Outline

• ANSYS Workbench
• Structure Mechanics
• Fluid Dynamics
• System Simulation
ANSYS Workbench 14.0

- System Coupling
- ANSYS RSM (Remote Solve Manager)
- ANSYS DesignXplorer
- ANSYS EKM (Engineering Knowledge Manager)
System Coupling 14.0

- Facilitates simulations that require tightly integrated couplings of analysis systems in the ANSYS portfolio
- Extensible architecture for range of coupling scenarios (one-, two- & n-way, static data, co-simulation...)
- ANSYS Workbench user environment and workflow
- Stand-alone coupling service delivers coupling management and mapping/interpolation
Multiphysics and System Coupling – FSI

Two-way surface force/displacement coupling between Fluent and Mechanical via System Coupling
- Steady/static and transient two-way FSI
- Integrated post-processing with CFD-Post
- Workbench based setup and execution
  - Windows and Linux
- Alternative execution from command line
  - including cross-platform
- Parallel processing with ANSYS HPC
  - RSM currently not supported
- Restarts for fluid-structure interaction
- Parameterization, design exploration and optimization

Clamped fuel rod in a cross flow (vorticity contours)
**ANSYS Remote Solve Manager (RSM) 14.0**

- RSM supports background update of the Solution (or Analysis) component for:
  - Mechanical (ongoing support)
  - MAPDL (now supports parallel solve)
  - CFX (now supports parallel solve, external files)
  - FLUENT (now supports parallel solve, UDFs)
- Queue multiple jobs on a local machine
  - Overnight or other low-usage times
- Submit jobs to remote machines
  - Distributed clusters
  - Management of files, including UDFs
- Update design points in parallel via RSM
RSM: Simultaneous Update of Design Points

- Get design point simulations done faster
- Job submission can be:
  - One job for all design points
  - One job for each design point
  - Specify max no. of jobs
ANSYS DesignXplorer 14.0

- Workbench Design Exploration and Optimization for increased understanding, innovation & simulation ROI
- New at 14.0
  - Reduced time required
    - 2 new adaptive DOEs
  - Distributed solve
  - Design point sorting
- Increased Robustness
  - Support for partial DOE’s
- Increased understanding
  - New charts
  - Improved GOF
  - Project report
ANSYS DesignXplorer

Advanced Technology

• DOE Technology to scientifically determine minimal parametric combinations to solve
• Advanced response surface fitting
• Advanced algorithms for Optimization

Valuable Analysis

• Understand correlation, sensitivity, determination...
• Understand design tradeoffs
• Six Sigma Analysis
  – 3.4 failures per million parts
ANSYS EKM 14.0

- EKM (Engineering Knowledge Mgr.)
  - Individual user
  - Workgroups/Shared user

- Integration with Workbench
  - Save Workbench projects to the repository
  - Automated indexing and Report generation for Workbench Projects
  - Search and Resume Workbench projects
  - Execute Workbench projects for parametric runs, DOE, Optimization
  - Compare multiple Workbench Projects to find the best fit candidate
ANSYS EKM: Simulation Data and Process Mgmt.

- Global engineering deployment
- Tools for simulation review, approval and version control
- Automatic metadata extraction
  - Search and re-use simulation assets
- Easily archive Workbench simulations to EKM
ANSYS EKM for Federated Data Storage

- Connect to multiple EKM data sources.
- Access data on all through single search.
Automatic Metadata Extraction from CAE Files

FLUENT Case: dp0-FFF-Fluent-FFF-2.cas.gz Properties:
- DPM Model: Off
- Energy Model: On
- FLUENT Version: fluent12.0.16
- Formulation: Explicit
- Materials: air, water-liquid, aluminum
- Multiphase: Off
- Model: Off
- Radiation: Off
- Model: Off
- Regions: outlet_water, inlet_air, interior-enclosure, interior-pipes, enclosure, outlet_air1, inlet_water, outlet_air2, wall-enclosure-pipes, wall-enclosure, pipes, wall-enclosure-pipes-shadow
- Solver: Segregated
- Space: 3D
- Time: Steady State
- Viscous Model: K Epsilon

