The Role of CFD in Engineering

One of the foremost expectations of today’s successful product driven companies is that they bring high value-added products, that meet customer needs, quickly to the market. In addition, successful companies proactively identify application scenarios that could result in unsatisfactory performance, product failures, customer dissatisfaction and/or develop design solutions that mitigate the potential risks.

Thermo-fluid analysis software

Since software simulation enables predicting performance without creating a hardware prototype, the tools can be used early in the planning state of product development to sift through preliminary design concepts. Simulation can also be used to predict performance of products where it is difficult to make experimental measurements. In addition, simulation software can be used to visualize invisible fluid flow and heat transfer. This results in increased engineering understanding while providing a vehicle for communicating this knowledge to non-experts.

Where does thermo-fluid analysis software come into play?

Thermo-fluid analysis software is indispensable for “Front-loading” product development to ensure the best product concepts that are identified early in the design process. Design quality will be improved during the conceptual design phase by conducting basic studies of fluid and thermal phenomena that directly affect product performance. During the detailed design phase, analyses are conducted under conditions similar to what the actual product will experience. From this work, design engineers can understand the source of problems that limit performance and investigate alternate design solutions before production begins.

Structured and unstructured mesh: the differences

Software Cradle offers two different types of thermo-fluid analysis tools: scSTREAM and HeatDesigner with structured mesh, scFLOW and SC/Tetra with unstructured mesh.

Structured mesh is simple and easy to construct. Structured mesh is comprised of many small cuboids so it can only approximate curved or angled surfaces with stair-case patterns. It is most useful for applications where tiny details and surface curvature or angles do not have a strong effect on the overall results. Examples of applications for structured mesh include electronics cooling, HVAC, and architecture.

Unstructured mesh is created using polyhedral elements. Mesh is generated such that it fits along the ridge lines of the original geometry. As a result, unstructured mesh is used for applications where precise representation of geometry is crucial. Examples of applications for unstructured mesh include vehicle aerodynamics, fan blade designs, and flows inside ducts.
Software Cradle develops and provides thermo-fluid simulation software and optional tools that suit various industries and objectives.

**Products**

Thermo-fluid simulation software and main peripheral tools

**scSTREAM**
- Structured mesh (Cartesian/cylindrical coordinate systems)
- Designing thermal and air flow inside an office
- Evaluating air flow around buildings
- Evaluating heat island effect
- Heat dissipation design of electronics and precision instruments
- Dust-proof and moisture-proof review of electronics and precision instruments
- Multi-phase flow analysis such as mixing, spray, solidification, melting, boiling, and condensation
- Analysis involving moving objects such as cars, controlled equipment, hydraulic and pneumatic equipment, and robots

**WindTool**
- Wind environment assessment tool

**Launcher (Autodesk® Revit®)**
- CAD add-in tool

**Launcher (ARCHICAD)**
- CAD add-in tool

**Launcher (SOLIDWORKS®)**
- CAD add-in tool

**HeatDesigner**
- Module for electronics
- Designing heat release of a printed circuit board
- Examining heat-releasing fins and the material
- Designing heat release of an enclosure with a fan

**ElectronicPartsMaker**
- Tool for semiconductor package modeling
- Real-time thermal analysis
- Board size design
- Layer composition design
- Parts layout design
- Review of the effects of wiring pattern and thermal vias

**PICLS**
- Dedicated tool for thermal analysis of printed circuit boards
- Real-time thermal analysis
- Board size design
- Layer composition design
- Parts layout design
- Review of the effects of wiring pattern and thermal vias

**scPOST**
- Comprehensive and versatile data visualization software
- Obtaining numerical information with simple operation
- Creating animation
- Mapping temperature information of a fluid analysis result to a structural analysis
- Comparing multiple analysis results

**Optimus® for Cradle**
- Optional tool for optimum solution search

**scWorkSketch**
- Tool for creating automated workflow

**scFLOW**
- Unstructured mesh (Polyhedral elements)
- Aerodynamic simulation for automobiles
- Prediction of cavitation and erosion
- Design of household electric appliances such as refrigerators and wash machines
- Internal flow analysis of ducts and nozzle
- Analysis involving chemical reactions including reactor, catalyst, furnace, combustor, and CVD
- Multi-phase flow analysis such as mixing, spray, solidification, melting, boiling, and condensation
- Analysis of multiphase flow phenomena such as mixing, blending, spraying, solidification, melting, boiling, and condensation
- Water tank test simulation of a vessel

**Structural Analysis**
- Structural analysis tool (linear static analysis)

**SmartBlades**
- Tool for modeling fan blades

**Fluid-Structure Interaction (Abaqus®)**
- Tool for two-way coupling

**FluidBearingDesigner**
- Tool for analyzing fluid bearing

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Is your analysis tool useful in years to come?
scSTREAM and HeatDesigner have proven track records for incorporating the latest leading edge technology

scSTREAM HeatDesigner
scSTREAM thermo-fluid software has serviced the electronics and architectural industries for more than thirty years. The ever-evolving software is characterized by its overwhelmingly user-friendly interfaces and high speed processing. HeatDesigner is based on scSTREAM and is specially developed for thermal design of electronics products. HeatDesigner provides physical functions required only for thermal design with its simple interfaces and powerful computing performance.

Various methods to represent shapes
The shape of a model to be analyzed can be represented by using the following methods: voxel method (slanted faces and curved faces are represented in cuboids), cut-cell method (the shape of a model created with a CAD tool can be represented more accurately), and finite element model method (a model of an arbitrary shape defined with unstructured mesh can be overlapped on a model defined with structured mesh to use the shape created with a CAD tool as is).

Moving objects
A flow generated by a moving rigid object can be calculated. Conditions including the motions of an object (translation, rotation, and elastic deformation), heat generation/absorption, and air supply/return can be set. The model of a moving object is created on another mesh. In this way, conditions such as the distance that the object moves are limited very little.

Large-scale calculation
In structured mesh, even a complicated model does not need to be modified almost at all and the shape or the scale of a model does not affect the difficulty of mesh generation. In addition, Solver performs a calculation at a high speed in parallel computing and achieves effective processing as the speed increases depending on the number of subdomains.

