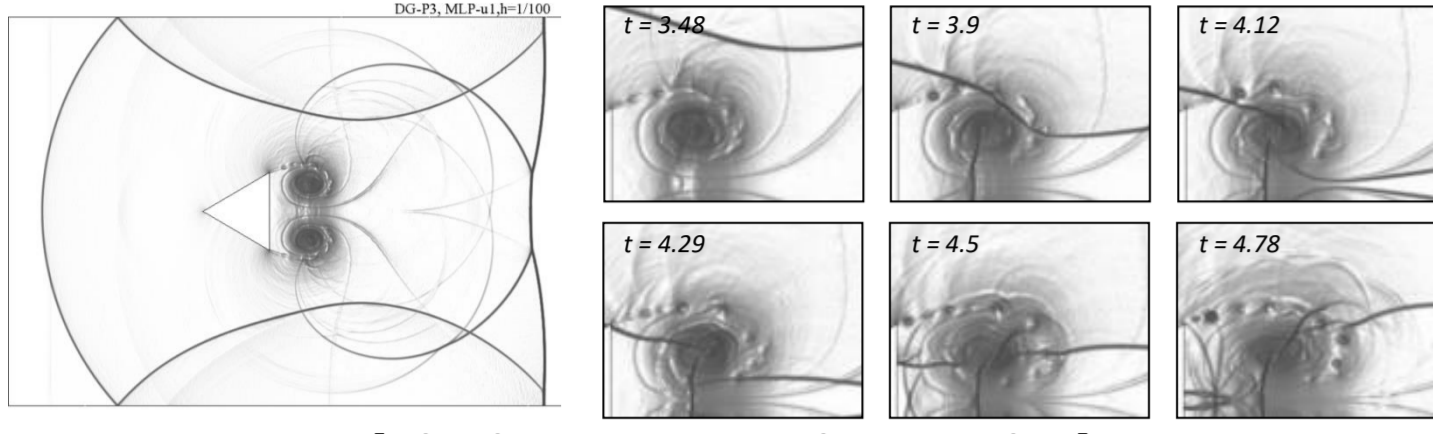
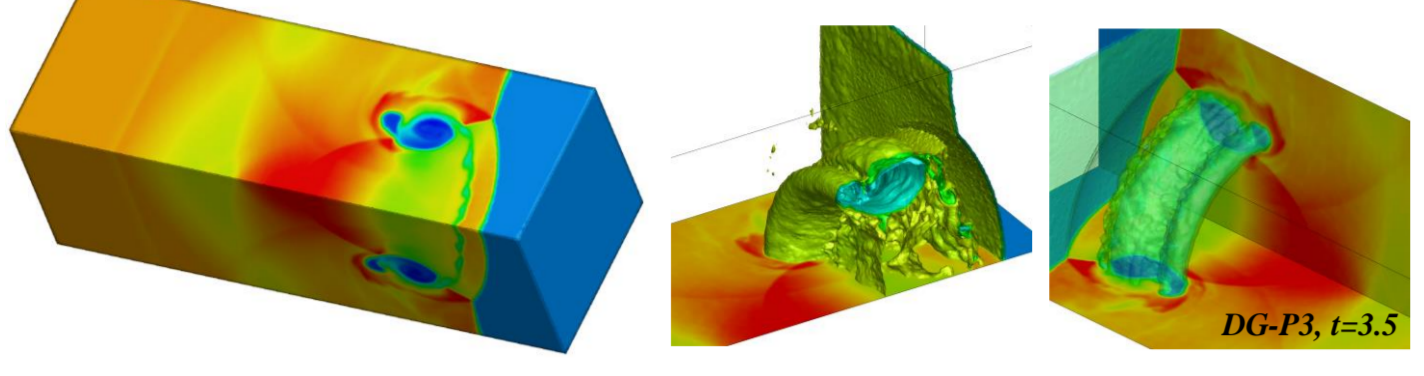


High-Order Methods for Conservation Laws

High-order Shock-capturing Schemes

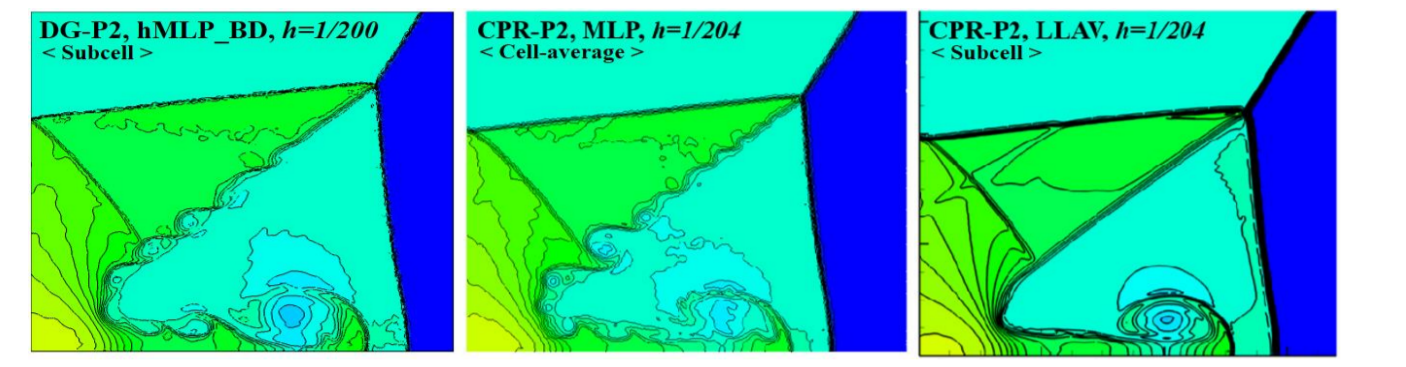


[Shock interaction with 2-D wedge]

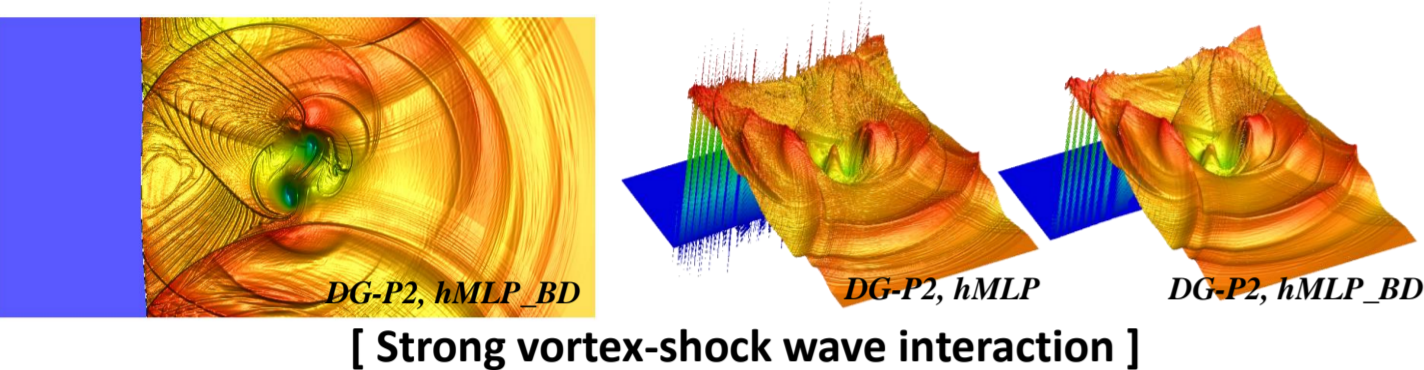


[3-D interaction of shock wave with density bubble]

Subcell Resolution for High-order Methods

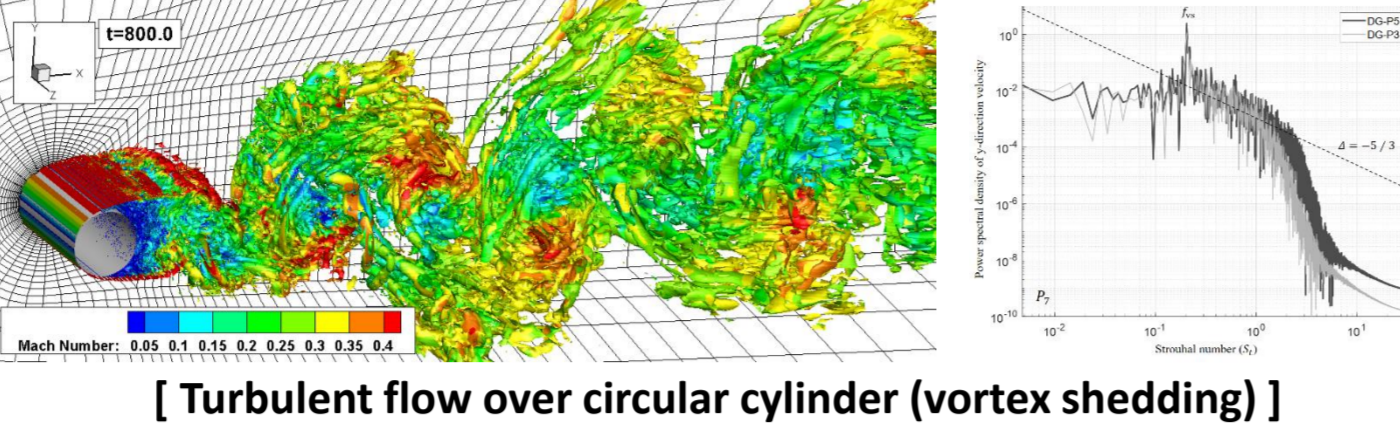


[Strong shock interaction with 2-D wedge (double Mach reflection)]