Mechanical Model: dp0-global-MECH-SYS.mech.db Properties:
- Analysis Types: Steady-State Thermal, Static Structural
- Contact Types:
- Elements: 920
- Geometry Source: \2Pipes\files\dp0\FFF\DM\FFF.agdb
- Mass:
- Material Behaviors: Linear Elasticity
- Material Properties: Elasticity
- Materials: Structural Steel
- Nodes: 5046
- Parts: 3
- Solution Names: Temperature, Total Deformation, Equivalent Stress
- Space: 3D
- Volume: 0.00370667

FileAttributes Properties:
- Acknowledgement Description:
- Restriction Description:
- Simulation Details Report: Properties Dependencies Permissions Content User names workspace Simulation
IT Efficiency, Consolidation, Operational Cost Control
Data Integration with PDM/PLM

- **ANSYS Solution**: EKM Datalink, based on OpenPDM provides high function multi-vendor solution

  ![ANSYS EKM](image)

  Geometry, CAE Inputs

  ![EKM Datalink](image)

  CAE Reports, Results

  ![PTC Windchill](image)

  ![Ennovia](image)

  ![SIEMENS Teamcenter](image)

- **Open Solutions with Partners**: ANSYS open file formats enable PDM vendors to develop direct file import/export between Workbench and third-party simulation data management solutions

  - ANSYS services can help you succeed

© 2011 ANSYS, Inc.
Geometry Advances

Focus on enhancing your productivity through new features, increased flexibility, efficiency and usability

• ANSYS DesignModeler
  – Core modeling improvements
    • Direct entity selections for Extrude, Sweep, Revolve...
    • Auto Freeze during Slicing
    • Tolerance for Mid-Surfacing
    • Color display for surface thickness
  – Application-specific modeling
• ANSYS SpaceClaim Direct Modeler
  – Improved Workbench integration
  – Enhanced Model Preparation
• Interoperability
  – Support for new CAD releases
  – New CAD file readers
Rapid and Robust Meshing

- Assembly meshing
- Selective Meshing Worksheet
  - Allows selective body meshing to remain persistent
  - User can record meshing operations, or add steps manually
- Inflation layers meshing speed up (~2x)
- Hex meshing and Cutcell robustness improvement
- Overall mesh quality improvement
- Virtual topologies
  - Clustering of faces/edges
  - Create hard vertex
  - Face splits

![Create hard vertex](image1)
![VT edge splits](image2)
![VT face splits](image3)

© 2011 ANSYS, Inc.
Structural Mechanics 14.0

- MAPDL/WB Integration
- Physics coupling and data mapping
- Rotating machines
- Composites & Fracture Mechanics
- Application Customization
- Thin structures modeling
- Contact analysis
- Advanced Modeling
- Performance
MAPDL/WB Integration

Direct FE
• Nodal Orientation
• Nodal Force
• Nodal Pressure
• FE Displacement
• FE Rotation
• Works with RESTART!
• Displacement Results

Nodes are oriented in cylindrical system for loads and boundary condition definitions

Node selections for applying loads and reviewing local results
Enhanced Data Mapping

- New data types
  - Heat flux
  - Heat generation
  - Thickness
  - Displacement (β)
- Weighting options
  - Kriging
  - Triangulation
  - Distance based average
- Multiple files import
  - Transient analysis
  - Multiple bodies
- New mapping validation

Accuracy control
Composites

- Data Integrate ACP Pre/Post into WB
- Composite failure material properties in Engineering Data
- Simple setup and post-processing of laminate composites in Mechanical (shells only at R14)
- Allow transfer of data between ACP and Mechanical at WB schematic level
Contact Analysis

• Rigid bodies
  – Speed and accuracy improvements
  • 2-5x overall speed-ups

• Flexible bodies
  – Projection based contact
  – Contact stabilization

Regular contact

Projection based

Smotherer temperature results on a multilayered structure
Advanced Materials

- More advanced models to include complex nonlinear phenomena
  - Anisotropic Hyperelasticity plus Viscoelasticity for strain rate effects
  - Hyperelasticity coupled with Pore Pressure element
  - Shape Memory Alloy enhanced with superelasticity, Memory effect, New Yield Function, Differentiated Moduli (Austenite, Martensite)
  - Holzapfel Model - Capture the behavior of fiber-reinforced tissue
  - Coupled field-elements for strongly coupled thermo-mechanical analysis now accounts for plasticity induced heat generation along with friction effect

Nonlinear materials support for coupled field elements – An example of Friction Stir Welding.