6-degree-of-freedom motion (6DOF)
The function can analyze passive translation and rotation of an object receiving a fluid force. A moving object is assumed to be a rigid body. Its movement whose maximum degree of freedom is six (3D translation + 3D rotation) can be solved. The function can simulate driftwood which is flowed by a force from water flow.
**ElectronicPartsMaker**

The tool can create detailed models of semiconductor packages including QFP, SOP, and BGA by specifying parameters, and simplified models using thermal resistor models such as DELPHI models and two-resistor models. Manufacturers of semiconductor packages can provide the data of semiconductor packages as thermal resistor models without releasing the inside information.

**HeatPathView**

The information on temperature of each part and a comprehensive amount of heat release obtained in post-processing of a general CFD analysis is not enough to know the heat path. HeatPathView displays heat paths and the amount of heat transfer in the whole computational domain in a diagram, a graph, and a table, allowing you to find the bottleneck of the heat paths easily.

**Multiblock**

Mesh can be refined partially to represent a model shape more accurately and perform a calculation more efficiently.

**Discrete element method (DEM)**

Multiphase analyses can be performed, which enables coupling of fluid analysis and flow analysis of particles.

**Parts library**

The shapes and conditions of frequently used parts can be registered. Conditions include the allocation position, material, and heat generation.

**Reading wiring patterns**

To calculate heat transfer conditions depending on wiring patterns of a printed circuit board (PCB) in detail, the module can read Gerber data output from an electric CAD tool and import the data as a model for a thermo-fluid analysis. By using Gerber data, a more realistic calculation result can be obtained with the consideration of heat transfer affected by an uneven wiring pattern.

**Radiation**

Radiation heat transfer with the consideration of diffusion, reflection, transmission, refraction, and absorption can be calculated. VF (view factor) method and FLUX method\(^1\) can be used. The lamp function can simulate radiant heat by a filament without detailed shape information of a lamp. In addition to the filament, laser beam and defective radiation specified by half-value angle can be used as a heat source model.

\(^1\) Only for scSTREAM
**BIM**

The software interface supports BIM 2.0. Autodesk® Revit® and GRAPHISOFT ARCHICAD have a direct interface (optional) through which a target part can be selected and the tree structure can be kept simplified. In addition, the module can load files in IFC format, which is the BIM-standard format.

**Illuminance analysis**

The software can calculate illuminance of various types of light; for example, daylight through an opening of a building and artificial lighting with consideration of its directivity. Object surfaces such as walls are treated as diffusive reflection surfaces. In general, the larger an opening of a building is, the larger heat loss tends to be. By calculating the illuminance, the balance between heat and light can be examined collectively.

**Using structure function from measurement**

Modeling of electronic device is possible by converting result data of heat change over time used for transient heat resistance measurement*1 into structure function (thermal resistance - heat capacity characteristics). Accurate thermal model can be generated by comparing test and analysis data on the basis of structure function.

**Electronic part model**

A wide range of models are available that enable to easily achieve thermal design of printed circuit boards and electronic enclosures, which includes DELPHI (multi-resistor) model, Peltier device and heat pipes. It is possible to consider pressure loss characteristics using slits, and P-Q characteristics of fans using swirling component. Generated models can be added in library.

*1 Measurement device is not included
Air-conditioner parts (CFD parts)
The model shapes of parts frequently used for room air-conditioning can be imported. The models include ceiling cassettes, anemostat models, and linear diffusers. The software can import CFD part data, such as air supply characteristics, provided by SHASE. Various parameters can be set to simulate air-conditioning operation in addition to simple air heating and cooling.

Solar radiation (ASHRAE, NEDO)
Climate data published by ASHRAE and NEDO is preset and can be used for condition setting. By entering arbitrary values of longitude, latitude, date, and time, the solar altitude and the azimuth angle of the sun at a specified location and time are calculated automatically. The effect of solar radiation can be examined in detail. Various parameters including absorption and reflectivity of solar radiation and materials which transmit light diffusely, such as frosted glass, can be set.

Humidity / dew condensation
The software can analyze humidity in the air. Dew condensation and evaporation on a wall surface due to temperature change can be considered and the amount of dew condensation and evaporation per time can be obtained. The software supports the analyses of moisture transfer inside a solid, and the function can be used to analyze a permeable object and dew condensation inside a part.

WindTool (outdoor wind environment assessment tool)
This tool helps assess outdoor wind environment. The assessment criteria can be selected from the ones proposed by Murakami et al. and by Wind Engineering Institute. By specifying a base shape and parameters required for wind environment evaluation, the parameters for 16 directions are calculated and the wind environment is ranked automatically. Detailed distributions of air current and pressure per direction can be visualized.
Electrostatic field
In addition to fluid force, the effect of an electrostatic field, which applies external force to charged particles, can be considered. By setting electric charge of particles and electric potential of a wall surface, the function can be used for analyses to consider area control of electrostatic coating. Velocity at which charged particles do not adhere on a wall surface can also be examined by using the function.

Mapping
When a target phenomenon is in a small range and the phenomenon is affected by a wide range of its surrounding area, analysis results of the surrounding area can be used for an analysis of the target phenomenon as boundary conditions to decrease the calculation load. To analyze only the inside of an enclosure for an electronic device highly affected by its outside, the analysis results of the outside can be used as boundary conditions.

Flow of foaming resin
The software calculates the behavior of filling up an object with foaming resin, which is used as a heat insulator for houses and refrigerators. To examine speed and pressure of filling-up and the position for injecting the resin, the software simulates the behavior in 3D. The simulation can provide more pieces of information in shorter time than an actual measurement.

Free surface
The software calculates the shape of an interface between a gas and a liquid. Either MARS or VOF method can be used, and the calculation target phase can be selected: both gas and liquid, only gas, or only liquid. The function is useful in a wide range of fields: from an analysis of tsunami in the civil engineering and construction field to an analysis of soldering in the electronic device field.
Solidification / melting

The phase change between fluid and solid, for example, water to ice and ice to water, can be considered. The following phenomena related to solidification/melting can be considered: change of flow affected by a solidified region, change of melting speed depending on the flow status, and latent heat at melting. A phenomenon that water in an ice maker becomes ice can be simulated using the function.