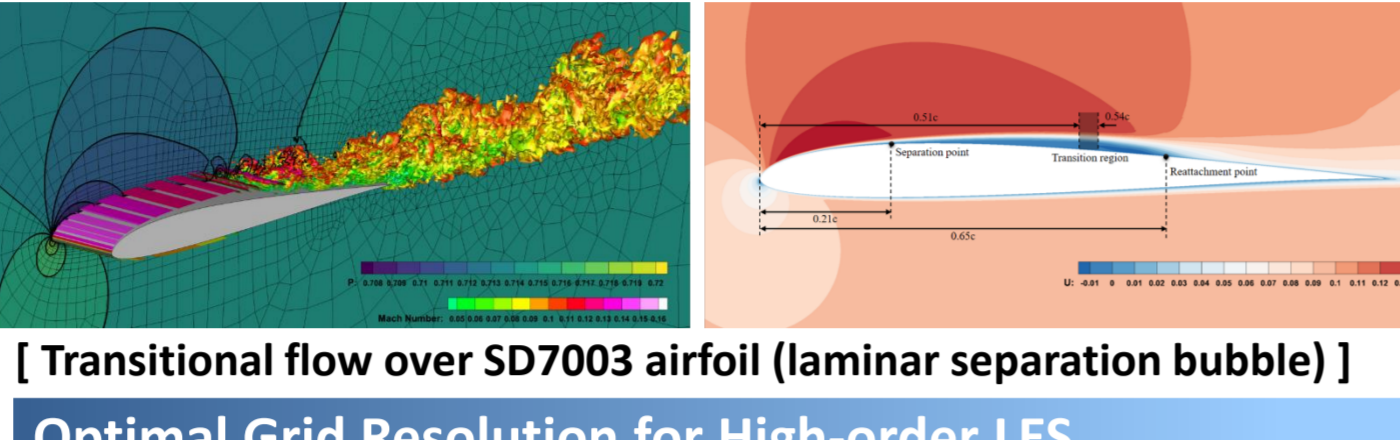


[Strong vortex-shock wave interaction]

Direct Reconstruction Method(DRM) for Discontinuous Galerkin

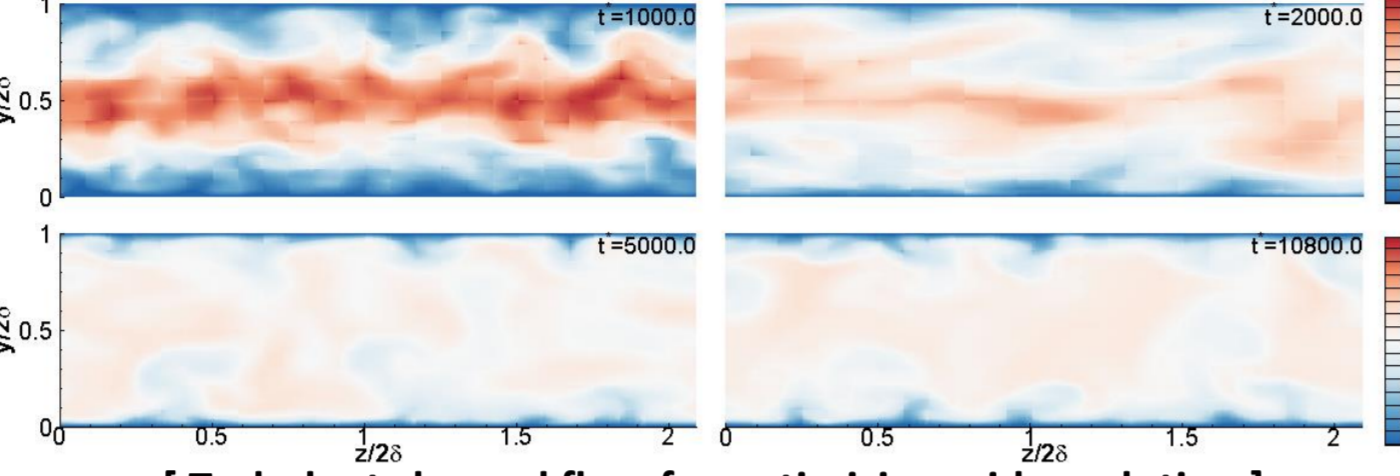


[Turbulent flow over circular cylinder (vortex shedding)]

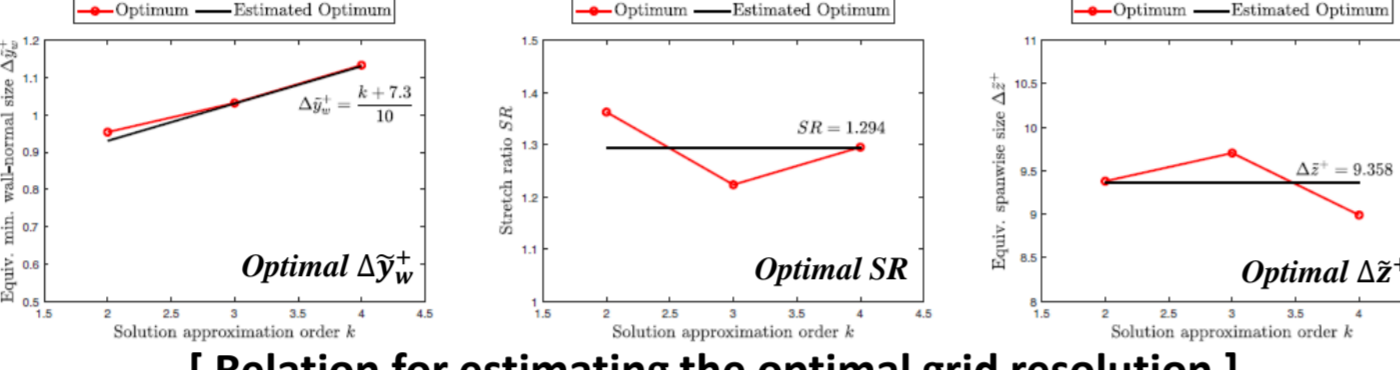


[Transitional flow over SD7003 airfoil (laminar separation bubble)]

Optimal Grid Resolution for High-order LES



[Turbulent channel flow for optimizing grid resolution]

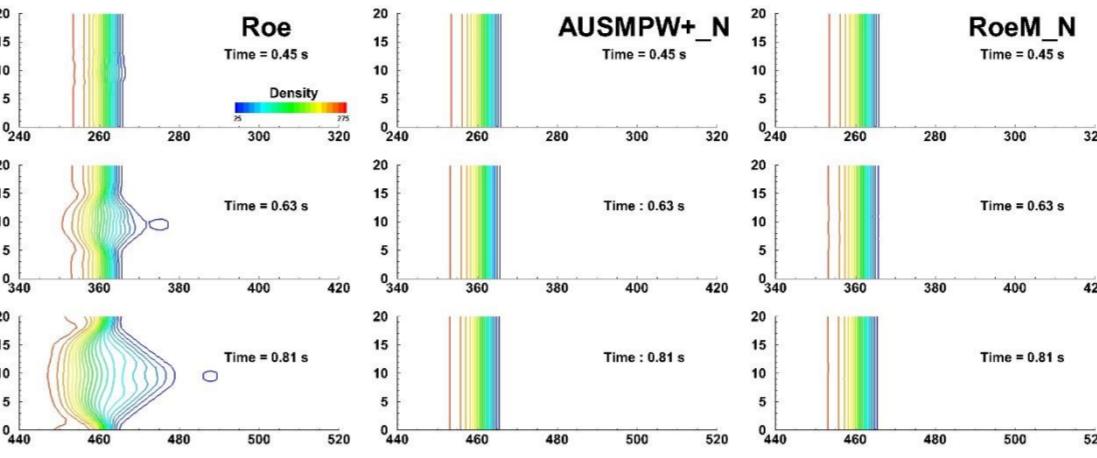


[Relation for estimating the optimal grid resolution]

All-Speed Compressible Multiphase Flows

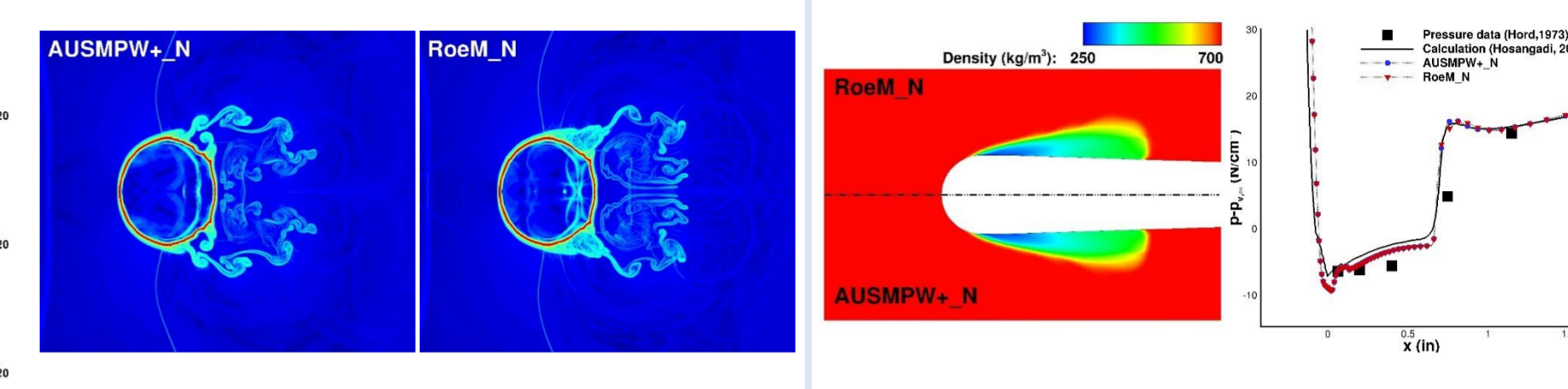
Numerical Methods for All-speed Multiphase Real Fluid Flows: AUSMPW+_N, RoeM_N