Advanced Materials for Biomechanical Applications
Advanced Models

- Enhanced 3D rezoning
- Moisture effects
- Coupled structure/acoustics
  - Quadratic tetrahedral acoustics elements (V13)
  - New acoustics sources
  - Absorbing areas
  - Symmetric FSI formulation
  - Near and far-field parameters

Coupled structures/acoustics simulations

Moisture diffusion
ANSYS Mechanical SMP – GPU Speedup

From NAFEMS World Congress May 2011 Boston, MA, USA

"Accelerate FEA Simulations with a GPU"
-by Jeff Beisheim, ANSYS

Solver Kernel Speedups

Overall Speedups

Tesla C2050 and Intel Xeon 5560
**GPU Acceleration for DANSYS**

**R14 Distributed ANSYS Total Simulation Speedups**

- **4 CPU cores**
- **4 CPU cores + 1 GPU**

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Speedup 4 CPU cores</th>
<th>Speedup 4 CPU cores + 1 GPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>V13cg-1</td>
<td>1.52</td>
<td></td>
</tr>
<tr>
<td>V13sp-1</td>
<td>1.16</td>
<td></td>
</tr>
<tr>
<td>V13sp-2</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>V13sp-3</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>V13sp-4</td>
<td>2.24</td>
<td></td>
</tr>
<tr>
<td>V13sp-5</td>
<td>1.44</td>
<td></td>
</tr>
</tbody>
</table>

- **Windows workstation**: Two Intel Xeon 5560 processors (2.8 GHz, 8 cores total), 32 GB RAM, NVIDIA Tesla C2070, Windows 7, TCC driver mode
Fluid Dynamics 14.0

- Workflow & Usability
- Multiphysics and Systems Coupling
- Solver and HPC Performance
- Rotating Machinery
- Automotive Power Train Modeling
- Multiphase Flow Modeling
- Comprehensive CFD Capabilities
Two-way surface force/displacement coupling between Fluent and Mechanical via Systems Coupling

- Steady/static and transient two-way FSI
- Integrated post-processing with CFD-Post
- Workbench based setup and execution
  - Windows and Linux
- Alternative execution from command line
  - including cross-platform
- Parallel processing with ANSYS HPC
  - RSM currently not supported
- Restarts for fluid-structure interaction
- Parameterization, design exploration and optimization
System Coupling: Oscillating Plate

- Oscillating Plate Verification
  - Excellent correlation between System Coupling, published data and MFX solver
Multiphysics – 1-way FSI

Significantly faster surface mapping for 1-way FSI (CFD-Post) $^\beta$

- New Octree mapping method → significantly faster algorithm
  - Need to set Option in CFD-Post

- 1-way FSI in ANSYS Workbench uses CFD-Post ‘under-the-hood’
  - Will use mapping option set by user in CFD-Post (which is stored in user preferences)
  - Status message with diagnostics report indicates new mapping method is being used
Complex multiphysics modeling
• New: Electromagnetic-thermal interactions inside Workbench using Fluent with Maxwell
  – One-way and two-way $\beta$ coupling
• Combine with 1-way FSI
Adjoints Solver for Fluent fully tested, documented, and supported at R14.0

- Provides information about a fluid system that is very difficult and expensive to gather otherwise
- Computes the derivative of an engineering quantity with respect to inputs for the system
- Engineering quantities available
  - Down-force, drag, pressure drop
- Robust for large meshes
  - Tested up to ~15M cell

