Leveraging Agile Model-Based Software Development to Implement an ARINC 661 CDS with MOSA

John Macauley
Manager, Application Engineering
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Ansys

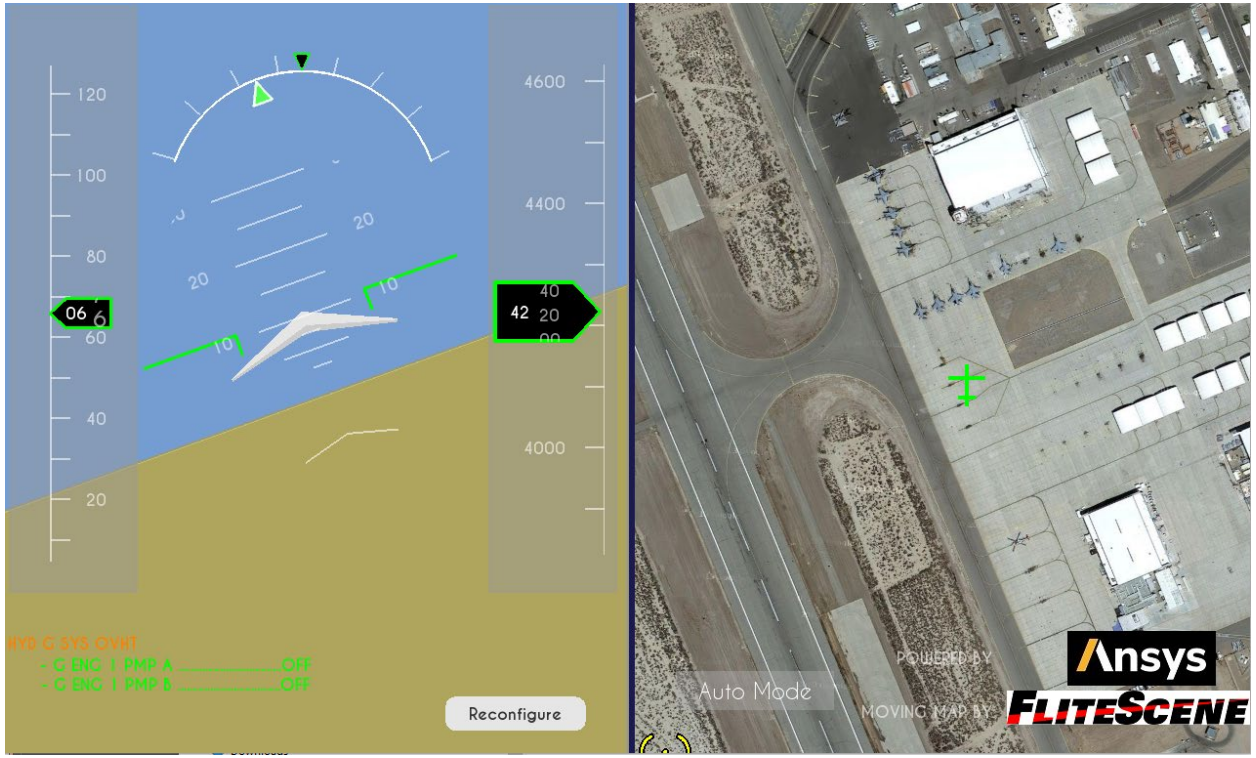
Objective

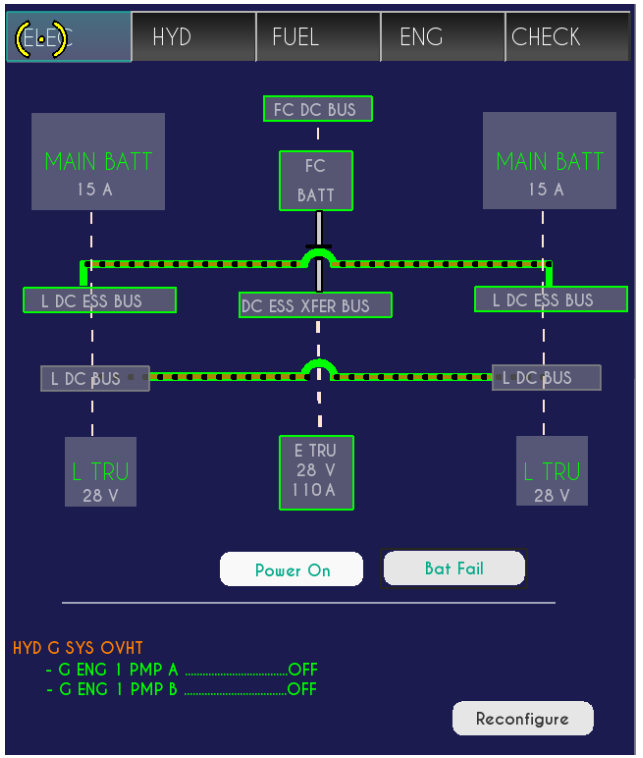
- Demonstrate an embedded Display System developed with MOSA:
- Open Standards
  - Conformance to FACE and ARINC 661 facilitates the integration of all components
- Innovation
  - A meta-modeling approach maximizes the flexibility and longevity of the solution
- Modular Design
  - Modeling and generation of artifacts required for mission and safety-critical systems, to reduce costs throughout the lifecycle

Demonstration

Demo – Ground Station Control

- Prototype running on commercially available hardware (Raspberry Pi)
- 1 FACE conformant ARINC 661 server – display rendering component
- 4 FACE Units of Portability (UoP) – portable software applications





Open Standards

MOSA – Reducing Costs through Enabling Standards

Modular Open Systems Approach (MOSA):

- Required for all major defense acquisition programs
  - ref: Title 10 U.S.C. 2446a.(b), Sec 805)
- Defined as a technical and business strategy for affordable, adaptable systems
- Achieved by leveraging Open Systems "Enabling" Standards
- MOSA Tri-services Memo (7Jan2019) recommends including specific standards:

> For the past several years, each of the Services has been developing, demonstrating, and validating common data standards through a cooperative partnership with industry and academia. This work has resulted in the establishment of Open Mission Systems/Universal Command and Control Interface (OMS/UCI), Sensor Open Systems Architecture (SOSA), Future Airborne Capability Environment (FACE) and Vehicular Integration for C4ISR/EW Interoperability (VICTORY) among other standards.

