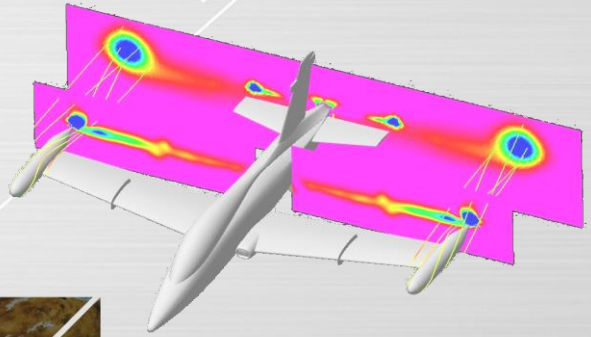
Sviluppo ed Integrazione di Modelli per Simulazione di Missioni Distribuite

Luca Cistriani

Milano 25/06/2019

Roma 26/06/2019



LEONARDO ELECTRONICS

MATLAB EXPO 2019

RIAce

Topics

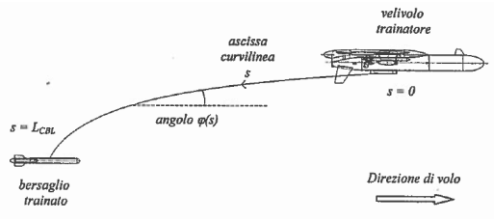
1. Introduction
2. The RIACE Synthetic Environment
3. Tools & Processes: a “MATLAB-Simulink centric” toolchain for an Engineering Unit
4. Examples
5. Conclusions

Who is speaking

1. I am a **MATLAB User from the mid ‘90s** (MATLAB used for the master thesis work in 1999)

2. I used **MATLAB & Simulink** as **standard tools** (in conjunction with legacy SW packages developed in FORTRAN, Pascal, etc.) for **UAV design** for many years.

3. In late 2007 I was tasked to organize an **Engineering Unit** specifically devoted to develop **math models** for **Training & Simulation** … We selected **MATLAB & Simulink** as the **core-suite** of our toolchain.



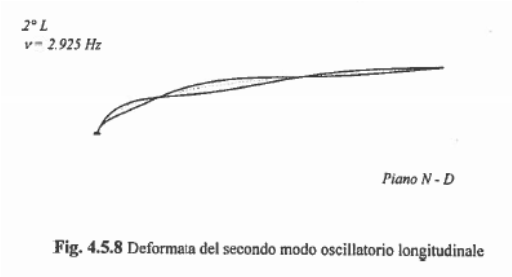
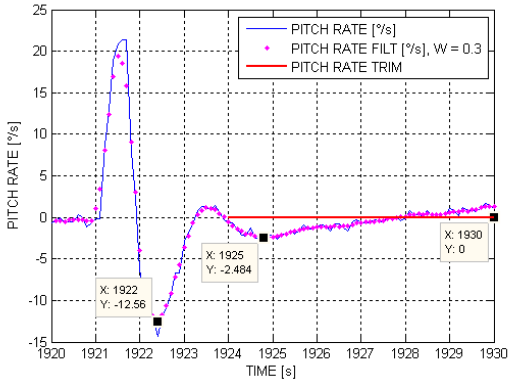


Fig. 4.5.8 Deformata del secondo modo oscillatorio longitudinale



Organization & Business

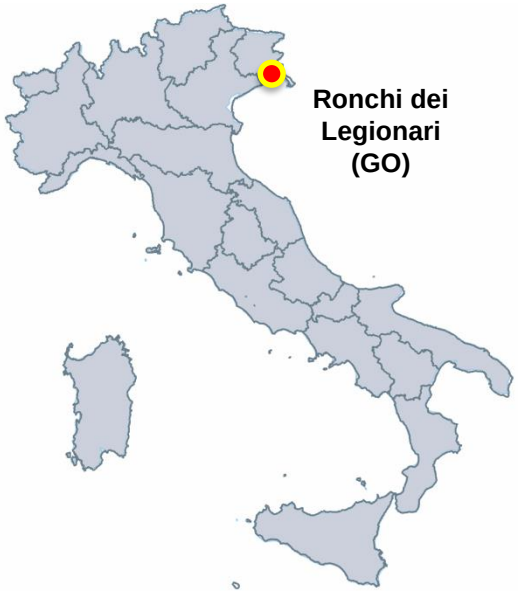
LEONARDO

REVENUES	NEW ORDERS	ORDER BACKLOG	R&D	EMPLOYEES
12,240	15,124	36,118	1,440	46,462

Figures as of 12/31/2018 (financials in EUR mln)

- ELECTRONICS
- HELICOPTERS
- AIRCRAFT
- AEROSTRUCTURES
- CYBER SECURITY

- CTO & Engineering
- Airborne & Space Systems ITALY
- UAS, Training & Simulation
- Modeling & Distributed Missions Simulation



