Development of a Java Framework for Parametric Aircraft Design

The Performance Analysis Module

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DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

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Introducing JPAD - Java Programs for Aircraft Design

- A software toolchain for aircraft preliminary design and MDO
- A modern, user friendly, modular framework.
- Support for simultaneous management/analysis of several aircraft and/or 'varied' configurations of the same aircraft.
- Conceived for collaborative design activities.
- Interoperability with other tools/disciplines (CAD/CFD/FEM analysis).

Main features

- Define a parametric representations of a complete aircraft with XML configuration/input files.
- Generate CAD geometries of aircraft assembly and sub-components. Measure lengths, areas, volumes.
- Perform various types of analysis (L0, L0.5, L1): **Aerodynamics**, **Stability & Control**, **Performance**, **Weight & Balance**, **Costs**.
- Exports analysis results in XML and Excel formats. Produce useful output charts for each analysis.
- Perform iterative analysis in order to reach an optimum configuration. (Work in progress)

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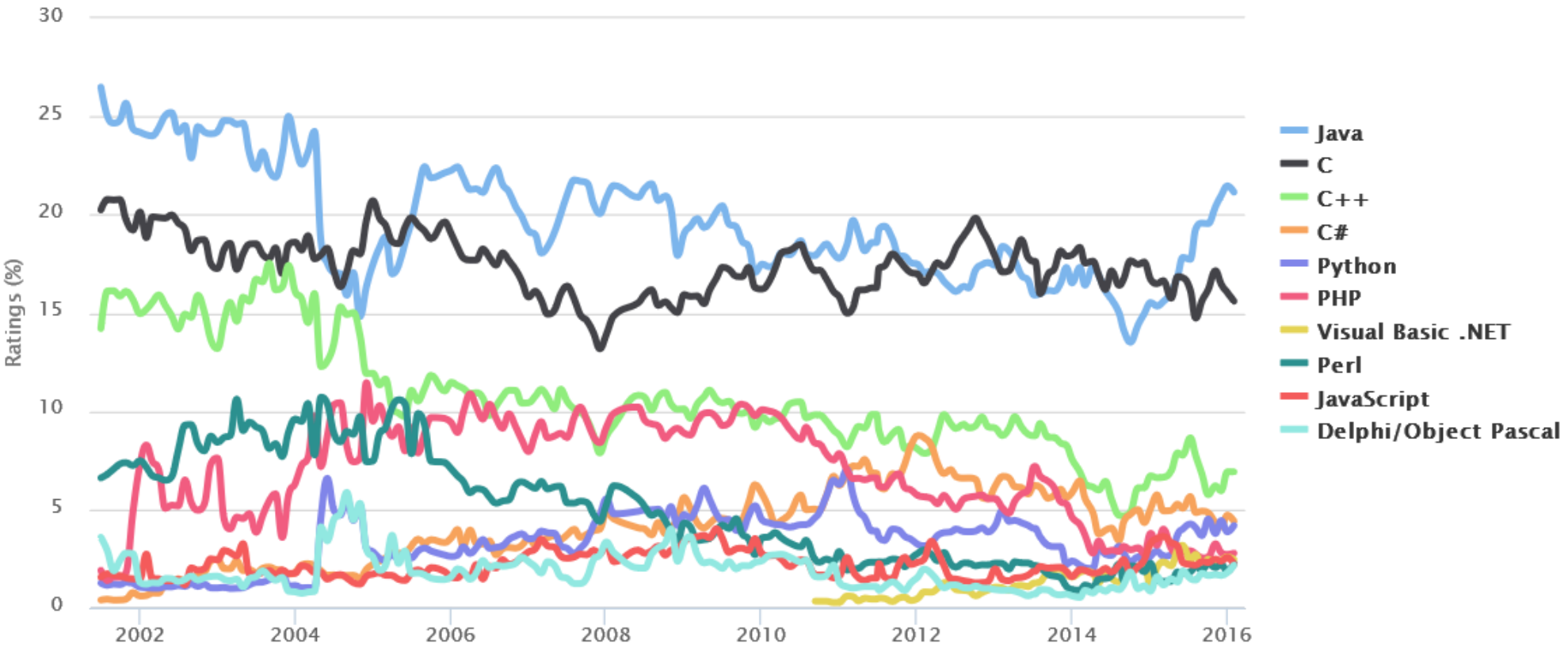
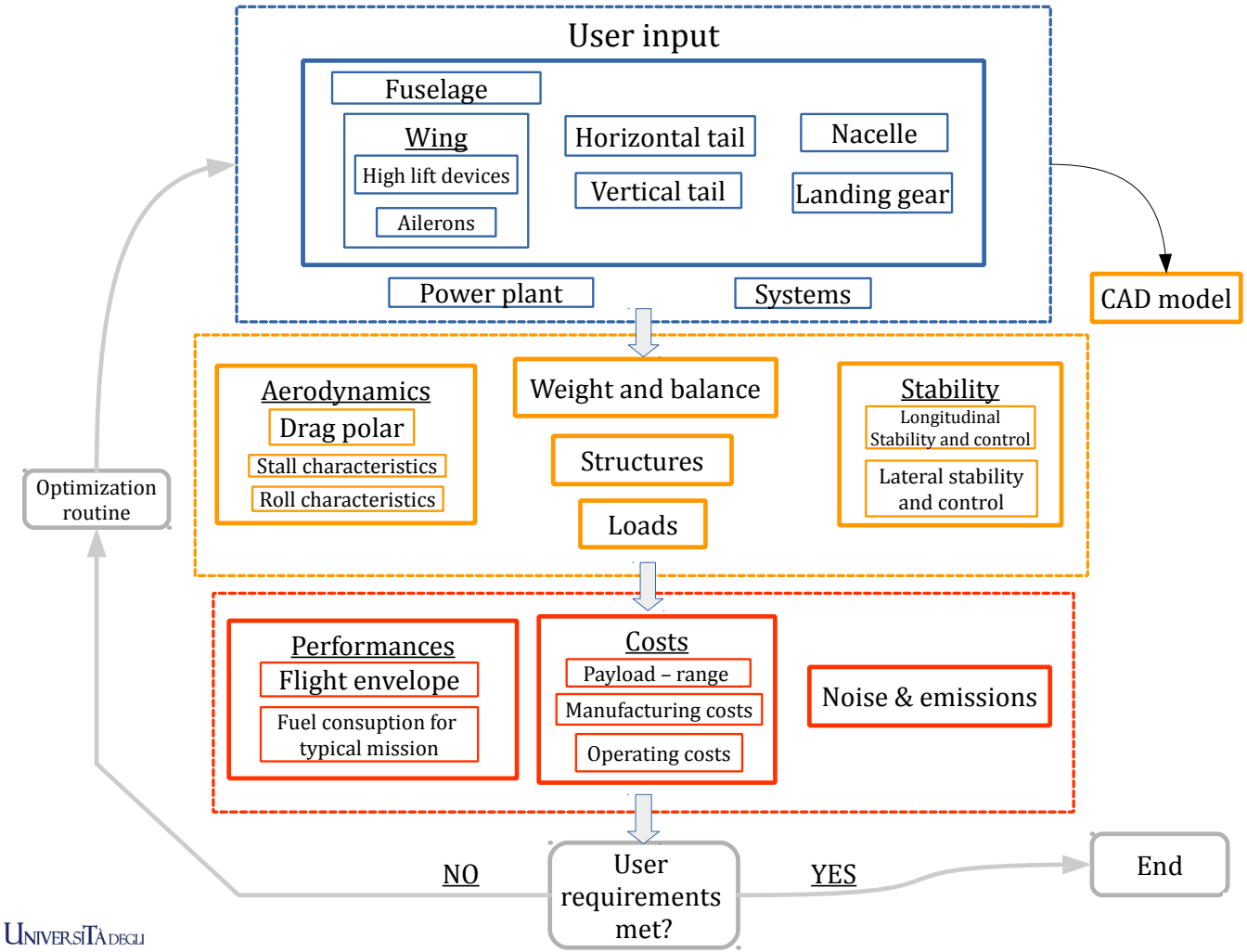
Java. Why?