The FACE™ standard

- The **Future Airborne Capability Environment** approach promotes innovation and rapid integration of **portable capabilities** across global defense programs

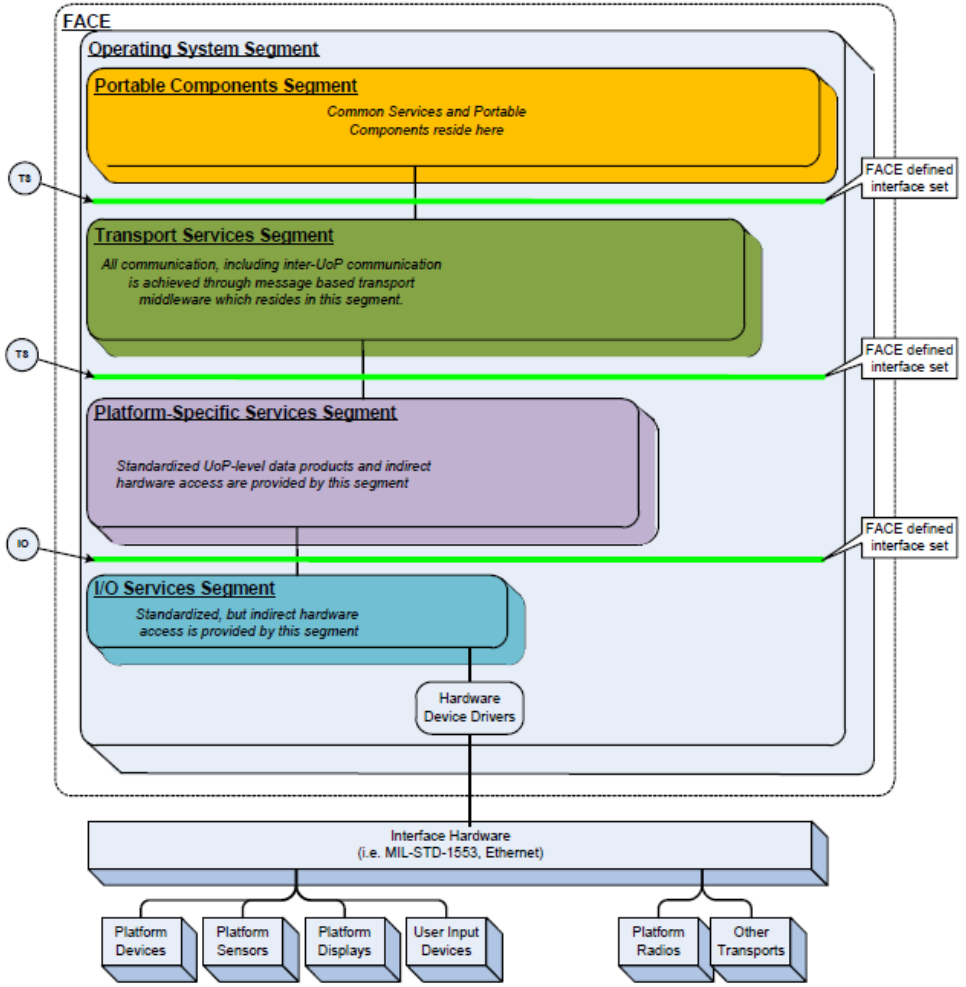
- FACE is a consortium defining:
  - a **Software Technical Standard** defines an open architecture
  - a **Business Model for the acquisition** of affordable software systems

Essential FACE Concepts

- A Unit of Portability (**UoP**) describes a software component with at least one service or mission-level capability, such as navigation or weapons management
- The **FACE Data Model Language** defines how elements are mapped to data types and structures
- The **FACE Shared Data Model** (**SDM**) provides standardized definitions to be used across all FACE conformant data models
- The Unit of Portability (UoP) Supplied Model (**USM**) defines all the software interfaces of the UoP in a standardized format