The RIACE Synthetic Environment

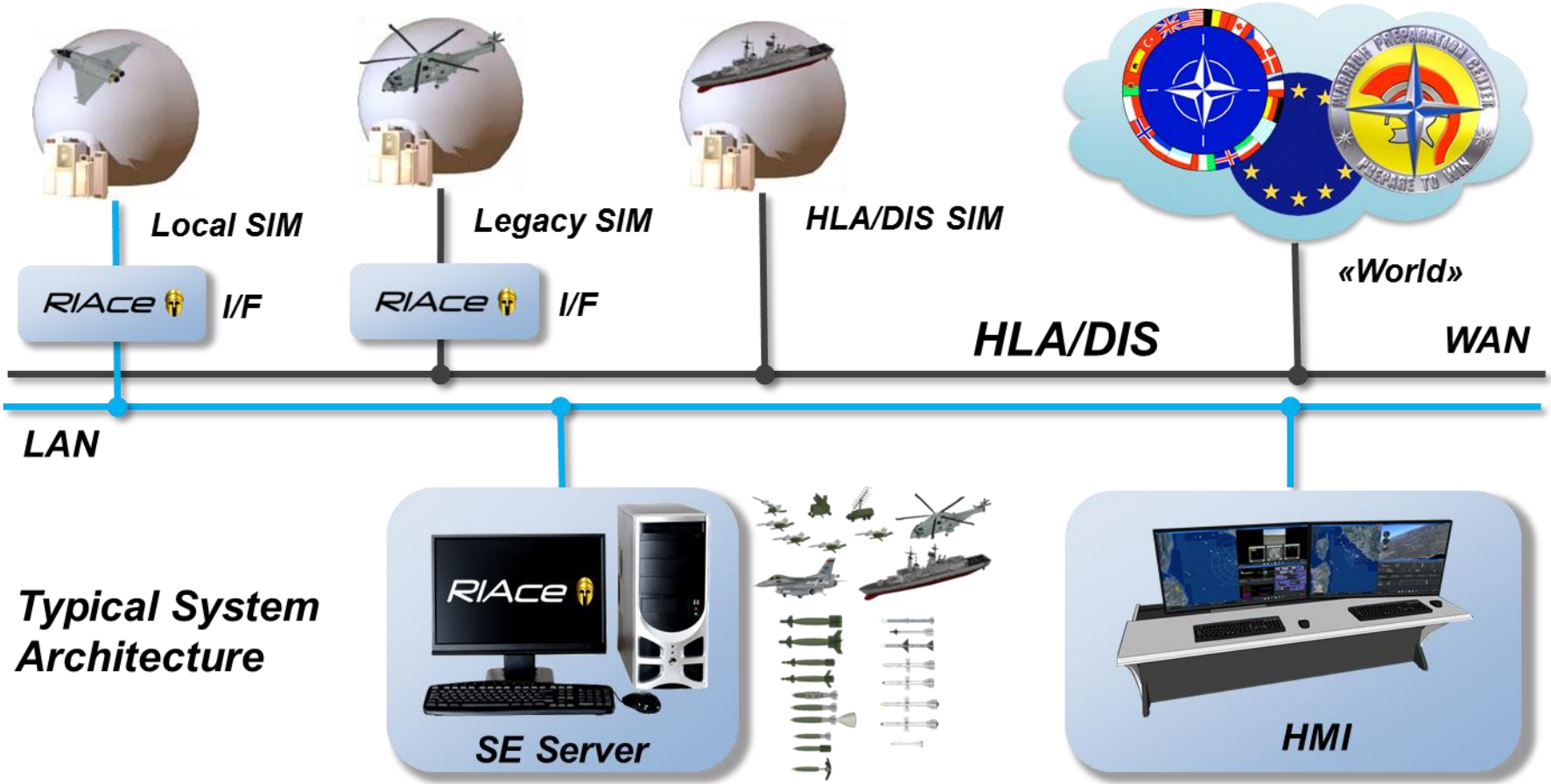
What is … how it is used

Realistic Intelligent Agents for computer environments

RIAce is a **Synthetic Environment (SE)**: a **computer-based representation** of the **real world** (including the **natural environment**, e.g. atmosphere, space, ocean, and terrain), within which any **combination of players** may **interact** on a **single computer** or over a **distributed network** connected by **local** and **wide area networks** and augmented by realistic special effects and accurate behavioral models.

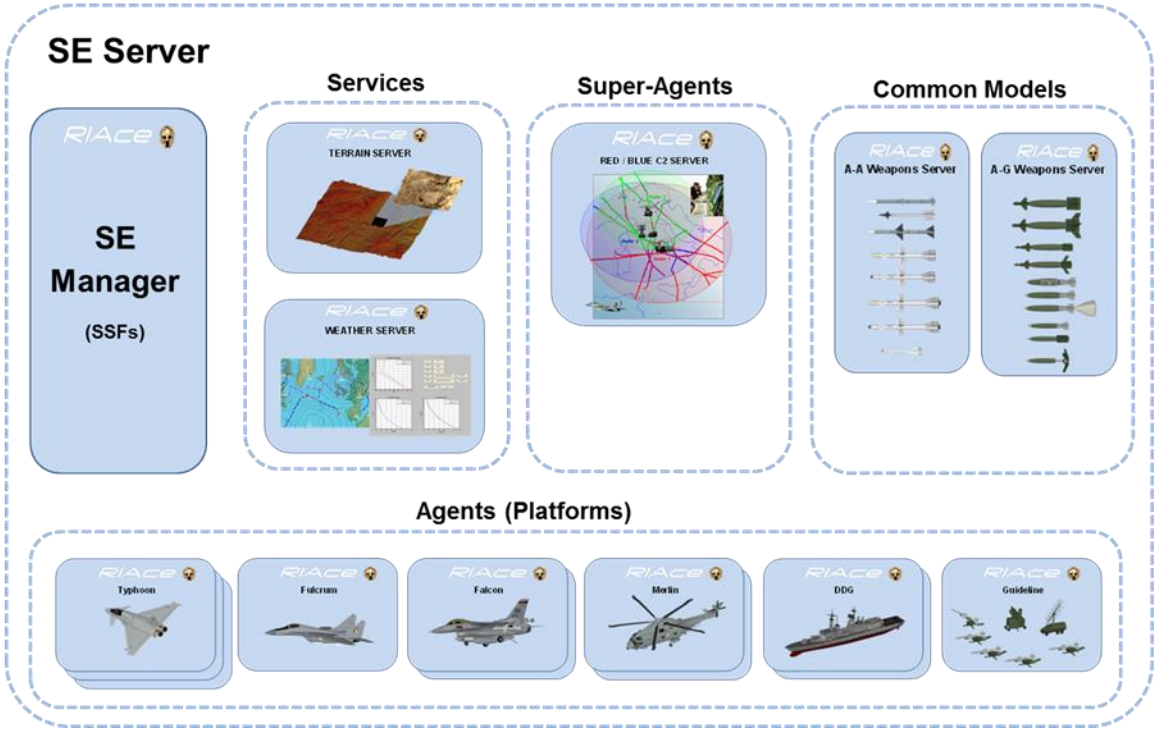
3D Renderings are used to illustrate the functionalities of the Synthetic Environment but the Rendering SW/HW (e.g. the Image Generator) is **NOT** part of a Synthetic Environment for **Distributed Simulation**.

Realistic Intelligent Agents for computer environments

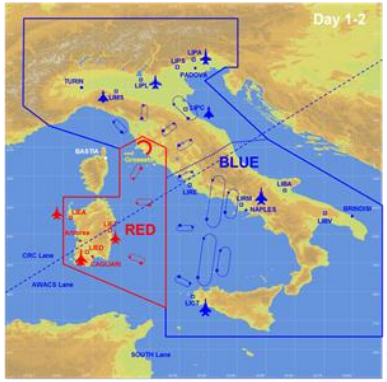


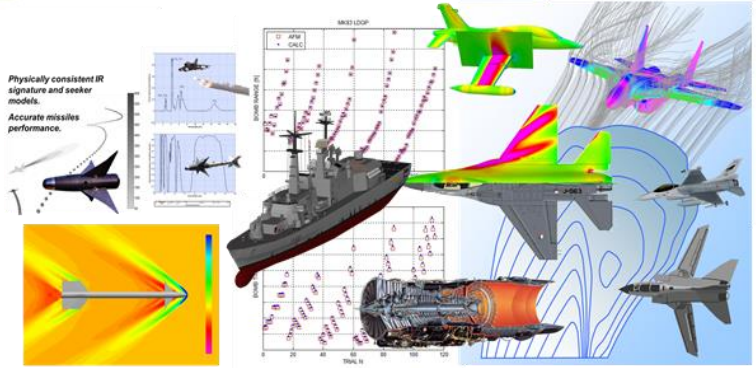
Realistic Intelligent Agents for computer environments

