



FINE™ / Marine

High-Fidelity and Automated CFD Simulation for Naval Architecture

COMPUTATIONAL FIELD VISUALIZATION AND ANALYSIS SYSTEM AROUND 2D/3D COMPLEX GEOMETRY:

- STRUCTURED MULTIBLOCK, UNSTRUCTURED AND NON CONFORMAL HEXAHEDRAL MESHES
- POWERFUL MACRO SYSTEM
- SCALAR AND VECTOR MULTIPLE REPRESENTATION MODES
- CALCULATION OF DERIVED QUANTITIES
- CARTESIANS PLOTS
- SPECIFIC FEATURES FOR TURBOMACHINERY
- MULTI-PROJECTS AND MULTI-VIEWS GRAPHICAL USER INTERFACES

GEOMETRY

- IJK surfaces for structured meshes
- Arbitrary cutting planes (XYZ, R θ)
- Boundary surfaces (solid, inlet, outlet...)
- Representation in cylindrical and blade-to-blade coordinates
- Iso-surfaces

MACRO SYSTEM

- Recording of all user action
- Easy editing of macros
- Saving screen as macro meta files
- Replay of any or pre-saved meta file
- Powerful language for user-defined routines, macros and formula

DERIVED QUANTITIES

- Derivation of any scalars and vectors
- Surface integrals and average of scalars and vectors on any surfaces
- Gradient divergence and curl computation

SCALAR REPRESENTATIONS

- Smooth, strip or threshold color contours
- Interactive or user-defined multi-isolines
- Full automatic Cartesian plots
- Local values
- Multi-scalar representation on any arbitrary surfaces

VECTORS AND STREAMLINES

- Vector fields, vector sections, local vectors
- Vector coloring
- Streamline computation
- Volumes or surfaces restricted streamlines
- Imported particle paths

CARTESIAN PLOTS

- Along grid lines, sections and boundaries on any surfaces
- Linear and logarithmic scaling
- Function of X, Y, Z, radius, arc length or normalized arc length
- Powerful and flexible edition capability
- Automatic comparison between numerical and experimental data along 2D or 3D curves

RENDERING

- Axi-symmetric and translation repetition
- Plane mirroring
- Perspective viewing
- Hidden line and surface removal
- Flat, Gouraud or Phong shading
- Outputs: PNG, PostScript, EPS, Bitmap, TIFF, JPEG

ANIMATION

- I, J, K surfaces scrolling
- Cutting planes scrolling
- unsteady data sets animation,
- Streamlines animation
- Video recording through MPEG files

APPROACH

- A state-of-the-art software development platform based on object-oriented methodology and C++
- Portable and modular software
- An advanced interactive graphical user interface
- High quality software available on all major graphics accelerators (PEX, OPENGL, GL, PHIGS)
- Ergonomic design

FIELDS OF APPLICATION

- Computational Fluid Dynamics
 - Structured, multi-block
 - Fully unstructured grids
- Finite Element Analysis
 - Mechanical engineering
 - Plastic modelling

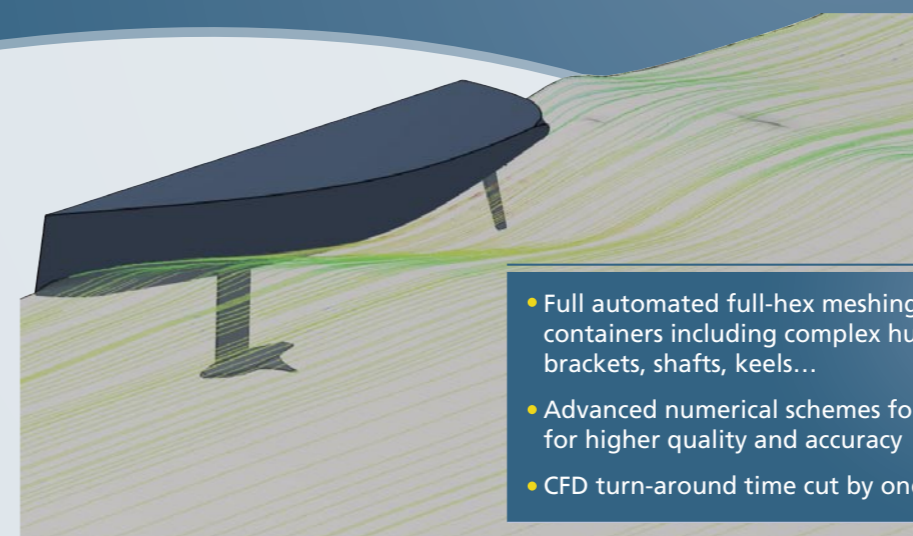
HARDWARE REQUIREMENTS

(recommended for full capabilities usage):

- Standard equipments: monitor, keyboard, mouse,
- CD-Rom drive,
- 3-button mouse,
- 24-bit color graphics and 1280x1240 pixel resolution monitor,
- Mandatory ethernet card for a node-locked license on LINUX.
- RAM minimum requirement : 256 Mb, > 512 Mb recommended (for 1 million points)
- Swap space: 3 times of installed RAM size,
- Hard disk storage capacity depends on project types and number of points; 100 Mb space is needed to store mesh and solution files of a 1-million-points project.

