What is Simplerer
Agenda

• Systems Overview
• Systems Challenges and ANSYS Solutions
• Simplover
• Successful Stories
Systems Overview
Systems – What We Mean

• System =
  – Well-defined part of an Industrial Product or Asset: Aircraft/Vehicle/Power Plant/Oil Rig/Pipeline/Train, etc....
  – Delivers a particular functionality

  – When the product is *simple* (a pump, a battery), the product itself is a system
  – When the product is very complex (a plane, a car...), it is generally a collection of systems, with sub-systems

• Systems of Systems refers to the interaction of many systems in a distributed manner: an air traffic control, an electrical grid, a subway covering a city... we don’t operate at this level
Systems are made of

• **Their Body**: Physical components that sustain multiple physical phenomena: stress, vibration, fluid/structure interactions, electromagnetic interference, noise, flutter, fatigue, heating, icing, combustion, deformations, aging, radiation, etc...

• **Their Nervous system**: Electronic components: sensors, actuators, integrated circuits, chip/package/electronic system, network interfaces

• **Their Intelligence**: Software components: controls, user interfaces, databases, data management, maintenance and health monitoring
Example: A&D

- Engine Interface
- Fuel Control
- Cooling System
- ATSU (Board / Ground communications)
- Cockpit Display System
- Flight Warning System
- Electrical Load Management System
- Braking and Steering System
- Anti-Icing System
- Thrust Reverser
- Flight Control System
Example: Automotive

- Doors, Locks & Body System
- Propulsion System
- Navigation & Infotainment System
- Collision Warning System
- Communication System
- Chassis System
- Braking System
Example: Railways

Traffic Tables: CONTROL CENTER

Routes & Safeguards: INTERLOCKING

Performance & Safety: TRAIN CONTROL SYSTEM

Simulators

Driver Machine Interfaces
Systems Challenges and ANSYS Solutions
Systems Development Challenges

- Managing Design Complexity
- Optimizing Overall System Performance
- Reducing Embedded Software Costs
- Reducing Physical Validation Costs
State-of-the-Art Engineering Practices

- Managing Design Complexity
- Reducing Embedded Software Costs
- Reducing Physical Validation Costs
- Optimizing Overall System Performance
- Model-Based Systems Engineering
- Model-Based Software Engineering
- 3D Physics Simulation
- Multi-Physics and System Simulation
ANSYS Model-Based Engineering Solutions

Model-Based Systems Engineering

SCADE System

SCADE Suite
SCADE Display

Model-Based Software Engineering

SCADE Test

3D Physical Simulation & Multiphysics

ANSYS Physics

Simplorer

System Simulation
ANSYS System Simulation Platform leverages simulation at the component level

**Physical components**
- Platform
- Multiphysics
- Fluids
- Structures
- Electronics
- Semiconductors

**Electronics components**

**Software components**
Modeling the System in Simplorer

- Language-Based Modeling
- Multi-Domain Model Libraries
- Co-simulation with 3D Physics
- Reduced Order Model Creation
- Embedded Software Integration
- 3rd Party Interoperability

- VHDL-AMS
- C/C++
- SPICE
- SML
- Modelica

- Multi-Domain
- Analog
- Digital
- Power Systems
- Manufacturers
- App-Specific

- ANSYS 3D Physics
  - EM
  - Fluid
  - Thermal
  - Mech

- ANSYS SCADE

- 3rd Party System Modeling tools
Modelica: 10x Productivity for Systems Verification

- **Power Electronics**
- **EM Device**
- **Mechanical Device**
- **SPICE**
- **VHDL-AMS**
  - Electrical, Digital, Mixed-Signal
- **C / C++**
  - General Programs
- **Controller**
- **Hydraulic Controller**
- **ROM**
  - 3D FEA
- **Modelica**
  - Multi-Domain, Mechanics, Fluids
- **CoSim**
  - 3D FEA, Control

→ Higher Accuracy!
→ 10x Performance
Connecting ANSYS Solutions

**Fluid Dynamics**
ANSYS Fluent

**Structural**
ANSYS Mechanical

**Rigid Body Dynamics**
ANSYS Mechanical RBD

**Embedded Software / HMI**
SCADE Suite / SCADE Display

**System Simulation**
ANSYS Simulor

**Electro-magnetics**
ANSYS Maxwell

**Electronics Cooling**
ANSYS Icepak

**HF / Signal Integrity**
ANSYS HFSS /SIwave

**Electrical Parasitics**
ANSYS Q3D

**Co-simulation**
Reduced-Order Model
Push-back Excitations
Multi-Domain, Multi-Fidelity Simulation

- Explore Concepts & Architectures
- Measure Performance
- Design & Optimize Components
- Validate Embedded Controls
- Integrate Multiple Domains
- Analyze Detailed Effects
- Optimize Design Robustness
- Assess Reliability
- Collaborate and Exchange
What Does it Mean to Model & Simulate a System?

