Our Ballistic Capabilities

Content

Ballistic Design and Analysis Topics

Ammunition design, optimization and analysis

- *Heavy weapon ammunitions*
- *Small weapon ammunitions*
- *Rocket*

Weapon system/subsystem design, optimization and analysis

- *Howitzer*
- *Tank*
- *Mortar*

Ballistic Capabilities

- Internal Ballistics
- External Ballistics
- Terminal Ballistics
- Projectile/Barrel Design & Design Optimization

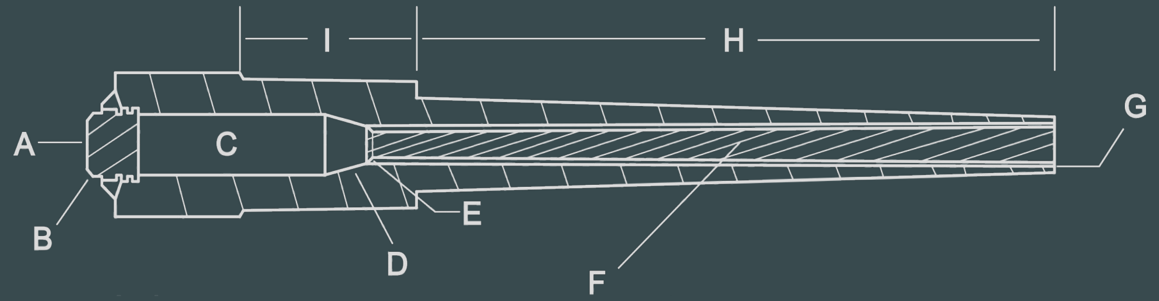
All studies are performed using BALLISTICeda and CAEeda

Internal Ballistics

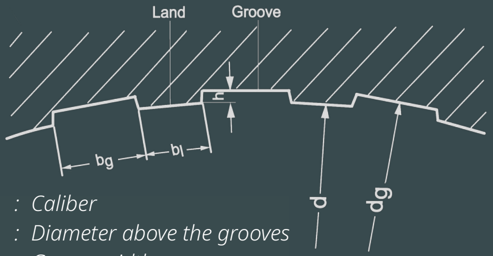
- Computation of propellant burning
- Computation and simulation of projectile motion in a rifled gun bore
- Structural and thermal analysis of gun barrels
- Computational analysis of base-bleed

