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TES SAVi AWESUM™

FACE™ Ecosystem - Model-based Tools designed for the FACE Technical Standard, Editions 3.0 & 2.1

Three Use Cases using the TES-SAVi AWESUM® Product Line model-based tool suite

Presented to

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Big Sky, Montana,
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FACE™ Future Airborne Capability Environment

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Presentation Outline

- ***Significance*** of Model-Based tooling to the FACE Eco-system
- ***Three Use Cases*** of FACE Data Model Conversion with Level of Effort (LOE) Savings Projections
- ***Lessons Learned*** using the FACE Eco-system (hybrid) tools and experiences within a ***cross-organizational integrated product team*** (IPT) environment
- ***Summarize*** the role of Model-Based tooling applied to the FACE Eco-system

Significance of Model-Based tooling to the FACE Eco-system

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Three Use Cases using the TES-SAVi AWESUM® Product Line model-based tool suite

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Significance to the FACE Eco-System

- TES-SAVi AWESUM® (FACE) eco-system tools
  - Was used to **Develop 26% of the FACE Conformant Products**, *two products added 2019*
  - Supports Open Systems Architecture (OSA) design, a Congressional Mandate 2020
  - Supports well-formed processes and cross-organizational development environments
    - Described/Published: Cross-Integration Successes – FACE TIM Paper, June 2017
  - Supports the Complete Lifecycle − Satisfies DO-178 software lifecycle objectives, processes which are support Air Force, Navy, and Army Lifecycle processes, *c.f.*, reference below
  - Speeds capability development & integration efforts (dev./test/fix agile development), and improves product quality
    - Described/Published: AF CI/CD – FACE TIM Paper, September 2018, TES & IDI
    - Described/Published: Auto-generated Code – FACE TIM Paper, September 2018, TES & RTI
  - Supporting HOST Ph-II SBIR – US Navy (HOST will be an Open System complement)
  - Supporting US Army CRADAs – MBSE for FACE and AWR investigations, Dec. 2019
  - As aircraft systems-of-systems (SoS) grow more complex, model-based tools will support life cycle requirements, development, VV&A, and model-based virtual simulations
    - Described/Published: Next-generation Model-based Systems Engineering Processes and Tools Supporting the Airworthiness efforts of Cyber Physical Systems (CPS), AHS International - FACE Development Publication, May 2016

Preferred choice when planning to manage the complexity of next-generation systems-of-systems developments, integration, testing, qualification, and sustainment

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26% (5 of 19) FACE Conformant Products

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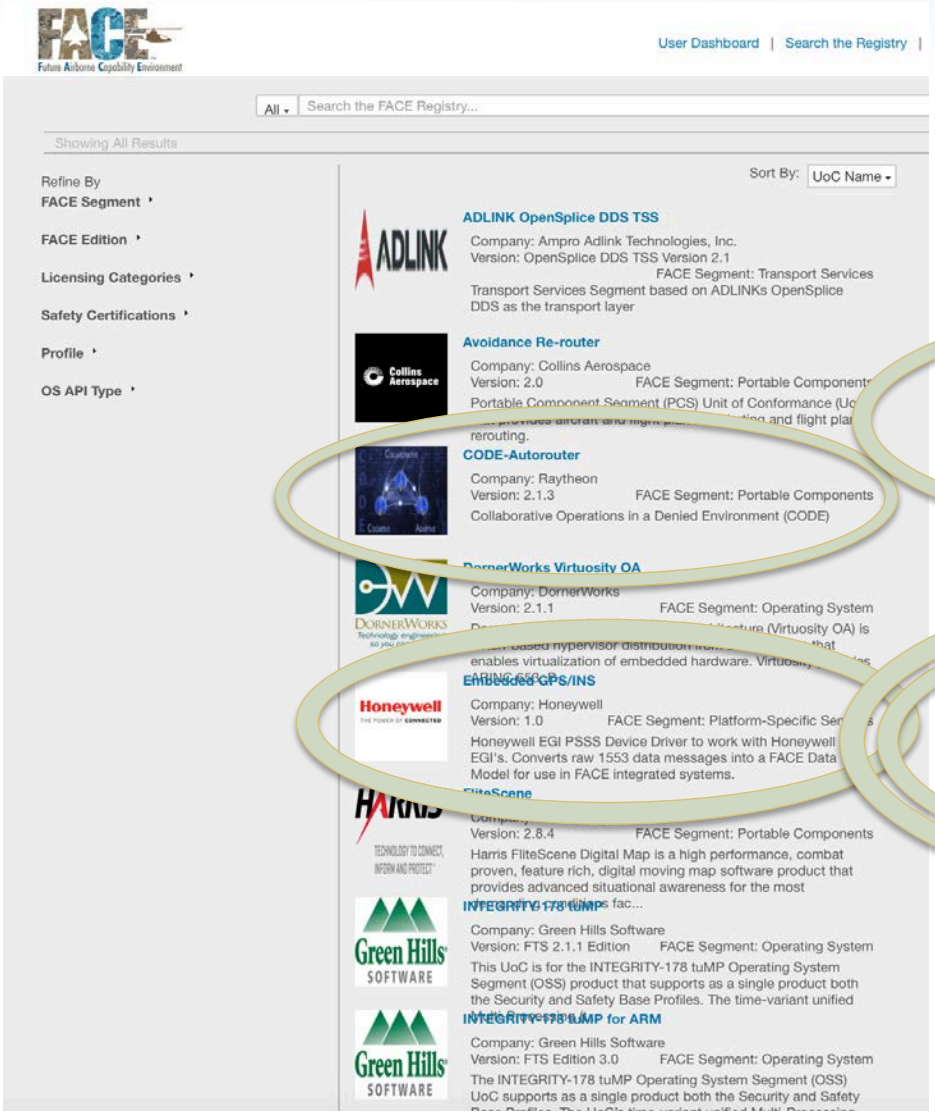

US Army's R2C2 – the Army's *first* to complete FACE Verification process, July 2016

26% (5 of 19) FACE Conformant Products

Raytheon

US Army's R2C2 – the Army's *first* to complete FACE Verification process, July 2016

Other FACE/MOSA Past Performances

- US Army R2C2 – completed **FACE Verification Process,** July 2016 – PEO-AVN – *an Army first*
- US Army MIS/ROSAS (SAVI) – ***aligned*** with the FACE Technical Standard, Army AWR – ADD S&T
- *IPT* - Honeywell EGI/INS – **FACE Conformance**, April 2017
- *IPT* - Raytheon CODE Auto Router – **FACE Conformance**, Sept 2018 – DARPA MOSA
- RTI DDS TSS – **FACE Conformance**, December 2018
- *IPT* - Raytheon CODE DSDM, 2.13 – **FACE Conformance**, April 2019 – DARPA MOSA
- *IPT* - Textron & TES, Collision Detection, 3.0 – **FACE Conformance**, July 2019