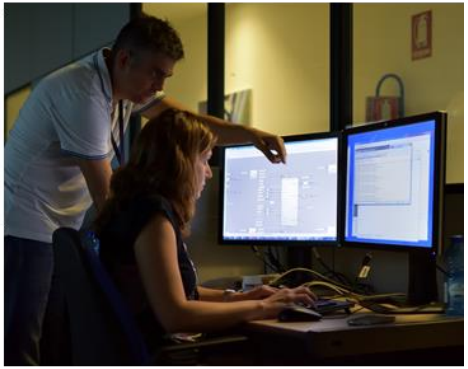
Synthetic Environment Server Architecture



NATO Spartan Alliance & Spartan Warrior Exercises





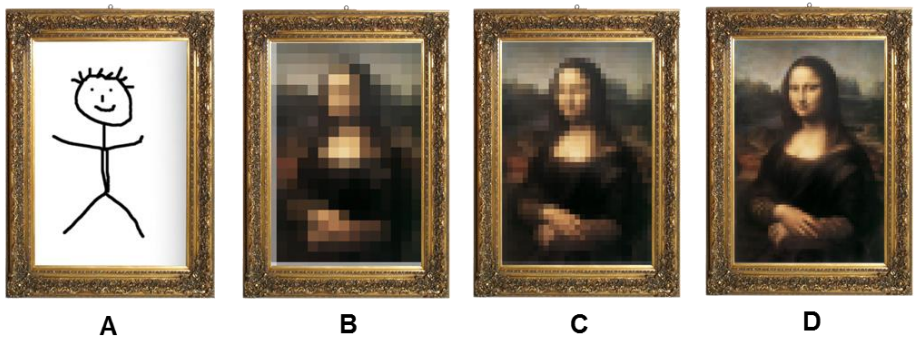


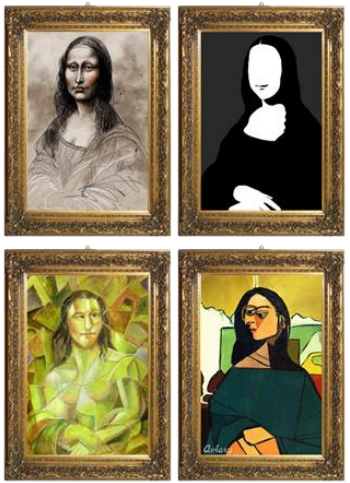
LEONARDO DISTRIBUTED MISSION OPERATIONS

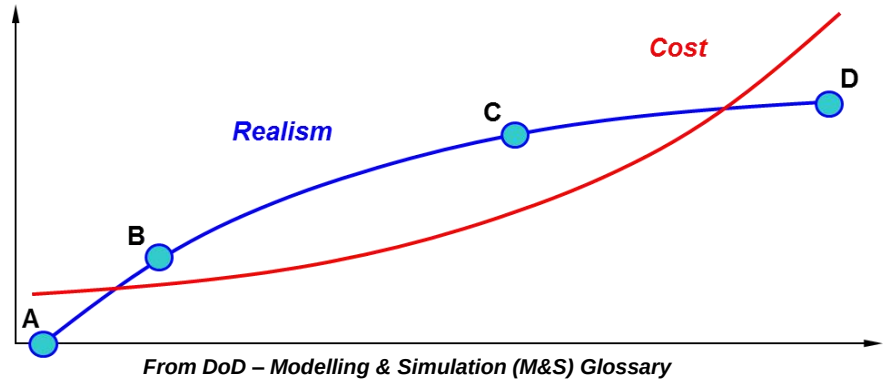
Goals & Challenges

1. Extremely **wide range** of applications.
2. Large scale simulations running a **great number of agents** with **different levels of fidelity** and **complexity** in **Real-Time**.
3. Modelling needs **accurate balance between accuracy** (complexity and fidelity) and **performance** (computational resources, execution time).
4. Needs a **coordinated effort** from a **team of specialists** with different skills.
5. "**Perceived realism of simulation**" needs some "preview" of the final application from the early stages of the development

«Realism» vs Cost and False Myths







From DoD – Modelling & Simulation (M&S) Glossary

*"Among models with **roughly equal** predictive power, the **simplest one** is the most desirable."*

In the era of internet it is easy to find reliable information to build your «realistic» math models

Tools & Processes

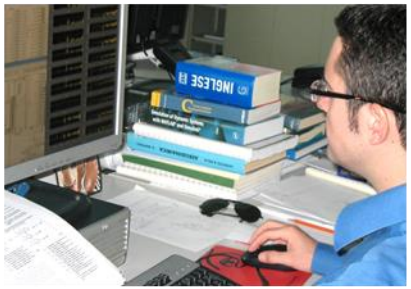
A “MATLAB-Simulink centric” toolchain for an Engineering Unit

