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# Tucson Embedded Systems and Raytheon

# FACE<sup>™</sup> 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

IEEE Aerospace Conference Yellowstone Conference Center Big Sky, Montana, Mar 7 - Mar 14, 2020



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Presented to IEEE Aerospace Conference, March 2020

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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

#### 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 *Tucson Embedded Systems & Raytheon*

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- 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 Raytheon





## 26% (5 of 19) FACE Conformant Products Raytheon

FACE:	User Dashboard   Search the Registry	US Army's P2C2 - the Army's	
All - Search	the FACE Registry	first to complete EACE Verification	
Showing All Results	Sort BV: LLoC Name	mist to complete TACE vernication	
Refine By		Mission - H Management Software	
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	Company: Green Hills Software Version: FTS Edition 3.0 FACE Segment: Operating System	First (15 March 2017) single-core and multi-core certified conformant FACE Operating System Segment (OSS) Safety Base Profile product for P4080.	

The INTEGRITY-178 tuMP Operating System Segment (OSS) UoC supports as a single product both the Security and Safety

SOFTWARE

Operating System Segment (OSS) Safety Base Profile product for P4080, P2020, and P3041 and other QorlQ Power architecture pr...

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- 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

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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

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 *Tucson Embedded Systems & Raytheon* 

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



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
- 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





#### 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...

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#### 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: <u>this does NOT replace any sanctioned FACE CTS tools</u>; 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

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Tool Demonstration(s) (1 of 3)



#### **BALSA** data model version 2.1 converted to 3.0

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







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





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## Air Force-hosted FACE and SOSA Expo & TIM Sept. 2019 Raytheon





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Tool Demonstration(s) (3 of 3)

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



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Raytheon

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

Demo – 1 Conversion of BALSA

**Tucson Embedded Systems** 

- Converted BALSA UoPs, Views & DM from v2.1 to v3.0 ۲
  - -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 ۲ from FACE Edition 2.1.3 to 3.0 AWESUM"
  - > 15,000 Data Model Elements
  - 1,200 3,000 hours saved
    - *i.e.*, 0.5 1.5 person-years saved using mbse automation



**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...

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- 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





# Raytheon

## 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 Raytheon





Raytheon

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

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#### Resolutions

Raytheon

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

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#### 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



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 *Tucson Embedded Systems & Raytheon* 

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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**



FACE Ecosystem Model-based Tools 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

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