Emerging Interoperability Standards for Unmanned Aerial Systems

Kerry Fisherkeller
Engineering Fellow - Systems Engineering & Architecture
Unmanned Systems Center of Excellence
Northrop Grumman Corporation

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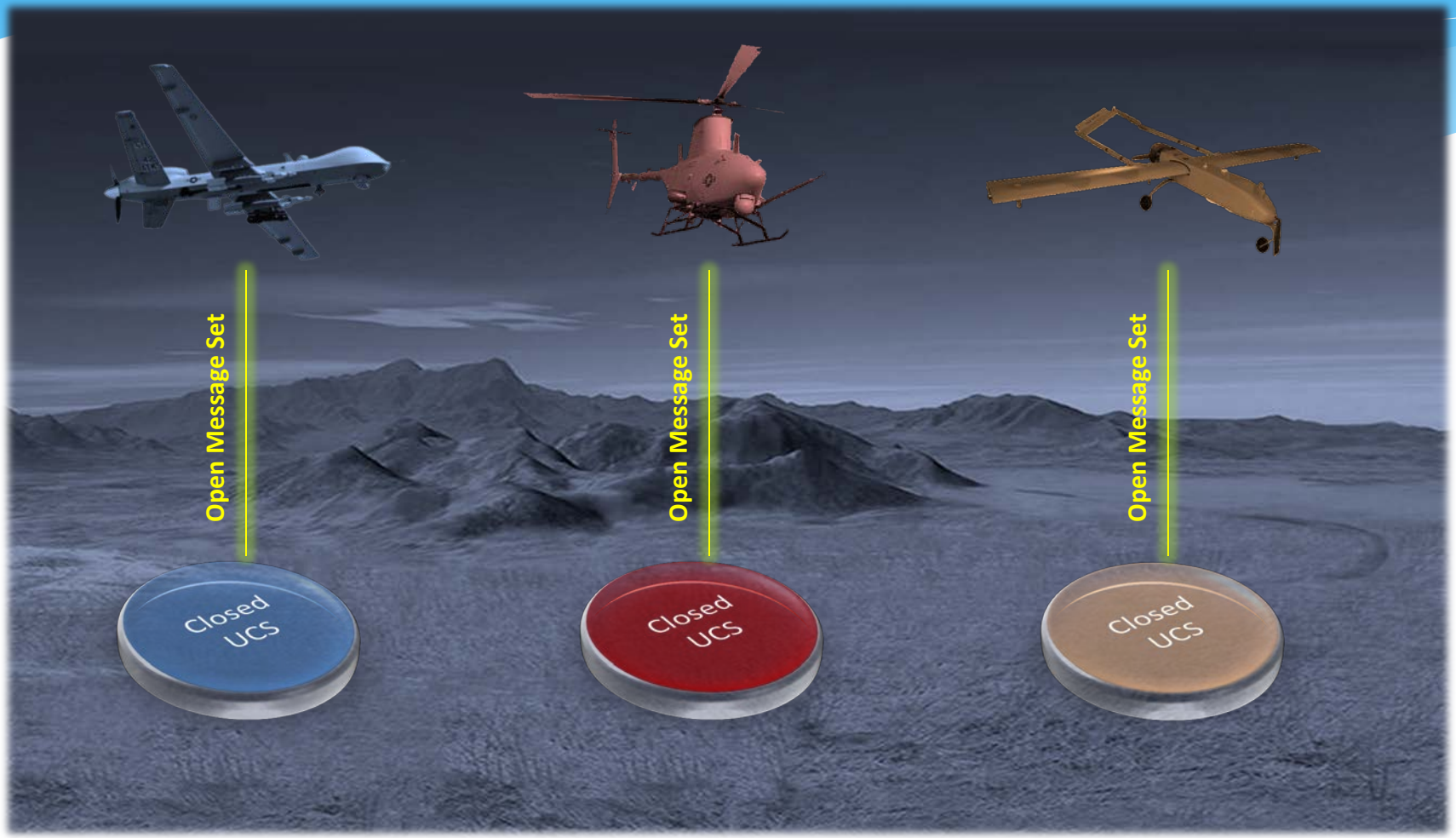
Model-based Systems Engineering and Beyond

Open System Interconnection (OSI), but not Open Architecture nor Interoperable



UCS – UAS Control Segment

Emergence of Standards

* As defined by Checkland, emergence is "the principle that entities exhibit properties which are meaningful only when attributed to the whole, not to its parts."
* Emergent system behavior can be viewed as a consequence of the interactions and relationships between system elements rather than the behavior of individual elements.
* ***Our challenge is to develop standards that enhance interoperability of systems, but do not limit beneficial emergent behavior of UAS developers and operators***