1. Shock stability in multiphase flows



[Quirk's odd-even decoupling test]

2. Multiphase real fluid flows

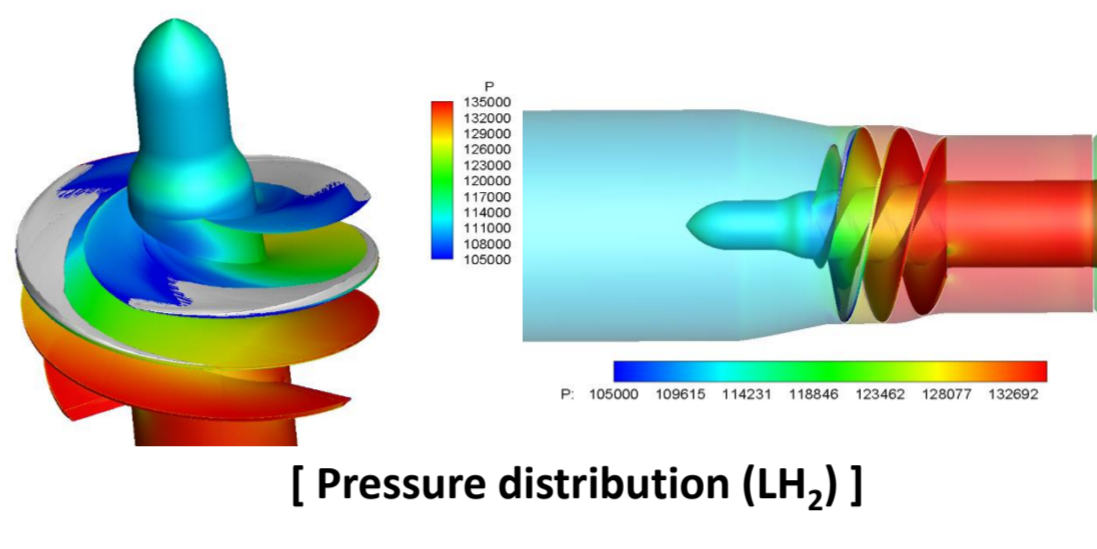


[Shock-water column interaction]

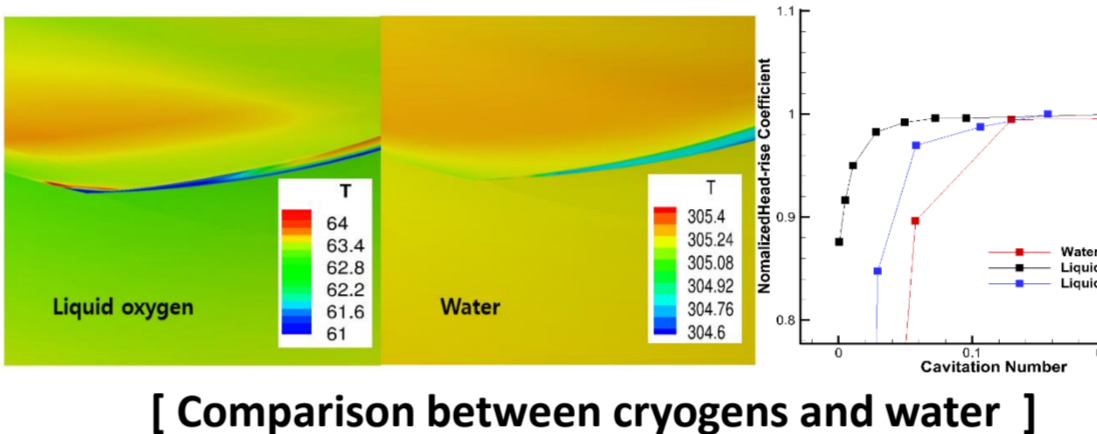
[Cryogenic cavitation around hydrofoil]

Applications of All-speed Multi-phase Real Fluid Flows

1. Cryogenic cavitation of turbopump inducer

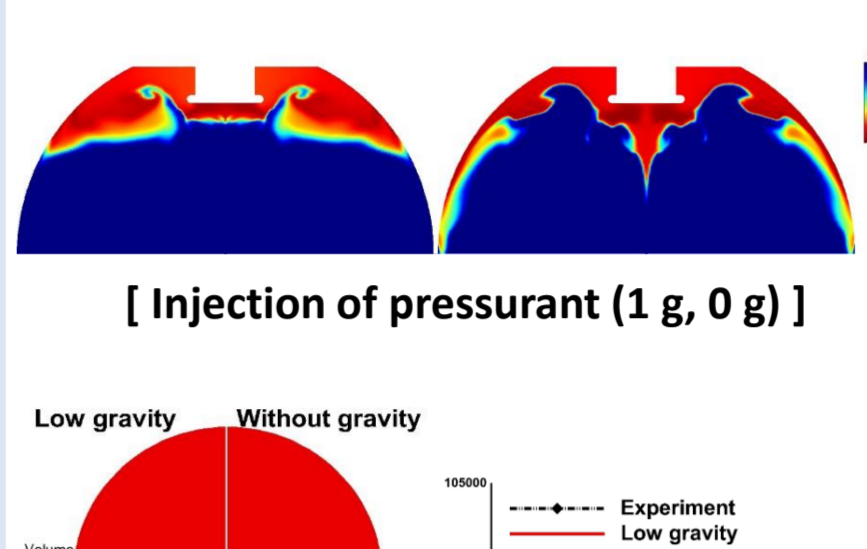


[Pressure distribution (LH₂)]

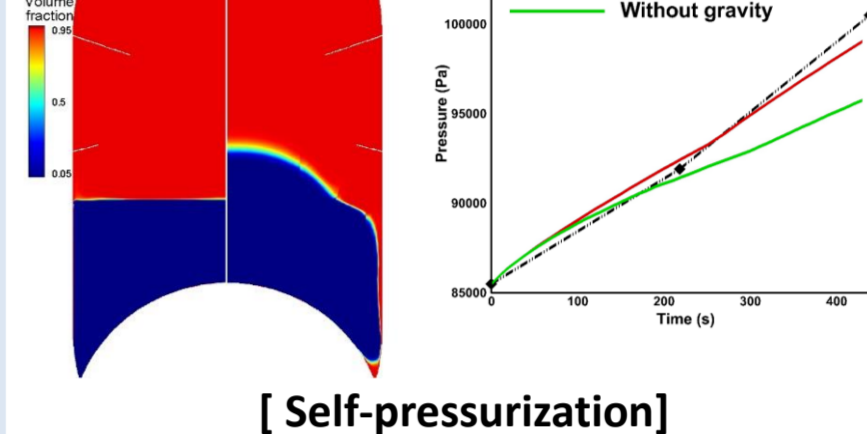


[Comparison between cryogenics and water]

2. Pressurization in liquid rocket tank

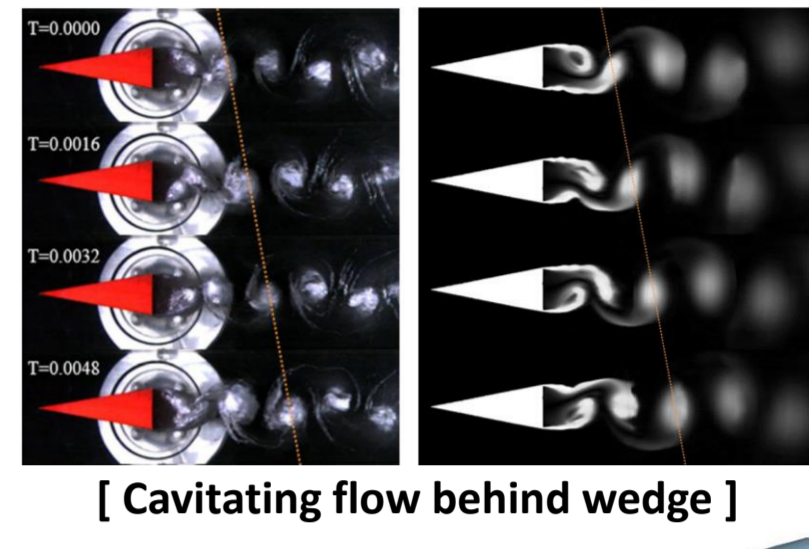


[Injection of pressurant (1 g, 0 g)]