- Language widely supported. This avoids the library to become obsolete due to the aging of the programming language used.
- The language promote the use of open source libraries, especially for I/O tasks and for complex mathematical operations.
- Widely supported GUI frameworks (SWT/JFace and JavaFX) and a GUI visual builders.
- Object-Oriented paradigm is naturally applied in the abstraction of typical Aircraft Design problems.
- Promotes modularity: easier to work with in an ever changing team.

TIOBE Programming Community Index



JPAD typical work session

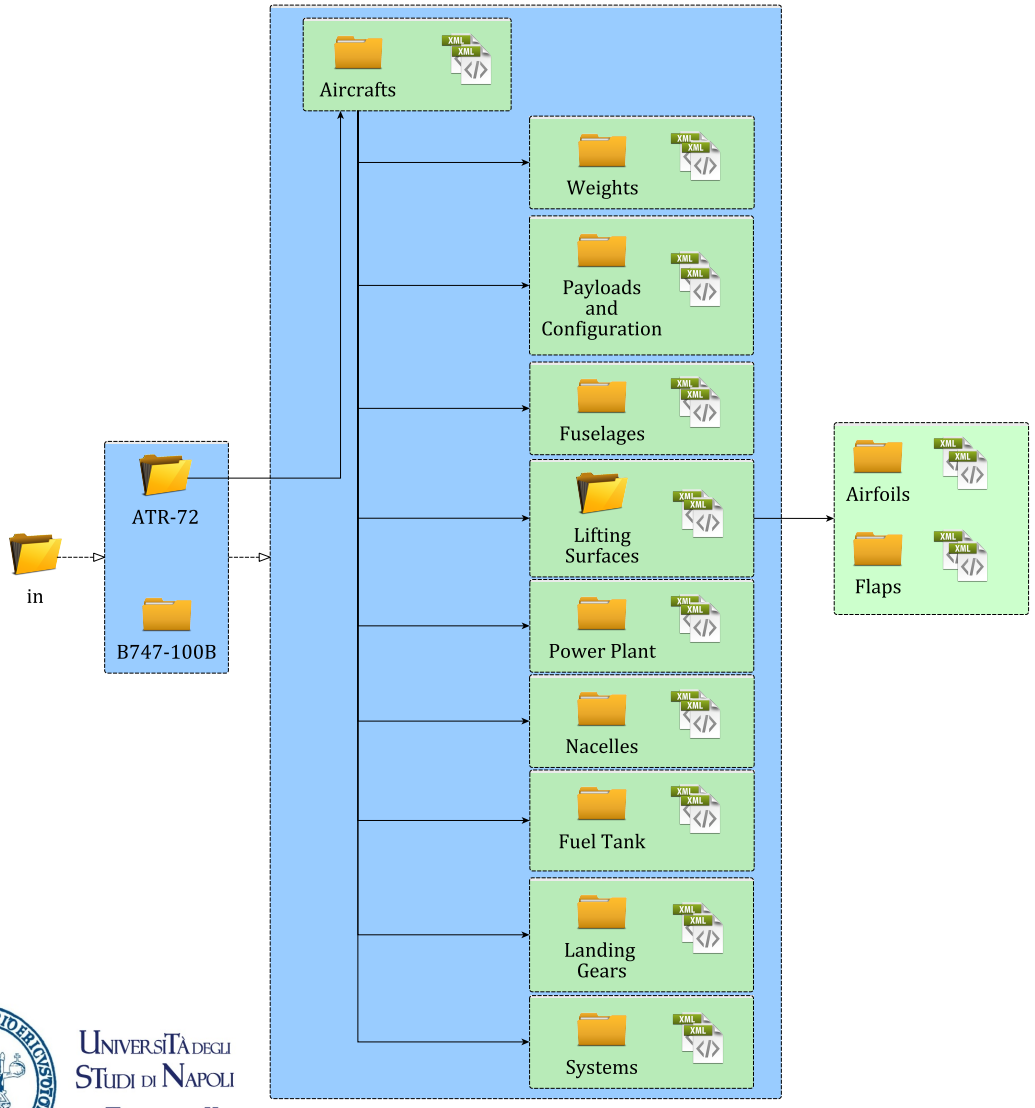


Input file

The input file type chosen is the XML (*eXtensible Markup Language*). It is a markup language that defines a set of rules for encoding documents in a format which is both *human-readable* and *machine-readable*; moreover its design goals of emphasize simplicity, generality and usability across the Internet.