Current Efforts

- *IPT* - Air Force R-EGI – CI/CD – AFRL (US Army reuse of R2C2 Memo for Record)
- HOST Ph-II SBIR – US Navy – (*emerging*) open systems hardware standard
- US Army CRADA – MBSE for FACE and AWR investigations, Dec. 2019, *BALSA Centralized Logging*
- *IPT* - VLC JMR Task 4 AV/MSA IDD – VLC consortium task modeling tool, model interoperability between FACE, UML and SysML models, with 14 VLC Collaborative Organizations
- *IPT* – GTRI VLC JMR FLARA Architectural Framework (FAF)
- *IPT* - US Army SUMIT – Force Lab
- US Army PM-Apache ASE – FACE v3.x, Conformance, TBD 2020
- US Army PM-AS ARCM Communications – FACE v3.x, Conformance, TBD 2021
- (NDA Zz) – DARPA/NAVAIR, FACE Conformance, 3.x TBD 2020

16+ Programs using AWESUM® MBSE tool suite for FACE and MOSA

Three Use Cases of FACE Data Model Conversion with Level of Effort (LOE) Savings Projections

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Three Use Cases using the TES-SAVi AWESUM® Product Line model-based tool suite

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We will Demonstrate Three Use Cases
FACE 2.1 to 3.0 data model translations

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TES-SAVi will demonstrate FACE Ecosystem tool, AWESUM®, converting

1. **BALSA** FACE 2.1 model to be FACE 3.0 conformant including conversion of FACE SDM from v2.1.35 to v3.0.3
2. Export and conversion of other FACE edition 2.1 and 3.0 data models from one data model of the **Army Common Engine FADEC Interface (CEFI) FACE component, including BALSA**
3. Export and conversion of **Raytheon's FACE Conformant CODE DSDM**, April 2019, real-world large, i.e., 15,000 data elements, data model from edition 2.1.3 to 3.0

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Raytheon Collaborative Operations in Denied Environment (CODE) Domain Specific Data Model (DSDM)

Company: Raytheon
Version: 2.1.3
FACE Segment: Domain Specific Data Model

Raytheon Collaborative Operations in Denied Environment (CODE) Domain Specific Data Model (DSDM). Leverages the Unmanned Systems (UxS) Control Segment (UCS) Architecture, taking the UCS conceptual dat...

TES-SAVi AWESUM® MBSE Capabilities Include Complete FACE Ecosystem Support (models to code)

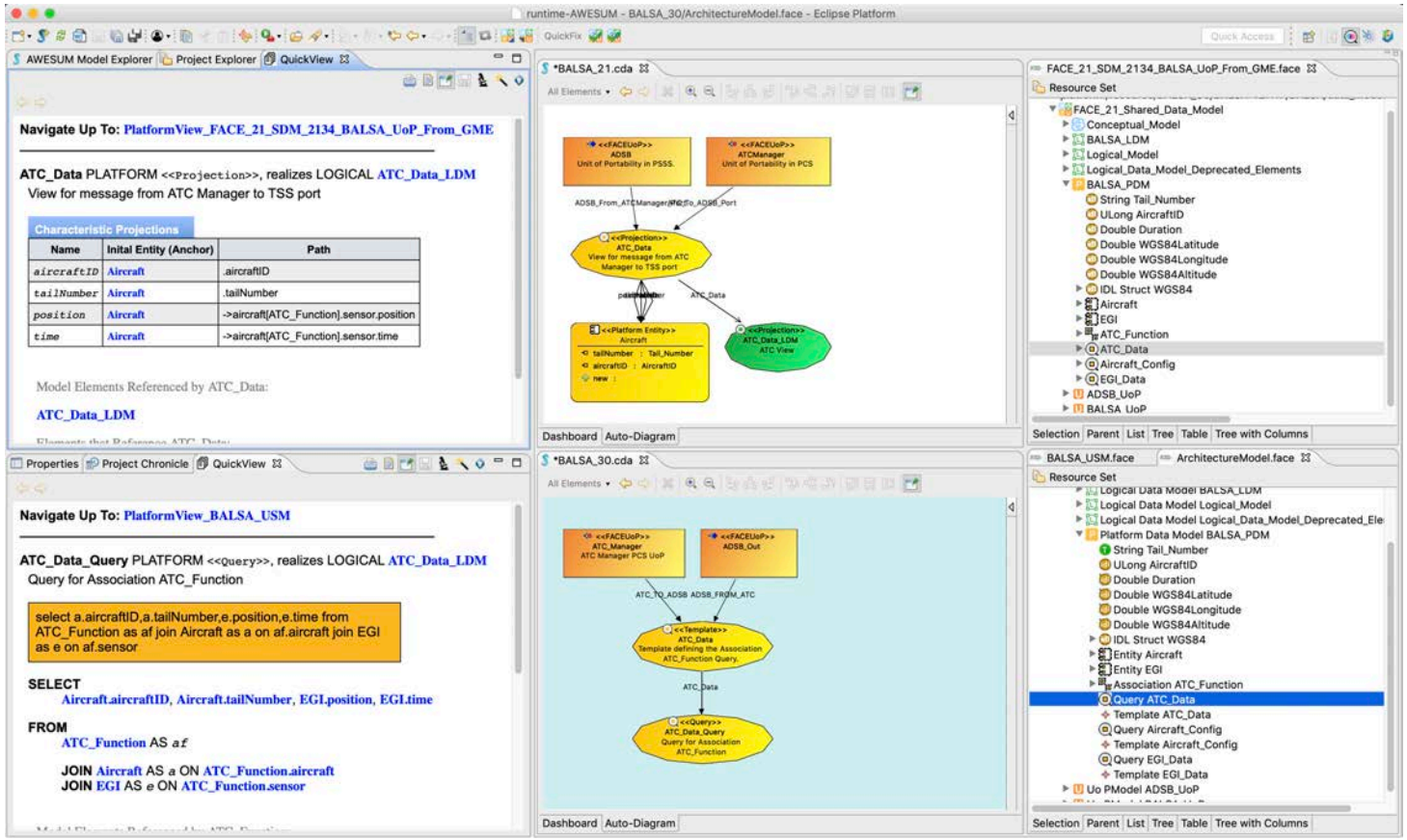
Data Models to Models to Code aligned with FACE Technical Standard