Boiling / condensation
(bubble nucleation, bubble growth / condensation)

With the function, the user can analyze a boiling flow, which is a gas-liquid two-phase flow caused by temperature difference between a liquid and a heat conduction surface. A boiling flow is analyzed as a free surface analysis using MARS method, and latent heat generation and volume change due to bubble growth / condensation are considered using phase change model.

Particle tracking

The software simulates the behavior of particles depending on their characteristics (diameter, density, and sedimentation speed) and action/reaction between particles and a fluid. This includes sedimentation due to gravity, inertial force for mass particles, and movement due to electrostatic force, liquefaction at adhering on a wall surface, evaporation and latent heat, the behavior as bubbles in a liquid for charged particles.

Panel
(heat conduction / transfer / thermal transport)

Material properties and motion conditions can be applied to a panel having no thickness in model, which allows for heat conduction to other parts and heat dissipation to air. This enables the simulations of paper feeding and film drying processes, where thin objects move and go under heating repetitively.

Transfer and thermal transport are only available on scSTREAM
## Functions (scSTREAM, HeatDesinger)

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</table>

### HeatDesinger
- Preprocessor (CUBERA)
- Modeler (HeatConductor, HeatConductor, HeatSource)
- Solver (HeatConductor, HeatConductor, HeatSource)

### scSTREAM
- Preprocessor (CUBERA)
- Modeler (HeatConductor, HeatConductor, HeatSource)
- Solver (HeatConductor, HeatConductor, HeatSource)
Functions (scSTREAM, HeatDesinger)

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Microsoft Visual Studio is a registered trademark of Microsoft Corporation in the United States and other countries.
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**ToolLicense Type**
- **Software**
- **What is CAE?**
- **PICLS**
- **Optimization**

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**Solver**
- **Thermal conditions**
  - Hard temperature
  - Amount of heat generation
  - Heat transfer coefficient
- **Wall conditions**
  - No-slip (stationary wall)
  - No-slip (symmetry wall)
- **Prescribed conditions**
  - Flow pressure
  - Volume loss
  - Surface roughness
  - Temperature
  - Time
- **Source conditions**
  - Wall velocity (pressure loss)
  - Wall thermal power
  - Turbulence generation
  - Simulation
- **User-defined conditions**
  - Heat transfer coefficient
  - Volume force / pressure loss
  - Grass establishment
  - Humidification
  - Turbulence generation
  - Smoke source (diffusing materials)
  - Heat source
- **Calculation control environment**
  - Monitoring the calculation status
  - Monitoring the calculation progress
  - Logging

**Postprocessor**
- **Displaying functions**
  - Pathlines
  - Streamlines, isosurface
  - Vortex center
  - Mirror / periodical copy
  - Drawing position / orientation:
    - Arbitrary plane, surface, entire volume, cylinder
    - Arbitrary pick
  - Special effects:
    - Marker particle
    - Cut-plane sweeping
    - Flow line animation
    - Animation:
      - Arbitrary view point
      - Variable registration (function registration)
      - Compressor:
        - Compressor
      - Analysis results:
        - Compressed area calculation
        - Heat transfer coefficient / heat transfer rate
      - Export of data:
        - Exported data format
        - Exported data format
  - Data image output:
    - Exported data format
  - Operation and control environment:
    - Important help function
    - Script run
    - Animation mouse operation mode
    - Stereoscopic data display mode

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**System Configuration**

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<th>Recommended environment</th>
<th>Approx. measure of analysis size</th>
<th>Compiler environment (User-defined function)</th>
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<tr>
<td>HeatDesigner</td>
<td>Linux: Red Hat Enterprise Linux 7 Red Hat Enterprise Linux 6 (6.1 onward)</td>
<td>[Memory] 16GB or more</td>
<td>[Memory] 5 million mesh elements / 2.5GB</td>
<td>Linux version GFortran (GNU Fortran compiler) Intel (Linux standard)</td>
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</table>

* Only compliant with Solver and Monitor.
* scMonitor Unsupported environment.
The ever-evolving latest CFD solution
Discover what you want from your CFD tool here

scFLOW SC/Tetra

SC/Tetra has been characterized by sophisticated mesh generation function, high speed computing capability, and user-friendly features throughout the operation. As its advanced version, scFLOW has been released. It is equipped with more stable Solver that achieves calculation speed three times faster (at maximum) than before, and new Preprocessor that helps entry-level users build complicated models and high-quality mesh. scFLOW, the new generation software, keeps on evolving.

Simplification of Preprocessor operations

From the CAD data to analysis mesh data, the required operations are grossly simplified compared to before. The conservation of assembly information and the settings of conditions on the parts bring the sense of continuity from the CAD operations and reduce the operational burden of the users.

Polyhedral mesher

Using polyhedral mesh elements improves stability and calculation accuracy of cell-centered solver. In scFLOWpre, mesh can be generated according to the target number of mesh elements and automatically refined near wall area. The automatic mesher function also enables users to specify mesh refinement level of each part and region.

Modifying CAD data

When CAD data to be used for simulation has a problem, the data can be modified with Preprocessor. Boundary conditions can be set based on the part names and color information set in the CAD data. When some regions are missing in the model, shapes such as cuboids and cylinders can be added.

Viewer mode

Preprocessor data can be displayed in the viewer mode without the Pre-/Post-processor license, when the license is taken by the mesher or by Postprocessor and is unavailable.
Mesh-adaptation analysis

With this function, mesh will be automatically refined where a flow or pressure changes greatly in a steady-state analysis. After the calculation in Solver is completed, Preprocessor automatically launches and executes gridding and meshing based on the calculation result. By specifying the target number of elements, coarse mesh is generated first and the mesh is automatically refined to be appropriate for the calculation. The function is useful for an analysis of flows in a tube with a complicated shape.

Discontinuous mesh

Flow with object motion can be calculated, including rotation of fans and turbines, and crossing travel of automobiles or trains (translation). The function enables an analysis with consideration on shear heating between rotor and pad in a disk brake. The function also makes it possible to analyze a combination of rotation and translation such as a piston pump.

