



## Triton Airspace Virtual Environment (TAV-E)

*Presented to:*

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# The Necessity for Live, Virtual, and Constructive Triton Airspace Modeling & Simulation



## ❑ NEED

- Establishing a satisfactory Due Regard Alternative Means of Compliance (DRAMOC) Target Level of Safety (TLS) via flight test alone would require a prohibitive number of flights.
- Provide the evidence to support the Sense and Avoid (SAA) Policy, Department of Defense Instruction (DODI) 4540.01 / NAVAIR Instruction (NAVAIRINST) 13034.4
  - *UAS must be operated under USD(P) approved due regard alternative means of compliance (commonly called DRAMOC) contingent upon a responsible Military Department or Combatant Commander making a case for such alternative means or conditions in achieving due regard for the safety of all aircraft.*

## ❑ SOLUTION METHOD

**Modeling & Simulation (M&S) provides an achievable means to obtain supporting evidence by greater than real-time constructive simulation as a flight hour multiplier.**

## ❑ SOLUTION

**Triton Airspace Virtual Environment (TAV-E) consisting of:**

- MQ-4C Triton emulator (Mission Control System (MCS) and high fidelity aircraft model)
- Virtual National Airspace System (NAS) and International Airspace System (IAS) environments with distributed elements from the Federal Aviation Administration (FAA)
- Real-time Re-configurable Radar Performance Model
- Wideband satellite communications and Traffic Alert and Collision Avoidance System (TCAS) simulator/stimulator
- Triton operational and tactical situation scenarios for FY16-17 hardware-in-the-loop (HITL) mission systems tests



# TRITON DRAMOC Safety Assessment



Acceptable Level of Safety (AcLS)

$$\text{AcLS}_{\text{(IFR)}} = 1.5 \times 10^{-8} \text{ collisions per flight hour}$$

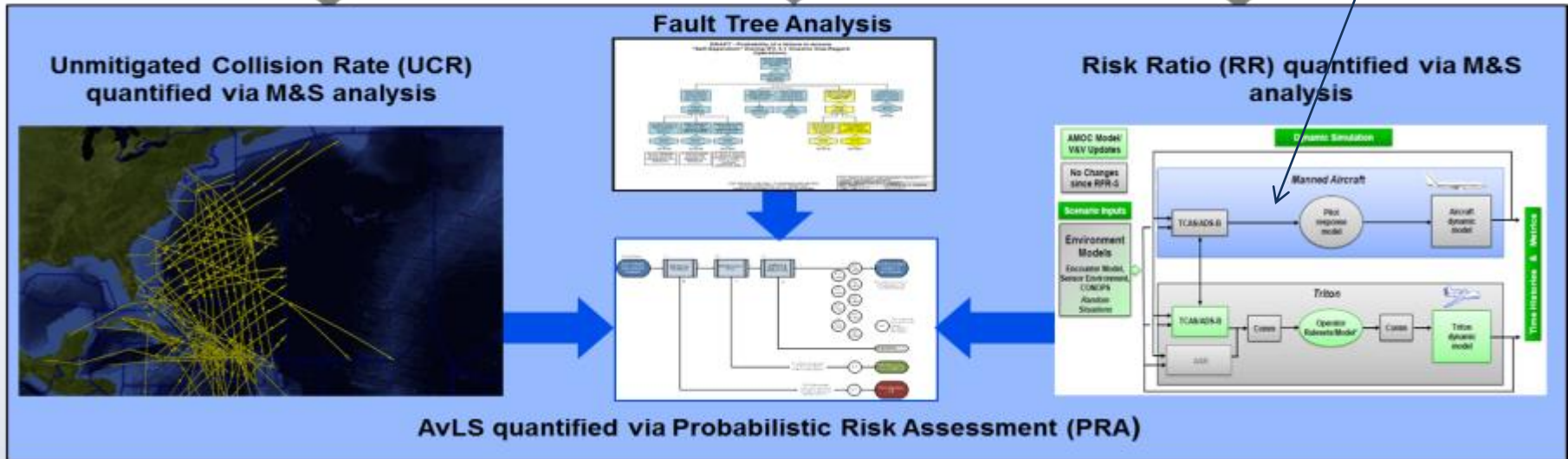
$$\text{AcLS}_{\text{(Non-IFR)}} = 1.0 \times 10^{-7} \text{ collisions per flight hour}$$