An example of an internal ballistics application

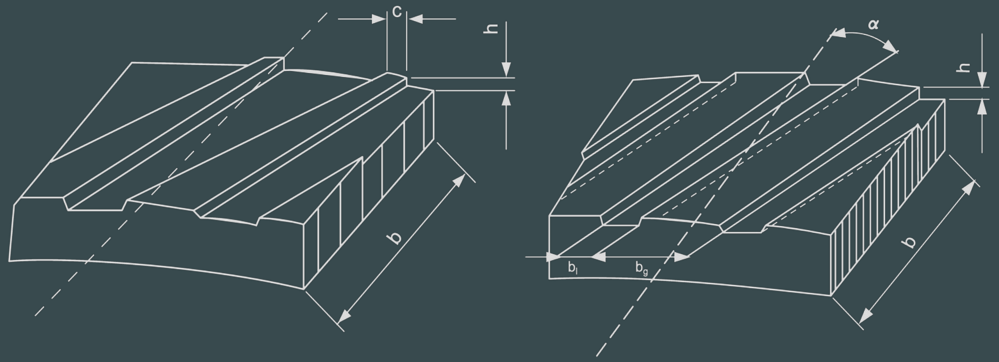
Barrel Geometry



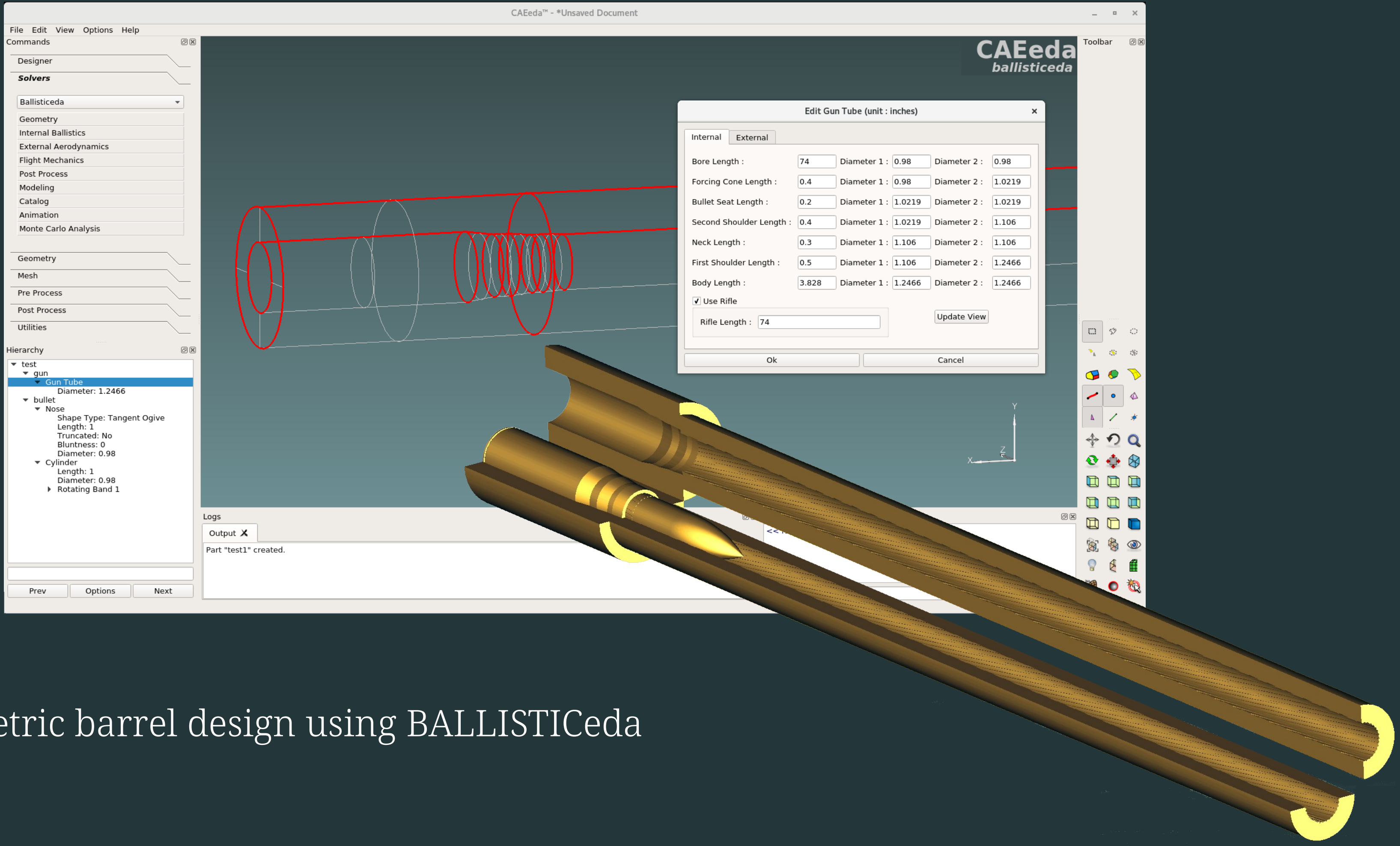
A : Breech
B : Breech block
C : Combustion chamber
D : Shoulder
E : Beginning of lands
F : Rifled bore
G : Muzzle
H : Chase
I : Slide cylinder



d : Caliber
d_g : Diameter above the grooves
b_g : Groove width
b_l : Land width
h : Groove depth
(n = Number of grooves)