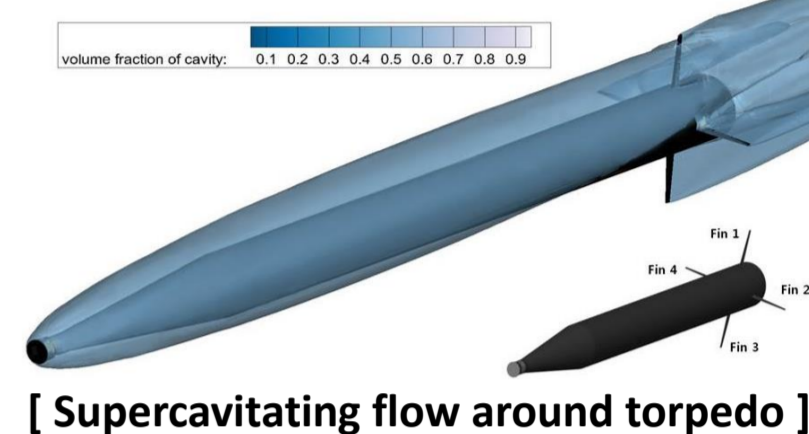


[Self-pressurization]

3. High-speed underwater vehicle



[Cavitating flow behind wedge]

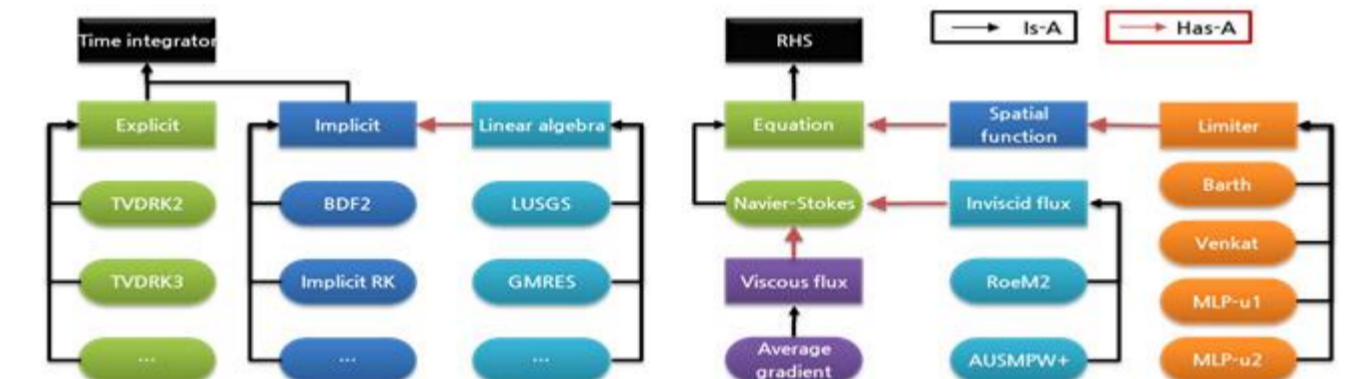


[Supercavitating flow around torpedo]

High Performance Code Development & Applications

High Performance In-house Code Development

1. Code structure based on Object-Oriented Programming



2. ACTFlow ver. 2.0 - Finite Volume Method (FVM)

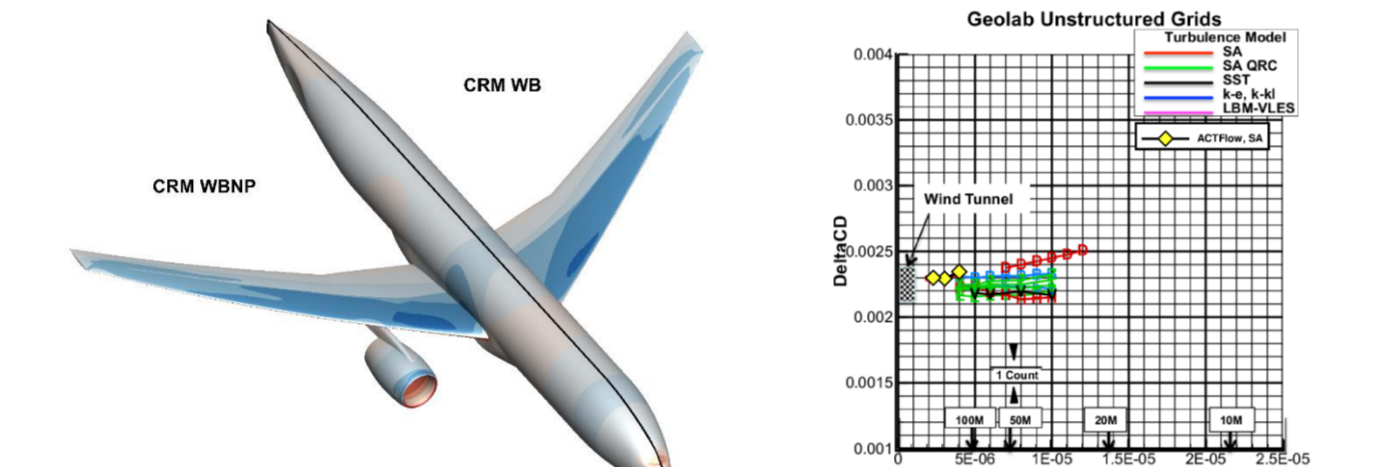
Compressible Full Navier-Stokes	
Grid	Cell-centered unstructured mixed-element grid
Flux	RoeM, AUSMPW+, Roe, AUSM+up
Space Discretization	Limiters: MLP-u1, MLP-u2, Barth, Venkatakrishnan Low Mach scaling for flux schemes
Time Discretization	Euler explicit, multi-stage RK, BDF2, Implicit RK Linear algebra: GMRES with preconditioner (DILU, ILU, LUSGS)
Acceleration Techniques	Local time stepping Low Mach Preconditioning for all-speed flow
Turbulent Model	SA, k-w SST, Hybrid RANS/LES, etc.
Boundary Condition	Farfield, inflow, outflow, mass flux, etc.
Parallelization	MPI with automatic grid decomposition for load balancing Parallel data writing process using MPI I/O (HDF5 + CGNS)

3. Deneb ver. 1.0 - High-order Method (HOM)

General Hyperbolic Conservation Laws with Diffusion Term	
Grid	Cell-centered unstructured high-order curved & mixed grid
Space Discretization	Space: Discontinuous Galerkin with direct reconstruction method Explicit Time: Euler, TVDRK, SSPRK Implicit Time: Euler, Rosenbrock-type RK, MBDF, TIAS
Limiters	hMLP, hMLP_BD
Parallelization	MPI with automatic grid decomposition for load balancing Parallel data writing process using MPI I/O