Achieved Level of Safety (AvLS)

TAV-E for Pilot Operator Model (POM) Development

AvLS compared to AcLS

$$\text{AvLS} = \text{Triton Unmitigated Collision Rate (UCR)} + \text{SAA Reliability} + \text{SAA Risk Ratio (RR)}$$



***Triton AvLS must meet or exceed the AcLS***

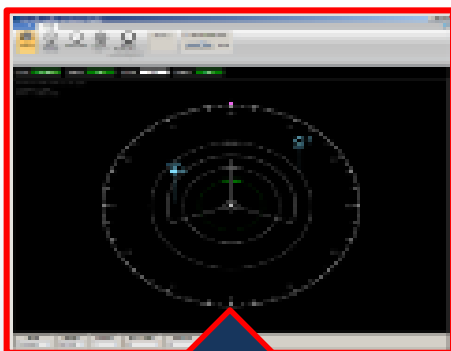


# TAV-E: Product Description



□ The Joint UAS Mission Environment (JUAS ME) project in cooperation with PMA-262 Triton constructed several elements to support the Triton UAS program and future UAS ground test events. The final product was named TAV-E. TAV-E consists of:

- MQ-4C Triton emulator (MCS and high fidelity aircraft model)
- Virtual NAS and IAS environments with distributed elements from the FAA
- Real-time Re-configurable Radar Performance Model
- Wideband satellite communications and TCAS simulator/stimulator
- Triton operational and tactical situation scenarios for FY16-17 HITL mission systems tests



Aircraft Collision Avoidance Display (ACAD) provides the pilot operator with information to aid in self-separation

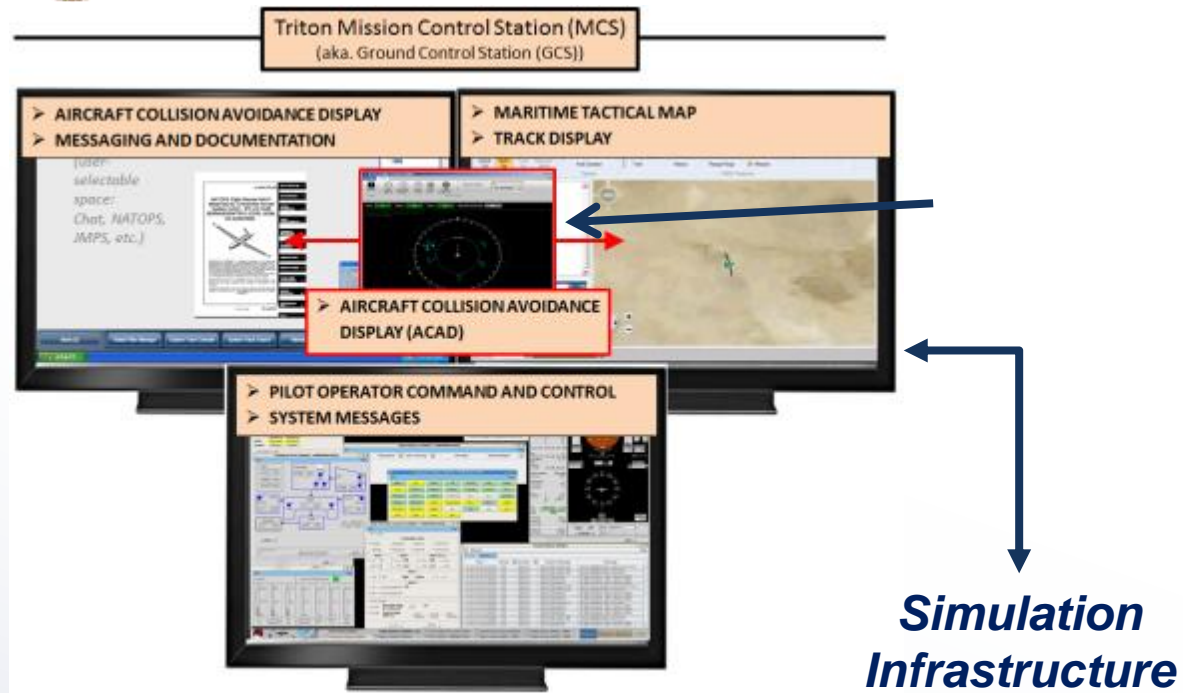


TAV-E featured on NAVAIR Flight Ready Airwaves Video:  
<https://www.youtube.com/watch?v=Jnb3Rg2bak4>





