CFD process at MBDA GE and possibilities for high-order methods
Michael Wurst, 06/19/2020
MBDA is a leading global company with a top level of national presence.

USA
- Westlake (CA)
- Huntsville (AL)
- Washington D.C.
- Orlando (FL) (MEADS Int.)

South Korea
- Seoul

Europe
- Lostock/Bolton
- Stevenage
- London
- Bristol
- Compiègne
- Le Plessis-Robinson
- Region Centre
- Madrid
- Ulm
- Schrobenhausen
- Aschau
- La Spezia
- Rome
- Fusaro

> 11,500 employees
€3.7 billion sales in 2019

3 shareholders:
- Airbus
- BAE Systems
- Leonardo
The European systems house for guided missile systems

Ground Based Air Defence
- TLVS

Air Defence
- Meteor
- Taurus

Battlefield Engagement
- Enforcer
- Ground support

Maritime Superiority
- RAM
Characterization of flow conditions and requirements for CFD solvers

- High velocity range (subsonic, transonic, supersonic, hypersonic)
- Different flight altitudes (low level, higher atmosphere)
- Different flight conditions (angle of attack, roll angle, rudder deflection)
- Chemical reacting flow / multiphase flow (engine, attitude control systems)
- Steady / unsteady flow

- Robustness in all velocity regimes
- Shock capturing
- Turbulence modeling
- Transition modeling

- Rarefied gas dynamics

- High prediction quality (e.g. for high $\alpha$)
- Automatisation

- Real gas modeling
  - Non-equilibrium flow with chem. reactions

- Fast convergence
  - Rigid body movement
  - Deformation
CFD tool chain

- Cadfix (CAD cleaning)
- Different meshing tools
- CFD solver: TAU (DLR)
- Post-processing: Tecplot / Python / Matlab
- Linux cluster with > 4000 cores
- Files server > 350TB
- Infiniband network
CFD solver: TAU solver from DLR

- 2nd order FV solver
- Central and upwind scheme (Roe, AUSM, van Leer, ...)
- RANS solver (k-w SST, SA, (algebraic) Reynolds stress, ...)
- Unsteady simulation with dual-time stepping
- Multigrid acceleration

- Unstructured hybrid solver
- Local adaptation possible (shocks, y+)
- Parallelized (domain decomposition)

- Chimera method
- Grid deformation
- Rigid body movement
- Non-equilibrium gas with chemical reactions

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Battlefield engagement: CFD for calculation of aerodynamic datasets

Generation of aerodynamic datasets of missiles:
- >200,000 data points / operating conditions
- Different angle of attacks, roll angles, rudder deflections
- Analysis of dynamic derivatives
- Analysis of loads / bending moments
Ground based air defense: Interceptor design

Interceptor missiles driven by high manoeuvrability

- Attitude control
- Aerodynamic devices
- Thrust vector control

- Wind tunnel tests almost not possible
- How to design such a system?
- Influence on wings / fins?
- Aerodynamic datasets needed
- Modeling challenges (geometrical / physical)

PAC 3 MSE (TLVS)
MBDA Aster missile
Ground based air defense: Interceptor design, CFD study with TAU

- 4 Nozzles
- Supersonic regime
- Different flight altitudes
- $k-\omega$ Wilcox SST
- High angles of attack (>20°)

Increasing flight altitudes
Ground based air defense: Threat analysis

Kinzhal missile

Hypersonic glide vehicle

Temperature of flow at different altitudes at Mach ≈ 20
Ground based air defense: Analysis of IR signature

- Analysis of thermal heating / plume characteristics of threats
Different design drivers:
- Endurance / range
- Speed
- Stealth design
- Agility
- Flight altitude

Simulation of missiles / cruise missiles:
- Accurate prediction of aero datasets
- Influence of inlets (ramjet / turbojet)
- Influence of engine jet

Release of missiles / separation of different stages (e.g. Booster):
- Quasi-steady approach
- Full unsteady approach (Chimera grids)
• CFD is essential for missile design, reduced costs and development time
• Many problems / tasks can be solved with high quality / accuracy
• Possible applications of high-order methods:
  • Vortex-dominated flows
    • Interaction of wing / body vortices on rudders
    • Combustion / mixing, e.g. ramjet propulsion
    • Missile release from helicopter
  • Physics-dominated flows
    • Attitude control systems (Jet in cross-flow)
    • Engine jets (Mixing layers)
    • Transition prediction
Thank you! Questions?

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