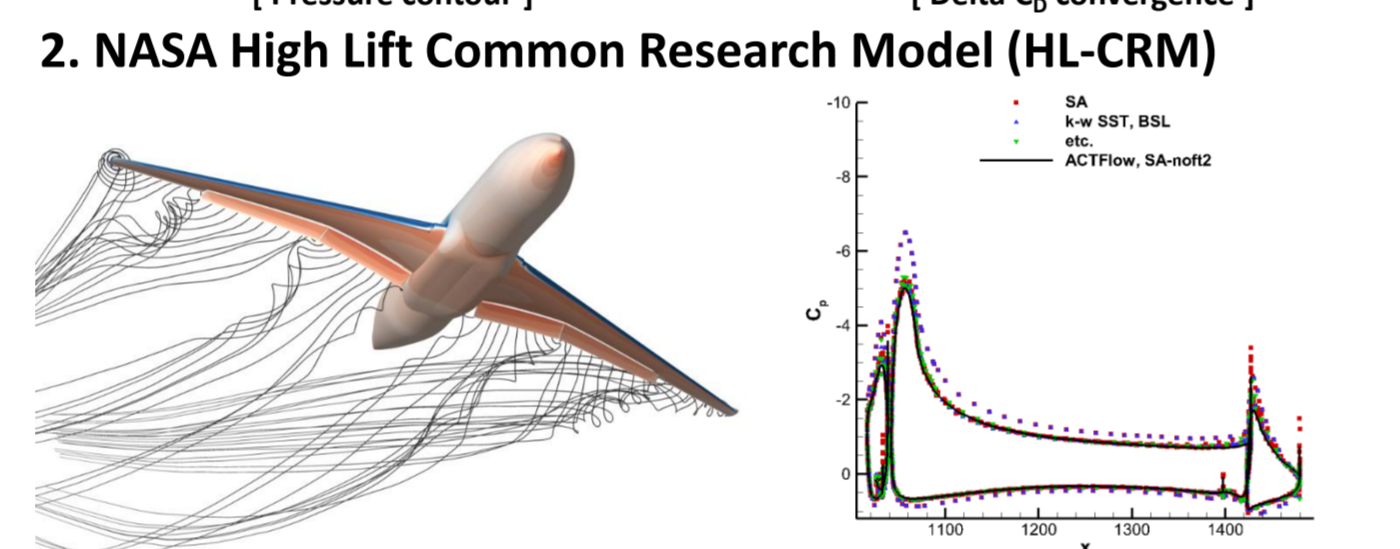
In-house Code Performance Assessment

1. NASA Common Research Model (CRM)



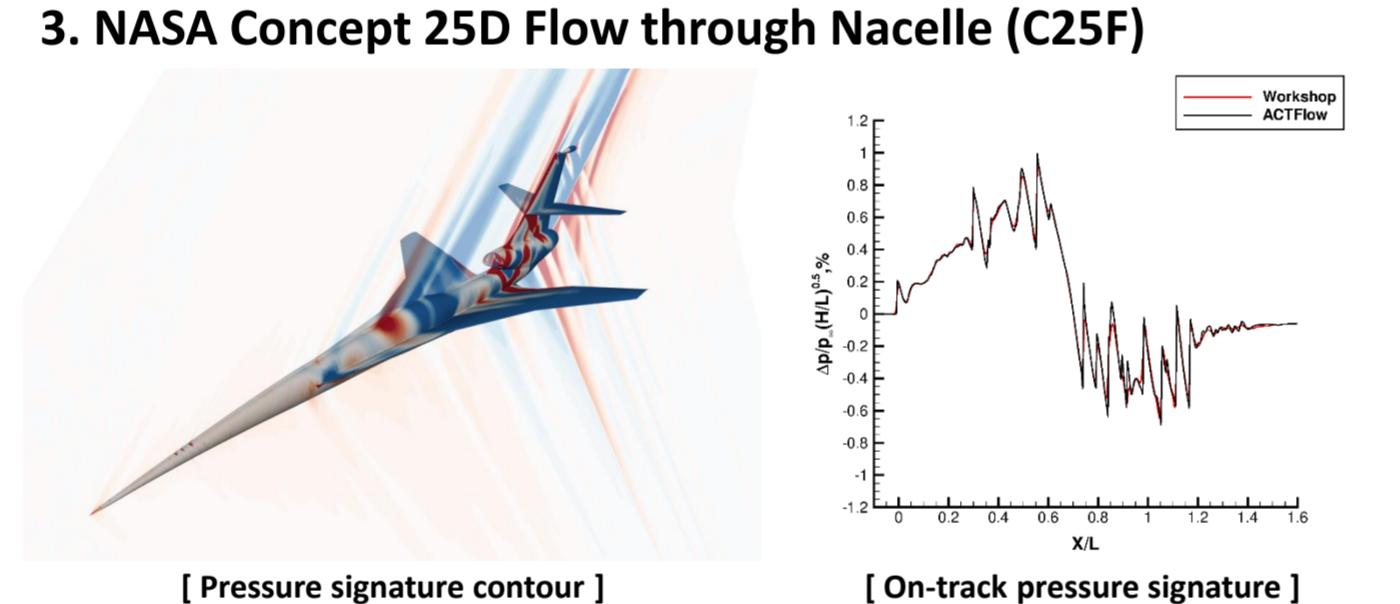
[Pressure contour]

[Delta C_p convergence]



[Pressure contour]

[C_p curve at wing section]



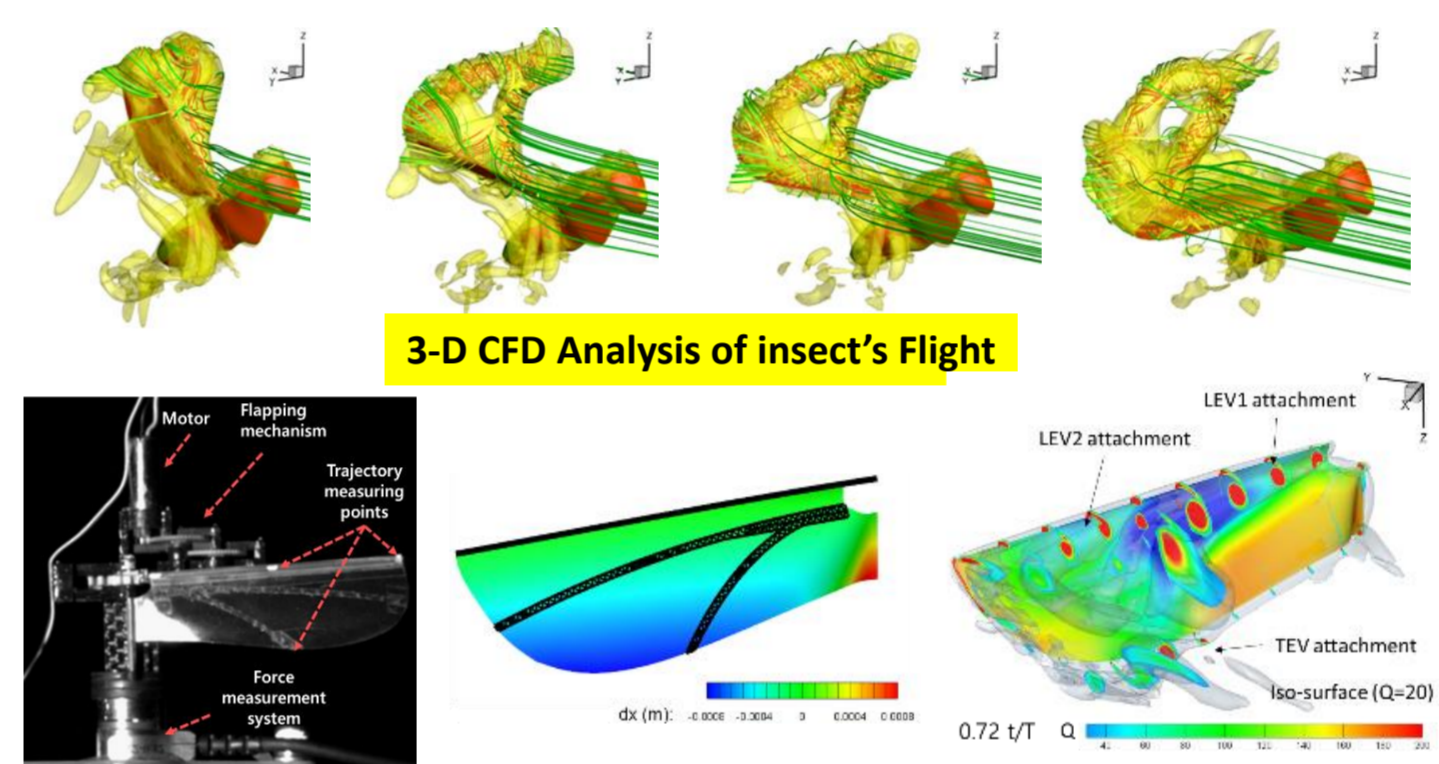
[Pressure signature contour]

[On-track pressure signature]

Fluid-Structure Interaction & Multi-Physics Computations

Bio-mimetic Aerodynamics & Flapping MAV Design

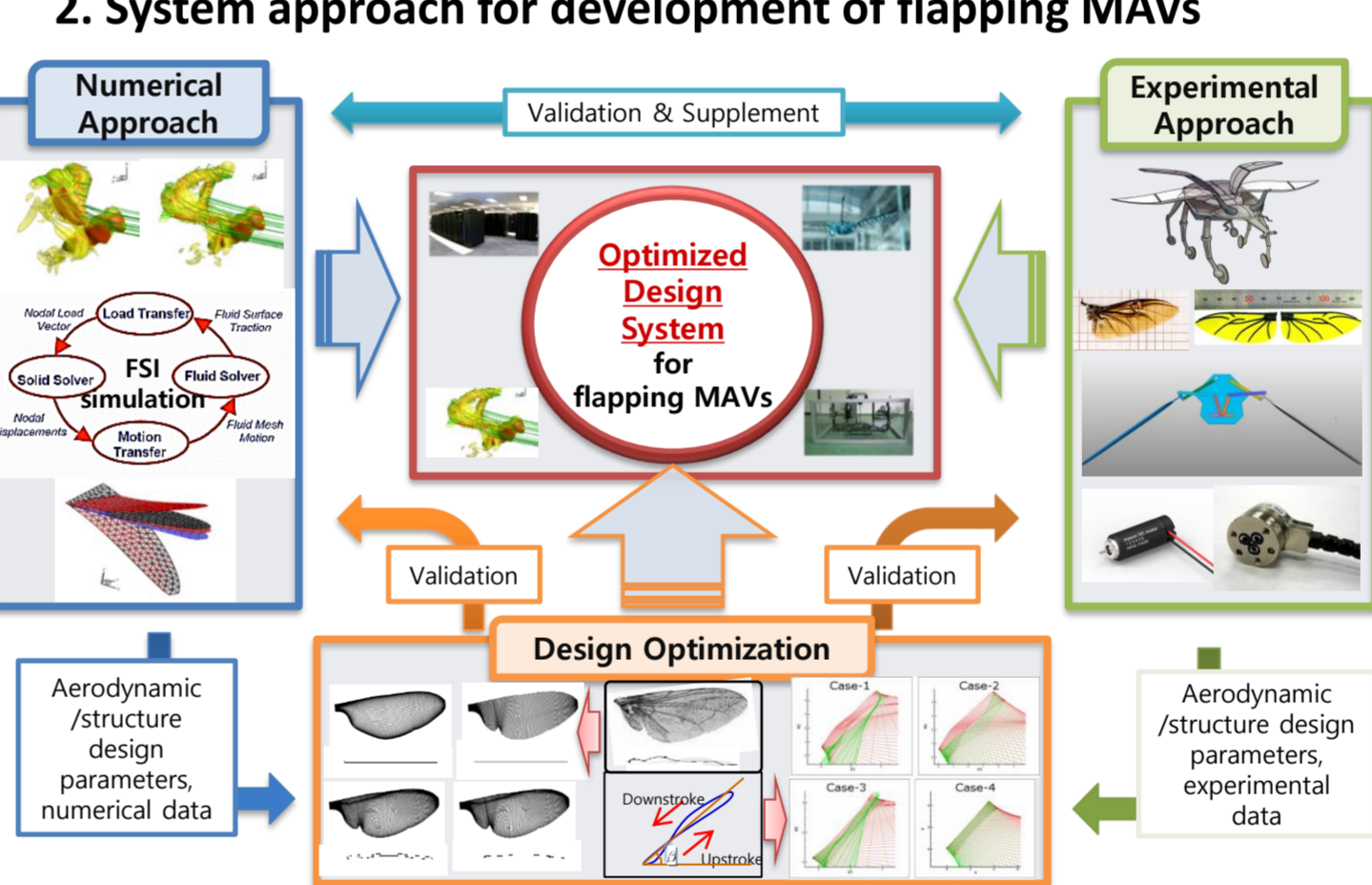
1. Numerical analyses on flapping flight