# TAV-E: Simulation Software and Interface Architecture



*Simulation Infrastructure*

**Airspace UA  
Payload Models  
(TCAS3000 and  
A/A Sensor)**

**Simulation Interfaces  
Messaging Support  
Architecture**

**JIMM Air Traffic  
Environment  
FAA ATC/NextGen via  
JMETC DREN**

**6DOF model of UA  
Payload Management  
C2/Flight Control  
Management  
Mission Plan Management**



# TAV-E: co-located with resources to conduct TRITON Ground Test



**Air Combat Environment Test and Evaluation Facility (ACETEF)**  
NAVAIR, AIR 5.4  
Patuxent River, MD

TAV-E in UAS Integration Lab (UASIL) with Defense Research and Engineering (DREN) connection to FAA Technical Center

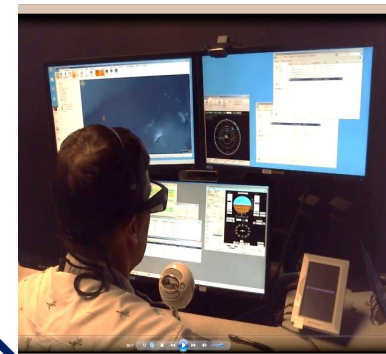
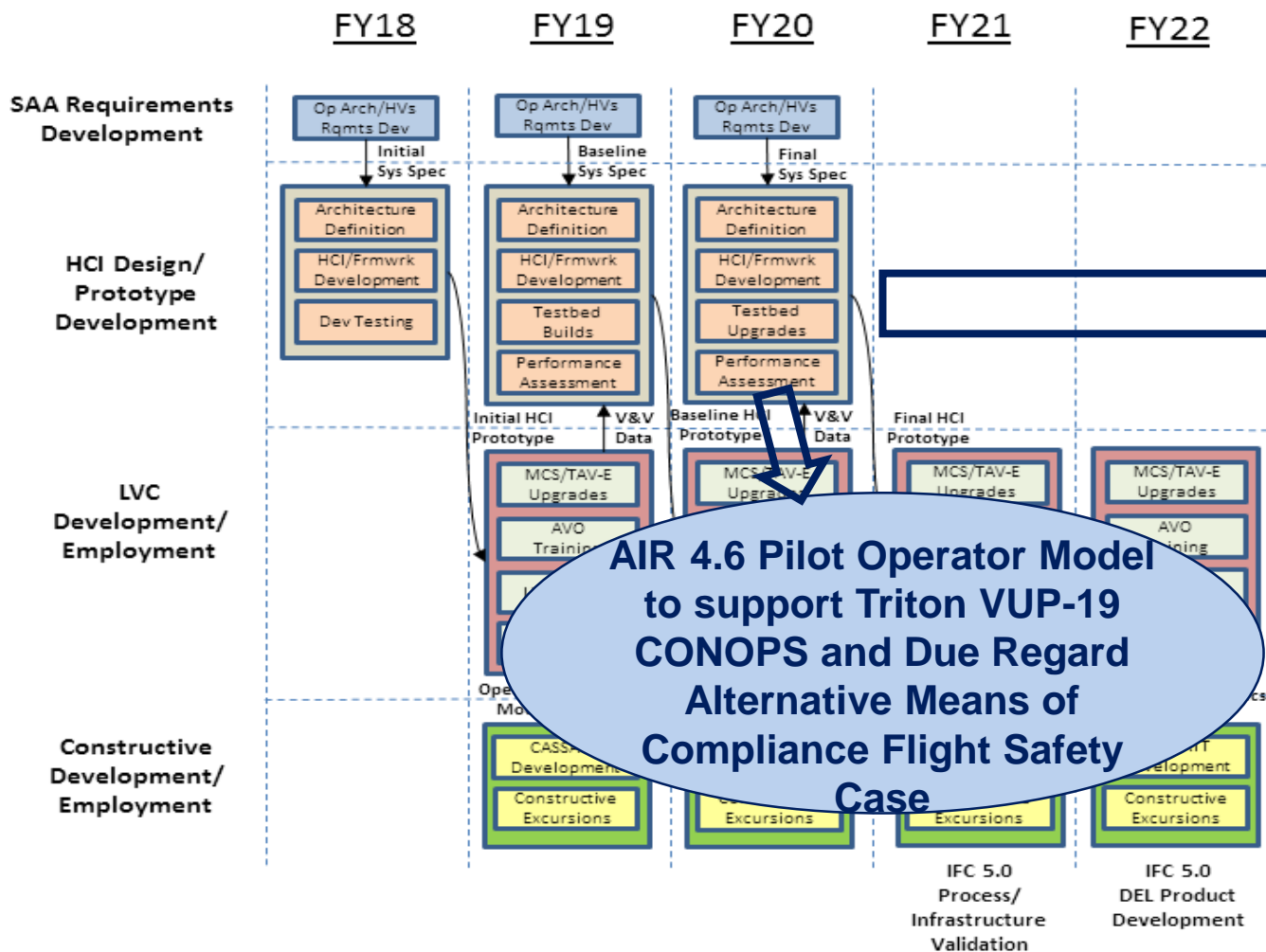




