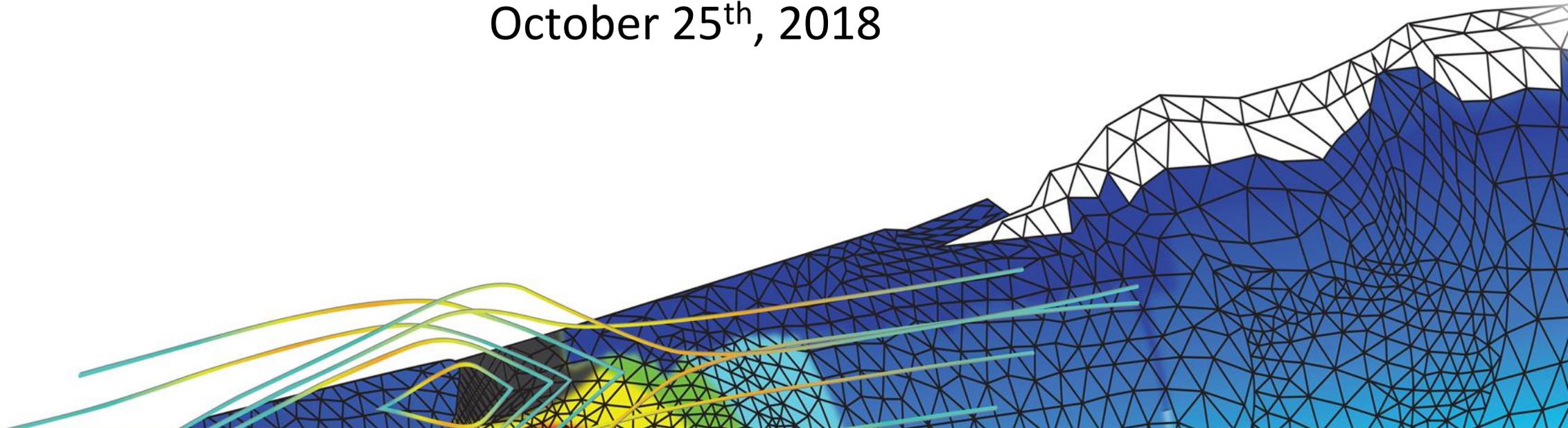


ANSYS®

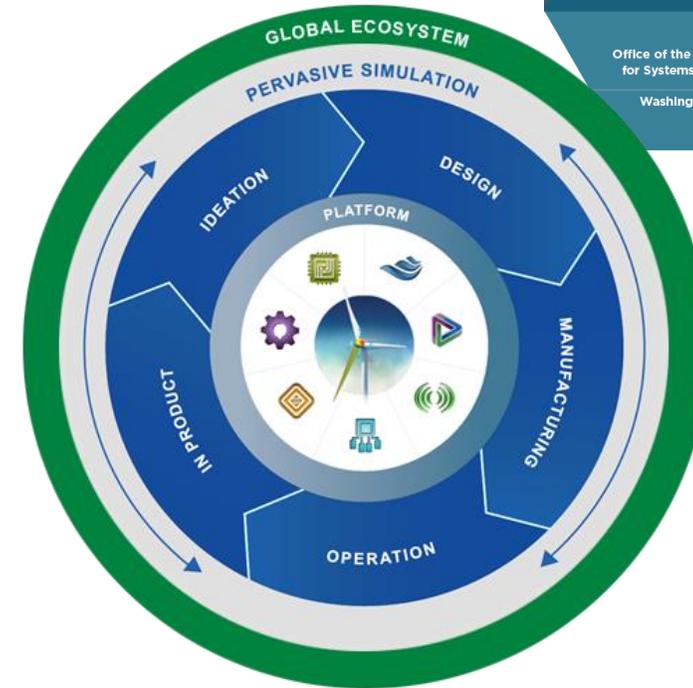
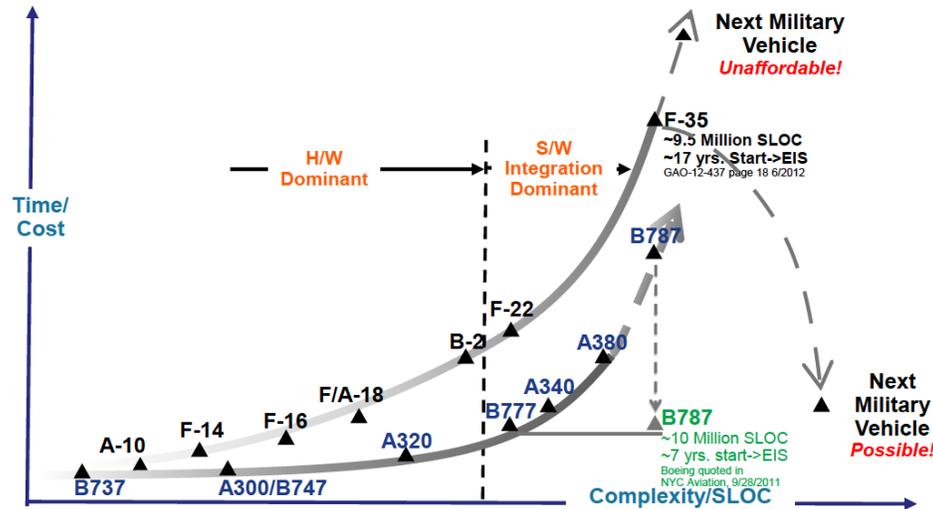
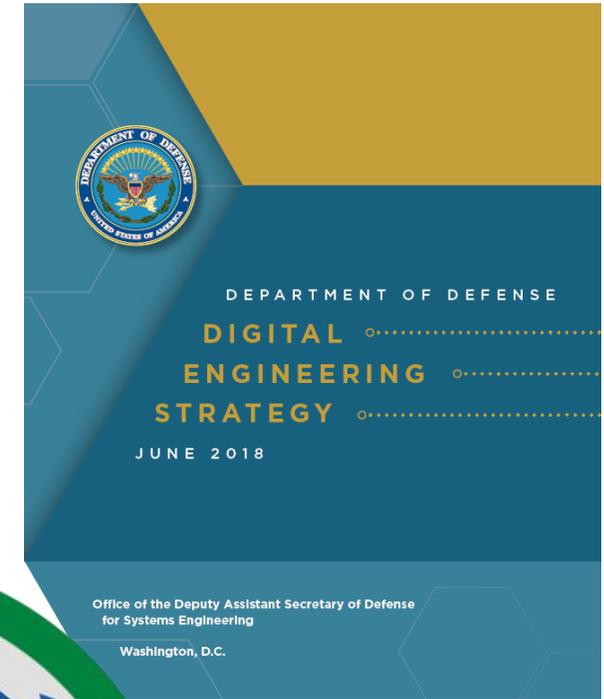
Connecting Detailed Physics into
MBSE Framework