Free surface (steady-state / transient)

The shape of an interface between a gas and a liquid can be simulated. Calculations by VOF method (new method: FIRM) are fast and accurate, and functions including moving boundary, overset mesh, and particle tracking can be used in combination. Because a phenomenon where the phase interface becomes stable can be analyzed in a steady-state calculation, the result can be obtained in a shorter time than before.

6-degree-of-freedom motion (6DOF)

Passive translation and rotation of a rigid body receiving a fluid force can be analyzed. With the function, the user can analyze a ball valve with consideration of the elasticity of the spring (1D translation), and paper airplane with consideration of 6-degree-of-freedom rigid-body motion (3D translation + 3D rotation). In addition, the function is applied to analyses of check valves, wind power generators, and blades of wave power generators.

Overset mesh

Free movement of regions, that cannot be analyzed using existing functions such as stretching or rotating elements, can now be simulated by overlapping mesh elements for stationary and moving regions. This function supports an overlap of multiple moving regions, a contact between objects, and a 6-degree-of-freedom motion of rigid bodies. This is useful to analyze opening and closing of a valve of an engine port or a gear pump where gears engage with each other.

Stabilization of calculation

Even for mesh data with elements of extremely low quality, the calculation can be stabilized by the automatic processing to avoid divergence. This function helps Solver be more robust.

Only scFLOW supports FIRM. FIRM cannot be used for overset mesh or steady-state analyses.
Fluid-structure interaction

This option is used for two-way FSI (fluid-structure interaction) with structural analysis software. With this option, not only rigid bodies but also elastic bodies can be treated. Deformation of an object caused by a fluid force and the change of fluid caused by the deformation can be analyzed.

Compressible fluid

The software can analyze phenomena such as supersonic flow and significant expansion/contraction of volume. For a compressible fluid, both the pressure-based and the density-based Solvers can be used. The density-based Solver keeps the calculation stable even with high Mach number. You can select either Solver depending on the analysis target and phenomenon.

Aerodynamic noise analysis

Sound caused by pressure oscillation of a fluid, such as wind noise, and sound caused by resonance can be predicted. The calculation can be performed accurately by using LES and the weak compressible flow model. The frequency of aerodynamic noise can also be analyzed using the Fast Fourier Transform (FFT) method from the CFD analysis result.

Evaporation/Condensation

Free surface analysis function (VOF method) of this software can simulate phase change between gas and liquid, such as evaporation and condensation. By considering phase change, not only simple heat conduction but also heat transfer from latent heat can be calculated. For example, this method can be applied to internal flow simulations for heat transfer devices such as heat pipes, in which a refrigerant liquid changes to vapor by absorbing heat from an outer region.

Dispersed multi-phase flow

This function can simulate flows containing many bubbles, droplets, or particles (dispersed phase), which are difficult to be analyzed using free surface. This function is a multi-fluid model that can predict volume fraction distribution and velocity distribution of each phase by solving the governing equation under the assumption that the dispersed phase is a fluid (continuous phase). The function is useful to analyze the bubble jet effect and aeration tanks.

Cavitation

This function enables simulation of a vaporization phenomenon called cavitation, which is caused at an area where pressure of a liquid becomes lower than in the surrounding area, such as with a propeller rotating at a high speed under water. The occurrence of cavitation can be predicted by applying the cavitation model based on the pressure values. The software also supports problems caused by cavitation such as erosion.
Particle tracking

Particle tracking function enables analyzing behavior of particles in flow. When analyzing small particles that follow the fluids movement (such as steam and dust), marker particle function can be used to evaluate particles in flow that change over time, which assumes that particle movement is in accordance with fluid velocity.

Humidity dew condensation

The amount of dew condensation on an object surface can be calculated from the surface temperature and water vapor in the air. You can output the amount of dew condensation per unit time in a steady-state analysis and the accumulated dew condensation in a transient analysis. Evaporation from a surface where dew condensation occurs can be calculated simultaneously, and this is useful for an analysis of a windshield defroster.

Liquid film model

The liquid film model is an extended function of the particle tracking function. By using the model, you the user can simulate the phenomenon that liquid particles change to a liquid film (water on a wall) when they reaching on the a wall. A liquid film on a wall flows with the influence of gravity and a gas-phase flowdown depending on an angle of the wall and collects in at a certain position. The analysis results are output as the thickness of a liquid film.

Thermoregulation-model (JOS)

Combination use of the thermoregulation-model (JOS) and a fluid analysis enables analyses of the surface temperature of a human body under a certain thermal environment. It can also be used to analyze temperature and humidity changes in the surrounding environment of a human body. The user can consider age, clothes, and physiological phenomena of the human body such as heat transfer by blood flow in addition to the surrounding environment of a human body such as temperature and velocity.

LES

LES is one of the turbulent flow models. It models eddies smaller than the mesh element in size and directly calculates other eddies. Although calculation load is large, LES enables simulations closer to real phenomena. LES is often used in noise analyses, significantly affected by time variation, to simulate the behavior of small eddies. The user can use the hybrid model with RANS, a turbulent model of small calculation load.

Radiation

Heat transfer by infrared-ray radiation can be considered by setting emissivity and temperature difference between objects. The user can choose VF (view factor) method or FLUX method as a calculation method. The user can also consider wavelength dependence, transmission, absorption, refraction, diffusion, and reflection of radiation. In FLUX method, the user can also consider directionality.
Mapping
When a target phenomenon is in a small range and the phenomenon is affected by a wide range of its surrounding area, analysis results of the surrounding area can be used for an analysis of the target phenomenon as boundary conditions to decrease the calculation load.

Fan model (rotating blades)
With this model, an average flow field around rotating blades can be simulated only by entering characteristic properties regardless of real shapes of fans or propellers. The user can use the non-dimensional swirl coefficient model, the simplified propeller model, and the simplified rotor model. This model is useful to analyze axial-flow windmills and waterwheels.

Operation logging by VB interface
The operations in Preprocessor can be saved as a log file using the VB interface. Making the user scripting unnecessary, this makes the construction of an automated system affordable in a short period of time based on the files storing the operation logs.

