

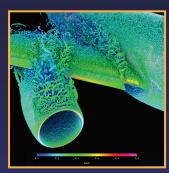
CFD Vision 2030

Vision Statement

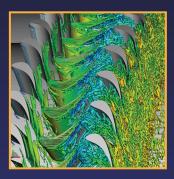
"A engineer/scientist must be able to generate, analyze, and interpret a large ensemble of related simulations in a time-critical period (e.g., 24 hours), without individually managing each simulation, to a pre-specified level of accuracy and confidence."

Vision Elements

- Emphasize physics-based, predictive modeling: Includes turbulence, transitional flow, unsteady/time-accurate, chemically-reacting flows, radiation, heat transfer, acoustics, etc.
- Manage simulation errors and uncertainties: Quantification of errors and uncertainties arising from physical modeling, mesh and discretization, etc.
- Develop automation in all steps of the analysis process: Geometry creation, meshing, large databases of simulation results, extraction and understanding of simulation information, etc.
- Harness future HPC architectures: Multiple memory hierarchies, latencies, bandwidths, programming paradigms and runtime environments, etc.
- Enable seamless integration with multi-disciplinary analyses and optimizations: High fidelity CFD tools, interfaces, coupling approaches, the science of integration, etc.









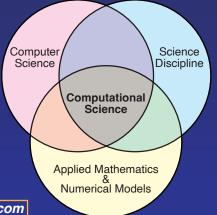
AIAA CFD 2030 Integration Committee

Integration Committee Mission

- **Promote a community of practice** engaged in developing methods, models, physical experiments, software, and hardware for revolutionary advances in computational simulation technologies for analysis, design, certification, and qualification of aerospace systems
- Guide the leveraging and integration of enabling technologies such as high-performance computing, physical modeling, numerical methods, geometry/grids, validation quality experiments, multidisciplinary analysis and optimization, with quantified uncertainties, to expand computational simulation capabilities.
- **Communicate** with other AIAA committees and communities to assure that IC membership engages with their peers and external constituencies in **shaping the future of simulation-based engineering.**
- Ensure CFD is an integral component of the Digital Transformation of engineering by advocating for its advancement toward the Vision 2030.

Keep up with the latest information and activities via the IC's website: www.cfd2030.com

CFD2030 Advancing Integrated Computational Science



Technology Development Roadmap CFD Vision 2030

TRL Low MEDIUM HIGH	Technology Milestone 2015	e 🔆 Technology Demonstration	Decision Gat	2020			2025		2020 Rev 2030
HPC		Demonstrate implementation of CFD algorith extreme parallelism in NASA CFD codes (e.g., F	i smi		Demor capabi	Demonstrate efficiently scaled Cl capability on an exascale system	Demonstrate efficiently scaled CFD simulation capability on an exascale system	30 exaFLOPS, unsteady, maneuvering flight, full engine simulation (with combustion) A	uvering flight, full with combustion) A
CFD on Massively Parallel Systems CFD on Revolutionary Systems (Quantum, Bio, etc.)		PETASCALE		Demonstrate solution of a representative model problem V	on of a roblem vEs		∱sa. ≎	VES NO	X •
	RANS Improved RST mod	RANS Improved RST models in CFD codes Antegrated transition prediction (1-5)	ed transition prediction (T-S)	Highly acc	curate RANS mod	Highly accurate RANS models for flow separation	Machine learning	Integrated transition prediction (General)	ion (General)
	Hybrid RANS/LES	>		Unsteady, complex geometry, separated flow at flight Reynolds number (e.g., high lift)_	ed flow at high lift) A		> < > <	>	-+{
Physical Modeling	LES		WMLES	WMLES for complex 3D flows at appropriate Rev	≍∹	Integrated transition prediction		WRLES for complex 3D flows at appropriate Re	ropriate Re
	Combustion calc	Chemical kinetics calculation speedup		Chemical kinetics in	Chemical kinetics in LES		Multiregime turbulence- chemistry interaction model	Lusteady, 3D geometry, separated flow el te.g., rotating turbomachinery with reactions)	y, separated flow achinery with reactions)
	Convergence/Robustness	S		oust solvers	Grid convergence for a complete configuration		Low-dissipation discretizations for scale-resolving methods	Pre	Production scalable entropy-stable solvers
Algorithms	Uncertainty Quantification	ion	Scalab	Scalable optimal solvers	× ←	> <	Long time integration Reliable error estimates in CFD codes	tion	Large scale stochastic capabilities
				Characterization of JQ in aerospace	Q in aerospace	Uncertain	Uncertainty propagation capabilities in CFD	Tail events	>
	Geometry Modeling			Reversible data transfer between opaque and open geometry models	etween models	Associative equivalence for manipulation	alence Distributed open Jation geometry platform	en Robust multidisciplinary data rm exchange open standard	y data ndard
Geometry	HPC Meshing		Large-scale parallel mesh generation	ration	Generate 10	Generate 100B cell fit-for-purpose me	se mesh	Generate 1T cell fit-for-purpose mesh	✓
Modeling and Mesh Generation	_	Tighter CAD coupling	Automa complex (Automatic generation of mesh on CAI complex geometry on first attempt	CAD coupling available in commercial grid generation	~	Automatic generation of family of meshes on complex configuration		
	Adaptive Meshing		Production AMR in CFD codes	Adaptive meshing accepts pragmatic geometry	sragmatic geome	~	Adaptive curved meshing	Demonstrate asymptotic convergence rate	Displace fixed meshes
Knowledge	Integrated Databases	Simplified data representation	¢	Creation of re simulations p	eal-time multifid lus test data wit	Creation of real-time multifidelity database: 1000 unsteady CFD simulations plus test data with complete UQ of all data sources	0 unsteady CFD Accepted data III data sources fusion techniques	data chniques	
Extraction	Visualization		×	On demand analysis/visualization of a 10B point unsteady	lization of a 10B	point unsteady	On demand analysis/vi	On demand analysis/visualization of a 100B point unsteady CFD simulation	eady CFD simulation
	Define standa to ot	Define standard for coupling to other disciplines	Robust CFD for complex MDAs	CFD simulation	Incorpora	hicorporation of UQ for MDAO	Full vehicle coupled analytic sensitivities, including geometric and subsystem		UQ-Enabled MDAO
MDAO		High fidelity coupling techniques/frameworks					MDAO simulation of an entire aircraft (e.g., aeroacoustics)	sen	Full vehicle coupled analytic sensitivities for chaotic systems

A copy of the roadmap can be found at www.cfd2030.com/report.html