Multiphysics Modeling and Simulation for Armament System Improvement

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Physics-Based Simulation
Electromagnetics, Thermal, Structural Mechanics, Fluid Dynamics
• Industry Trends
Industry Trends Are Reshaping A&D Product Development

- Rising Fuel Costs
- Safety and Environmental Considerations
- New Space Race
- Fiscal Constraints
- Geopolitical Drivers
- Warfare Revolution
• Key Implications
Constricting Defense Budgets Cause Focus On Affordability, Reduction In New Procurement And The Extension Of The Service Life Of Equipment---Need to design for **Affordability**

- Do more without more
- Shift from procurement to sustainment

**Key Business Initiatives**
- Design for Affordability
- Engineer for Sustainment

**Fiscal Constraint**
Commercial And Military Competition Drives Innovation And Increases The Pressure On Deployment Timeframe --- Need to Design and Implement systems Faster.

Key Business Initiatives

- Faster Design Cycles
- Commercial design practices
- Employ up-front analysis

Emerging competition in commercial aero and space

System Sophistication

Heavy investment in defense technologies in emerging markets
As The Nature Of Warfare Changes, The Demand For Intelligence, Surveillance And Reconnaissance (ISR) Technology Is Increasing Significantly --- Need to develop **Smart** systems

**Key Business Initiatives**

- Design in more intelligence
- Increased use of electronics
- Increased need for Multiphysics evaluation

**Warfare Revolution**

- Field recognition of the importance of novel ISR capabilities
- More sophisticated, robust and affordable unmanned systems
- Increase sensor complexity
- Manage size, weight and power (SWaP)
Industry trends are driving the development of more sophisticated electronic systems in shorter time frames and with greater fiscal scrutiny.

Fiscal constraint, coupled with the increasing demands of sophistication, competition and time pressure mean that system robustness is more important than ever.

Working with thousands of customers around the globe, we (Ansys) observe industry leaders adopting best practices to tackle robust design through simulation based engineering.

Simulation based engineering is a key enabler for Robust design using Accurate, Multi-Physics based analysis tools.
• Multi-Physics Simulation
Why is multiphysics based design a best practice for robustness and affordability?

Amedeo Larussi  
Sr Principal Electrical Engineer  
Raytheon Space and Airborne Systems

“Traditional engineering methods are not able to accurately anticipate performance degradation and/or product failures because does not combine all performance factors”

Idga/webinars
ANSYS’s Aerospace and Defense Best Practices Derived from Cross-Industry Knowledge Bring Best-In-Class Insights to Solve Your Product Development Challenges

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<th>ANSYS’s Cross-Industry Best Practices</th>
<th>ANSYS’s A&amp;D Best Practices</th>
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<td>Advanced Lightweight Materials Design</td>
<td>Efficient Design Of Lightweight Composites For Multifunctional Applications</td>
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<td>Robust Electrical and Electronics System Design</td>
<td>Integrated Multiphysics Simulations for Robust Platform-Payload Integration</td>
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<td>Fluid Structure Interaction</td>
<td>Integrated Multiphysics Simulations for Emerging Aeroelastic Challenges</td>
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<td>Fluid-Thermal System Design</td>
<td>Reduce Fuel Burn Through the Design Of More Efficient Engines</td>
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The Workbench Environment

- **CAD Geometry**
  - Automated geometry transfer and data exchange of solution shown by connections

- **Available Physics**

- **Parameter Set**
  - Controls inputs and views outputs of each simulation, i.e. Input = Antenna Scan Angle, Output = Max Radome Deformation

- **Design Exploration**

- **Coupled Physics Solutions**
Benefits of Integration

- Utilizes intuitive multi-physics layout
  - Automated data exchange
  - Coupled physics solutions
- Efficient system design exploration
- Streamlined geometry handling
  - CAD integration in ANSYS Workbench provides bi-directional link to 3rd party CAD tools
  - Multiple physics can share the common geometry
Electromagnetic Solutions

- Overview ANSYS EM Capabilities
  - FEM, IE, PO, hybrid solvers
  - RCS
  - Antenna Placement/Co-Site Analysis
- Antenna Array
  - Unit Cell and Finite Array Analysis
  - Array Platform Analysis
- Feed Network
Electronics Applications

- Circuit & System Design
- RF and SI Physical Design
- Electromechanical Design

 ANTENNAS   PACKAGE/PCB   EMI/EMC
 MOTORS/ACTUATORS   POWER ELECTRONICS
Mechanical Solutions

- Overview ANSYS Mechanical Capabilities
  - Steady State/Transient
  - Explicit Solvers (Impact)
  - Solid, Shell, Beam, and Point Mass Elements
  - Convection/Conduction/Radiation/Advection
  - Layered Composite Shells and Solids
  - Automatic Contact Setup (Thermal and Structural)
  - HPC for large model support
Computational Fluid Dynamics Solutions

- Overview of CFD Capabilities
  - Incompressible/Compressible Flow
  - Extensive Turbulence Models
  - Multi-Species & Reacting Flow
  - Conjugate Heat Transfer
  - Fluid Structure Interaction – 1 way & 2 way
  - Dynamic, moving & sliding meshes
Radome and Antenna Multi-Physics Example: Workbench Project

- **Geometry**
  - Bi-Directional Link to most CAD tools
  - Radome geometry from CAD can be used for all physics

- **EM Analysis**
  - HFSS
  - Data link antenna pattern and Radome

- **Thermal Analysis**
  - Ansys Mechanical
  - Boundary conditions for convection and other thermal properties applied

- **Structural Analysis**
  - Ansys Mechanical
  - Structural boundary conditions and any external loads can be added

Incorporating Fluid Dynamics into Multi-Physics Simulation Flow

Steady State Thermal and CFD -
Convection coefficients determined from CFD solution

Static Structural and CFD –
Pressure/forces mapped from CFD solution impacting geometry deformation
Simulation Flow – HFSS/Thermal/Stress Simulation Overview

• Antenna and Radome Simulation Flow
  - EM Solution of Antenna Array
  - EM Solution of Radome using array solution as excitation (data link)
  - Losses passed to Ansys Mechanical for thermal analysis
  - Thermal loading applied to structural solution to calculate deformation

• Antenna System Simulation Iterations
  - Temperature Dependent Material properties can be applied in EM solution
  - Mesh Deformations (v14.5)

Design Exploration
- DOE Based Response Surface
- 6σ, Optimization, Statistics
Using Workbench for Design Exploration

DesignXplorer (DX) is a tool for designing and understanding the analysis response of parts and assemblies.

The Response Surface Method allows for optimization and six-sigma studies efficiently.

DX uses Design of Experiments (DOE)
— DOE method determines how many, and which, design points should be solved for the most efficient approach to optimization
— Response surface is fit to solved DOE
• DSO – Distributed Solve Option

• DDM – Domain Decomposition Method
  – Feature of HPC licensing

• SDM – Spectral Decomposition Method
  – Feature of HPC licensing

• MPO – Multi-processing option
  – Feature of HPC licensing

HPC distributes mesh subdomains to networked processors and memory

SDM distributes the spectral content of a frequency sweep across networked processors
Further information:

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