- **Export** a Unit of Conformance (UOC) **FACE data model or Domain Specific Data Model** (DSDM) to FACE Standard, Editions 2.1 and/or 3.0 (soon 3.1) from one model
- **Convert** FACE data models **from** FACE Standard, Editions **2.1 to 3.0**
  - **Includes Upgrading the dependency** of the UOC Supplied Model (USM) FACE Shared Data Model (SDM) from FACE Standard, Editions 2.1.x to 3.0.x
- **Validate the Metamodel**, the **SDM**, and the **Query & Template Languages**
  - **Note**: *this does NOT replace any sanctioned FACE CTS tools*; but it does speed model and software development and verification processes in preparation ahead of FACE verification efforts
- **And using the model**, **generate the software** aligned to the FACE Technical Standards, Editions 2.1 and 3.0
  - using these ecosystem tools, TES-SAVi AWESUM® and RTI's Connext
    - [*c.f.*, TIM paper references 10 & 11]
- Produces products *prepared for* FACE Verification Processes and FACE Certification

Full FACE Ecosystem Lifecycle Development Support

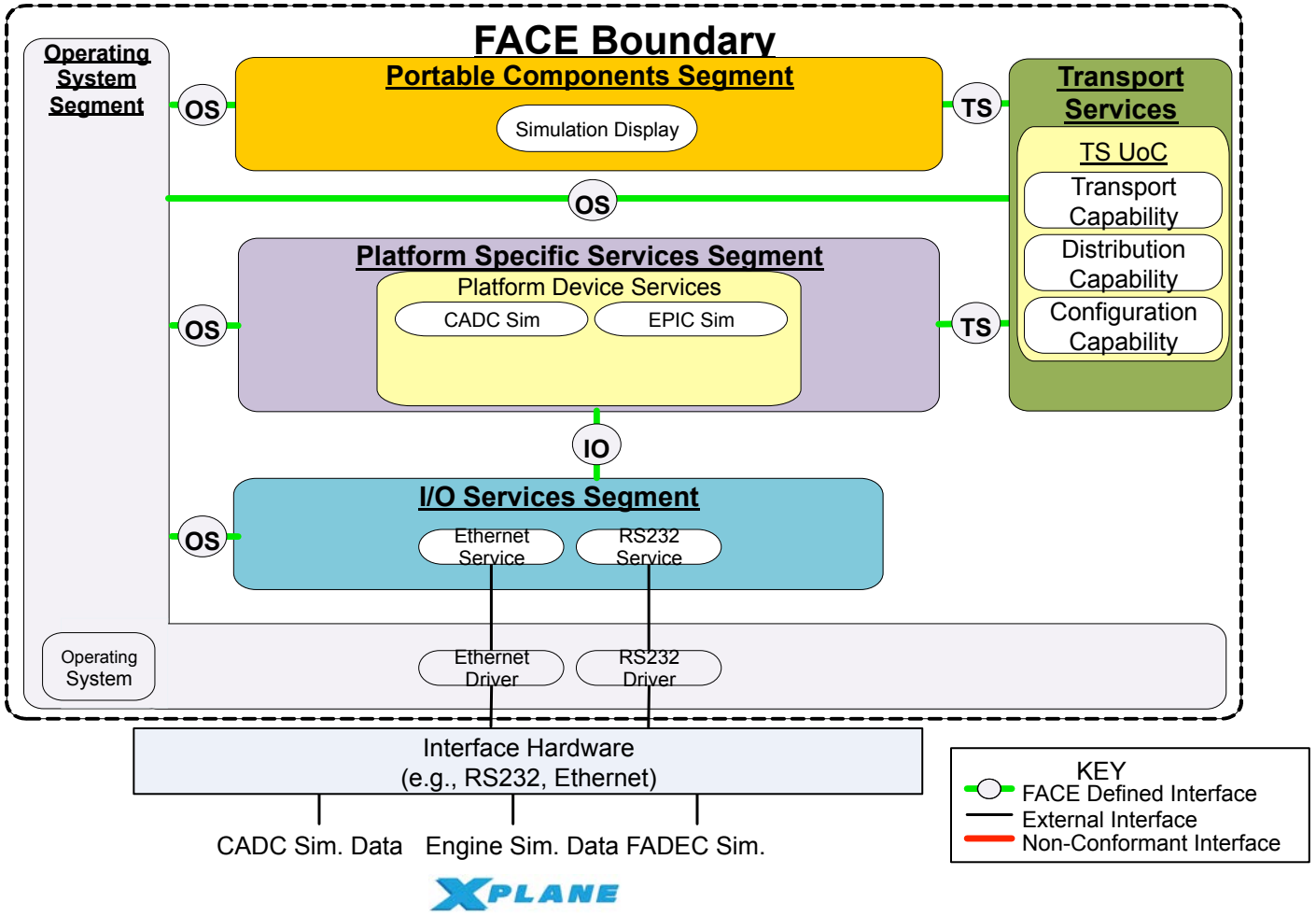
Tool Demonstration(s) (1 of 3)

BALSA data model version 2.1 converted to 3.0



Tool Demonstration(s) (2 of 3)
Common Avionics Engine Interface, A18-080
Architectural Concept - FACE Architectural Diagram

A18-080 Common Avionics Engine Interface - FACE Diagram



Common Avionics Engine Interface, A18-080 Components w/ Engine Messages

FACE PCS-*like*
Engine tab on MFD

3.1.3 *AC to Eng.*
FACE Msg(s)
Airspeed
Altitude
Air Temp

FACE TSS ↔ FACE TSS

FACE PSSS
CADC (Sim.)