From: http://www.sebokwiki.org/wiki/Emergence

Evolution of UAS Interoperability Standards

UAS Standard	ORG	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
4586	NATO	North Atlantic Treaty Organization - *Standardization Agreement* (STANAG) *4586*											
UCI	USAF			COS		UCI - UAS Control Initiative							
IOP	Army			IOP – Interoperability Profile									
UCS	OSD						UCS - UAS Control Segment Architecture						
OMS	USAF							OMS - Open Mission Systems					
FACE	Navy							Future Airborne Capability Environment					
NIOP	Navy								Navy Inter-Operability Profile				
CoT	Mitre	CoT - Cursor on Target											

Open System Architecture
2011 DoD Mandate "Procure Open Systems"

* The Defense Acquisition Guidebook Chapter 4 states that "OSA is identified as a key tenet of Better Buying Power, under Promoting Effective Competition, because it enhances system interoperability and the ability to integrate new capabilities without redesign of entire systems or large portions of the enterprise."

* OSA Benefits (GAO-13-651, July 2013)
  * Reduced life-cycle cost
  * Increased innovation
  * Reduced schedule to field
  * Faster & less costly repairs and upgrades
  * Enhanced interoperability
  * Increased competition

STANAG 4586 Evolution

STANAG 4586 Edition 2

Edition 2 Ratified / Promulgated Fall 2007

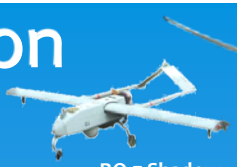
Edition 2 Amendment 1 Superseded Edition 2 in August 2009 (9 DCPs – Correction of Factual Errors & Editorial/Clarification)

Edition 2 Amendment 2 Sent to NATO March 2010 (13 DCPs – Correction of Factual Errors & Editorial/Clarification)

Edition 2 Amendment 3 In Work. Will be Reclassified as an "Open" Document

Sweden's control station for their Tactical UAS Skeldar V-200 platform is using STANAG 4586 Edition 2.

The US Army continues to stress STANAG 4586 Edition 2 Amendment 1 as the command & control protocol for all current and future systems.

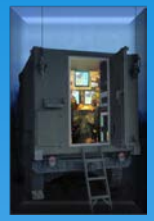


RQ-7 Shadow

MQ-1C Grey Eagle

MQ-5 Hunter

UGCS



STANAG 4586 Edition 4

Tentative Release 2014
May Include a Redesigned Architecture with Focus on Service Oriented Architecture (SOA)

UK MOD – Israel – Working to implement STANAG 4586 LOI 2 into the army-operated Watchkeeper UAS

Turkey has implemented and tested Edition 2 DLI EO/IR payload messages into a Turkish MALE GCS.

VTUAV Fire Scout and the Tactical Control System (TCS) Block 2 Version 4 implements STANAG 4586.

US Navy's Open UMI's (OU) implements Edition 2 Amendment 1 which routinely and simultaneously control an UAV and UGVs.

