Aeronautical Systems Center

Engineering for War Fighter Integration of Net-Centric Systems

Presentation to the 13th Annual Systems Engineering Conference

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Overview

- Air Force Integrated Collaborative Environment (AF-ICE) Description
- Systems Engineering Process
- VV&A
- Air-to-Ground Integration Layer Exploration (AGILE) Live, Virtual, and Constructive (LVC) Venue
- AFICE today and tomorrow

AFICE Objectives

- **Thorough testing with credible analysis** to deliver better products at reduced costs
- **An acquisition lifecycle-assessment approach** to leverage resources and expertise at distributed locations
- **An analytically based, system engineering process** to support traceability of war fighter requirements throughout the acquisition life cycle
- **Compose- able, reusable, non-duplicative** networked and instrumented infrastructure resources, consisting of LVC assets
- **Primary focus: Identify, categorize, assess, and report integration and interoperability gaps and seams**
- **Secondary mission: Assessment test-bed for risk-reduction activities for any program**

Assess the "Seams"

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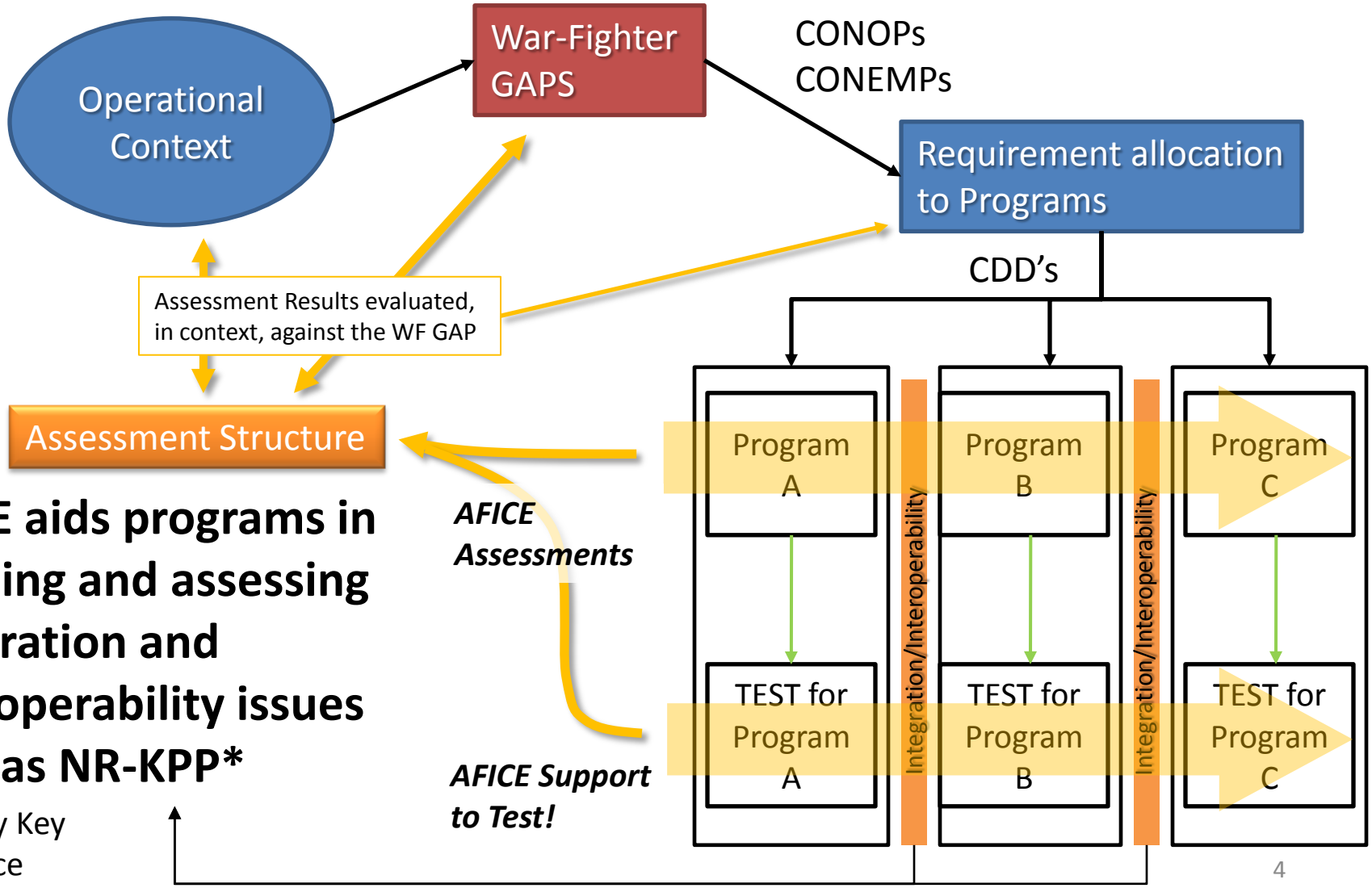