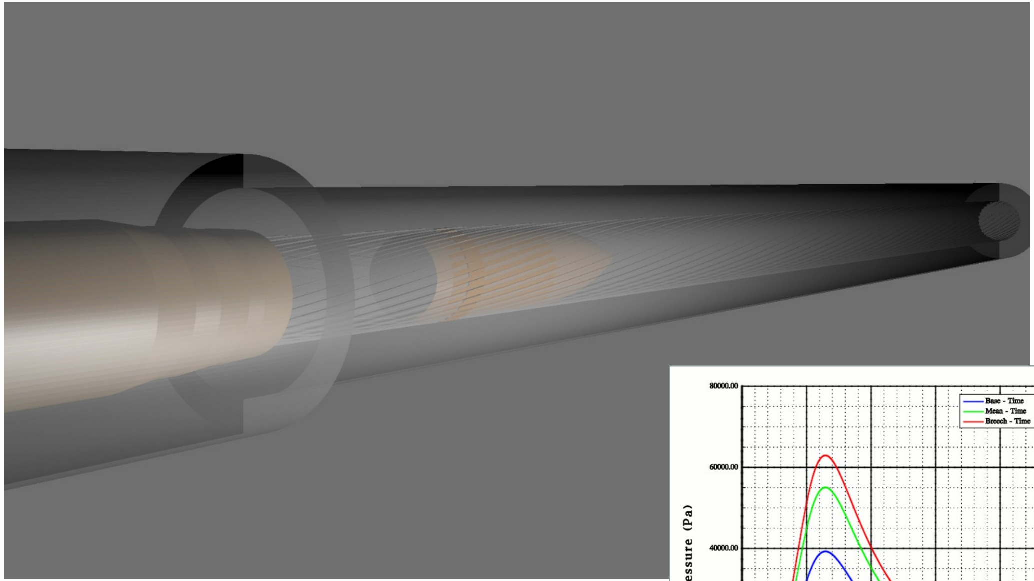


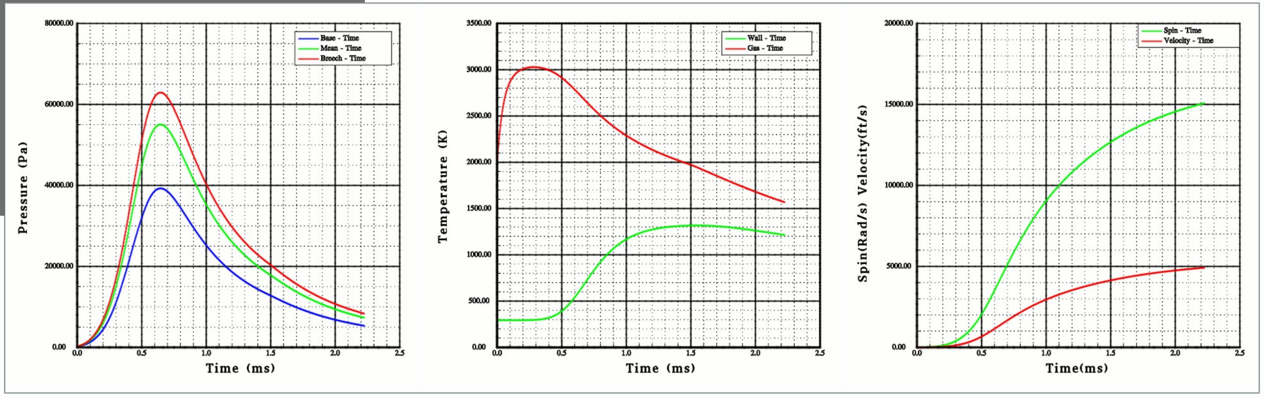
Rifle Parameters



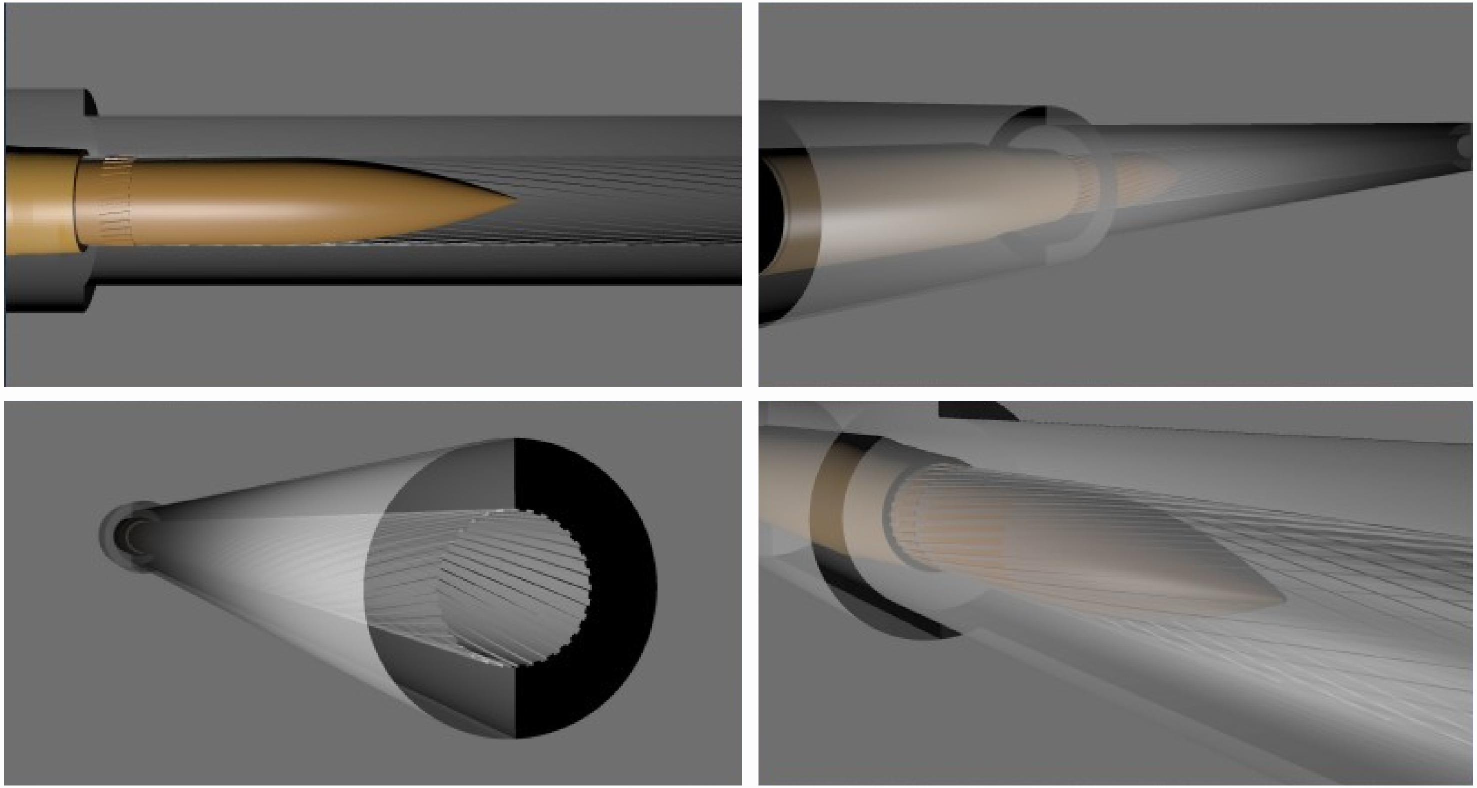
Parametric barrel design using BALLISTICeda