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

97 FORTUNE
 of the **100**
 industrials

More than
45,000
 customers worldwide

ISO 9001
 CERTIFIED

PROVEN

Member of the prestigious **STANDARD & POOR'S 500**

\$15B+ market capitalization

GLOBAL

2,900+
 employees globally

75 offices in **40** countries



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

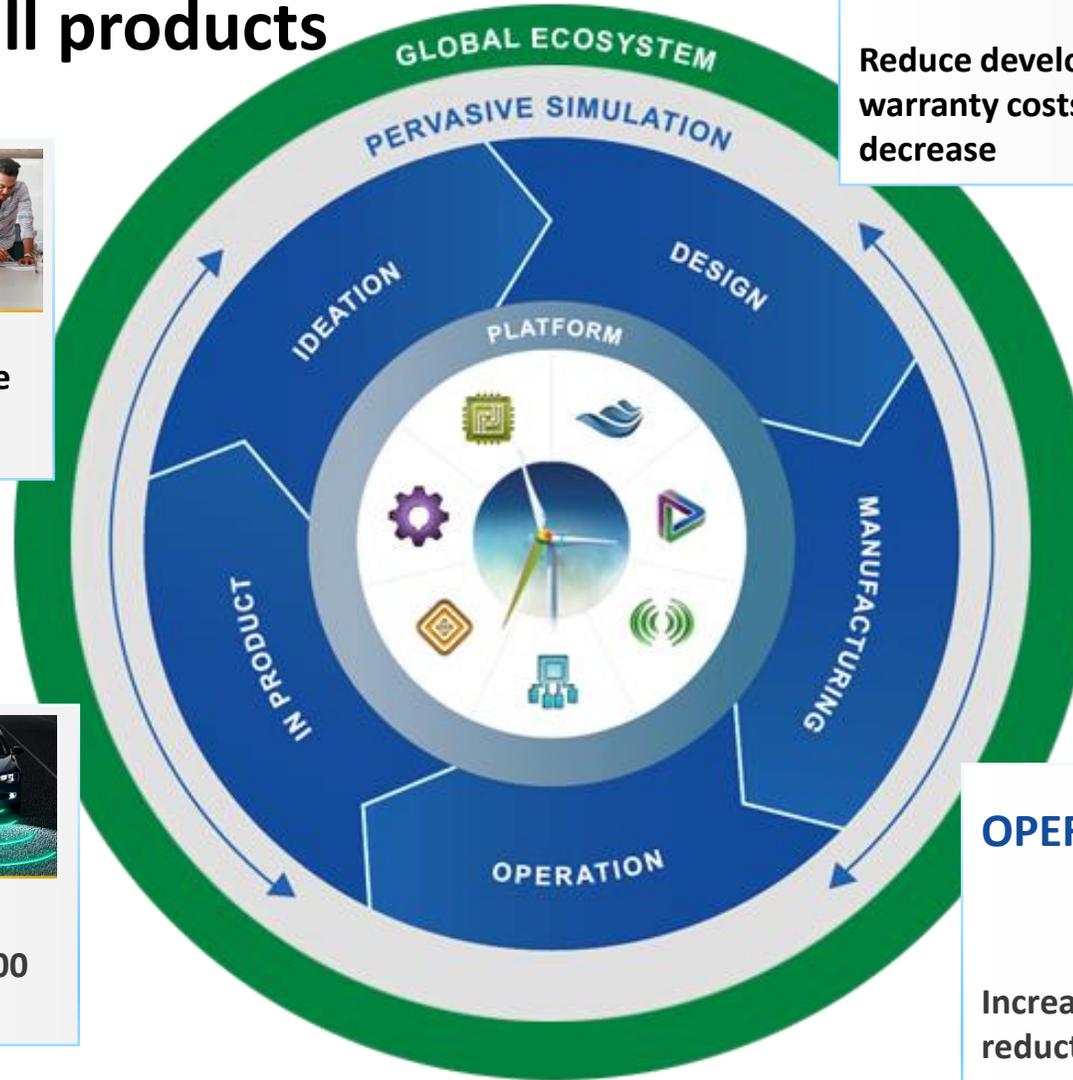


80% of costs locked in early in the design phase

IN PRODUCT



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



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

OPERATIONS

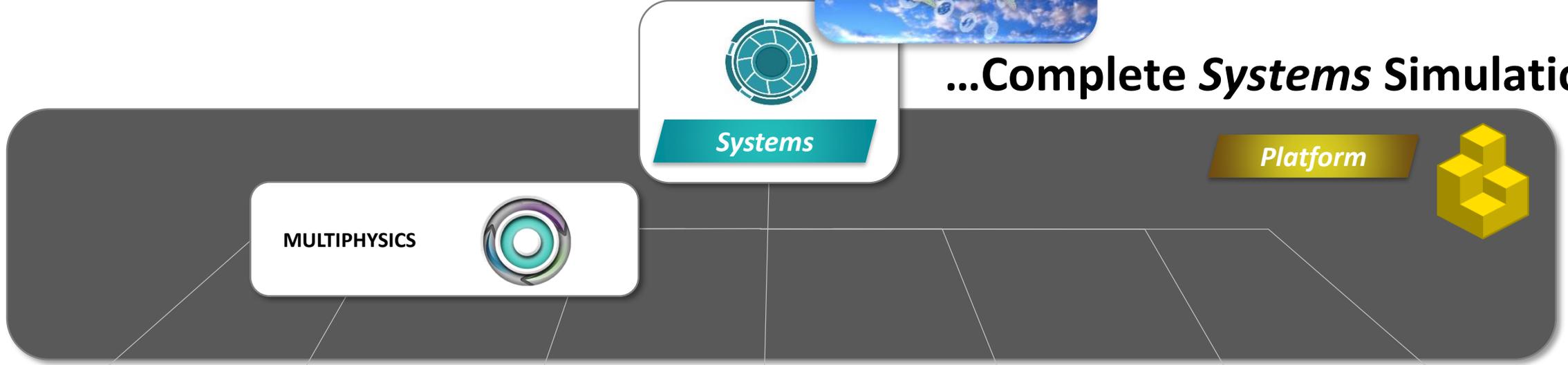


Increased performance with 10-20% reduction in maintenance costs

ANSYS Simulation Platform...