AFICE aids programs in defining and assessing integration and interoperability issues such as NR-KPP*

*Net-Ready Key Performance Parameter

AF-ICE Vision:

It's all about the integration

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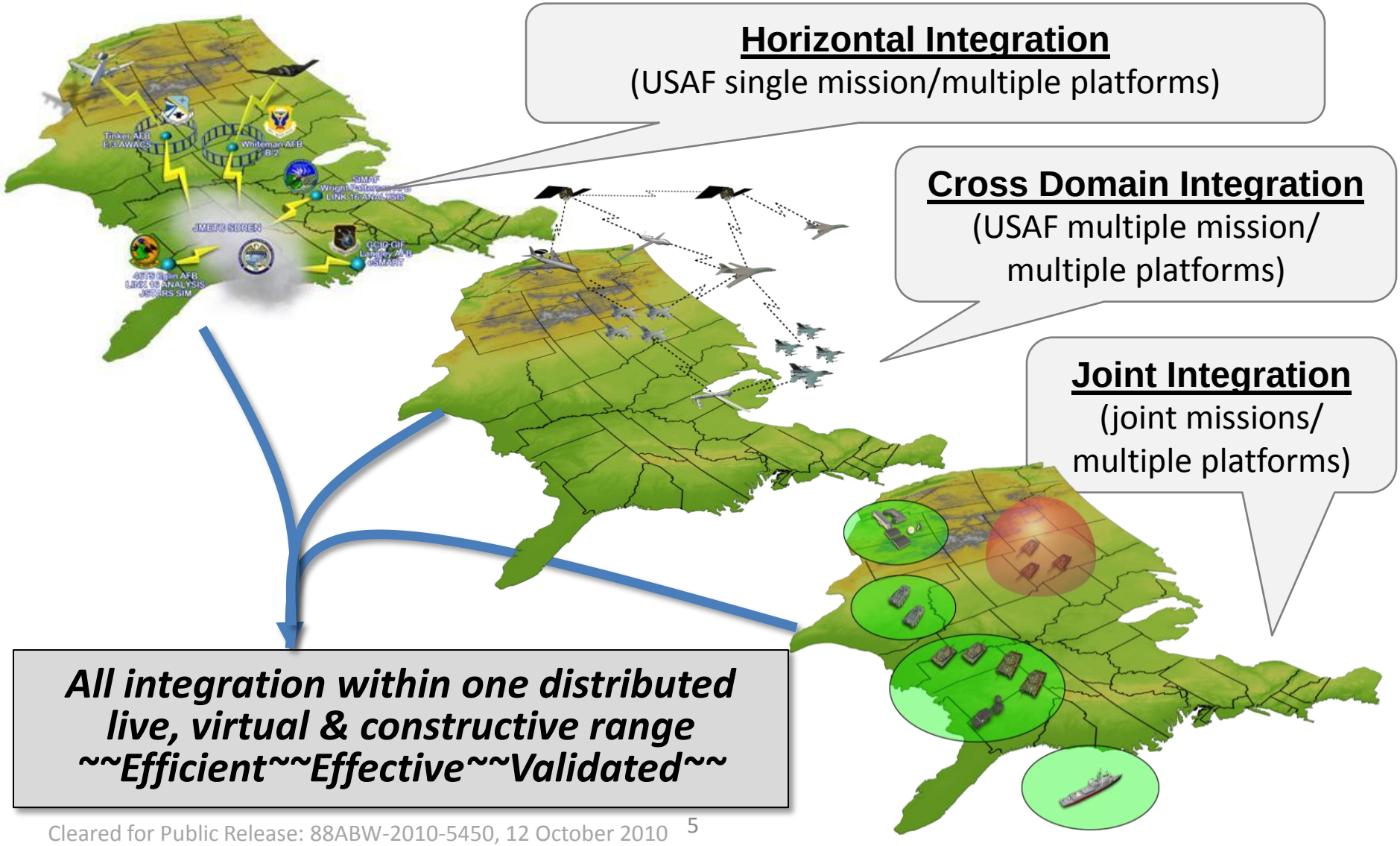

Investment Strategy

Three AFICE Key "Tenets"