Future initiatives in current and future Editions

Evolving Technology

National Review Comments

National Implementation and Testing Efforts

International Technology Development Programs

Industry Review Comments

STANAG 4586 Edition 3

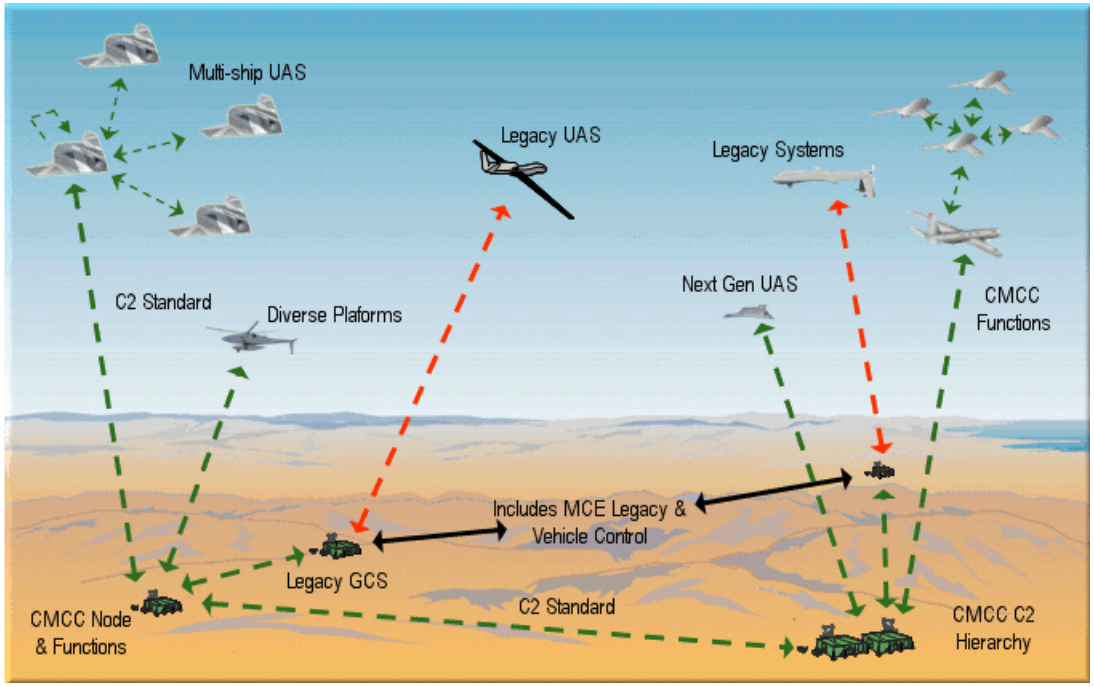
Ratified January 2011
Promulgation Scheduled for May 2011. Will be Promulgated as an "Open" Document
Enhanced Capabilities in Future Amendments will Include:
- Weaponisation Capability

Enhanced Capabilities in Future Amendments may Include:
- Net-Centric Capability
- Extension to Multi-domain Unmanned Vehicle (UV) Platforms
- Enhanced Support for Automated Operations
- Support of Sense and Avoid (SA) Capability

Enhanced Capabilities to Edition 3 Include:
- Bandwidth Reduction
- Interoperable UAS Mission Planning via CRD Extensions (e.g. , Addition of Planning for Sensor and Communications
- Increased Level of Autonomy

Improvements:
- Definition of Standard Metadata Elements (Standard KLV Parameters)
- LOI Definitions Updated/Clarified to Allow Flexibility (e.g., Payload Control, Monitor or Control and Monitor