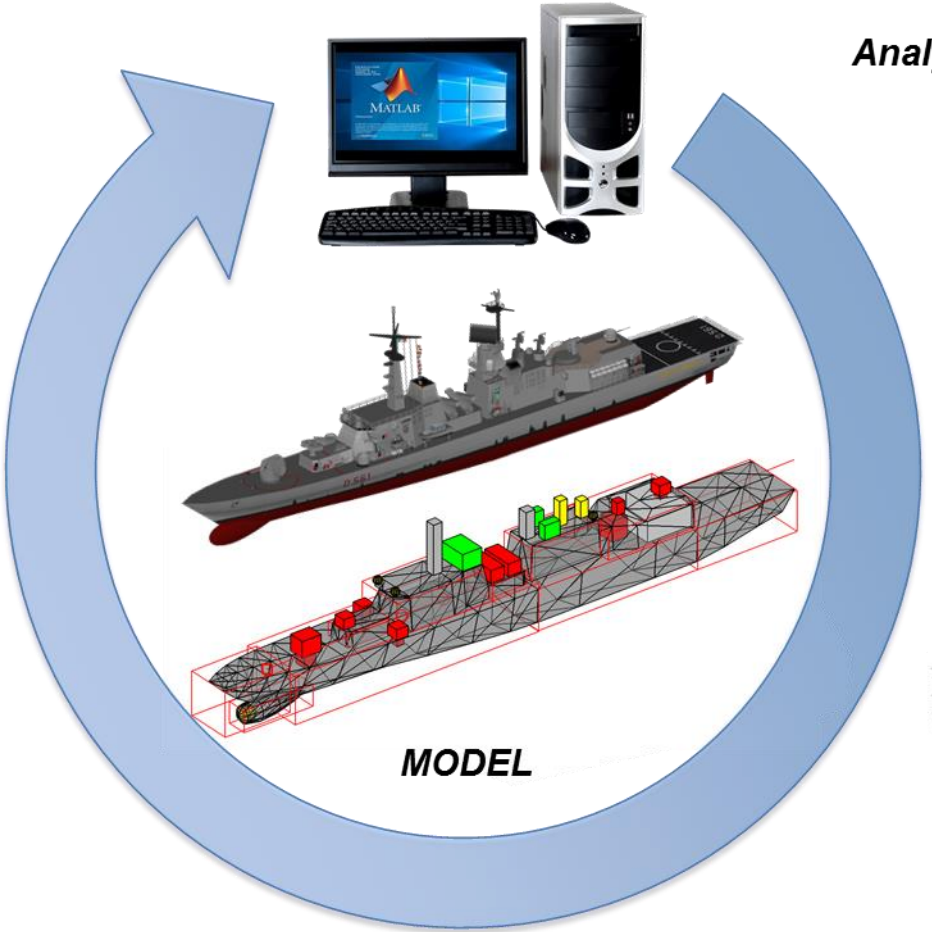
Code generation

MATLAB SIMULINK

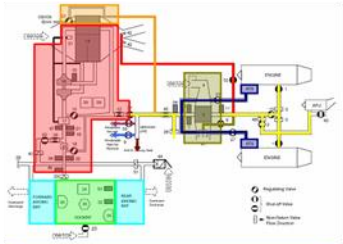
Microsoft Visual C++

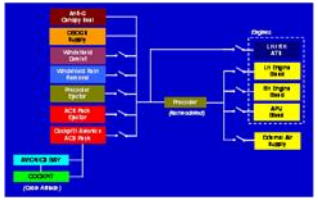
V&V



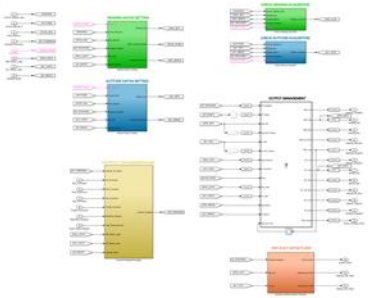


Analysis of Requirements

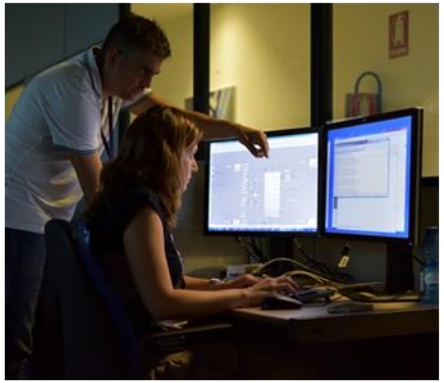




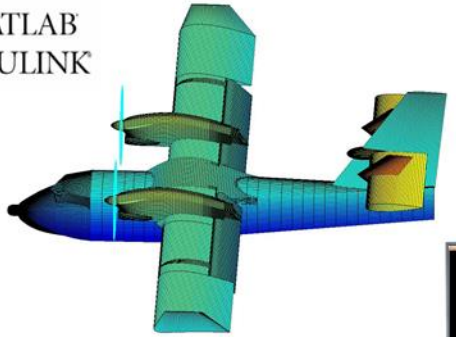
Development



Modelling

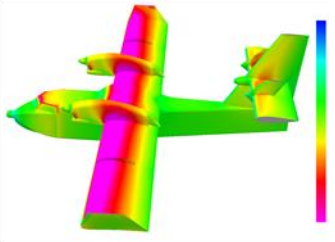


MATLAB SIMULINK



Rendering

Analyzing



XPLANE 10

AMI Analytical Methods, Inc.

MATLAB SIMULINK

Model Engineer's PCs

- MATLAB
- Simulink
- …

MATLAB-Simulink Work Stations

- MATLAB
- Simulink

MATLAB SIMULINK

- Aerospace Blockset
- Aerospace Toolbox
- Control System Toolbox
- Embedded Coder
- Fuzzy Logic Toolbox
- MATLAB Coder
- Optimization Toolbox
- Parallel Computing Toolbox
- Simulink 3D Animation
- Simulink Coder
- Simulink Design Optimization
- Simulink Desktop Real-Time
- Stateflow
- System Identification Toolbox
- …

CFD

- MGAERO
- OMNI3D

AMI Analytical Methods, Inc.

3D

- X-Plane
- Plane Maker

XPLANE 10

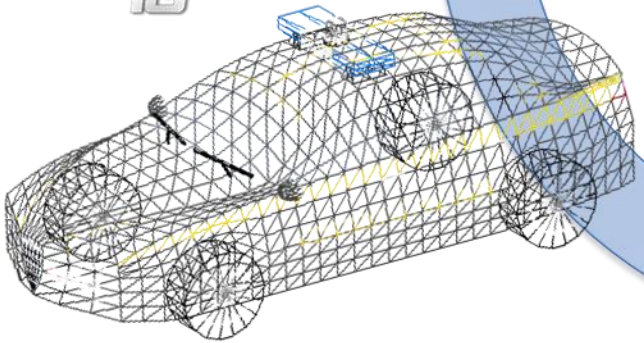
Enabling Factors and Features

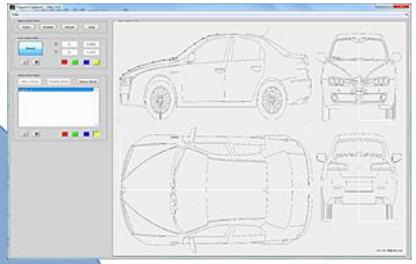
1. Most of the applications use **formatted text files for I/O** … this makes exchange of data easier.

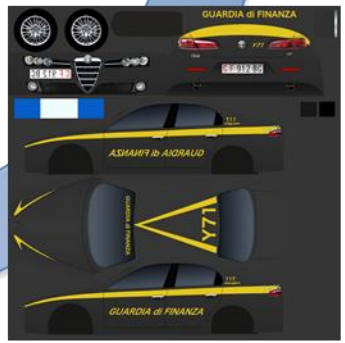
2. MATLAB & Simulink allow the implementation of **“libraries”** of tools and components for reuse in math models and applications.

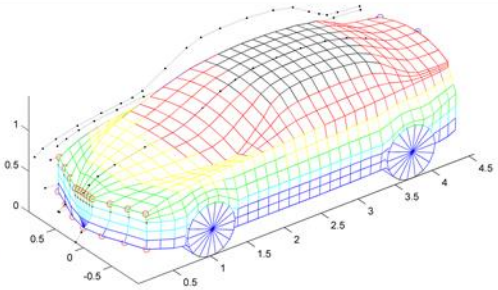
3. Intrinsic **modularity** of MATLAB & Simulink exploited to develop complex models from **building blocks** (**referenced models**).