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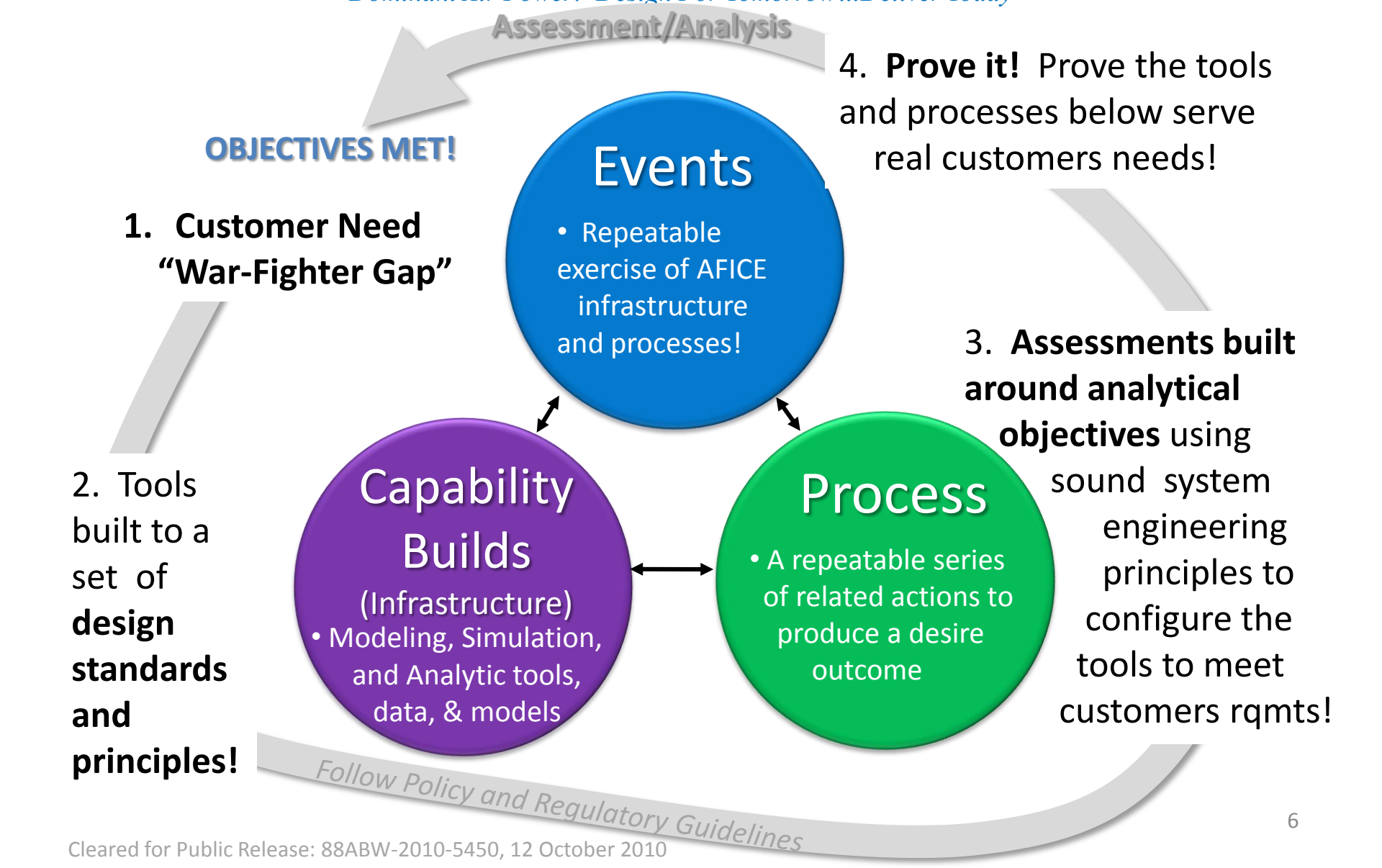

"M&S Battle-space"