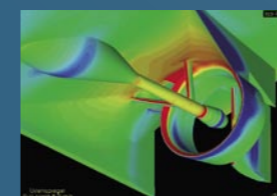
COMPUTER PLATFORMS:

- SGI
- SUN
- HP
- IBM
- DEC Alpha
- Linux
- Pentium/Athlon (WindowsNT, 2000, XP)

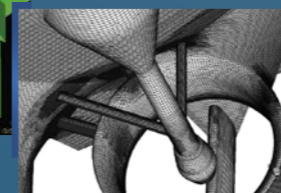


Full 3D simulation of wave generation on the water surface around a high performance yacht (Courtesy Van Oossanen & Associates)

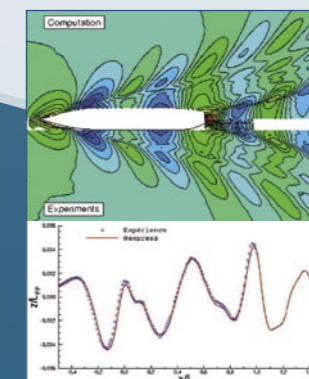
- Full automated full-hex meshing for ships, boats, yachts, containers including complex hulls and appendages such as brackets, shafts, keels...
- Advanced numerical schemes for sharp wave capturing for higher quality and accuracy
- CFD turn-around time cut by one order of magnitude at least



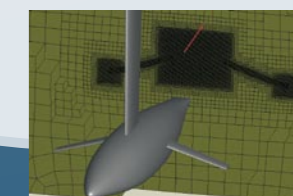
Uilenspiegel : Nozzle, V-brackets and shaft details (mesh and Pressure distribution) (Courtesy IHC HOLLAND DREDGERS BV)



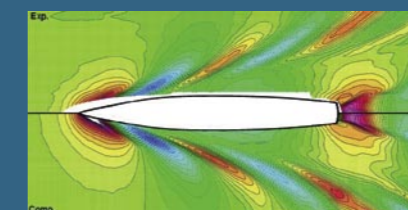
Limiting wall streamlines on model and full scale ship



CFD Tokyo Workshop 2005 - Free-surface flow around the KRISO Container Ship - Global view and longitudinal cut at Y/L=0.1509 (Exps. vs. comp.)



High precision boat keel wake capturing (Courtesy - Chalmers University of Technology, Göteborg)



CFD Workshop Tokyo 2005 - DTMB5415 in head waves - Mean free-surface amplitude system (Exps. vs. comp.)

FINE™/Marine

Technical Specification

NUMECA, a new wave in fluid dynamics



Hexpress™

Technical Specification

NUMECA, a new wave in fluid dynamics



A fully integrated platform of Computational Fluid Dynamics dedicated for naval architecture based on fully hexahedral un-structured Grid System combining :

- **HEXPRESS™** : Automatic Full Hexahedral Grid Generation system,
- **ISIS-CFD™** : 3D Unstructured Incompressible Navier-Stokes Solver
- **CFView™** : Computational Field Visualization System,
- **FINE™ GUI** : Interactive Graphic User Interface,
- **Computational MONITORING**

HARDWARE REQUIREMENTS

(recommended for full capabilities usage) :

- Parallel machine with fast inter-connexion.
- Ram requirement: about 2Gb per million nodes in double precision
- Recommended CPU loading: less than 500 000 nodes per processor
- 64 bits machine with sufficient memory required for preprocessing (350Mb per million nodes)

COMPUTER PLATFORMS

- Linux Intel 32 bits
- Linux Opteron 64 bits
- IBM Power PC

ISIS-CFD™ FLOW SOLVER

NUMERICAL METHOD

- Fully unstructured
- Cell centred conservative finite volume method
Pressure equation formulation
- Free-surface capturing strategy with high-resolution interface schemes
- Spatial discretization:
2nd order centered and backward schemes
- Time discretization
2nd order backward scheme

PARALLEL PROCESSING

- Up to 999 processors
- Domain decomposition with Metis
- Distributed memory (MPI based)
- Automatic partitioning
- Automatic solution reconstruction

BOUNDARY CONDITIONS

- **Inlets:**
 - Flow field imposed
 - Prescribed Stokes waves (1st, 2nd and 3rd order)
- **Outlets:**
 - Prescribed pressure
 - Extrapolated pressure gradient
- **Walls:**
 - Euler
 - Navier-Stokes walls
 - Moving walls
- **Symmetry Conditions:**
 - Plane of symmetry