<table>
<thead>
<tr>
<th>Geometry</th>
<th>Lift Force (N)</th>
<th>Predicted</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original</td>
<td>---</td>
<td>555.26</td>
<td>555.26</td>
</tr>
<tr>
<td>Mod. 1</td>
<td>577.7</td>
<td>578.3</td>
<td></td>
</tr>
<tr>
<td>Mod. 2</td>
<td>600.7</td>
<td>599.7</td>
<td></td>
</tr>
<tr>
<td>Mod. 3</td>
<td>622</td>
<td>621.8</td>
<td></td>
</tr>
</tbody>
</table>
Solver and HPC Performance

Improved scalability (FL)

- Scalability to higher core counts
- Simulations with monitors including plotting and printing
- Cluster-to-cluster view factor file writing optimization

Sample cluster-to-cluster view factor data writing using 32-way parallel and Infiniband.
Rotating Machinery

Highly efficient time accurate simulations with Transient Blade Row capability (CFX)

- Several models available
  - Time Transformation (TT)
    - Inlet Disturbance
    - Single Stage TRS
  - Fourier Transformation (FT)
    - Inlet Disturbance
    - Single Stage TRS $\beta$
    - Blade Flutter $\beta$

Surface pressure distribution (top) and monitor point pressure (left) from an axial fan stage:
Equivalent solution with Time Transformation at fraction of computational effort
Automotive Power Train

- New IC Engine Analysis System provides unified and simplified set-up for internal combustion engines
  - Automate combustion and spray set-up
- New Battery Model
- After Treatment
  - Selective Catalytic Reduction (SCR)
  - Catalytic Converter Light-Off
Model dense particulate flows with DEM (FL)

- DEM enabled as a collision model in the DPM model panel
- Use in combination with single phase and DDPM simulations
- Works in parallel
- Particle size distributions
- Prediction of the packing limit
- Head-on collisions
- Collisions with walls
- Example applications: Bubbling and circulating fluidized beds, particle deposition in filtering devices, particle discharge devices (silos)

Note that channeling is observed in the 15-30 sec animation
Improved accuracy with simplicity of immersed solids (CFX)

- Addition of boundary model for more realistic velocity forcing with immersed solids
  - Track nodes nearest to immersed solid
  - Assume constant shear (laminar) or use scalable wall function (turbulent) to modify forcing at immersed solid ‘wall’

- Can improve immersed solid predictions significantly
  - Continuing development for further improvements and broader applications
ANSYS Icepak

• New GUI and graphics enhancement
  – Context aware right click menus in graphics window
• ECAD import enhancement
  – Stacked die and PoP import
  – ODB++ import
  – ANF import from 3rd party tools in both binary and ASCII
• CSV import of parametric trials and polygonal sources
• Solar radiation with transparent surfaces
• Layer stack-up for PCB object
• Local coordinate system based on flow direction for flow resistance specifications
• LED source and High Density Datacenter component macros
• Thermostat transient feedback macros for heat sources and fans
Electronic CAD Interfaces

- ANSYS Icepak supports for IDF MCM, BRD and generic ANF
- Ansoft Links provide many additional import options
- Import Gerber with ANSYS Icegrb

Electronic CAD Interfaces

<table>
<thead>
<tr>
<th>Electronic CAD Interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODB++</td>
</tr>
<tr>
<td>Cadence Allegro</td>
</tr>
<tr>
<td>Cadence APD</td>
</tr>
<tr>
<td>Cadence Virtuoso</td>
</tr>
<tr>
<td>Synopsys Encore</td>
</tr>
<tr>
<td>Zuken CR5000</td>
</tr>
<tr>
<td>Zuken CADSTAR</td>
</tr>
<tr>
<td>Altium</td>
</tr>
<tr>
<td>Mentor Boardstation</td>
</tr>
<tr>
<td>Mentor Expedition</td>
</tr>
<tr>
<td>Mentor PADS</td>
</tr>
<tr>
<td>Gerber</td>
</tr>
</tbody>
</table>
Interface to SIwave

- SIwave and ANSYS Icepak exchange power map and temperature
  - Accounts for copper resistive losses in printed circuit boards and packages
Summary

ANSYS 14.0 contains a wide range of enhancements:

• New infrastructure for flexible coupling between solvers to enable multiphysics and system level simulations

• Faster and robust solvers with highly scalable HPC for solving ever larger and more complex models with high fidelity and accuracy in less time

• Enhanced workflow and usability for greater user experience and productivity
System Simulation
Hierarchical Modeling

Ryan Magargle, Ph.D.
Ansys, Inc.
3/14/2012
System Modeling

- Hierarchical System Models
  - Multiple levels of physics
  - Reusable terminal based models of varying complexity
System Simulation

How fast can solenoid valve close?