...Complete Systems Simulation



MULTIPHYSICS

Systems

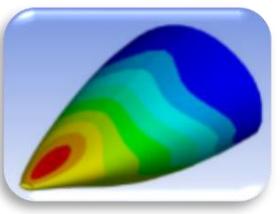
Platform



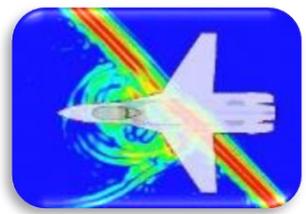
Fluids



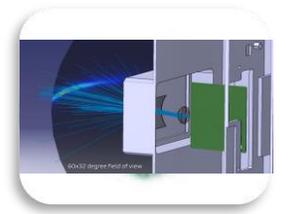
Structures



Electromagnetics



Optics



Semiconductors



Design & Additive



Software

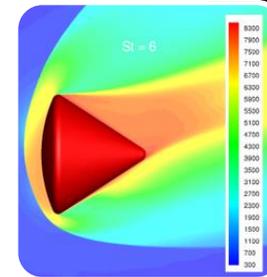
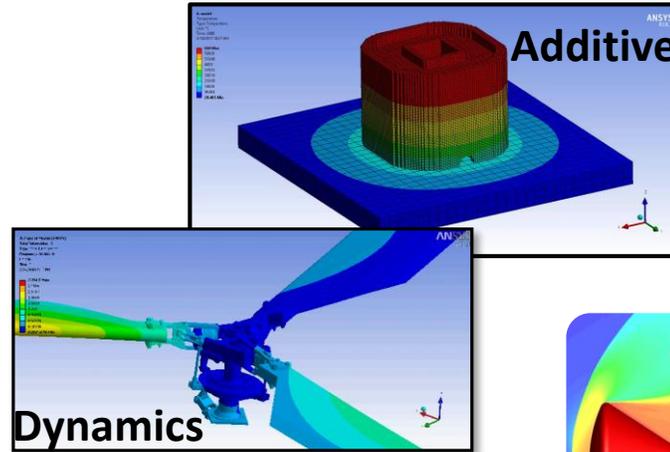


Weaving the Thread from Detailed Design to Operations

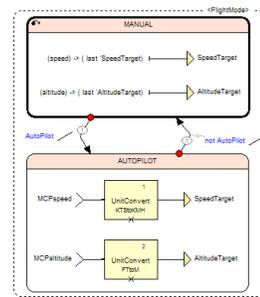
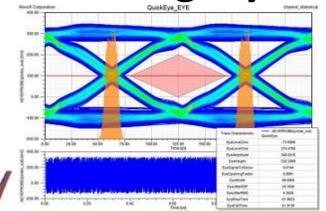
Breadth & Depth of Physics