System Modeling
- Mathematical descriptions of behavior
- Captured in a formal modeling language
- Connected together (so they can interact)

System Simulation
- Injects inputs and sets conditions
- Calculates the response of the system
- Produces outputs to evaluate performance

Inputs
- Turn on / off
- Speed up
- Follow a Profile
- ...

Outputs
- How fast?
- How accurate?
- How efficient?
A Quick Aside: Behavioral Modeling

Mathematical Description of Behavior

Expressed in a Formal Language Characterized with Empirical Data

\[ L_f \frac{d i_f}{dt} + R_f i_f = v_f \]

\[ I_f = \frac{V_f}{R_f} \]

\[ L_a \frac{d i_a}{dt} + R_a i_a + e_a = \]

\[ R_a i_a + E_a = V_a \]

\[ E_a = K_m \phi w \]

end architecture behav;
The Hard Part: Models

- Who/what creates it?
- What detail does it contain? At what fidelity?
- What are the assumptions / limitations?
- What is its interface?
- How accurate is it?
- How is it validated?
- How does it perform?
- How stable is it?
- ...
Model Detail & Fidelity

Models come from many places
- Data (measured, simulated, ...)
- First principles
- Characterization
- 3D simulation
- ...

Which physical effects are modeled?

How accurately do the modeled effects replicate physical behavior?
Simplorer – Core Capabilities
Simplorer – Physical Modeling & Simulation

Multi-Fidelity, Multi-Domain Modeling

Proven in Power Electronics

Links with Detailed Physics

Embedded Control / SW

Simulation-Based Test
### System Simulation

<table>
<thead>
<tr>
<th>What is simulated?</th>
<th>Integrated assemblies of components – all powered, actuated, controlled and sensed together</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models</td>
<td>Equation-based descriptions of behavior</td>
</tr>
<tr>
<td>Size / Complexity</td>
<td>10s to 1,000s of physical, electrical and/or software component models</td>
</tr>
<tr>
<td>Simulation</td>
<td>Single solver used for all domains</td>
</tr>
<tr>
<td><strong>ANSYS Solution</strong></td>
<td>Simulor + Model Libraries + ROMs</td>
</tr>
</tbody>
</table>

### 3D Multiphysics Component Simulation

<table>
<thead>
<tr>
<th>What is simulated?</th>
<th>Singular components or sub-assemblies – typically focused on the “pure” physics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models</td>
<td>Geometries, meshed into cells / elements</td>
</tr>
<tr>
<td>Size / Complexity</td>
<td>1,000s to 1,000,000s of cells / elements</td>
</tr>
<tr>
<td>Simulation</td>
<td>Different solvers for each physics domain, coupled by a simulation platform</td>
</tr>
<tr>
<td><strong>ANSYS Solution</strong></td>
<td>Workbench + 3D Solvers</td>
</tr>
</tbody>
</table>
Modeling Flexibility, Reusability, Interoperability

Essential to Virtual Prototyping

Language-Based Behavioral Modeling

Multi-Domain Model Libraries & Tools

Connections with 3D Physics

Tight Integration with Embedded Control & SW

Functional Mockup Interface

Standards-Based Interoperability
Languages Common to Design Disciplines

**IEEE**

Language-Based
Behavioral Modeling

**VHDL-AMS**
Electrical, Digital, Mixed-Signal

**C / C++**
General Programs

**Modelica**
Multi-Domain, Mechanics, Fluids

**SPICE**
Electronic Components
Model Libraries for Multi-Domain Systems

- Control Systems
- Hydraulics
- Mechanics
- Digital
- Electrical
- Power Systems
- Manufacturers
- Automotive
- Aerospace
Reduced-Order Modeling (ROM) Interfaces

- Preserves essential accuracy
- Simulates in a fraction of the time required by 3D Techniques for all ANSYS physics
Physical Modeling for Embedded Control

MiL Design/Tuning
Co-simulation

SiL Validation
Code Import

Power Source
Power Electronics:
Inverter
Power Cables
Traction Motor (PMSM)

Physical Model

Code Generation

Mechanical Dynamics & Loads

Tight Integration with Embedded Control & SW
Standards-Based Interoperability

MODEL PORTABILITY
TOOL INTEROPERABILITY
ENTERPRISE DEPLOYABILITY

Example: Flight Control System

FMI for Integrated System Simulation