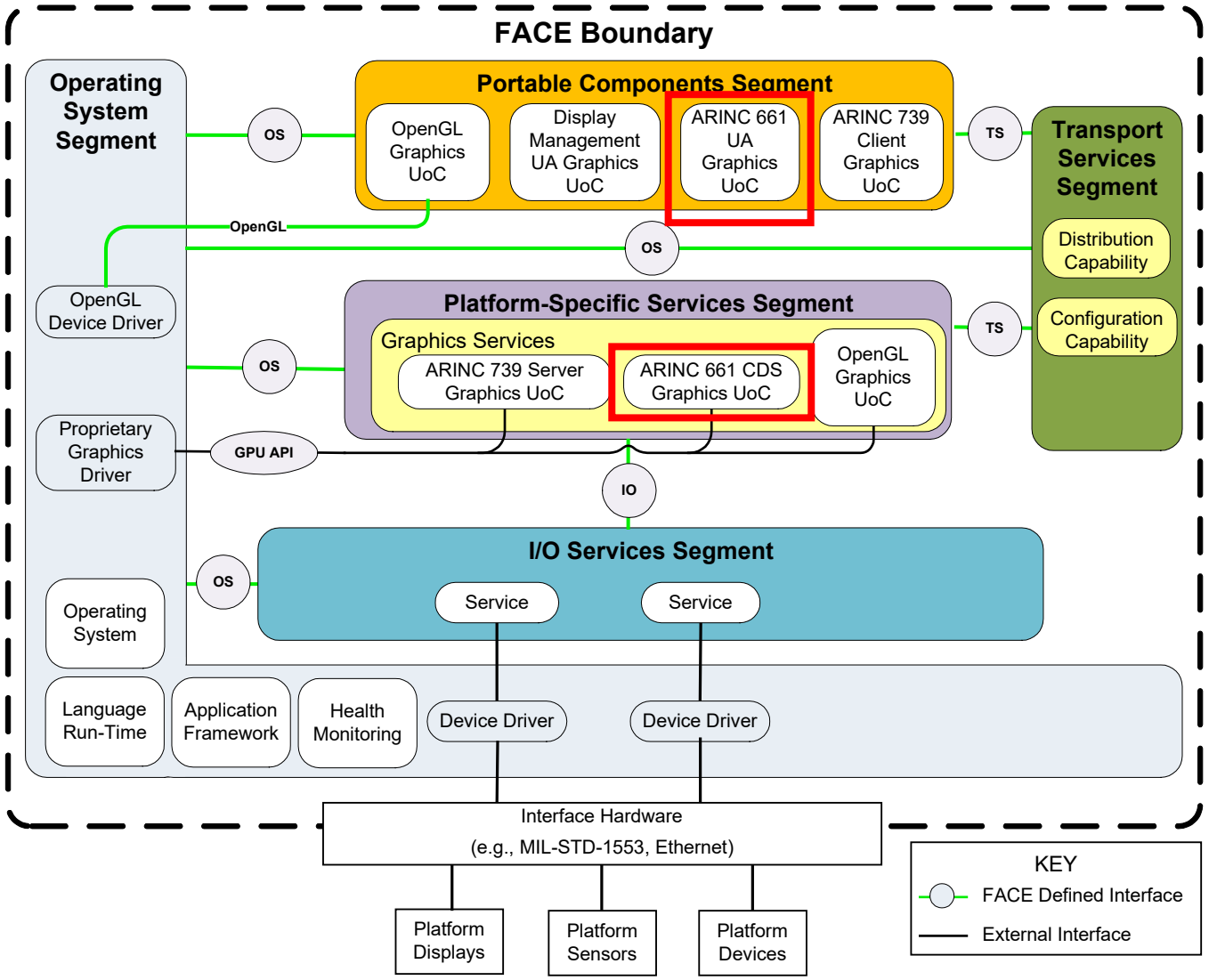
FACE Software Architecture

- Defines functional interfaces to ensure portable software
- Consists of 5 segments, including:
  - Portable Components Segment (PCS)
  - Platform-Specific Services Segment (PSSS)
- **PCS** and **PSSS** are decomposed into functional **UoPs** to implement a software component



Source: ©The Open Group

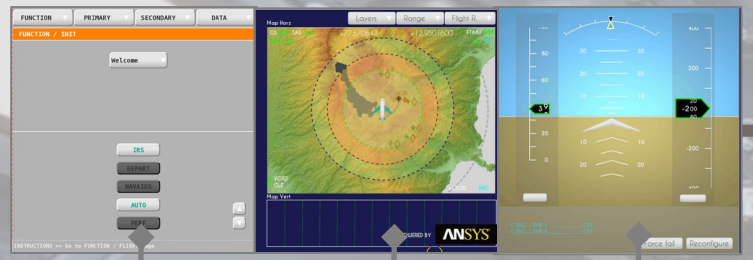
FACE references ARINC 661 for display rendering (v3.1, s3.12)



Intro to ARINC 661

- ARINC 661 is an avionics standard defining interactive Cockpit Display Systems (CDS) through:
  - A predefined set of avionics specific, and standard, HMI Widgets
  - The runtime communication between pilots (through the CDS) and the multiple distant/distributed User Applications (UA) managing the avionics functions
- The standard ensures a modular approach:
  - Minimize integration risks and maximize interoperability
  - Addition of new capabilities ensures minimal cost impact
- ARINC 661 is useful for a variety of graphical applications, including Ground Control Stations

The ARINC 661 standard at a glance



Definition Files composed of ARINC 661 Widgets and Layers

ARINC 661 Binary Definition Files

0110101 0100011 1001010 100

0110101 0100011 1001010 100

0110101 0100011 1001010 100

Loaded at definition time

UA1
e.g. FMS

UA2
e.g. TCAS

UA3
e.g. ADI

Set Parameter

Notify

A661 Run Time Server

Pilot inputs

Embedded IMA System
Logics

ARINC 661 runtime communication

Embedded Cockpit Display System
Graphics

UA SUPPLIERS

CDS SUPPLIER

FACE 3.0 Conformant ARINC 661 CDS Server

FACE
Future Airborne Capability Environment

THE Open GROUP

Conformance Certificate

Certificate number: **16158286**

Certificate date: **March 15, 2021**

The following UoC has been certified FACE Conformant.

Software Supplier	Ansys
UoC Name	Ansys SCADE ARINC 661 Server
Conformant Variants	n/a
UoC Part Number	2020 R2 Ansys SCADE CDS Server with Widget Library
UoC Version	2020 R2
FACE Segment	Platform-Specific Services
FACE Profile	Safety Base Sub-profile
FACE Technical Standard	3.0
FACE Verification Authority	VA-US Army AMRDEC

FACE Certification Authority

Listed within the Registry of FACE certified products:

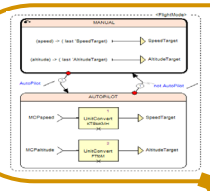
Ansys SCADE ARINC 661 Server

Company: Ansys, Inc.
Version: 2020 R2 FACE Segment: Platform-Specific Services

ARINC 661 Server with Part 5/6 Widget Library, FACE 3.0, POSIX

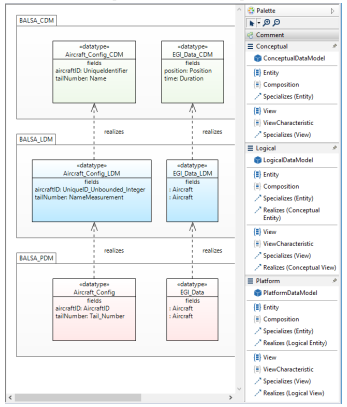
https://www.facesoftware.org/registry

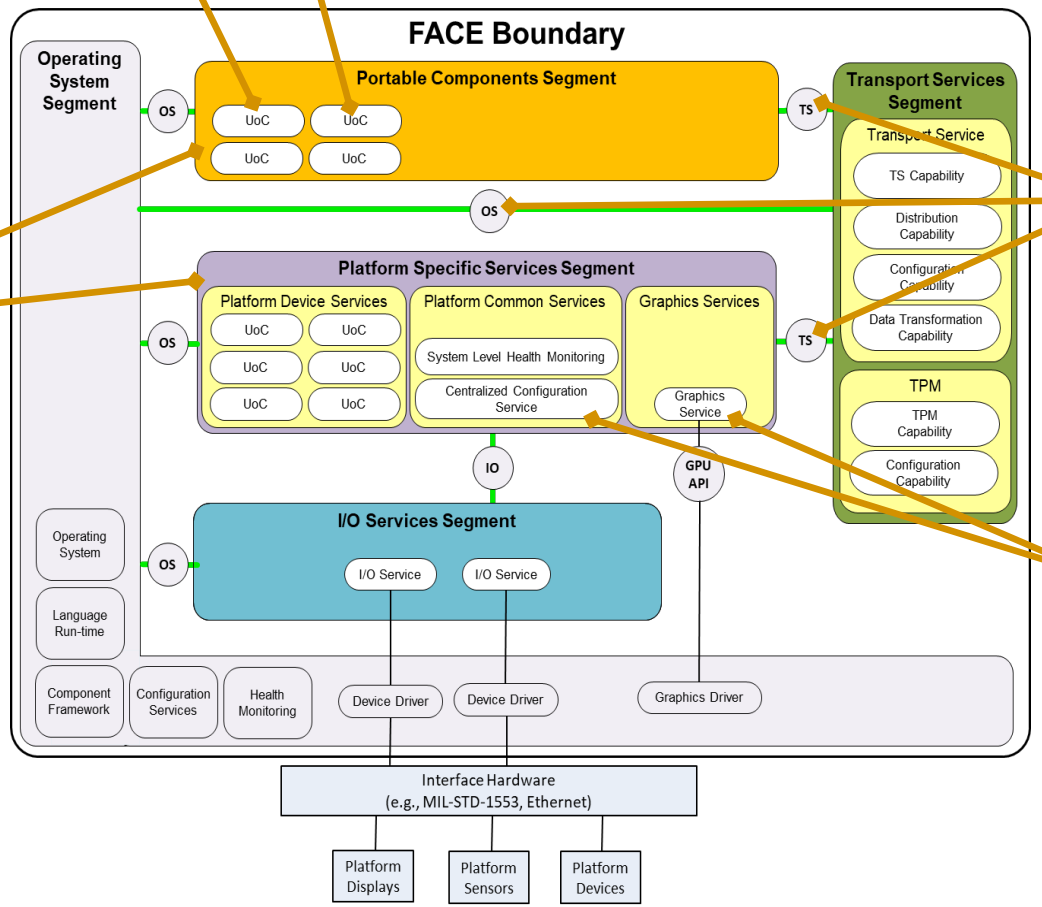
Development Aligned to the FACE Technical Standard