- Structures
- Fluids
- Electronics
- Embedded Software/Systems

Advanced Weapons
require advanced solutions



Signal Integrity



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



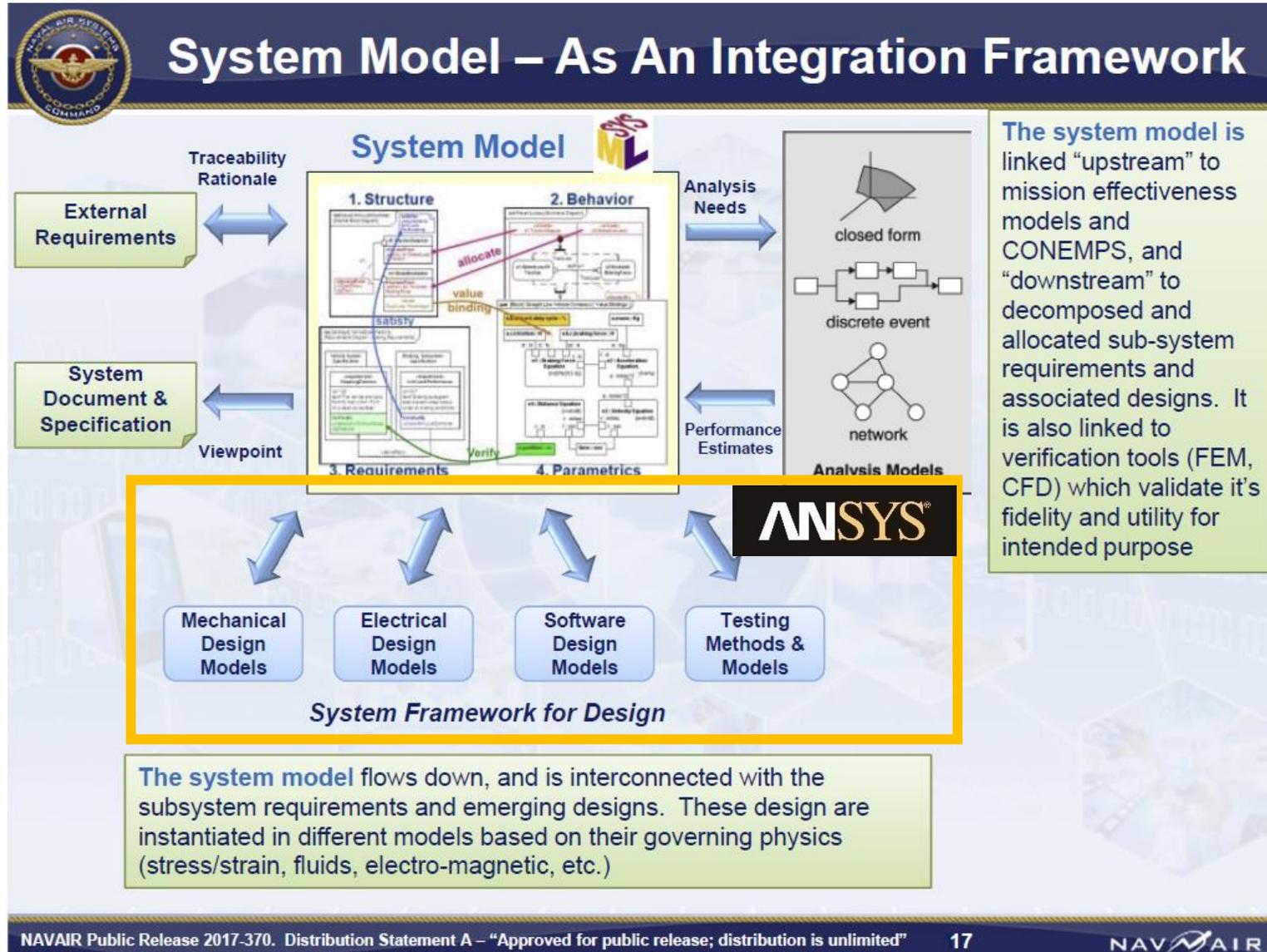
RCS for
Stealth



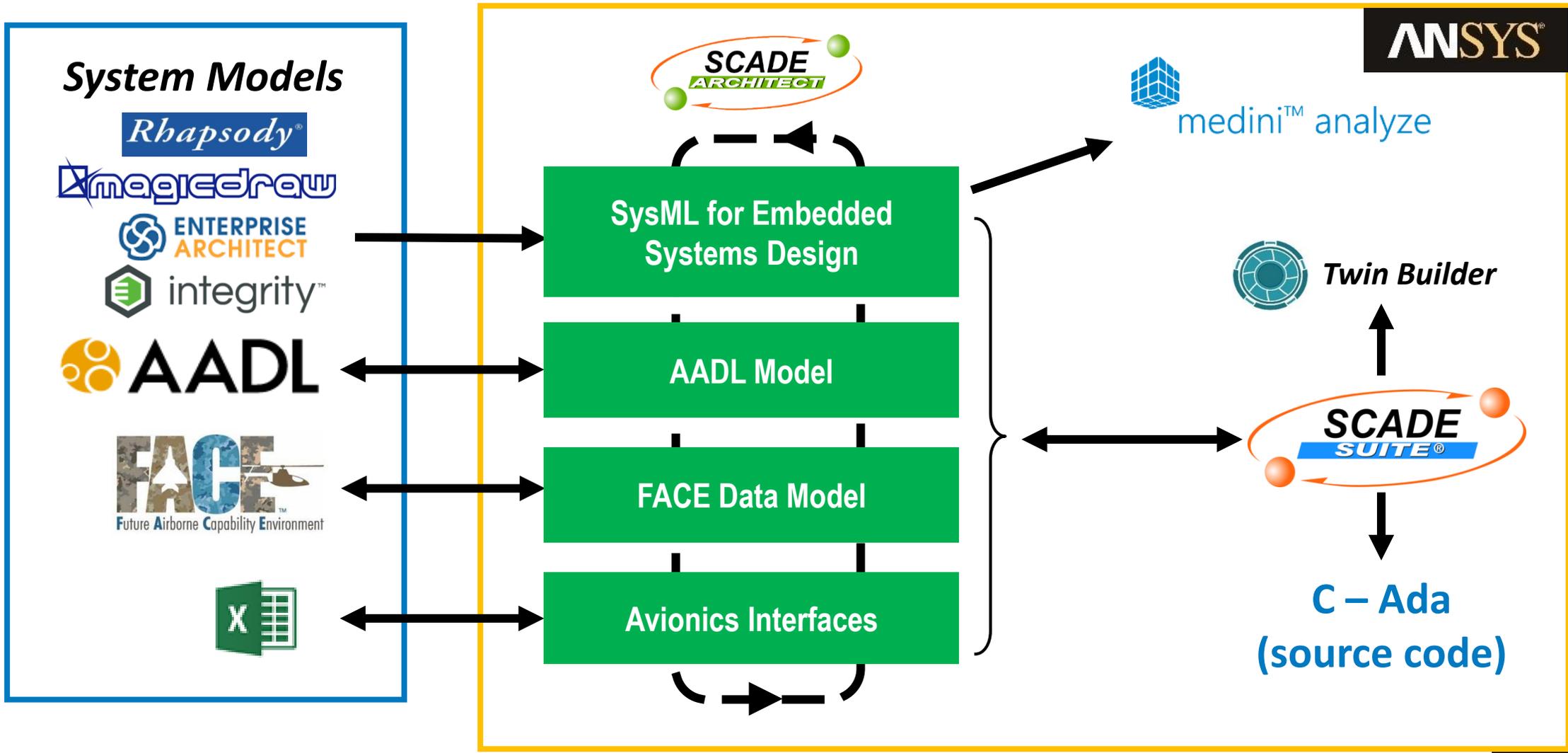
Multi-Domain
Antenna



Where does Ansys fit into SET?



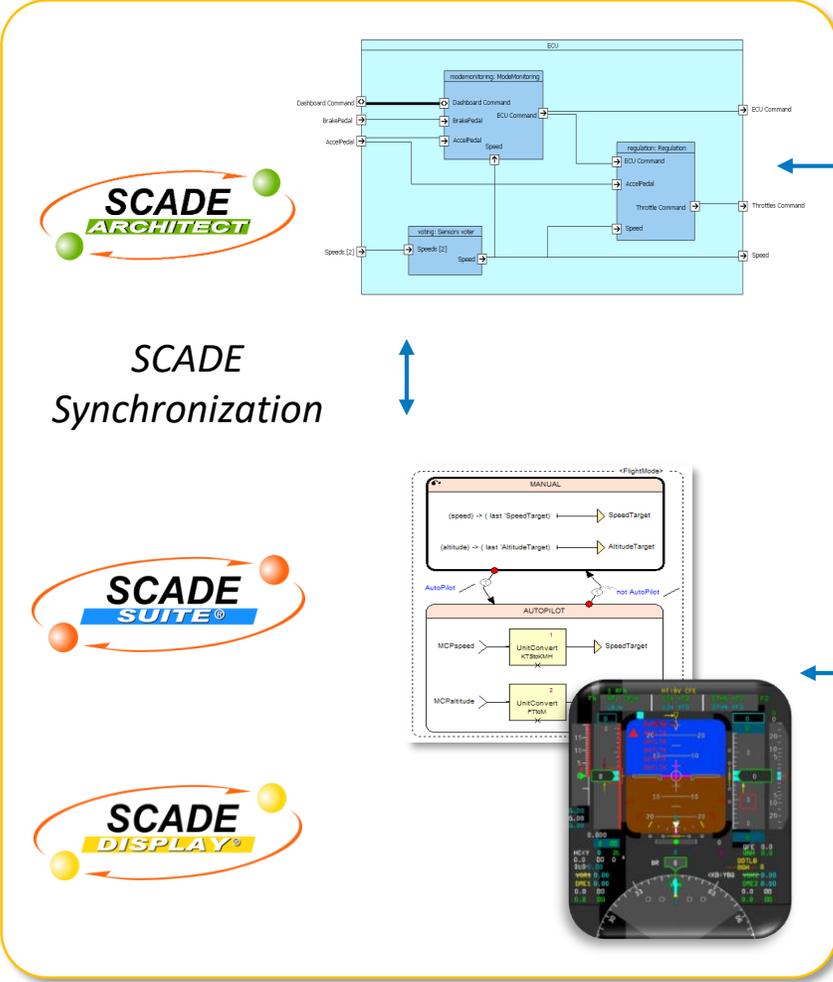
MBSE Workflow Capabilities supported by Ansys-SCADE