FACE PSSS
EPIC

3.1.4 *Eng. to AC*
FACE Msg(s)
Turbine Speed
Torque
Turbine Temp

FACE IOS

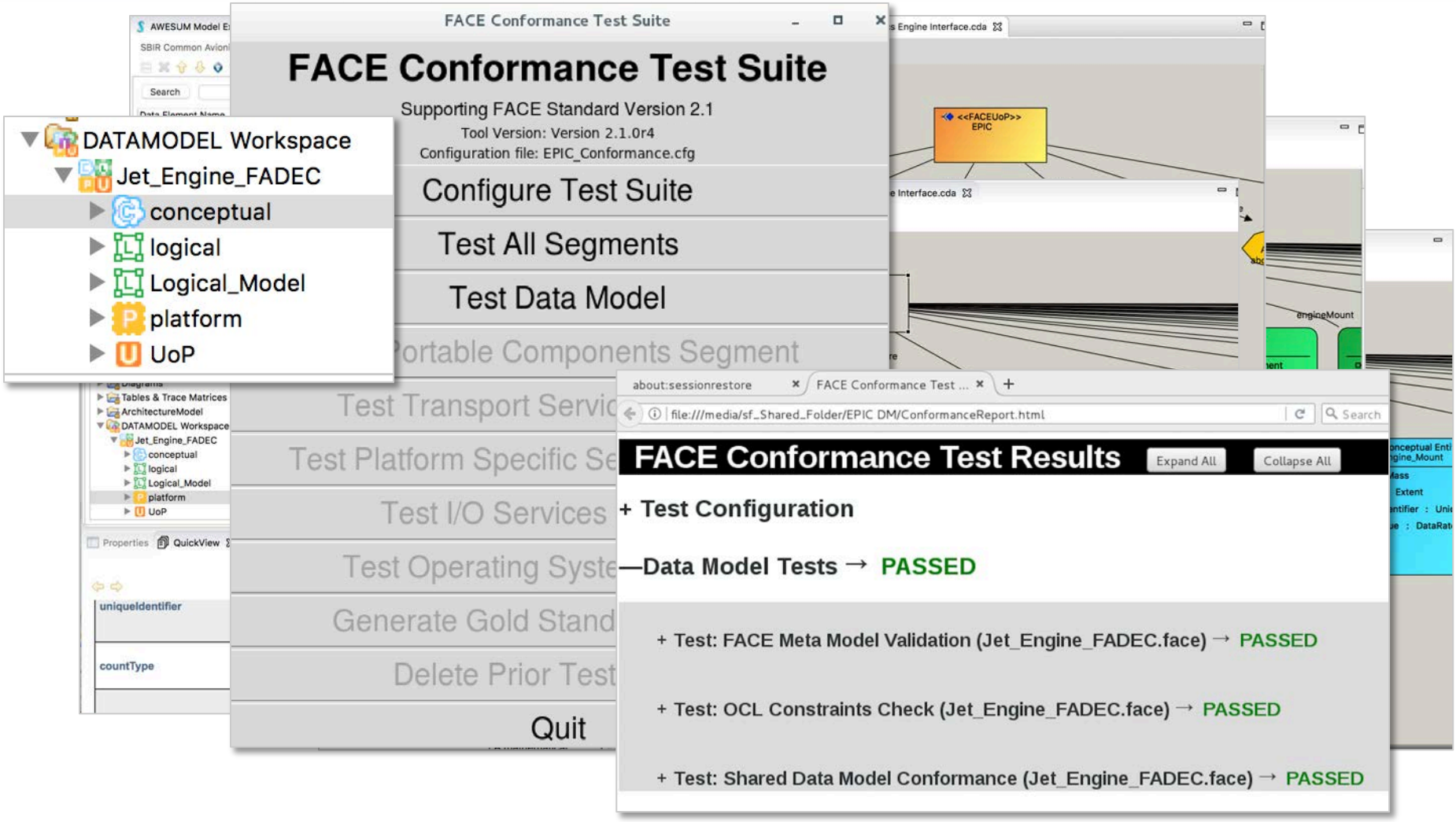
FACE IOS

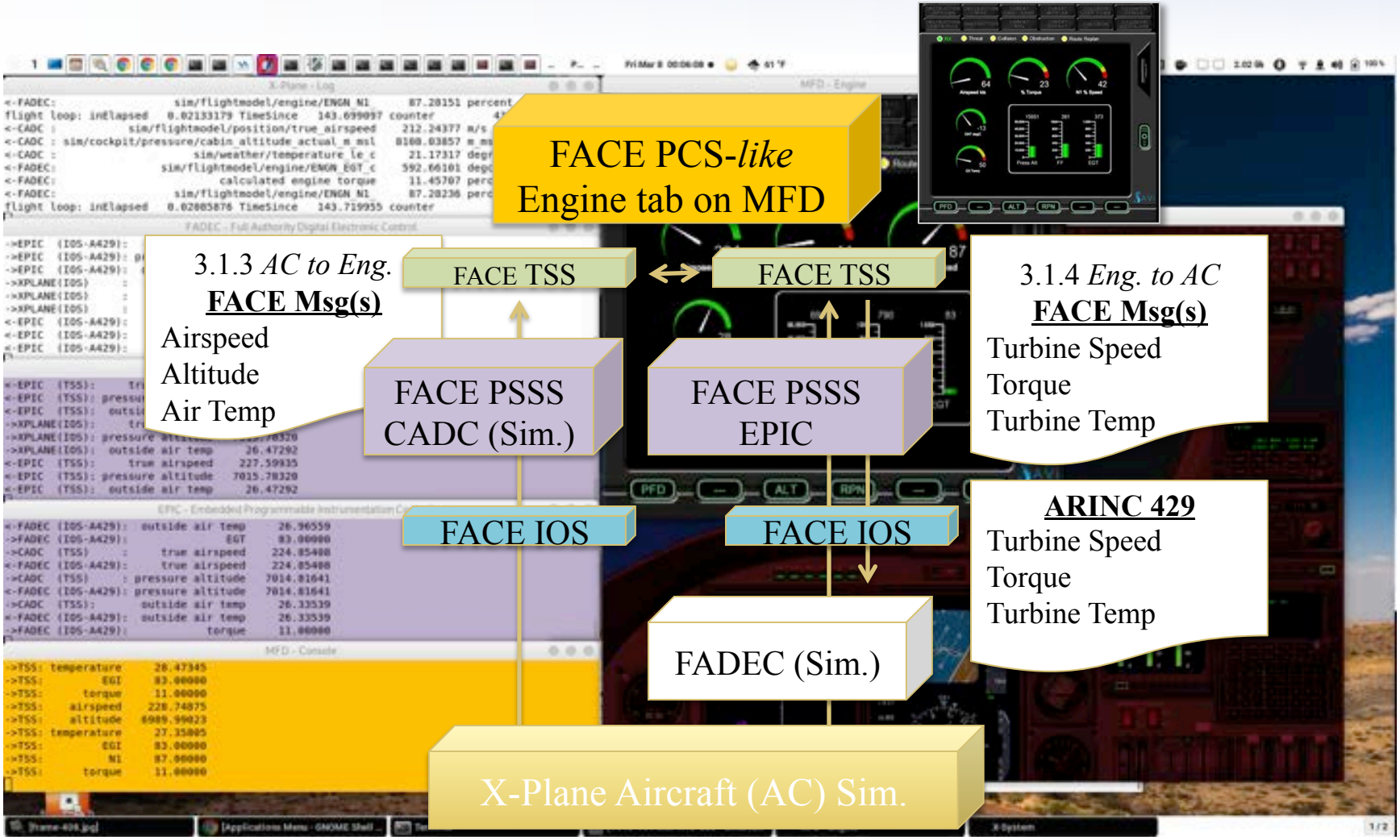
ARINC 429
Turbine Speed
Torque
Turbine Temp

FADEC (Sim.)