The simulation of projectile motion in a rifled tube



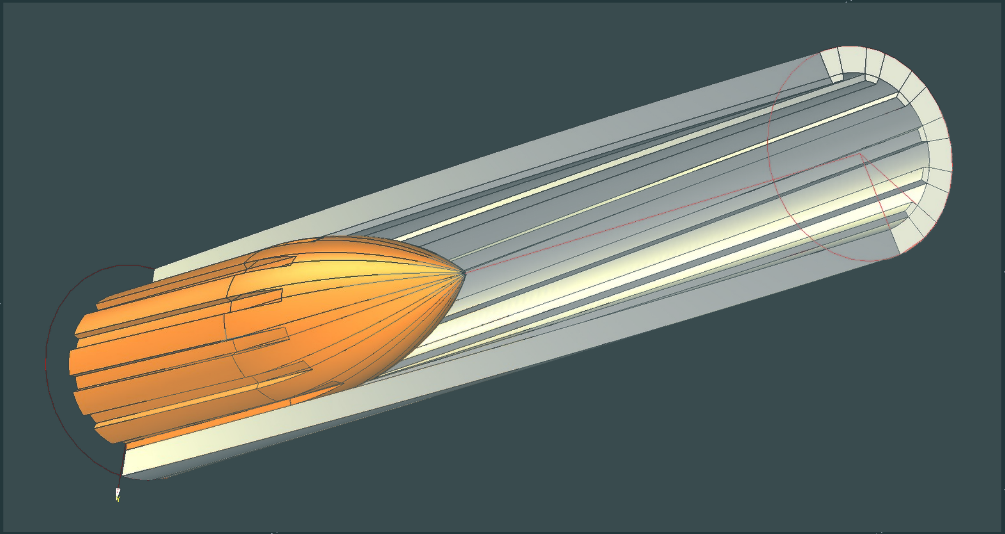


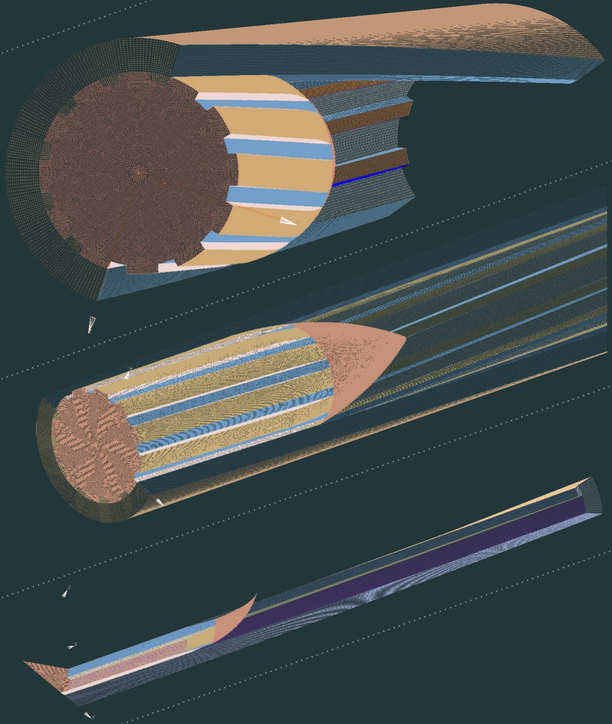
The simulation of projectile motion in a rifled tube