Coupled analysis with GT-SUITE
Coupled analysis with GT-SUITE is available. The entire flow in an intake and exhaust system is calculated with GT-SUITE and small flows of each part are interpolated with scFLOW or SC/Tetra. This will enhance calculation accuracy of the whole system.
Script functions

Before, complicated settings, including time-coordinate-dependent material properties or boundary conditions, required a coding and compilation of user-defined function in C language. With the script functions, compilation is not required. Functions can be written in Preprocessor based on JavaScript.

SmartBlades

This function is useful for analyzing the shape of a fan automatically throughout creating the shape of a fan (CAD data), calculating the flow, and post-processing. The shape of a fan can be created easily by specifying parameters including the number of blades, fan diameter, rake angle, and skew angle.

FluidBearingDesigner

The function creates groove patterns of fluid bearings (dynamic-pressure bearing) and generates mesh. You can select the shape of grooves such as journal and thrust and materials such as porous material. From calculation results, you can obtain parameters for designing fluid bearings such as axial force and drag coefficient.

Functions for turbomachinery

One-pitch shape can be extracted from a periodic model such as an impeller or a vane of turbomachinery. The analysis result of the one-pitch model can be checked in the meridian plane. Two regions whose pitches are different can also be analyzed. The calculation load will be reduced by using this function.
Functions (scFLOW, SC/Tetra)

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<td>Volume force / pressure loss</td>
<td>Heat generation</td>
</tr>
<tr>
<td></td>
<td>Turbulence generation</td>
<td>Smoke source (diff using materials)</td>
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<tr>
<td></td>
<td>Solid shear heating</td>
<td>Simplified propeller model</td>
</tr>
<tr>
<td>User-defined conditions</td>
<td>Variability table / functions</td>
<td>User-defined function (compilation required)</td>
</tr>
<tr>
<td>Calculation control environment</td>
<td>Final resolution of the calculation</td>
<td>All tools</td>
</tr>
<tr>
<td>Postprocessor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawing functions</td>
<td>Mesh, vector, contour plots</td>
<td>Analyze, isosurface, pathlines, volume rendering</td>
</tr>
<tr>
<td></td>
<td>Axis, angle, patterns, color rendering</td>
<td>Heat designer, isosurface, pathlines</td>
</tr>
<tr>
<td></td>
<td>Contour rendering</td>
<td>Pathlines</td>
</tr>
<tr>
<td></td>
<td>Volume rendering</td>
<td>Arbitrary slicing</td>
</tr>
<tr>
<td></td>
<td>Viewpoint picking</td>
<td>Point picking (surface, edge)</td>
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<tr>
<td></td>
<td>Light source picking</td>
<td>Light source picking (surface, edge)</td>
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<tr>
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<td>Surface lighting</td>
<td>Surface lighting (surface, edge)</td>
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<td>Lighting filter, gradient</td>
<td>Lighting filter, gradient (surface, edge)</td>
</tr>
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<td>Special effects</td>
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<tr>
<td>Animation</td>
<td>Vertex animation</td>
<td>Status animation</td>
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<tr>
<td></td>
<td>Camera movement</td>
<td>Camera movement</td>
</tr>
<tr>
<td></td>
<td>Camera target</td>
<td>Camera target</td>
</tr>
<tr>
<td></td>
<td>Viewpoint translation</td>
<td>Camera translation between cycles</td>
</tr>
<tr>
<td>Analysis results</td>
<td>Variable registration</td>
<td>Variable registration</td>
</tr>
<tr>
<td></td>
<td>Export to ODS</td>
<td>Export to ODS</td>
</tr>
<tr>
<td></td>
<td>Export to csv</td>
<td>Export to csv</td>
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<tr>
<td></td>
<td>Export to pdf</td>
<td>Export to pdf</td>
</tr>
<tr>
<td>Data/image output</td>
<td>Import/DX, VRML, OBJ</td>
<td>Import/DX, VRML, OBJ</td>
</tr>
<tr>
<td>Operation and control environment</td>
<td>Selectable help functions</td>
<td>OpenGL animation</td>
</tr>
<tr>
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<td></td>
<td>3D rendering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selectable mouse operation model</td>
</tr>
</tbody>
</table>

System Configuration

<table>
<thead>
<tr>
<th>Product</th>
<th>Compliant OS</th>
<th>Recommended environment</th>
<th>Approx. measure of analysis size</th>
</tr>
</thead>
<tbody>
<tr>
<td>scFLOW</td>
<td>Windows: Windows 10 (Verified by Version 1803)</td>
<td>[Memory] 8GB or more</td>
<td>scFLOW: 1.5 million mesh elements / 4.0GB</td>
</tr>
<tr>
<td></td>
<td>Windows 8.1</td>
<td>[Hard disk] 180GB or more free capacity recommended</td>
<td>SC/Tetra: 1.5 million mesh elements / 4.0GB</td>
</tr>
<tr>
<td></td>
<td>Windows 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windows Server 2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windows Server 2012 R2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windows Server 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windows Server 2008 R2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC/Tetra</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RedHat Enterprise Linux 7 (Verified by 7.4)</td>
<td>[Memory] 8GB or more</td>
<td>scFLOW: 1.5 million mesh elements / 4.0GB</td>
</tr>
<tr>
<td></td>
<td>RedHat Enterprise Linux 6 (6.1 or later)</td>
<td>[Hard disk] 180GB or more free capacity recommended</td>
<td>SC/Tetra: 1.5 million mesh elements / 4.0GB</td>
</tr>
<tr>
<td></td>
<td>SUSE Linux Enterprise Server 12 (Verified by SP3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SUSE Linux Enterprise Server 11 (SP3 or later)**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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*1 Only compliant with Solver, Monitor and Meshing function of Preprocessor.
*2 [scMonitor] Unsupported environment.
Visualize your multiphysics phenomena in one environment
Postprocessor regularly installed in Software Cradle products can be purchased separately

**scPOST**

**Postprocessor**
In Postprocessor, you can visualize the simulation results calculated in Solver. It is effective for product design reviews because in Postprocessor, you can check, for example, temperature distribution at the places that cannot be measured or observed in the actual products. You can output not only still images but also animations, as well as output files for CradleViewer.