Mapping between the real and virtual battle-spaces

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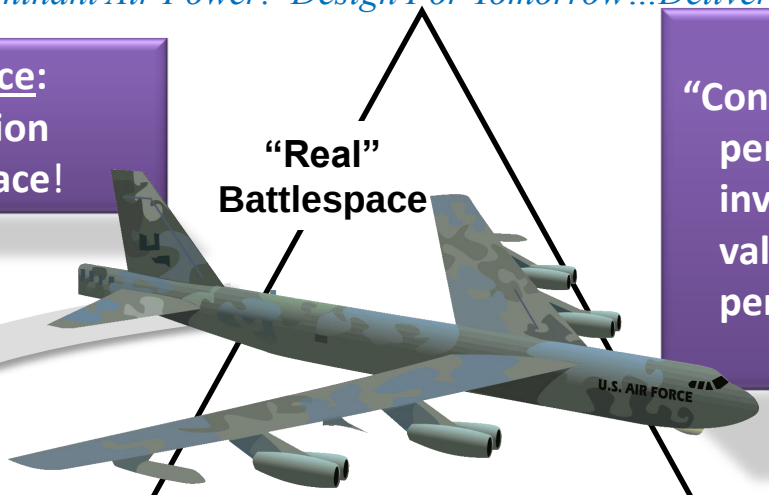
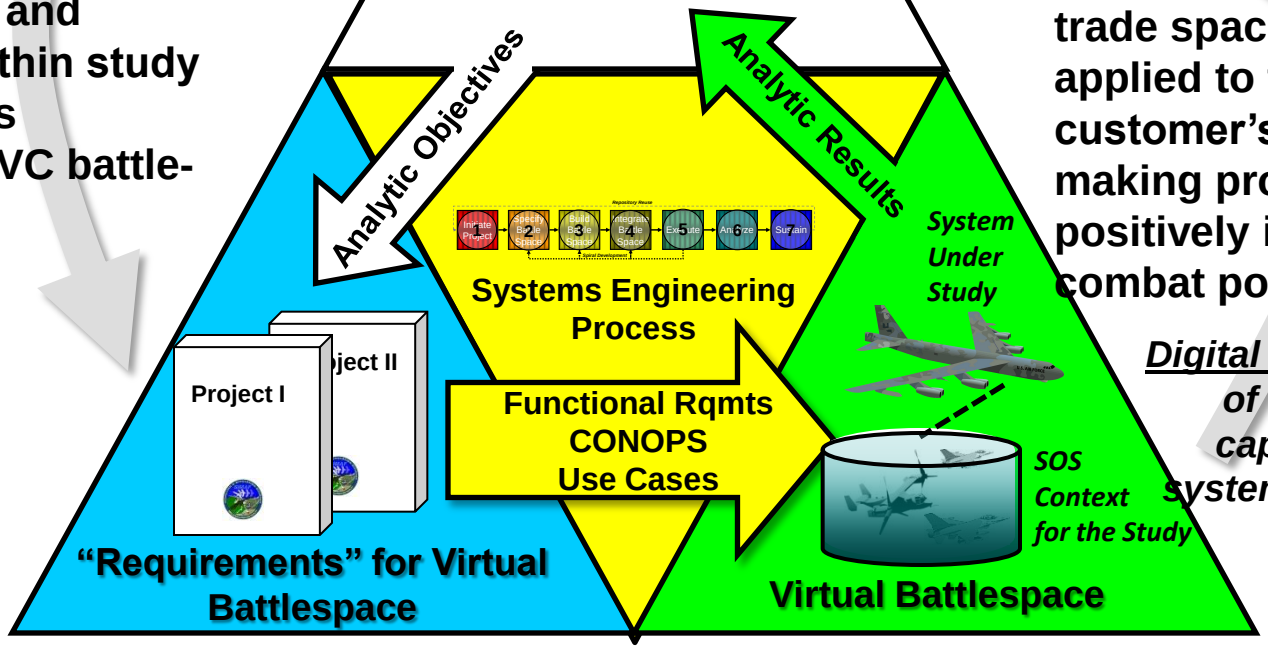
Virtual Battlespace:
Computer representation of the actual battle-space!

End-to End Approach:
"Constructive" requirements & performance characterization investigation, leading to "Virtual" validation and verification performance assessments (aircrew in the loop)

Problem of interest is defined from the real battle space and "scoped" within study requirements (inside the LVC battle-space).