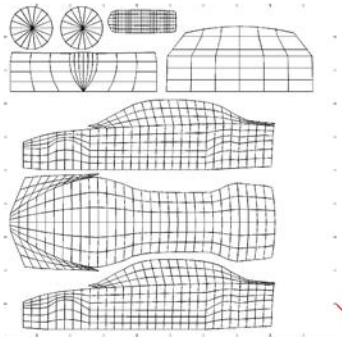
4. Storage of **data templates** (e.g. data buses) allows multiple applications to maintain their **interfaces aligned**.

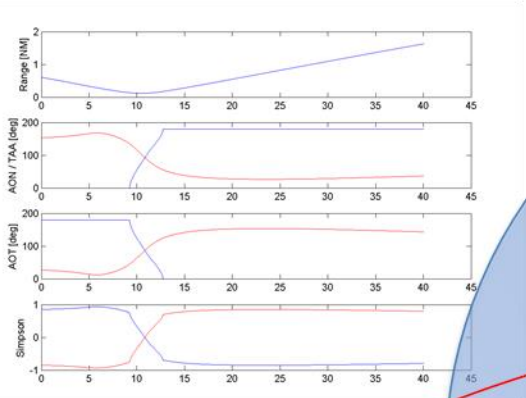


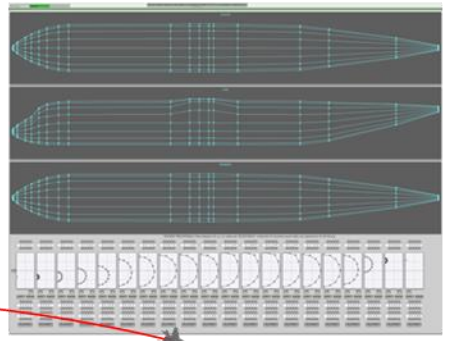




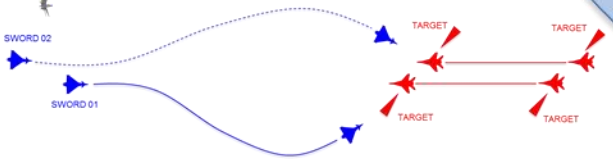


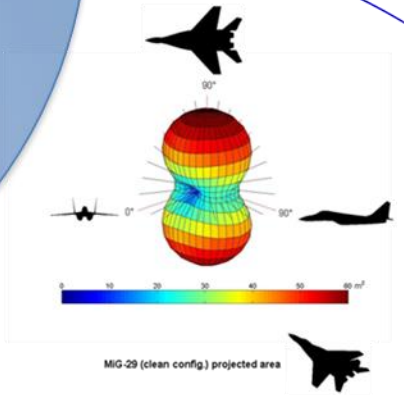






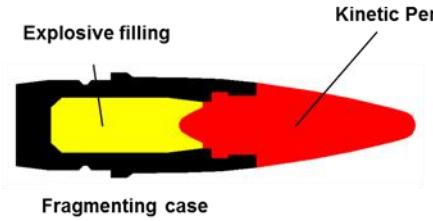
MATLAB SIMULINK





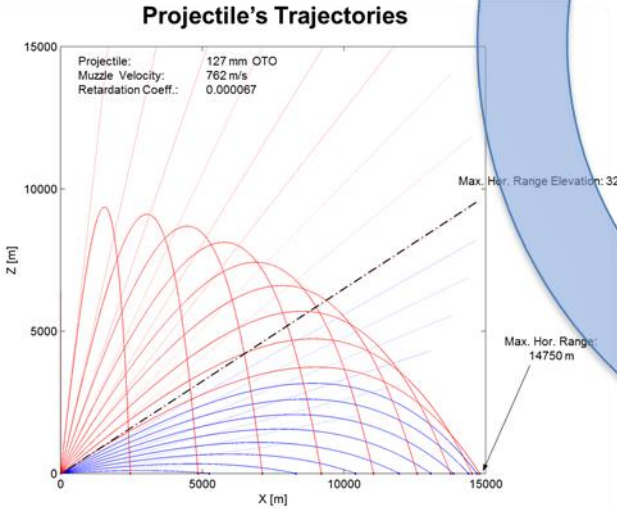
Example: Simulation of Ballistic Munitions

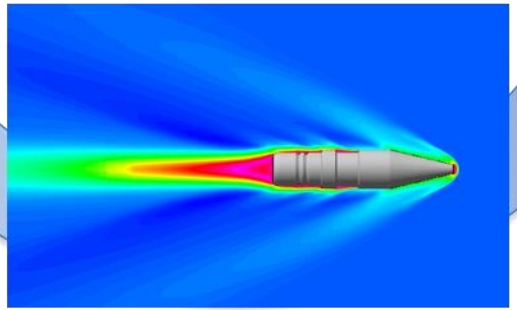
Modeling of trajectory and terminal effects



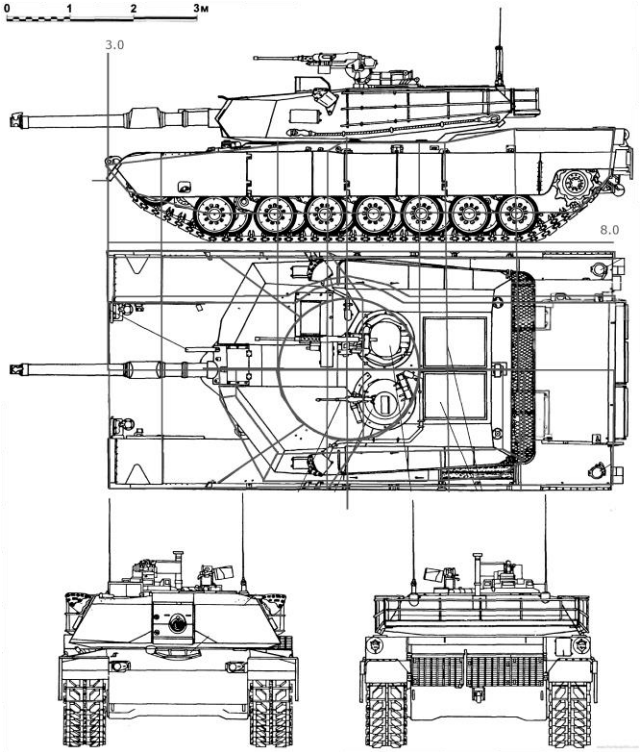
$$v = \frac{V_0}{1 + K_0 \cdot V_0 \cdot ToF}$$