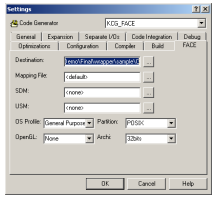
PCS
UoPs

Data Modeling
(USM)





Integration
Code



PSSS
UoPs
(ARINC 661)

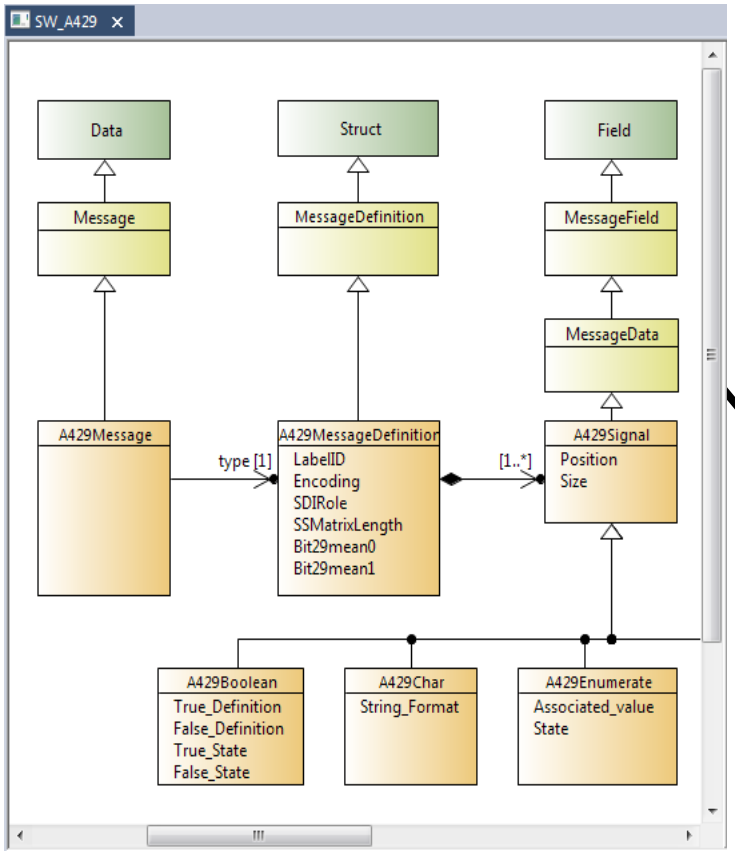
KEY
FACE Defined Interface
External Interface
Non-Conformant Interface

Innovation

Meta-modeling Framework

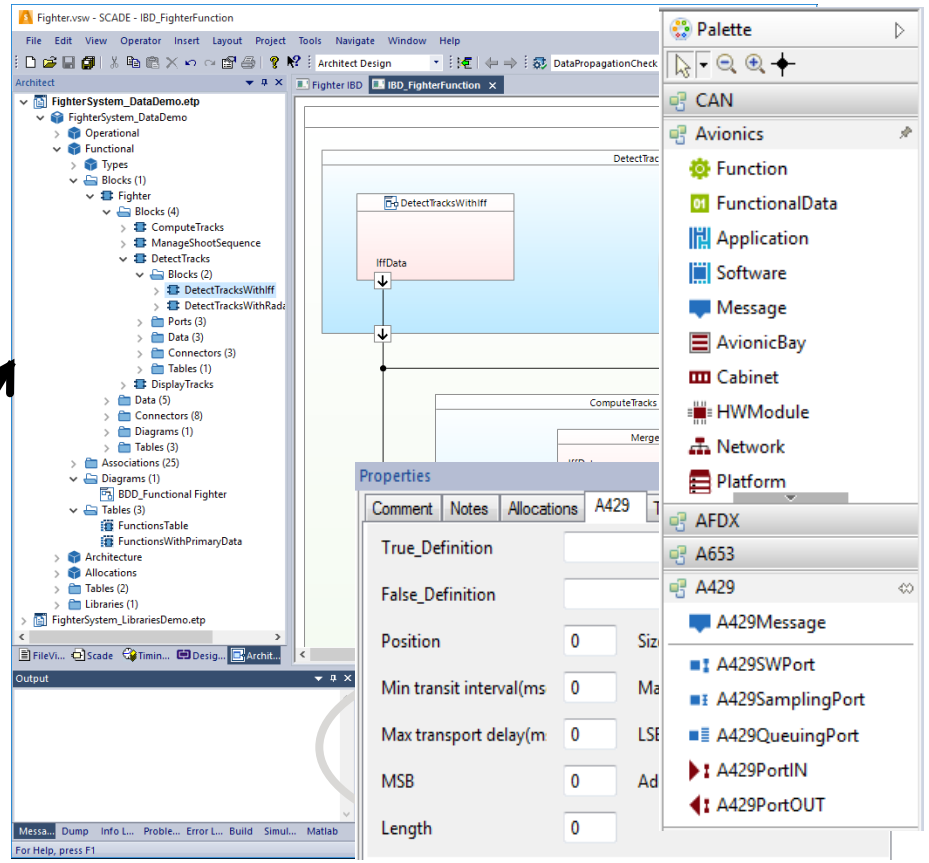
- Meta-modeling allows engineers to define the language used to define the system