# TAV-E: Alignment to Triton Test Schedule



## HCI/M&S Development Interrelationship



**AIR 4.5/4.6  
ACAD  
Developmental  
Engineering  
Design for  
Production and  
Integration on  
IFC-5.0 Triton**

**AIR 4.6 Pilot Operator Model  
to support Triton VUP-19  
CONOPS and Due Regard  
Alternative Means of  
Compliance Flight Safety  
Case**



# SUMMARY



- **TAV-E provides a way to include manned and unmanned pilot operators along with air traffic control in studies of airspace encounters**
- **M&S of the pilot operator based on TAV-E data has been successful and advancements are planned**
- **Unmanned aircraft policy and regulations make sense and avoid certification possible with a combination of live, virtual, and constructive M&S-based T&E inputs**
- **NAVAIR sense and avoid unmanned capability is advancing via platform and ground segment upgrades**
- **NAVAIR is taking the lead in developmental engineering and development test for unmanned and autonomous system sense and avoid capability**





# SUPPLEMENTAL INFORMATION



# TAV-E Development 2010-2016



**The OSD Test Resource Management Center Joint Unmanned Aircraft Systems Mission Environment (JUAS ME) project filled the gap in the joint services ability to test UAS features, which are different from manned aircraft, within the context of a UAS-relevant mission environment, by adding the following in three test areas:**

- I. Airspace Integration (AI) – provide the capability to test UAS in various airspace environments**
  - Test UAS flight safety cases via local and distributed simulations
  - Test UAS collision avoidance assets via lab, ground, and flight test
  - Test Sense And Avoid (SAA) payloads & displays with Hardware-In-the-Loop (HITL)
  
- II. Manned and Unmanned Integration (MUMI)**
  
- III. Networking and Interoperability**



# TAV-E: Timeline



**2012**: JUAS ME, in cooperation with PMA-262, posted a Federal Business Opportunities announcement [<https://www.fbo.gov/spg/DON/NAVAIR/N00019/1300236220/listing.html>] for UAS emulator design work. This issue was featured in a NAVAIR article in the February 6, 2012 edition of “Inside the Navy.”