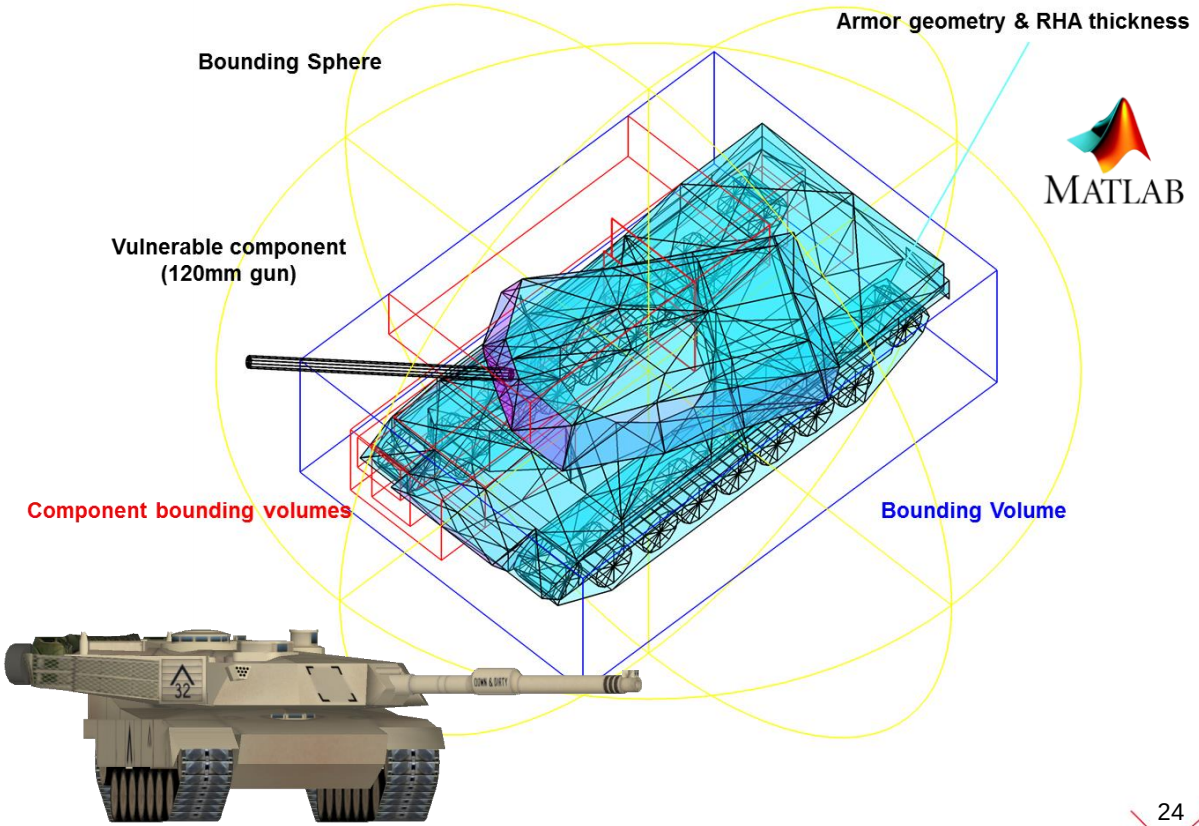
$$s = \frac{1}{K_0} \cdot \log\left[\left(ToF + \frac{1}{K_0 \cdot V_0}\right) \cdot K_0 \cdot V_0\right]$$