X-Plane Aircraft (AC) Sim.

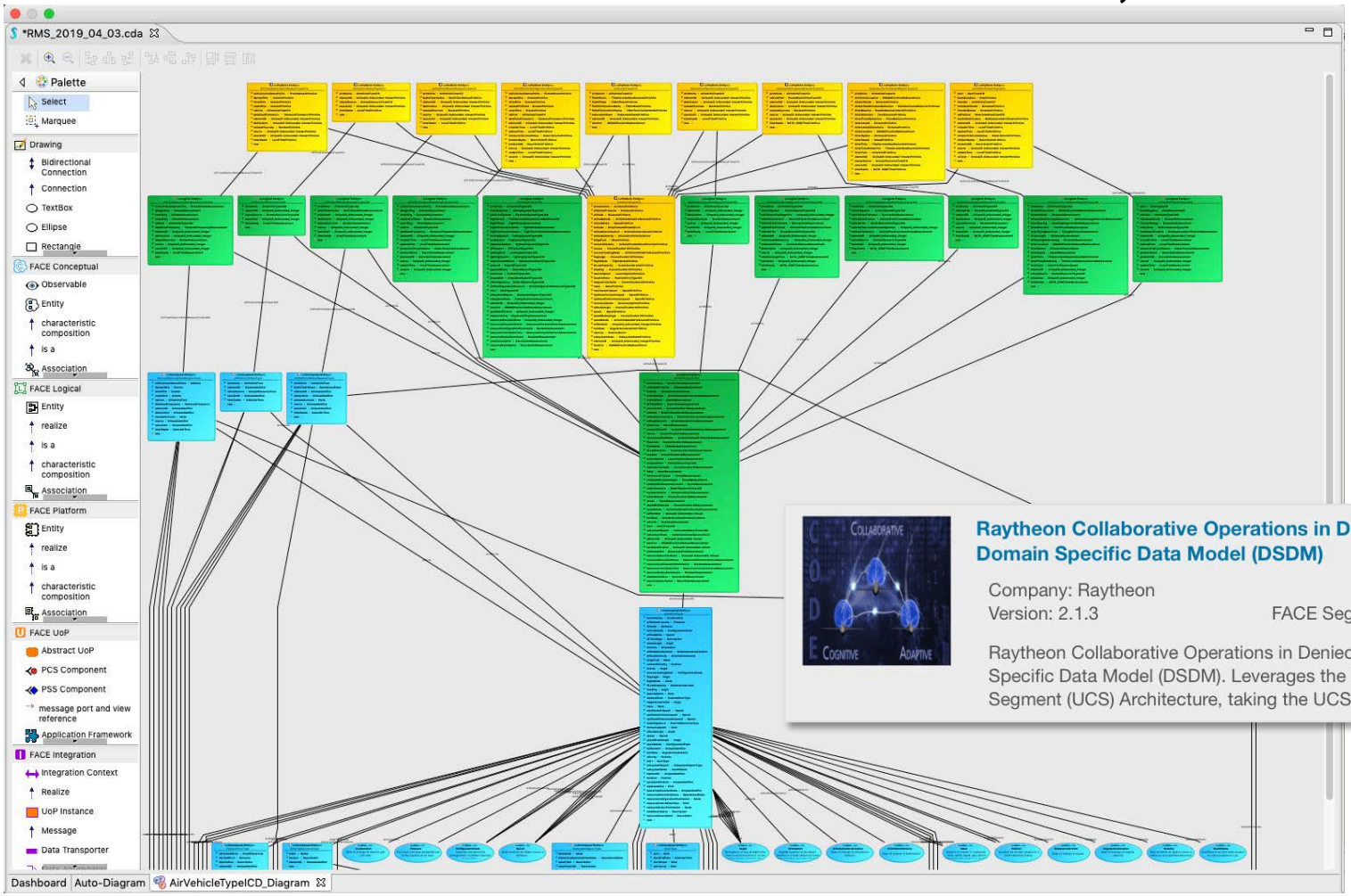
Common Avionics Engine Interface, A18-080
FACE Message Data Model – *Conformance Results*





Tool Demonstration(s) (3 of 3)

Raytheon's FACE Conformant CODE DSDM, version 2.1.3 converted to FACE Technical Standard, Edition 3.0



MBSE Automated Level of Effort - *What just happened*?

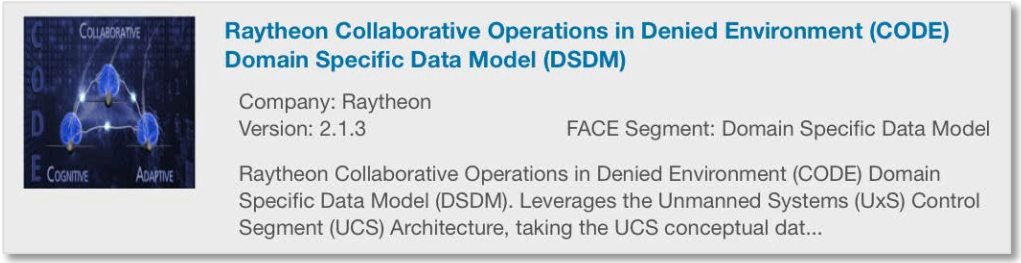
Demo – 1 Conversion of BALSA

- Converted BALSA UoPs, Views & DM from v2.1 to v3.0
  - 4 UoPs, 3 Views, < 100 DM Elements
  - **8 – 40 hours saved**

Demo – 3 Conversion of RMS CODE DSDM

- (also) Converted (FACE Conformant) RMS CODE DSDM from FACE Edition 2.1.3 to 3.0
  - > 15,000 Data Model Elements
  - **1,200 – 3,000 hours saved**
  - *i.e.*, **0.5 – 1.5 person-years saved using mbse automation**