[3-D CFD Analysis of insect's flight]

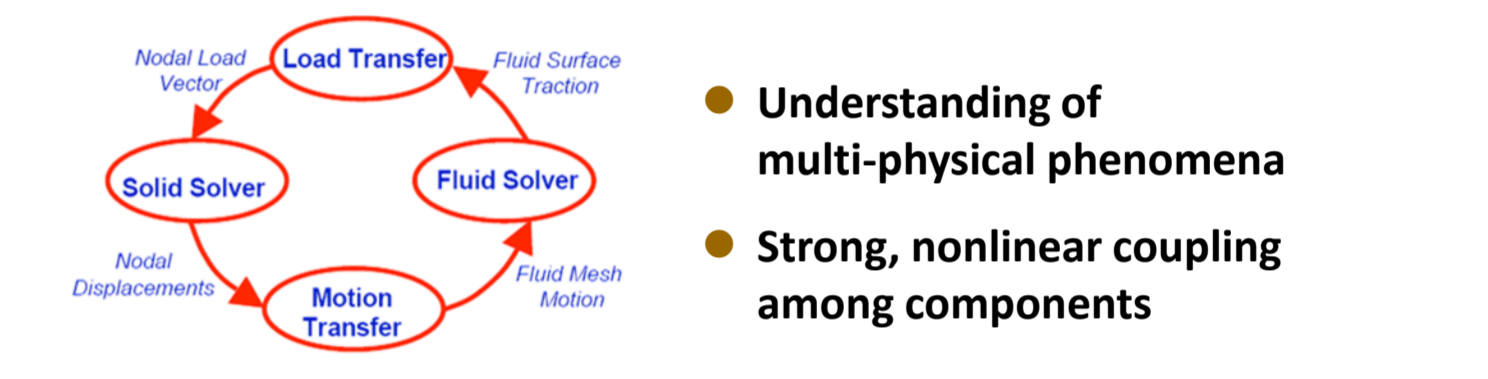
[3-D FSI Analysis of FMAVs]

2. System approach for development of flapping MAVs



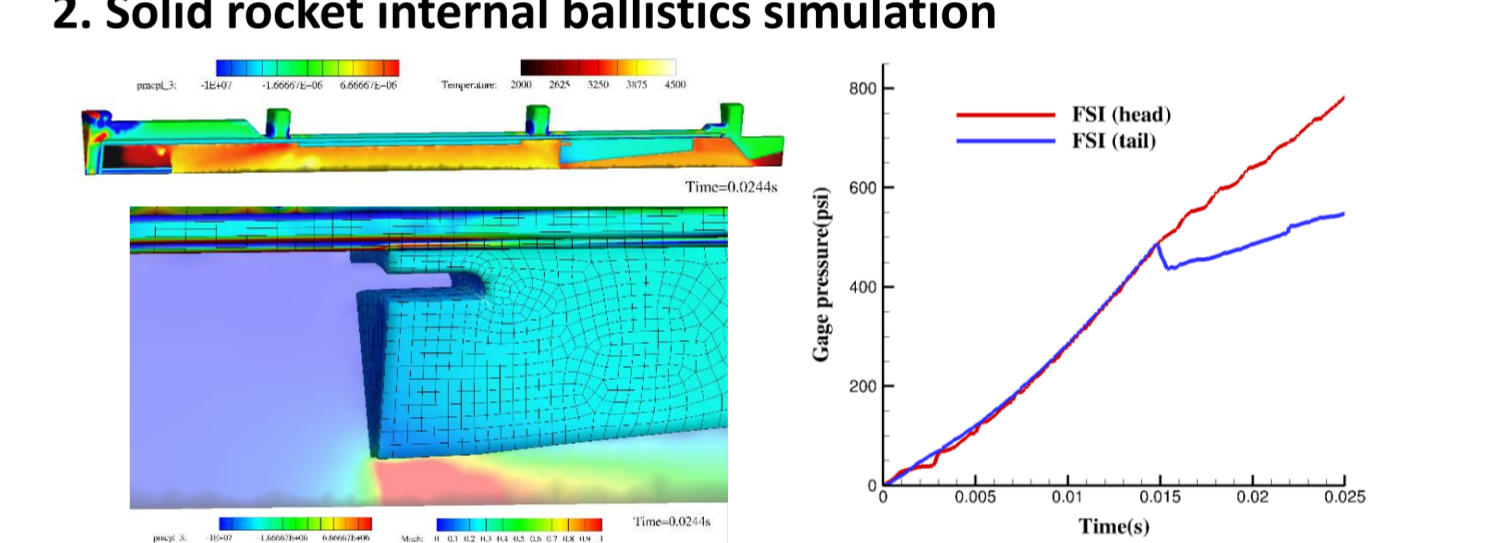
FSI (Fluid-Structure Interaction) of Solid Rocket & Rocket Nozzle

1. Complex physics inside solid rocket & rocket nozzle



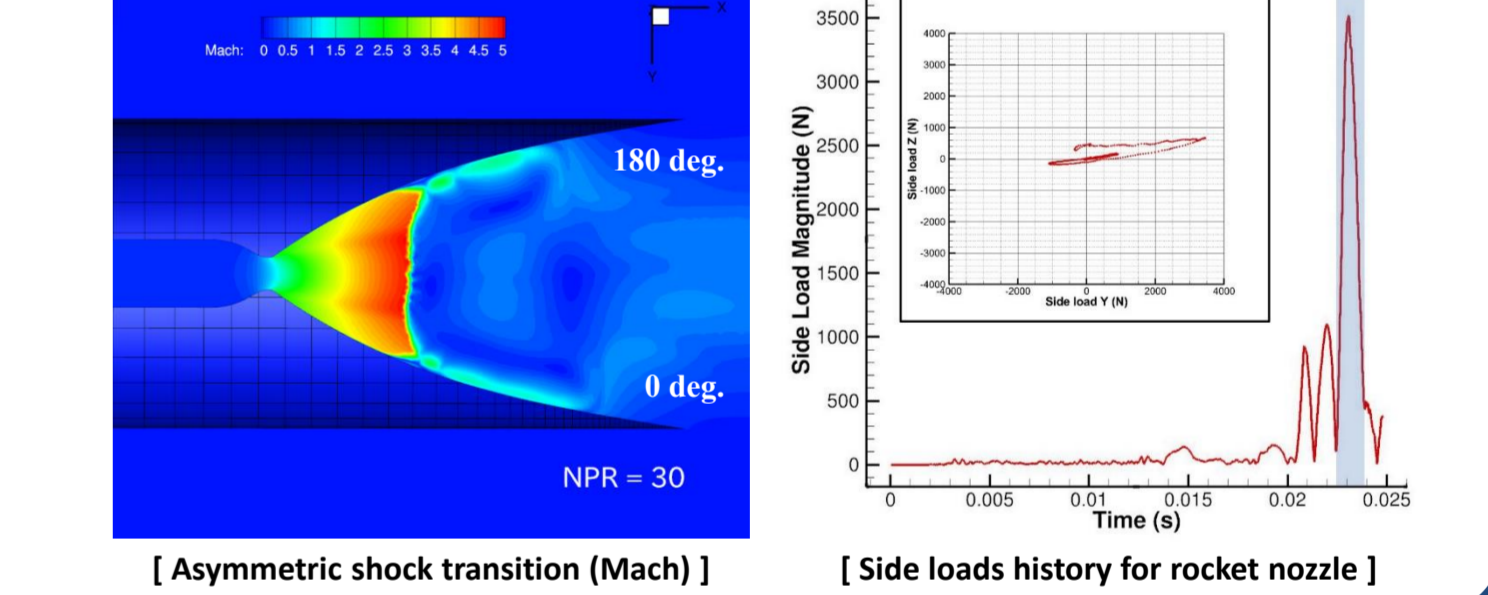
- Understanding of multi-physical phenomena
- Strong, nonlinear coupling among components

2. Solid rocket internal ballistics simulation



[Strain rate, temperature and Mach contour] [Pressure history inside solid rocket]