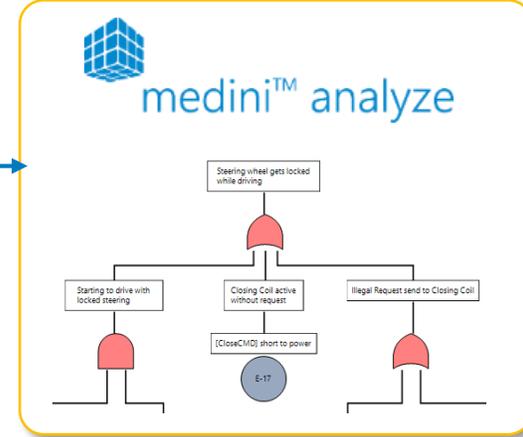
Ansys-Systems Product Toolbox Integration

Model-Based Systems & Software Engineering

System Safety Analysis



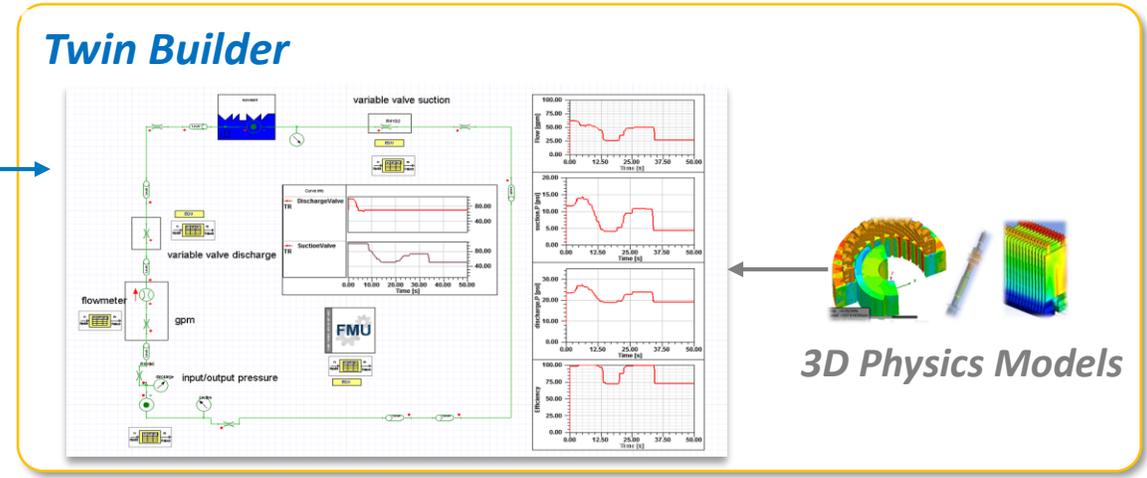
System Architecture
SysML 'Models'



Control Software
Components



System Simulation/Digital Twin

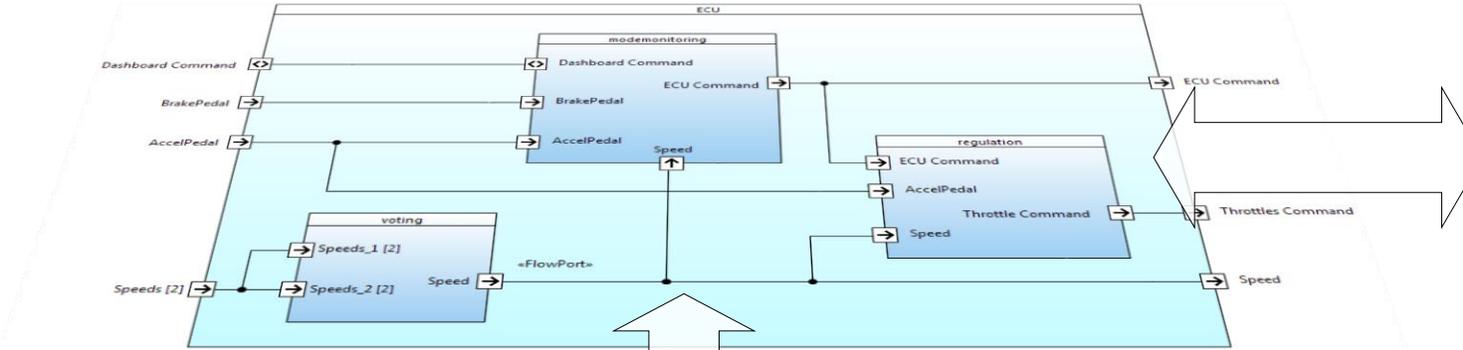


Functional Mock-up Interface (FMI) is a tool independent standard to support both model exchange and co-simulation of dynamic models using a combination of xml-files and compiled C-code