FLOWS CAPABILITIES*

- Free-surface or mono-fluid flows
- Propeller modelled through an actuator-disk theory
- Cartesian coordinates
- Euler
- Laminar
- Turbulent
- Steady state flow
- Unsteady flow
- Incompressible
- Gravity
- Turbulence Models:
 - Spalart-Allmaras 1 equation model
 - k-ε model Launder-Sharma
 - k-omega (SST)
 - k-omega (BSL)
 - k-omega (Wilcox)
 - EARS (Explicit Algebraic Reynolds Stress Model)

All models can be used with:

- wall functions
- low-Reynolds formulations
- rotation correction

except the Spalart-Allmaras model (only available in low Reynolds mode)

FINE™ GUI*

INTERACTIVE GRAPHIC USER INTERFACE

- Fully integrated GUI
- Simple user-friendly POINT & CLICK graphical user interface (GUI) :
 - Mouse-driven
 - Context-sensitive
 - Intuitive and fast to learn interaction
- Easy-to-use object-oriented interface:
 - pulldown menus
 - pullright menus
 - dialogue boxes
 - keyboard input areas
- Selection of graphical entities by :
 - mouse picking or
 - keyboard entries
- View buttons operations for geometry and quantity representations in any perspective, with immediate visual feedback
- Multiwindows environment
- Access to pre and post processors
- Task management
- Convergence tracking
- Parallel computation set-up
- Batch mode

COMPUTATIONAL MONITORING:*

Direct run-time Convergence History monitoring of:

- Global and Block Residuals
- Forces: Lift, Drag, Momentum
- Turbulence Variables

* available in the next release

- **A STAND ALONE MESH GENERATOR FOR NON-NUMECA'S SOLVER AND CSM CODES OR EMBEDDED IN NUMECA'S UNSTRUCTURED CFD SUITE FINE™/MARINE AND FINE™/HEXA**
- **3D GEOMETRIES PURE HEXAHEDRAL CELLS WITHIN PASSAGE AND NEAR SURFACE BOUNDARIES**
- **LIMITED USER INPUT**
- **EASE OF USE:**
 - ▶ **COMPREHENSIVE WIZARD FOR STEP-BY-STEP GRID GENERATION**
 - ▶ **FULLY AUTOMATED TEMPLATES FOR SIMILAR GEOMETRIES**

FEATURES

- Fast and Automatic mesh generator
- Non-conformal all-hexahedra meshes
- Mesh generation in 2 main parts:
 - Domain to mesh preparation (CAD data processing)
 - Mesh generation (Volume to surface, Octree approach)
- Geometry Manipulation Menu
- Domain simplification:
 - Manual Edge/Face Merge/Split utility
 - Automatic Edge/Face Merge utility based on feature angle recognition
- All-hexahedra meshes
 - Accuracy of classical numerical schemes
 - High aspect ratio cells in boundary layer
- Mesh Periodicity
- Multi-domain and FNMB connections
- Multi-block Meshing
- Hybrid mesh generation
- Grid Quality Monitoring
- Interactive mesh correction tool
- Automatic Mesh partitioning (in FINE™/Marine and FINE™/Hexa)
- Face orientation correction in Star-CD surface mesh to STL conversion
- Batch Mode
- 64 bits Mesh Generation

MESH WIZARD

- **Initiate meshing**
 - Transfer your CAD file to a computational domain
 - Automatically set an initial grid for your domain or import a pre-used mesh
- **Mesh refinement/adaptation**
 - Choose generic meshing criteria:
 - surface curvature
 - number of cells between two surfaces
 - Set a target cell size either:
 - locally (close to selected surfaces) or
 - within an interactively created volume
- **Finalize meshing**
 - Automatically snap the grid points on CAD geometry
- **Optimize mesh quality**
- **Insert Boundary Layers** around surfaces and curves
- Possibility to **STOP** meshing process at each step

IMPORT FORMATS

- Direct import for:
 - CATIA V5 (*.CatPart) files:
 - PARASOLID files:
 - STL + properties files (Stereolithographics)
- Through CADfix:
 - Simple and fast file import:
 - IGES

- STEP
- STL
- ACIS
- CADDs
- Pro-Engineer
- Powerful and efficient CAD cleaning tool

EXPORT FORMATS

- FINE/Marine and FINE/HEXA
- STAR-CD
- FLUENT
- CSM code (SAMCEF BACON)

COMPUTER PLATFORMS

- Unix:
 - SGI
 - SUN
 - HP
 - IBM
 - DEC
 - Alpha
 - Itanium 2
 - PA-RISC 64 bits machines
- Linux:
 - Opteron (LINUX 64 bits)
 - Pentium EM64T (LINUX 64 bits)
- Pentium/Athlon (Windows2000, XP)

High Fidelity CFD system for Naval Architecture

Automated Unstructured Full HEX-meshing