3. Rocket nozzle side loads simulation

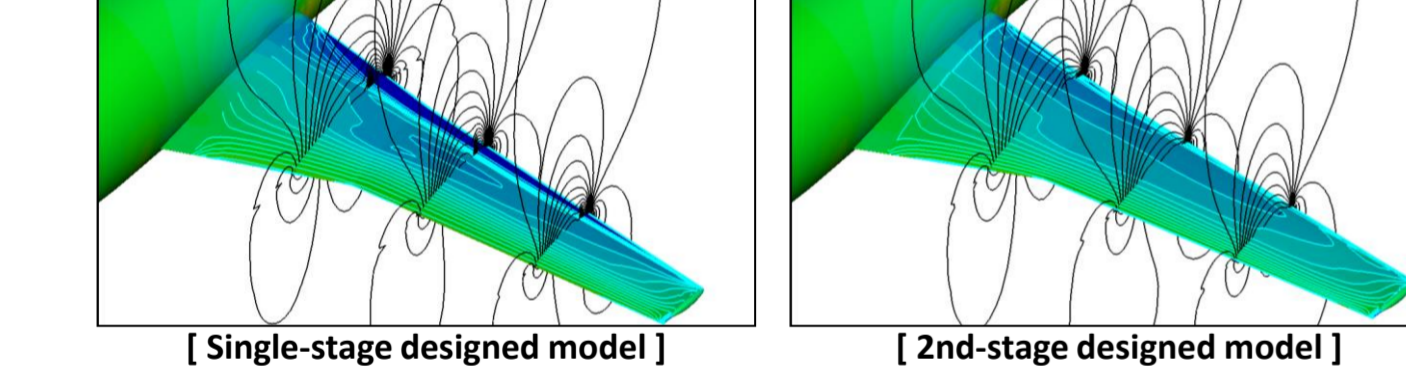


[Asymmetric shock transition (Mach)] [Side loads history for rocket nozzle]

Design Optimization & Active Flow Control / EDISON_CFD Center

Design Optimization

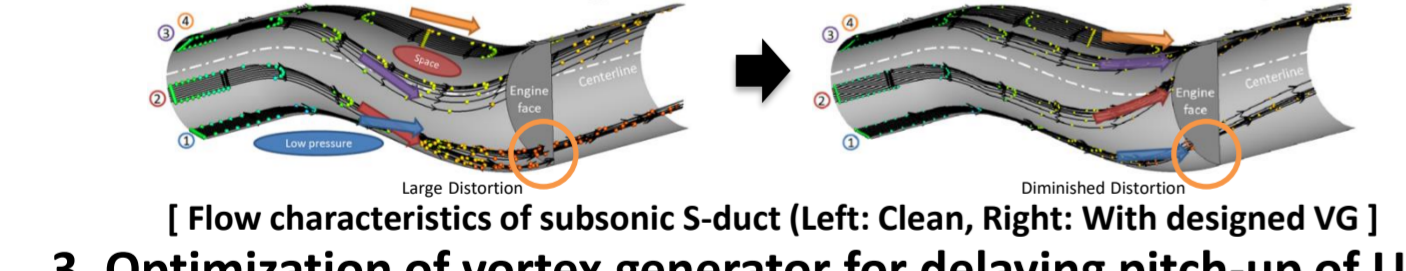
1. Multi-stage wing-body design



[Single-stage designed model]

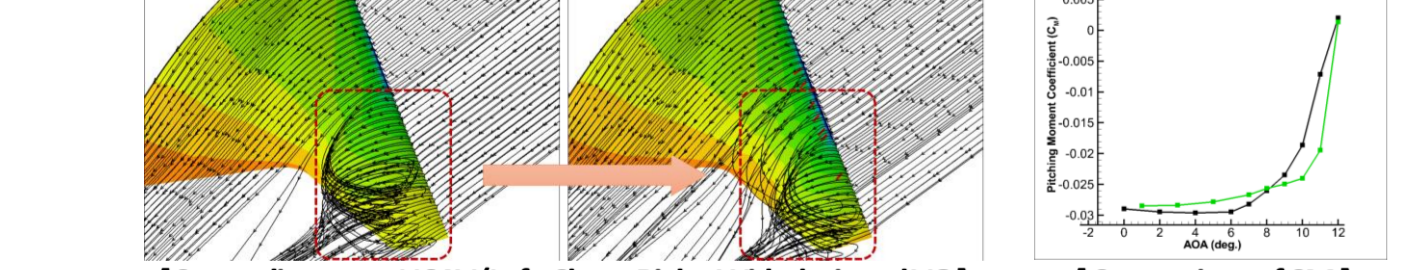
[2nd-stage designed model]

2. Optimization of vortex generator for flow control of S-duct



[Flow characteristics of subsonic S-duct (Left: Clean, Right: With designed VG)]

3. Optimization of vortex generator for delaying pitch-up of UCAV

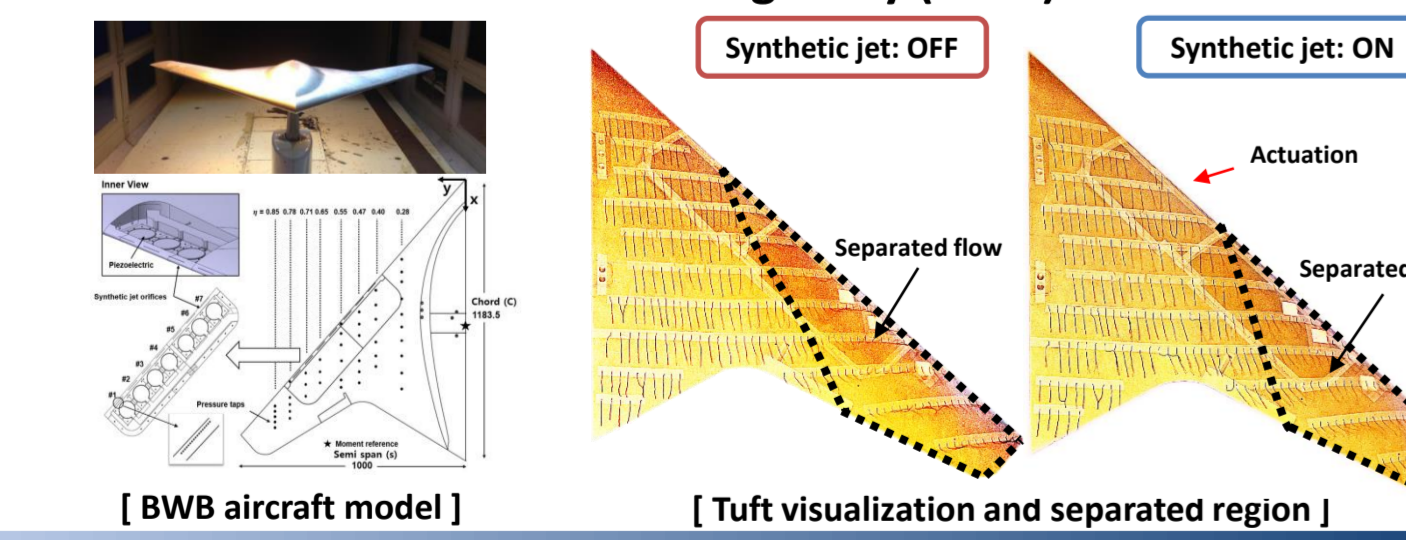


[Streamlines over UCAV (Left: Clean, Right: With designed VG)]

[Comparison of CM]

Active Flow Control by Synthetic Jet

1. Flow control on Blended-Wing-Body (BWB) aircraft

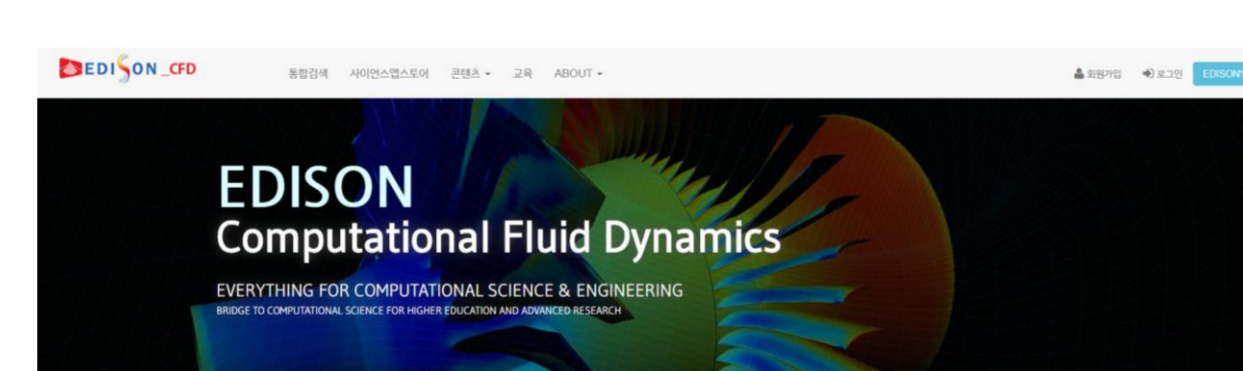


[BWB aircraft model]