AWESUM™



Background to Level of Effort

- TES has been working common reusable software solutions for PEO-Aviation since 2003; joined FACE in inception 2010; and formally began commercialization of TES-SAVi AWESUM® in 2013
  - We have supported every FACE BITS and every FACE TIM event
  - We have supported development of 26% of all FACE Conformant products
- 10+ years of development efforts have gone into this TES-SAVi AWESUM® FACE eco-system tool suite
- SBIR LOE: The Army SBIR FADEC FACE modeling and software implementation was completed by two engineers within 5-weeks LOE; but understand TES resources are skilled in the art developing products to the FACE Technical Standard
- *More Others*: Two Consortium Companies recently (July 2019) achieved FACE Conformance to 3.0 as IPT Partner Software Suppliers, *i.e.*, Textron Systems and TES, using the TES-SAVi AWESUM® tool suite in 5-weeks

https://tes-savi.com, https://www.rti.com/products, or FACE 3rd Party Tools

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Lessons Learned using the FACE Ecosystem (hybrid) tools and experiences within a cross-organizational integrated product team (IPT) environment

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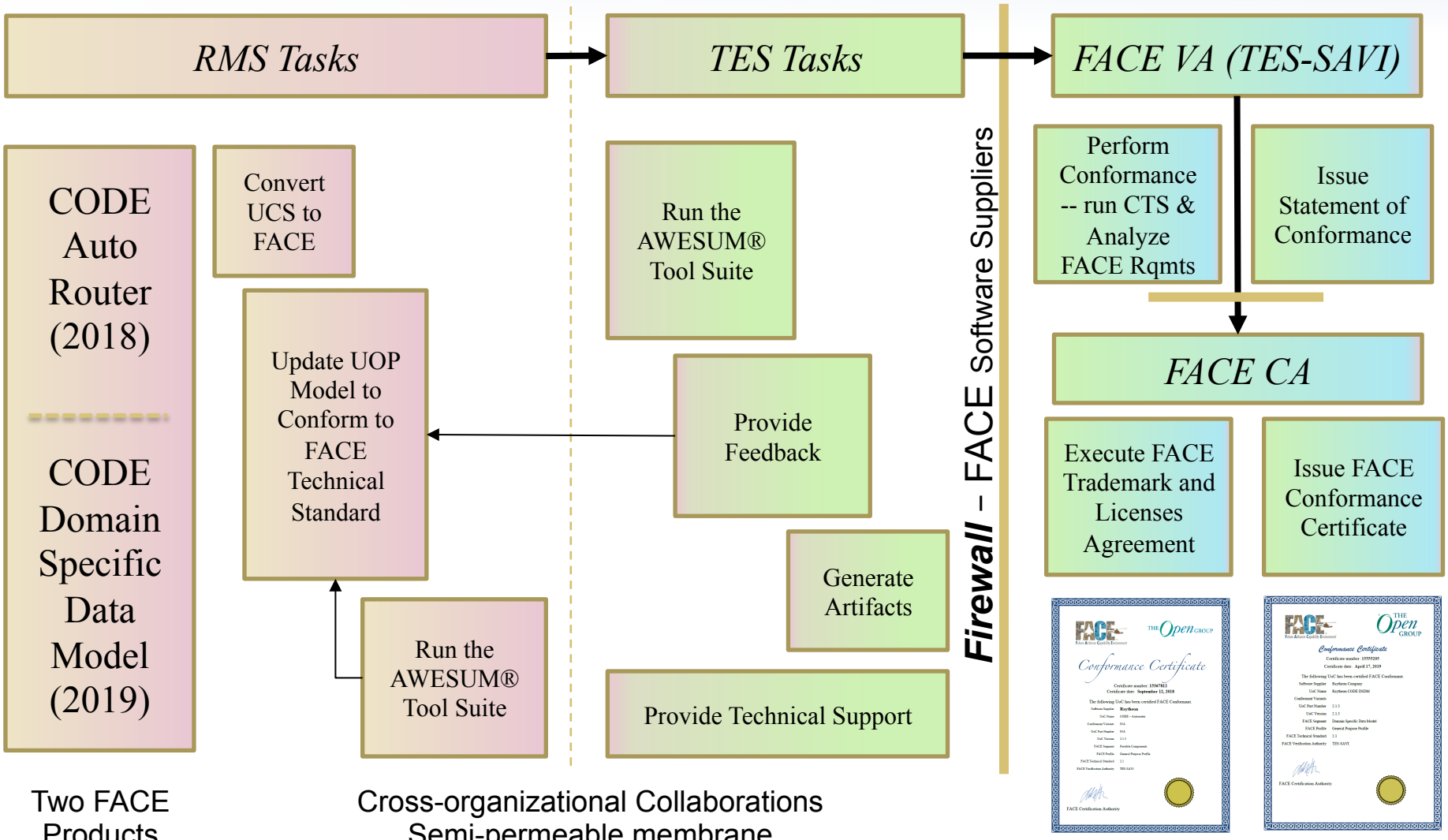
FACE Ecosystem Processes
Distribution of Tasks and Collaborations, and FACE Verification and Conformance Processes