Specialist Define the Meta-Model



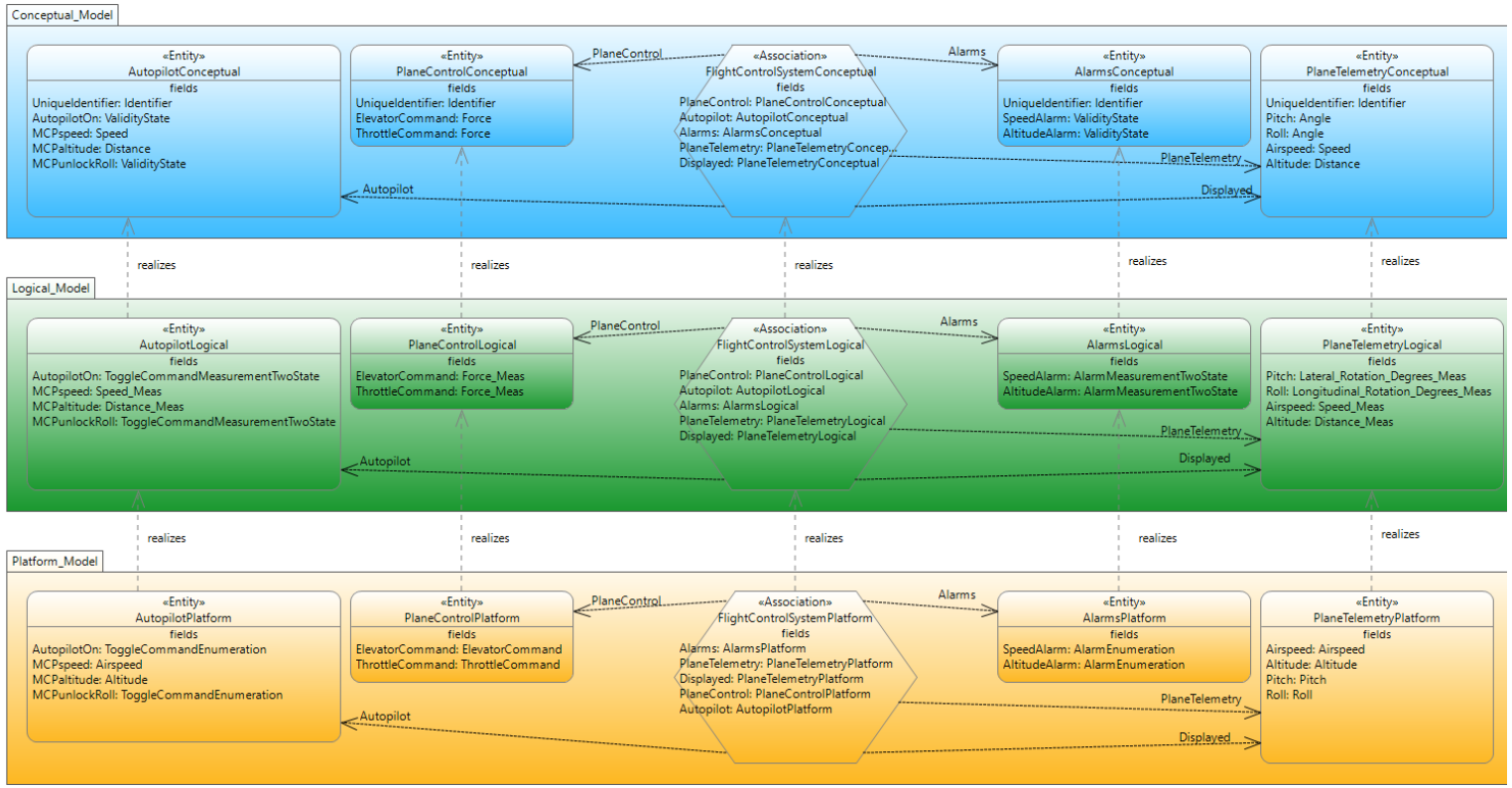
Plug-in

End-User Create Models in the New Language

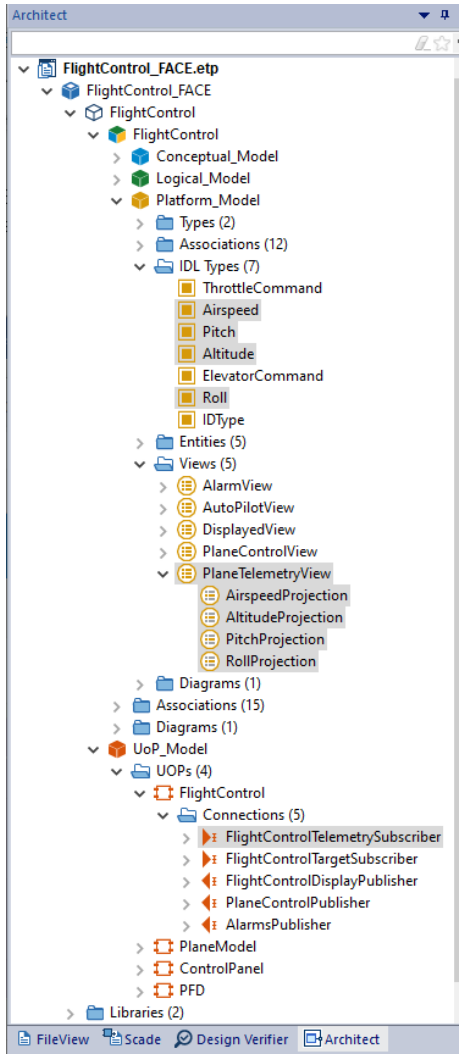


Meta-Modeling Benefits

- Our Enabling Standards are themselves modeled in an open format
- Developers control the underlying language of their MBSE specification
  - Eliminates vendor-lock & facilitates upgrades throughout the product lifecycle