- *Markup Language* due to the use of tags that describes the content.
- *extensible* because the markup symbols are unlimited and self-defining, so that it is possible to use a personal tag for each data.

Input file structure prototype




```xml
<?xml version="1.0" encoding="utf-8"?>
<jpad_config>
    <aircraft>
        <wings>
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                <position>
                    <x unit="m">12.0</x>
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            </wing>
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                <position>
                    <x unit="m">0.0</x>
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                    <z unit="m">0.0</z>
                </position>
            </fuselage>
        </fuselages>
    </aircraft>
</jpad_config>
```
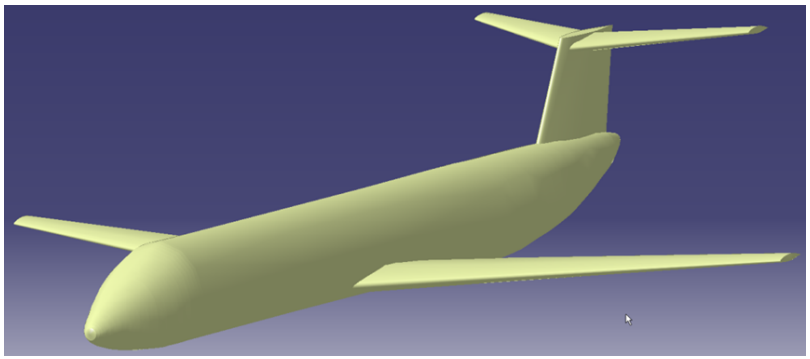

JPAD Output

- XML
- Microsoft Excel
- Charts
- CAD model



Multiple aircraft analysis result comparisons

REPORT_ALL.xls - LibreOffice Calc

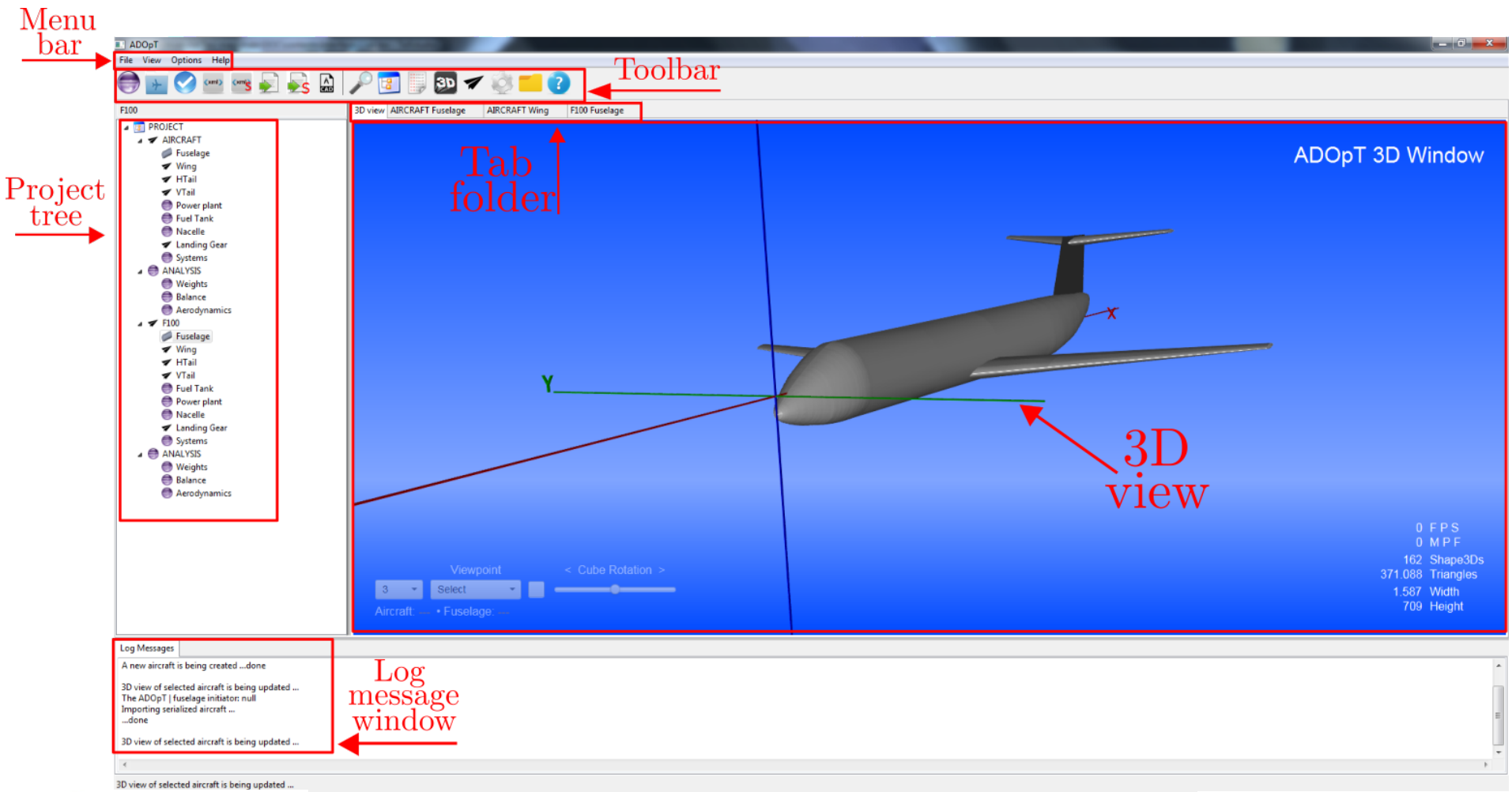
File Modifica Visualizza Inserisci Formato Strumenti Dati Finestra ?