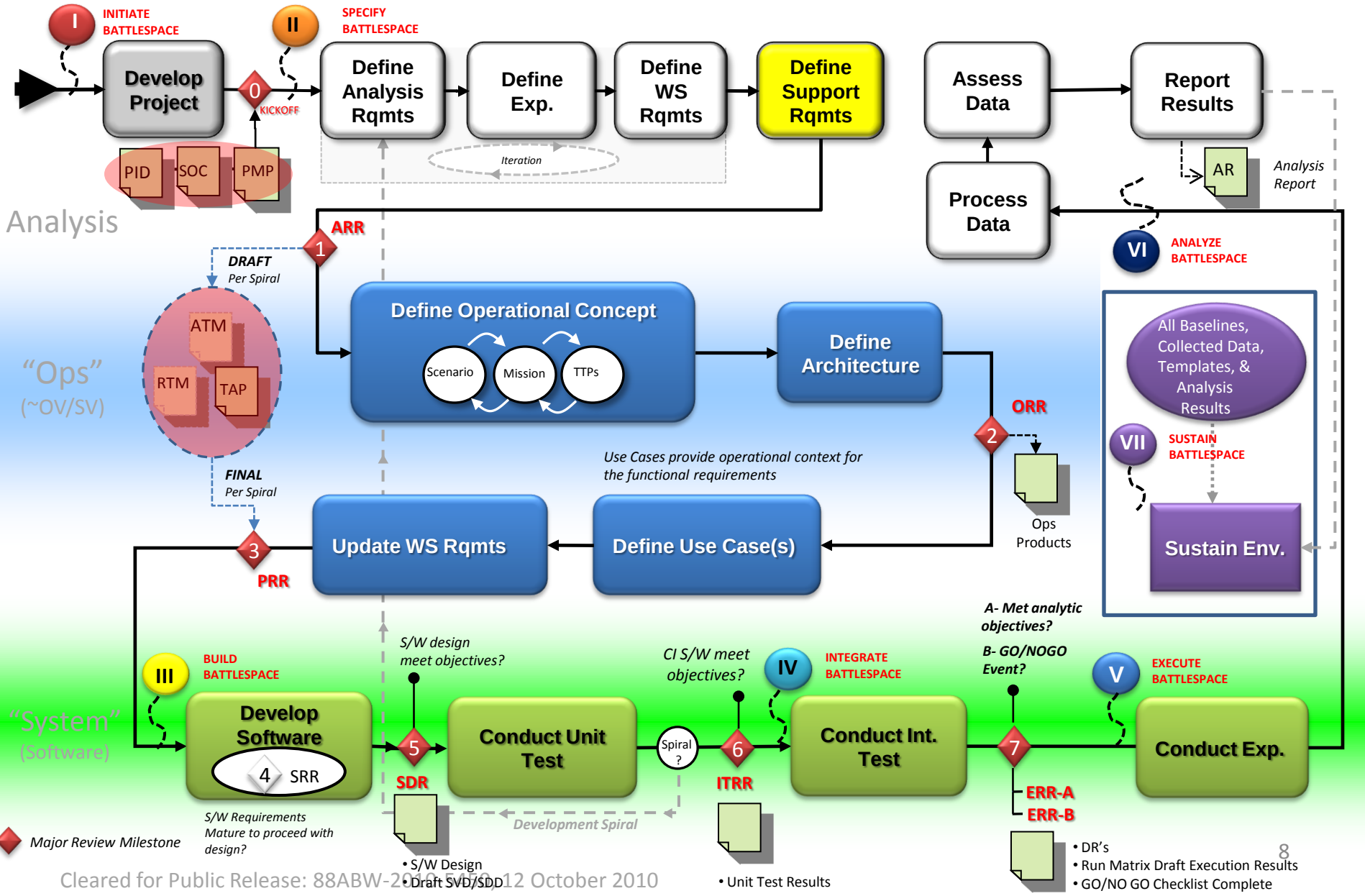


Analysis results provide insight into the trade space and are applied to the customer's decision making process to positively impact combat power!

Digital representation of key functional capabilities of the system(s) necessary to support the analytic objectives

FY11 SIMAF Master Event Process

SE embedded process in a product life-cycle, Updated 1 Oct 2010



Organization of Requirements

Functional Requirement Lexicon applied to all Projects

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1.0 (C2): Command & Control
-Receive and respond to Messages for C2 assignments from C2 Nodes

2.0 (FM): Fly & Maneuver
-Aerodynamic Rqmts
- Max Speed Mach @ High Alt
-Combat Radius
- Range per Msn type
-Aerodynamic Model
- Degrees of Freedom model

3.0 (CM): Communicate
-Voice Radio
-Data Link Radio
-Message Sets

4.0 (UP): Understand, Predict, & React
-Virtual Cockpits with HOTAS
-OTW Displays
-Display Messages on Displays

5.0 (SD): Sense & Detect
-Radar: Type & Capabilities
-RWR: System Specific
-IFF: System Specific

6.0 (SC): Special Category

7.0 (LM): Launch Munitions
-Radar Missile, # needed
-IR Missile, # needed
-Jettisonable Centerline Tank

8.0 (EW): Electronic Warfare
- Internal Counter-measures system
-Chaff/flare dispenser

9.0 (DE): Directed Energy Attack

10.0 (IR): IR Attack & Support
-Chaff/Flare dispenser

11.0 (IN): Instrumentation

Key Takeaway: Requirement owners speak in the an organized and consistent language to the software developers! Reduces errors and Requirement Churn!