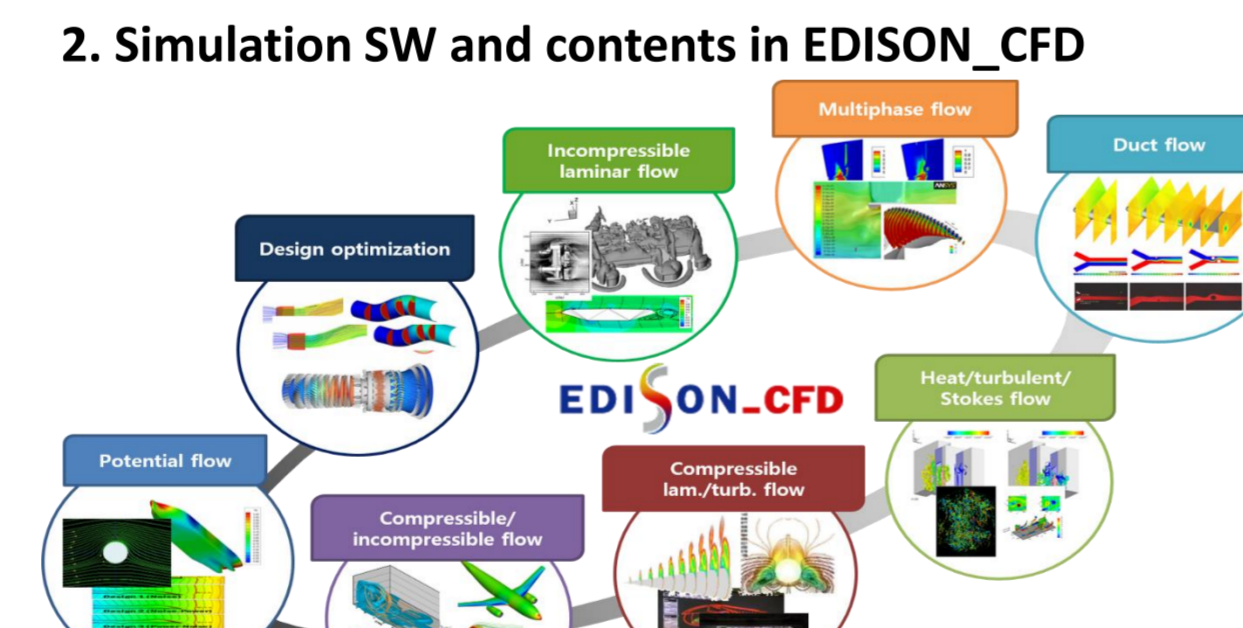
[Tuft visualization and separated region]

EDISON_CFD to Provide Computational Environments

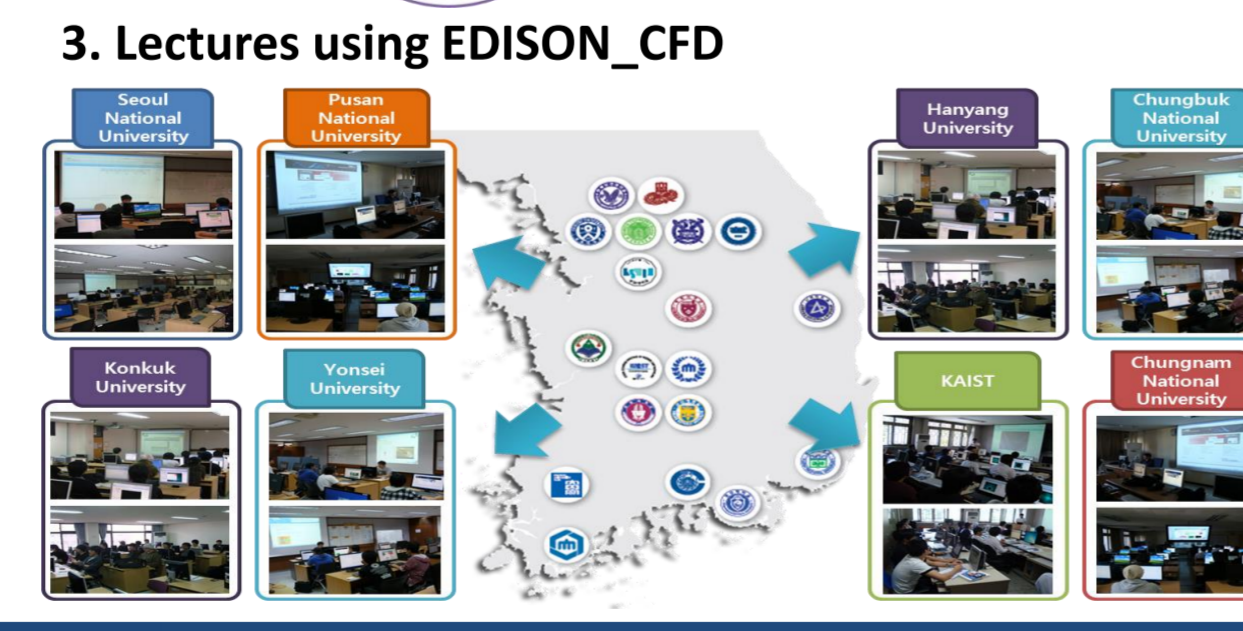
1. Main page of EDISON_CFD (<http://cfd.edison.re.kr>)



2. Simulation SW and contents in EDISON_CFD



3. Lectures using EDISON_CFD



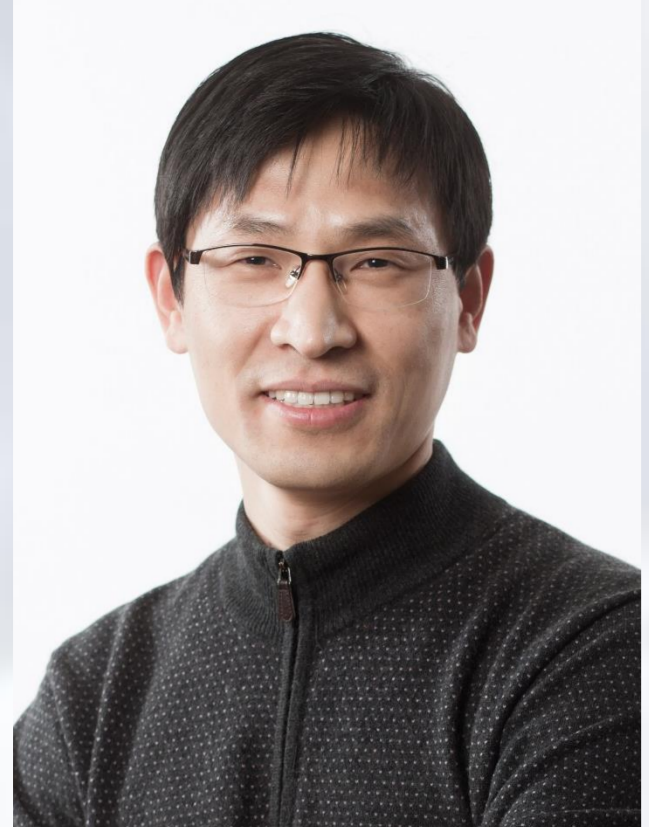
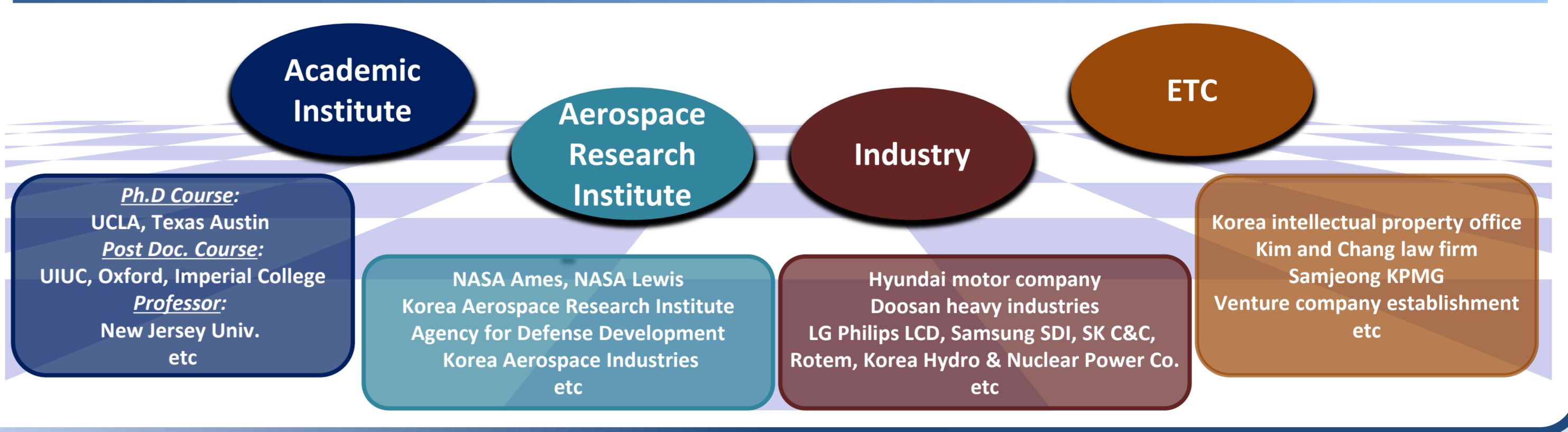
Research Facilities and Alumni

In-house Computing Facilities

- In-house Computing resource (cluster machine)
- Total 156 nodes / 3492 cores (as of 2021 Sep.)

Cluster	Head Node	Computing Node	Node #	Total Core #	Network System	Note
Linux-based Cluster #1	Intel Xeon E5-2430 V2 (2.5GHz, 12 cores)	Intel Xeon E5-2650 V2 (2.6GHz, 16 cores) + Intel Xeon E5-2650 V3 (2.3GHz, 20 cores) + Intel Xeon E5-2650 V4 (2.2GHz, 24 cores) + Intel Xeon Gold 6230 (2.1GHz, 40 cores)	108	3008	Infiniband Network	Lustre-based Storage Server
Linux-based Cluster #2	Intel Xeon E5620 (2.4GHz, 8 cores)	Intel Xeon E5620 (2.4GHz, 8 cores) + Intel Xeon E5649 (2.53GHz, 12 cores)	48	484	Gigabit Network	Storage Server

Alumni



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