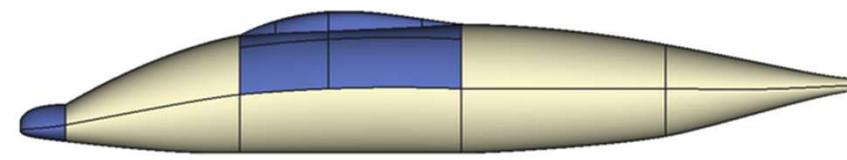
Top View



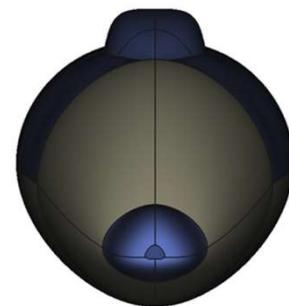
P-1HH CAD of the wing-body



Back View



Side View



Front View

- The methods developed successfully generate a CAD for fuselages of any complexity that is watertight.
- The CAD generation process is fast, automatic, and based on intuitive modeling.
- The new capabilities fit well within JPAD, a software that supports optimization workflows based on multidisciplinary analysis (MDAO).
- Improve automation through the use of an *ad hoc* metalanguage that the user will use to obtain the results of repetitive operations.
- Update JPAD-CAD and JPAD-Core Modules. The new features will become part of the next release of JPAD Modeller v2026, making them available to both experienced and entry-level users of JPAD.

**JPAD**  
**MODELLER**

# Questions?

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Thank you for your  
ATTENTION TO THIS MATTER!