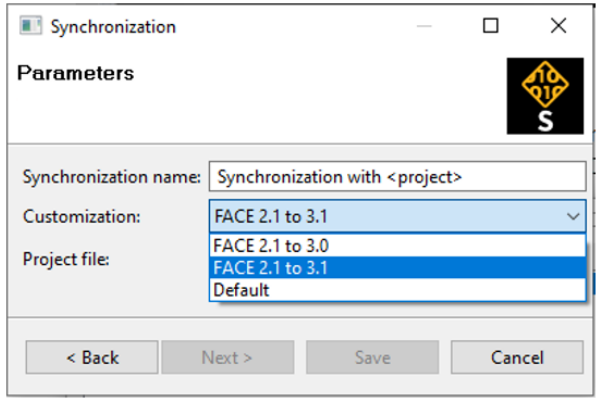


Case Study: FACE upgrade from 2.x to 3.x

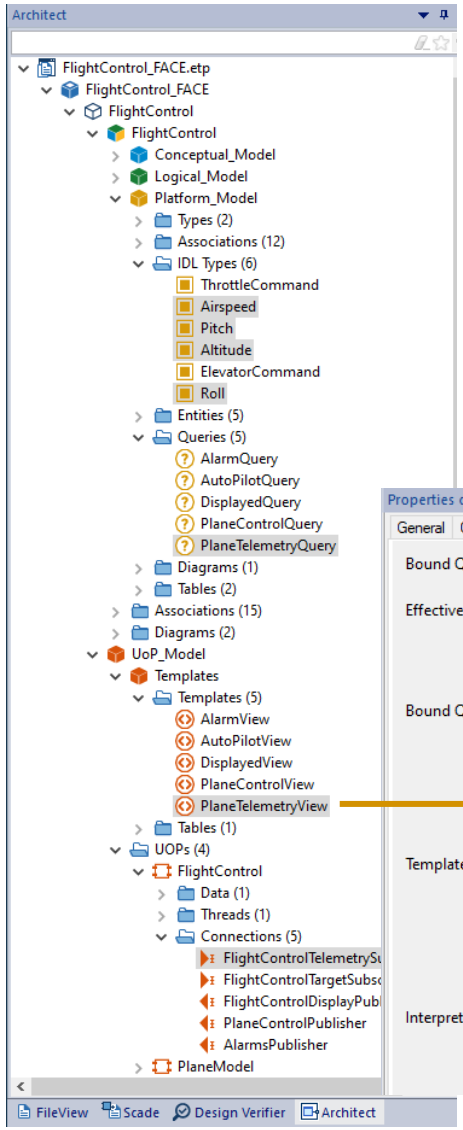


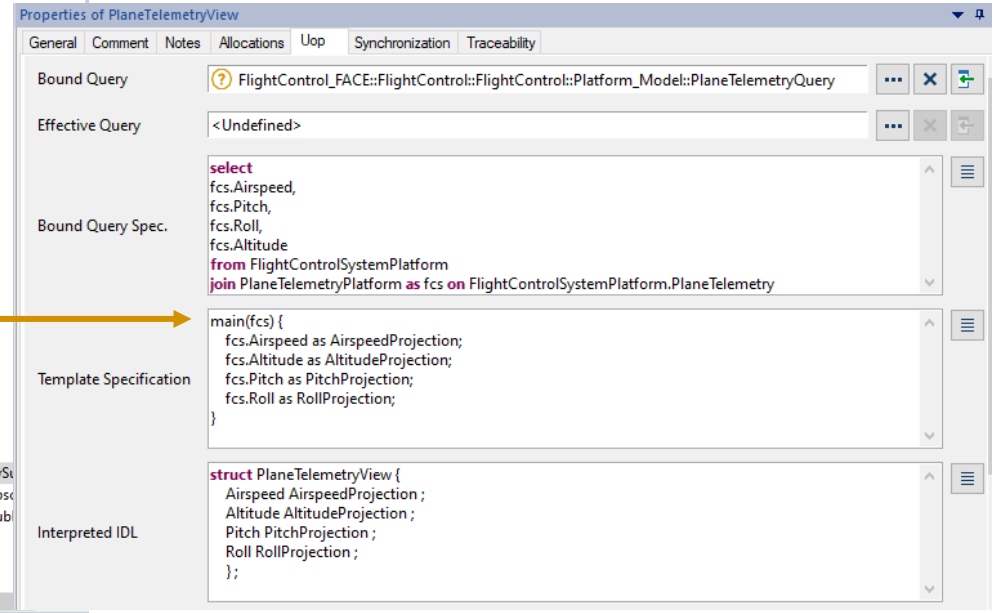
FACE 2.1

Automated transformation

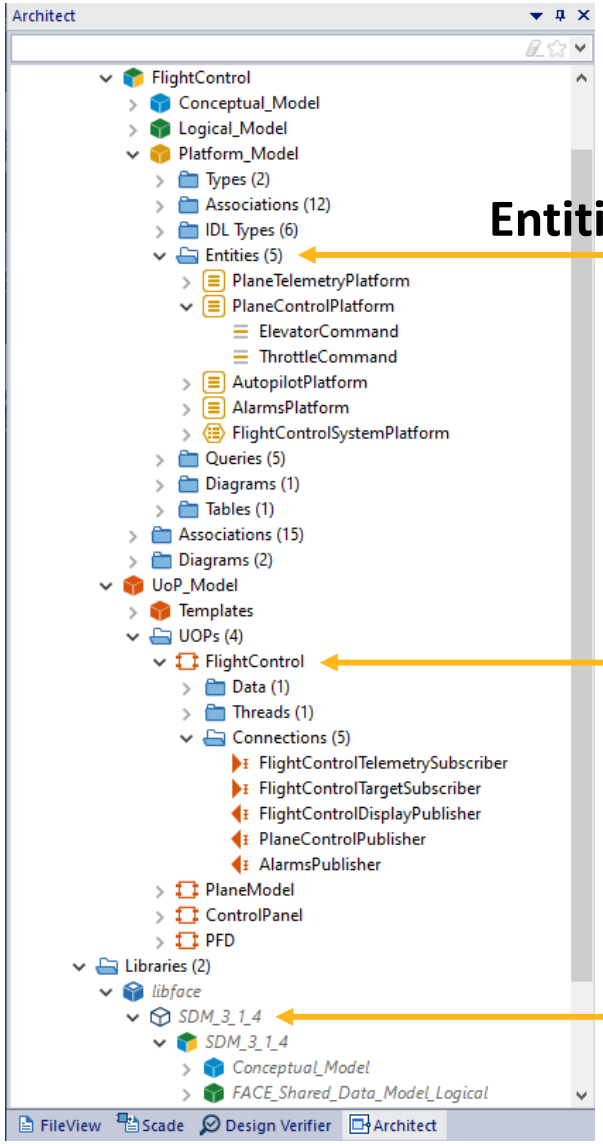


FACE 3.1





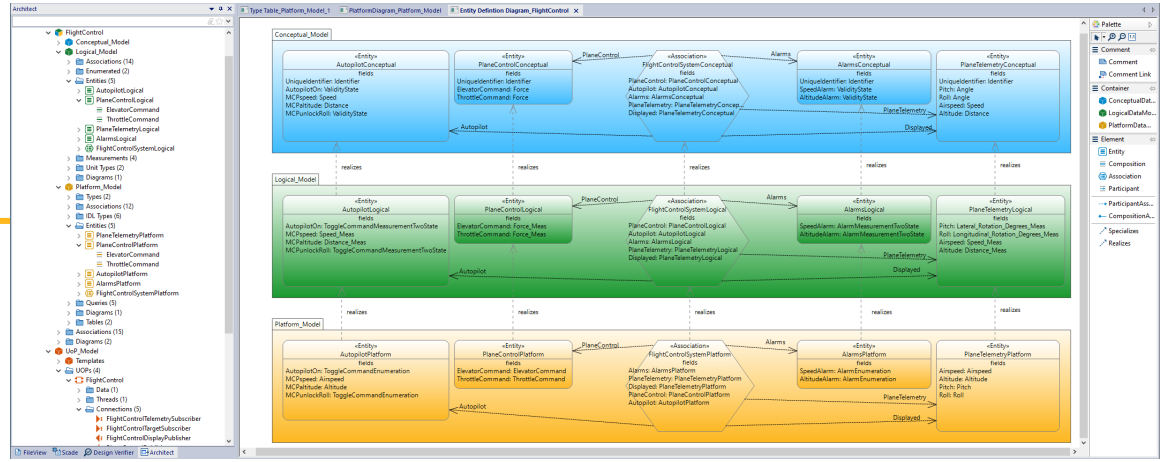
FACE Data Model Import / Design



Entities

UoP

FACE Shared Data Model



Graphical diagrams:

- Entities,
- Observables
- Measurements, etc.

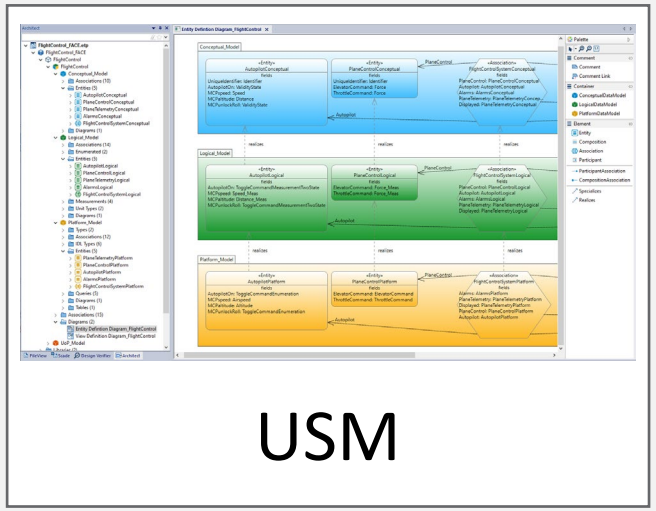
Supports import / export from any FACE-conformant USM

Modular Design

FACE Workflow

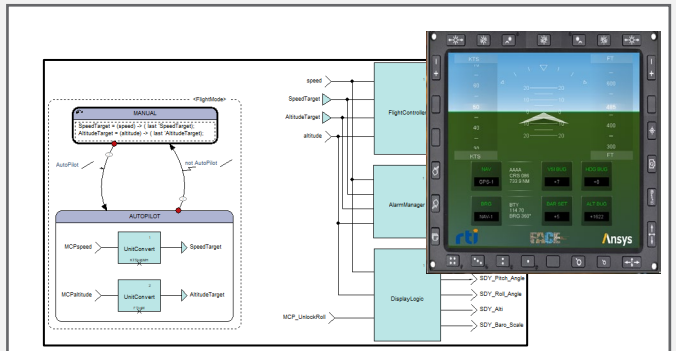
FACE file

Import/Export



USM

Synchronization



UoP

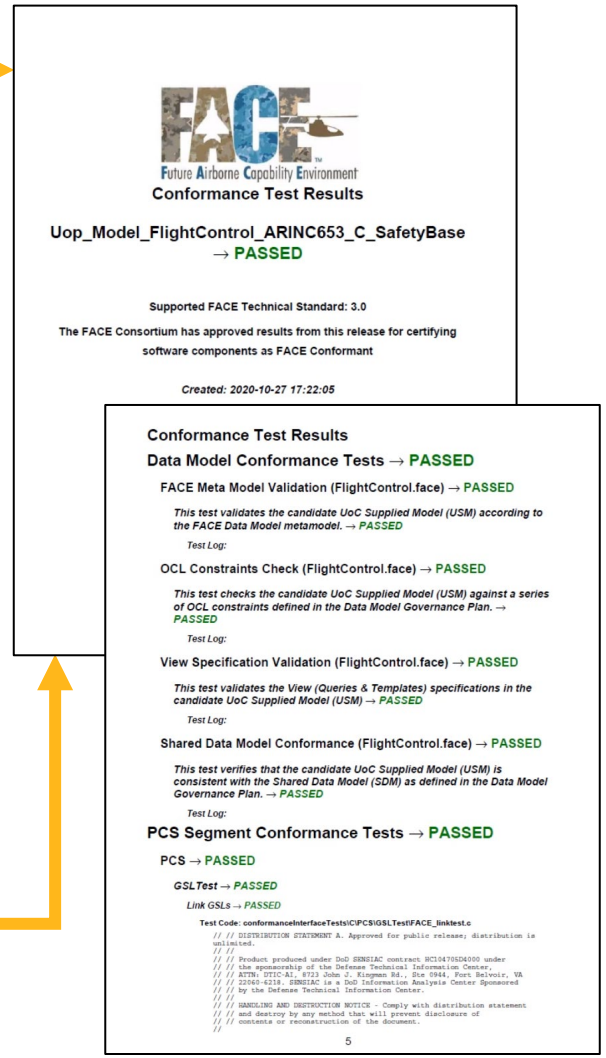
Code generation

TSS
IOS
OSS

Auto-generated behavior code (MISRA C: 2012)

FACE Standard API

FACE Transport Service (TSS) & Operating System Segment (OSS)



Future Airborne Capability Environment

Conformance Test Results

Uop_Model_FlightControl_ARINC653_C_SafetyBase → PASSED

Supported FACE Technical Standard: 3.0

The FACE Consortium has approved results from this release for certifying software components as FACE Conformant

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Conformance Test Results

Data Model Conformance Tests → PASSED

FACE Meta Model Validation (FlightControl.face) → PASSED

This test validates the candidate UoC Supplied Model (USM) according to the FACE Data Model metamodel. → PASSED

Test Log:

OCL Constraints Check (FlightControl.face) → PASSED

This test checks the candidate UoC Supplied Model (USM) against a series of OCL constraints defined in the Data Model Governance Plan. → PASSED

Test Log:

View Specification Validation (FlightControl.face) → PASSED

This test validates the View (Queries & Templates) specifications in the candidate UoC Supplied Model (USM) → PASSED