Internal Ballistics - Structural Mechanics Interaction

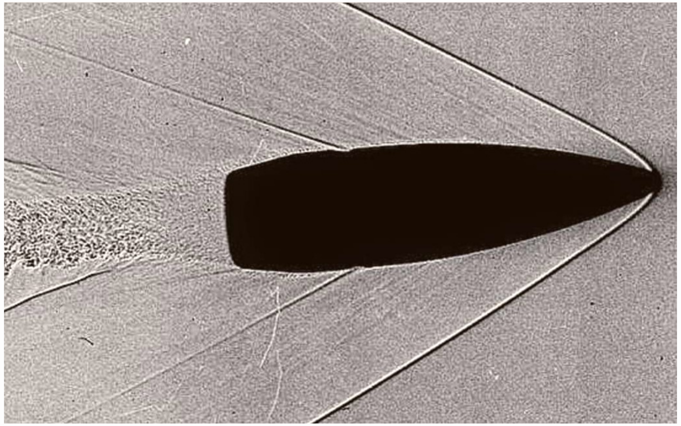
Method : Dynamic mesh coupling



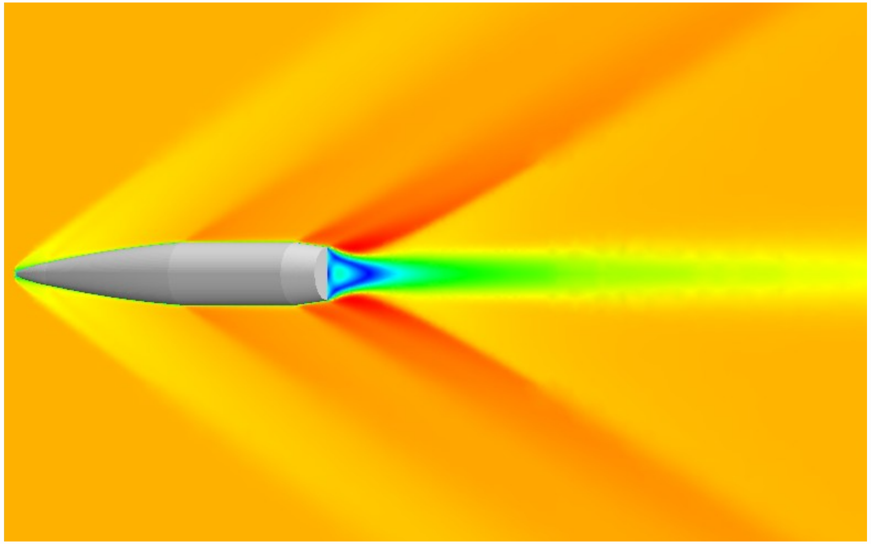


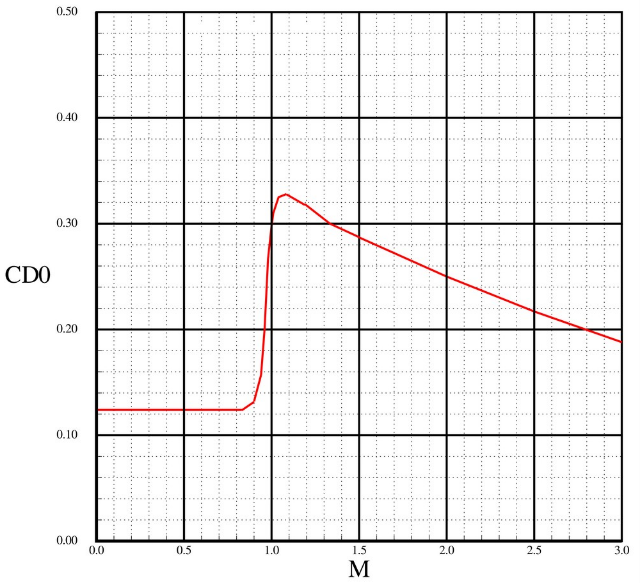
External Ballistics

- Calculation of aerodynamic coefficients (static and dynamic) of projectiles and missiles using engineering methods and CFD
- Flight simulation of spinning missiles and projectiles by using aerodynamic tables or CFD coupling
- Extraction of aerodynamic coefficients from radar data