Integrated Workflow for SW-intensive Systems



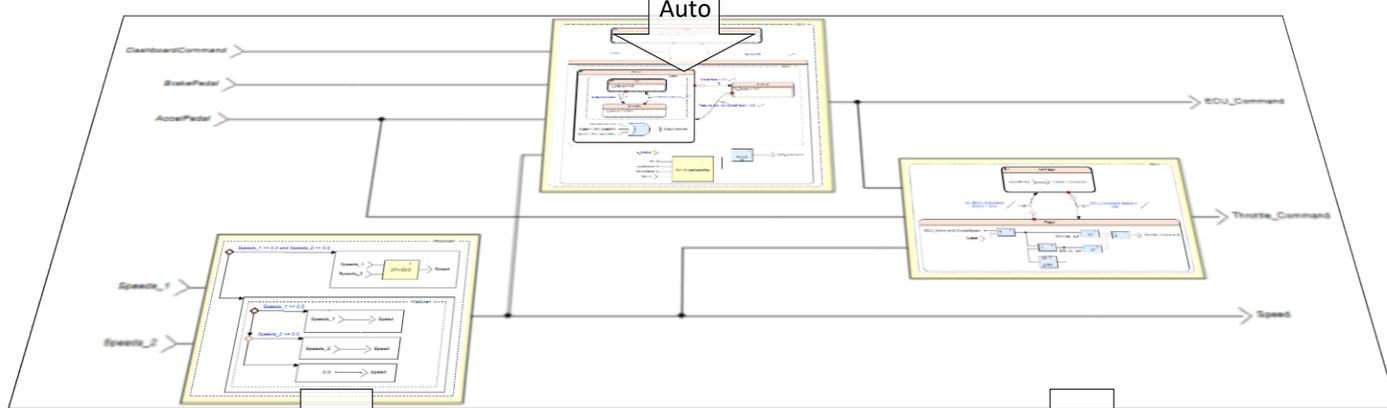
SW Architecture
(SysML)



medini™ analyze
Safety Analysis



SW Design
(Scade models)



SW Coding
w/Qualified Code
Generator
(Source code)

```

/* Architecture::Regulation
void Regulation_Architecture
/* ECU_Command/ */
tECU_cmd_Architecture *ECU_Command,
/* AccelPedal/ */
tPercent_Architecture AccelPedal,
/* Speed/ */
tVehicleSpeed_Architecture Speed,
outC_Regulation_Architecture *outC)
{
    kcg_float32 tmp;
    /* SM1:Regul_L3/ */
    kcg_float32 _L3_Regul_SM1;
    /* SM1: */
    SSM_ST_SM1 SM1_state_act;
    /* SM1: */
    kcg_bool SM1_reset_act;
    /* SM1: */
    switch (outC->SM1_state_nxt) {
    case SSM_st_NotRegul_SM1 :
        SM1_reset_act = (*ECU_Command).Status == ON_Architecture;
        if (SM1_reset_act) {
            SM1_state_act = SSM_st_Regul_SM1;
        }
        else {
            SM1_state_act = SSM_st_NotRegul_SM1;
        }
        break;
    }
}
    
```

