Connecting Detailed Physics into MBSE Framework
October 25th, 2018
Goals

1. In addition to a broad physics portfolio, Ansys provides a model based system & SW environment

2. This environment facilitates integrating engineering level simulations with systems/engagement level simulations
ANSYS is the simulation leader

FOCUSED
This is all we do.
Leading product technologies in all physics areas. Largest development team focused on simulation

TRUSTED
More than 45,000 customers worldwide
ISO 9001 CERTIFIED

PROVEN
Member of the prestigious STANDARD & POOR’S 500
$15B+ market capitalization

GLOBAL
75 offices in 40 countries
2,900+ employees globally

LARGEST
3x the size of our nearest competitor (revenue)

INDEPENDENT
Long-term financial stability
CAD agnostic

COMMITTED
Overall customer satisfaction globally is at 87.8% in 2017

DRIVEN
Helping customers address new market challenges: digital exploration, additive manufacturing and digital twins
Pervasive simulation is continuous simulation with all physics across the entire lifecycle for all products

**IDEATION**

80% of costs locked in early in the design phase

**DESIGN**

Reduce development time 9X while warranty costs 89% more likely to decrease

**MANUFACTURING**

Reduce weight of part by 25% through topology optimization and additive manufacturing

**IN PRODUCT**

Reduce time needed to validate autonomous vehicles from 10,000 years to 2-3 years

**OPERATIONS**

Increased performance with 10-20% reduction in maintenance costs
ANSYS Simulation Platform...

...Complete Systems Simulation

MULTIPHYSICS

Fluids  Structures  Electromagnetics  Optics  Semiconductors  Design & Additive  Software
Weaving the Thread from Detailed Design to Operations

Breadth & Depth of Physics
- Structures
- Fluids
- Electronics
- Embedded Software/Systems

Advanced Weapons require advanced solutions

DO-187C, EN50128, ISO 26262, IEC 61508

DO-187C, EN50128, ISO 26262, IEC 61508

RCS for Stealth

Multi-Domain Antenna

Hypersonic Re-entry

Store Separation

Additive

Dynamics

Signal Integrity
Where does Ansys fit into SET?

Ansys can execute detailed M&S and then connect them into the subsystems baseline

- Structures
- Fluids
- Electronics
- Optics
- Embedded Software
- Safety
MBSE Workflow Capabilities supported by Ansys-SCADE

System Models
- Rhapsody
- magicedraw
- ENTERPRISE ARCHITECT
- integrity
- AADL
- FACE
- Excel

SysML for Embedded Systems Design

AADL Model

FACE Data Model

Avionics Interfaces

medini™ analyze

Twin Builder

C – Ada (source code)
Ansys-Systems Product Toolbox Integration

Model-Based Systems & Software Engineering

System Safety Analysis

System Simulation/Digital Twin

SCADE Synchronization

System Architecture
SysML ‘Models’

Twin Builder

Control Software Components

3D Physics Models

Functional Mock-up Interface (FMI) is a tool independent standard to support both model exchange and co-simulation of dynamic models using a combination of xml-files and compiled C-code
Integrated Workflow for SW-intensive Systems

SW Architecture (SysML)

SW Design (Scade models)

SW Coding w/Qualified Code Generator (Source code)
Requirements Based Workflow

Operational Analysis

User Requirements

System Requirements

System Design

System Functions

System Architecture

Supports

Traceability

Allocation

Synchronization
(detailed interfaces & SW Architecture)

Supports

Software Requirements

Software Design
ANSYS Workflow with SysML Integration

Model-Based Systems Engineering

System Safety Analysis

System Simulation & Digital Twins

Model-Based Software Engineering

Physics Simulation

System Architecture

SW Components (FMI)

System/SW Architecture
Reduced Order Models (ROM)

- CAE and CAD models cannot be reconstructed from 0D/1D ROMs – they provide blueprint IP protection
- Parameters define interfaces of the physics based simulation within the system
- Input parameters are typically operating conditions and actuators (e.g., fan, motor, heater)
- Output parameters can be sensors (real or virtual) that provide feedback to [SW] controllers

\[ (x, \Theta) \simeq \text{ROM}(x, \Theta) = \sum_{m=1}^{M} \Phi_m(x) \alpha_m(\Theta) \]

x, the fields
\( \Theta \), input parameters
\( \Phi \), modal basis
\( \alpha \), interpolation coefficients

Wheel Braking System
ROM Interfaces

Connecting Detailed Physics to the System Level
- Structures
- Fluids
- Electronics
- Thermal

Cabin Air Pressure Control

ARP4754A: System Requirements
DO-331: Software Requirements

Electric Machines

Battery Life & Safety

Pump Field Deployment
Open Architecture and Cert Kit Solutions

• **SCADE Avionics Solutions**
  • Design templates for avionics systems compliant with ARINC 653, ARINC 429, CAN and ARINC 664 (AFDX)
  • Comprehensive solution for FACE conformant modeling and code generation
  • Comprehensive solution for AADL modeling

• **SCADE Solutions for ARINC 661**
  • A fully-integrated COTS solution for the specification, development and certification of avionics displays following the ARINC 661 standard, both for Cockpit Display Systems (CDS) and User Applications (UA)

• **DO-178B/C Certification Plans for SCADE Suite**
  • Generic plans developed from ANSYS experience in supporting DO-178C certification process for applications developed with SCADE Suite
Summary

1. In addition to a broad physics portfolio, Ansys provides a model based system & SW environment

2. This environment facilitates integrating engineering level simulations with systems/engagement level simulations