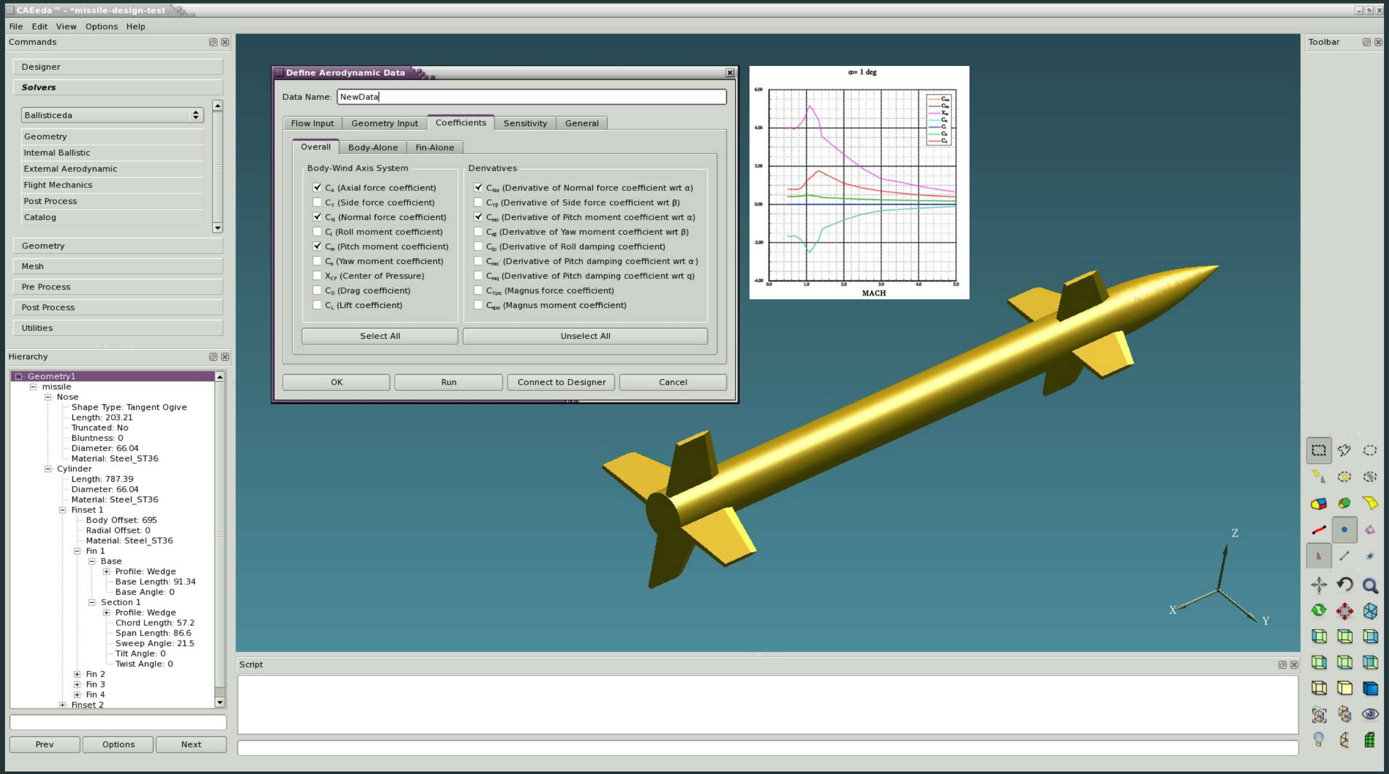


Calculation of aerodynamic coefficients using FAPeda (CFD module of CAEeda)