UCI - UAS Control Initiative



XML Messaging Schema

Developed by Government-Industry Consortium

NORTHROP GRUMMAN

LOCKHEED MARTIN

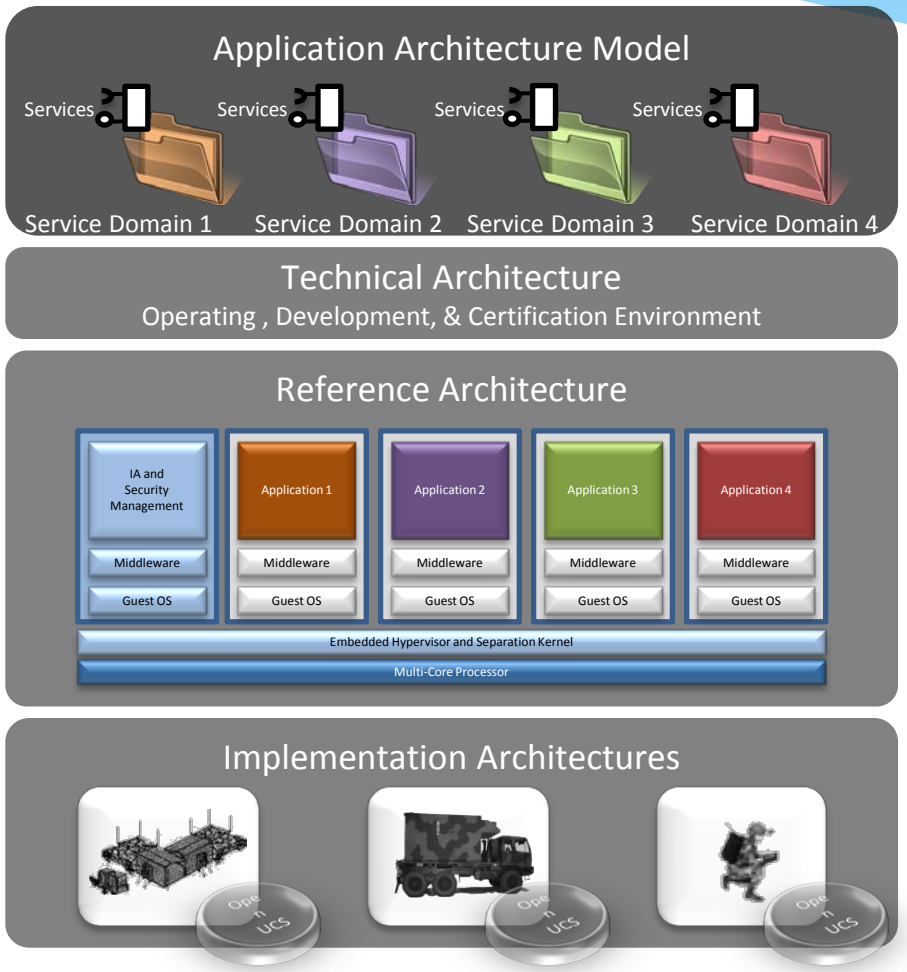
BOEING

GENERAL ATOMICS

Raytheon

UCS - UAS Control Segment

Service Oriented Architecture (SOA) Approach



Services Views

Standards /Certification Views

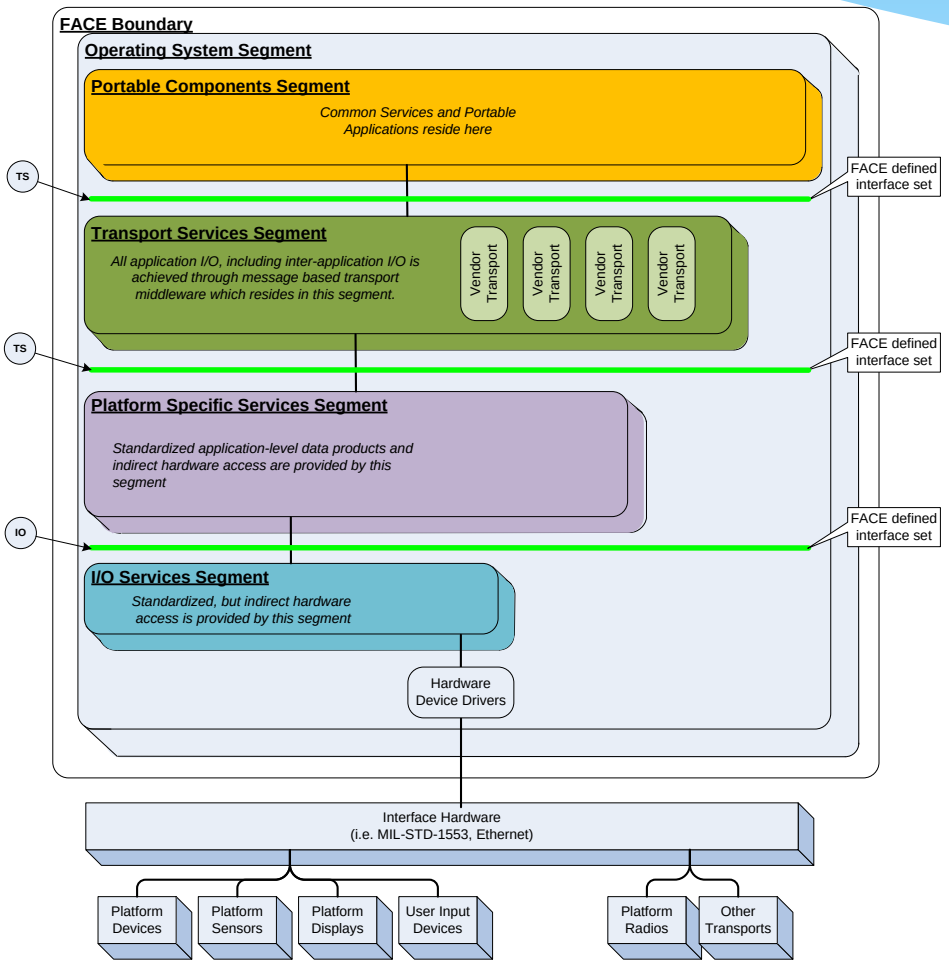
System Views

Deployment Views

Sponsored by:
OUSD/ AT&L
Office of Under Secretary of Defense / Acquisition, Technology & Logistics

Future Airborne Capability Environment (FACE)