EAAGLES

Extensible Architecture for Analysis and Generation of Linked Simulations

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- ❑ Capability-Based Design
- ❑ Electronic combat environment
- ❑ Robust air-to-air *and* air-to-ground
- ❑ Designed for hundreds of players
- ❑ *Proven* real-time architecture
- ❑ Optimized for the PC, yet platform independent
- ❑ Variable and Scalable Fidelity, Object Oriented
- ❑ Hardware: Dual to Networked PC "clusters"
- ❑ Hardware-in-the-Loop
- ❑ Distributed simulation via DIS, HLA, & TENA
- ❑ Government owned and managed software

OpenEAAGLES Simulation Framework

The EAAGLES framework is publically released and available via ***www.openeaagles.org***

Infrastructure Matters! Environment is engineered for real-time SoS assessments!

AFICE Distributed LVC Team

Mapping local processes

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AFICE Lead IPT

- Integration Lead
  - Gov't Lead
  - Tech Lead
- Event Dir
  - Ops Lead
- LVC Lead
- Analysis Lead
- Infrastructure Lead
- Security Lead

PARTICIPATING LOCAL SITES IPTs

VV&A Problem Statement

- **The primary role of V&V is to reduce risk.**
  - The greater the risk, the more V&V are required.

- **Requirements and intended use must exist before V&V can be conducted**; acceptability criteria must be developed and documented:
  - Acceptability criteria should be agreed upon between the test manager and the accreditation authority.
  - Acceptability criteria are a measure of the risk the accreditation authority is willing to accept prior to conducting the test.

- **V&V is a never-ending process**
  - V&V continues during test execution. Information may need to be collected during actual test/event execution to ensure that the environment is correct, the simulations are running correctly, and the simulations are interacting with each other correctly.

VV&A Process Framework

Structuring the Project

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Issue Category	Description (see notes page for more details)	Example Issue
Environment	Experimental design defines what needs to be represented in the environment: entities, databases, etc. at different locations may have inconsistent representations.	Environment database may vary across simulations and likely differs from a live asset on an open air range
Fidelity of models	May have improper simulation interactions due to differences in simulation fidelity. This can arise from desire to reuse existing resources without ensuring proper "fit."	"High fidelity" simulator may introduce additional factors and variables that confound test results
Data consistency	Network components introduce minor (and stochastic) latencies between transmittal and receipt of data between/among interacting entities.	May introduce improper simulation interactions if latencies are too high
Data collection and management	LVC data sets typically include multiple recording points, formats, and data rates; time reference standards become critical.	Time reference may be inconsistent due to transmission latencies
Infrastructure	Network protocols and hardware may impact quality of service and security.	How to handle lost data packets due to network performance
Administrative	V&V documentation at one location may not be sufficient for another location's test needs.	Inconsistencies in documentation or semantics

Step 1. Identify & Categorize VV&A Issues

Maturity Level	Use Characterization	Validation Referent	V&V Evidence
0	None	None	None
1	SME judgments	SME opinion of system behavior	SME judgment of completeness & accuracy
2	Representation requirements + primary use risks	SME opinion of system behavior	Inventory of completeness + SME judgment of accuracy
3	Level 2 + tolerable error characteristics & use risk estimates for errors & bounds	Quantitative estimate of system behavior & accuracy of estimate	Completeness & accuracy of evaluation results
4	Level 3 + tolerable uncertainties & sensitivities	Level 3 + uncertainty in behavior estimates	Level 3 + uncertainty evaluation results
5	Level 4 + mathematical derivation description	Level 4 + mathematical derivation description	Level 4 + mathematical proof

Step 2. V&V Maturity Levels

Consequence*	Probability that issue will lead to the consequences for the intended use*			
	Substantial	Moderate	Small	Slight
Catastrophic	4-5	4-5	3-4	3
Critical	4-5	3-4	3	1-2
Marginal	3	2-3	1-2	1
Negligible	2	1-2	1	1

- Numbers in boxes indicate desired V&V maturity level to support an accreditation decision
- Desired V&V maturity levels must be justified based on test objectives
- See notes page for more information

Step 3. V&V Risk Matrix

- Risk Level = V&V Maturity Required – V&V Maturity Achieved (or Achievable)

Risk Level	VV&A Type	Risk Description
5/Very High	Verification Failure	Model/simulation is specifically unable to meet requirement referent for intended use.
4/High	Negative Indication to Verify	V&V accomplished was inconclusive to fully determine verification requirement but data trends suggest model or simulation will fail compliance criteria for intended use.
2-3/Moderate	Failure to Verify	V&V accomplished failed to determine whether the model or simulation meets requirement referent for intended use.
1/Low Risk	Positive Indication to Verify	V&V accomplished was inconclusive to fully determine verification requirement but data trends suggest model or simulation may be compliant and is suitable for intended use.
<1/Very Low Risk	Verified	V&V accomplished indicates model or simulation is verified against the requirement referent for intended use.