**2015**: Triton NAS and IAS JUAS ME Use Cases with the FAA Technical Center

**2017**: Alternative Means of Compliance 1 Run Matrix Execution (IFC 2.2 SW), POM development, and Commander’s Team Award for JUAS ME

**2018**: DRAMOC and Alternative Means of Compliance 2 Run Matrix (IFC 3.1 SW) and POM upgrade

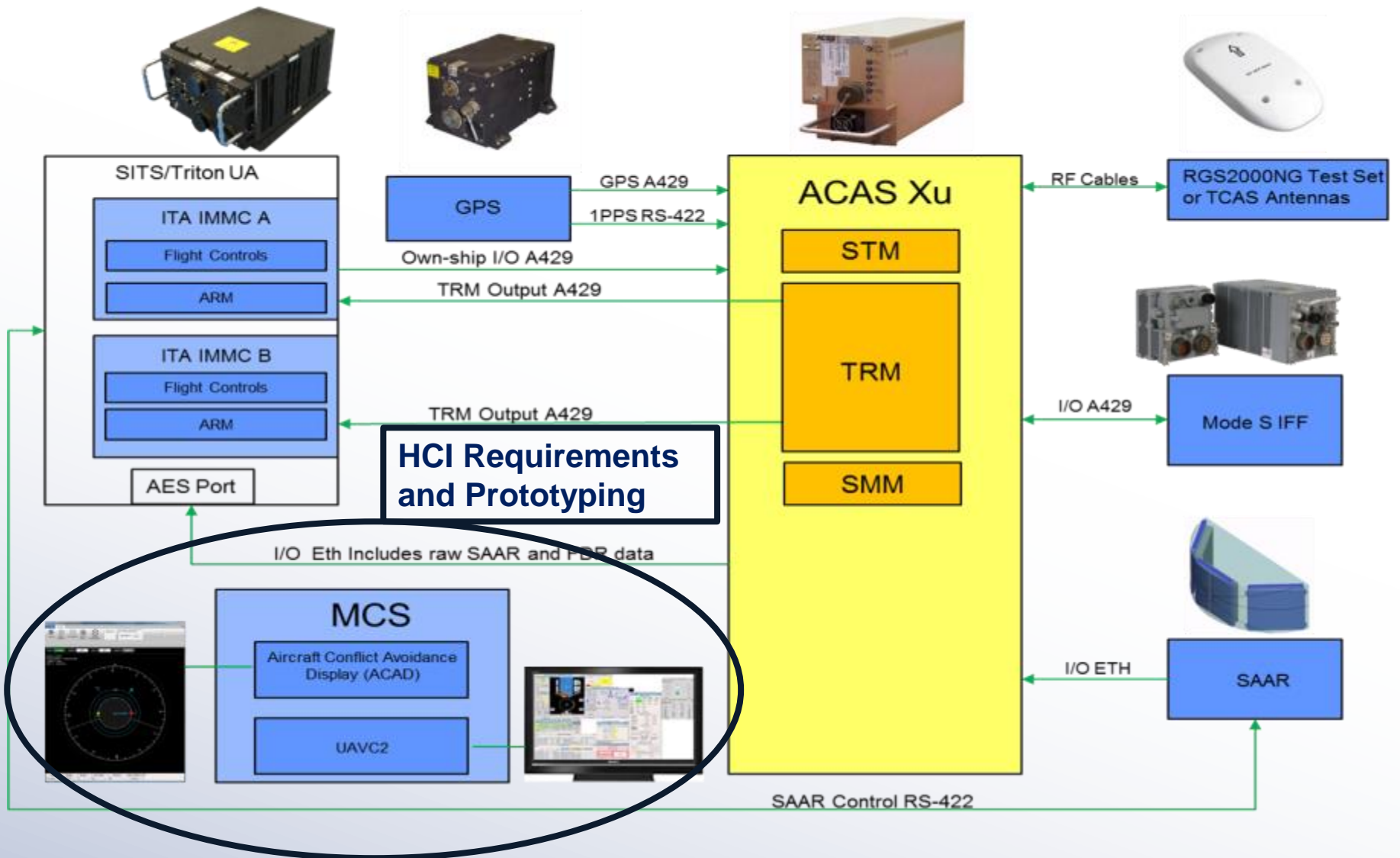
**2019**: TAV-E Upgrade to IFC 4

**2020**: TAV-E elements provided to support IFC 5 Human Computer Interface ACAD prototyping, developmental engineering and Triton ACAD upgrade

**2020-2021**: PMA-262/OSD TRMC Autonomous System Test Tool Sets/UAS T&E Improvements Block II Solution to add C-band radar and FAA ACAS-Xu simulation components to TAV-E



# TRITON: Sense and Avoid Schematic







# TRITON: Sense and Avoid Certification Activities