**Characteristics**
You can:
- Obtain numerical information with simple operation.
- Create beautiful animation quickly in Postprocessor.
- Easily map temperature information obtained in a fluid analysis to a structural analysis.
- Easily compare multiple analysis results.
- Easily calculate heat transfer and grasp a whole of heat-related matters.
- Output images supporting VR.

*Output in the equirectangular format with parallax

**Useful functions (example)**
- Creates animation automatically
- Saves display status
- Develops the image on the meridian plane
- Compares results
- Calculates (integral, registering functions)

**Compatible formats for import/export**

<table>
<thead>
<tr>
<th>Formats supported</th>
<th>Other format</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Import</strong></td>
<td></td>
</tr>
<tr>
<td>• MSC Nastran2018 (.h5)</td>
<td>• Images (BMP, PNG)</td>
</tr>
<tr>
<td>• MSC Marc 2018 (.t19, .t16)</td>
<td>• 3D geometry data (STL, OBJ)</td>
</tr>
<tr>
<td>• Generic format for fluid data (.cgn) [ADF only]</td>
<td></td>
</tr>
<tr>
<td><strong>Export</strong></td>
<td></td>
</tr>
<tr>
<td>• Generic format for fluid data (.cgn) [Only ADF can be exported through scCONVERTER]</td>
<td>• Images (BMP, JPEG, PNG)</td>
</tr>
<tr>
<td></td>
<td>• Animation (AVI, WMV)</td>
</tr>
<tr>
<td></td>
<td>• 3D geometry data (STL, VRML, FBX)</td>
</tr>
</tbody>
</table>

**Drawing samples**

- Isosurface
- Contour
- Oil flow
- Volume rendering
- Vectors
Co-simulation with MSC Software products
Integration of multidisciplinary analyses – from materials to systems

More realistic coupled fluid – mechanical – structural analyses
Capturing movement and deformation more precisely and expressing boundary conditions in fluid analyses with more reality

Co-simulation platform
The platform for coupled analyses with MSC mechanical and structural analysis solvers provides seamless co-simulation.

MSC CoSim Engine
Co-simulation using FMI
Co-simulation using FMI a tool independent standard of 1D co-simulation interface

Co-simulation with Actran, acoustic analysis software
scFLOW and SC/Tetra are used to create fluid sound sources and Actran is used for propagation analysis of sound waves.

Acoustic analysis using fluid analysis results as a source sound
Wow! Was it this easy?!
Non-experts can start thermal analysis right away with easy operation in 2D and real-time results

PICLS is a thermal simulation tool which helps designers easily perform thermal simulation of PCBs. Even if you are unfamiliar with thermal simulation, you will obtain a simulation result without stress through the tool’s easy and quick operation in 2D. You can import the data of a PCB created in PICLS to scSTREAM and HeatDesigner, that is, you can pass the analysis data seamlessly from the PCB design stage to the mechanical design stage.

Advantages

- Easy to use
  (Operation in 2D, integrated GUI for pre- and post-processing)
- Inexpensive
- Capable of real-time analysis

Thermal countermeasures using PICLS

- Checking the layout of components to avoid interference of heat between them
- Troubleshooting thermal issues of current products
- Considering heat release depending on a wiring pattern (coverage ratio)
- Examining the location and the number of thermal vias
- Examining the performance of a heatsink
- Examining the size of a PCB
- Examining the number of layers and the thickness of copper foil
- Considering natural/forced air cooling
- Considering radiant heat
- Considering heatsinks (number of fins, size)
- Examining heat dissipation performances by connection to enclosure
- Considering PCB mounting environment

Functions available in PICLS and PICLS Lite

- Multiple layers
- 3D preview
- Real-time display
- Radiation
- IDF3.0 interface
- Library
- Wiring area specification
- Displaying each layer
- Automatic report output
- Contact thermal resistance
- Considering a heatsink
- Wiring data (Gerber) import
- Thermal via
- Cutting out a PCB
- Forced air cooling
- Temperature margin, alert function
- Consideration of simple enclosure
- Drill data import

* PICLS Lite is provided online
Main features of PICLS and PICLS Lite

Modeling

External file interface
You can import IDF 3.0 and Gerber data

Consideration of simple enclosure
You can consider heat dissipation by connection to enclosure

Cutting out a PCB
You can create a PCB of arbitrary shape using cut-out function.

Heatsink
You can allocate and display parts such as plate fins and heat dissipation plates

Library
You can register and reuse created parts to the library

Preview
You can check the layout of components in the 3D image.

Calculation and Post-Processing

Real-time display
The translation of components is displayed in real time.

Report output
You can output analysis results as reports.

Alert function
You can check parts whose temperature is higher than threshold

System Configuration

<table>
<thead>
<tr>
<th>Compliant OS</th>
<th>Recommended environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows 10</td>
<td></td>
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<tr>
<td>Windows 8.1</td>
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<tr>
<td>Windows 7</td>
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<tr>
<td>Windows Server 2016</td>
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<tr>
<td>Windows Server 2012 R2</td>
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<td>Windows Server 2012</td>
<td></td>
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<tr>
<td>Windows Server 2008 R2</td>
<td></td>
</tr>
<tr>
<td>RedHat Enterprise Linux 7 *1</td>
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<tr>
<td>RedHat Enterprise Linux 6 (6.1 onward) *1</td>
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<tr>
<td>SUSE Linux Enterprise Server 12 *2</td>
<td></td>
</tr>
<tr>
<td>SUSE Linux Enterprise Server 11 (SP3 onward) *1</td>
<td></td>
</tr>
</tbody>
</table>

*1 Supports license manager only.

*2 Supports co-simulation with MSC products.
Analysis Procedure
—scSTREAM (HeatDesigner), scFLOW and SC/Tetra

There are three major steps in the workflow for obtaining simulation results.

**STEP.1 Preprocessor**

With Preprocessor, create or import analysis models, set analysis conditions, and generate mesh.

**STEP.2 Solver**

Flow/thermal calculations are performed using input data created in the Preprocessor. During the computation, calculation status can be monitored. The amount of time required for the computation depends on the size of the model (number of mesh elements), quality of the model, and hardware. A parallel Solver is available for reducing the computational time of large-scale models.