Step 4. Determine Risk Level

- Provide a list of all potential issues identified by category and show the V&V maturity level desired and actually achieved to address each issue
  - The V&V maturity level must be supported with evidence!
  - Document each potential issue using the "V&V RISK ANALYSIS" outline on the next chart
- For each risk area identified, provide the chart depicted in Step 4, along with the following information:
  - Specific problem
  - The specific known potential consequences
  - Any additional risk mitigation or V&V activities that may take place before use of the simulation environment
  - A projected schedule and cost to raise the V&V Maturity to the desired level (if possible)

Step 5. Report Risk

VV&A Process Complete

VV&A Approach

Applying VV&A to AFICE LVC Distributed Assessments

- Apply template to selected potions of AGILE Fire III
- Report, by project, results to mock Accreditation Authority or Authorities
  - Include Assessed Risk Levels, Ability to mitigate Risk, and Resulting VV&A Risk levels per template
- Report , for entire event, results to mock “Event Accreditation Authority”
- Document lessons learned
- Collect VV&A documentation where applicable
- Provide feedback to further update the template
  - Assess applicability in whole or part (with new upgrades) in preparing for AGILE FIRE IV
- Document entire process as a Use Case

AFICE Venue

Unique Venue to support AFICE Objectives

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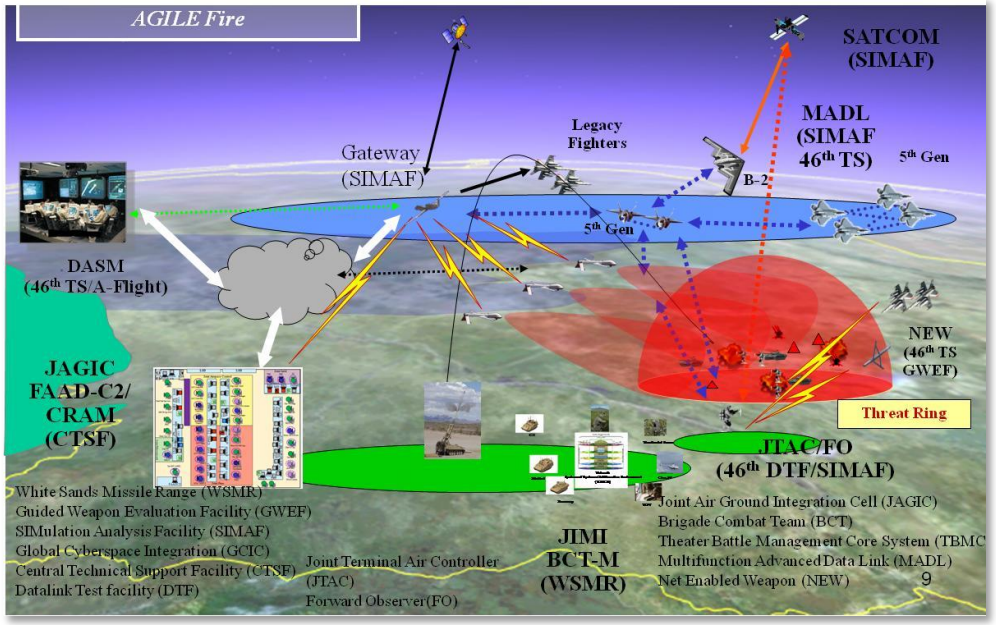
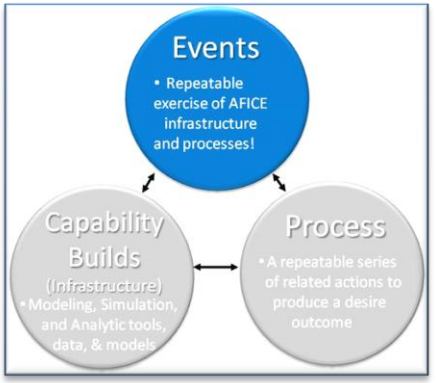
- **Focus on the interoperability within and between space, air and ground communication layers**
- **Capture the requirements for emerging technologies/ interfaces to existing force structure in mission contexts.**
- **Support the customers by enabling a SOS environment to meet their Net Centric assessment needs!**
  - Requirements drive assessments
  - Analysis rooted in mission threads
  - Net Centric Focus to link their system performance to their operational partners