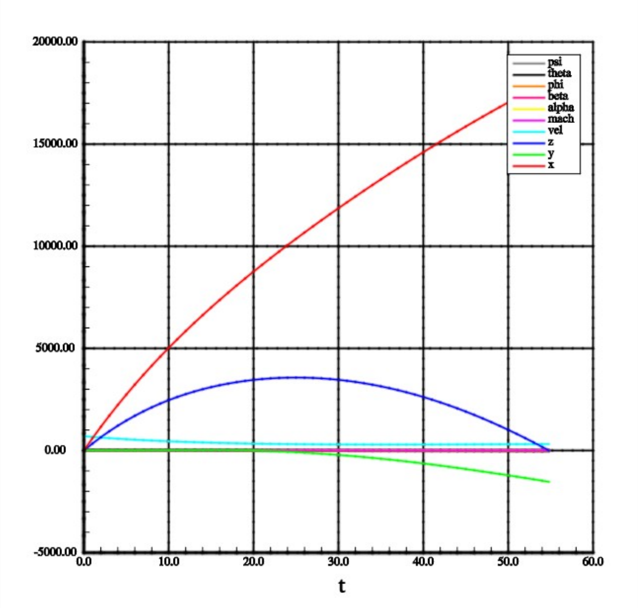


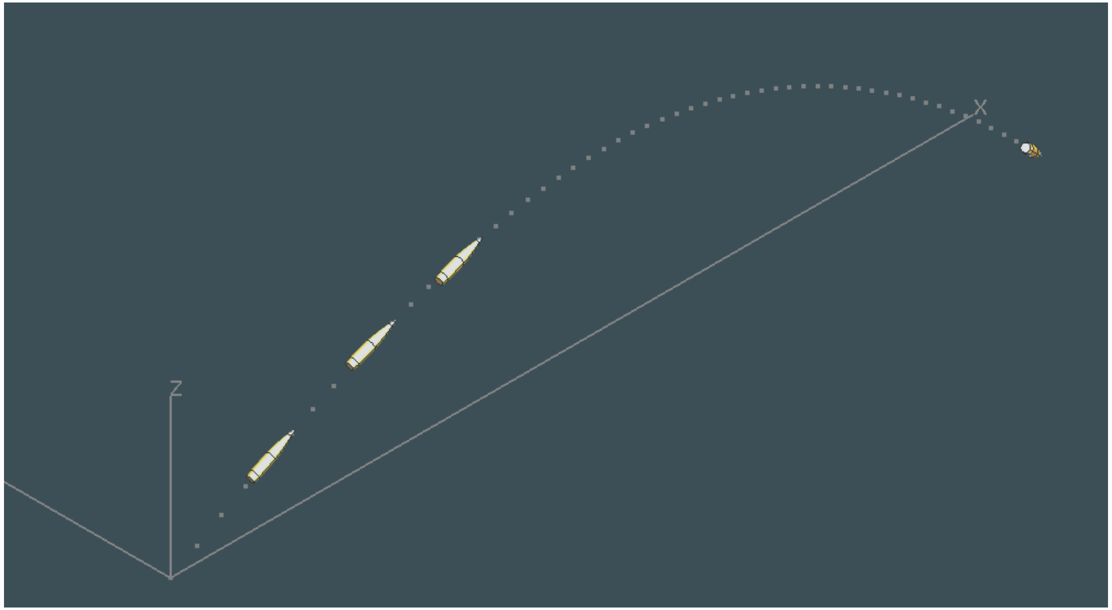


Calculation of aerodynamic coefficients using engineering methods (BALLISTICeda)



Flight mechanics simulations using BALLISTICeda





Terminal Ballistics

- Dispersion analysis
- Hit target analysis

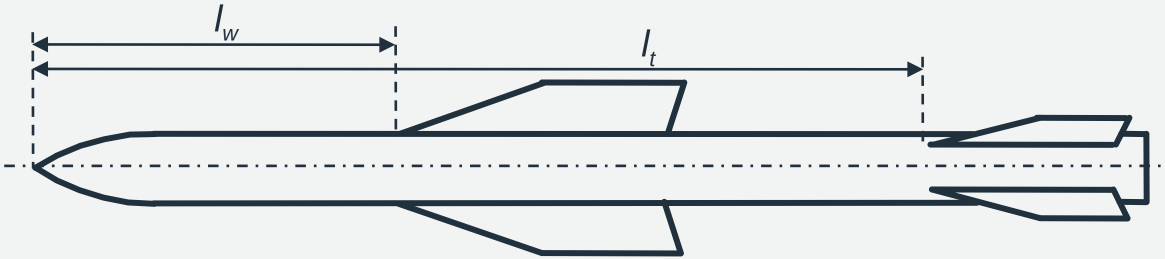
Projectile and Barrel Design & Design Optimization

- Aerodynamic shape optimization of projectiles
- **Design and optimization** of kinetic energy projectiles
- Sabot design
- Structural/thermal design and optimization of barrels

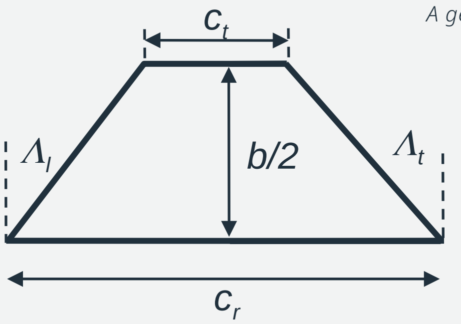
Example : Airframe shape optimization for range maximization