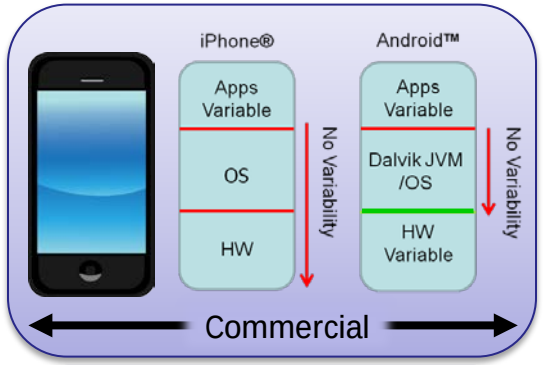
Interoperability Provided via Units of Portability (UoPs)



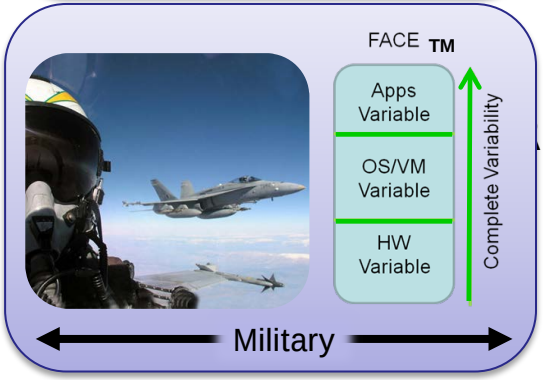
Sponsored by NAVAIR

Managed by THE Open GROUP

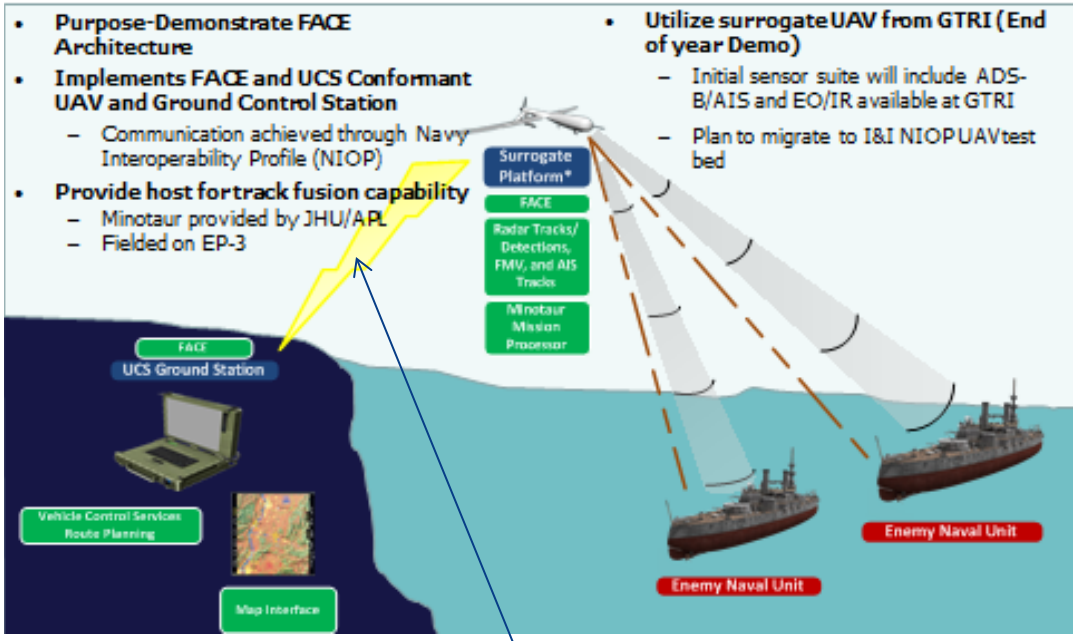
Smart Phone Model



FACE Open Model



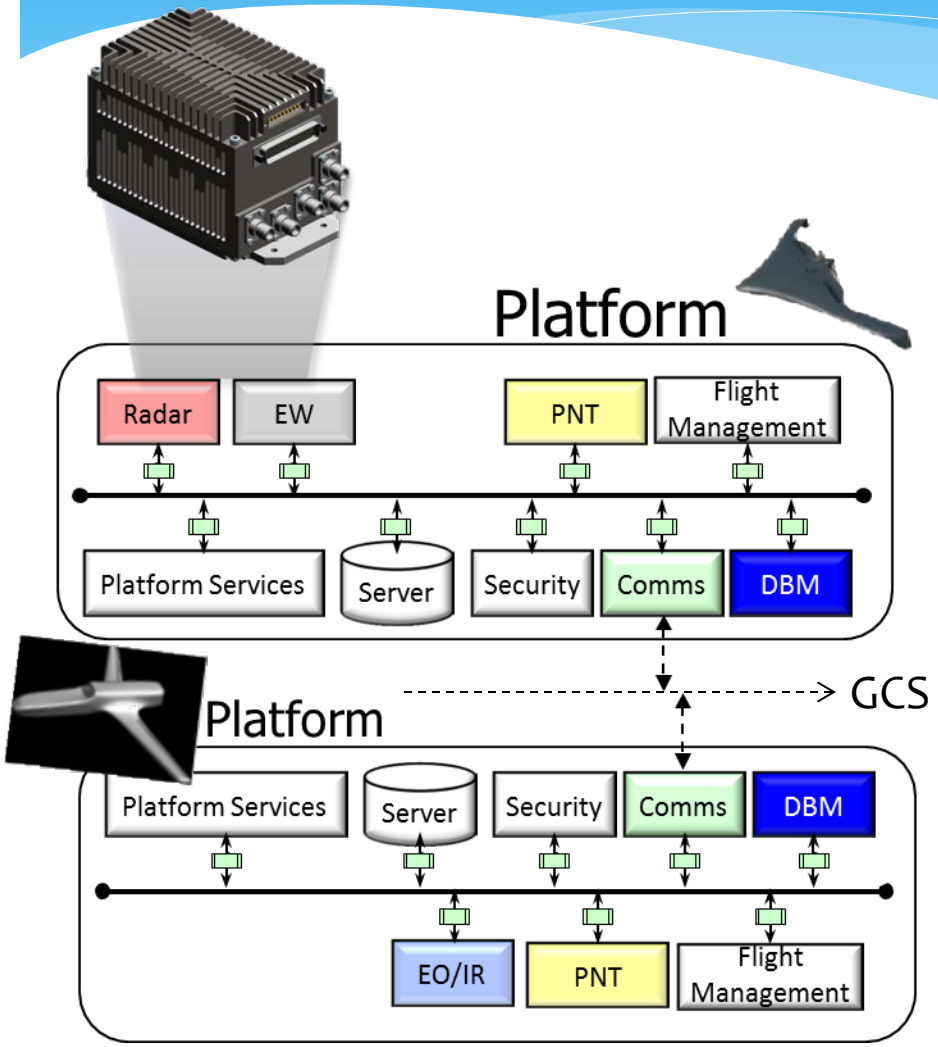
Naval Interoperability Profile (NIOP) XML Based Messaging Schemas



NIOP Messages

* Sponsored by NAVAIR
* Developed via joint government-industry Interface Control Working Group (ICWG)
* Capture of common commands in XML based messaging schemas

Open Mission Systems (OMS) Airborne Avionics Architecture



* Developed by USAF/RCO
* Adopted by DARPA for System of System (SoS) integration programs
* Utilizes commercially developed Service Oriented Architecture (SOA) concepts and middleware

Cursor on Target (CoT) Schema Captures What, When, Where

12 Mandatory fields minimum

Field	Description
Version	Schema version, stable at 2.0 since about May 2003
UID	Unique ID much like IP address
Type	What is this event? friendly tank, hostile target?
Time	Time event was generated
Start	Start of “valid” interval for event
Stale	End of “valid” interval for event
Lat	Latitude based on WGS84 in decimal degrees
Lon	Longitude based on WGS84 in decimal degrees
CE	Circular error about point (Gaussian 1 Sigma) in meters
HAE	Height above ellipsoid based on WGS84 in meters
LE	Linear error about HAE (Gaussian 1 Sigma) in meters
How	Indication of how event was generated (machine, human)

* Example XML message

```
<?xml version='1.0' standalone='yes'?>
<event version="2.0"
    uid="J-01334"
    type="a-h-A-M-F-U-M"

    time="2005-04-05T11:43:38.07Z"
    start="2005-04-05T11:43:38.07Z"
    stale="2005-04-05T11:45:38.07Z" >

  <detail>

  </detail>
```

* Use in military and medical research

Summary

* UAS C2 Standards are now contract requirements for control nodes, C2 messaging and payload interfaces
* Refinement will continue based on demonstration feedback and user evaluations

References

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3. STANAG 4586- http://nso.nato.int/nso/
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5. UCI- http://ucistandard.org/about-uci.html
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10. CoT - https://www.mitre.org/sites/default/files/pdf/09_4937.pdf