- **Solver features (examples)**
  - Setting the degree of parallelism
  - Monitoring job status
  - Visualizing results in real-time

**STEP.3 Postprocessor**

The Solver outputs field data for visualization using the Postprocessor. This permits examining flow, temperature, pressure, and other analysis results. Visualized results can be converted to images, animations and/or CradleViewer (details on P23) files for later use.

- **Various drawing functions**
  - Vector plot
  - Isosurface
  - Contour map
  - Pathline (available only in SC/Tetra)
  - Streamline
  - Oil flow
  - Still image and animation output

* See page 25 (HPC Solution) for more information about parallel calculation
Main Mutual Features

**CAD Interface**

Software Cradle analysis software can import native data from major 3D CAD software as well as import most generalized intermediate data formats. This eliminates the cumbersome process of data conversion.

**Import**

<table>
<thead>
<tr>
<th>CAD / geometry data</th>
<th>CAD interface</th>
<th>Format</th>
<th>V14 compliant versions</th>
</tr>
</thead>
<tbody>
<tr>
<td>CATIA V5</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>CATIA V4</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>Creo Elements/Pro/Pro/E</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>SOLIDWORKS</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>UG NX</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>SolidEdge</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>Autodesk® Inventor*</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>Autodesk® Revit*</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>ARCHICAD</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>IGES</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>VDAFS</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>ACIS</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>Parasolid</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>STEP</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
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<td>ST</td>
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<td>SHAPE</td>
<td>ST</td>
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<td>3ds</td>
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<tr>
<td>STL</td>
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<td>HD</td>
<td>FLOW</td>
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<tr>
<td>Nastran</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
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<tr>
<td>SketchUp</td>
<td>ST</td>
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<tr>
<td>Alaska*</td>
<td>ST</td>
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<td>DesignSpace</td>
<td>ST</td>
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<td>Plot3D</td>
<td>ST</td>
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<td>CGNS</td>
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<td>DFX</td>
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<td>IDF</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
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<td>GERBER</td>
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<td>HD</td>
<td>FLOW</td>
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</table>

**Export**

<table>
<thead>
<tr>
<th>CAD / geometry data</th>
<th>CAD interface</th>
<th>Format</th>
<th>V14 compliant versions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parasolid</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>STL</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>Nastran</td>
<td>ST</td>
<td>HD</td>
<td>FLOW</td>
</tr>
<tr>
<td>CGNS</td>
<td>ST</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HPC (High Performance Computing) Solution**

Large-scale, high-speed simulation with parallel computing technologies

Parallel computing makes possible solving existing models faster, conducting more analyses, and/or solving more detailed models with a greater number of mesh elements.

**scSTREAM V14**

- Projector: Approx. 20 million elements
- Arena: Approx. 70 million elements
- Degree of parallelism
  - Speed up ratio
  - Degree of parallelism

**scFLOW V14**

- Convertible: Approx. 15 million elements
- Skoano fan: Approx. 15 million elements
- Degree of parallelism
  - Speed up ratio
  - Degree of parallelism

**www.cradle-cfd.com**
Main Mutual Features

scMonitor
You can visualize the progress of the simulations in scMonitor during the Solver calculations. You can check, for example, pressure contour of a registered surface and temperature contour and flow vector on axial planes.

LFileView
LFileView is a dedicated viewer for L files, which are output during the simulations automatically. You can check the progress of the simulations numerically with variable values for each cycle and the maximum/minimum/average values for the specified output.

VB Interface
The software supports COM technology provided by Microsoft. You can control the software by using Microsoft Office products and Visual Basic (VB). A tool to create and execute the automatic operation flow, scWorks ketch, is bundled with the software. By using the tool, you can create your original automatic operation flow easily. In addition, you can register the created flow as a template and reuse it.

Parametric Study Tool
Using the parametric study tool, you can set analysis conditions to multiple cases all at once - for instance, when you run several calculations with modified parameters such as flow rate or amount of heat. The interface is user-friendly with spreadsheet-like settings. You can check, in the same interface, the status of each case and the output parameters such as the maximum/minimum temperature or average pressure on a specified plane.

Useful functions
- Tool to create a report automatically
- Unique GUI
- Tool to create a model from the 2D data automatically

*To use this function, a Postprocessor license is required in some areas.

*This tool is available in scSTREAM, HeatDesigner, and SC/Tetra
CradleViewer

The simulation result visualized in Postprocessor can be saved in a file and the file can be opened in a simple viewer. In the viewer, the viewpoint and the distance can be changed with the mouse and by touch operation*. CradleViewer is provided free of charge. You can share the simulation result even in an environment without Postprocessor installed.

*Operation using two fingers is supported on a multitouch-compatible screen in a Windows 10 or Windows 8.1 environment.

HeatPathView

Using HeatPathView, you can review heat dissipation measures with focus on each component. The tool enables the intuitive and comprehensive evaluation of heat balance and search of heat dissipation paths. By understanding the flow of heat, you can make your heat dissipation designs more reliable.

scCONVERTER

Data (FLD/FPH files) such as pressure, temperature, and heat transfer coefficient obtained in thermo-fluid analyses can be mapped to input data of structural analysis software (Abaqus, I-DEAS, Nastran). In addition, input data of structural analyses can be converted to an FLD or FPH file. scCONVERTER can create an animation file from multiple still images (BMP/PNG files), edit FLD/FPH files, and convert a P file to an FLD file or an FLD file to an iFLD file.

Analysis result of SC/Tetra

Mapping to structural analysis mesh
Introducing Optimus®
Optimus is an integration platform of simulation tools with optimization and automation as its cores

* Software Cradle handles Optimus® only in Japan

1. Optimus®
Optimus has a direct interface with scSTREAM, scFLOW and SC/Tetra, and the optimization can be performed without any additional customization. It also supports a creation of an original GUI using API and an optimization using Quality Engineering (Taguchi Method).

### Automation/Integration
Executes the processes automatically just by constructing a simulation workflow with icons.

### Data Mining
Visualizes data immediately. Relationships between the parameters can be grasped easily from sensitivity and correlation analyses.

### Optimization
Optimization algorithm automatically searches the parameters yielding the best performance.

### Robustness, Reliability
Predicts the variations in performance from the variations of parts. This enables the design with consideration on the variations in advance.