- Multiple Physics
- Reusable Models

Magnetic Forces

Mechanical/Hydraulic Forces

Digital

Electrical

Digital Control

Solenoid

Mechanical

Hydraulic

© 2011 ANSYS, Inc.
Where Do System Models Come From?

Simplorer
System Design

Maxwell
Electromagnetic Components

Mechanical
Thermal/Stress/MBD

CFD
Flow / Thermal

© 2011 ANSYS, Inc.
Model Creation

Co-Simulation: ANSYS products use Workbench

© 2011 ANSYS, Inc.
Model Creation

Extraction: Create non-linear ‘lookup table’, or other type of reduced order model.

ANSYS solvers can automatically generate these types of models.
Simplorer V10

System Modeling Examples
System Examples: Subsea Pipe Heating

DEH Cable

Optimize compensation capacitor

FEM simulation of cable

Power Factor

Automatically search and size capacitor for 0.9 PF
System Examples: Power System Cabling

- Complex cable geometry electrical parasitics are extracted from Q3D and dynamically linked to Simploter.

- Increased cable lengths see greater signal delay and oscillation.
System Examples: Rigid Body Dynamics
System Examples: Rigid Body Dynamics

- Forces applied every cycle
- Two forces out of phase
- Small starting torque
- Measure rotation (used in force calculation)
System Examples: Rigid Body Dynamics

- Force Applied on Pistons
- Rotational Displacement
- Rotational Velocity
System Examples: Electronics Cooling

Simplorer – ANSYS Icepak Link through Model Extraction

Current profile

Temperature profile
System Examples: Structural Pipe

Pipe Segments

- Stiffness extracted from ANSYS Mechanical
- Small reusable model segment
- Pipes vibrate in borehole and contact wall
System Examples: Battery Thermal

Single battery cell

**Inputs:** Inlet Flow Rate (Kg/s) and Heat Source (W/m³)

**Output:** Outlet Temperature (K)
Results: Open Loop

<table>
<thead>
<tr>
<th>Flow Rate</th>
<th>Heat Source</th>
<th>Temperature Change @250 Sec</th>
<th>Temperature Change @1200 Sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>400k</td>
<td>37.9155</td>
<td>64.8926</td>
</tr>
<tr>
<td></td>
<td>800k</td>
<td>75.8207</td>
<td>129.787</td>
</tr>
<tr>
<td>0.02</td>
<td>400k</td>
<td>29.7525</td>
<td>39.201</td>
</tr>
<tr>
<td></td>
<td>800k</td>
<td>59.4059</td>
<td>78.402</td>
</tr>
</tbody>
</table>

Results verified with Fluent alone
Non-linear dependency on Flow Rate
System Examples: CFD Battery Co-Simulation

Results: Closed Loop

Flow is adjusted to maintain constant temperature
Summary

• Schematic based system simulation enables robust hierarchical modeling.

• Automated model generation is available through co-simulation or model extraction.

• Reusable built-in and extracted or co-simulated models enables efficient re-design and engineering.
ANSYS, Inc. at a Glance

SOFTWARE
- ANSYS Mechanical
- ANSYS CFD
- ANSYS AQWA
- ANSYS Multiphysics
- ANSYS AUTODYN
- ANSYS ICEM CFD
- Maxwell
- Simplorer
- HFSS

TECHNICAL SUPPORT
- Local
- Nation-wide
- Phone
- E-mail
- Online
- On-site

TRAINING
- Standard courses
- Custom courses
- On-site trainings
- Classroom trainings
- Online trainings

CONSULTING
- Value-added services
- New applications
- Custom development
- Integration of technologies

© 2011 ANSYS, Inc.