FACE Ecosystem Processes -- *Issues Observed*

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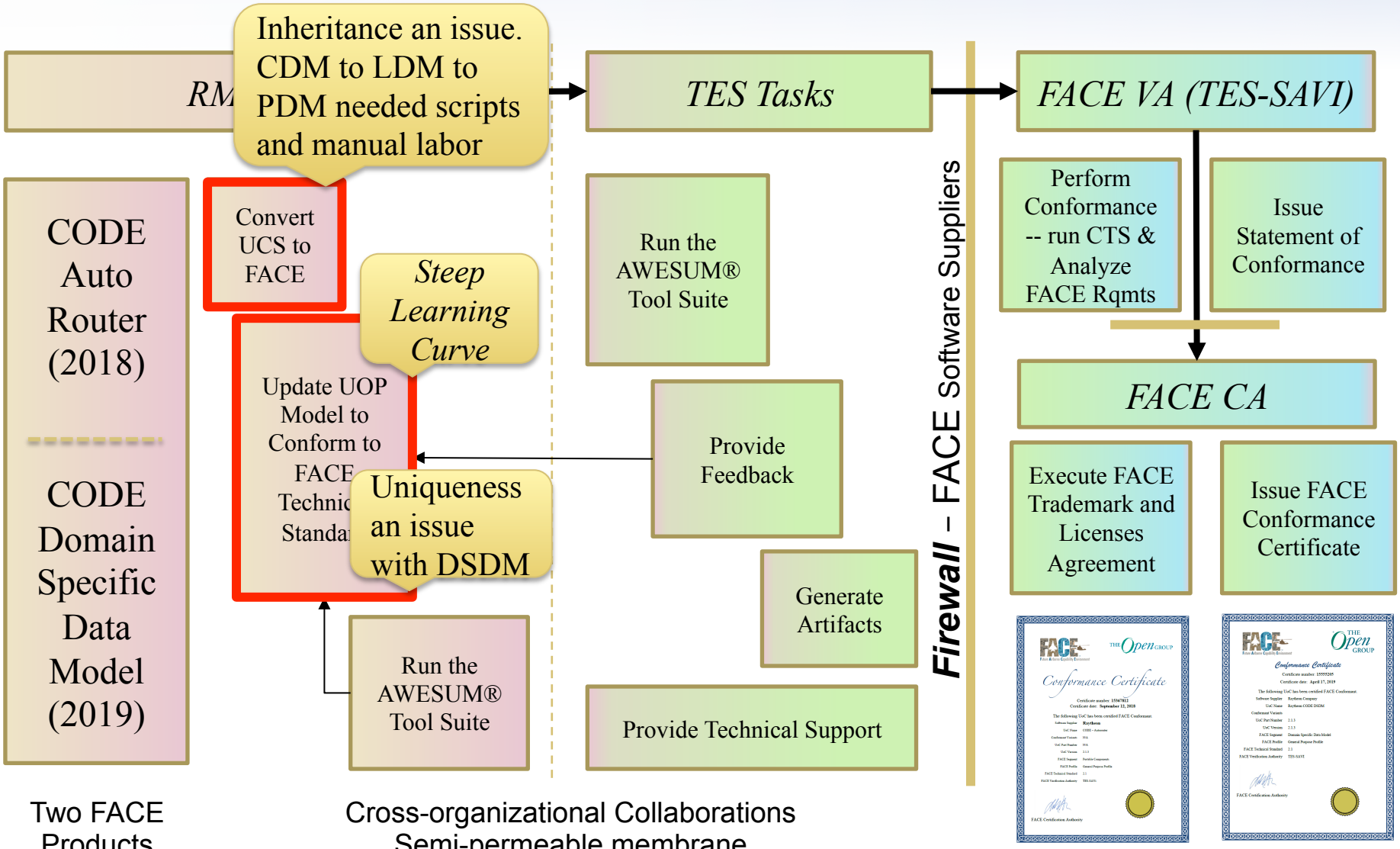
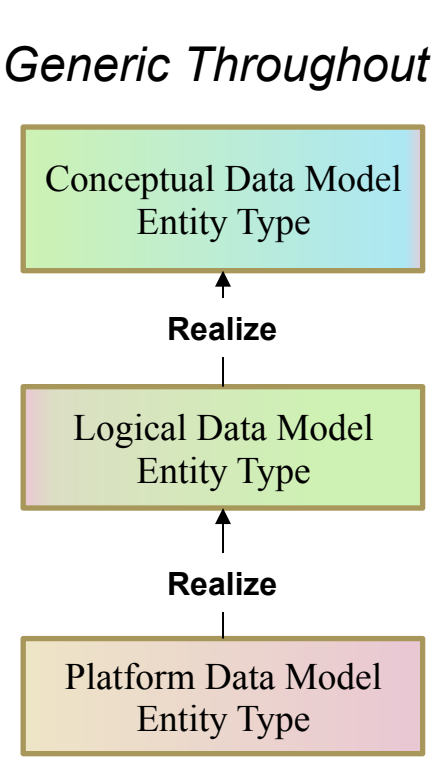


Two FACE Products

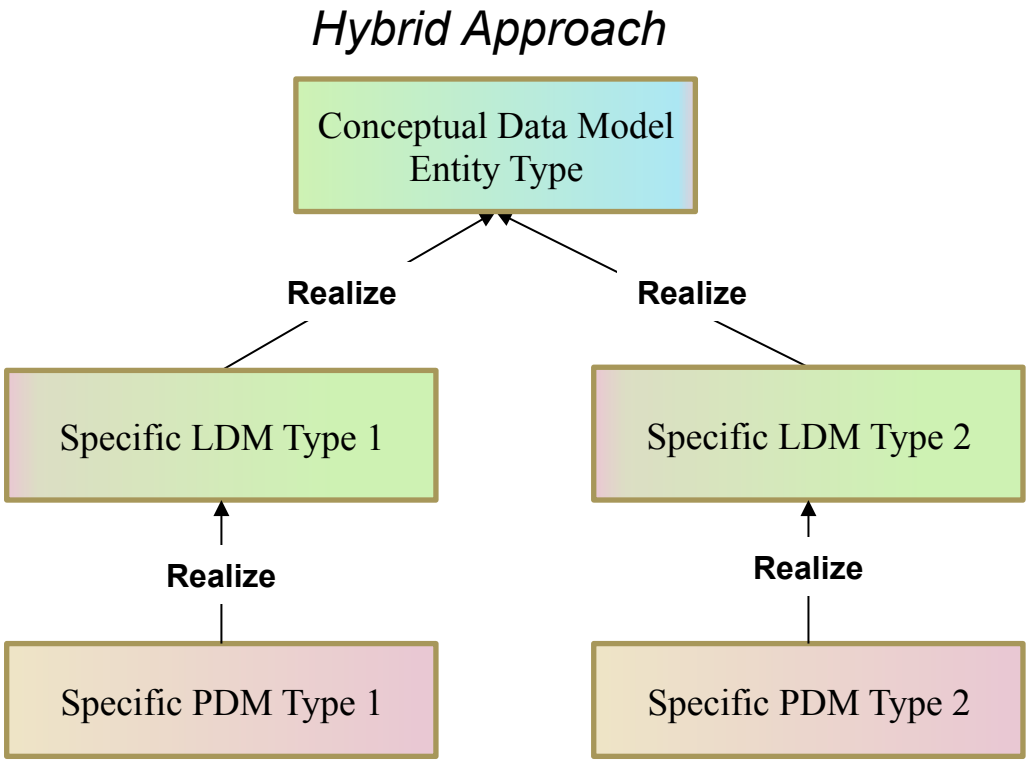
Cross-organizational Collaborations
Semi-permeable membrane

Resolutions

Employed multiple realization methods based on particulars of the CODE model itself