Test Log:

Shared Data Model Conformance (FlightControl.face) → PASSED

This test verifies that the candidate UoC Supplied Model (USM) is consistent with the Shared Data Model (SDM) as defined in the Data Model Governance Plan. → PASSED

Test Log:

PCS Segment Conformance Tests → PASSED

PCS → PASSED

GSLTest → PASSED

Link GSLs → PASSED

Test Code: conformanceInterfaceTests\C\PCS\GSLTest\FACE_linktest.c

```
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5

UoP Development with Ansys SCADE

Fully Integrated Model-Based Development Environment

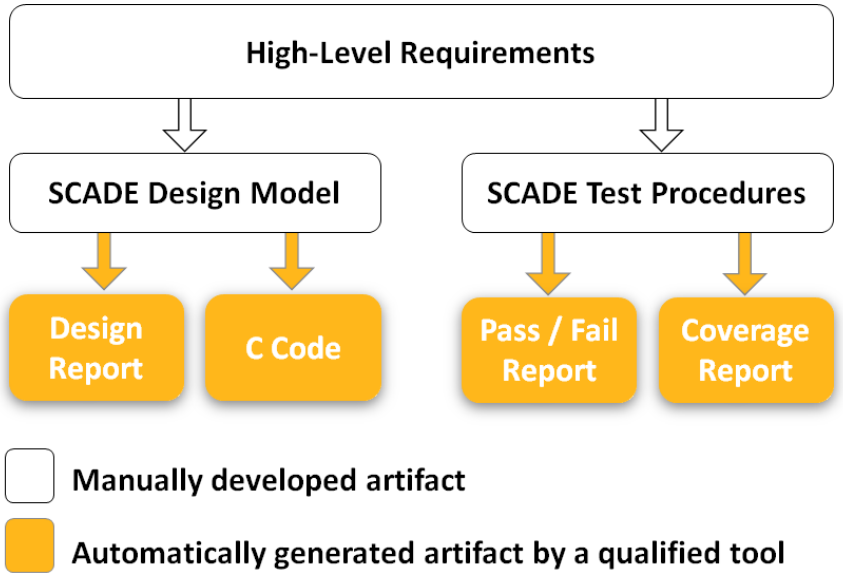
- Mission, Safety-Critical Embedded Software Systems
- Advanced guidance, navigation, controls, display/HMI

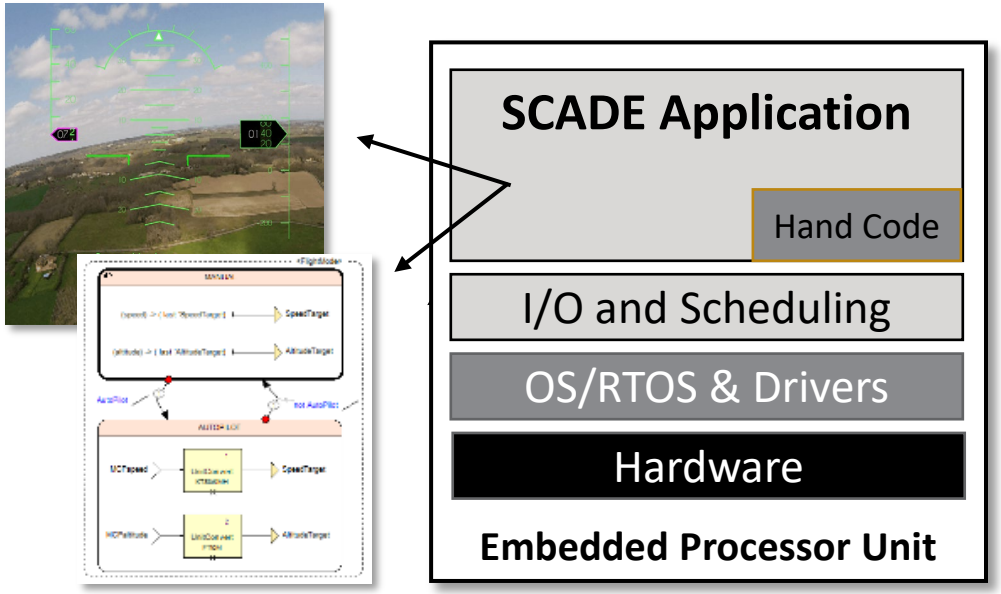
Efficient Development with a Focus on Safety, Security

- Automatic, reproducible and qualified code generation
  - DO-178C/DO-330 – TQL-1 code generator
  - MISRA C: 2012 human-readable source code
  - Cert C compliant (security code quality)

Software Architecture Modeling

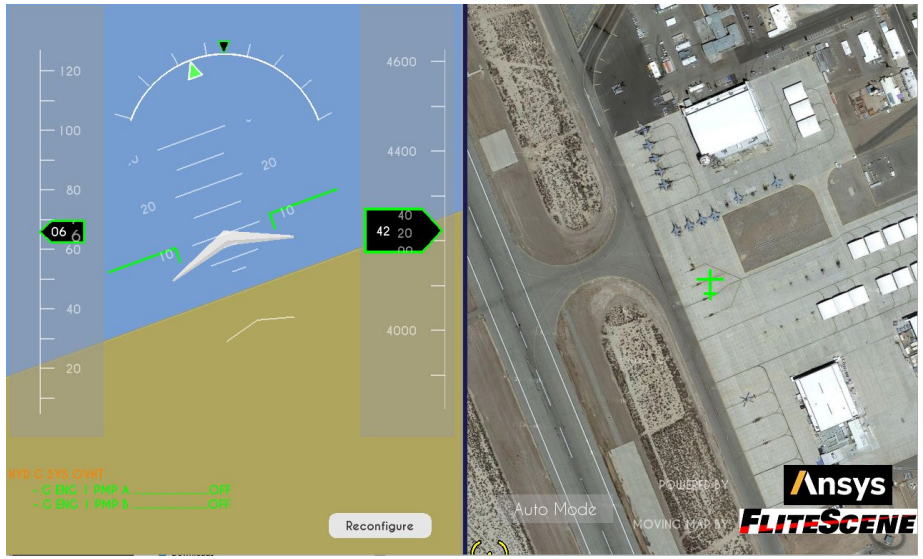
- Automatic import from the FACE USM





Conclusion

- The meta-modeling approach accelerates standards-based software development
  - ➢ Auto-generate a plugin to the MBSE tool itself
- MBSE tools aligned to FACE and ARINC 661
  - ➢ Auto-generate the communication code between components
- Modular software tools reduce cost of component development and verification
  - ➢ Auto-generate software code and related artifacts

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