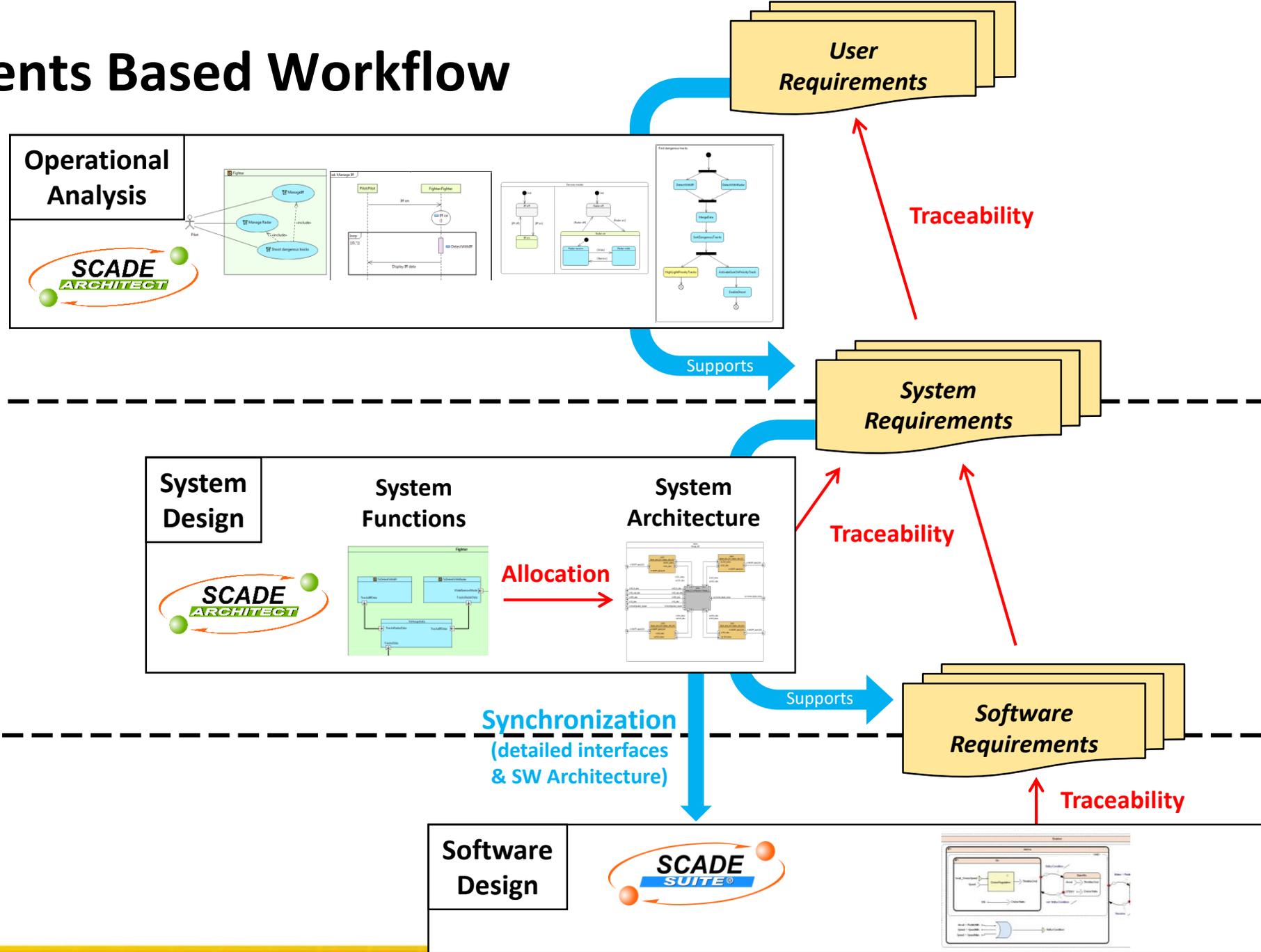
C

```

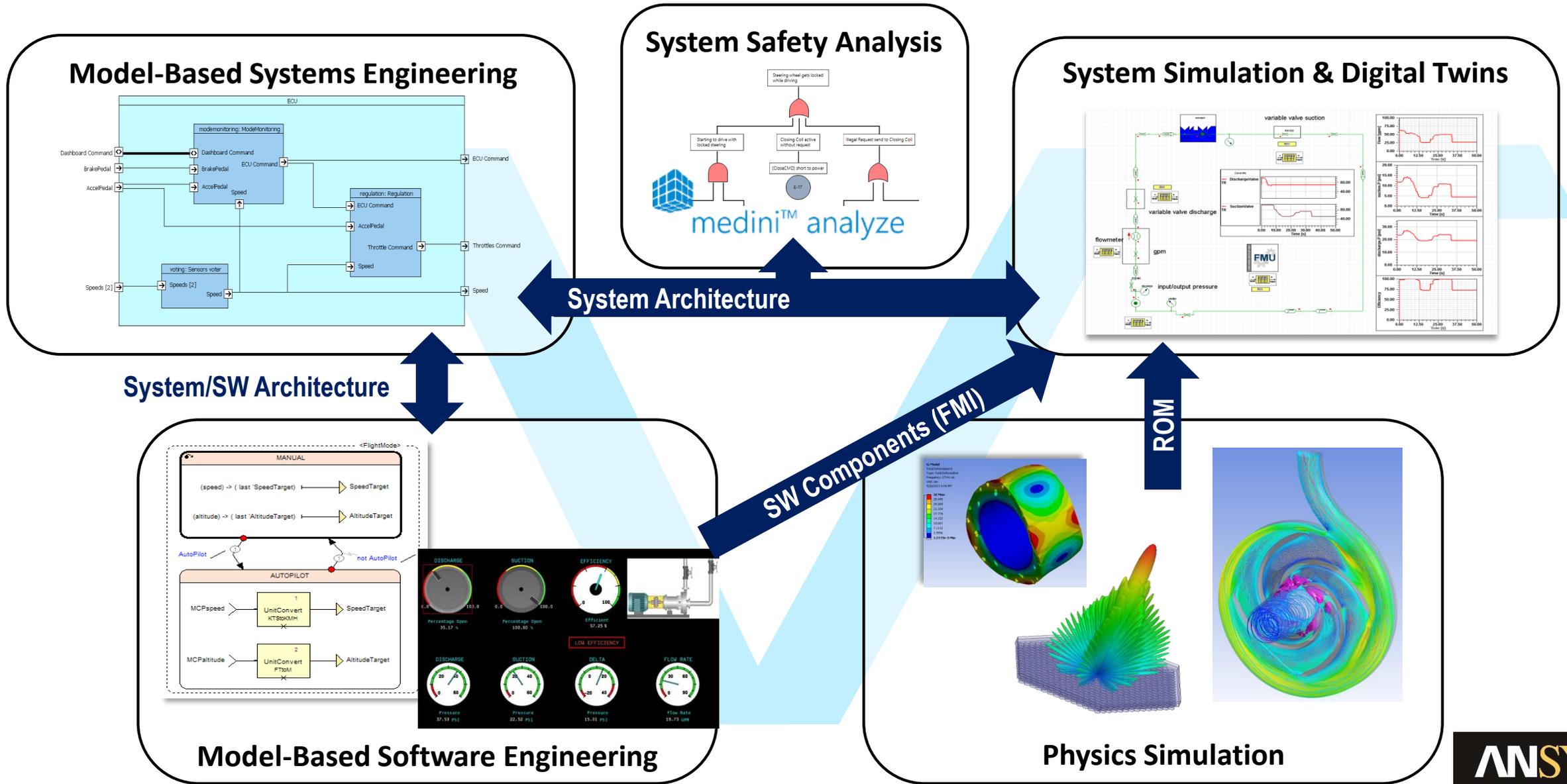
-- Architecture::Regulation
procedure Regulation(
    -- ECU_Command/
    ECU_Command : in tECU_cmd;
    -- AccelPedal/
    AccelPedal : in tPercent;
    -- Speed/
    Speed : in tVehicleSpeed;
    Ctx : in out Context_Regulation)
is
    -- SM1:
    SM1_state_act : Kcg_Types.SSM_ST_SM1;
    -- SM1:
    SM1_reset_act : Boolean;
    -- SM1:Regul_L3/
    L3 : Kcg_Config.Kcg_Float32;
    tmp : Kcg_Config.Kcg_Float32;
begin
    case (Ctx.SM1_state_nxt) is
    when Kcg_Types.SSM_st_NotRegul =>
        SM1_reset_act := ECU_Command.Status = Kcg_Types.ON;
        if (SM1_reset_act) then
            SM1_state_act := Kcg_Types.SSM_st_Regul;
        else
            SM1_state_act := Kcg_Types.SSM_st_NotRegul;
        end if;
    end case;
end if;
    
```

Ada

Requirements Based Workflow



ANSYS Workflow with SysML Integration



Reduced Order Models (ROM)

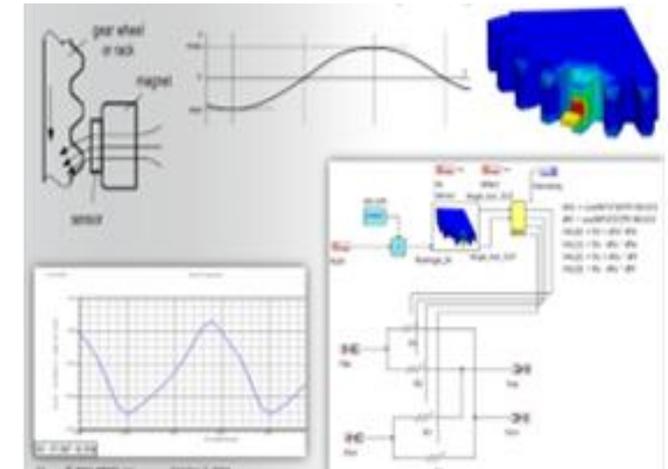
$$(\underline{x}, \underline{\theta}) \approx \text{ROM}(\underline{x}, \underline{\theta}) = \sum_{m=1}^M \Phi_m(\underline{x}) \alpha_m(\underline{\theta})$$

Hours/Days
Seconds!