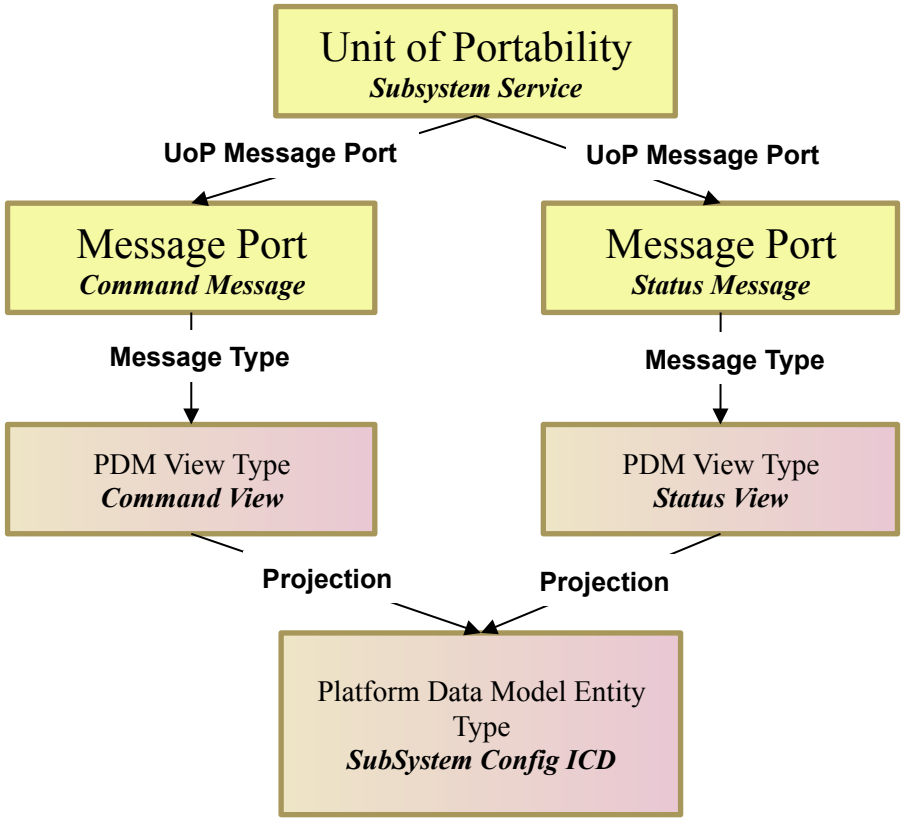
Single LDM and PDM Realization Method (Preferred)



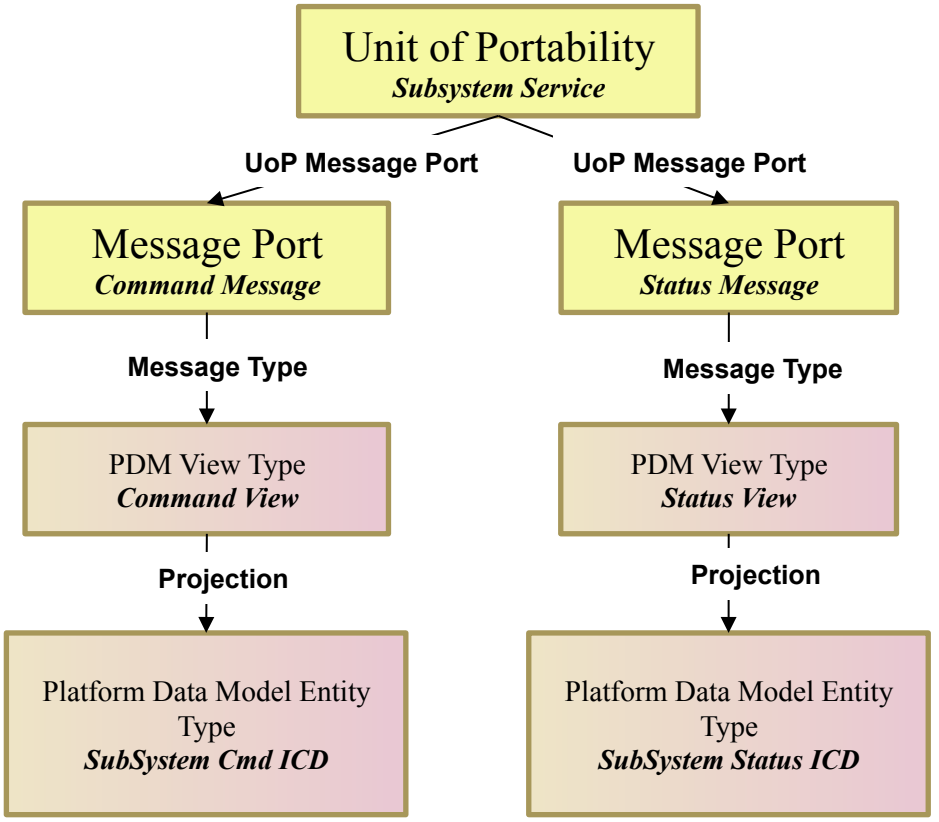
One-to-Many Realization of CDM to Separate LDM and PDM Entity Types Used too preserve identity of LDM and PDM types

Resolutions

PDM View Types project each method based on particulars of the CODE model



Common PDM Entity Type Projected by Both View Types



Each View Type Projects own PDM Entity Type

Summary of RMS' FACE Eco-systems modeling Lessons Learned

- Steep learning curve – access to data model SMEs was propitious
- FACE Reference Implementation Guide – useful, but lacking guidance for complex applications
- UCS to FACE conversion was hard – standards not well–aligned
  - Generalizations in Edition 2.1 do not support inheritance
  - Generalizations in Edition 2.1 are ambiguous – issues during characteristic projection and code generation
  - Edition 3.0 utilizes specializations instead of generalizations
- Missing measurements: errors / uncertainties in general, covariance, angle-based FOV
- Non-uniqueness in UCS specification was an issue; resolved by
  - Condensing non-unique entities to a generic CDM entity type where possible
  - Modifying characteristic composition (add, delete, modify) to achieve uniqueness
- Conversion from Edition 2.1 to 3.0
  - 15,000 data elements
  - Using TES-SAVi AWESUM® saved ~1,200 – 3,000 hours labor, *i.e.*, 0.5 – 1.5 person-years

Summary

Model-Based tooling applied to the FACE Eco-system

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Summary of Model-Based tooling applied to the FACE Eco-system

- Three Use Cases of FACE Data Model Conversion with Level of Efforts Savings projections − these *illustrate* the benefits of model based processes and tools to FACE Ecosystem

- Lessons Learned from using FACE Ecosystem (hybrid) tool within cross-organizational team environment provided insight into how complex systems-of-systems *e.g.*, Future Vertical Lift (FVL) will be developed in our near future*, and*

- As *illustrated and as quantified*, the promise of reusability, maintainability, and lifecycle sustainment are realized using the combination of MOSA and model-based systems engineering tools and processes

Preferred choice when planning to manage the complexity of next-generation systems-of-systems developments, integration, testing, qualification, and sustainment

Questions / Discussion

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designed for the FACE Technical Standard, Editions 3.0 & 2.1

For additional information on our
TES-SAVi model-based FACE Ecosystem tools

https://tes-savi.com, https://www.rti.com/products, or FACE 3rd Party Tools