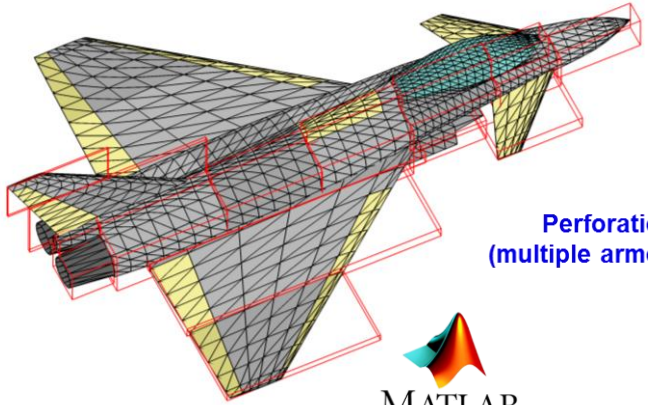


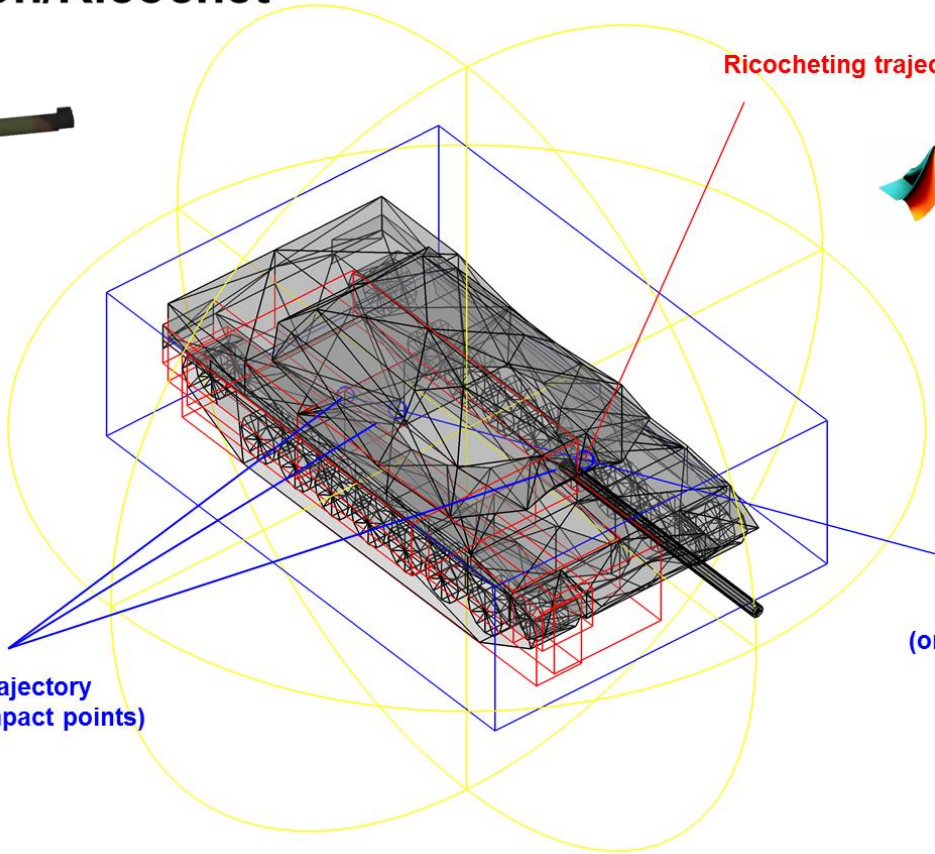
M1A2 Medium Fidelity Tank Model





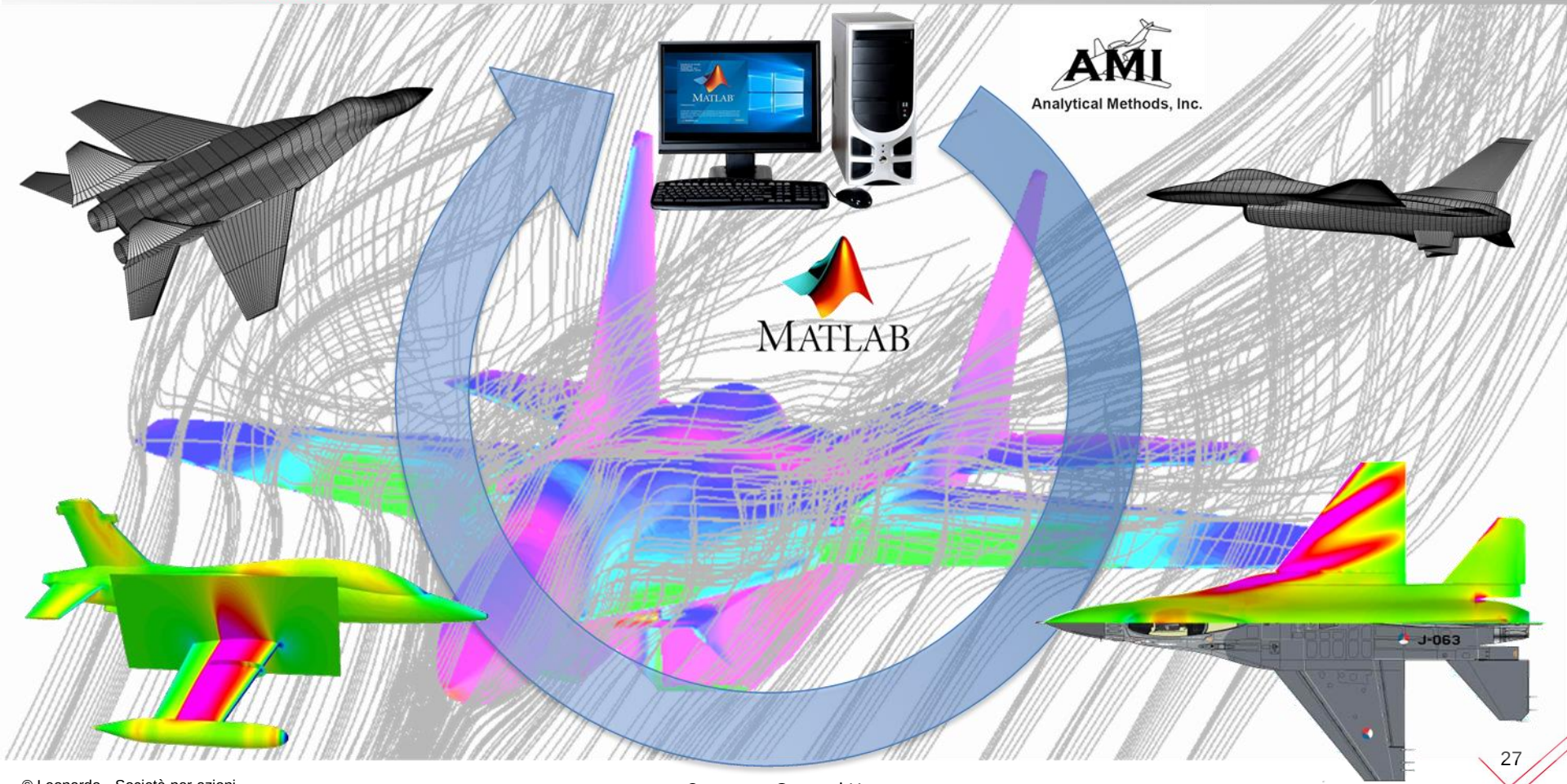
Perforation/Ricochet

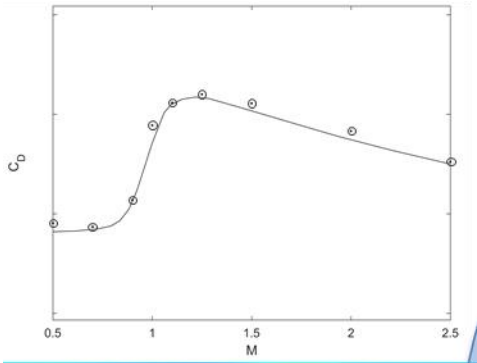


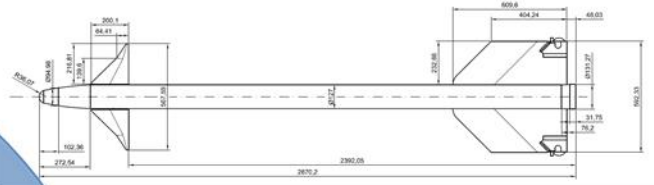


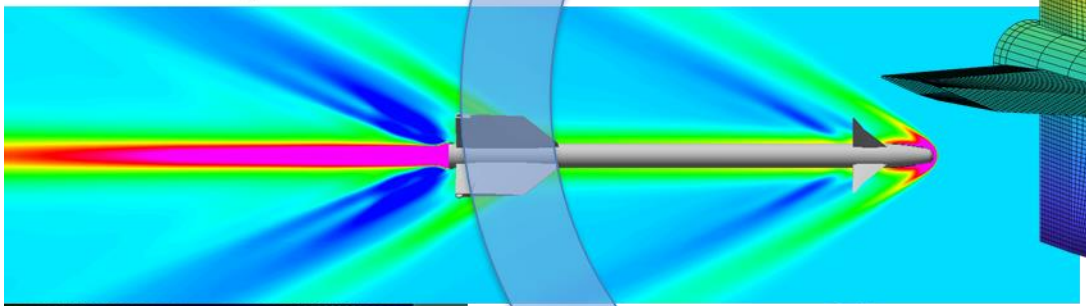
Example: Simulation of Air-to-Air Missiles

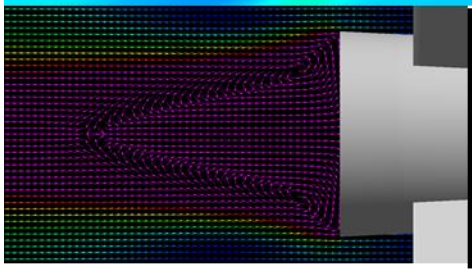
Geometric Modelling for CFD, Dynamics, Seeker and Guidance Model