	A	B	C	D	E	F
1			ATR72	F100	A320	B747_100B
2	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**
3	Material density	kg/m³	2711.00000	2711.00000	2711.00000	2711.00000
4	Maximum zero fuel mass	kg	19998.24551	34774.75497	56206.95596	192272.98603
5	Maximum landing mass	kg	20698.42095	40968.19348	68104.61636	305739.45542
6	Maximum take off mass	kg	22998.24550	45516.48164	75668.59596	339684.42269
7	Fuselage mass	kg	3203.33333	5378.00000	8392.66667	32349.66667
8	Wing mass	kg	2332.50000	4722.00000	8519.00000	40195.00000
9	HTail mass	kg	212.00000	461.50000	619.50000	3429.50000
10	VTail mass	kg	275.00000	369.50000	459.00000	1938.33333
11	Nacelle mass	kg	143.50000	389.50000	753.00000	1321.50000
12	Landing gear mass	kg	763.00000	1656.33333	2076.00000	13485.50000
13	Structure mass	kg	7072.83333	13366.33333	21572.16667	96684.00000
14	Power plant mass	kg	1329.14176	4134.85560	7647.87160	22087.08000
15	Systems mass	kg	2324.25622	3231.22575	4447.76585	12935.29415
16	Furnishings and Equipment mass	kg	1252.00000	1853.00000	2891.00000	0
17	Manufacturer empty mass	kg	11978.23131	22585.41468	36558.80412	131706.37415
18	Crew mass	kg	306.05819	459.08729	535.60184	1377.26187
19	Operating Items mass	kg	585.95600	939.25300	1292.55000	4739.35000
20	Operating empty mass	kg	12870.24551	23983.75497	38386.95596	137822.98603
21	Passengers mass	kg	6732.00000	10791.00000	14850.00000	54450.00000
22	ZeroFuelMass	kg	19602.24551	34774.75497	53236.95596	192272.98603