AGILE II/III Description

Air and Ground Integrated Layer Exploration

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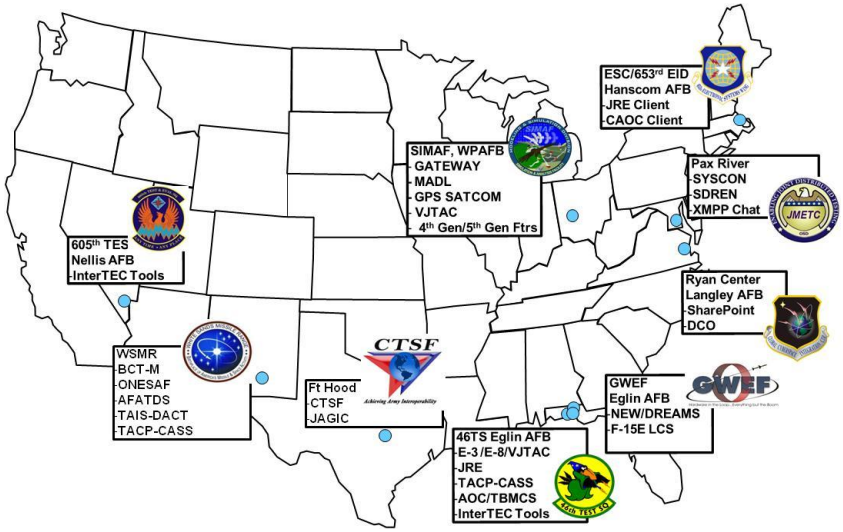
- Multifunction Advanced Data Link (MADL)
  - AFMC/Electronic Systems Center (ESC), SAF/A6W
- Gateway
  - AFMC/ESC; Air Force Command and Control Integration Center (AFC2IC)
- AFATDS – TACP CASS
  - PM AFATDS/TACP-CASS/Ft Sill FSC
- Joint Air Ground Integration Cell (JAGIC)
  - ACC/A3D – USAF OPR
  - Joint and Combined Integration (JACI) – USA OPR
- Dynamic Air Space Management
  - AFMC/ESC-PM TBMCS/PM TAIS/PM AFATDS
- Counter – Rocket Artillery and Mortar (C-RAM)
  - PEO C3T/PD- CRAM
- Net-Enabled Weapon (NEW)
  - NEW Interoperability Working Group (NEWIG), SAF/A6W
- Capability Net Centric Test & Training (CNCTT)
  - 505th Command Control Wing (CCW)



AGILE III's Schedule

- AGILE III's next planning Conference is 26 to 28 Oct at WPAFB
- First Integration Spiral is December 2010

AGILE FIRE PHASE III adds 5 new projects

Using AGILE

AGILE III and VV&A

- Part of OSD "VV&A Use Case" project tied to M&S Coordination Office High Level Task
- Used Networked-Enabled Weapon (NEW) as notional SUT
- Applied draft "Evaluation and Reporting Framework"
  - Risk-based framework
  - Pragmatic approach designed to achieve confidence in LVC environment while minimizing cost and schedule impacts
  - Focused on Live, Virtual, Constructive Distributed Environment (LVC-DE) for Test and Evaluation
- Reported results to mock Accreditation Authority (SAF/A6W SL) on 17 Aug 10
- Updated draft framework based on feedback
- **Reapply as Part of AGILE III, and IV in FY10**

Formalizing AFICE

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Air Force Integrated Collaborative Environment

Implementation Concept of Operations (CONOPS)

September 2010

Submitted by:

LAN CAWTHON, GS-15
Chief, Modeling & Simulation Policy Division
Directorate of Warfighting Systems Integration

Approved by:

WILLIAM J. BENDER, Brig Gen, USAF
Director, Warfighter Systems Integration
Office of Warfighting Integration and
Chief Information Officer

- **CONOPs signed by Brig Gen Bender (SAF/A6W) on 1 October 2010**
- **CONOPs establishes AFICE focus on program Integration and Interoperability**
- **Formalizes AFICE Governance**
  - *-Relationship to WFI GOSG*
  - *-Formation of an O-6/GS15 AFICE Advisory Group (AAG)*
  - *-Formation of an AFICE Users Group (AUG)*
- **CONOPS identifies a process for nomination of a War Fighter Gap**

AFICE and NR-KPP

Present and Future

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- **Begin to formalize Interoperability assessments**
  - Consistent with existing test
  - Not duplicative
    - Focus on testing the capability in mission threads vice message compliance within the System
  - Work with the NR-KPP experts

AFICE Goal: Move beyond finding problems after system release to engaging with programs and supporting primes to discover interoperability problems before system release

Summary

- AFICE uses a robust SE process to establish and maintain requirement traceability from analytic objectives through software development
- The resulting LVC environment is uniquely "engineered" for each customer based upon their analysis needs - Tied to a War Fighting Requirement
- **AFICE uses these environments to support integration and interoperability assessments based upon War-Fighter capability gaps**

Contact Information

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