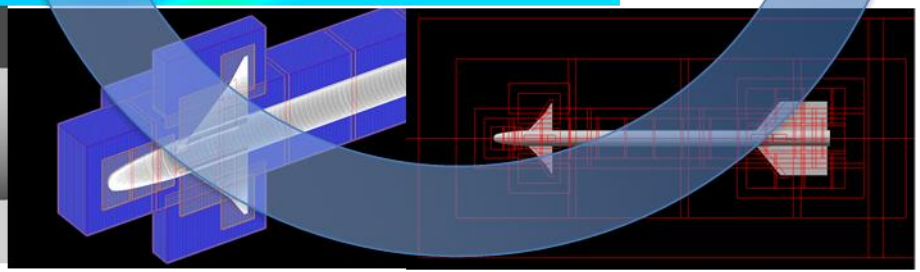












MATLAB

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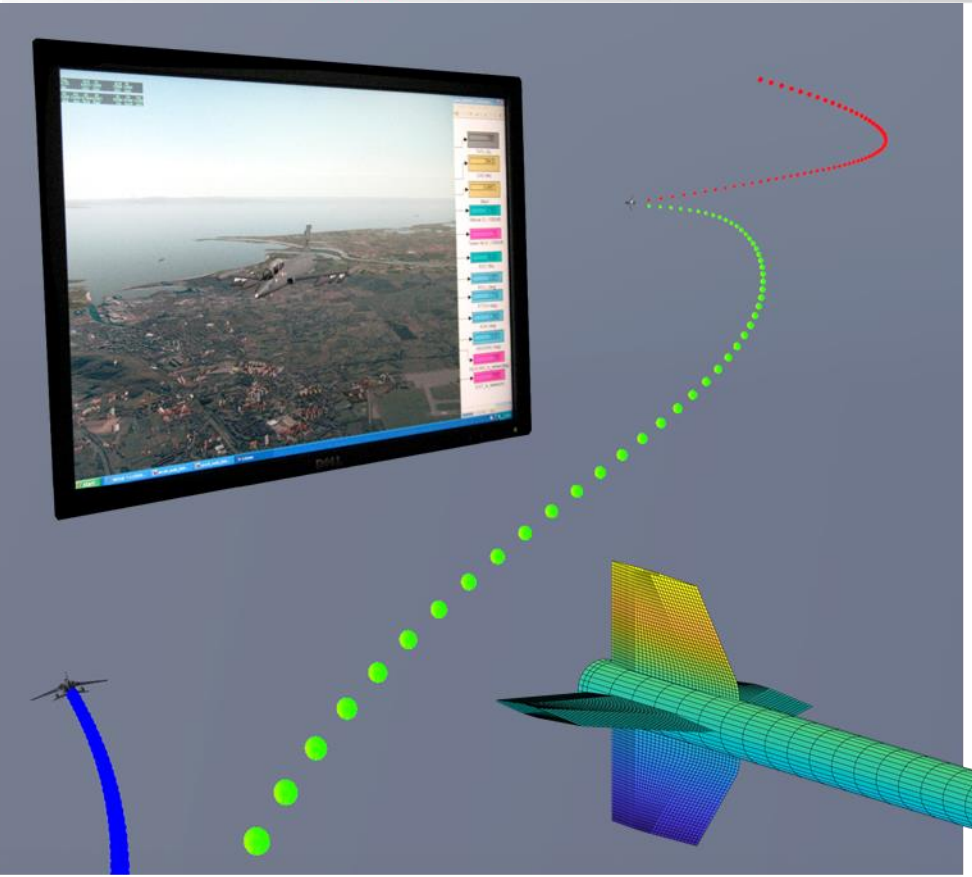
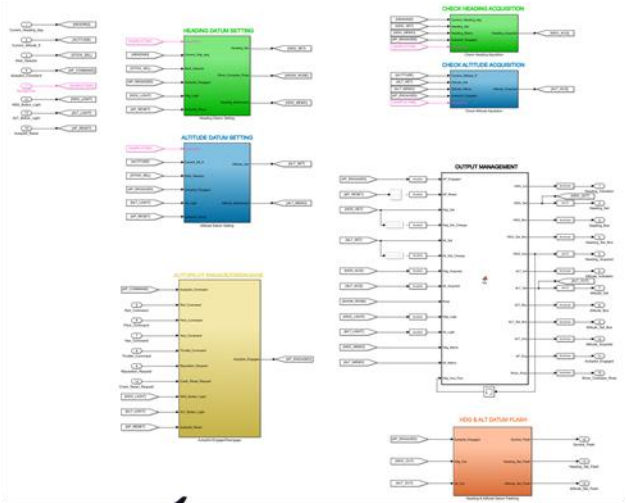
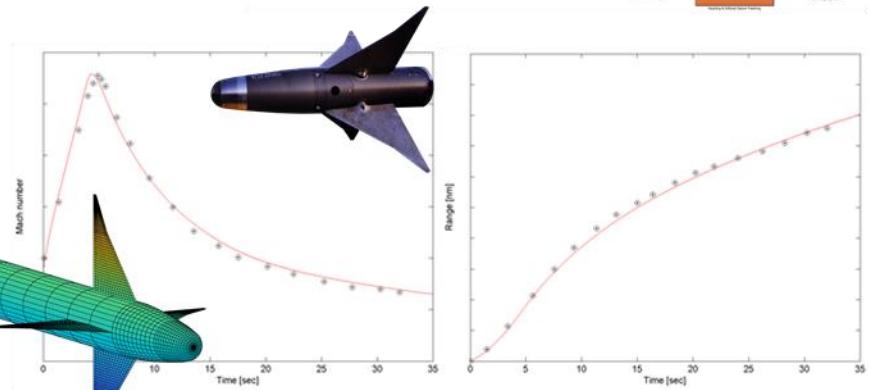


MATLAB SIMULINK

UDP

XPLANE 10





Conclusions

Achievements and further ideas

Achievements and further ideas

1. Cannot say how much we improved our performance … we simply cannot imagine our work without MATLAB & Simulink.
2. The fully integrated toolchain allows large scale projects to be developed in reasonable times but is also highly effective for prototyping and demonstration purposes.
3. After several years of usage and improvement, the building blocks have an high reliability (high number of hours and low bugs rate).
4. Looking forward, we aim to extend the portfolio of toolboxes to better exploit the availability of ready-to-use resources from MathWorks

Point Of Contact:

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THANK **YOU** FOR YOUR ATTENTION

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