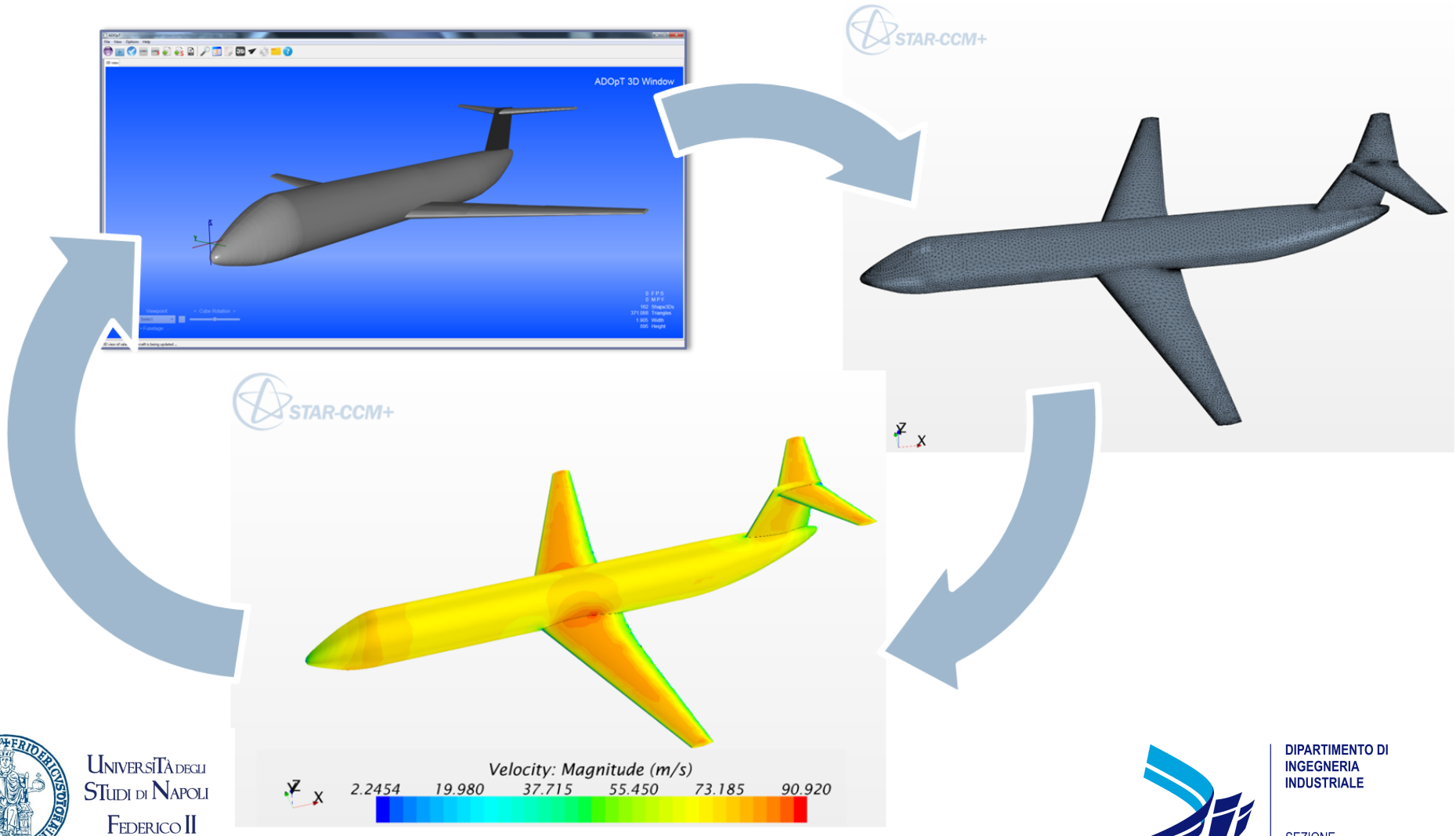
ADOpT GUI

- Menu bar, holds all the available actions.
- Toolbar, holds the actions needed to interact with the application.
- Project tree, provides access to all the aircraft components and the analysis results any time.
- 3D view, shows the CAD model which can be updated each time.
- Log message window, tells the status of pending operations.
- Tab folder, contains all the windows opened.

ADOpT GUI - Layout



Interoperability



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