2. Optimus® for Cradle
Optimus® for Cradle is an optional tool which allows for the uses of optimization functions of Optimus directly on Software Cradle products. Optimization can be performed with ease, by inputting design variables and other parameters from the dedicated GUI.

* Optimus for Cradle direct interface for scFLOW will be available in V2020

### Comparison Table: Optimus® and Optimus® for Cradle

<table>
<thead>
<tr>
<th>Description</th>
<th>Optimus®</th>
<th>Optimus® for Cradle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linkage to Software Cradle products</td>
<td>Condition setting</td>
<td>(Direct interface)</td>
</tr>
<tr>
<td>Linkage to third party products</td>
<td>Shape modification using CAD</td>
<td>(Direct interface)</td>
</tr>
<tr>
<td>Calculation method</td>
<td>Simulation linkage</td>
<td>–</td>
</tr>
<tr>
<td>Response surface</td>
<td>DOE</td>
<td>Total 23 methods</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All 5 + Optional 11 methods</td>
</tr>
<tr>
<td>Single-objective optimization</td>
<td>Local: Total 5 methods</td>
<td>Global: Total 7 + Optional 5 methods</td>
</tr>
<tr>
<td>Multi-objective optimization</td>
<td>Total 11 + Optional 5 methods</td>
<td>–</td>
</tr>
<tr>
<td>Robustness / Reliability / Quality Engineering</td>
<td>Total 7 methods, orthogonal table L4-512, static/dynamic characteristics</td>
<td>–</td>
</tr>
<tr>
<td>Postprocessing</td>
<td>Method</td>
<td>Total 23 types</td>
</tr>
<tr>
<td></td>
<td>Model</td>
<td>Total 13 types</td>
</tr>
</tbody>
</table>
License type

We provide various license types based on customer operations from on-premise to cloud.

1. On-premise license: Features
   - Underpriced
   - Internally manageable machines
   - Existing hardware resources
   - No data transfer
   - Internally controlled security
   - In-house tools (e.g. automation)
   - Multiple tools in combination

2. Cloud license: Features
   - On-demand offer\(^1\)
   - No hardware required
   - Large-scale calculations
   - Support for sudden need
   - No maintenance required
   - Underpriced for infrequent users
   - Not an asset

Recommended for customers who want to...

- Incorporate analysis into design workflow constantly and reduce cost
- Elaborate a combinational use of multiple analysis tools with a simple system
- Simplify analysis operations for obtaining design pointers and allow several users short-term uses

Recommended for customers who want to...

- Finish large-scale calculations in a short time although ordinary calculations can be performed with on-premise licenses
- Use outside resources temporarily because in-house resources is insufficient at the time
- Handle intensive calculation jobs efficiently for one project without placing burden on in-house resources

License type lookup table

<table>
<thead>
<tr>
<th>Software Key</th>
<th>License</th>
<th>Agreement type, period</th>
<th>License server</th>
<th>Internet</th>
<th>Pre/Post</th>
<th>Solver</th>
<th>Pre/Post</th>
<th>Solver</th>
</tr>
</thead>
<tbody>
<tr>
<td>scSTREAM SC/Tetra</td>
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\(^1\) Only available in a certain region
\(^2\) Agreement type available with Altair Partner Alliance (APA) provided by Altair Engineering, Inc. For details, go to the official website of APA.
1. Electromagnetic Field Analysis Software

Using the data output from the electromagnetic analysis software, the effect of heat source distribution due to an electromagnetic field can be analyzed.

- JMAG-Designer
  Developed by JSOL Corporation (Japan)
- Femtet®
  Developed by Murata Software Co., Ltd (Japan)
- EMsolution®
  Developed by Science Solution International Laboratory, Inc. (Japan)

Heat source distribution calculated by using EMsolution
Analysis results obtained by using SC/Tetra

2. Acoustic Analysis Software

The acoustics of aerodynamic noise can be analyzed using SC/Tetra output data.

- LMS Virtual.Lab
  Developed by Siemens PLM Software (USA)
- FlowNoise
  Developed by CEDIC (Korea)

CFD analysis results using SC/Tetra (velocity vector)
Analysis results using Actran

3. Structural Analysis Software

Using the output data from scFLOW, SC/Tetra and scSTREAM, structural analysis can include the influence of heat transfer and other fluid interactions.

- Abaqus*
  Developed by Dassault Systèmes S.A. (France)
- Nastran
- Femtet®
  Developed by Murata Software Co., Ltd (Japan)
- Femtet®
  Developed by Murata Software Co., Ltd (Japan)
- ADVENTURECluster
  Developed by Allied Engineering Corporation (Japan)

Analysis results obtained by using SC/Tetra (temperature contour map)
Results of thermal stress analysis obtained by using Femtet (displacement distribution)
4. Thermal Environment Simulation Software

The surface temperature distribution is output from the thermal environment simulation software. The output data can be used as boundary conditions for scSTREAM calculation to analyze the distribution of wind velocity and temperature.

5. One-Dimensional Analysis Software

Computational load can be reduced by not solving all of the thermo-fluid analysis in three dimensions but using one-dimensional analysis software for some part.

6. Chemical Reaction Analysis Software

Using material property parameters and chemical reaction database of LOGE, coupled analysis with SC/Tetra can be performed. This enables analysis of overall chemical reactions and detailed chemical reactions, which could not be analyzed by SC/Tetra alone.

8. Optimization Software

Software Cradle products can be used in conjunction with optimization software for automation and/or optimizing product design.

9. Visualization Software

Read, visualize and edit FLD data (analysis results file from Software Cradle products) using other visualization software.
About Software Cradle

Software Cradle Co., Ltd. is an innovative provider of computational fluid dynamics (CFD) simulation software. Established in 1984, the company has pursued to offer unique, innovation focused, and highly reliable CFD solutions that enhance customers' product quality and creativity. In 2016, the company joined MSC Software Corporation (headquartered in Newport Beach California, US), the worldwide leader in the field of multidiscipline simulation. As a truly global company, Software Cradle delivers all-inclusive multi-physics solutions.

For more information about MSC Software Corporation, please visit: