



**Foundations '02 Workshop
Session T-2: Managing V&V**

Tomahawk Simulation Management

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Tomahawk Simulation Management

Discussion Points

- **Tomahawk Simulation Management Overview**
 - Organization
 - Accreditation Process
 - Responsibilities
- **To show DOD and DON requirements for verification, validation, and accreditation of Tomahawk models, simulations, and test configurations**
- **To illustrate pertinent differences between simulation and test configuration accreditation**



Tomahawk Simulation Management *History*

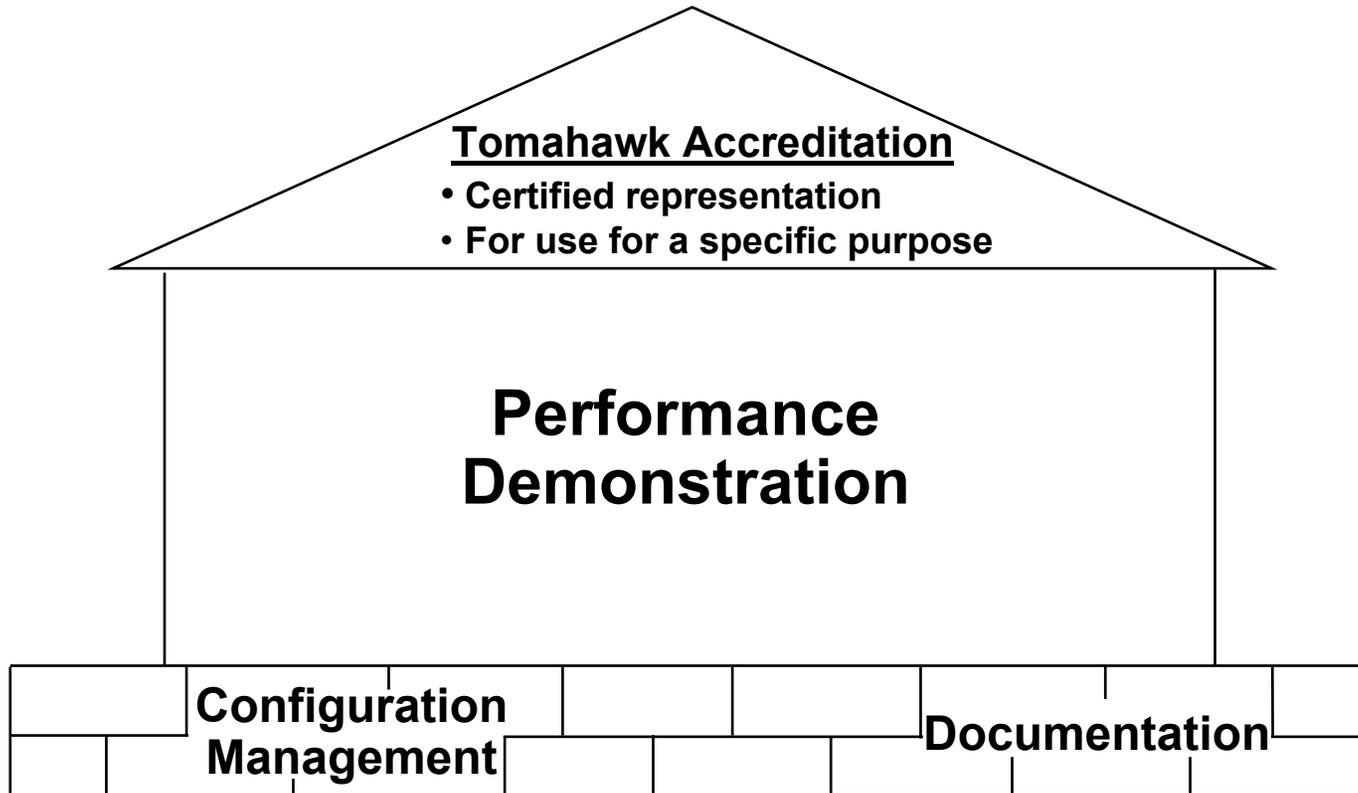
- **Problem Statement from *JCMPO 00/211 dated 14 March 83***
 - “Different Tomahawk... simulations have been developed and are being used by various... activities.”
 - “The assured interpretation of results obtained from one or another model is at best difficult. An in-depth understanding of the applicability and limitations of individual simulation outputs in relation to results derived from other models is often a difficult undertaking.”
 - “It is essential that procedures for the planning and coordination of all involved simulation activities be established.”
- **Problem Solution: Tomahawk Simulation Management**
 - Originated in 1983
 - Established organization, plans and procedures, and responsibilities to provide information for assured interpretation of simulation results.

Conclusion

The Tomahawk program has been successfully validating, accrediting, and managing its simulation assets for nearly 20 years.



Building Tomahawk Simulation Accreditation



- **Tomahawk Simulation Management defining documents (i.e., the blueprints for the building)**
 1. Tomahawk Simulation Management Policy, PEO(W)INST 5232.1A, 17 June 2002.
 2. Tomahawk Simulation Management Plan, PEO(CU) 5232/4, December 1998.
- **Tomahawk Simulation Management was established in 1983 under charter from Joint Cruise Missiles Project Office.**



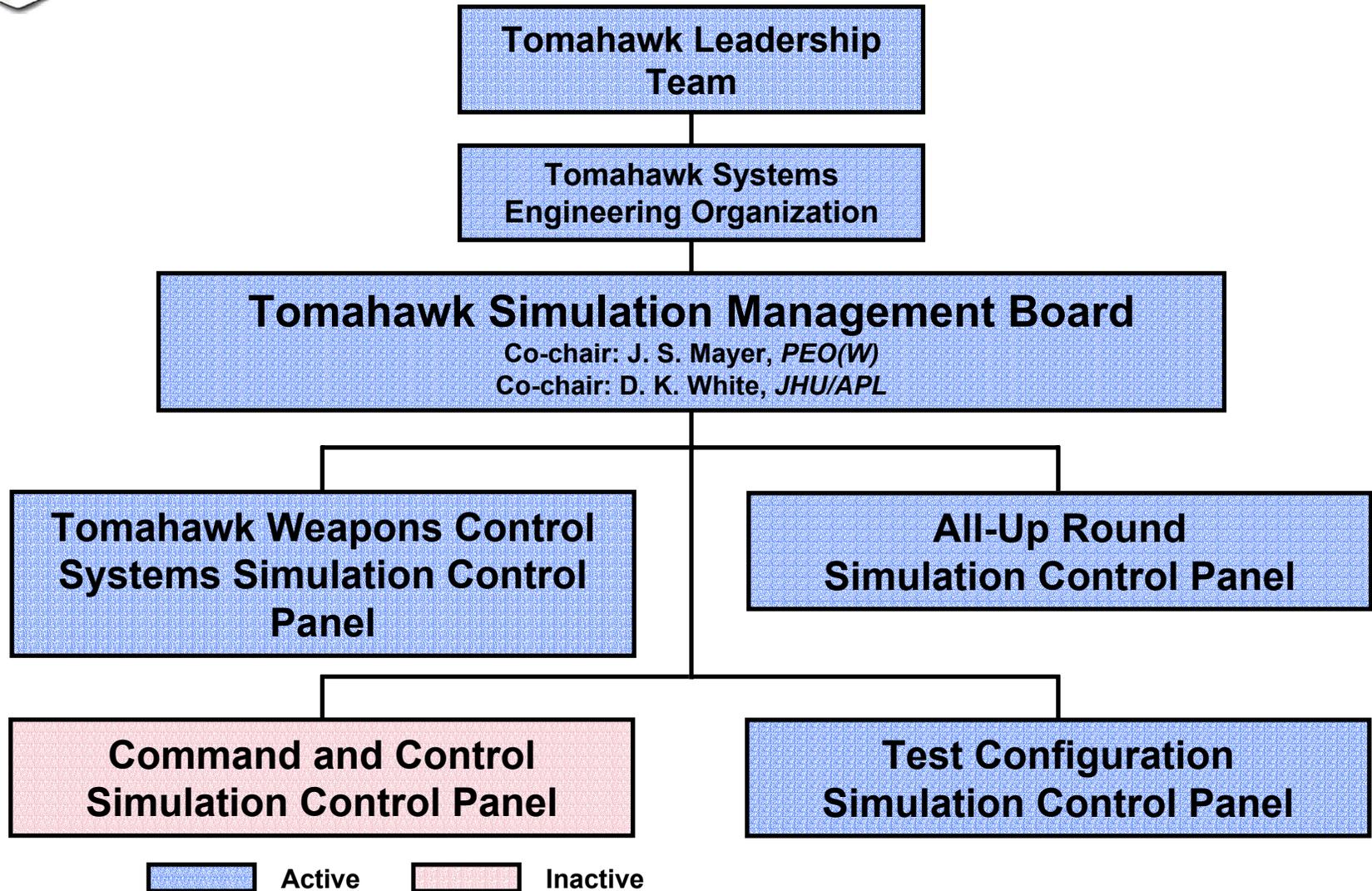
Tomahawk Simulation Management

Other Relevant Instructions

- **SECNAVINST 5200.40, *Verification, Validation, and Accreditation (VV&A) of Models and Simulations*, 19 Apr 1999.**
 - Establishes Navy policy, procedures, and responsibilities for M&S VV&A requirements
 - PEO(W)INST 52332.1A is consistent with SECNAV instruction
- **SECNAVINST 5200.38A, *Department of the Navy Modeling and Simulation Management*, 28 Feb 2002.**
 - Provides guidance and establishes organizational structure for management of Navy M&S
- **COMOPTEVFORINST 5000.1, *Use of Modeling and Simulation (M&S) in Operational Testing*, 05 Sep 1995.**
 - To promulgate procedures that make M&S useable by operational testers
- **DMSO RPG Build 2, *VV&A Recommended Practices Guide*, 16 May 2000**
 - Broad ranging VV&A guidance for DOD.



Tomahawk Simulation Management Organization





Tomahawk Simulation Management Board

- **Tomahawk Simulation Management Board (TSMB) is the principal agent for development and implementation of Tomahawk simulation management policy**
 - **Membership selected from PEO(W), JHU/APL, Navy Laboratories, and Navy field activities.**
 - **Responsibilities include:**
 - **Review of simulations for accreditation and accreditation update based on recommendations received from the Simulation Control Panels.**
 - **Ensure authorized Tomahawk simulations are identified, technically characterized, and documented in the Tomahawk Simulation Catalog.**
 - **Maintain the Tomahawk Simulation Archive**
 - **Providing program-specific M&S expertise and coordination among programs.**



Simulation Control Panels

- **Simulation Control Panels (SCPs) are staffed with subject matter experts.**
 - **Responsibilities**
 - **Provide technical support to the TSMB**
 - **Technical review of simulation verification and validation data**
 - **Recommends accreditation to the TSMB**
 - **Maintains accreditation plans and schedules**
 - **Subject matter experts (SMEs) drawn from responsible organizations. Experts in Tomahawk, flight dynamics, weapon control system components, simulation.**
 - **SCP is not their “day job”**
 - **Participation is expected to be long-term**
 - **Organizations providing representation on AUR/SCP include: RMS, SAIC, WPC, NSWC/IHD, NSWC/DD, COTF, JHU/APL, NAWCWPNS/CL.**
 - **Organizations providing representation on TWCS/SCP include: NSWC/DD, NUWC/DN, JHU/APL, RMS, PMS-425, COTF.**
 - **Organizations providing representation on TC/SCP include: NSWC/DD, NUWC/DN, PMA-280, PMA-281, PMA-282, Cruise Test, NAWC/AD, JHU/APL, COTF, SEO.**



Tomahawk Simulation Management

Aspects of Current VV&A Process

- **Tomahawk Simulation Accreditation defines fundamental process for accreditation of simulations and test configurations**
- **Fundamental components of VV&A**
 - **Advocacy**
 - **Independent assessment**
 - **Accreditation Plan and Catalog Entry**
 - **Validation adequate to justify desired accreditation**
 - **Technical review by SMEs**
 - **Defined representation and applicability**
 - **Accreditation Package**
 - **Plan, catalog entry, accreditation report, user's guide, version description document, configuration control plan, source code, reference checkcases.**
 - **Certificate**
 - **Issued by TSMB based on accreditation package review and cognizant SCP recommendation.**



Accreditation Template Synopsis

- **Process is applicable for accreditation of new or updated simulations as well as expanded application of an accredited simulation**
 - **Authorize simulation**
 - **Approve Accreditation Plan**
 - **Present Accreditation Report to SCP**
 - **Documents validation results of Accreditation Plan**
 - **Includes technical demonstration of correctness and consistency by one or more methods**
 - Validation by comparison with test data
 - Validation by comparison with other accredited simulation results
 - Validation through audit of technical data
 - **SCP reviews and approves report and documentation**
 - SCPs reach accreditation decision by consensus
 - **Certificate is awarded by TSMB after recommendation by cognizant SCP**
 - **SCP recommendation approved or action items assigned for completion prior to approval**
 - **ALL accreditation material in Tomahawk Simulation Archive for full accreditation**



Accreditation... What it is not.

- **An administrative activity**
- **Easy**
- **Show and Tell**
- **One size fits all**
- **An approbation**



Accreditation... What it is.

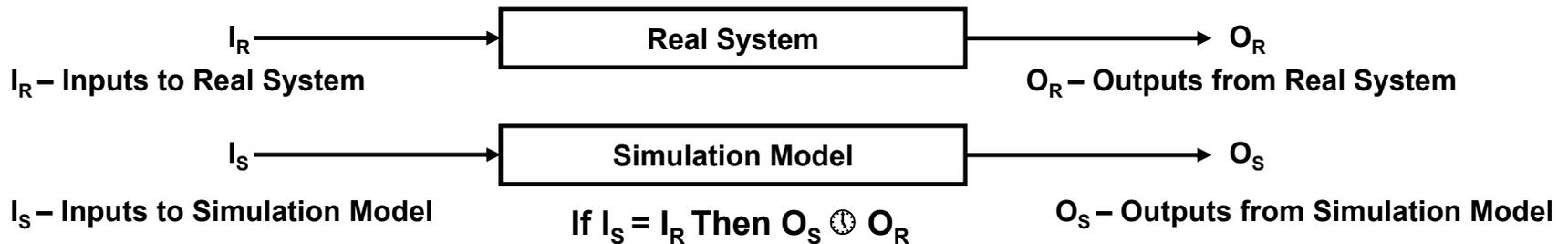
- **The official determination that a model or simulation is acceptable to use for a specific purpose. (TSMP and SECNAVINST 5200.40)**
 - The evidence required for the accreditation determination is a function of the intended use of the simulation.
- **A value-added technical activity**
 - Assures accreditation authority (decision maker), who doesn't have time to understand all the many technical details of a complex simulation, can trust the credibility of the simulation results he's received and the capability of the simulation users because subject matter experts have technically reviewed the validity and management of the simulation in light of its intended use.
- **Unique to each M&S**
 - Because representation and applicability are unique for every M&S
- **Required by the DOD, DON, and the Tomahawk Program.**
- **Well established**
 - First Tomahawk accreditations in 1987
 - Panel membership is expected to be (and is) long-term



How AUR/SCP Validates Simulations

- **Results-based validation using subject matter experts**
 - ✓ Tough-minded Simulation Control Panel
 - ✓ SCP assesses validation data credibility and simulation results prior to use
 - ✓ Accreditation effort builds consensus and is ongoing
 - ✓ Validation is difficult because important real world inputs can be unknown or poorly calibrated

• The Validation Process



The TSMB has never fully accredited an AUR simulation without results-based validation traceable to missile flight test.



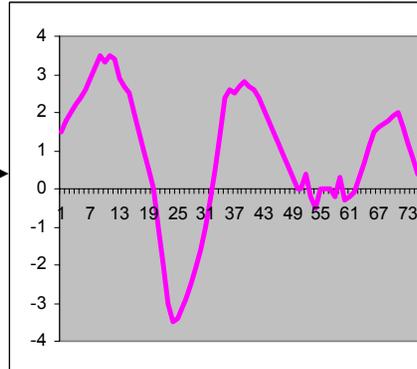
An Example Showing Results-Based Validation

Real System Inputs (I_R)

- Flight Test Mission
- Environment
- Disturbances
- Instrument Errors
- In-spec Parameter Variations

Tomahawk
Weapon
System

Flight Test Results (O_R)

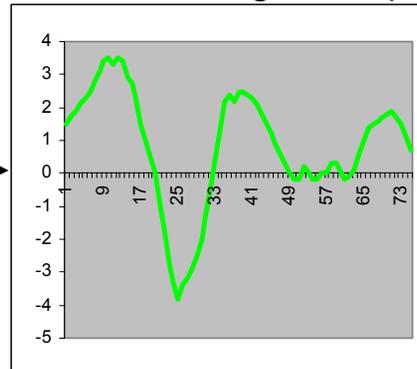


Simulation Inputs (I_S)

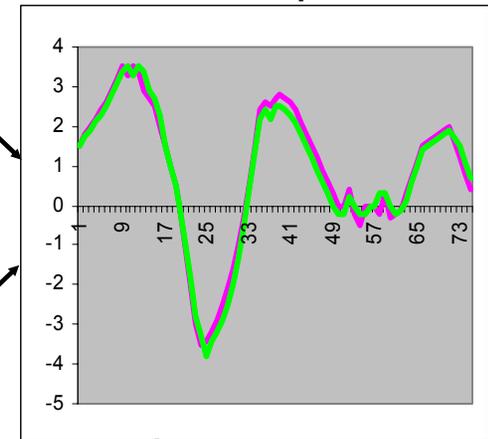
- Flight Test Mission
- Flight Test Conditions
- Assumptions

Tomahawk
Simulation

Simulation of Flight Test (O_S)



Results Comparison



Good
Enough?

Yes

No

Assess
Next Case

Verification of:

- Simulation
- Flight Test Mission
- Flight Test Conditions
- Assumptions
- Simulation Initial Conditions



How AUR/SCP Determines “Good Enough”

- **Based on expertise, experience, and engineering judgment**
 - SMEs review the results for reasonableness and to ensure the results are consistent with how they perceive the system should operate.
 - Most AUR/SCP members have accredited simulations so they know what is reasonable and where “gotchas” are.
- **It depends on the parameter**
 - Outer loop variables such as latitude, longitude, altitude ought to match extremely well.
 - First derivatives should match; peaks may not match.
 - Inner loop variables should show same trends, transients, and dynamics but may not match perfectly.
- **It depends on the accreditation**
 - A reference HIL simulation used for missile performance prediction will be held to a higher standard than, say, an FGT HIL simulation which is accredited for hardware checkout and not performance prediction.



How AUR/SCP Determines “Good Enough”

- **Is it subjective?**
 - Yes but it’s also practical permitting examination of the representational quality of parameters as a function of time.
 - Consensus building and understanding among experts is ongoing.
 - Thus SCP reviews are actually more useful to responsible organization than structured criteria. Each SME brings his expertise to the table.
 - Technical concerns opened from checkcase review must be closed as part of accreditation – by whatever means necessary to address them.
 - The SCP looks out for Tomahawk program but will provide assistance to responsible organization.
- **Can “objective” criteria be used?**
 - Only for most trivial site accreditation. (*Does it binary-match?*)
 - None are defined for Tomahawk 6DOFs. Meaningful, technically defensible criteria would have to be defined, defended, and agreed-to. Nearly all Tomahawk 6DOF practitioners are extremely dubious of this approach.
 - Real world processes are usually non-stationary and correlated making use of statistical tests questionable.
 - Uncertainty in test conditions, TM noisiness, timing differences, quantization make this notion very problematic.
 - Does not obviate the need for results-based comparisons.



Motivation for Test Configuration Accreditation Process Development

- The tester needs to understand the limitations and capabilities of the simulations and test configurations.
- Tomahawk Strike Network expands the end-to-end testing performed.
- COMOPTEVFOR (operational tester) supplements actual test with M&S.
 - Will not accredit something the TSMB has not.
- Test configuration accreditation requirement exists under current DOD and DON VV&A instructions.

Bottom Line

The tester has a need to have appropriate subject matter experts characterize the HIL system as a test resource.

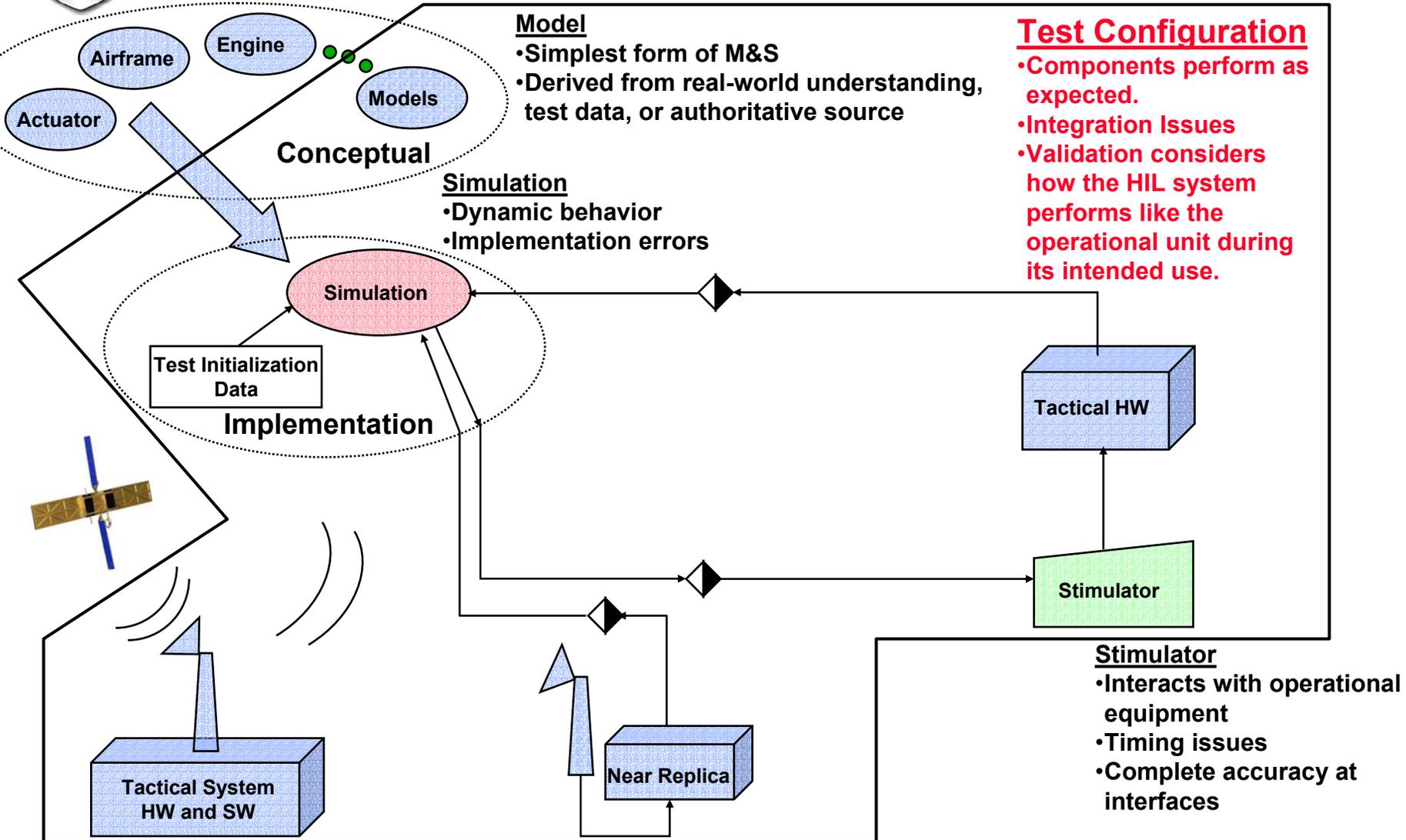


Test Configuration Accreditation Adaptations to TSMB Template

- **Each test configuration will have its own Catalog Entry and Accreditation Plan.**
- **Require individual accreditation of M&S components in the HIL configuration.**
 - Tactical components and systems are not accredited. Facilities are not accredited. Configurations of facilities are not accredited. Specific tests using a specified test configuration are accredited.
- **Require configuration management of the test configuration in addition to individual component CM.**
 - Benchmark checkcase data from accreditation used during testing.
- **Implement a single Test Configuration Simulation Control Panel (TC/SCP) to recommend accreditation of test configurations.**
- **Recommend that System-level test configuration accreditation status be incorporated into the test readiness review process.**



Tomahawk Simulation Management Accreditation Requirement Rationale



Model

- Simplest form of M&S
- Derived from real-world understanding, test data, or authoritative source

Simulation

- Dynamic behavior
- Implementation errors

Test Configuration

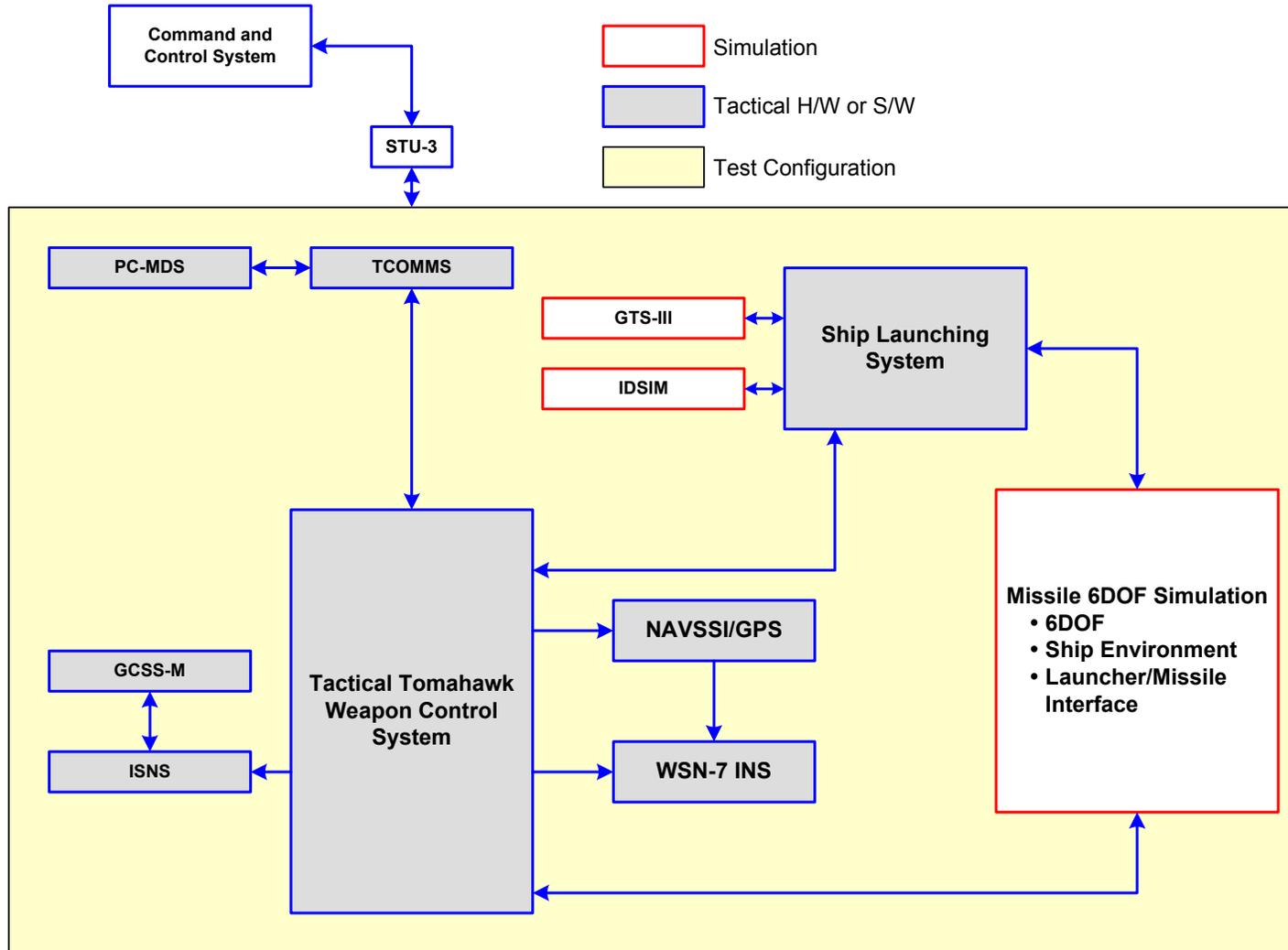
- Components perform as expected.
- Integration Issues
- Validation considers how the HIL system performs like the operational unit during its intended use.