\underline{x} , the fields
 $\underline{\theta}$, input parameters
 Φ , modal basis
 α , interpolation coefficients

- 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

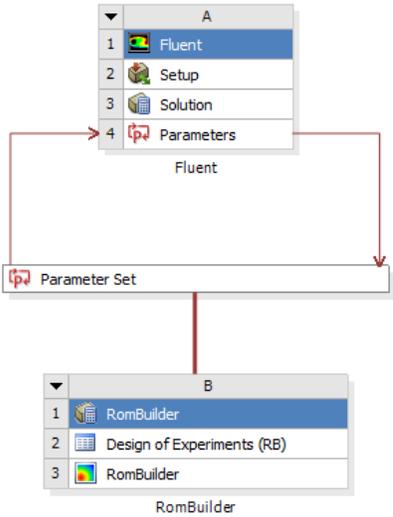
Wheel Braking System



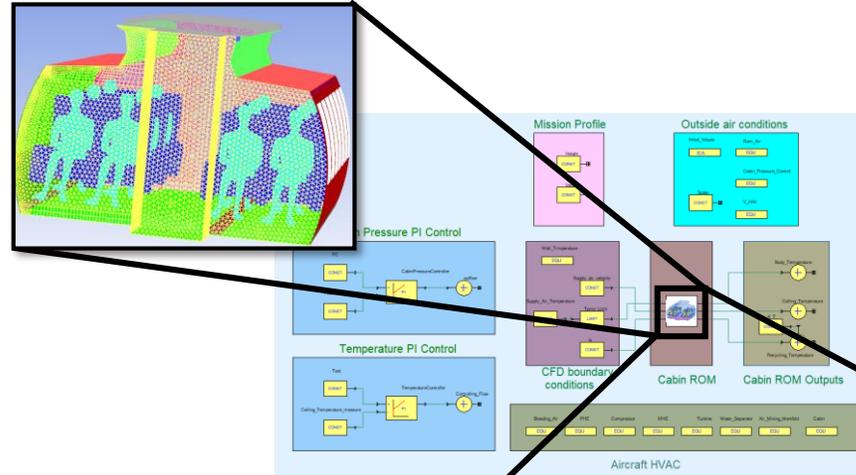
ROM Interfaces

Connecting Detailed Physics to the System Level

- Structures
- Fluids
- Electronics
- Thermal

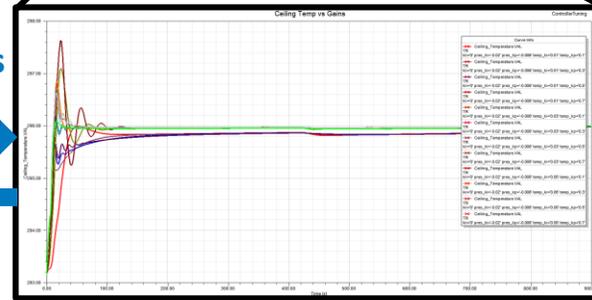


Cabin Air Pressure Control

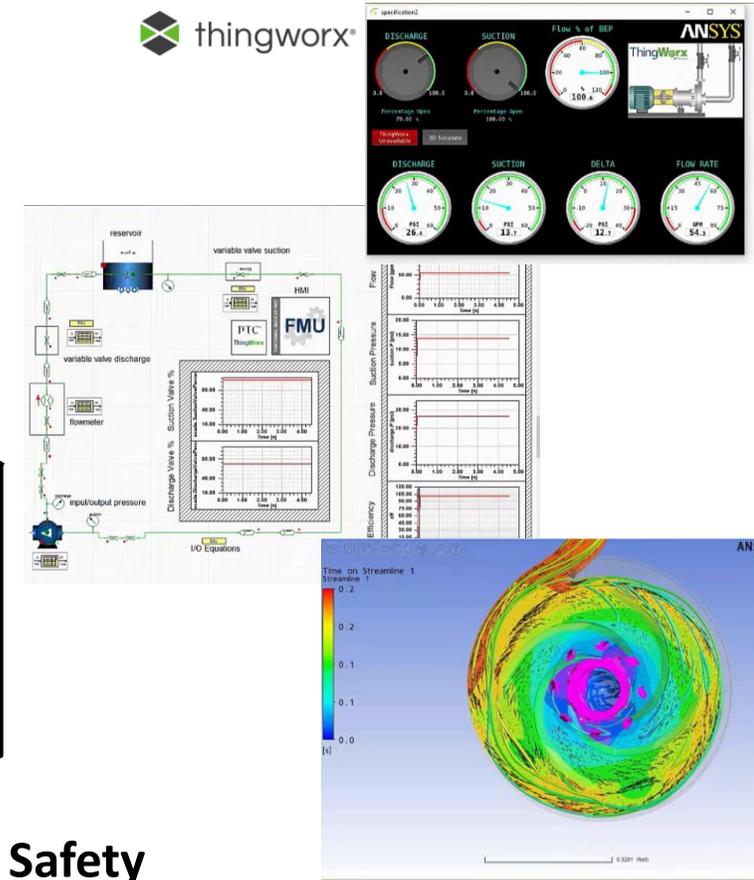


ARP4754A: System Requirements

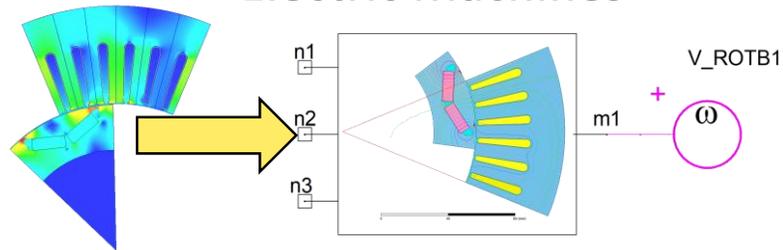
DO-331: Software Requirements



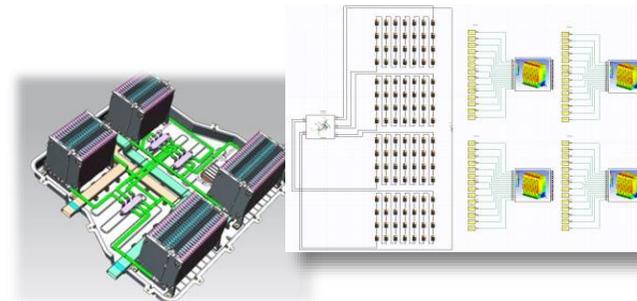
Pump Field Deployment



Electric Machines



Battery Life & Safety



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