Missile Design Optimization Using Genetic Algorithm

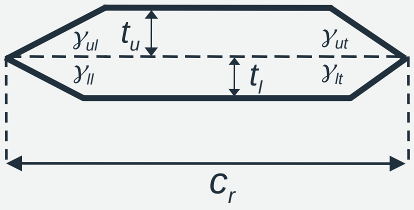
Design Parametrization



A generic missile geometry

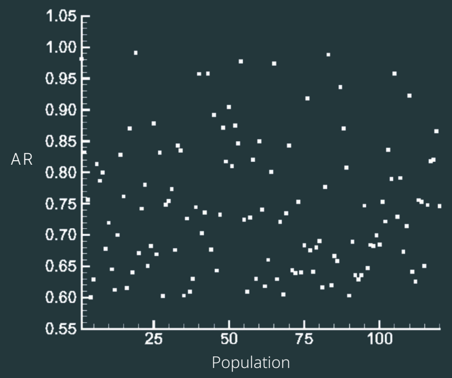


Horizontal cross-section of wing and tail fin

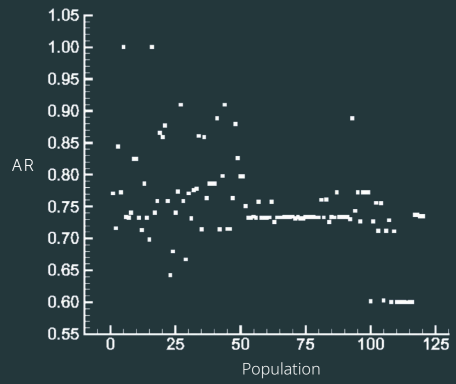


Vertical cross-section of wing and tail fin

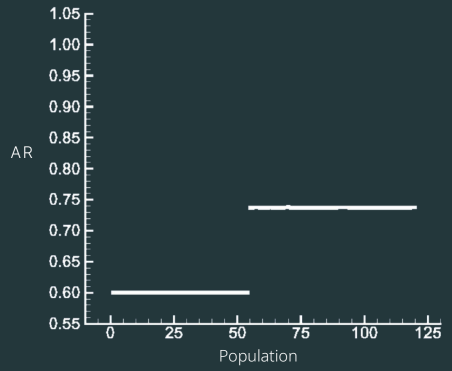
Design Steps



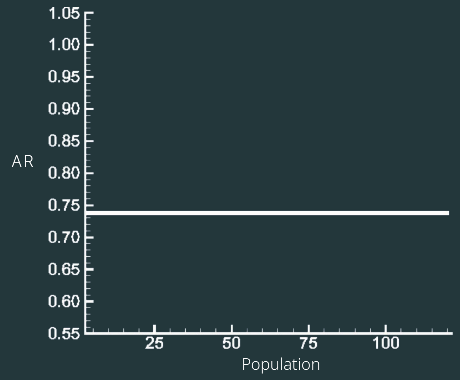
(1) Initial aspect ratio of the missile tail fin



(2) Intermediate aspect ratio of the missile tail fin



(3) Intermediate aspect ratio of the missile tail fin



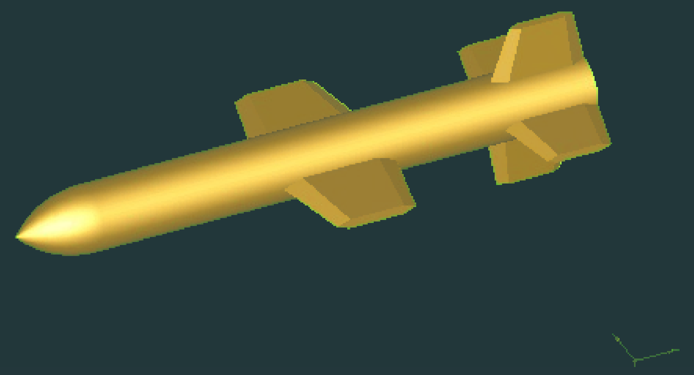
(4) Optimum aspect ratio of the missile tail fin

CAD, MESH, CFD Coupling for Design Automation and Optimization

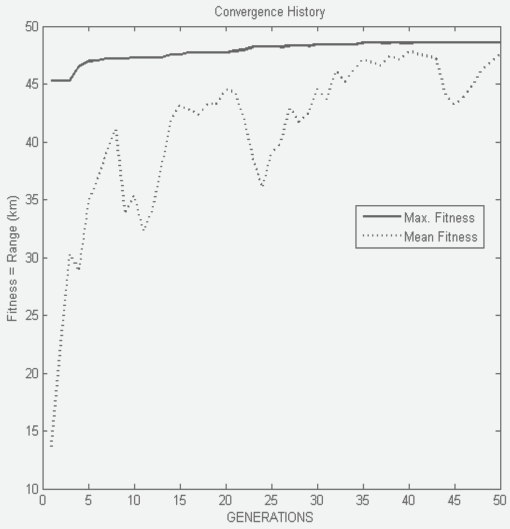
Sample Application : Wing and Tail Shape Optimization to Extend the Range of a Missile

Final Design

Design Parametrization



Objective : Maximum range
Fixed geometries : Nose and body
Variable geometries : Wing and tail fins
Starting range : 45 km
Final range : 48 km



Our Ballistic Design Approach

Objectives & Constraints
Performance criteria *Desired range* *Desired CEP* *Desired efficiency* *Weapon compatibility*
Cost & time limits of project

Design Stages
Conceptual design
Preliminary design
Detail design
Firing tests

The Scope of Ballistic Design & Analysis

- Geometric modeling
- Aerodynamic analysis
- Internal ballistic analysis
- Flight mechanics analysis
- Structural mechanics analysis
- Thermal analysis
- Optimization
- Design automation
- Post processing (plots & animations)

Tools and Methods Used

- Geometric modeling
  - *Automatic and parametric 2D & 3D CAD modeling using the Geometry Module of CAEeda*
  - *Automatic and parametric projectile & missile modeling using the Geometry Module of BALLISTICeda*
- Aerodynamic analysis
  - *Rough engineering solutions using the Aerodynamics module of BALLISTICeda*
  - *Precise CFD solutions using FAPeda module of CAEeda code*
- Internal Ballistic Analysis
  - *Rough engineering solutions using the Intenal-Ballistics module of BALLISTICeda*
  - *Precise CFD solutions using the FAPeda module of CAEeda*
- Flight Mechanics Analysis
  - *3DOF, Modified Point Mass, 5DOF, 6DOF solutions using Flight Mechanics module of BALLISTICeda*
- Structural mechanics analysis using the SAPeda module of CAEeda
- Heat transfer analysis using the TAPeda module of CAEeda
- Design optimization by designer module of CAEeda
- Post processing using POSTeda module of CAEeda

Thank you

EDA Engineering Design & Analysis