Stimulator

- Interacts with operational equipment
- Timing issues
- Complete accuracy at interfaces



Tactical Tomahawk OT-IIB Test Configuration





Tomahawk Simulation Management

Tomahawk Simulation Accreditation

Full Accreditation: All requirements have been met.

Provisional Accreditation: Performance has been demonstrated but not all accreditation requirements have been satisfied. (e.g., document preparation due to inadequate funding or sponsor accreditation timeline.)

Limited Accreditation: Validation against real system data is incomplete although validation against all existing comparison data indicates correct performance and results consistent with other simulations.

- Typically applies to an emerging development or when no real-world data exists.
- Limitation on applicability is expressed on the certificate (e.g., Full accreditation for development flight test prediction).

Site Accreditation: Applies when an accredited Tomahawk simulation is installed and used at an additional site.

- **Accreditation applies to:**
 - ✓ All TWS models and simulations producing results that are presented outside the responsible organization.
- **Tomahawk accreditation satisfies DON and COMOPTEVFOR requirements.**



Tomahawk Simulation Management Generic Accreditation Certificate

TOMAHAWK Simulation Management Board Certificate

To: Simulation Using Organisation
From: TOMAHAWK Simulation Management Board
Subject: [Full; Provisional]{Site}{Reference Simulation/Model/Database/Test Configuration} Accreditation {limitation} of _____ {at _____}

Accredited to Represent: _____

For Use In: _____

Responsible Organization: Simulation Responsible Organization

<p>This Limited Accreditation is for:</p> <p style="text-align: center;">Version Dated (version date)</p> <p>Based on the following major activities:</p> <p><input checked="" type="checkbox"/> _____]</p> <p><input checked="" type="checkbox"/> _____]</p> <p>Previous Accreditation:</p> <p style="text-align: center;">[Initial Tomahawk Accreditation/Version, Date]</p>	<p>The following materials support accreditation:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;"> <input type="checkbox"/> Accreditation Plan <input type="checkbox"/> Accreditation Report <input type="checkbox"/> Configuration Control Plan <input type="checkbox"/> Current Catalog Entry <input type="checkbox"/> Version Description Document </td> <td style="width: 50%; border: none;"> <input type="checkbox"/> Users Manual <input type="checkbox"/> Benchmark Checkcases <input type="checkbox"/> Reference Checkcases <input type="checkbox"/> Source Code/ Listing </td> </tr> </table>	<input type="checkbox"/> Accreditation Plan <input type="checkbox"/> Accreditation Report <input type="checkbox"/> Configuration Control Plan <input type="checkbox"/> Current Catalog Entry <input type="checkbox"/> Version Description Document	<input type="checkbox"/> Users Manual <input type="checkbox"/> Benchmark Checkcases <input type="checkbox"/> Reference Checkcases <input type="checkbox"/> Source Code/ Listing
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Accreditation Recommended:

AUR-SCP Co-Chair: _____
Date

AUR-SCP Co-Chair: _____
Date

Accreditation Approved:

Co-Chair, Tomahawk Simulation Management Board Date



Tomahawk Simulation Management *Relationship to COMOPTEVFOR*

- **Originated with briefing to DOT&E May 1992**
 - Briefed history and accreditation activities
 - Oriented toward simulation-based OT
 - Resulted in acceptance of Tomahawk accreditation
- **Expanded/formalized for TBIP and weapons systems**
 - RADM Zerr advertisement of Tomahawk Simulation Management
 - COMOPTEVFOR membership on SCPs
- **COMOPTEVFOR accreditation based on Tomahawk accreditation**
 - Joint review, independent action
 - COMOPTEVFOR never accredits a Tomahawk simulation or test configuration without prior TSMB accreditation



Tomahawk Simulation Management *Summary*

- **Tomahawk Simulation Management VV&A procedures conform to DON instruction.**
- **Tomahawk program managers and simulation proponents view TSMB accreditation process as a value-added, if painful, activity.**
 - Defects in simulations, flight software, and design have been found in the 20 years of Tomahawk Simulation Management.
- **Accreditation of Tomahawk M&S is performed by each contractor and government activity as a continuing part of its assigned tasking.**
- **Accreditation of test configurations supporting Tactical Tomahawk operational evaluation.**
 - TSMB accreditation highly regarded by Navy operational testers.